Structure Foundation Exploration
Proposed Bridge Replacement
LUC-Corduroy Road,
PID 119725

Corduroy Road over Otter Creek
Oregon, Lucas County, Ohio

Geotechnical Subsurface Investigation

City of Oregon
5330 Seaman Road
Oregon, Ohio 43616

July 2, 2024

CT Project No. 232516

CT Consultants, Inc.

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July 2, 2024 **CT Project No. 232516**

Mr. Rodney Shultz, P.E.
City of Oregon
5330 Seaman Road
Oregon, Ohio 43616

DRAFT Report
Structure Foundation Exploration
Proposed Bridge Replacement
LUC-Corduroy Road, PID 119725
Corduroy Road over Otter Creek
Oregon, Lucas County, Ohio

Dear Mr. Shultz:

Following is the report of the structure foundation exploration performed by CT Consultants, Inc. (CT) at the site of the referenced project. This exploration was performed in general accordance with CT Proposal No. 232516R, dated December 7, 2023, and was authorized with the City of Oregon Purchase Order No. 20232421-00, dated December 15, 2023.

A design memorandum was submitted on February 26, 2024 containing recommendations for support of the new three-sided culvert on spread foundations. It was later indicated that the structure will be supported on driven piles. Scour soil parameters were provided to the design team on April 24, 2024, and pile foundation recommendations followed on May 9, 2024. This report contains the results of our study, our engineering interpretation of the results with respect to the project characteristics, and our recommendations for design and construction of foundations. This report is being submitted as "Draft" pending questions and comments by City of Oregon or the design team. This report is considered complete and comprehensive with respect to the requested scope of work.

Should you have any questions regarding this report or require additional information, please contact our office.

Sincerely,

CT Consultants, Inc.

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DRAFT REPORT
STRUCTURE FOUNDATION EXPLORATION
PROPOSED BRIDGE REPLACEMENT
LUC-CORDUROY ROAD, PID 119725
CORDUROY ROAD OVER OTTER CREEK
OREGON, LUCAS COUNTY, OHIO

FOR

CITY OF OREGON
5330 SEAMAN ROAD
OREGON, OHIO 43616

SUBMITTED

JULY 2, 2024
CT PROJECT NO. 232516

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EXECUTIVE SUMMARY

This structure foundation exploration report has been prepared for the replacement of the existing Corduroy Road bridge over Otter Creek in Oregon, Lucas County, Ohio. This exploration included two structure borings. A summary of the conclusions and recommendations of this study are as follows:

1. The borings were performed within the grassed area in close vicinity of the pavement edges, and the encountered surface materials consisted of topsoil on the order of 4 to 18 inches in thickness.

2. The subsoils encountered underlying the topsoil material can be generally described as three soil strata. The strata included upper profile predominantly granular existing fill materials underlain by marginal strength cohesive soils underlain by "hardpan" consisting of interbedded cohesive and granular soils.

   Stratum I consisted of predominantly granular **existing fill materials** underlying the topsoil materials extending to depths of 12.5 feet (refusal on apparent wingwall concrete) and 14 feet below the existing grade (Elevs. 567.5± and 566.5±) in Borings B-001-1 and B-002, respectively. The granular soils consisted of crushed stone mixed with sand, as well as fine sand (ODOT A-1-a and A-1-b, as well as A-3). Within the predominantly granular existing fill in Boring B-002, **intermittent layers of cohesive existing fill** were encountered. The cohesive fill consisted of silt and clay as well as silty clay (A-6a and A-6b).

   Stratum II consisted of predominantly medium stiff to stiff cohesive soils underlying Stratum I to a depth of 43.5 feet in both borings (Elev. 537±). These cohesive soils consisted of silt and clay (ODOT A-6a).

   Stratum III consisted of dense to very dense granular soils with interbedded hard sandy silt zones (commonly referred to as "hardpan") underlying Stratum II to termination at a depth of 73.7 feet (Elev. 506.5±) in Boring B-001 and to a depth of 73.5 feet (Elev. 507±) in Boring B-002. The granular soils consisted of coarse and fine sand (ODOT A-3a), or gravel and stone fragments with sand and silt (ODOT A-2-4). Within Stratum III, intermittent layers of hard sandy silt (A-4a) were encountered in both borings.

3. A zone of apparent weathered bedrock was encountered over the last 5-inch SSR sample interval in Boring B-002. Boring B-002 was terminated after SSR at a depth of 73.9 feet (Elev. 506.5±).

4. It is our opinion that the "normal" groundwater level at this structure location will generally occur at or slightly above the stream flow water level in Otter Creek, which was at a depth of approximately 10 feet below the existing roadway grade (Elev. 570±) at the time of the borings exploration. Temporary sheet-pile cutoff walls or cofferdams to direct streamflow may be required to manage groundwater in addition to pumping from prepared sumps.

5. Pile foundations consisting of 12-inch diameter cast-in-place (CIP) concrete piles with driven pipe shells or HP 10x42 piles were found to have the same tip depth for the indicated Ultimate

Bearing Value (UBV). Order lengths were found to be 45 feet for the rear (west) abutment and 40 feet for the forward (east) abutment.

This executive summary highlights our evaluations and recommendations and should only be utilized in conjunction with the accompanying report, including the detailed findings, analysis and recommendations, and qualifications presented herein.

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1.0 INTRODUCTION

This structure foundation exploration report has been prepared for the replacement of the existing Corduroy Road bridge over Otter Creek in Oregon, Lucas County, Ohio. The project area is located approximately 2/3 mile east of Wheeling Street intersection with Corduroy Road, as shown on the Site Location Map (Plate 1.0).

This exploration was performed in general accordance with CT Proposal No. 232516R, dated December 7, 2023, and was authorized with the City of Oregon Purchase Order No. 20232421-00, dated December 15, 2023.

1.1 Purpose and Scope of Exploration

The purpose of this exploration was to evaluate the subsurface conditions relative to the design and construction of foundations for a new bridge structure. To accomplish this, CT performed two test borings, field and laboratory soil testing, a geotechnical engineering evaluation of the test results, and a review of available geologic and soils data for the project area.

This report summarizes our understanding of the proposed construction, describes the investigative and testing procedures utilized to evaluate the subsurface conditions at the site, and presents our findings from the field and laboratory testing. This report also provides design and construction recommendations for foundations for the proposed bridge replacement structure.

This report includes:

- A description of the subsurface soils and groundwater conditions encountered in the borings.
- Design recommendations for foundations associated with the bridge replacement.
- Recommendations concerning soil- and groundwater-related construction procedures such as site preparation, earthwork, foundation construction, as well as related field testing.

This exploration did not include an environmental assessment of the surface or subsurface materials at the site.

1.2 Proposed Construction

It is our understanding that the existing bridge will be replaced with a new three-sided culvert. Final roadway grades are anticipated to approximate existing grades.

Initially, the replacement structure was planned to be supported on shallow spread foundations bearing at approximately Elev. 568. Due to existing fill materials (likely associated with backfill for construction of the existing structure), as well as underlying marginal bearing soils extending relatively deep below the bearing elevation encountered in the borings, it is now planned to support the structure on driven pile foundations.

Previously provided spread foundation recommendations are provided in Section 5.1.2 (italicized to reflect the archive status of these recommendations), and archive spread foundation recommendations are provided in Appendix B.

For the currently planned driven piles for support of the new structure, bottom of abutment elevation is indicated at Elev. 568.68 and 2 feet of stickup is planned in the abutment for both the rear (west) and forward (east) abutments. Based on previously provided scour soil parameters, it was indicated by EMH&T that scour evaluations should be based on Elev. 566. The ultimate bearing value (UBV) was indicated to be 236 kips. Recommendations for these piles are provided in Section 5.1.1, and our evaluations are provided in Appendix A.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 General Geology and Hydrogeology

Published geologic maps from the Ohio Department of Natural Resources (ODNR) Division of Geological Survey indicate that the project site is located in the Maumee Lake Plains Physiographic Region. This region is within the Huron-Erie Lake Plains Section.

Within the Maumee Lake Plains Physiographic Region, the upper profile geology includes predominantly Pleistocene-age silts and clays that were lake-laid (lacustrine) sediments, underlain by glacial till deposits, which are underlain by sedimentary bedrock.

The USDA Natural Resource Conservation Service (NRCS) Web Soil Survey indicates that soils in the project area are predominantly mapped as Udorthents Loamy soils, which are soils that have been excavated and spread or replaced. The upper profile soils consist of backfill placed after installation of the existing bridge structure.

The lacustrine sediments were deposited in historic glacial lakes following retreat and melting of glacial ice. The glacial till, also referred to as moraine, was deposited by the advance and retreat of glacial ice. Due to the weight of the ice mass, the till deposits are moderately to highly over-consolidated, that is, the existing soil deposits have experienced a previous vertical stress significantly higher than the effective vertical stress presently caused by the remaining overlying soil strata in the profile. Additionally, within the glacial till, it is not uncommon to encounter cobbles, boulders, and seams of granular soils, which may or may not be water bearing.

Bedrock in the project area is broadly mapped on the "Geologic Map of Ohio" as Monroe limestone. Specific to the project site, the uppermost carbonate rock formation is mapped as Greenfield dolomite. Bedrock in the project vicinity is mapped at approximately 60 to 80 feet below existing grades, corresponding to Elevs. 520± to 500±. Apparent weathered rock was encountered upon encountering split-spoon refusal over the final sample interval in Boring B-002 performed for this exploration.

2.2 Observations of the Project

The site is located in an area with residences to the south and the City of Toledo Collins Park Water Treatment Plant to the north. Roadway grades in the general project area are relatively flat. Existing roadway pavements consist of asphalt pavement. At the time of our exploration, the water level in the creek was approximately 10 feet below existing grades.

3.0 EXPLORATION

3.1 Historic Borings

A review of the ODOT Transportation Information Mapping System (TIMS) indicated no historic test borings were performed in the vicinity of the project structure.

3.2 Project Exploration Program

This exploration included two test borings, designated as Borings B-001-0-23 and B-002-0-23, performed by Ridgeway Drilling on January 8 and 10, 2024. Boring B-001-0-23 encountered apparent concrete of wingwall at a depth of approximately 12½ feet below existing grade and was offset approximately 30 feet west then designated as B-001-1-23. Four other attempts were made to advance the boring within about 5 to 10 feet of the original B-001-0 location, but they were not successful for advancement beyond approximately 12½ feet. These locations were not numerated or presented in this report.

The borings are fully designated as Borings B-001-0-23, B-001-1-23, and B-002-0-23 in accordance with ODOT protocol, but the "-0-23" or "-23" portion of the nomenclature is generally omitted for ease of identification in the discussions within this report.

Borings B-001-0 and B-002-0 were located in the field by City of Oregon, and B-001-1 was located in the field by Ridgeway Drilling with coordination by CT and City of Oregon. Borings B-001-0 and B-001-1 were performed just off the edge of road next to the westbound lane, west of the bridge. Boring B-002-0 was performed just off the edge of road next to the eastbound lane, east of the bridge. The approximate locations of the borings are shown on the Test Boring Location Plan (Plate 2.0).

Ground surface elevations and coordinates for the as-drilled locations of B-001-1 and B-002-0 were provided by City of Oregon. Stations and offsets at these locations were provided by EMH&T per direction of City of Oregon. Based on the approximately 30 feet offset for Boring B-001-1 from B-001-0, we estimated the coordinates, station, offset, and elevation (rounded to nearest whole foot) of B-001-0. The boring data is summarized in the following table.

Table 3.2 General Boring Information

Boring Number	Coordinates	Approximate Station (feet)	Approximate Offset (feet)	Ground Surface Elevation (feet)	Boring Termination Depth (feet)
B-001-0[(1)]	727283.8030 N, 1701871.1810 E	102+52	24 LT	580	12.6
B-001-1	727283.8030 N, 1701841.1810 E	102+22	24 LT	580.4	73.7

B-002	727240.9530 N, 1701900.2910 E	102+81	20 RT	580.6	73.9

(1)Boring Data estimated from B-001-1 based on approximate 30 feet offset.

The borings were performed in general accordance with Ohio Department of Transportation (ODOT) requirements and guidelines of "Specifications for Geotechnical Explorations" (SGE), Section 303.7.3 (Structure Borings – Culverts, Type E2a).

Experience indicates that the actual subsoil conditions at a site could vary from those generalized on the basis of test borings made at specific locations. Therefore, it is essential that a geotechnical engineer be retained to provide soil engineering and inspection services during the site preparation, excavation, and foundation phases of the proposed project. This is to observe compliance with the design concepts, specifications, and recommendations, and to allow design changes in the event subsurface conditions differ from those anticipated prior to the start of construction.

3.3 Boring Methods

The test borings performed during this exploration were drilled with a Diedrich D-50 ATV-mounted drill rig (SN:328). The borings were extended utilizing 3¼-inch inside diameter hollow-stem augers. During borehole advancement, samples were generally taken at 2½-foot intervals to a depth of 30 feet and at 5-foot intervals thereafter. Continuous sampling to obtain additional samples for evaluation of potential scour was performed from 12½ to 18½ feet using 18-inch sample drives. The samples obtained using a split-spoon sampler (as discussed below) were sealed in jars and transported to our laboratory for further classification and testing.

Split-spoon (SS) soil samples were obtained by the Standard Penetration Test Method (ASTM D 1586). The Standard Penetration Test (SPT) consists of driving a 2-inch outside diameter split-spoon sampler into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler was driven in three successive 6-inch increments, with the number of blows per increment being recorded, and these data are presented under the "SPT" column on the Logs of Test Borings attached to this report. The sum of the number of blows required to advance the sampler the second and third 6-inch increments is termed the Standard Penetration Resistance, or N_m-value, and is typically reported in blows per foot (bpf). The N_m-values were corrected to an equivalent rod energy ratio of 60 percent, N_{60}. The hammer/rod energy ratio was 81.8 percent for the Diedrich D-50 ATV-mounted drill rig (SN:328) utilized on this project, based on calibration performed on January 27, 2024. The N_{60}-values are presented on the attached Logs of Test Borings attached to this report. In conjunction with published data and typical correlations, the N_{60}-values can be evaluated as a measure of soil compactness/consistency as well as shear strength and bearing capacity.

Shelby tube samples, designated ST on the Logs of Test Borings, were obtained in Boring B-001-1, ST-5 (8½ to 20½ feet) and in Boring B-002, ST-12 (23½ to 25½ feet) by hydraulically advancing a 3-inch diameter, thin-walled sampler approximately 24 inches beyond the hollow-stem auger into relatively undisturbed soil in accordance with ASTM D 1587. The Shelby tubes were then extracted from the subsoils, and the ends were capped and sealed. The samples were transported to our laboratory where they were extruded, classified, and tested.

During auger advancement in Boring B-002, hard sandy silt with some rock fragments was encountered at a depth of 55 feet. Apparent auger refusal occurred at this depth. Therefore, a 5-foot "rock" core run was attempted using an NX core barrel. When the soil material was recovered in the core barrel, the boring was advanced to the next planned sample interval at 63½ feet where split-spoon sampling continued.

Soil conditions encountered in the test borings are presented in the Logs of Test Borings along with information related to sample data, SPT results and corresponding N_{60}-values, water conditions observed in the borings, and laboratory test data. Field and laboratory data were incorporated into gINT™ software for presentation purposes. It should be noted that these logs have been prepared on the basis of laboratory classification and testing as well as field logs of the encountered soils.

3.4 Laboratory Testing Program

All soil samples were visually or manually classified in accordance with the ODOT Soil Classification System. All samples of the subsoils were also tested in our laboratory for moisture content (ASTM D 2216). Atterberg limits tests (ASTM D 4318) and particle size analyses (ASTM D 6913 and D 7928) were performed on selected samples to determine soil classification and index properties as well as for scour potential analysis. Dry density determinations and unconfined compressive strength tests (ASTM D 2166) by the constant rate of strain method were performed on the Shelby tube samples and selected intact cohesive split-spoon samples. Unconfined compressive strength estimates were obtained for the remaining intact cohesive samples using a calibrated hand penetrometer. These test results are presented on the Logs of Test Borings attached to this report. Gradation results are also provided in graphical form attached to this report. Additionally, stress-strain curves for the unconfined compressive strength tests performed on the Shelby tube samples are attached to this report.

It should be noted that dry density determinations and unconfined compressive strength tests were performed on intact split-spoon (SS) samples as well as Shelby tube (ST) samples. Due to the sample size and sampling disturbance effects on split-spoon samples, dry density and

unconfined compressive strengths may be less precise than for Shelby tube samples. Typically, unconfined compressive strength results from SS samples will tend to be lower than those from ST samples, and this trend is often more pronounced for soft clays than for stiff to hard clays. Nevertheless, test results from SS samples can be used as "index" parameters to compare and contrast soil properties within similar strata and between different strata.

4.0 FINDINGS

4.1 General Site Conditions

The project site is located along Corduroy Road, at the crossing of Otter Creek, approximately 2/3 mile east of the intersection with Wheeling Street, in Oregon, Lucas County, Ohio. Roadway grades in the project area are generally level, with ground surface elevations at the boring locations on the order of Elev. 580. Per the drillers' observation, the water level in the creek at the time of our exploration was approximately 10 feet below roadway grades, at Elev. 570±.

The borings were performed just beyond the pavement edges, in grassy areas. The encountered surface materials consisted of topsoil on the order of 4 to 18 inches in thickness.

4.2 General Soil Conditions

The subsoils encountered underlying the topsoil material can be generally described as three soil strata. The strata included upper profile predominantly granular existing fill materials underlain by marginal strength cohesive soils underlain by "hardpan" consisting of interbedded cohesive and granular soils.

Stratum I consisted of predominantly granular **existing fill materials** underlying the topsoil materials extending to depths of 12.5 feet (refusal on apparent wingwall concrete) and 14 feet below the existing grade (Elevs. 567.5± and 566.5±) in Borings B-001-1 and B-002, respectively. The granular soils consisted of crushed stone mixed with sand, as well as fine sand (ODOT A-1-a and A-1-b, as well as A-3). SPT N_{60}-values ranged from 3 to 16 blows per foot (bpf) for the crushed stone, indicating **very loose** to medium dense compactness. In the sand zone, the SPT resulted in N_{60}-values ranging from 74 to 83 bpf, or split-spoon refusal (SSR), indicating very dense compactness. Moisture contents ranged from 5 to 15 percent.

Within the predominantly granular existing fill in Boring B-002, **intermittent layers of cohesive existing fill** were encountered. The cohesive fill consisted of silt and clay as well as silty clay (A-6a and A-6b). SPT N_{60}-values for cohesive fill ranged from 3 to 11 bpf, indicative of **soft** and stiff consistency, respectively. Moisture contents ranged from 13 to 23 percent. An unconfined compressive strength of 3,000 pounds per square foot (psf) was determined for the stiff sample, as the soft sample was not intact enough for a compressive strength determination.

Stratum II consisted of predominantly medium stiff to stiff cohesive soils underlying Stratum I to a depth of 43.5 feet in both borings (Elev. 537±). These cohesive soils consisted of silt and clay (ODOT A-6a). SPT N_{60}-values generally ranged from 5 to 15 bpf. Unconfined compressive

strengths generally ranged from 1,500 to 4,000 pounds per square foot (psf). Moisture contents ranged from 12 to 20 percent.

