# ROADWAY EXPLORATION

## Proposed Intersection Improvements

LUC-023-11.75, PID 105889

US Route 23 at State Route 51

Sylvania, Lucas County, Ohio

Submitted to ARCADIS U.S., Inc.
DRAFT REPORT Date *July 2023*

Prepared by

TTL associates inc
Environmental, Geotechnical Engineering & Testing

OHIO DEPARTMENT OF TRANSPORTATION

# ARCADIS U.S., Inc.
# Cleveland, Ohio

## DRAFT Report
## Roadway Exploration
## LUC-023-11.75, PID 105889
## Interchange Improvements
## US Route 23 at State Route 51
## Sylvania, Lucas County, Ohio

## July 2023

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July 1, 2023 **TTL Project No. 2065201**

Mr. Craig Hebebrand, P.E.
ARCADIS U.S., Inc.
1100 Superior Avenue, Suite 1250
Cleveland, Ohio 44114

**DRAFT Report**
**Roadway Exploration**
**LUC-023-11.75, PID 105889**
**Interchange Improvements**
**US Route 23 at State Route 51**
**Sylvania, Lucas County, Ohio**

Dear Mr. Hebebrand:

Following is the report of our roadway exploration performed by TTL Associates, Inc. (TTL) for the referenced site. This study was performed in accordance with TTL Proposal No. 2065201R3, dated April 14, 2021, and was authorized via ARCADIS U.S., Inc. (ARCADIS) Agreement for Subcontractor Services, dated May 28, 2021 and fully executed on July 17, 2021. This study was also performed in accordance with Modification No. 1 (TTL Proposal No. 2065201R6), dated September 19, 2022, which was authorized with a modified subconsultant agreement received by TTL on December 20, 2022, which was fully executed on January 11, 2023.

Previous preliminary memorandum submittals were provided containing design recommendations for various portions of the project. Those recommendations have been incorporated into this report. This report also contains the results of our study, our engineering interpretation of the results with respect to the project characteristics, bridge foundation and pavement design recommendations, recommended soil nail wall design soil parameters, embankment settlement evaluations, as well as special benching and sidehill embankment fill evaluations. This report is considered complete and comprehensive with respect to the requested scope of work. However, in accordance with ODOT protocol, the report is being submitted "DRAFT" for review and comment by ARCADIS and/or ODOT District 2.

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

Sincerely,
**TTL Associates, Inc.**

Christopher P. Iott, P.E.
Chief Geotechnical Engineer

Curtis E. Roupe, P.E.
Vice President

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# DRAFT REPORT
# ROADWAY EXPLORATION
# LUC-023-11.75, PID 105889
# INTERCHANGE IMPROVEMENTS
# US ROUTE 23 AT STATE ROUTE 51
# SYLVANIA, LUCAS COUNTY, OHIO

**FOR**

**ARCADIS U.S., INC.**
**1100 SUPERIOR AVENUE, SUITE 1250**
**CLEVELAND, OHIO 44114**

**SUBMITTED**

**JULY 1, 2023**
**TTL PROJECT NO. 2065201**


**TTL ASSOCIATES, INC.**
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## EXECUTIVE SUMMARY

This roadway exploration report has been prepared for the proposed interchange improvements for US Route 23 (US 23) at State Route 51 (SR 51, Monroe Street) in Sylvania, Ohio, designated as LUC-023-11.75, PID 105889. This exploration included performance of 41 test borings, 8 of which included pavement cores. A summary of the findings, conclusions, and recommendations of this study are as follows:

1. Borings were performed in roadway areas and grass areas beyond existing roadways. Existing pavements typically consisted of asphalt overlying aggregate base or a composite section that also included concrete underlying the asphalt.

2. Fill or embankment fill was encountered in 15 of the borings. Based on the borings performed for this exploration, random or rubble fill materials were not encountered. The embankment fill / backfill consisted of both cohesive soils and granular soils. The native soils encountered underlying the surface materials and existing fill materials consisted of predominantly cohesive soils (approximately ¾ of the recovered soil samples) with interbedded zones of granular soils. Relatively shallow bedrock is present at the site. As such, structure borings typically encountered bedrock and many borings included rock coring. Top of bedrock was encountered at Elevs. 626± to 605±.

3. Based on the limited data available, such as the soil characteristics and the groundwater conditions encountered in the borings, it is our opinion that the "normal" groundwater level may be encountered at elevations on the order of Elev. 623 in the vicinity of the SR51 bridge over US 23, and on the order of Elev. 612 in the proximity of Ottawa River.

4. This project includes new embankment fill to be placed on slopes generally graded at 2 horizontal to 1 vertical (2H:1V). As such, it is anticipated that some of the embankment fill placement would fall under the specifications of ODOT Geotechnical Bulletin GB-2, "Special Benching and Sidehill Embankment Fills," (now ODOT GDM Section 800). Isolated areas will include fill placement along slopes that are steeper than 4H:1V, and may include sliver fills with design fill widths based on "neat" lines and plateaus of less than 8 feet. Where sidehill fills are planned on the face of an existing slope which is steeper than 4H:1V, ODOT Office of Geotechnical Engineering (OGE) recommends special benching to assure that the new fill section and existing embankment are "knitted" together.

5. Total settlement was calculated to be on the order of 1 to 3 inches for the maximum fill heights of approximately 7 to 19 feet indicated for this project. Some of this settlement will be occurring during construction so that post-contraction settlement will be less than the calculated theoretical values.

6. For SR 51 over US 23, the widened substructures of the four-span structure will include abutments supported by driven piles end-bearing on bedrock (Section 5.2.1) and three piers supported by footings bearing on bedrock (Section 5.2.2).

7. Consideration was given to support of the new Ramp A and Ramp B bridges over Ottawa River using footings bearing on bedrock. However, the rock was evaluated to be scourable

and drilled shafts socketed into bedrock are now planned. Recommendations are provided in Section 5.2.3.

8. A soil nail retaining wall is planned immediately west of the SR 51 over US 23 bridge rear abutment to facilitate re-routing of Ramp B south (instead of north) from SR 51 and then between Pier 3 and the rear abutment. Recommendations for this wall are provided in Section 5.3.

9. Where embankments are constructed for the project, the new embankment fill is anticipated to be suitable for pavement subgrade support. For portions of the project where pavement subgrade borings were performed for new roadway and ramp alignment that will approximate existing roadway alignment without significant grade change, an evaluation of the subgrade soils was completed in general accordance with ODOT Geotechnical Bulletin GB-1 "Plan Subgrades" (Now ODOT GDM Section 600). Recommendations are provided in Section 5.4. Recommended design CBR and k-values are provided in Sections 5.5 and 5.6, respectively, for asphalt and concrete pavement design, respectively.

10. Groundwater seepage, perched water, and surface water runoff into shallow excavations in predominantly cohesive soils should be controllable by pumping from prepared sumps. If excavations extend below the groundwater level in granular soils, installation of multiple well points may be required in addition to pumping from prepared sumps. Installation of the intermediate piers in Ottawa River may require temporary cofferdams to divert streamflow to manage groundwater in addition to pumping from prepared sumps. Otherwise, steel casing may also be used to help facilitate groundwater control. In any case, as mentioned in Section 5.2.3, it is likely that temporary steel casing will be required to support the walls of the drilled shafts, in addition to facilitating control groundwater seepage.