Stratum III consisted of dense to very dense granular soils with interbedded hard sandy silt zones (commonly referred to as "hardpan") underlying Stratum II to termination at a depth of 73.7 feet (Elev. 506.5±) in Boring B-001 and to a depth of 73.5 feet (Elev. 507±) in Boring B-002. The granular soils consisted of coarse and fine sand (ODOT A-3a), or gravel and stone fragments with sand and silt (ODOT A-2-4). Within these soils, the SPT generally resulted in split-spoon refusal (SSR). Moisture contents for the granular soils ranged from 7 to 13 percent.

Within Stratum III, intermittent layers of hard sandy silt (A-4a) were encountered in both borings. Within these soils, the SPT resulted in SSR. The recovered samples were brittle so they were typical non-intact, so unconfined compressive strength determinations could not be made. Moisture contents ranged from 8 to 13 percent.

A zone of apparent weathered bedrock was encountered over the last 5-inch SSR sample interval in Boring B-002. Boring B-002 was terminated after SSR at a depth of 73.9 feet (Elev. 506.5±).

Additional descriptions of the stratigraphy encountered in the borings are presented on the Logs of Test Borings.

4.3 Groundwater Conditions

Groundwater was initially encountered during drilling in Borings B-001-1 and B-002 at depths of 17 feet and 7 feet below existing grade, respectively (Elevs. 563.5± and 573.5±, respectively). Groundwater was not observed upon completion of drilling in any of the borings. It should be noted that borings were drilled and sealed within the same day. Therefore, stabilized water levels may not have occurred over this limited time period. Instrumentation was not installed to observe long-term groundwater levels.

Based on the soil characteristics and moisture conditions encountered in the borings, it is our opinion that "normal" groundwater levels at this structure location will generally occur at or slightly above the stream flow level in Otter Creek, which was at a depth of approximately 10 feet below existing roadway grade (Elev. 570±) during our exploration. It should be noted that groundwater elevations can also fluctuate with seasonal and climatic influences, as well as streamflow conditions in the creek. Therefore, the groundwater conditions may vary at different times of the year from those encountered during this exploration.

4.4 Potential Scour Evaluations

Based on gradation, plasticity, and strength testing for selected samples near bottom of creek elevation, evaluations of critical shear stress and erosion category were made. Results of these evaluations are presented in a table in Appendix A.

4.5 Remedial Measures

Based on the conditions encountered in the borings, the subsoils consisted of predominantly granular existing fill materials extending to approximate bearing elevation for the initially considered culvert spread foundations. The fill materials were underlain by marginal cohesive soils extending relatively deep below bearing elevation. As such, it is now planned to use driven piles to support the replacement structure.

During construction, temporary sheet-pile cutoff walls or cofferdams to direct streamflow may be required to manage groundwater in addition to pumping from prepared sumps.

5.0 ANALYSES AND RECOMMENDATIONS

The following analyses and recommendations are based on our understanding of the proposed construction and upon the data obtained during our field exploration. If the project information or location as outlined is incorrect or should change significantly, a review of these recommendations should be made by CT.

5.1 Culvert Foundations

5.1.1 Pile Foundations

We understand that the proposed three-sided culvert foundations will be designed using LRFD specifications. For piles not driven to refusal on bedrock, the ODOT Bridge Design Manual (BDM) indicates that piles should be specified as CIP concrete piles with driven pipe shells. We have evaluated closed-end pipe shells. It is our recent experience that H-piles may be an economical alternative for the bridge foundations. Therefore, we have also included recommendations in this report for use of H-piles.

As mentioned in Section 1.2, for the currently planned driven piles for support of the new structure, bottom of abutment elevation is indicated at Elev. 568.68 and 2 feet of stickup is planned in the abutment for both the rear (west) and forward (east) abutments. Based on previously provided scour soil parameters, it was indicated by EMH&T that scour evaluations should be based on Elev. 566. The ultimate bearing value (UBV) was indicated to be 236 kips.

ODOT BDM Section 305, ODOT Geotechnical Design Manual (GDM) Section 1304, and LRFD Bridge Design Specifications Section 6.5.4.2 indicate that, for piles not driven to refusal on bedrock, dynamic resistance factors of 0.70 for CIP pipe piles and 0.60 for H-piles are to be used for piles in compression under good driving conditions (not requiring a pile tip). Per ODOT BDM Section 305.3.5.6 criteria, steel pile points or shoes are not required for this site. As such, maximum total factored loads (TFLs) for a certain pile size and type are 70 percent and 60 percent of the maximum UBV values presented in the below table for CIP piles and H-piles, respectively.

For the indicated Ultimate Bearing Value of 236 kips, ODOT commonly used pile sizes that meet this design criteria are summarized in the following table.

Table 5.1.1.A. ODOT Prescribed Maximum Ultimate Bearing Values (UBV) for Common Pile Sizes	
Pile Type/Size	**Maximum UBV (kips)**
12-Inch CIP Pipe Pile	330
HP 10x42 H-pile	310

Pile resistance analyses were performed using FHWA pile analysis software DRIVEN. In the DRIVEN analyses, adhesion for cohesive soils was modeled using the Tomlinson method (1979), and resistance in the "cohesionless" soils were determined by the Peck, Hanson, and Thornburn method (1974), using SPT N_{60}-values.

DRIVEN analyses were initially performed by "assigning" undrained shear strengths for calculation of end-bearing and side frictional capacities of all cohesive soil layers. However, based on our experience in the Northwest Ohio area, the Stratum III hard cohesive glacial till "hardpan" layer is better modeled by treating these soils as an FHWA "cohesionless" soil by assigning an effective internal angle of friction (ϕ') to this layer based on the SPT N_{60}-value determined for these soils (split-spoon refusal, SSR, assigned 100 bpf). The Stratum III cohesive "hardpan" soils were modeled using a ϕ'-value of 43 degrees based on the SPT N_{60}-value of 100 bpf for split-spoon refusal.

As presented in the following table, DRIVEN analyses indicate that the CIP piles and H-piles are expected to achieve the UBV upon encountering Stratum II or after extension approximately 5 feet into the Stratum III soil layer. The 12-Inch CIP concrete piles with driven pipe shells were found to have the same tip elevation as the HP 10x42 piles.

Results of the DRIVEN analyses are attached to this report, and are summarized in the following table. The estimated pile length includes the calculated length from anticipated pile cut-off elevation to pile tip elevation, rounded to the nearest 5 feet. The order length is the estimated length plus 5 feet.

Table 5.1.1.B: 12-Inch CIP and HP 10x42 Piles for UBV 236 kips		
Item	**Rear (West) Abutment B-001-0/B-001-1**	**Forward (East) Abutment B-002-0**
Pile Stickup Length into Abutment (ft)	2 ft	2 ft
Bottom of Abutment Elev.	568.68	568.68
Bottom of Scour Elev.	566.00 *(rounded down to nearest 1 ft)*	566.00 *(rounded down to nearest 1 ft)*
Side Resistance in Scour Zone (kips)	12" CIP: 6 HP 10x42: 6.5	12" CIP: 3 HP 10x42: 3.5
Drive Pile to this UBV (kips)[(1)]	12" CIP: 248 HP 10x42: 249	12" CIP: 242 HP 10x42: 243
Shallowest Pile Tip Elev.	531.9	537.1
Estimated Length (ft)	40	35
Order Length (ft)	45	40

[(1)]Drive pile to higher UBV than design UBV to account for driving through potential scour zone. Side resistance from scour zone may not be available if scour occurs. Therefore, need additional skin friction from material below equal to that within the scour zone, and need to account for material being present in the scour zone during driving and as part of the analysis.

ODOT BDM specifications indicate that the maximum center-to-center spacing of driven piles should be 8 feet in capped pile abutments and the front row of stub abutments. The maximum center-to-center spacing of driven piles should be 7 feet for the front row of wall-type abutments. Although close pile spacing is not anticipated, we recommend that the minimum center-to-center spacing for piles be 6 pile diameters to avoid superposition of stresses and possible reduction in group resistance due to close spacing, based on the encountered cohesive subsoil profile and ODOT BDM Section 305.3.4 guidance.

Piles shall be installed in accordance with ODOT Construction and Materials Specifications (CMS) 507 "Bearing Piles" and CMS 523 "Dynamic Load Test". A static pile load test (ASTM D 1143) is required only if the total pile order length for an individual structure exceeds 10,000 feet for piling of the same size and UBV. As such, a static pile load test is **not** expected to be required for this project. ODOT requires dynamic load testing to establish the driving criteria (i.e., blow count) for all piling not driven to refusal on bedrock. For an individual structure, the designer shall specify one dynamic load testing item for each pile size. If multiple pile capacities are required for a given pile size, the designer shall specify one testing item for each UBV. Although not anticipated, if static load tests are required, additional provisions include two dynamic load testing items **and** two restrike items for each static load test item. One dynamic load testing item consists of testing a minimum of two piles and performing a Case Pile Wave Analysis Program (CAPWAP) analysis on one of the two piles. One restrike item consists of performing dynamic testing on two piles and performing CAPWAP analysis on one of the two

piles. Driven piles should be installed under adequate specifications and monitored by a qualified geotechnical engineer.

Although cobbles and/or boulders were not encountered during this investigation, they are not uncommon in glacial till soils, particularly in the lower-profile very dense and hard soils. If cobbles or boulders are encountered, these conditions could hamper pile-driving operations and possibly damage some piles. If piles are observed to meet refusal at a depth/elevation less than that indicated above, cobble or boulder obstruction may be indicated. For an isolated occurrence, one or more replacement piles could be driven with relatively little additional cost on pile cap re-design. If persistent boulder conditions are indicated, a static pile load test should be performed in accordance with the standard referenced above to evaluate the bearing resistance of the pile(s).

If suitable pile resistance is not observed in the field with driving of the entire pile order length, a pile setup period may be required. The ODOT BDM indicates a typical 7-day waiting period, but additional guidance is provided in BDM Table 606-1 based on the required percent setup. It is our experience that pile setup can occur within a few days, but more typically occurs within one to three weeks.

5.1.2 Spread Foundations (Superseded by Pile Foundations)

Original spread foundation recommendations are being provided for reference, as design was an iterative process that resulted in recommendations for a replacement structure supported on deep foundations. Since the structure is no longer planned to be supported by spread foundations, these archive recommendations are shown in italics as a method of differentiation.

The proposed structure is planned as a three-sided culvert supported on spread footings. Foundations should bear at least 3½ feet below finished grades to provide protection from frost penetration. Deeper embedment may be required depending on scour considerations. The foundation bearing depth was indicated to be on the order of 12 feet below existing roadway grades, corresponding to approximately Elevs. 569± to 568±.

Based on the conditions encountered in the borings, the soils at the indicated bearing elevations are anticipated to consist of ***loose*** *to very dense* ***granular existing fill materials*** *and* ***soft cohesive existing fill materials****, likely associated with the installation of the existing structure at the site. Due to their variable consistency, as well as the loose and soft conditions of the materials, the existing fill materials are not considered suitable for support of the proposed*

structure. These materials will require over-excavation and replacement with new engineered fill as described below.

Boring B-002 encountered existing fill materials to Elev. 566.5±, corresponding to approximately 2 feet below anticipated veering elevation. Boring B-001-0 encountered auger refusal on the apparent existing concrete wingwall at Elev. 567.5±, corresponding to approximately a half foot below anticipated bearing elevation for the new structure. The offset Boring B-001-1, located approximately 30 feet west of the original boring location, encountered native medium stiff to stiff cohesive soils at the re-sampling depth of 12½ feet below existing grade (Elev. 568±). Care and diligence will be required to evaluate the bearing conditions and potential depth of existing fill over-excavation for the new culvert foundation installation.

Predominantly medium stiff to stiff native cohesive soils are anticipated at the base of over-excavation of existing fill materials. These soils are considered generally suitable for support of the proposed culvert spread foundations. For design considerations, we have evaluated these materials based on an average unconfined compressive strength of 2,000 pounds per square foot (psf), or 2.0 kips per square foot (ksf).

Where existing fill materials, bearing soils with unconfined compressive strengths less than 2,000 psf, or other unsuitable foundation soils are encountered, over-excavation should extend through these materials to suitable bearing soils. The base of the over-excavation should be widened one foot for every foot of depth below the proposed bearing elevation, with the excavation centered along the footing. The over-excavated areas should be backfilled with dense-graded aggregate, placed in controlled lifts, and compacted to not less than 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor). Alternatively, the over-excavated areas could be replaced with lean concrete having a minimum compressive strength of 1,500 pounds per square inch (psi) or other flowable controlled-density fill (CDF) having a minimum compressive strength of 300 psi. If foundations will be placed at the base of the over-excavation or the lean concrete fill option will be utilized, widening the footing over-excavation will not be required. If the controlled-density fill option is utilized, the footing over-excavation shall be widened one foot for every foot of over-excavation below the original bearing elevation, and centered along the footing.

We understand that the culvert foundations will be designed using LRFD specifications. At the ***service*** *limit state, we recommend a nominal (unfactored) bearing resistance (q_n) of 2.5 kips per square foot (ksf) for foundations bearing on medium stiff to stiff native cohesive soils, or the engineered replacement fill described above. At the service limit state, the resistance factor (ϕ_b)*

is 1.0. Therefore, the factored bearing resistance (q_r) is 2.5 ksf. From a conventional allowable stress design comparison, this is roughly akin to using an allowable bearing pressure. At the ***strength*** *limit state, we recommend a nominal bearing resistance (q_n) of 5.4 ksf for foundations bearing on medium stiff to stiff native cohesive soils, or the engineered replacement fill described above. At the strength limit state, the resistance factor (ϕ_b) is 0.5. Therefore, the factored bearing resistance (q_r) is 2.7 ksf. From a conventional allowable stress design comparison, this is roughly akin to calculating an ultimate bearing capacity and applying a factor of safety. Our evaluations were based on the medium stiff to stiff bearing stratum exhibiting a minimum unconfined compressive strength of 2,000 psf.*

Settlement of the culvert foundation was calculated by conventional consolidation theory utilizing the recompression index, based on empirical relations using moisture content, as well as incorporating the C' method for the deeper dense granular soils/hard sandy silt soils. Based on the bearing pressure of 2.5 ksf at the service limit state, total settlement was calculated to be on the order of 1¼ to 1¾ inches. It should be noted that settlement is dependent on the foundation width. The calculated total settlement was based on an assumed foundation width of 10 feet. If the foundation width is increased for overturning resistance, it is anticipated that the average bearing pressure would be less than 2.5 ksf. Presumably, increases in footing size with corresponding reductions in average bearing pressure would result in total settlements no greater than approximately 1½ inches. If settlement is limited to approximately 1 inch, our evaluations indicate that the factored bearing resistance at the service limit state would need to be limited to approximately 1,500 psf. When the foundation design is being finalized, footing width and bearing pressures should be reviewed to confirm tolerable settlement.

We strongly recommend that the bearing capacity at the bottom of all footing excavations be checked during construction by a CT geotechnical engineer or qualified representative to verify that the exposed soil conditions at the bearing elevations are consistent with the subsurface conditions encountered in the test borings, and that foundations extend through the existing fill materials. Additionally, the presence of our engineer will help facilitate the timely remediation of unsuitable soils. *If the results of hand penetrometer or other strength tests indicate the exposed soil conditions are less favorable than those indicated by the borings, it may be necessary to increase the footing size to accommodate the lower bearing strengths, or to over-excavate and backfill with new engineered fill.*

If foundation excavations will not be concreted the same day as excavation occurs, we recommend that a thin mat of lean concrete be placed over the cohesive bearing soils to protect the bearing surface from groundwater seepage and/or construction.

Culvert footings should be at least 24 inches wide. For shallow foundations, overturning and sliding stability due to wall backfill should also be considered for the headwalls, and wider footings may be needed to satisfy stability for these loading conditions. Additionally, scour/erosion protection of the shallow foundations should be considered.

5.2 Culvert Walls and Headwalls

Headwall foundations should be designed in accordance with the recommendations presented in Section 5.1.1, if pile-supported, or 5.1.2, if supported on spread foundations. However, we caution that settlement associated with the culvert supported on deep foundations is negligible and total settlement associated with spread foundation-supported headwalls would be equal to the differential settlement between the headwalls and culvert.

For culvert walls and headwalls that are restrained from rotation and are considered rigid and non-yielding, lateral earth pressure should be assumed for at-rest conditions. It is anticipated that excavated on-site, either cohesive or granular soils will be utilized for the majority of the backfill behind the new walls. For the cohesive soils, an at-rest earth pressure coefficient (k_o) of 0.50 should be used in determining the lateral pressure acting on the walls, along with a total (moist) soil unit weight of 130 pounds per cubic foot (pcf). Alternatively, an equivalent fluid weight of 65 pcf may be used for the at-rest case design. If lower at-rest earth pressures are preferred for structural reasons or to improve overturning/sliding stability, we recommend that a select, free-draining granular fill (such as No. 57 or 67 stone) be utilized for the entire wall backfill zone. For these granular fill types, k_o may be taken as 0.40, and the soil unit weight may be assumed as 120 pcf. Alternatively, an equivalent fluid weight of 50 pcf may be used for these granular fills.

Headwalls that are not restrained at the top of the wall may be designed for active lateral earth pressure condition. If the on-site cohesive soils are utilized for the backfill behind the headwalls, a k_a value of 0.33 may be used for design along with a soil unit weight of 130 pcf or alternatively, an equivalent fluid weight of 45 pcf may be used. If a free-draining granular fill is utilized, a k_a value of 0.25 may be used for design along with a soil unit weight of 120 pcf, or alternatively, an equivalent fluid weight of 30 pcf may be used.

It should also be noted that these earth pressures do not include hydrostatic pressures that may result from elevated groundwater conditions above the normal stream level. We recommend that consideration be given to headwall drainage to prevent build-up of unbalanced hydrostatic pressures behind the walls. We recommend that headwalls greater than 4 feet in height include a minimum 2-foot granular drainage zone behind the wall, in combination with wall weepholes

and/or longitudinal foundation drain pipe at the base of the wall footing that is free to drain by gravity discharge. Otherwise, the wall design should consider an appropriate resistance factor based on flood elevations or other seasonal groundwater conditions.

Additionally, the earth pressures indicated above are based on a level backfill condition behind the headwall, which is expected to be the case for this construction. However, if there are areas where appreciable sloping backfill is required near the top of the wall, surcharge loading or equivalent higher earth pressure coefficients should be evaluated, based on backfill material, backfill slope, and proximity to the wall. In general, 50 percent of the vertical surcharge load may be assumed for lateral loading in the design of the wall.

Culverts should be backfilled concurrently with nearly equal fill heights on both sides to avoid inducement of overturning or sliding instability. Headwall footings should also be checked for sliding stability. We recommend that passive pressure be considered negligible at the toe of the headwall due to the potential for erosion and/or freeze-thaw behavior that would significantly reduce reliance on passive earth pressure. Without passive pressure considerations, the LRFD factored sliding resistance (R_R) is determined by $\phi_T R_T$, where R_T is the nominal sliding resistance on the base of the footing. For cohesive soil beneath the wall foundation, the nominal sliding resistance may be taken as the cohesion of the clay. Based on the encountered conditions, we recommend a cohesion of the Stratum II medium stiff to stiff bearing soils of 1,000 pounds per square foot (psf). For cast-in-place or precast concrete bearing on cohesive soils, the resistance factor is 0.85. Therefore, the factored sliding resistance (R_R) is 850 psf.

5.3 Construction Dewatering and Groundwater Control

As previously mentioned, at the time of our site reconnaissance, the water level in the creek was approximately 10 feet below roadway grades, at Elevs. 570±.

Based on the soil characteristics and moisture conditions encountered in the borings, it is our opinion that “normal” groundwater levels at this structure location will generally occur at or slightly above the streamflow levels in Otter Creek.

Even for normal streamflow conditions, installation of the bridge culvert foundations is expected to require excavation below the “normal” groundwater level. Predominantly granular existing fill materials are anticipated to be present in excavations below the “normal” groundwater elevation until native medium stiff to stiff cohesive soils are encountered at Elevs. 568± to 566.5±. Significant seepage may occur from the granular existing fill materials.

In the absence of a diversion of the creek flow, we anticipate that the most effective means of temporary groundwater management and control of seepage gradients in the bottom of the excavation will consist of a system of temporary sheetpiling driven into the underlying clays acting as a cut-off wall, in conjunction with a prepared sump-and-pump operation in the bottom of the excavation. We recommend that sheet-pile cutoff walls extend a minimum of 10 feet below the planned bearing/bottom of abutment depth for control of groundwater seepage and flow gradients. Deeper embedment may be required for resistance of lateral earth pressures and stability of the excavation support system. In the event excessive seepage is encountered during construction, CT should be notified to evaluate whether other dewatering methods are required.

5.4 Construction

5.4.1 Sedimentation and Erosion Control

In planning the implementation of earthwork operations, special consideration should be given to provide measures to prevent or reduce soil erosion and the subsequent sedimentation into nearby waterways. These measures may include some or all of the following:

1. Scheduling of earthwork operations such that erodible areas are kept as small as possible and are exposed for the shortest possible time.
2. Using special grading practices, along with diversion or interceptor structures, to reduce the amount of run-off water from an erodible area.
3. Providing vegetative buffer zones, filter berms, or sedimentation basins to trap sediment from surface run-off water.

A specific and detailed soil erosion and sedimentation control program and permits may be required by local, state, or federal regulatory agencies.

5.4.2 Site Preparation and Earthwork

Prior to proceeding with construction operations, site preparation activities should include the removal of any remaining structures or substructures, as well as topsoil, root systems, and vegetation from all proposed foundation areas.

5.4.3 Fill

Material for engineered fill or backfill required to achieve design grades should meet ODOT Item 203 “Embankment Fill” placement and compaction requirements.

The upper profile on-site soils consist of granular and cohesive existing fill materials. As such, the contractor should be prepared to use a sheepsfoot roller to provide effective compaction of the cohesive soils. For granular materials, a vibratory smooth-drum roller should be provided for compaction. In narrow utility or footing excavations, the on-site cohesive soils may be difficult to compact; therefore, a clean granular material, lean concrete, or other flowable controlled-density fill (CDF) may be required in these areas.

5.4.4 Excavations and Slopes

The sides of temporary excavations for utility installations and other construction should be adequately sloped to provide stable sides and safe working conditions. Otherwise, the excavation must be properly braced against lateral movements. Due to the required depth of excavation below the groundwater table and normal creek level, we anticipate sheet-pile cutoff walls may be necessary to manage groundwater and control of seepage gradients in combination with excavation support to avoid an excessively large, open excavation.

Design of sheet-pile cutoff walls should be the responsibility of the contractor, since their installation and performance is integrally tied to the contractor's means and methods of construction. In any case, applicable Occupational Safety and Health Administration (OSHA) standards must be followed. It is the responsibility of the installation contractor to develop appropriate installation methods and equipment specifications prior to commencement of work, and to obtain the services of a qualified engineer to design or approve sloped or benched excavations and/or lateral bracing systems as required by OSHA criteria. In addition, OSHA requires that excavations with open-cut slopes higher than 20 feet, or braced excavation support systems such as sheetpiling or cofferdams be reviewed and designed by a registered professional engineer.

If the excavation is to be performed with sloped banks, adequate stable slopes must be provided in accordance with the criteria presented below. The soils encountered in the test borings within the anticipated depth of excavation may be classified as the following OSHA designations:

- Predominantly Type C soils (existing fill materials) to approximate bearing elevations, underlain by
- Type B soils (cohesive soils with unconfined compressive strengths greater than 1,000 psf but less than 3,000 psf).

For temporary excavations in Type B and C soils, side slopes must be no steeper than 1 horizontal to 1 vertical (1H:1V) and 1½H:1V, respectively. For situations where a higher

strength soil is underlain by a lower strength soil and the excavation extends into the lower strength soil, the slope of the entire excavation is governed by that required by the lower strength soil. In all cases, flatter slopes may be required if lower strength soils or adverse seepage conditions are encountered during construction.

There was concern regarding temporary sloped excavations flatter than 1H:1V for construction. Based on the existing fill materials associated with the previous structure installation, it should be anticipated that much of the temporary slopes for construction will need to be on the order of 1½H:1V or flatter (depending on seepage conditions).

For permanent excavations and slopes, we recommend that grades generally be no steeper than 3H:1V. It should be noted that ODOT routinely uses 2H:1V slopes for roadway embankments and spill-through sections. While these steeper slopes may be used, it is our experience that the embankment faces on these slopes are more prone to erosion and sloughing. All slopes along the channel of Otter Creek should be lined with rip-rap or other channel erosion protection.

6.0 QUALIFICATION OF RECOMMENDATIONS

Our evaluation of bridge culvert and headwall foundation design and construction conditions has been based on our understanding of the site and project information and the data obtained during our field investigation. The general subsurface conditions used were based on interpretation of the subsurface data at specific boring locations. Regardless of the thoroughness of a subsurface investigation, there is the possibility that conditions between borings will differ from those at the boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the soil conditions. Therefore, experienced geotechnical engineers should observe earthwork and foundation construction to confirm that the conditions anticipated in design are noted. Otherwise, CT assumes no responsibility for construction compliance with the design concepts, specifications, or recommendations.

The design recommendations in this report have been developed on the basis of the previously described project characteristics and subsurface conditions. If project criteria or locations change, a qualified geotechnical engineer should be permitted to determine whether the recommendations must be modified. The findings of such a review will be presented in a supplemental report.

The nature and extent of variations between the borings may not become evident until the course of construction. If such variations are encountered, it will be necessary to reevaluate the recommendations of this report after on-site observations of the conditions.

Our professional services have been performed, our findings derived, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. CT is not responsible for the conclusions, opinions, or recommendations of others based on this data.

PLATES

Plate 1.0 Site Location Map
Plate 2.0 Test Boring Location Plan

LEGEND

APPROXIMATE SITE LOCATION

N

APPROXIMATE SCALE – FEET

0 1,800 3,600

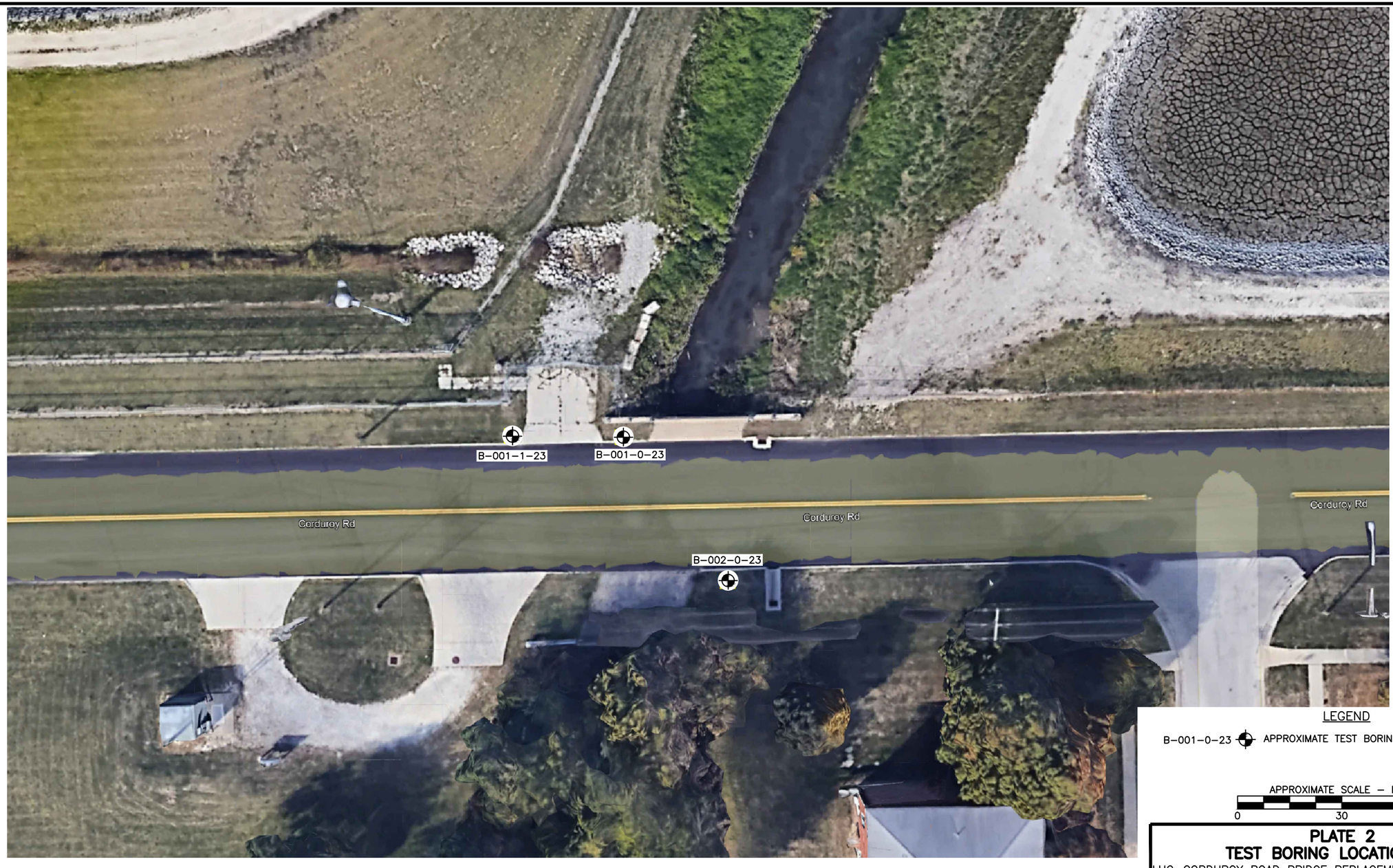
PLATE 1.0
SITE LOCATION MAP

LUC–CORDUROY ROAD BRIDGE OVER OTTER CREEK
PID 119725
OREGON, OHIO

PREPARED FOR
CITY OF OREGON
5330 SEAMAN ROAD, OREGON, OHIO

DRAWN TRR/2–7–24	CHECKED
REVISED	APPROVED
JOB NO. 232516	
DRAWING NUMBER B_232516–01–PLATE 1 SM	

your trusted advisor consultants engineers architects planners



N

LEGEND

B–001–0–23 ⊕ APPROXIMATE TEST BORING LOCATION

APPROXIMATE SCALE – FEET

0 30 60

PLATE 2
TEST BORING LOCATION PLAN

LUC–CORDUROY ROAD BRIDGE REPLACEMENT OVER OTTER CREEK
PID 119725
OREGON, OHIO

PREPARED FOR
CITY OF OREGON
5330 SEAMAN ROAD, OREGON, OHIO

DRAWN TRR/2–8–24	CHECKED
REVISED	APPROVED
JOB NO. 232516	
DRAWING NUMBER **B_232516–01–PLATE 2 BLP**	

your trusted advisor consultants engineers architects planners

FIGURES

Logs of Test Borings
Legend Key
Grain Size Distribution Curves
Unconfined Compressive Strength Test Results (Undisturbed Samples)

PROJECT: CORDUROY RD@OTTER CREEK
TYPE: BRIDGE
PID: 119725 SFN: N/A
START: 1/10/24 END: 1/10/24

DRILLING FIRM / OPERATOR: RIDGEWAY / KEVIN
SAMPLING FIRM / LOGGER: RIDGEWAY / KKC
DRILLING METHOD: HSA
SAMPLING METHOD: SPT

DRILL RIG: DIEDRICH D50 YELLOW AT
HAMMER: DIEDRICH AUTOMATIC
CALIBRATION DATE: 1/27/24
ENERGY RATIO (%): 81.8

STATION / OFFSET: 102+52, 24' LT.
ALIGNMENT: CORDUROY ROAD
ELEVATION: 580.0 (NAVD88) EOB: 12.6 ft.
COORD: 727283.8030 N, 1701871.1810 E

EXPLORATION ID: B-001-0-23
PAGE: 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
TOPSOIL - 4 INCHES	580.0																	
	579.7																	
MEDIUM DENSE, GRAY, **CRUSHED STONE**, SOME SAND, TRACE SILT, TRACE CLAY, DAMP FILL		1	6	16	44	SS-1	-	-	-	-	-	-	-	-	-	6	A-1-a (V)	
		2	5															
		3	7															
	576.5																	
VERY DENSE, GRAY, **FINE SAND**, TRACE CRUSHED STONE, TRACE SILT, TRACE CLAY, MOIST FILL		4	14	74	33	SS-2	-	-	-	-	-	-	-	-	-	12	A-3 (V)	
		5	23															
			31															
		6	16	83	44	SS-3	-	-	-	-	-	-	-	-	-	15	A-3 (V)	
		7	21															
			40															
		8																
		9	30	-	100	SS-4	-	-	-	-	-	-	-	-	-	15	A-3 (V)	
			50/2"															
		10																
		11	27	-	114	SS-5	-	-	-	-	-	-	-	-	-	15	A-3 (V)	
			50/1"															
	567.5	12																
APPARENT CONCRETE OF WINGWALL	567.4	EOB	50/1"	-	100	SS-6	-	-	-	-	-	-	-	-	-	9		

NOTES: AUGER REFUSAL ON WINGWALL OF EXISTING STRUCTURE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 3 CF CEMENT-BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 2/26/24 13:07 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

PROJECT: CORDUROY RD@OTTER CREEK	DRILLING FIRM / OPERATOR: RIDGEWAY / KEVIN	DRILL RIG: DIEDRICH D50 YELLOW AT	STATION / OFFSET: 102+22, 24' LT.	EXPLORATION ID B-001-1-23	
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: RIDGEWAY / KKC	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: CORDUROY ROAD		
PID: 119725 SFN: N/A	DRILLING METHOD: HSA	CALIBRATION DATE: 1/27/24	ELEVATION: 580.4 (NAVD88) EOB: 73.7 ft.	PAGE 1 OF 3	
START: 1/10/24 END: 1/10/24	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 81.8	COORD: 727283.8030 N, 1701841.1810 E		

MATERIAL DESCRIPTION AND NOTES	ELEV. 580.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
SEE B-001-0-23																		
	567.9																	
VERY STIFF, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, DAMP			4 7 9	22	78	SS-1	4.50	8	6	17	25	44	28	17	11	12	A-6a (7)	
@14': LITTLE SAND, Qu - 74.8 PSI = 5.39 TSF			4 6 9	20	78	SS-2	4.50	7	6	9	21	57	28	17	11	13	A-6a (8)	
@15.5': STIFF TO VERY STIFF, SOME SAND, MOIST			5 7 8	20	56	SS-3	1.50	2	8	13	23	54	28	17	11	20	A-6a (8)	
		W 563.4																
@17': VERY STIFF, DAMP			4 5 8	18	56	SS-4	2.75	-	-	-	-	-	-	-	-	16	A-6a (V)	
@18.5': STIFF, LITTLE SAND, Qu - 19.5 PSI = 1.40 TSF					100	ST-5	1.50	6	6	9	22	57	31	18	13	17	A-6a (9)	
			2 4 4	11	89	SS-6	1.25	-	-	-	-	-	-	-	-	16	A-6a (V)	
	556.9																	
MEDIUM STIFF TO STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST			3 5 5	14	78	SS-7	0.75	4	7	7	21	61	30	18	12	20	A-6a (9)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 2/26/24 13:07 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

PID: 119725	SFN: N/A	PROJECT: CORDUROY RD@OTTER CREEK	STATION / OFFSET: 102+22, 24' LT.	START: 1/10/24	END: 1/10/24	PG 2 OF 3	B-001-1-23

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)	HOLE SEALED
MEDIUM STIFF TO STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST *(continued)*	554.4	27	1 3 4	10	56	SS-8	1.25	-	-	-	-	-	-	-	-	19	A-6a (V)	
@26': Qu - 8.8 PSI = 0.63 TSF		28																
@28.5': TRACE SAND		29	1 2 3	7	56	SS-9	1.00	-	-	-	-	-	-	-	-	20	A-6a (V)	
		30																
		31																
		32																
		33																
@33.5': LITTLE SAND		34	5 4 4	11	100	SS-10	1.00	-	-	-	-	-	-	-	-	18	A-6a (V)	
		35																
		36																
		37																
		38																
@38.5': STIFF, DAMP		39	3 3 5	11	100	SS-11	1.25	-	-	-	-	-	-	-	-	16	A-6a (V)	
	536.9	40																
		41																
		42																
		43																
DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, LITTLE GRAVEL, TRACE CLAY, MOIST		44	1 4 22	35	100	SS-12	-	16	26	24	31	3	24	18	6	13	A-3a (0)	
		45																
		46																
		47																
		48																
	531.9	49	47 50/5"	-	55	SS-13	-	12	16	19	40	13	26	18	8	11	A-4a (3)	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, LITTLE GRAVEL, DAMP		50																
		51																
		52																
		53																
	526.9																	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 2/26/24 13:07 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

PID: 119725	SFN: N/A	PROJECT: CORDUROY RD@OTTER CREEK	STATION / OFFSET: 102+22, 24' LT.	START: 1/10/24	END: 1/10/24	PG 3 OF 3	B-001-1-23

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)	HOLE SEALED
VERY DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, LITTLE GRAVEL, TRACE CLAY, DAMP *(continued)*	526.6		50	-	100	SS-14	-	-	-	-	-	-	-	-	-	8	A-3a (V)	
@58.5': TRACE GRAVEL			22 50	-	50	SS-15	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
			50/1"	-	0	SS-16	-	-	-	-	-	-	-	-	-	-	A-3a (V)	
HARD, GRAY, **SANDY SILT**, LITTLE ROCK FRAGMENTS, LITTLE CLAY, DAMP	511.9		50/4"	-	100	SS-17	-	-	-	-	-	-	-	-	-	8	A-4a (V)	
VERY DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, LITTLE GRAVEL, TRACE CLAY, DAMP	506.9 506.7	EOB	50/2"	-	100	SS-18	-	-	-	-	-	-	-	-	-	8	A-3a (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 21 CF CEMENT-BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 2/26/24 13:07 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

PROJECT: CORDUROY RD@OTTER CREEK	DRILLING FIRM / OPERATOR: RIDGEWAY / KEVIN	DRILL RIG: DIEDRICH D50 YELLOW AT	STATION / OFFSET: 102+81, 20' RT.	EXPLORATION ID B-002-0-23	
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: RIDGEWAY / KKC	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: CORDUROY ROAD		
PID: 119725 SFN: N/A	DRILLING METHOD: HSA	CALIBRATION DATE: 1/27/24	ELEVATION: 580.6 (NAVD88) EOB: 73.9 ft.		PAGE 1 OF 3
START: 1/8/24 END: 1/8/24	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 81.8	COORD: 727240.9530 N, 1701900.2910 E		