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 roadway exploration report has been prepared for the proposed interchange improvements for US Route 23 (US 23) at State Route 51 (SR 51, Monroe Street) in Sylvania, Ohio, designated as LUC-023-11.75, PID 105889. Maximum extents for this project are shown on the attached Site Location Map (Plate 1.0), and are summarized as follows:

- Along SR 51, approximately 500 feet west of Harroun Road to 300 feet east of the Sylvania River Trail,
- Along State Route 184 (SR 184, Alexis Road), from the western extent to 300 feet east of Acres Road (may be extended in the future to Elliot Road to incorporate a U-turn with loon),
- Along the northbound US 23 entrance ramp (current Ramp B, to be abandoned and re-routed beneath the SR 51 overpass bridge between Pier 3 and the Forward Abutment), extending 1,000 feet north,
- Along the southbound US 23 exit ramp (Ramp C), starting 550 feet north of the SR51 overpass of US 23,
- Along Harroun Road, 100 feet south of SR 51,
- Along Glasgow Road, 100 feet north of SR 51,
- Along Acres Road, 200 feet north of Alexis Road, and
- Along US 23/Ramp A/Ramp D, extending 500 feet south of the current ramp bridge crossings of Ottawa River.

This study was performed in accordance with TTL Proposal No. 2065201R3, dated April 14, 2021, and was authorized via ARCADIS U.S., Inc. (ARCADIS) Agreement for Subcontractor Services, dated May 28, 2021 and fully executed on July 17, 2021. This study was also performed in accordance with Modification No. 1 (TTL Proposal No. 2065201R6), dated September 19, 2022, which was authorized with a modified subconsultant agreement received by TTL on December 20, 2022, which was fully executed on January 11, 2023.

TTL provided a Modification 2 proposal (Proposal No. 2065201 Mod2 Rev0), dated February 20, 2023 for sign-support foundation borings, laboratory testing, and evaluations. As part of the drilling services that were in progress at that time, already planned borings nearby proposed sign-support foundation locations were extended deeper to meet ODOT Type E5 boring requirements. However, it was indicated by ODOT that it was preferred to delay this portion of the exploration until final sign-support foundation locations had been determined. Authorization has not been provided at the time of this draft report preparation. As such, the additional field exploration that was performed for the sign-support foundations has not been invoiced, laboratory testing has not been performed, and evaluations have not been made for these structures. Additionally, test borings that were planned in Modification 2 only for sign-support foundations were not performed.

It should be noted that the ODOT Geotechnical Design Manual (GDM) (July 15, 2022) was utilized for evaluation of soil and rock parameters as part of our exploration. However, this document was not available at the time of the original contract for this exploration. Therefore, references are made throughout the report to the historic Geotechnical Bulletin designations that have since been retired and incorporated into the GDM, but reference is also made to the new GDM section in which the Geotechnical Bulletins now reside.

## 1.1 Purpose and Scope of Exploration

The purpose of this exploration was to obtain soils data to evaluate the following:

- Magnitude and rate of potential settlement associated with the construction of the proposed realigned ramps and widened embankments for the widened SR 51 bridge over US 23,
- Special benching and sidehill embankment fill for the new embankment construction per ODOT Geotechnical Bulletin GB-2,
- Bridge foundations for widening of the SR 51 four-span bridge to the south, the new northbound US 23 exit ramp bridge over Ottawa River (Ramp A), as well as the new southbound US 23 entrance ramp bridge over Ottawa River (Ramp D),
- Recommended design soil parameters for a soil nail retaining wall planned for re-alignment of Ramp B just to the west of the Forward Abutment for SR 51 overpass of US 23, as well as
- Subgrade conditions for the realigned ramps, SR 51, Alexis Road, Acres Road, Harroun Road, and Glasgow Road, including completion of the ODOT Geotechnical Bulletin GB-1 spreadsheet with associated subgrade modification and CBR design value recommendations.

To accomplish this, TTL performed 41 test borings, 8 of which included pavement cores, field and laboratory soil testing, a geotechnical engineering evaluation of the test results, and 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 presents our evaluations and conclusions in accordance with ODOT GB-1 "Plan Subgrades" (Now ODOT GDM 600) and ODOT GB-2 "Special Benching and Sidehill Embankment Fills" (Now ODOT GDM Section 800). This report also provides design and construction recommendations for new roadway embankments, pavements, bridge foundations, and a retaining wall associated with the proposed interchange modification.

This report includes:

- A description of the type and thickness of surface cover at the boring locations.
- A description of the subsurface soil, rock, and groundwater conditions encountered in the borings.
- Design recommendations for bridge foundations, a retaining wall, and pavements.
- Recommendations concerning soil and groundwater-related construction procedures such as site preparation, earthwork (including embankment construction), foundation and pavement construction, as well as related field testing.

ODOT Design Checklists have been completed and are included in Appendix L.

The scope of this study did not include an environmental assessment of the surface or subsurface materials at this site.

## 1.2 Proposed Construction

It is our understanding that the project consists of intersection improvements for US 23 at SR 51 in Sylvania, Ohio. An approximate depiction of the planned intersection improvements is shown on the Test Boring Location Plans (Plates 2.1 through 2.3). It should be noted that the ramp alignments have been shifted slightly from what is depicted as design has progressed.

The existing four-span SR 51 bridge over US 23 will be widened to the right (south). As such, new widened embankment approaches will be required. The northbound exit ramp (Ramp A) will include new alignment to the west which will require a new three-span bridge over Ottawa

River, as well as embankment fill. The existing Ramp A bridge over Ottawa River will be razed. The northbound entrance ramp (Ramp B) will be completely re-routed to extend south of the intersection and then loop under the SR 51 overpass of US 23 immediately west of the Forward (East) Abutment. New embankment fill and a retaining wall beneath the SR 51 bridge will be required for the new Ramp B alignment. The southbound exit ramp (Ramp C) will have little change, with the exception of some embankment widening. The southbound entrance ramp (Ramp D) will be re-routed to the west which will require a new three-span bridge over Ottawa River and new embankment construction. The existing Ramp D bridge over Ottawa River is integrally connected to the southbound US 23 bridge over Ottawa River, so it will remain.

It is assumed that the embankment fill will consist of cohesive soils similar to the native soils encountered at the site. Specific embankment information, bridge foundation and loading information, and retaining wall information are provided in the recommendations Section 5 of this report.

Pavements are anticipated to consist of predominantly flexible (asphalt) sections, but rigid (concrete) sections may be used for the ramps.

## 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 within the Maumee Sand Plains District of the Maumee Lake Plains Physiographic Region of the Huron-Erie Lake Plains Section. Within this district, the geologic deposits consist of late Wisconsinan-age sand overlying clay till and lacustrine deposits, which are underlain by Silurian-age carbonate rock and shale that is generally present relatively deep in the subsurface profile (although portions of the project area contained relatively shallow bedrock).

The USDA Natural Resource Conservation Service (NRCS) Web Soil Survey indicates that upper-profile soils in the project area are mapped as predominantly Sloan loam, Ottokee-Urban land complex, Sisson loam, St. Clair silty clay loam, and Udorthents/Urban land. The Sloan loam soils consist of alluvium formed on flood plains, and are considered very poorly drained. The Ottokee soils consist of eolian (wind-blown) deposits formed on beach ridges and dunes on lake plains, and are considered moderately well drained. The Sisson soils consist of lacustrine (lake-laid) deposits formed on lake plains or on deltas on lake plains, and are considered well drained. The St. Clair silty clay loam soils consist of till formed on lake plains, end moraines, and ground moraines. The "Urban land complex" notation, "Udorthents", and "Urban land" soil types indicate that the soils may have been altered by past cutting-and-filling construction operations.

Sandy beach lacustrine deposits are typically encountered overlying lacustrine silts and clays. The cohesive lacustrine soils are generally characterized as mostly soft to medium stiff silts and clays, often with a desiccated stiffer layer within the upper portion of the profile. The lacustrine deposits generally do not exhibit significant overconsolidation, although the desiccation effects induce some apparent overconsolidation within the near-surface soils.

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 present effective vertical stress due to the remaining overlying soil strata in the profile. The till may contain cobbles and/or boulders left in the till soil matrix. Additionally, seams of granular soils may also be encountered within glacial tills.

Bedrock in the project area is broadly mapped on the "Geologic Map of Ohio" as Silurian-age Monroe limestone. Specific to the project site, the uppermost carbonate rock formation is mapped as Tymochtee dolomite. Based on available bedrock maps, the top of bedrock was mapped generally at depths of 40 feet or less below existing grades. Structure borings performed for this exploration typically encountered bedrock and many borings included rock coring. Top of bedrock was encountered at Elevs. 626± to 605±. The depths and elevations at which bedrock was encountered in specific borings during this exploration are summarized in Section 4.2.3.

Based on the ODNR mining maps, no mining is indicated in the project area. The closest mining is indicated to be bedrock mining from the surface for aggregate production, approximately 3½ miles west of the site. Based on the ODNR Ohio Karst Areas map, the site is not located in an area of probable karst.

## 2.2 Observations of the Project

TTL performed site reconnaissance on October 13, 2021 as part of the initial boring layout at the extents of the project area, and then throughout the project corridor on January 20, 2023 and February 10, 2023.

The western and eastern portions of the site include mostly commercial development. The northern portion of the site includes mostly residential development. Ottawa River traverses through the southern portion of the project site. A multi-use path with subgrade-supported portions in the east and raised/boardwalk portions in the west traverses north of Ottawa River beneath existing ramp and mainline overpass bridges over the river. Relatively short retaining walls were present north of the multi-use path as it traversed between the northern piers and the north abutments for the US 23 mainline bridges over Ottawa River. A hospital is present to the southwest and a golf course is present to the southeast. Noise walls were being installed along the eastern right-or-way, north of the interchange, at the time of our exploration.

Historic embankment fill was placed for the SR 51 approaches to the US 23 overpass bridge, as well as for ramp construction at the interchange. Existing embankment slopes throughout the site were graded at approximately 2 horizontal to 1 vertical (2H:1V) or flatter. The ramp infields to the west of mainline are generally grassy. The ramp infield east of mainline includes rolling topography with woods and drainageways. Cattails were present in the low-lying areas. The Ottawa River was flooded during portions of the spring. Evidence of slope instability was not observed. However, is rock slope protection along a portion of the Ramp C embankment. It is not apparent whether it is present due to slope instability due to grade or possibly as part of a recent apparent repair to a drainage structure in the area.

Each of the bridges appeared to have some areas of spalling concrete. Steel girders were present for the existing SR 51 bridge over US 23, whereas the bridges over the Ottawa River had concrete spans. A cylindrical vault extending above grade with a steel manhole was present just north of the multi-use path, between US 24 northbound and Ramp A.

Roadway pavements consisting of flexible (asphalt) surfaces were observed throughout the project area. The pavements appeared to be in generally good to fair condition with some areas of cracking. Some of the side streets appeared to have relatively new pavement or a relatively recent overlay. Based on the borings performed in the pavements, some areas include composite sections with asphalt overlying concrete. Other borings were performed in grass areas.

## 3.0 EXPLORATION

### 3.1 Historic Borings

Review of ODOT records for the project area indicated many historic test borings had been performed. Moisture content and soil type were generally available in the historic boring logs and Soil Profile drawings. It should be noted that Standard Penetration Test (SPT) blow counts or N-values were not provided for the majority of the historic borings. Additionally, detailed rock core data was not typically available. As such, they were not included in the analyses and reporting for this project.

Borings that did include classification, moisture content, SPT results, and hand penetrometer results were reviewed for a project performed along the north side of SR 51, between Harroun Road and the US 23 interchange. The project was designated LUC-CR4-9.77, PID 109598. Two test borings, identified as B-003-0-19 and B-005-0-19, were performed for this exploration. The boring location plan and logs of test borings for this project are attached in Appendix K.

The borings encountered predominantly medium stiff to very stiff cohesive soils consisting of A-4a, A-6a, and A-6b soils. Boring B-005-0-19 encountered granular fill (A-3a with crushed stone) in the upper approximately 3 feet. Boring B-003-0-19 encountered augerable weathered bedrock at Elev. 629 (15½ feet below grade), extending to termination at a depth of approximately 19 feet.

### 3.2 Project Exploration Program

Forty one (41) test borings were drilled for this exploration by TTL during the period from November 1, 2021 through April 19, 2023. The borings are numerated B-001-0-21 through B-043-0-21, but some boring numbers are skipped and others include an offset designation due to changes in alignments and scope during the exploration. The borings have been designated in general accordance with ODOT protocol, but the “-21” portion of the nomenclature is generally omitted in the discussions within this report.

Upon initial authorization in 2021, prior to final decisions regarding alignment for the ramps, select borings were authorized for performance during November 2021, since they were at the extents of the project area where changes in ramp alignment would not affect the need or location for these borings. Those borings included:

- Roadway borings designated as B-001-0 and B-015-0 (SR 51), B-002-0 (Harroun Road), B-016-0 (Glasgow Road), B-032-0 and B-033-0 (SR 184) and B-034-0 (Acres Road). The roadway borings included a core of the existing pavement.
- Bridge Borings B-006-0 and B-006-1 at the SR 51 rear abutment as well as B-010-0 at the SR 51 forward abutment.

After Modification 1 was authorized in December 2022, drilling operations commenced again in January 2023 for borings along SR 51, outside of ODOT right-of-way pending receipt of an ODOT Permit. Once the ODOT permit was received February 9, 2023, field boring operations commenced again within ODOT right-of-way. The remaining boring scope included:

- Roadway borings along SR 51: B-003-0, B-004-0 (deeper for sign pole), B-011-0, B-012-0, and B-013-0 (deeper for sign pole).
- Roadway boring along SR 184: B-031 (deeper for sign pole).
- Roadway/embankment borings along Ramp A: B-026-0/B-026-1 (deeper for sign pole), B-027-0, B-029-1 (deeper for sign pole), and B-030-0.
- Roadway/embankment/retaining wall borings for Ramp B: B-14-0/B-014-1, B-039-0/B-039-1, B-040-0, B-041-0, and B-043-0.
- Roadway/embankment borings for Ramp C and Ramp D: B-017-0 (deeper for sign pole), B-021-0, and B-024-0.
- SR 51 intermediate pier bridge Boring B-008-0.
- Ramp A over Ottawa River bridge Borings B-028-0, B-028-1, B-028-2 (through bridge deck), and B-029-0.
- Ramp D over Ottawa River bridge Borings B-022-0, B-022-1, B-022-2/B-022-3, and B-023-0.