MATERIAL DESCRIPTION AND NOTES	ELEV. 580.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
TOPSOIL - 18 INCHES	579.1																	
MEDIUM DENSE, BROWN/GRAY, **CRUSHED STONE WITH SAND**, LITTLE SILT, LITTLE CLAY, TRACE ORGANICS, MOIST FILL	577.1		4 5 4	12	89	SS-1	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	
STIFF, GRAY/BROWN, **SILT AND CLAY**, LITTLE SAND, LITTLE CRUSHED STONE, TRACE ORGANICS, MOIST FILL	574.6		4 4 4	11	78	SS-2	1.50	-	-	-	-	-	-	-	-	23	A-6a (V)	
VERY LOOSE, GRAY, **CRUSHED STONE WITH SAND**, LITTLE SILT, LITTLE CLAY, MOIST FILL	572.1	W 573.6	2 1 1	3	11	SS-3	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
VERY LOOSE, GRAY, **CRUSHED STONE WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP FILL	569.6		1 1 2	4	22	SS-4	-	-	-	-	-	-	-	-	-	5	A-1-a (V)	
SOFT, GRAY, **SILTY CLAY**, LITTLE SAND, LITTLE CRUSHED STONE, DAMP FILL	568.1		2 1 1	3	11	SS-5	-	-	-	-	-	-	-	-	-	13	A-6b (V)	
LOOSE, GRAY, **CRUSHED STONE WITH SAND**, SOME SILT, TRACE CLAY, WET FILL, (FREE WATER NOTED)	566.6		1 3 2	7	22	SS-6	-	57	13	7	21	2	NP	NP	NP	11	A-1-b (0)	
MEDIUM STIFF TO STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	565.1		1 2 2	5	33	SS-7	1.75	6	8	10	21	55	28	17	11	16	A-6a (8)	
STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP			2 4 6	14	33	SS-8	2.00	4	6	8	21	61	29	17	12	16	A-6a (9)	
@17': MEDIUM STIFF TO STIFF, MOIST, Qu - 8.6 PSI = 0.62 TSF			3 4 6	14	67	SS-9	0.75	-	-	-	-	-	-	-	-	18	A-6a (V)	
@18.5': Qu - 10.2 PSI = 0.73 TSF			2 3 4	10	67	SS-10	1.00	-	-	-	-	-	-	-	-	18	A-6a (V)	
@21': MEDIUM STIFF			2 2 4	8	89	SS-11	0.50	-	-	-	-	-	-	-	-	18	A-6a (V)	
@23.5': STIFF, Qu - 17.9 PSI = 1.29 TSF					100	ST-12	1.75	7	6	7	21	59	29	17	12	18	A-6a (9)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 2/26/24 13:07 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

PID: 119725	SFN: N/A	PROJECT: CORDUROY RD@OTTER CREEK	STATION / OFFSET: 102+81, 20' RT.	START: 1/8/24	END: 1/8/24	PG 2 OF 3	B-002-0-23

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)	HOLE SEALED
STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP *(continued)*	554.6		3 5 6	15	100	SS-13	1.75	-	-	-	-	-	-	-	-	14	A-6a (V)	
@26': DAMP		27																
		28																
@28.5': MEDIUM STIFF TO STIFF		29	3 4 6	14	100	SS-14	0.75	-	-	-	-	-	-	-	-	15	A-6a (V)	
		30																
		31																
		32																
		33																
@33.5': MOIST		34	3 4 5	12	100	SS-15	0.75	-	-	-	-	-	-	-	-	18	A-6a (V)	
		35																
		36																
		37																
		38																
@38.5': MEDIUM STIFF, DAMP		39	2 3 3	8	100	SS-16	0.50	-	-	-	-	-	-	-	-	17	A-6a (V)	
		40																
		41																
		42																
		43																
	537.1																	
VERY DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP		44	40 50/4"	-	60	SS-17	-	26	24	16	31	3	25	18	7	7	A-2-4 (0)	
		45																
		46																
		47																
		48																
	532.1																	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE ROCK FRAGMENTS, DAMP		49	50/2"	-	100	SS-18	-	-	-	-	-	-	-	-	-	13	A-4a (V)	
		50																
		51																
		52																
		53																
	527.1																	
			-															

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 2/26/24 13:07 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

PID: 119725	SFN: N/A	PROJECT: CORDUROY RD@OTTER CREEK	STATION / OFFSET: 102+81, 20' RT.	START: 1/8/24	END: 1/8/24	PG 3 OF 3	B-002-0-23

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)	HOLE SEALED
VERY DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, TRACE ROCK FRAGMENTS, TRACE CLAY, MOIST *(continued)*	526.8		50/1"		100	SS-19	-	-	-	-	-	-	-	-	-	10	A-3a (V)	
	525.6	55																
HARD, GRAY, **SANDY SILT**, SOME CLAY, SOME ROCK FRAGMENTS, DAMP		56																
		57			77	NX-20	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
		58																
		59																
		60																
		61																
		62																
		63																
		64	23 50	-	100	SS-21	-	20	10	10	35	25	27	18	9	11	A-4a (5)	
		65																
		66																
		67																
		68																
		69	42 50/5"	-	55	SS-22	-	-	-	-	-	-	-	-	-	10	A-4a (V)	
		70																
		71																
		72																
		73																
	507.1																	
GRAY, **WEATHERED ROCK**, LITTLE SAND, TRACE SILT, TRACE CLAY	506.7	TR EOB	50/5"	-	100	SS-23	-	-	-	-	-	-	-	-	-	5	Rock (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 21 CF CEMENT-BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 2/26/24 13:07 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

KEY TO SYMBOLS

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT CORDUROY RD@OTTER CREEK **PID** 119725

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

A-1-A: Ohio DOT: A-1-a, gravel and/or stone fragments

A-1-B: Ohio DOT: A-1-b, gravel and/or stone fragments with sand

A-2-4: Ohio DOT: A-2-4, gravel and/or stone fragments with sand and silt

A-3: Ohio DOT: A-3, fine sand

A-3A: Ohio DOT: A-3a, coarse and fine sand

A-4A: Ohio DOT: A-4a, sandy silt

A-6A: Ohio DOT: A-6a, silt and clay

A-6B: Ohio DOT: A-6b, silty clay

CONCRETE: Concrete

TOPSOIL: Ohio DOT: Sod and Topsoil

WEATHERED DOLOMITE: Ohio DOT: Highly or Severely Weathered Dolomite

SAMPLER SYMBOLS

Thin Walled Undisturbed Sample

WELL CONSTRUCTION SYMBOLS

Cement/Bentonite Grout

ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
W - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
-200 - PERCENT PASSING NO. 200 SIEVE
PP - POCKET PENETROMETER (TSF)

TV - TORVANE
PID - PHOTOIONIZATION DETECTOR
UC - UNCONFINED COMPRESSION
ppm - PARTS PER MILLION

Water Level at Time Drilling, or as Shown

Water Level at End of Drilling, or as Shown

Water Level After 24 Hours, or as Shown

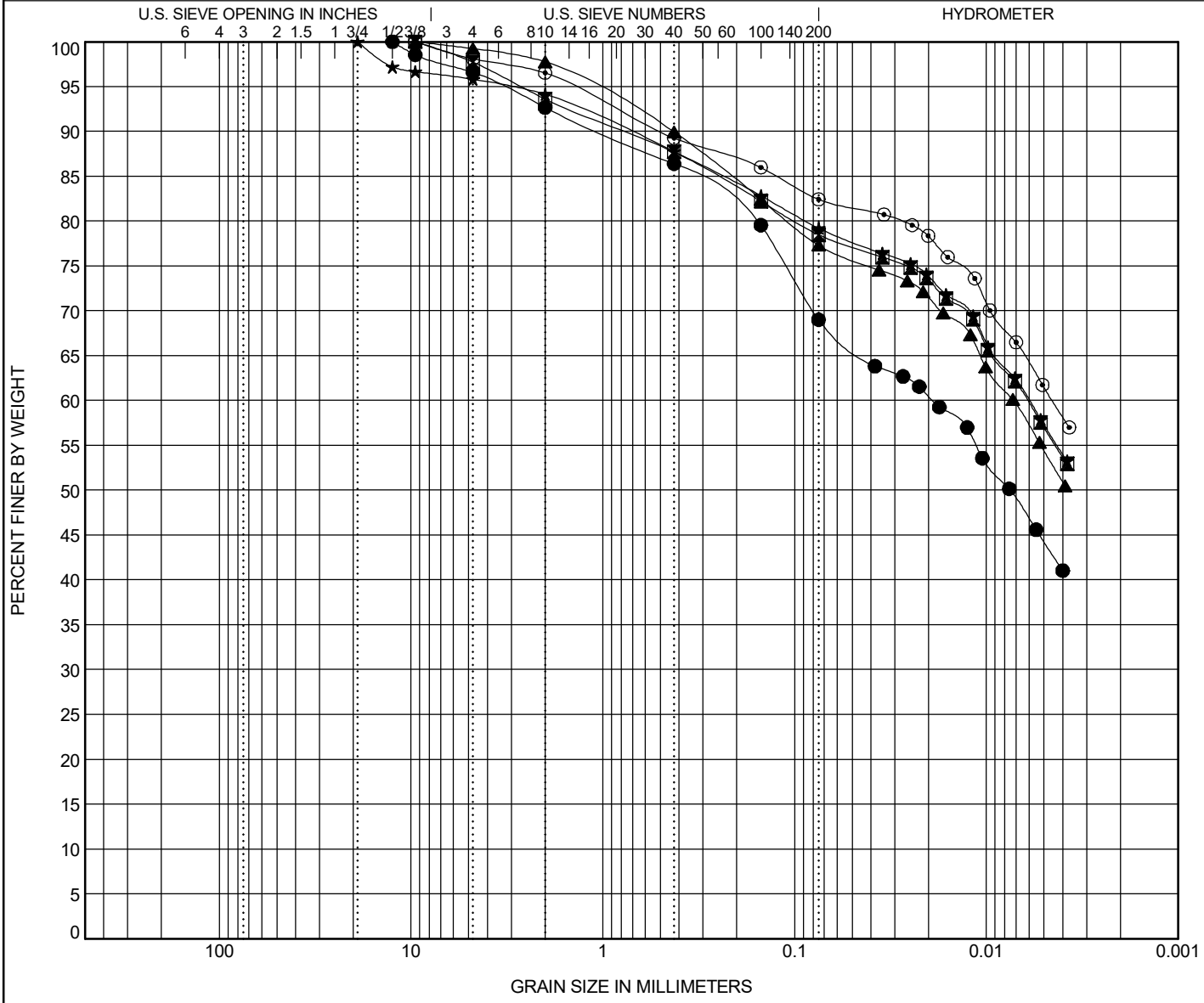
KEY TO SYMBOLS - OH DOT.GDT - 2/26/24 14:41 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT CORDUROY RD@OTTER CREEK **PID** 119725

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-001-1-23	12.5	A-6a ~ SANDY LEAN CLAY(CL)	28	17	11
⊠	B-001-1-23	14.0	A-6a ~ LEAN CLAY with SAND(CL)	28	17	11
▲	B-001-1-23	15.5	A-6a ~ LEAN CLAY with SAND(CL)	28	17	11
★	B-001-1-23	18.5	A-6a ~ LEAN CLAY with SAND(CL)	31	18	13
⊙	B-001-1-23	23.5	A-6a ~ LEAN CLAY with SAND(CL)	30	18	12

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-001-1-23	12.5	1.035	0.008			8	6	17	25	44		
⊠	B-001-1-23	14.0	0.777				7	6	9	21	57		
▲	B-001-1-23	15.5	0.43				2	8	13	23	54		
★	B-001-1-23	18.5	0.732				6	6	9	22	57		
⊙	B-001-1-23	23.5	0.498				4	7	7	21	61		

GRAIN SIZE - OH DOT.GDT - 2/26/24 13:09 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

GRAIN SIZE DISTRIBUTION

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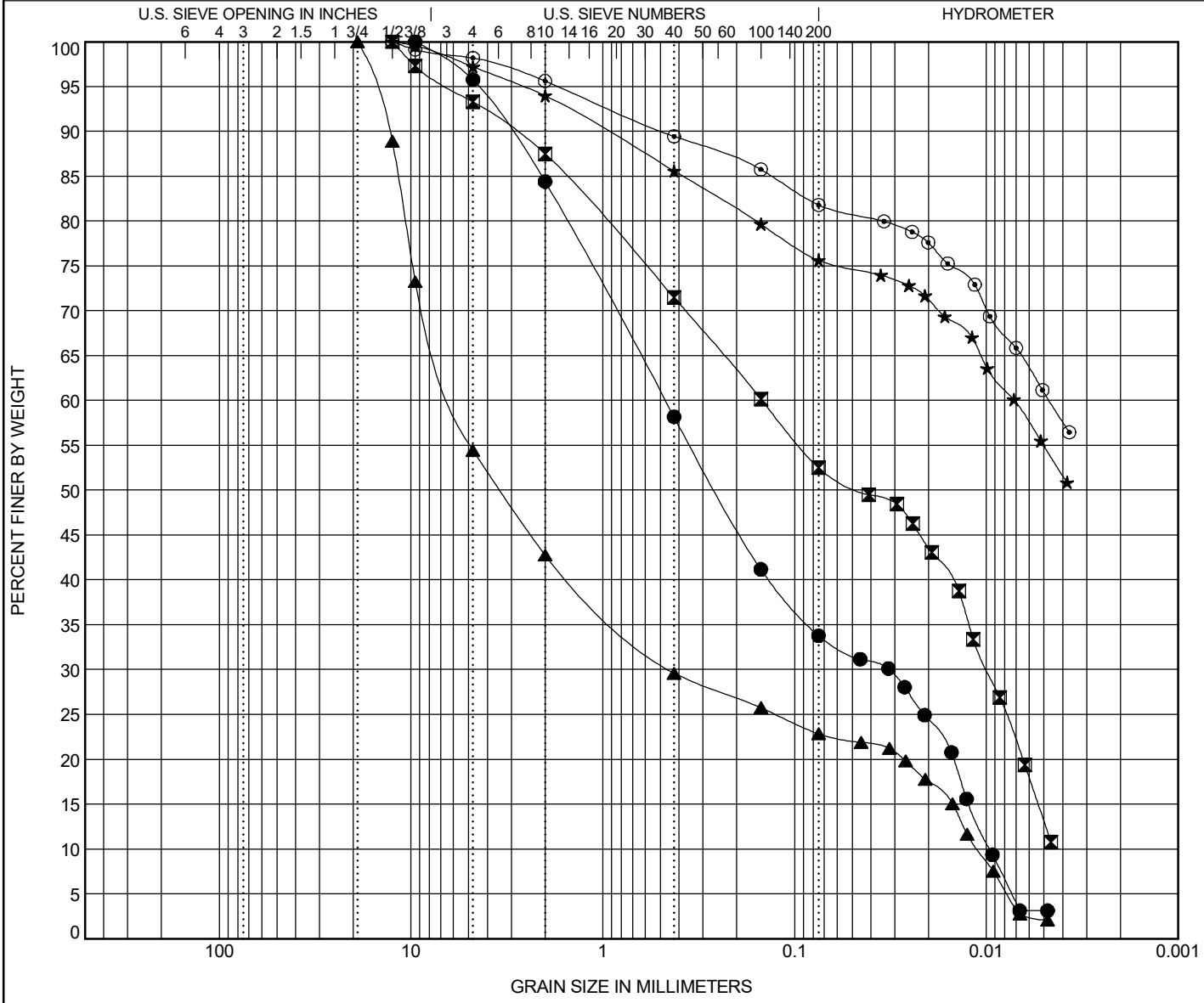
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT CORDUROY RD@OTTER CREEK **PID** 119725

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-001-1-23	43.5	**A-3a ~ SILTY, CLAYEY SAND(SC-SM)**	**24**	**18**	**6**
⊠	B-001-1-23	48.5	**A-4a ~ SANDY LEAN CLAY(CL)**	**26**	**18**	**8**
▲	B-002-0-23	12.5	**A-1-b ~ SILTY GRAVEL with SAND(GM)**	**NP**	**NP**	**NP**
★	B-002-0-23	14.0	**A-6a ~ LEAN CLAY with SAND(CL)**	**28**	**17**	**11**
⊙	B-002-0-23	15.5	**A-6a ~ LEAN CLAY with SAND(CL)**	**29**	**17**	**12**

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-001-1-23	43.5	**3.061**	**0.258**	**0.032**	**0.01**	**16**	**26**	**24**	**31**	**3**	**0.23**	**49.24**
⊠	B-001-1-23	48.5	**2.903**	**0.045**	**0.01**		**12**	**16**	**19**	**40**	**13**		
▲	B-002-0-23	12.5	**13.027**	**3.419**	**0.446**	**0.011**	**57**	**13**	**7**	**21**	**2**	**3.07**	**523.96**
★	B-002-0-23	14.0	**0.958**				**6**	**8**	**10**	**21**	**55**		
⊙	B-002-0-23	15.5	**0.488**				**4**	**6**	**8**	**21**	**61**		

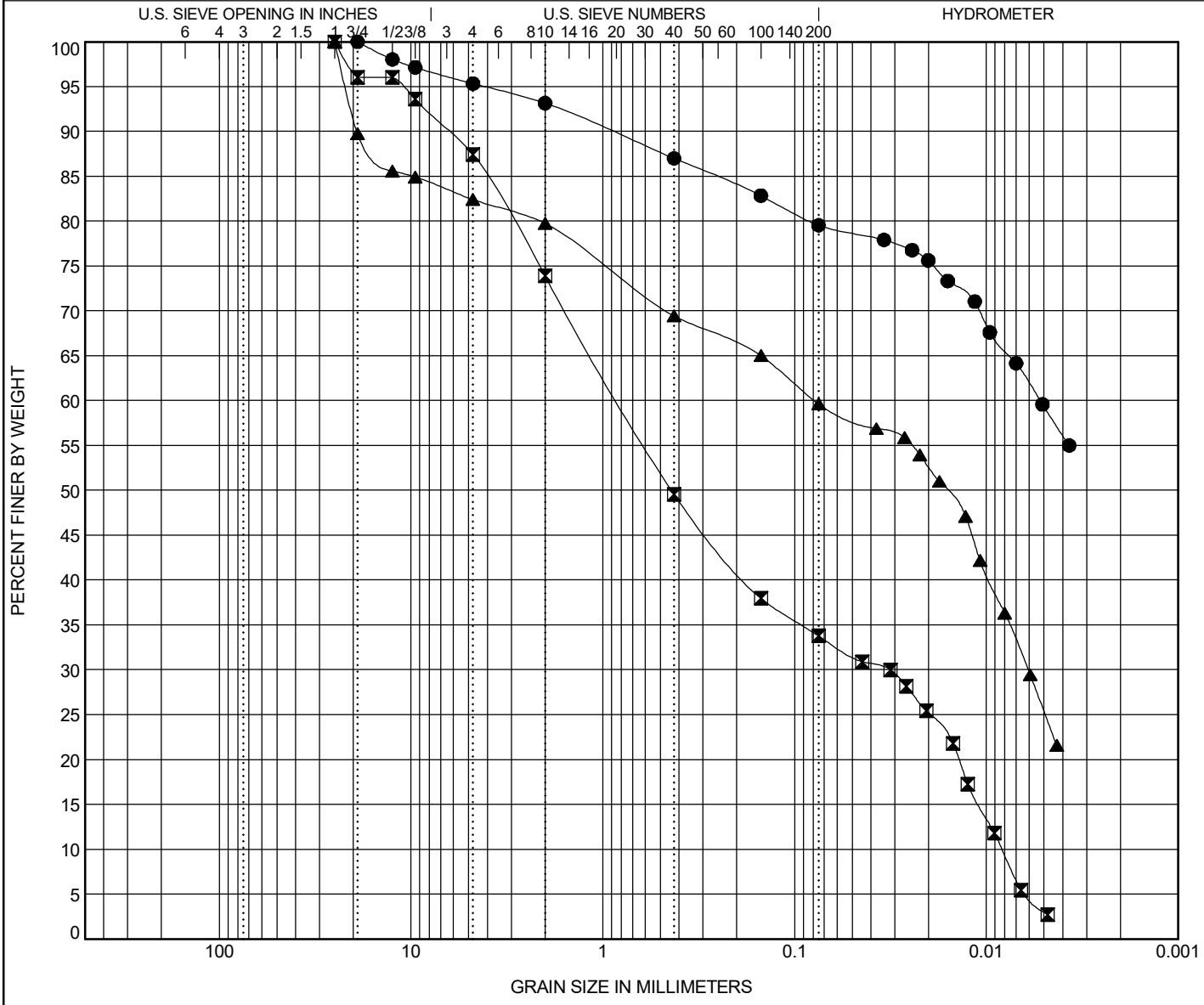
GRAIN SIZE - OH DOT.GDT - 2/26/24 13:09 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT CORDUROY RD@OTTER CREEK **PID** 119725