The locations of the borings were established in the field by TTL by pacing and taping methods from existing site features, as well as by using the Google Earth mobile application. Coordinates and ground surface elevations were obtained by TTL using a handheld GPS unit. These data are presented on the logs of test borings. Station and offset was not available at the time of preparing this proposal. As such, the borings are left as "DRAFT" pending inclusion of this information. The existing and (approximate) proposed roadway and ramp alignments, as well as approximate locations of the borings are presented on the Test Boring Location Plans (Plates 2.1, 2.2, and 2.3).

Pavement cores were obtained at selected boring locations using a nominal 4-inch diameter single-wall, diamond-tipped core barrel. Pavement core photographic logs are provided in

Appendix H. The test borings were completed in accordance with geotechnical investigative procedures outlined in ODOT "Specifications for Geotechnical Explorations" (SGE). Due to relatively shallow bedrock at the site, many of the structure borings included rock coring as described in the following section.

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 and rock 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 CME 550 ATV-mounted drilling rig, a Diedrich D70 track-mounted drill rig, a CME 75 truck-mounted drilling rig, as well as a track-mounted GeoProbe® 7822DT with drilling capabilities. The borings were extended utilizing 3¼-inch and 4¼-inch inside diameter hollow-stem augers, as well as 3½-inch diameter solid-stem augers. During auger advancement in the ODOT Type A borings, split-spoon drive samples were taken continuously utilizing an 18-inch sample drive. In the ODOT Type B, Type B1, and Type E1 borings, split-spoon drive samples were generally taken at 2½-foot intervals in the upper soil profile, and at 5-foot intervals thereafter.

Split-spoon (SS) soil samples were obtained by the Standard Penetration Test Method (ASTM D 1586), and were sealed in jars and transported to our laboratory for further classification and testing. 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. The number of blows per increment was recorded at each depth interval, 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 calibrated hammer/rod energy ratio for the various drill rigs utilized for this exploration is summarized in the following table. The $N_{60}$-values are presented on the attached Logs of Test Borings.

| Table 3.3 Drill Rig Calibrated Hammer/Rod Ratio Information | | |
|---|---|---|
| **Drill Rig** | **Energy Ratio** | **Calibration Date** |
| CME 75 Truck 844 (2021 Borings) | 66.0 | 3/15/2021 |
| CME 75 Truck 844 (2023 Borings) | 72.9 | 2/20/2023 |
| CME 550 ATV-Mounted Rig | 75.2 | 2/20/2023 |
| Diedrich D70 Track-Mounted Rig | 90.0 | 4/13/2022 |
| GeoProbe® 7822DT Track-Mounted Rig | Limited to 90 | 3/16/2022 |

Shelby tube samples, designated ST on the Logs of Test Borings, were obtained at varying depths from selected embankment and retaining wall borings as shown on the attached Logs of Test Borings. The Shelby tube samples were obtained 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.

Upon encountering auger refusal in structure borings, rock coring was performed in general accordance with ASTM D 2113 using a diamond-bit core barrel. Cores were generally obtained in 5-foot rock core runs. Recovery of the core is expressed as the percentage ratio of the recovered rock length to the total length of the core run. The Rock Quality Designation (RQD) is the percentage ratio of the summed length of rock pieces 4 inches in length and greater to the total length of the run. The rock core samples are shown on the Logs of Test Borings. Photographic logs of the rock cores are provided in Appendix I.

Soil and bedrock conditions encountered in the test borings are presented in the Logs of Test Borings along with information related to sample data, SPT results, water conditions observed in the borings, and laboratory test data. 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.

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 and bedrock.

## 3.4 Laboratory Testing Program

All soil samples were visually or manually classified in accordance with the ODOT Soil Classification System. Atterberg limits tests (ASTM D 4318) and particle size analyses (ASTM D 422) were performed on selected samples to determine soil classification and index properties. All samples of the subsoils were also tested in our laboratory for moisture content (ASTM D 2216). Dry density determinations and unconfined compressive strength tests by the constant rate of strain method (ASTM D 2166) were performed on selected intact cohesive 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. Additionally, graphical depictions of the grain size distributions are included in Appendix G.

Sulfate content determinations (ODOT Supplement 1122) were performed on one sample from each roadway boring, within 3 feet of the proposed subgrade. These test results are presented on the Logs of Test Borings.

Organic content determinations by the loss-on-ignition (LOI) method (ASTM D 2974) were performed on selected samples. These test results are presented on the Logs of Test Borings attached to this report.

Additionally, a one-point unconsolidated-undrained (UU) triaxial compressive strength test (ASTM D 2850) was performed on a sample from Boring B-039-1 (ST-1). The UU test was performed on a specimen tested at confining pressure approximately equal to the existing overburden pressure at the sample depth. The results of this test are attached to this report in Appendix G.

A consolidated-undrained (CU') triaxial compressive strength test with pore water pressure measurements (ASTM D 4767) was performed on a sample from Boring B-014-1 (ST-2). The CU' test was performed on specimens tested at confining pressures approximately equal to the existing overburden pressure at the sample depth, as well as half and double this pressure. The results of this test are attached to this report in Appendix G.

One-dimensional consolidation tests (ASTM D 2435) were performed on samples from Borings B-028-0 (ST-3) and B-039-1 (ST-1). The results of these tests are presented in Appendix G.

Unconfined compressive strength tests for rock specimens (ASTM D 7012, Method C) were performed, and the results are presented on the Logs of Test Borings. Additionally, the results are presented in Appendix J.

For scour consideration of foundations bearing on or in rock, for the Ramp A and Ramp D bridges over Ottawa River, slake durability tests (ASTM D 4644) were performed on selected rock specimens. Results of these tests are presented on the Logs of Test Borings.

# 4.0 FINDINGS

## 4.1 General Site Conditions

The site is located at the US 23 interchange with SR 53 in Sylvania, Lucas County, Ohio. Observations of the site conditions were provided in Section 2.2.

Boring were performed in roadway areas and grass areas beyond the roadways. The encountered surface materials and subgrade soils in the following table.