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

	Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-002-0-23	23.5	**A-6a ~ LEAN CLAY with SAND(CL)**	**29**	**17**	**12**
⊠	B-002-0-23	43.5	**A-2-4 ~ SILTY, CLAYEY SAND(SC-SM)**	**25**	**18**	**7**
▲	B-002-0-23	63.5	**A-4a ~ SANDY LEAN CLAY with GRAVEL(CL)**	**27**	**18**	**9**

	Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-002-0-23	23.5	**0.903**				**7**	**6**	**7**	**21**	**59**		
⊠	B-002-0-23	43.5	**6.332**	**0.437**	**0.032**	**0.008**	**26**	**24**	**16**	**31**	**3**	**0.15**	**99.48**
▲	B-002-0-23	63.5	**19.122**	**0.016**	**0.006**		**20**	**10**	**10**	**35**	**25**		

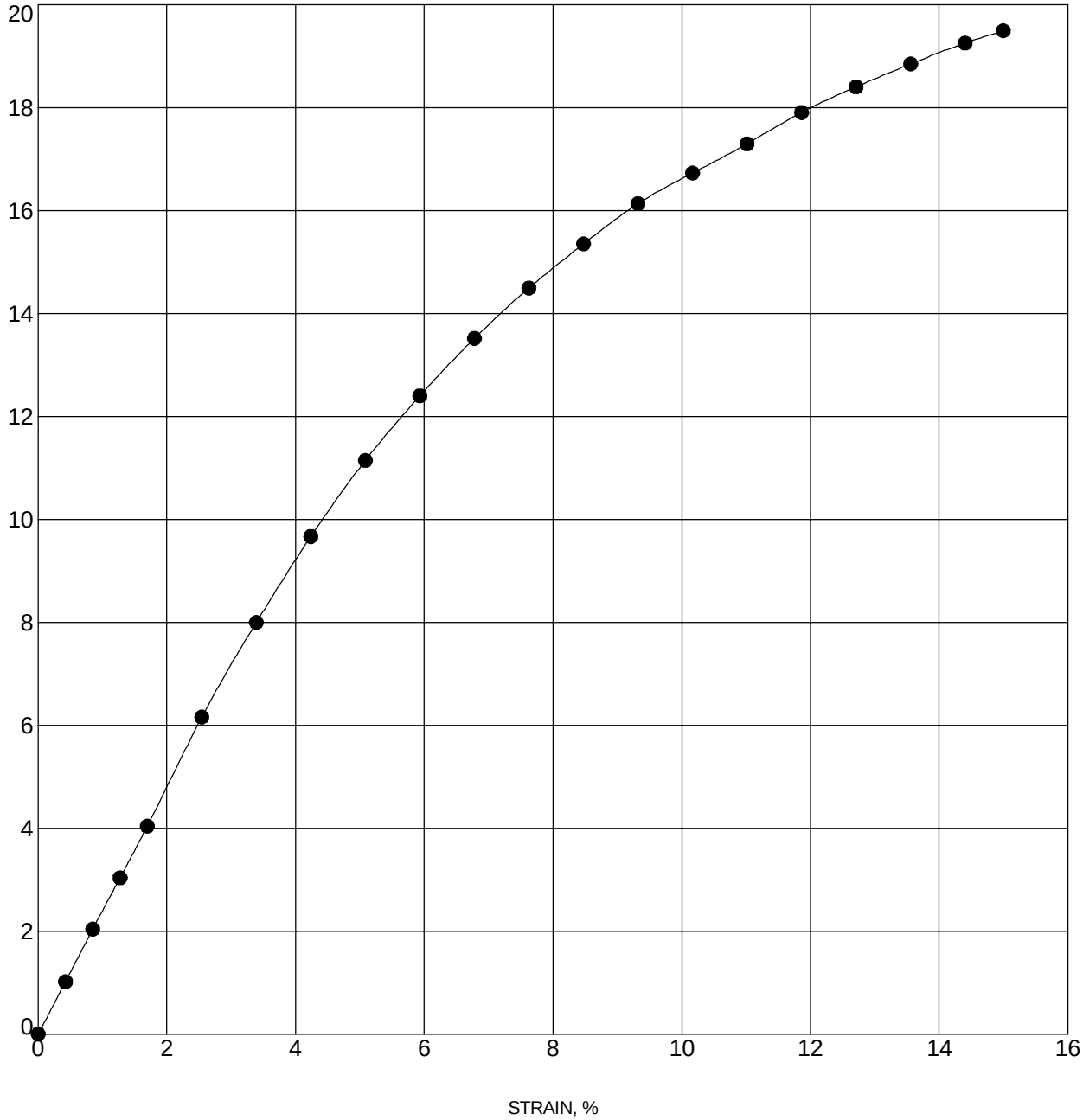
GRAIN SIZE - OH DOT.GDT - 2/26/24 13:09 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

UNCONFINED COMPRESSION TEST

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT CORDUROY RD@OTTER CREEK **PID** 119725

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



Specimen Identification		Classification	γ_d	MC%
●	**B-001-1-23 18.5**	**A-6a**	**115**	**17**

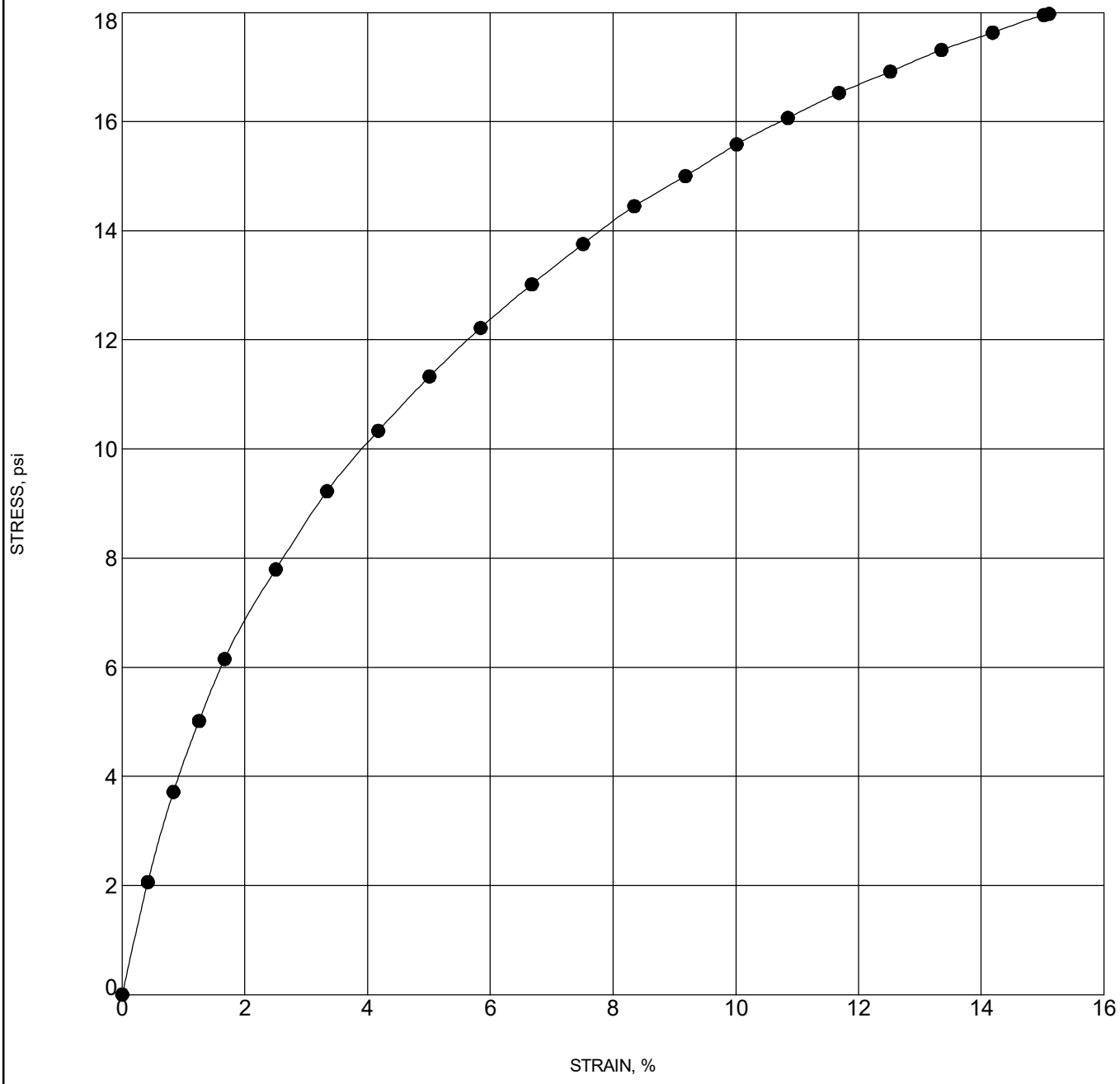
UNCONFINED - OH DOT.GDT - 2/26/24 13:10 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

UNCONFINED COMPRESSION TEST

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT CORDUROY RD@OTTER CREEK **PID** 119725

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



Specimen Identification	Classification	γ_d	MC%
● **B-002-0-23 23.5**	**A-6a**	**118**	**18**

UNCONFINED - OH DOT.GDT - 2/26/24 13:11 - \\TOL-DFS1.TTL.LOCAL\GINT\PROJECTS\232516.GPJ

APPENDIX A

Engineering Calculations

	Calculations:	NT	2/16/2024	Rev. 5/9/2024			Average Soil Properties - Bearing Materials											
	Review:	CPI	2/26/2024	Rev. 5/9/2024														
	Borings B-001-0-23 and B-001-1-23											Boring B-002-0-23						
	DEPTH	SAMPLE	N60	HP tsf	Qu tsf	MC	DRIVEN PARAMETERS					DEPTH	SAMPLE	N60	HP tsf	Qu tsf	MC	DRIVEN PARAMETERS
Med D	1	SS-1	16			6	N60 for phi				Med D Cr St Fill	1	SS-1	12			11	N60 for phi
V Dense	3.5	SS-2	74			12	N60 for phi				Stiff Fill	3.5	SS-2	11	1.5		23	Conservative: c=N60x125=1375 psf, say 1,000 psf
Granular	6	SS-3	83			15					V Loose Fill	6	SS-3	3			10	N60 for phi
Fill	8.5	SS-4	SSR			15	N60 = 100 bpf for phi					8.5	SS-4	4			5	
	11	SS-5	SSR			15					Soft Fill	11	SS-5	3			13	c=N60x125=375 psf
MS-S	12.5	SS - 1	22	4.5		12	For upper Med Stiff to Stiff:				Cr Stone Fill	12.5	SS -6	7			11	N60 for phi
	14	SS - 2	20	4.5	5.39	13	per below c=1000 psf				MS-S	14	SS -7	5	1.75		16	For upper Med Stiff to Stiff:
	15.5	SS - 3	20	1.5		20						15.5	SS -8	14	2		16	per below c=1000 psf
	17	SS - 4	18	2.75		16						17	SS -9	14	0.75	0.62	18	
	18.5	ST - 5		1.5	1.40	17						18.5	SS -10	10	1	0.73	18	
	21	SS - 6	11	1.25		16						21	SS -11	8	0.5		18	
	23.5	SS - 7	14	0.75		20						23.5	ST -12		1.75	1.29	18	
	26	SS - 8	10	1.25	0.63	19						26	SS -13	15	1.75		14	
	28.5	SS - 9	7	1		20						28.5	SS -14	14	0.75		15	
	33.5	SS - 10	11	1		18						33.5	SS -15	12	0.75		18	
	38.5	SS - 11	11	1.25		16						38.5	SS -16	8	0.5		17	
Dense	43.5	SS - 12	35			13	Granular use N60 = 35 BPF				V Dense	43.5	SS -17	SSR			7	Granular use 100 bpf for SSR
Hard	48.5	SS - 13	SSR			11	Silt SSR... for c-analysis c=4500 psf, phi analysis, SSR=100 bpf				Hard	48.5	SS -18	SSR			13	Run only phi analysis, using N60=100 bpf for SSR in Sandy Silt (better model for hardpan)
V Dense	53.5	SS - 14	SSR			8	Granular to 68.5, use 100 bpf FOR SSR				V Dense	53.5	SS -19	SSR			10	Granular use 100 bpf for SSR
	58.5	SS - 15	SSR			9					Hard	63.5	SS-21	SSR			11	Run only phi analysis, using N60=100 bpf for SSR in Sandy Silt (better model for hardpan)
	63.5	SS - 16	SSR									68.5	SS-22	SSR			10	
Hard	68.5	SS - 17	SSR			8	Silt SSR... for c-analysis c=4500 psf, phi analysis, SSR=100 bpf				Rock	73.5	SS-23	SSR			5	SSR 100 bpf for rock
V Dense	73.5	SS - 18	SSR			8	Not modeled...piles will fetch before this layer.											
	Medium Stiff to Stiff Bearing Soils (Bearing at about 12 feet)																	
	B-001-1-23											B-002-0-23						
	DEPTH	SAMPLE	N60	HP tsf	Qu tsf	MC						DEPTH	SAMPLE	N60	HP tsf	Qu tsf	MC	
	AVERAGE		12	1.93	1.02	17						AVERAGE		11	1.15	0.88	17	
UCS N60x250			2929								UCS N60x250			2778				
	Su (psf)		1464	1932	1015							Su (psf)		1389	1150	880		
Su (psf), Avg all 3	1470										Su (psf), Avg all 3	1140						
					Design Su (psf):	1000	(Confirm in field minimum HP value of 1 tsf)											
					Design Su (ksf):	1.0												
	Red text: Don't use outlier.																	
	Bold Purple Text: ST Sample																	

Project Name: LUC-Corduroy Road Bridge over Otter Creek, PID 119725
Project Number: 232516
Calculated by: NT/04-16-2024
Reviewed By: CPI / 04-23-2024

Bridge: LUC-Corduroy Road over Otter Creek

West Abutment

Boring Number	Sample Number	Depth (feet)	Applicable Elevation (feet)	ODOT Classification	w (percent)	Fines (<75 µm) (percent)	PI (percent)	q_u (psf)	Granular Sample D_{50} (mm)	Critical Shear Stress, τ_c (psf)	Critical Shear Stress, τ_c (Pa)	Cohesive Sample D_{50} equiv (mm)	Erosion Category (EC)	Notes
B-001-1-23	SS-1	12.5-14	567.9-566.4	A-6a (7)	12	69	11	9,000	-	0.716	33.64	33.64	4.032	(1)
B-001-1-23	SS-2	14-15.5	566.4-564.9	A-6a (8)	13	78	11	10,780	-	0.838	39.38	39.38	4.114	(1)
B-001-1-23	SS-3	15.5-17	564.9-563.4	A-6a (8)	20	77	11	3,000	-	0.207	9.72	9.72	3.385	(1)
B-001-1-23	ST-5	18.5-20.5	563.4-559.9	A-6a (9)	17	79	13	2,800	-	0.364	17.12	17.12	3.680	(1)

Notes: (1) EC calculated by PI for cohesive condition exceeds maximum indicated 4.5. Therefore, EC was calculated using granular soil calculatin and D_{50} equiv.

East Abutment

Boring Number	Sample Number	Depth (feet)	Applicable Elevation (feet)	ODOT Classification	w (percent)	Fines (<75 µm) (percent)	PI* (percent)	q_u (psf)	Granular Sample D_{50} (mm)	Critical Shear Stress, τ_c (psf)	Critical Shear Stress, τ_c (Pa)	Cohesive Sample D_{50} equiv (mm)	Erosion Category (EC)	Notes
B-002-0-23	SS-6	12.5 - 14	568.1-566.6	A-1-b (0)	11	23	NP	-	3.4186	0.071	3.4186	-	2.841	(2)
B-002-0-23	SS-7	14-15.5	566.6-565.1	A-6a (8)	16	76	11	3,500	-	0.335	15.74	15.74	3.636	(1)
B-002-0-23	SS-8	15.5-17	565.1-563.6	A-6a (9)	16	82	12	4,000	-	0.460	21.64	21.64	3.802	(1)

Notes: (1) EC calculated by PI for cohesive condition exceeds maximum indicated 4.5. Therefore, EC was calculated using granular soil calculatin and D_{50} equiv.

(2) Tested specimen is existing fill materials in backfill zone behind existing culvert. Consideration should be given to ignoring this data for scour evaluation.

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: R:\GEOTECH\DRIVEN\232516\B-1_C.DVN
Project Name: LUC-Corduroy Project Date: 05/08/2024
Project Client: City of Oregon
Computed By: CPI
Project Manager: CPI

Cohesion for cohesive hardpan materials. For comparison only. Not utilized for recommendations.