**Table 4.1. Encountered Surface Materials and Subgrade Soils**

| Boring Number | Location | Surface Cover Thickness (in) | | | | Subgrade Soil |
|---|---|---|---|---|---|---|
| | | Asphalt | Concrete | Aggregate | Topsoil | |
| B-001-0 | Monroe St (SR51) | 3.75 | 9.75 | 5.5 | - | A-4a |
| B-002-0 | Harroun Rd | 7.75 | - | 8.25 | - | A-4a |
| B-003-0 | Monroe St (SR51) | 6 | 10 | - | - | A-3 |
| B-004-0 | Monroe St (SR51) | 6.5 | 9.5 | - | - | A-3a |
| B-006-0 | Monroe St (SR51) | 2 | 13.5 | 5.5 | - | A-4a |
| B-006-1 | See B-006-0 | | | | | |
| B-008-0 | US23 | - | - | - | 5 | A-4a |
| B-010-0 | Monroe St (SR51) | 2.5 | 9 | 9 | - | A-4a |
| B-011-0 | Monroe St (SR51) | 6 | - | 11 | - | A-4a |
| B-012-0 | Monroe St (SR51) | 6 | - | 11 | - | A-4a |
| B-013-0 | Monroe St (SR51) | 3 | - | - | - | A-4a |
| B-014-0 | New Ramp B | - | - | - | 5 | A-4b |
| B-014-1 | See B-014-0 | | | | | |
| B-015-0 | Monroe St (SR51) | 3.5 | 9 | 5.5 | - | A-4a |
| B-016-0 | Glasgow Rd | 4.5 | - | - | - | A-6a |
| B-017-0 | New/Existing Ramps C/D | 8 | - | 17(1) | - | A-4a |
| B-021-0 | New Ramp D | - | - | - | 5 | A-4a |
| B-022-0 | New Ramp D Bridge over Ottawa River | - | - | - | 8 | A-6a |
| B-022-1 | | - | - | - | 3 | A-4a |
| B-022-2 | | - | - | 18 | - | A-4a |
| B-022-3 | | See B-022-2 | | | | |
| B-023-0 | | - | - | 6(2) | - | A-2-4 |
| B-024-0 | New/Existing Ramp D @ US23 | 11 | - | 8 | - | A-3 |
| B-026-0 | New Ramp A | - | - | - | 10 | A-4a |
| B-026-1 | See B-026-0 | | | | | |
| B-027-0 | New Ramp A | - | - | - | 10 | A-6b |
| B-028-0 | New Ramp A Bridge over Ottawa River | - | - | - | 2 | A-3a |
| B-028-1 | | - | - | - | 3 | A-4b |
| B-028-2 | | - | 22(3) | - | - | N/A(3) |
| B-029-0 | | - | - | - | 5 | A-3a |
| B-029-1 | New/Existing Ramp A @ US23 | 16 | - | 5 | - | A-3 |
| B-030-0 | New/Existing Ramp A @ US23 | 10 | - | 8 | - | A-3a |

| Table 4.1. Encountered Surface Materials and Subgrade Soils | | | | | | |
|---|---|---|---|---|---|---|
| **Boring Number** | **Location** | **Surface Cover Thickness (in)** | | | | **Subgrade Soil** |
| | | **Asphalt** | **Concrete** | **Aggregate** | **Topsoil** | |
| B-031-0 | New Alexis Rd (SR184)/ Monroe St (SR51) Intersection | - | - | - | 10 | A-4a |
| B-032-0 | Acres Rd @ Alexis Rd (SR184) | 10.75 | - | 9.25 | - | A-4b |
| B-033-0 | Alexis Rd (SR184) | 2.5 | 9 | - | - | A-4a |
| B-034-0 | Acres Rd | 9.5 | - | 6.5 | - | A-4a |
| B-039-0 | US23 | 5.5 | - | 11.5 | - | A-3 |
| B-039-1 | See B-039-0 | | | | | |
| B-040-0 | US23 | 8 | - | 9 | - | A-3a |
| B-041-0 | US23 | 10 | - | 7 | - | A-3a |
| B-043-0 | Existing Ramp B | 9 | - | 7 | - | A-3a |

(1)This layer consists of 7 inches of aggregate underlain by 2 inches of sand underlain by 8 inches of aggregate.
(2)Aggregate underlain by 8 inches of mulch.
(3)Boring extended through bridge deck.

Photographic logs of the pavement cores obtained at selected boring locations are provided in Appendix H.

## 4.2 General Soil and Bedrock Conditions

### 4.2.1 Existing Fill and Embankment Fill

Based on the borings performed for this exploration, random or rubble fill materials were not encountered. However, we reviewed historic plans with respect to grading for the existing interchange to help identify "embankment fill" that was placed to achieve design grades for the existing development. It was often difficult to differentiate embankment fill from the original native soils, possibly since nearby borrow sources of similar materials may have been used for the embankment fill. In some cases, trace organics (typically root hairs) were noted in samples near the expected original grade elevation. This may be an indication of the bottom of historic topsoil stripping which left trace organics that would not be detrimental to embankment or subgrade support.

There were other areas where embankment fill was not anticipated from historic grading research, but there were soils with presence of non-soil materials (typically crushed stone or trace organics), or that exhibited an unusual texture, for which a fill designation was provided on the boring logs. These may be areas of backfill associated with subgrade modification in roadways, backfill for utility installations, or other previous construction activities.

The encountered fill materials consisted of both cohesive soils and granular soils. The depths and elevations at which embankment fill was encountered in the borings is summarized in the following table.

**Table 4.2.1. Encountered Fill Materials**

| Boring Number | Location | Bottom of Embankment Fill | | Soil Type(s) |
|---|---|---|---|---|
| | | Depth (ft) | Elevation | |
| B-003-0 | Monroe St (SR51) | 4 | 637.7 | A-3(1) |
| B-004-0 | Monroe St (SR51) | 4.5 | 639.1 | A-3a(1) |
| B-006-0 | Monroe St (SR51) | 8 | 644 | A-4a |
| B-010-0 | Monroe St (SR51) | 11 | 640 | A-4a, A-3a |
| B-011-0 | Monroe St (SR51) | 5.5 | 642.6 | A-4a |
| B-012-0 | Monroe St (SR51) | 5 | 640.4 | A-4a |
| B-016-0 | Glasgow Rd | 2.3 | 643.6 | A-6a(1) |
| B-017-0 | New/Existing Ramps C/D | 4.5 | 633.5 | A-4a |
| B-023-0 | New Ramp D Bridge over Ottawa River | 3.5 | 620.7 | A-2-4 |
| B-024-0 | New/Existing Ramp D @ US23 | To Termination at 7.5 ft | 621.8 or deeper | A-3, A-3a, A-4a |
| B-028-0 | New Ramp A Bridge over Ottawa River | 6 | 614.3 | A-3a, A-4a |
| B-029-0 | | 9 | 611.5 | A-3a, A-4a |
| B-029-1 | New/Existing Ramp A @ US23 | 14 | 616.7 | A-3a |
| B-030-0 | New/Existing Ramp A @ US23 | To Termination at 7.5 ft | 625.8 or deeper | A-3a, A-4a |
| B-031-0 | New Alexis Rd (SR184)/ Monroe St (SR51) Intersection | 4.5 | 642 | A-4a |
| B-032-0 | Acres Rd @ Alexis Rd (SR184) | To Termination at 8.5 ft | 636.8 or deeper | A-4b(1), A-2-6(1), A-4a(1) |

(1)Possible backfill

The embankment soils are considered generally conducive for the proposed development. Due to the presence of granular soils in the existing embankments, flatter layback will be required as part of special benching operations as discussed in Section 5.1.1.

### 4.2.2 Native Soils

The native soils encountered underlying the surface materials and existing fill materials consisted of predominantly cohesive soils (approximately ¾ of the recovered soil samples) with interbedded zones of granular soils.

The cohesive soils consisted of predominantly A-4a soils, but A-6a, A-6b, and a few A-4b soil zones were also present. The cohesive soils generally exhibited medium stiff to very stiff consistency.

The granular soil zones typically included A-3a soils, but A-3, A-2 series, and A-1 series soils were also encountered. The granular soil zones generally exhibited loose to medium dense compactness.

Soil properties associated with the cohesive and granular soils were evaluated for particular subgrade support and foundation support applications and results of these evaluations are provided in Appendices A through F, with soil lab test results also provided on the logs of test borings and in Appendix G.

### 4.2.3 Bedrock

Relatively shallow bedrock is present at the site. As such, structure borings typically encountered bedrock and many borings included rock coring. Top of bedrock was encountered at Elevs. 626± to 605±. The following table includes a summary of the depths and elevations at which weathered (augerable) bedrock and more intact bedrock (based on auger refusal) were encountered in the borings.

**Table 4.2.3. Encountered Bedrock Conditions**

| Boring Number | GSE | Top of Weathered Rock | | Top of Cored Rock / Auger Refusal | |
|---|---|---|---|---|---|
| | | Depth (ft) | Elev. | Depth (ft) | Elev. |
| B-004-0 | 643.6 | 17.5 | 626.1 | 18.8 | 624.8 |
| B-006-1 | 652.0 | 29.0 | 623.0 | 38.0 | 614.0 |
| B-008-0 | 630.8 | 13.5 | 617.3 | 14.0 | 616.8 |
| B-010-0 | 651.0 | N.E. | N.E. | 35.4 | 615.6 |
| B-021-0 | 615.9 | 6.0 | 609.9 | 6.4 | 609.5 |
| B-022-0 | 615.1 | N.E. | N.E. | 8.0 | 607.1 |
| B-022-1 | 616.1 | 7.0 | 609.1 | 8.6 | 607.5 |
| B-022-2 | 616.1 | 6.0 | 610.1 | 6.7 | 609.4 |
| B-022-3 | 616.0 | 6.0 | 610.0 | 9.3 | 606.7 |
| B-023-0 | 624.2 | 16.0 | 608.2 | 16.5 | 607.7 |
| B-026-0 | 622.7 | N.E. | N.E. | 8.3 | 614.4 |
| B-026-1 | 623.1 | N.E. | N.E. | 11.0 | 612.1 |
| B-027-0 | 622.9 | N.E. | N.E. | 2.7 | 620.2 |
| B-028-0 | 620.3 | 11.0 | 609.3 | 13.0 | 607.3 |
| B-028-1 | 616.6 | 11.0 | 605.6 | 11.1 | 605.5 |

| Table 4.2.3. Encountered Bedrock Conditions | | | | | |
|---|---|---|---|---|---|
| Boring Number | GSE | Top of Weathered Rock | | Top of Cored Rock / Auger Refusal | |
| | | Depth (ft) | Elev. | Depth (ft) | Elev. |
| B-028-2 | 609.0 | 0.9 | 608.1 | 1.5 | 607.5 |
| B-029-0 | 620.5 | 11.5 | 609.0 | 16.0 | 604.5 |
| B-029-1 | 630.7 | 20.3 | 610.4 | 22.5 | 608.2 |
| B-039-0 | 636.2 | N.E. | N.E. | 15.0 | 621.2 |
| B-043-0 | 647.6 | N.E. | N.E. | 27.7 | 619.9 |
| N.E. = Not Encountered. | | | | | |

Detailed descriptions as well as laboratory test results for the rock are provided on the logs of test borings, as well in Appendix J. Additionally, rock core photographs are provided in Appendix I.

## 4.3 Groundwater Conditions

For the borings that encountered groundwater, the groundwater conditions encountered in the borings are summarized in the following table.

| Table 4.3. Encountered Groundwater Conditions | | | | | | |
|---|---|---|---|---|---|---|
| Boring Number | GSE | Groundwater Initially Encountered During Drilling | | Groundwater Observed at Completion of Boring | | Notes |
| | | Depth (ft) | Elev. | Depth (ft) | Elev. | |
| B-004-0 | 643.6 | 10.4 | 633.2 | N.E. | N.E. | |
| B-006-1 | 652.0 | 38 | 614.0 | 12.7 | 639.3 | (1) |
| B-008-0 | 630.8 | 14 | 616.8 | 3.8 | 627.0 | (1) |
| B-010-0 | 651.0 | 16 | 635.0 | 17.4 | 633.6 | (1) |
| B-015-0 | 648.2 | 2.8 | 645.4 | | 648.2 | |
| B-016-0 | 645.9 | 5 | 640.9 | | 645.9 | |
| B-017-0 | 638.0 | 21 | 617.0 | 23.4 | 614.6 | |
| B-021-0 | 615.9 | 3.4 | 612.5 | 2.8 | 613.1 | |
| B-022-0 | 615.1 | 3.5 | 611.6 | 3.4 | 611.7 | (1) |
| B-022-1 | 616.1 | 4.5 | 611.6 | 3.8 | 612.3 | (1) |
| B-022-2 | 616.1 | 3.3 | 612.8 | N.E. | N.E. | |
| B-022-3 | 616.0 | 8 | 608.0 | 5.2 | 610.8 | (1) |
| B-023-0 | 624.2 | 11 | 613.2 | 10.3 | 613.9 | (1) |
| B-026-1 | 623.1 | N.E. | N.E. | 9.7 | 613.4 | (1) |
| B-028-0 | 620.3 | 6 | 614.3 | 8.8 | 611.5 | (1) |
| B-028-1 | 616.6 | 8 | 608.6 | 5.2 | 611.4 | (1) |
| B-028-2 | 609.0 | 0 | 609.0 | 0 | 609.0 | (2) |

| Table 4.3. Encountered Groundwater Conditions | | | | | | |
|---|---|---|---|---|---|---|
| Boring Number | GSE | Groundwater Initially Encountered During Drilling | | Groundwater Observed at Completion of Boring | | Notes |
| | | Depth (ft) | Elev. | Depth (ft) | Elev. | |
| B-029-1 | 630.7 | 20.3 | 610.4 | 14.5 | 616.2 | (1) |
| B-031-0 | 646.5 | 12 | 634.5 | N.E. | N.E. | |
| B-032-0 | 645.3 | 4.2 | 641.1 | N.E. | N.E. | |
| B-033-0 | 646.4 | 3 | 643.4 | N.E. | N.E. | |
| B-034-0 | 649.0 | 7 | 642.0 | N.E. | N.E. | |
| B-039-0 | 636.2 | 15 | 621.2 | 17.4 | 618.8 | (1) |
| B-041-0 | 646.8 | 4.7 | 642.1 | 6.5 | 640.3 | |
| B-043-0 | 647.6 | 20.6 | 627.0 | 11.3 | 636.3 | (1) |
| N.E. = Not Encountered. | | | | | | |
| (1): Water level after coring completed. Water was used for coring so presence of water indicates water return, **not groundwater level**. | | | | | | |
| (2): Boring extended through bridge deck into Ottawa River then to mudline. Ottawa River Level Elev. 611.5. | | | | | | |

It should be noted that the boreholes were generally drilled and backfilled/sealed within the same day, and stabilized water levels may not have occurred over this limited time period.