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 11.70 ft
Diameter of Pile: 12.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	7.00 ft
	- Driving/Restrike	7.00 ft
	- Ultimate:	7.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	12.50 ft	0.00%	120.00 pcf	33.4/33.4	Nordlund
2	Cohesive	1.90 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
3	Cohesive	29.10 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
4	Cohesionless	5.00 ft	0.00%	0.00 pcf	35.9/35.9	Nordlund
5	Cohesive	5.00 ft	0.00%	135.00 pcf	4500.00 psf	T-79 Steel
6	Cohesionless	15.00 ft	0.00%	120.00 pcf	43.0/43.0	Nordlund
7	Cohesive	5.00 ft	0.00%	135.00 pcf	4500.00 psf	T-79 Steel

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
11.69 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
11.70 ft	Cohesionless	1110.72 psf	19.65	N/A	0.00 Kips
12.49 ft	Cohesionless	1133.47 psf	19.65	N/A	1.10 Kips
12.51 ft	Cohesive	N/A	N/A	812.55 psf	1.14 Kips
14.39 ft	Cohesive	N/A	N/A	821.95 psf	5.99 Kips
14.41 ft	Cohesive	N/A	N/A	822.05 psf	6.04 Kips
23.41 ft	Cohesive	N/A	N/A	867.05 psf	30.56 Kips
32.41 ft	Cohesive	N/A	N/A	912.05 psf	57.62 Kips
41.41 ft	Cohesive	N/A	N/A	950.00 psf	86.63 Kips
43.49 ft	Cohesive	N/A	N/A	950.00 psf	92.84 Kips
43.51 ft	Cohesionless	3252.09 psf	21.13	N/A	92.92 Kips
48.49 ft	Cohesionless	3096.71 psf	21.13	N/A	117.47 Kips
48.51 ft	Cohesive	N/A	N/A	1260.00 psf	117.56 Kips
53.49 ft	Cohesive	N/A	N/A	1260.00 psf	137.27 Kips
53.51 ft	Cohesionless	3303.69 psf	25.29	N/A	137.39 Kips
62.51 ft	Cohesionless	3562.89 psf	25.29	N/A	215.78 Kips
68.49 ft	Cohesionless	3735.11 psf	25.29	N/A	274.17 Kips
68.51 ft	Cohesive	N/A	N/A	1260.00 psf	274.31 Kips
73.49 ft	Cohesive	N/A	N/A	1260.00 psf	294.02 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	50.64	45.71 Kips	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	50.64	45.71 Kips	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	50.64	45.71 Kips	0.00 Kips
11.69 ft	Cohesionless	0.00 psf	50.64	45.71 Kips	0.00 Kips
11.70 ft	Cohesionless	1110.72 psf	50.64	45.71 Kips	28.83 Kips
12.49 ft	Cohesionless	1156.22 psf	50.64	45.71 Kips	30.02 Kips
12.51 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
14.39 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
14.41 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
23.41 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
32.41 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
41.41 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
43.49 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
43.51 ft	Cohesionless	3251.78 psf	76.78	116.99 Kips	116.99 Kips
48.49 ft	Cohesionless	2941.02 psf	76.78	116.99 Kips	116.99 Kips
48.51 ft	Cohesive	N/A	N/A	N/A	31.81 Kips
53.49 ft	Cohesive	N/A	N/A	N/A	31.81 Kips
53.51 ft	Cohesionless	3303.98 psf	307.00	532.19 Kips	532.19 Kips
62.51 ft	Cohesionless	3822.38 psf	307.00	532.19 Kips	532.19 Kips
68.49 ft	Cohesionless	4166.82 psf	307.00	532.19 Kips	532.19 Kips
68.51 ft	Cohesive	N/A	N/A	N/A	31.81 Kips
73.49 ft	Cohesive	N/A	N/A	N/A	31.81 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
6.99 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
11.69 ft	0.00 Kips	0.00 Kips	0.00 Kips
11.70 ft	0.00 Kips	28.83 Kips	28.83 Kips
12.49 ft	1.10 Kips	30.02 Kips	31.11 Kips
12.51 ft	1.14 Kips	7.07 Kips	8.20 Kips
14.39 ft	5.99 Kips	7.07 Kips	13.06 Kips
14.41 ft	6.04 Kips	7.07 Kips	13.11 Kips
23.41 ft	30.56 Kips	7.07 Kips	37.63 Kips
32.41 ft	57.62 Kips	7.07 Kips	64.69 Kips
41.41 ft	86.63 Kips	7.07 Kips	93.70 Kips
43.49 ft	92.84 Kips	7.07 Kips	99.90 Kips
43.51 ft	92.92 Kips	116.99 Kips	209.91 Kips
48.49 ft	117.47 Kips	116.99 Kips	234.47 Kips
48.51 ft	117.56 Kips	31.81 Kips	149.37 Kips
53.49 ft	137.27 Kips	31.81 Kips	169.08 Kips
53.51 ft	137.39 Kips	532.19 Kips	669.58 Kips
62.51 ft	215.78 Kips	532.19 Kips	747.96 Kips
68.49 ft	274.17 Kips	532.19 Kips	806.35 Kips
68.51 ft	274.31 Kips	31.81 Kips	306.12 Kips
73.49 ft	294.02 Kips	31.81 Kips	325.83 Kips

Cohesion for cohesive hardpan materials for comparison only. Not utilized for recommendations.

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: R:\GEOTECH\DRIVEN\232516\B-1_N.DVN
Project Name: LUC-Corduroy Project Date: 05/08/2024
Project Client: City of Oregon
Computed By: CPI
Project Manager: CPI

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 11.70 ft
Diameter of Pile: 12.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	7.00 ft
	- Driving/Restrike	7.00 ft
	- Ultimate:	7.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	12.50 ft	0.00%	120.00 pcf	33.4/33.4	Nordlund
2	Cohesive	1.90 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
3	Cohesive	29.10 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
4	Cohesionless	5.00 ft	0.00%	120.00 pcf	35.7/35.7	Nordlund
5	Cohesionless	5.00 ft	0.00%	135.00 pcf	43.0/43.0	Nordlund
6	Cohesionless	15.00 ft	0.00%	120.00 pcf	43.0/43.0	Nordlund
7	Cohesionless	5.00 ft	0.00%	135.00 pcf	43.0/43.0	Nordlund

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
11.69 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
11.70 ft	Cohesionless	1110.72 psf	19.65	N/A	0.00 Kips
12.49 ft	Cohesionless	1133.47 psf	19.65	N/A	1.10 Kips
12.51 ft	Cohesive	N/A	N/A	812.55 psf	1.14 Kips
14.39 ft	Cohesive	N/A	N/A	821.95 psf	5.99 Kips
14.41 ft	Cohesive	N/A	N/A	822.05 psf	6.04 Kips
23.41 ft	Cohesive	N/A	N/A	867.05 psf	30.56 Kips
32.41 ft	Cohesive	N/A	N/A	912.05 psf	57.62 Kips
41.41 ft	Cohesive	N/A	N/A	950.00 psf	86.63 Kips
43.49 ft	Cohesive	N/A	N/A	950.00 psf	92.84 Kips
43.51 ft	Cohesionless	3252.69 psf	20.97	N/A	92.92 Kips
48.49 ft	Cohesionless	3396.11 psf	20.97	N/A	118.83 Kips
48.51 ft	Cohesionless	3540.76 psf	25.29	N/A	118.97 Kips
53.49 ft	Cohesionless	3721.54 psf	25.29	N/A	164.28 Kips
53.51 ft	Cohesionless	3903.69 psf	25.29	N/A	164.47 Kips
62.51 ft	Cohesionless	4162.89 psf	25.29	N/A	256.05 Kips
68.49 ft	Cohesionless	4335.11 psf	25.29	N/A	323.21 Kips
68.51 ft	Cohesionless	4767.76 psf	25.29	N/A	323.44 Kips
73.49 ft	Cohesionless	4948.54 psf	25.29	N/A	383.68 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	50.63	45.68 Kips	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	50.63	45.68 Kips	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	50.63	45.68 Kips	0.00 Kips
11.69 ft	Cohesionless	0.00 psf	50.63	45.68 Kips	0.00 Kips
11.70 ft	Cohesionless	1110.72 psf	50.63	45.68 Kips	28.82 Kips
12.49 ft	Cohesionless	1156.22 psf	50.63	45.68 Kips	30.00 Kips
12.51 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
14.39 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
14.41 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
23.41 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
32.41 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
41.41 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
43.49 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
43.51 ft	Cohesionless	3252.98 psf	72.89	107.11 Kips	107.11 Kips
48.49 ft	Cohesionless	3539.82 psf	72.89	107.11 Kips	107.11 Kips
48.51 ft	Cohesionless	3541.13 psf	307.00	532.19 Kips	532.19 Kips
53.49 ft	Cohesionless	3902.67 psf	307.00	532.19 Kips	532.19 Kips
53.51 ft	Cohesionless	3903.98 psf	307.00	532.19 Kips	532.19 Kips
62.51 ft	Cohesionless	4422.38 psf	307.00	532.19 Kips	532.19 Kips
68.49 ft	Cohesionless	4766.82 psf	307.00	532.19 Kips	532.19 Kips
68.51 ft	Cohesionless	4768.13 psf	307.00	532.19 Kips	532.19 Kips
73.49 ft	Cohesionless	5129.67 psf	307.00	532.19 Kips	532.19 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth		Skin Friction	End Bearing	Total Capacity
0.01 ft	GSE: 580.4	0.00 Kips	0.00 Kips	0.00 Kips
6.99 ft		0.00 Kips	0.00 Kips	0.00 Kips
7.01 ft		0.00 Kips	0.00 Kips	0.00 Kips
11.69 ft	Abut: 568.7	0.00 Kips	0.00 Kips	0.00 Kips
11.70 ft		0.00 Kips	28.82 Kips	28.82 Kips
12.49 ft		1.10 Kips	30.00 Kips	31.10 Kips
12.51 ft		1.14 Kips	7.07 Kips	8.20 Kips
14.39 ft	Scour 566	5.99 Kips	7.07 Kips	13.06 Kips
14.41 ft		6.04 Kips	7.07 Kips	13.11 Kips
23.41 ft		30.56 Kips	7.07 Kips	37.63 Kips
32.41 ft		57.62 Kips	7.07 Kips	64.69 Kips
41.41 ft		86.63 Kips	7.07 Kips	93.70 Kips
43.49 ft		92.84 Kips	7.07 Kips	99.90 Kips
43.51 ft		92.92 Kips	107.11 Kips	200.02 Kips
48.49 ft		118.83 Kips	107.11 Kips	225.94 Kips
48.51 ft		118.97 Kips	532.19 Kips	651.16 Kips
53.49 ft		164.28 Kips	532.19 Kips	696.46 Kips
53.51 ft		164.47 Kips	532.19 Kips	696.65 Kips
62.51 ft		256.05 Kips	532.19 Kips	788.24 Kips
68.49 ft		323.21 Kips	532.19 Kips	855.39 Kips
68.51 ft		323.44 Kips	532.19 Kips	855.63 Kips
73.49 ft		383.68 Kips	532.19 Kips	915.87 Kips

Skin in scour to 14.4 feet is 6 kips
UBV is 236 kips. Need 236+6 kips for resistance during driving through potential scour zone that may not be there in the future, and + 6 kips since it was already included in the "ultimate" capacity above. Therefore, looking at 248 kips.

Get 248 kips at 48.5 ft below ex grade = Elev 531.9

Abutment = 568.7 + 2 ft stickup is top of pile at 570.7

Calculated Length = 570.7 - 531.9 = 38.8 ft

Estimated Length = roundup to 40 ft

Order Length = 40 ft + 5 ft = 45 ft

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: R:\GEOTECH\DRIVEN\232516\B-1_N_H.DVN
Project Name: LUC-Corduroy Project Date: 05/08/2024
Project Client: City of Oregon
Computed By: CPI
Project Manager: CPI

PILE INFORMATION

Pile Type: H Pile - HP10X42
Top of Pile: 11.70 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	7.00 ft
	- Driving/Restrike	7.00 ft
	- Ultimate:	7.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	12.50 ft	0.00%	120.00 pcf	33.4/33.4	Nordlund
2	Cohesive	1.90 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
3	Cohesive	29.10 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
4	Cohesionless	5.00 ft	0.00%	120.00 pcf	35.7/35.7	Nordlund
5	Cohesionless	5.00 ft	0.00%	135.00 pcf	43.0/43.0	Nordlund
6	Cohesionless	15.00 ft	0.00%	120.00 pcf	43.0/43.0	Nordlund
7	Cohesionless	5.00 ft	0.00%	135.00 pcf	43.0/43.0	Nordlund

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
11.69 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
11.70 ft	Cohesionless	1110.72 psf	24.49	N/A	0.00 Kips
12.49 ft	Cohesionless	1133.47 psf	24.49	N/A	1.13 Kips
12.51 ft	Cohesive	N/A	N/A	824.50 psf	1.17 Kips
14.39 ft	Cohesive	N/A	N/A	835.70 psf	6.35 Kips
14.41 ft	Cohesive	N/A	N/A	835.82 psf	6.40 Kips
23.41 ft	Cohesive	N/A	N/A	889.41 psf	32.79 Kips
32.41 ft	Cohesive	N/A	N/A	943.01 psf	62.35 Kips
41.41 ft	Cohesive	N/A	N/A	950.00 psf	90.95 Kips
43.49 ft	Cohesive	N/A	N/A	950.00 psf	97.46 Kips
43.51 ft	Cohesionless	3252.69 psf	26.14	N/A	97.54 Kips
48.49 ft	Cohesionless	3396.11 psf	26.14	N/A	123.27 Kips
48.51 ft	Cohesionless	3540.76 psf	31.52	N/A	123.40 Kips
53.49 ft	Cohesionless	3721.54 psf	31.52	N/A	166.23 Kips
53.51 ft	Cohesionless	3903.69 psf	31.52	N/A	166.41 Kips
62.51 ft	Cohesionless	4162.89 psf	31.52	N/A	252.97 Kips
68.49 ft	Cohesionless	4335.11 psf	31.52	N/A	316.45 Kips
68.51 ft	Cohesionless	4767.76 psf	31.52	N/A	316.67 Kips
73.49 ft	Cohesionless	4948.54 psf	31.52	N/A	373.61 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	50.63	39.47 Kips	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	50.63	39.47 Kips	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	50.63	39.47 Kips	0.00 Kips
11.69 ft	Cohesionless	0.00 psf	50.63	39.47 Kips	0.00 Kips
11.70 ft	Cohesionless	1110.72 psf	50.63	39.47 Kips	24.91 Kips
12.49 ft	Cohesionless	1156.22 psf	50.63	39.47 Kips	25.93 Kips
12.51 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
14.39 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
14.41 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
23.41 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
32.41 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
41.41 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
43.49 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
43.51 ft	Cohesionless	3252.98 psf	72.89	92.55 Kips	92.55 Kips
48.49 ft	Cohesionless	3539.82 psf	72.89	92.55 Kips	92.55 Kips
48.51 ft	Cohesionless	3541.13 psf	307.00	459.87 Kips	459.87 Kips
53.49 ft	Cohesionless	3902.67 psf	307.00	459.87 Kips	459.87 Kips
53.51 ft	Cohesionless	3903.98 psf	307.00	459.87 Kips	459.87 Kips
62.51 ft	Cohesionless	4422.38 psf	307.00	459.87 Kips	459.87 Kips
68.49 ft	Cohesionless	4766.82 psf	307.00	459.87 Kips	459.87 Kips
68.51 ft	Cohesionless	4768.13 psf	307.00	459.87 Kips	459.87 Kips
73.49 ft	Cohesionless	5129.67 psf	307.00	459.87 Kips	459.87 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth		Skin Friction	End Bearing	Total Capacity
0.01 ft	GSE: 580.4	0.00 Kips	0.00 Kips	0.00 Kips
6.99 ft		0.00 Kips	0.00 Kips	0.00 Kips
7.01 ft		0.00 Kips	0.00 Kips	0.00 Kips
11.69 ft		0.00 Kips	0.00 Kips	0.00 Kips
11.70 ft	Abut 568.7	0.00 Kips	24.91 Kips	24.91 Kips
12.49 ft		1.13 Kips	25.93 Kips	27.05 Kips
12.51 ft		1.17 Kips	6.11 Kips	7.28 Kips
14.39 ft	Scour 566	6.35 Kips	6.11 Kips	12.46 Kips
14.41 ft		6.40 Kips	6.11 Kips	12.51 Kips
23.41 ft		32.79 Kips	6.11 Kips	38.90 Kips
32.41 ft		62.35 Kips	6.11 Kips	68.46 Kips
41.41 ft		90.95 Kips	6.11 Kips	97.05 Kips
43.49 ft		97.46 Kips	6.11 Kips	103.57 Kips
43.51 ft		97.54 Kips	92.55 Kips	190.09 Kips
48.49 ft		123.27 Kips	92.55 Kips	215.82 Kips
48.51 ft		123.40 Kips	459.87 Kips	583.28 Kips
53.49 ft		166.23 Kips	459.87 Kips	626.10 Kips
53.51 ft		166.41 Kips	459.87 Kips	626.28 Kips
62.51 ft		252.97 Kips	459.87 Kips	712.85 Kips
68.49 ft		316.45 Kips	459.87 Kips	776.33 Kips
68.51 ft		316.67 Kips	459.87 Kips	776.55 Kips
73.49 ft		373.61 Kips	459.87 Kips	833.49 Kips

Skin in scour to 14.4 feet is about 6.5 kips.
UBV is 236 kips. Need 236+6.5 kips for resistance during driving through potential scour zone that may not be there in the future, and + 6.5 kips since it was already included in the "ultimate" capacity above. Therefore, looking at 249 kips.

Get 249 kips at 48.5 ft below ex grade = Elev 531.9

Abutment = 568.7 + 2 ft stickup is top of pile at 570.7

Calculated Length = 570.7 - 531.9 = 38.8 ft

Estimated Length = roundup to 40 ft

Order Length = 40 ft + 5 ft = 45 ft

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: H:\2024\DRIVEN\B-2_N.DVN
Project Name: LUC-Corduroy Project Date: 05/09/2024
Project Client: City of Oregon
Computed By: CPI/NT
Project Manager: CPI

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 11.90 ft
Diameter of Pile: 12.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	7.00 ft
	- Driving/Restrike	7.00 ft
	- Ultimate:	7.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	3.50 ft	0.00%	135.00 pcf	32.9/32.9	Nordlund
2	Cohesive	2.50 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
3	Cohesionless	5.00 ft	0.00%	0.00 pcf	28.1/28.1	Nordlund
4	Cohesive	1.50 ft	0.00%	120.00 pcf	375.00 psf	T-79 Steel
5	Cohesionless	1.50 ft	0.00%	130.00 pcf	29.8/29.8	Nordlund
6	Cohesive	0.60 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
7	Cohesive	28.90 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
8	Cohesionless	5.00 ft	0.00%	130.00 pcf	43.0/43.0	Nordlund
9	Cohesionless	5.00 ft	0.00%	0.00 pcf	43.0/43.0	Nordlund
10	Cohesionless	1.50 ft	0.00%	0.00 pcf	43.0/43.0	Nordlund
11	Cohesionless	18.50 ft	0.00%	135.00 pcf	43.0/43.0	Nordlund