Based on the limited data available, such as the soil characteristics and the groundwater conditions encountered in the borings, it is our opinion that the "normal" groundwater level may be encountered at elevations on the order of Elev. 623 in the vicinity of the SR51 bridge over US 23, and on the order of Elev. 612 in the proximity of Ottawa River. However, this investigation did not include research of possible hydrological influences at the project site. It should be noted that groundwater elevations can fluctuate with seasonal and climatic influences. In particular, groundwater levels may be affected by the water levels in the ditches within the project area, as well as in Ottawa River. Additionally, perched water may be encountered in granular soils that are underlain by relatively impermeable cohesive soils. Therefore, the groundwater conditions may vary at different times of the year from those encountered during this exploration.

## 4.4 Remedial Measures

New Embankment Fill

This project includes new embankment fill to be placed on slopes generally graded at 2 horizontal to 1 vertical (2H:1V). As such, it is anticipated that some of the embankment fill placement would fall under the specifications of ODOT Geotechnical Bulletin GB-2, "Special

Benching and Sidehill Embankment Fills," (now ODOT GDM Section 800). Isolated areas will include fill placement along slopes that are steeper than 4H:1V, and may include sliver fills with design fill widths based on "neat" lines and plateaus of less than 8 feet. Where sidehill fills are planned on the face of an existing slope which is steeper than 4H:1V, ODOT Office of Geotechnical Engineering (OGE) recommends special benching to assure that the new fill section and existing embankment are "knitted" together. Additional discussion regarding special benching is provided in Section 5.1.1.

Regardless of overall global slope stability, slopes graded steeper than 3H:1V may be prone to shallow surface sloughing. This type of shallow sliding is generally <u>not</u> problematic (by itself), but left unchecked, it can lead to progressive slope movements that eventually impact overall performance of the embankment. In addition to slope protection, such as well-established vegetative cover and rock-lined channels in surface run-off collection ditches and swales, we recommend that surface drainage from pavement areas on the crest of the embankment should be directed to catch basins or storm drains and not allowed to sheet flow over the slope. Global stability evaluations for the new embankments were beyond the scope of this exploration. However, additional general discussion regarding stability of the proposed embankment slopes is provided in Section 5.1.2.

The calculated settlements on the order of 1 to 3 inches for the maximum fill heights of approximately 7 to 19 feet indicated for this project are not anticipated to be problematic. Some of the embankment settlement will occur during placement of the fill. For a typical limit of 1 inch or less of post-construction foundation/embankment settlement, the settlement period is anticipated to be on the order of 1 to 2 weeks after completion of fill placement. Additional discussion regarding embankment settlement is provided in Section 5.1.3.

<u>SR 51 Bridge Foundations</u>

The SR 51 bridge widening abutments will bear on piles driven to bedrock. Additionally, the SR 51 bridge widening piers will bear on spread foundations bearing on bedrock. As such, remedial measures related to soft embankment foundation soils, stability problems, and settlement are not anticipated. Augerable weathered bedrock is anticipated at the bearing elevation for the west pier (Pier 1), for which a lower factored bearing resistance is recommended compared to the other two piers bearing on bedrock beyond the depth of auger refusal in the borings. In any case, the factored bearing resistance is anticipated to be suitable for support of the Pier 1. Additional discussion regarding the SR 51 bridge abutments and piers is provided in Sections 5.2.1 and 5.2.2, respectively.

Ramp A and Ramp B over Ottawa River Bridge Foundations

Consideration was given to spread foundations bearing on bedrock for the Ramp A and Ramp D bridges over Ottawa River. However, Based on our evaluations, none of the samples of the upper potential bearing rock met all of the criterion required to be considered scour-resistant rock in accordance with ODOT Bridge Design Manual (BDM) Section 305.2.1.2.b. The RQD values, RMR values, and GSI values were lower than the minimum requirements. These structures are now planned to be supported by drilled shafts socketed into bedrock.

The sockets are typically planned to extend 10 feet below the scour elevation. However, for the Ramp D Pier 1 location, the end-bearing elevation associated with the extension of the shaft/socket 10 feet below the scour elevation was just above a highly fractured zone with open fractures at Elev. 592.7. At this elevation, the driller noted loss of water during coring. Due to suspect end-bearing of this material, we recommend the shaft/socket extend 1-foot deeper, to an elevation where the driller noted 50% water return and we encountered more intact rock at Elev. 591.7.

Consideration was given to downdrag at the Ramp A and Ramp D bridge abutment locations due to the embankment fill that will be placed. No downdrag load needs to be incorporated into design for the Ramp A forward abutment or the Ramp D rear abutment. However, recommendations are provided in Section 5.2.3 for downdrag for the other two abutment substructures for these two ramp bridges over Ottawa River.

In addition to the downdrag loads on the drilled shaft foundations, the embankment fill placed behind the abutment walls and drilled shaft caps will experience settlement that could cause downdrag loads on the walls. We recommend coating these portions of the abutment substructures that are above existing grade with low viscosity bituminous asphalt and then covering or wrapping those components with a durable thick plastic visqueen to avoid additional downdrag loads on these exposed elements. Otherwise, alternative methods to avoid downdrag on the walls and footings could be considered.

Roadway Subgrades

Where embankments are constructed for the project, the new embankment fill is anticipated to be suitable for pavement subgrade support. For portions of the project where pavement subgrade borings were performed for new roadway and ramp alignment that will approximate existing roadway alignment without significant grade change, an evaluation of the subgrade soils was completed in general accordance with ODOT Geotechnical Bulletin GB-1 “Plan Subgrades” (Now ODOT GDM Section 600).

Based on GB-1 criteria, subgrade soils with moisture contents greater than 3 percent above optimum likely indicate the presence of unstable subgrade that may require some form of subgrade modification. Approximately half of the evaluated samples exhibited moisture contents greater than 3 percent above the optimum as determined using GB-1 criteria. It should be noted that approximately 80 percent of the samples with moisture contents greater than 3 percent above optimum had moisture contents greater than or equal to 5 percent above optimum. Thus, where moisture contents were wet of optimum, they were appreciably wet of optimum. These data indicate that scarification and aeration methods may not be feasible to achieve satisfactory proof rolling and stabilization of the predominantly cohesive subgrades. However, scarification and aeration methods may be utilized in areas where granular subgrades wet of optimum are present, provided weather conditions and construction schedule will allow such soil modification.

Based on the GB-1 analysis results, subgrade modification may consider global chemical stabilization using cement to a depth of 12 inches, or over-excavation and replacement with new granular engineered fill. With more than 30 percent of the project indicating likely need for modification, ODOT GB-1 indicates that global chemical stabilization will likely be the more economical method of modification. However, consideration should be given to construction phases that may require multiple mobilizations of the chemical stabilization equipment that may negatively affect the economical nature of this method of subgrade modification.