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
3.49 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
3.51 ft	Cohesive	N/A	N/A	0.00 psf	0.00 Kips
5.99 ft	Cohesive	N/A	N/A	0.00 psf	0.00 Kips
6.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
10.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
11.01 ft	Cohesive	N/A	N/A	0.00 psf	0.00 Kips
11.89 ft	Cohesive	N/A	N/A	0.00 psf	0.00 Kips
11.90 ft	Cohesive	N/A	N/A	309.28 psf	0.00 Kips
12.49 ft	Cohesive	N/A	N/A	310.66 psf	0.58 Kips
12.51 ft	Cohesionless	634.64 psf	17.51	N/A	0.59 Kips
13.99 ft	Cohesionless	684.66 psf	17.51	N/A	1.45 Kips
14.01 ft	Cohesive	N/A	N/A	820.05 psf	1.49 Kips
14.59 ft	Cohesive	N/A	N/A	822.95 psf	2.98 Kips
14.61 ft	Cohesive	N/A	N/A	823.05 psf	3.04 Kips
23.61 ft	Cohesive	N/A	N/A	868.05 psf	27.58 Kips
32.61 ft	Cohesive	N/A	N/A	913.05 psf	54.67 Kips
41.61 ft	Cohesive	N/A	N/A	950.00 psf	83.62 Kips
43.49 ft	Cohesive	N/A	N/A	950.00 psf	89.23 Kips
43.51 ft	Cohesionless	2730.24 psf	25.29	N/A	89.33 Kips
48.49 ft	Cohesionless	2898.56 psf	25.29	N/A	124.62 Kips
48.51 ft	Cohesionless	3067.59 psf	25.29	N/A	124.77 Kips
53.49 ft	Cohesionless	2912.21 psf	25.29	N/A	160.21 Kips
53.51 ft	Cohesionless	2755.59 psf	25.29	N/A	160.35 Kips
54.99 ft	Cohesionless	2709.41 psf	25.29	N/A	170.15 Kips
55.01 ft	Cohesionless	2662.66 psf	25.29	N/A	170.28 Kips
64.01 ft	Cohesionless	2989.36 psf	25.29	N/A	236.05 Kips
73.01 ft	Cohesionless	3316.06 psf	25.29	N/A	316.19 Kips
73.49 ft	Cohesionless	3333.49 psf	25.29	N/A	320.87 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	46.46	37.89 Kips	0.00 Kips
3.49 ft	Cohesionless	0.00 psf	46.46	37.89 Kips	0.00 Kips
3.51 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
5.99 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
6.01 ft	Cohesionless	0.00 psf	23.16	10.46 Kips	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	23.16	10.46 Kips	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	23.16	10.46 Kips	0.00 Kips
10.99 ft	Cohesionless	0.00 psf	23.16	10.46 Kips	0.00 Kips
11.01 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
11.89 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
11.90 ft	Cohesive	N/A	N/A	N/A	2.65 Kips
12.49 ft	Cohesive	N/A	N/A	N/A	2.65 Kips
12.51 ft	Cohesionless	634.98 psf	29.18	10.46 Kips	8.37 Kips
13.99 ft	Cohesionless	735.02 psf	29.18	10.46 Kips	9.68 Kips
14.01 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
14.59 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
14.61 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
23.61 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
32.61 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
41.61 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
43.49 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
43.51 ft	Cohesionless	2730.58 psf	307.00	532.19 Kips	516.18 Kips
48.49 ft	Cohesionless	3067.22 psf	307.00	532.19 Kips	532.19 Kips
48.51 ft	Cohesionless	3067.28 psf	307.00	532.19 Kips	532.19 Kips
53.49 ft	Cohesionless	2756.52 psf	307.00	532.19 Kips	521.08 Kips
53.51 ft	Cohesionless	2755.28 psf	307.00	532.19 Kips	520.85 Kips
54.99 ft	Cohesionless	2662.92 psf	307.00	532.19 Kips	503.39 Kips
55.01 ft	Cohesionless	2663.03 psf	307.00	532.19 Kips	503.41 Kips
64.01 ft	Cohesionless	3316.43 psf	307.00	532.19 Kips	532.19 Kips
73.01 ft	Cohesionless	3969.83 psf	307.00	532.19 Kips	532.19 Kips
73.49 ft	Cohesionless	4004.67 psf	307.00	532.19 Kips	532.19 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth		Skin Friction	End Bearing	Total Capacity
0.01 ft	GSE: 580.6	0.00 Kips	0.00 Kips	0.00 Kips
3.49 ft		0.00 Kips	0.00 Kips	0.00 Kips
3.51 ft		0.00 Kips	0.00 Kips	0.00 Kips
5.99 ft		0.00 Kips	0.00 Kips	0.00 Kips
6.01 ft		0.00 Kips	0.00 Kips	0.00 Kips
6.99 ft		0.00 Kips	0.00 Kips	0.00 Kips
7.01 ft		0.00 Kips	0.00 Kips	0.00 Kips
10.99 ft		0.00 Kips	0.00 Kips	0.00 Kips
11.01 ft		0.00 Kips	0.00 Kips	0.00 Kips
11.89 ft	Abut 568.7	0.00 Kips	0.00 Kips	0.00 Kips
11.90 ft		0.00 Kips	2.65 Kips	2.65 Kips
12.49 ft		0.58 Kips	2.65 Kips	3.23 Kips
12.51 ft		0.59 Kips	8.37 Kips	8.96 Kips
13.99 ft		1.45 Kips	9.68 Kips	11.14 Kips
14.01 ft		1.49 Kips	7.07 Kips	8.55 Kips
14.59 ft	Scour 566	2.98 Kips	7.07 Kips	10.05 Kips
14.61 ft		3.04 Kips	7.07 Kips	10.11 Kips
23.61 ft		27.58 Kips	7.07 Kips	34.65 Kips
32.61 ft		54.67 Kips	7.07 Kips	61.74 Kips
41.61 ft		83.62 Kips	7.07 Kips	90.69 Kips
43.49 ft		89.23 Kips	7.07 Kips	96.30 Kips
43.51 ft		89.33 Kips	516.18 Kips	605.51 Kips
48.49 ft		124.62 Kips	532.19 Kips	656.80 Kips
48.51 ft		124.77 Kips	532.19 Kips	656.95 Kips
53.49 ft		160.21 Kips	521.08 Kips	681.29 Kips
53.51 ft		160.35 Kips	520.85 Kips	681.19 Kips
54.99 ft		170.15 Kips	503.39 Kips	673.53 Kips
55.01 ft		170.28 Kips	503.41 Kips	673.68 Kips
64.01 ft		236.05 Kips	532.19 Kips	768.23 Kips
73.01 ft		316.19 Kips	532.19 Kips	848.37 Kips
73.49 ft		320.87 Kips	532.19 Kips	853.05 Kips

Skin in scour to 14.6 feet is 3 kips
UBV is 236 kips. Need 236+3 kips for resistance during driving through potential scour zone that may not be there in the future, and + 3 kips since it was already included in the "ultimate" capacity above. Therefore, looking at 242 kips.

Get 242 kips at 43.5 ft below ex grade = Elev 537.1

Abutment = 568.7 + 2 ft stickup is top of pile at 570.7

Calculated Length = 570.7 - 537.1 = 33.6 ft

Estimated Length = roundup to 35 ft

Order Length = 35 ft + 5 ft = 40 ft

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: H:\2024\DRIVEN\B-2_N_H.DVN
Project Name: LUC-Corduroy Project Date: 05/09/2024
Project Client: City of Oregon
Computed By: CPI/NT
Project Manager: CPI

PILE INFORMATION

Pile Type: H Pile - HP10X42
Top of Pile: 11.90 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	7.00 ft
	- Driving/Restrike	7.00 ft
	- Ultimate:	7.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	3.50 ft	0.00%	135.00 pcf	32.9/32.9	Nordlund
2	Cohesive	2.50 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
3	Cohesionless	5.00 ft	0.00%	0.00 pcf	28.1/28.1	Nordlund
4	Cohesive	1.50 ft	0.00%	120.00 pcf	375.00 psf	T-79 Steel
5	Cohesionless	1.50 ft	0.00%	130.00 pcf	29.8/29.8	Nordlund
6	Cohesive	0.60 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
7	Cohesive	28.90 ft	0.00%	130.00 pcf	1000.00 psf	T-79 Steel
8	Cohesionless	5.00 ft	0.00%	130.00 pcf	43.0/43.0	Nordlund
9	Cohesionless	5.00 ft	0.00%	0.00 pcf	43.0/43.0	Nordlund
10	Cohesionless	1.50 ft	0.00%	0.00 pcf	43.0/43.0	Nordlund
11	Cohesionless	18.50 ft	0.00%	135.00 pcf	43.0/43.0	Nordlund

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
3.49 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
3.51 ft	Cohesive	N/A	N/A	0.00 psf	0.00 Kips
5.99 ft	Cohesive	N/A	N/A	0.00 psf	0.00 Kips
6.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
10.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
11.01 ft	Cohesive	N/A	N/A	0.00 psf	0.00 Kips
11.89 ft	Cohesive	N/A	N/A	0.00 psf	0.00 Kips
11.90 ft	Cohesive	N/A	N/A	314.60 psf	0.00 Kips
12.49 ft	Cohesive	N/A	N/A	316.24 psf	0.61 Kips
12.51 ft	Cohesionless	634.64 psf	21.83	N/A	0.63 Kips
13.99 ft	Cohesionless	684.66 psf	21.83	N/A	1.57 Kips
14.01 ft	Cohesive	N/A	N/A	833.43 psf	1.61 Kips
14.59 ft	Cohesive	N/A	N/A	836.89 psf	3.21 Kips
14.61 ft	Cohesive	N/A	N/A	837.01 psf	3.26 Kips
23.61 ft	Cohesive	N/A	N/A	890.61 psf	29.68 Kips
32.61 ft	Cohesive	N/A	N/A	944.20 psf	59.28 Kips
41.61 ft	Cohesive	N/A	N/A	950.00 psf	87.81 Kips
43.49 ft	Cohesive	N/A	N/A	950.00 psf	93.69 Kips
43.51 ft	Cohesionless	2730.24 psf	31.52	N/A	93.79 Kips
48.49 ft	Cohesionless	2898.56 psf	31.52	N/A	127.14 Kips
48.51 ft	Cohesionless	3067.59 psf	31.52	N/A	127.28 Kips
53.49 ft	Cohesionless	2912.21 psf	31.52	N/A	160.79 Kips
53.51 ft	Cohesionless	2755.59 psf	31.52	N/A	160.91 Kips
54.99 ft	Cohesionless	2709.41 psf	31.52	N/A	170.18 Kips
55.01 ft	Cohesionless	2662.66 psf	31.52	N/A	170.30 Kips
64.01 ft	Cohesionless	2989.36 psf	31.52	N/A	232.46 Kips
73.01 ft	Cohesionless	3316.06 psf	31.52	N/A	308.22 Kips
73.49 ft	Cohesionless	3333.49 psf	31.52	N/A	312.64 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	46.46	32.74 Kips	0.00 Kips
3.49 ft	Cohesionless	0.00 psf	46.46	32.74 Kips	0.00 Kips
3.51 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
5.99 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
6.01 ft	Cohesionless	0.00 psf	23.16	9.04 Kips	0.00 Kips
6.99 ft	Cohesionless	0.00 psf	23.16	9.04 Kips	0.00 Kips
7.01 ft	Cohesionless	0.00 psf	23.16	9.04 Kips	0.00 Kips
10.99 ft	Cohesionless	0.00 psf	23.16	9.04 Kips	0.00 Kips
11.01 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
11.89 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
11.90 ft	Cohesive	N/A	N/A	N/A	2.29 Kips
12.49 ft	Cohesive	N/A	N/A	N/A	2.29 Kips
12.51 ft	Cohesionless	634.98 psf	29.18	9.04 Kips	7.23 Kips
13.99 ft	Cohesionless	735.02 psf	29.18	9.04 Kips	8.37 Kips
14.01 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
14.59 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
14.61 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
23.61 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
32.61 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
41.61 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
43.49 ft	Cohesive	N/A	N/A	N/A	6.11 Kips
43.51 ft	Cohesionless	2730.58 psf	307.00	459.87 Kips	446.04 Kips
48.49 ft	Cohesionless	3067.22 psf	307.00	459.87 Kips	459.87 Kips
48.51 ft	Cohesionless	3067.28 psf	307.00	459.87 Kips	459.87 Kips
53.49 ft	Cohesionless	2756.52 psf	307.00	459.87 Kips	450.28 Kips
53.51 ft	Cohesionless	2755.28 psf	307.00	459.87 Kips	450.08 Kips
54.99 ft	Cohesionless	2662.92 psf	307.00	459.87 Kips	434.99 Kips
55.01 ft	Cohesionless	2663.03 psf	307.00	459.87 Kips	435.01 Kips
64.01 ft	Cohesionless	3316.43 psf	307.00	459.87 Kips	459.87 Kips
73.01 ft	Cohesionless	3969.83 psf	307.00	459.87 Kips	459.87 Kips
73.49 ft	Cohesionless	4004.67 psf	307.00	459.87 Kips	459.87 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth		Skin Friction	End Bearing	Total Capacity
0.01 ft	GSE: 580.6	0.00 Kips	0.00 Kips	0.00 Kips
3.49 ft		0.00 Kips	0.00 Kips	0.00 Kips
3.51 ft		0.00 Kips	0.00 Kips	0.00 Kips
5.99 ft		0.00 Kips	0.00 Kips	0.00 Kips
6.01 ft		0.00 Kips	0.00 Kips	0.00 Kips
6.99 ft		0.00 Kips	0.00 Kips	0.00 Kips
7.01 ft		0.00 Kips	0.00 Kips	0.00 Kips
10.99 ft		0.00 Kips	0.00 Kips	0.00 Kips
11.01 ft		0.00 Kips	0.00 Kips	0.00 Kips
11.89 ft	Abut 568.7	0.00 Kips	0.00 Kips	0.00 Kips
11.90 ft		0.00 Kips	2.29 Kips	2.29 Kips
12.49 ft		0.61 Kips	2.29 Kips	2.91 Kips
12.51 ft		0.63 Kips	7.23 Kips	7.86 Kips
13.99 ft		1.57 Kips	8.37 Kips	9.94 Kips
14.01 ft		1.61 Kips	6.11 Kips	7.72 Kips
14.59 ft	Scour 566	3.21 Kips	6.11 Kips	9.32 Kips
14.61 ft		3.26 Kips	6.11 Kips	9.37 Kips
23.61 ft		29.68 Kips	6.11 Kips	35.79 Kips
32.61 ft		59.28 Kips	6.11 Kips	65.39 Kips
41.61 ft		87.81 Kips	6.11 Kips	93.91 Kips
43.49 ft		93.69 Kips	6.11 Kips	99.80 Kips
43.51 ft		93.79 Kips	446.04 Kips	539.83 Kips
48.49 ft		127.14 Kips	459.87 Kips	587.01 Kips
48.51 ft		127.28 Kips	459.87 Kips	587.16 Kips
53.49 ft		160.79 Kips	450.28 Kips	611.06 Kips
53.51 ft		160.91 Kips	450.08 Kips	610.99 Kips
54.99 ft		170.18 Kips	434.99 Kips	605.17 Kips
55.01 ft		170.30 Kips	435.01 Kips	605.30 Kips
64.01 ft		232.46 Kips	459.87 Kips	692.34 Kips
73.01 ft		308.22 Kips	459.87 Kips	768.09 Kips
73.49 ft		312.64 Kips	459.87 Kips	772.51 Kips

Skin in scour to 14.6 feet is about 3.5 kips
UBV is 236 kips. Need 236+3.5 kips for resistance during driving through potential scour zone that may not be there in the future, and + 3.5 kips since it was already included in the "ultimate" capacity above. Therefore, looking at 243 kips.

Get 243 kips at 43.5 ft below ex grade = Elev 537.1

Abutment = 568.7 + 2 ft stickup is top of pile at 570.7

Calculated Length = 570.7 - 537.1 = 33.6 ft

Estimated Length = roundup to 35 ft

Order Length = 35 ft + 5 ft = 40 ft

APPENDIX B

Archive Spread Foundations Calculations

	Calculations:		NT	2/16/2024				Average Soil Properties - Bearing Materials									
		Review:	CPI	2/26/2024													
	Boring B-001-1-23										Boring B-002-0-23						
	DEPTH	SAMPLE	N	N60	HP tsf	Qu tsf	MC				DEPTH	SAMPLE	N	N60	HP tsf	Qu tsf	MC
MS-S	12.5	SS - 1	16	22	4.5		12			Cr Stone Fill	12.5	SS -6	5	7			11
	14	SS - 2	15	20	4.5	5.39	13			MS-S	14	SS -7	4	5	1.75		16
	15.5	SS - 3	15	20	1.5		20				15.5	SS -8	10	14	2		16
	17	SS - 4	13	18	2.75		16				17	SS -9	10	14	0.75	0.62	18
	18.5	ST - 5			1.5	1.40	17				18.5	SS -10	10	10	1	0.73	18
	21	SS - 6	8	11	1.25		16				21	SS -11	6	8	0.5		18
	23.5	SS - 7	10	14	0.75		20				23.5	ST -12			1.75	1.29	18
	26	SS - 8	7	10	1.25	0.63	19				26	SS -13	11	15	1.75		14
	28.5	SS - 9	5	7	1		20				28.5	SS -14	10	14	0.75		15
	33.5	SS - 10	8	11	1		18				33.5	SS -15	9	12	0.75		18
	38.5	SS - 11	8	11	1.25		16				38.5	SS -16	5	8	0.5		17
Dense	43.5	SS - 12	62	35			13			V Dense	43.5	SS -17	50	SSR			7
	48.5	SS - 13	50	SSR			11				48.5	SS -18	50	SSR			13
	53.5	SS - 14	50	SSR			8				53.5	SS -19	50	SSR			10
	Medium Stiff to Stiff Bearing Soils (Bearing at about 12 feet)																
	B-001-1-23										B-002-0-23						
	DEPTH	SAMPLE	N	N60	HP tsf	Qu tsf	MC				DEPTH	SAMPLE	N	N60	HP tsf	Qu tsf	MC
	AVERAGE			12	1.93	1.02	17				AVERAGE			11	1.15	0.88	17
UCS N60x250				2929						UCS N60x250				2778			
	Su (psf)			1464	1932	1015					Su (psf)			1389	1150	880	
Su (psf), Avg all 3	1470									Su (psf), Avg all 3	1140						
						Design Su (psf):		1000	(Confirm in field minimum HP value of 1 tsf)								
						Design Su (ksf):		1.0									
	Red text: Don't use outlier.																
	Bold Purple Text: ST Sample																

Project: LUC-Corduroy Road over Otter Creek, Oregon, Ohio
CT Project No.: 232516

By: NT Date: 2/16/2024 Checked: CPI Date: 2/26/2024

GENERAL FOUNDATION INFORMATION:

3-Sided Culvert strip foundations bearing at about 12 feet below grade. Over-excavated granular existing fill to underlying medium stiff or better native cohesive soils

New 3-sided culvert

Assume Footing width about 10 feet (if wider, could use box culvert) and length 65 feet (length of existing culvert)

GENERAL SOIL INFORMATION:

Borings B-001-0-23, B-001-1-23, and B-002-0-23 were used for our evaluation

After over-excavation of granular existing fill materials, will bear in:
Native medium stiff to stiff cohesive soils

USE c =	1.0	ksf for this analysis

Groundwater

Model groundwater in creek above foundatation bearing elevation

Project: LUC-Corduroy Road over Otter Creek, Oregon, Ohio
CT Project No.: 232516

By: NT Date: 2/16/2024 Checked: CPI Date: 2/26/2024

STRENTH LIMIT STATE:

$q_R = \varphi_b * q_n$ (AASTHO LRFD 10.6.3.1.1-1)

q_R = factored resistance at strength limit state (ksf)
φ_b = resistance factor (Article 10.5.5.2.2)
q_n = nominal bearing resistance (ksf)

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma}$ (AASTHO LRFD 10.6.3.1.2a-1)
$N_{cm} = N_c s_c i_c$ (AASTHO LRFD 10.6.3.1.2a-2)
$N_{qm} = N_q s_q d_q i_q$ (AASTHO LRFD 10.6.3.1.2a-3)
$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$ (AASTHO LRFD 10.6.3.1.2a-4)

c = cohesion, undrained shear strength (ksf)
N_c = cohesion term (Table 10.6.3.1.2a-1)
N_q = surcharge term (Table 10.6.3.1.2a-1)
N_g = unit weight term (Table 10.6.3.1.2a-1)
γ = total (moist) unit weight (kcf)
D_f = footing embedment depth (ft)
B = footing width (ft)
C_{wq} , $C_{w\gamma}$ = groundwater correction factors (Table 10.6.3.1.2a-2)
s_c , s_γ , s_q = shape correction factors (Table 10.6.3.1.2a-3)
d_q = shear resistance thought cohesionless material correction factor (Table 10.6.3.1.2a-4)
i_c , i_γ , i_q = inclination correction factors

Project: LUC-Corduroy Road over Otter Creek, Oregon, Ohio
CT Project No.: 232516

By: NT Date: 2/16/2024 Checked: CPI Date: 2/26/2024

Bearing in Very Stiff to Hard cohesive soils

Setup	c =	1.0	ksf	
	ϕ_f =	0	degrees	assumed zero in cohesive soil
	N_c =	5.14	*units*	
	N_q =	1.0	*units*	for soil with a ϕ_f = 0 Degrees
	N_γ =	0.0	*units*	
	γ =	0.058	kcf	(0.120 soil - 0.062 water)
	D_f =	3.5	ft	Frost depth below bottom of creek
	B =	10	ft	Width
	L =	65	ft	Length
	D_w =	0	ft	highest anticipated groundwater depth
	C_{wq} =	0.5	*units*	where D_w = 0.0
	$C_{w\gamma}$ =	0.5	*units*	(above D_f)
	s_c =	1.03	*units*	$s_c = 1 + (B/(5L))$
	s_g =	1.00	*units*	for $\phi_f = 0$ $s_\gamma = 1$
	s_q =	1.00	*units*	$s_q = 1$
	d_q =	1.0	*units*	taken as 1 since cohesive soil
	i_c , i_γ , i_q =	1.0	*units*	Assumed loaded without inclination

$1.5B + D_f$ = 18.5

D_f / B = 0.35

for $\phi_f > 0$ $s_g = 1 - 0.4(B/L)$

$s_q = 1 + ((B/L)\tan(\phi_f))$

$s_c = 1 + (B/(5L))(Nq/Nc)$

calculation

$N_{cm} = N_c s_c i_c$ = 5.14 * 1.031 * 1 = 5.299

$N_{qm} = N_q s_q d_q i_q$ = 1 * 1 * 1 * 1 = 1

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$ = 0 * 1 * 1 = 0

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma}$

= (1*5.299) + (0.0576*3.5*1*0.5) + (0.5*10*0*0.5) =

= (5.299) + (0.101) + (0) =

cN_{cm} = 5.299

$\gamma D_f N_{qm} C_{wq}$ = 0.101

$0.5\gamma B N_{\gamma m} C_{w\gamma}$ = 0

q_n = 5.4 ksf

φ_b = 0.5 based on theoretical method (Munfakh et al., 2001), in clay

$q_R = \varphi_b * q_n$ = 0.5 * 5.4 = 2.7 ksf

Factored resistance at the strength limit state for the proposed spread foundation is equal to 2.7 ksf

Project: LUC-Corduroy Road over Otter Creek, Oregon, Ohio
CT Project No.: 232516

By: NT Date: 2/16/2024 Checked: CPI Date: 2/26/2024

SERVICE LIMIT STATE:

Based on : (Table C10.6.2.6.1-1)

"Presumptive Bearing Resistance for Spread Footing Foundations at the Service Limit State" Table

Native medium stiff to stiff cohesive soils

within applicable borings and depths:

Consistency	Soil Type	Bearing Resistance (ksf)	
		Ordinary Range	Recommended Value of Use*
"Medium Dense"	Lean Clay (CL)	2-6	2.5

* recomented value based on Table C10.6.2.6.1-1 is 4 ksf, but soils at the site are closer to medium stiff.

Therefore, recommended value closer to low end of range of medium stiff to stiff.

φ_b = 1

Factored bearing resistance = 2.5 ksf

Settlement Calcs: 2.5 ksf results in approx 1 1/4 to 1 3/4 inches of settlement.

Recommend 1.5 ksf if need settlement ~1" max.

(see attached *Settlement Calculation*)

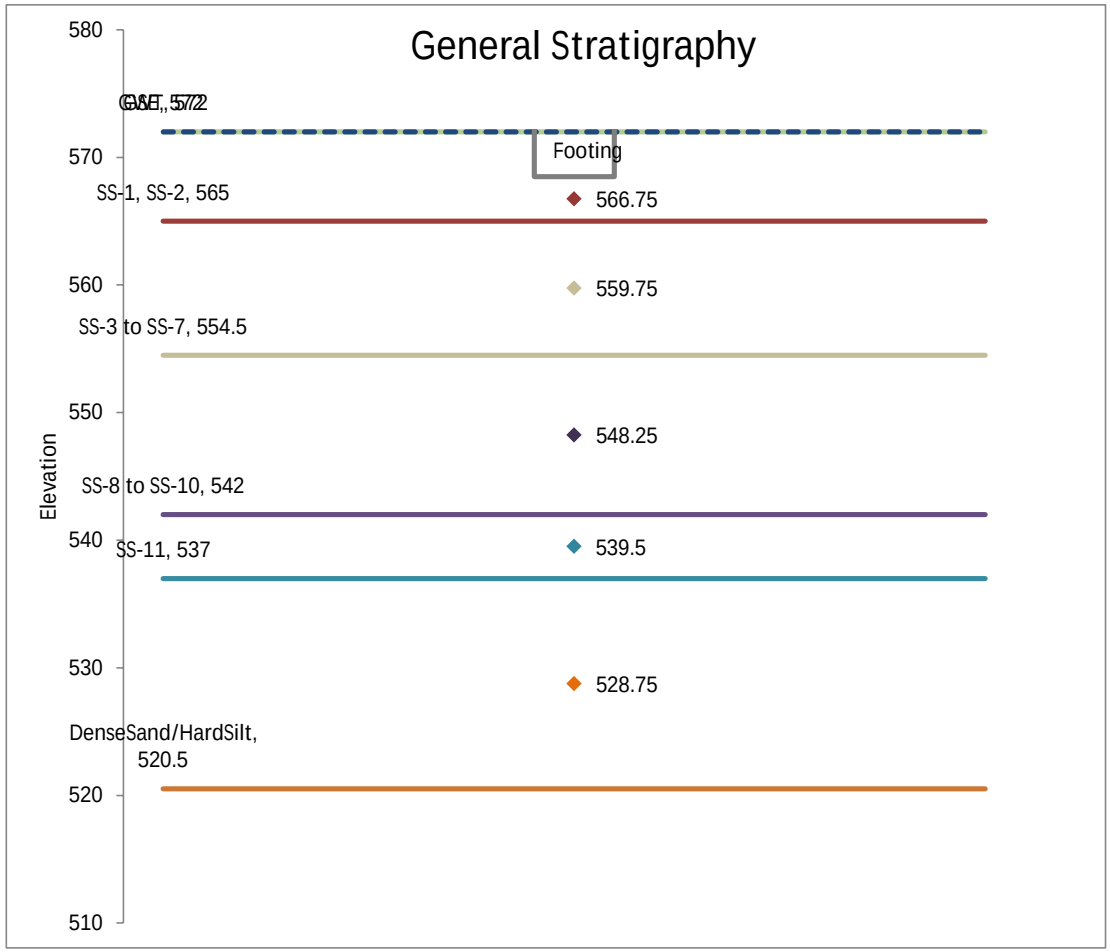
Project Name: 232516
Project Number: LUC-Corduroy Road
Calculated by: CPI

Boring Number B-001-1-23
Analysis Type Boussinesq Continuous

Settlement at
Service Limit State Bearing Resistance

Layer	H (feet)	C_r	e_o	sigma v (psf)	z (feet)	b (feet)	(z-Df)/b	I_z	delta p@	2298 psf	(check) sigma v+ΔP	delta H (inches)		C'	delta H w/C'
SS-1, SS-2	3.5	0.013	0.59	302	1.75	10	0.2	1	2298.4	Cr, since Pc>>	2601	0.32		0	#DIV/0!
SS-3 to SS-7	10.5	0.018	0.67	706	8.75	10	0.9	0.6	1379.04		2085	0.64		0	#DIV/0!
SS-8 to SS-10	12.5	0.019	0.68	1368	20.25	10	2.0	0.3	689.52		2058	0.30		0	#DIV/0!
SS-11	5	0.016	0.64	1872	29	10	2.9	0.2	459.68		2332	0.06		0	#DIV/0!
DenseSand/Hard	16.5	0.011	0.44	2574	39.75	10	4.0	0.1	229.84		2804	0.06		69	0.11
											Total delta H (in.)	1.42			#DIV/0!
											+15%	1.64			#DIV/0!
											-15%	1.21			#DIV/0!

Say 1 1/4 to 1 3/4 inches



Pc=Su/(0.11+0.00037PI)
Su (psf) 1000
PI 13 Governs, worst of MS-S Clays
Pc(psf) 8710

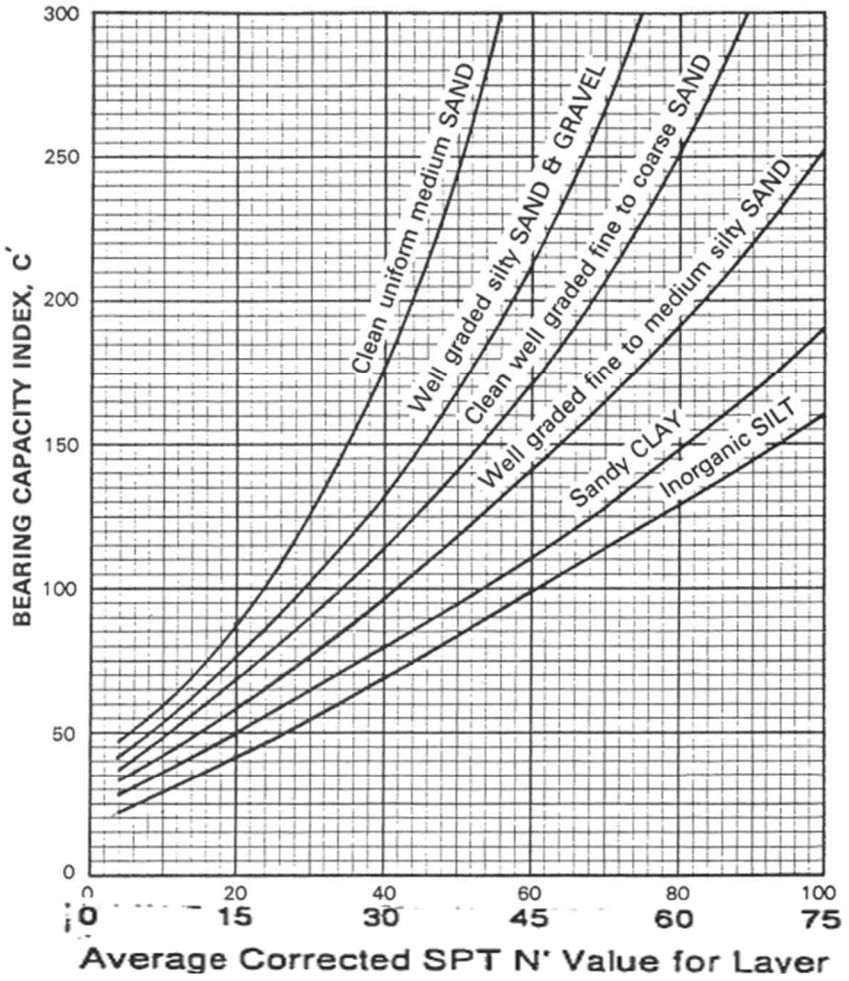
Project Number:	232516	Boring Number	B-001-1-23
Project Name:	LUC-Corduroy Road	Analysis Type	Boussinesq Continuous
Calculated by:	CPI 2/26/2024		(Homogeneous)

Governs, same native soils as B-002-0, but deeper removal of existing fill in B-002

H:\2023\232516\PHASE\01 Geotec\Project Data\Calculations\[232516 LRFD Shallow Foundations Bearing.xlsx]Analysis for Report

G (assumed)	2.7				
GSE	572	Approx 3.5 ft above bearing at 12 ft below existing grade.			
GWT	572			Stress Limit State Factored Bearing (psf):	2500
Bearing Elev	568.5	based on 3.5 foot min below creek bottom		Overburden to Bearing (psf):	201.6
D_f	3.5	ft		Net change in pressure causing settlement (psf):	2298.4
Footing Width, B	10	ft	Assumed		
P	2298.4	psf			
Rig		Ridgeway Yellow ATV ER 81.8 per calibration 1-27-24			

	Bot. Elev.	Centroid (C) Elev.	H (ft)	z below footing	z below GSE	γ_T (pcf)	γ_d (pcf)	H_{GWT-C}	w at C (%) (or C_rx1000)	e_o	Depth of Influence = (z-D_f)/B	I_z	σ_v' (psf)	N'/N	N60		N'	C'
SS-1, SS-2	565	566.75	3.5	1.75	5.25	120	106	5.25	13	0.59	0.18	1	302	2.4				
SS-3 to SS-7	554.5	559.75	10.5	8.75	12.25	120	102	12.25	18	0.67	0.9	0.6	706	1.64				
SS-8 to SS-10	542	548.25	12.5	20.25	23.75	120	101	23.75	19	0.68	2.0	0.3	1368	1.05				
SS-11	537	539.5	5	29	32.5	120	103	32.5	16	0.64	2.9	0.2	1872	0.95				
DenseSand/HardSilt	520.5	528.75	16.5	39.75	43.25	130	117	43.25	11	0.44	4.0	0.1	2574	0.86	35		30	69



Donut Safety

Figure 5-19: Bearing Capacity Index versus Corrected SPT
(Cheney & Chassie, 2000, modified from Hough, 1959)

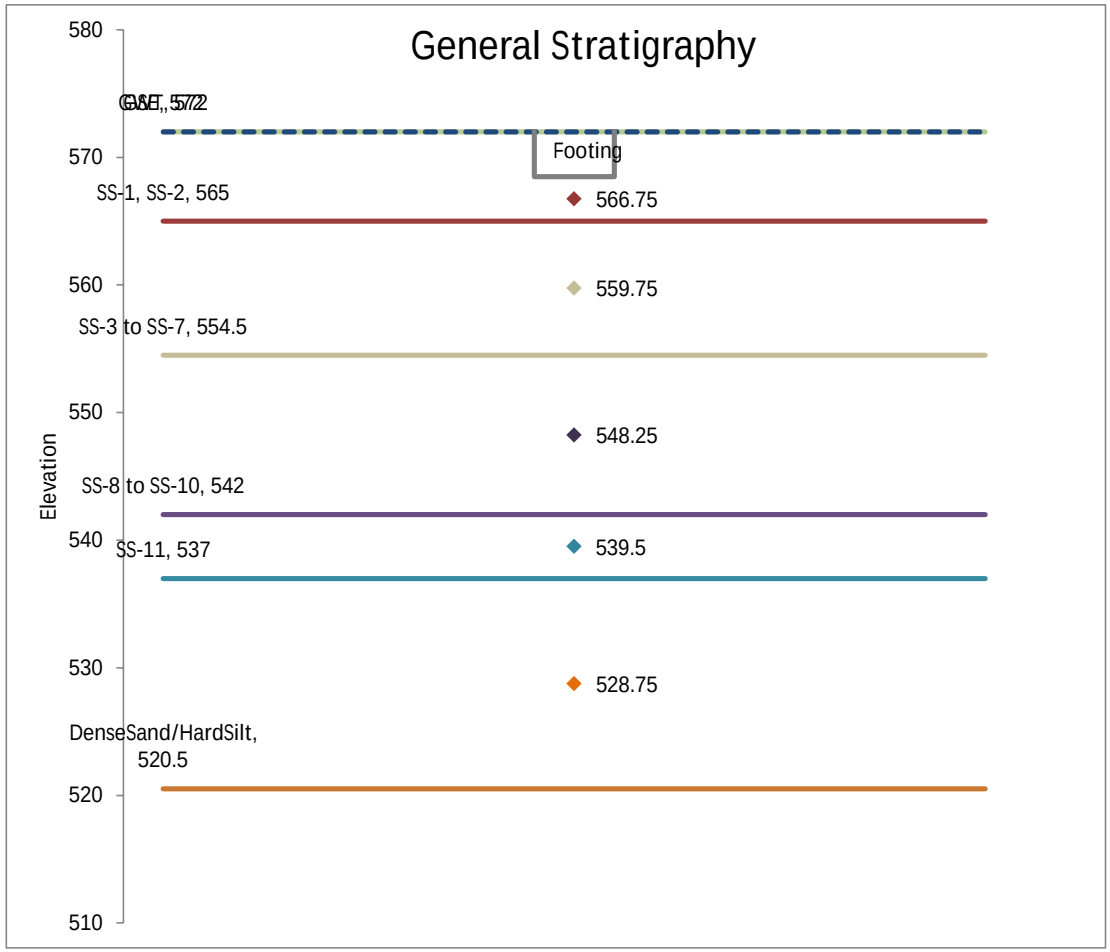
Project Name: 232516
Project Number: LUC-Corduroy Road
Calculated by: CPI

Boring Number B-001-1-23
Analysis Type Boussinesq Continuous

1500 psf
Pressure to limit to approx. 1 inch of settlement

Layer	H (feet)	C_r	e_o	sigma v (psf)	z (feet)	b (feet)	(z-Df)/b	I_z	delta p@	1298 psf	(check) sigma v+ΔP	delta H (inches)		C'	delta H w/C'
SS-1, SS-2	3.5	0.013	0.59	302	1.75	10	0.2	1	1298.4	Cr, since Pc>>	1601	0.25		0	#DIV/0!
SS-3 to SS-7	10.5	0.018	0.67	706	8.75	10	0.9	0.6	779.04		1485	0.44		0	#DIV/0!
SS-8 to SS-10	12.5	0.019	0.68	1368	20.25	10	2.0	0.3	389.52		1758	0.18		0	#DIV/0!
SS-11	5	0.016	0.64	1872	29	10	2.9	0.2	259.68		2132	0.03		0	#DIV/0!
DenseSand/Hard	16.5	0.011	0.44	2574	39.75	10	4.0	0.1	129.84		2704	0.03		69	0.06
											Total delta H (in.)	0.97			#DIV/0!
											+15%	1.11			#DIV/0!
											-15%	0.82			#DIV/0!

Say approx 1 inch



Pc=Su/(0.11+0.00037PI)
Su (psf) 1000
PI 13 Governs, worst of MS-S Clays
Pc(psf) 8710

Project Number:	232516	Boring Number	B-001-1-23 Governs, same native soils as B-002-0, but deeper removal of existing fill in B-002
Project Name:	LUC-Corduroy Road	Analysis Type	Boussinesq Continuous
Calculated by:	CPI 2/26/2024		(Homogeneous)

H:\2023\232516\PHASE\01 Geotec\Project Data\Calculations\[232516 LRFD Shallow Foundations Bearing.xlsx]Analysis for Report

G (assumed)	2.7				
GSE	572	Approx 3.5 ft above bearing at 12 ft below existing grade.			
GWT	572			Stress Limit State Factored Bearing (psf):	1500
Bearing Elev	568.5	based on 3.5 foot min below creek bottom		Overburden to Bearing (psf):	201.6
D_f	3.5	ft		Net change in pressure causing settlement (psf):	1298.4
Footing Width, B	10	ft	Assumed		
P	1298.4	psf			
Rig		Ridgeway Yellow ATV ER 81.8 per calibration 1-27-24			

	Bot. Elev.	Centroid (C) Elev.	H (ft)	z below footing	z below GSE	γ_T (pcf)	γ_d (pcf)	H_{GWT-C}	w at C (%) (or C_rx1000)	e_o	Depth of Influence = (z-D_f)/B	I_z	σ_v' (psf)	N'/N	N60		N'	C'
SS-1, SS-2	565	566.75	3.5	1.75	5.25	120	106	5.25	13	0.59	0.18	1	302	2.4				
SS-3 to SS-7	554.5	559.75	10.5	8.75	12.25	120	102	12.25	18	0.67	0.9	0.6	706	1.64				
SS-8 to SS-10	542	548.25	12.5	20.25	23.75	120	101	23.75	19	0.68	2.0	0.3	1368	1.05				
SS-11	537	539.5	5	29	32.5	120	103	32.5	16	0.64	2.9	0.2	1872	0.95				
DenseSand/HardSilt	520.5	528.75	16.5	39.75	43.25	130	117	43.25	11	0.44	4.0	0.1	2574	0.86	35		30	69