<u>Construction Dewatering and Groundwater Control</u>

Groundwater seepage, perched water, and surface water runoff into shallow excavations in predominantly cohesive soils should be controllable by pumping from prepared sumps. If excavations extend below the groundwater level in granular soils, installation of multiple well points may be required in addition to pumping from prepared sumps. Installation of the intermediate piers in Ottawa River may require temporary cofferdams to divert streamflow to manage groundwater in addition to pumping from prepared sumps. Otherwise, steel casing may also be used to help facilitate groundwater control. In any case, as mentioned in Section 5.2.3, it is likely that temporary steel casing will be required to support the walls of the drilled shafts, in addition to facilitating control groundwater seepage.

## 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 TTL.

### 5.1 New Embankment Fill

Fill will be placed for widening to the south of SR 51 for the widened bridge overpass of US 23, as well as for re-alignment of Ramps A, B, C, and D for the interchange. Maximum fill heights are generally estimated to be on the order of 7 to 13 feet. However, maximum fill of approximately 18 to 20 feet is planned for the re-alignment of Ramp D. We have assumed that the new fill will consist of cohesive soils from a nearby borrow source.

#### 5.1.1 Special Benching and Sidehill Embankment Fills

Where fill will be placed along slopes that are flatter than 4 horizontal to 1 vertical (4H:1V) but steeper than 8H:1V, ODOT Construction and Materials Specifications (CMS) Item 203.05, which describes "standard specification" benching, should be followed. This project includes new embankment fill to be placed on slopes generally at 2 horizontal to 1 vertical (2H:1V). As such, it is anticipated that some of the embankment fill placement would fall under the specifications of ODOT Geotechnical Bulletin GB-2, "Special Benching and Sidehill Embankment Fills" (now ODOT GDM Section 800).

Special benching is to be used whenever there will be a stability problem with new fill and/or there are weak soils in an existing slope. Special benching is utilized to improve stability in a sidehill fill placed on an existing slope, or to remediate an unstable existing slope. Based on our site reconnaissance, the existing slopes in the project area appear to be performing satisfactorily, and are not in need of remediation due to instability.

Based on the project cross-section drawings, the areas of widening and/or new ramp alignment will generally include fill in areas with relatively flat grades, fill in areas of previous cut such that the fill will be "buttressed" between existing slopes, or fill along slopes which include more than 8 feet of plateau at the toe of the new fill. For these areas, only "standard specification" benching would be required.

However, there are some areas that will include fill placement along slopes that are steeper than 4H:1V, and may include sliver fills with design fill widths based on “neat” lines and plateaus of less than 8 feet. Where sidehill fills are planned on the face of an existing slope which is steeper than 4H:1V, ODOT Office of Geotechnical Engineering (OGE) recommends special benching to assure that the new fill section and existing embankment are “knitted” together. Fill placement along slopes steeper than 4H:1V are anticipated to require special benching in the following areas:

- US 23 in the vicinity of Stations 931+00 to 932+00,
- US 23 in the vicinity of Stations 933+00 to 936+00,
- US 23 in the vicinity of Stations 938+00 to 939+50,
- Ramp B in the vicinity of Station 27+00,
- Ramp C-D in the vicinity of Station 14+00,
- Ramp C-D in the vicinity of Stations 15+89 to 16+60, and
- Ramp D in the vicinity of Stations 26+50 to 29+50.

Examples of special benching for these sections are included in Appendix A, “Embankment Evaluations.”

In general, one bench is prescribed for fill height of 10 feet or less. Where there is more than 10 feet of embankment fill requiring special benching, two to three benches are prescribed for the existing slopes. Although not anticipated to be prevalent, if there are locations where benches intercept existing roadways, special measures for maintenance of traffic (MOT) will be required.

The soils in the project area where benching will be performed consist of predominantly interbedded granular and cohesive soils. Where granular soils are present, GB-2 indicates that a 1.75H:1V backslope (assuming an effective friction angle of approximately 30 degrees) should be planned. As such, much of the project has been designated for use of 1.75H:1V backslope. Portions of Ramp C sliver fills are located where cohesive soils are anticipated (based on Boring B-017-0), for which GB-2 indicates a 1H:1V backslope may be planned. Based on the conditions encountered in the boring B-017-0, a 1H:1V backslope should be generally achievable for short-term excavations in this area.

### 5.1.2 Global Stability

Global stability evaluations for the new embankments were beyond the scope of this exploration. New embankment slopes are generally planned at 2 horizontal to 1 vertical (2H:1V) or flatter, which are generally the same as the existing embankment slopes. Based on our site reconnaissance, the existing slopes in the project area appear to be performing satisfactorily, and are not in need of remediation due to instability.

Regardless of overall global slope stability, slopes graded steeper than 3H:1V may be prone to shallow surface sloughing. This type of shallow sliding is generally not problematic (by itself), but left unchecked, it can lead to progressive slope movements that eventually impact overall performance of the embankment.

In addition to slope protection, such as well-established vegetative cover and rock-lined channels in surface run-off collection ditches and swales, we recommend that surface drainage from pavement areas on the crest of the embankment should be directed to catch basins or storm drains and not allowed to sheet flow over the slope.

### 5.1.3 Settlement

For each of the encountered soil strata, soil compressibility parameters were evaluated for use in embankment settlement calculations. The compressibility parameters of the cohesive soils were evaluated using one-dimensional consolidation test results, as well as correlations with moisture contents and Atterberg limits test results. Results of the one-dimensional consolidation tests are provided in Appendix D. Granular soil compressibility parameters were evaluated based on SPT $N_{60}$-values and overburden pressure at the sample depth.

Based on the provided cross-section drawings for the project, settlement was evaluated based on maximum embankment fill heights and widths, along with corresponding thickest overburden soils overlying bedrock. Total embankment settlement calculations include consolidation of the foundation soils as well as settlement of the embankment fill under its own weight. Calculated total settlement at the analyzed sections, and the corresponding maximum fill heights, are summarized in the following table.

| Table 5.1.3. Embankment Settlement | | | | |
|---|---|---|---|---|
| Boring Number | Relative Location | Approximate Station | Estimated Fill Height (feet) | Calculated Total Embankment Settlement (inches) |
| B-010-0 | SR 51 Forward Abutment | SR 51 Sta 183+00 | 7 | 1 to 1¼ |
| B-028-0 & B-028-1 | Ramp A Rear Abutment | Ramp A Sta 31+45 | 13 | 1½ to 1¾ |
| B-029-0 | Ramp A Forward Abutment | Ramp A Sta 32+75 | 10 | 1 to 1¼ |
| B-022-1 | Ramp D Rear Abutment | Ramp D Sta 22+97 | 18(1) | 2 to 2¼(2) |
| B-023-0 | Ramp D Forward Abutment | Ramp D Sta 24+87 | 19 | 2¼ to 2¾(2) |

(1)Approximately 20 feet of fill at Sta 21+50, but less overburden soils overlying bedrock than at Sta. 22+97.
(2)Approximately half of settlement is associated with self-weight settlement of embankment soils. Depending on schedule, post-construction settlement may be less.

The calculated settlements for the fill heights indicated above are not anticipated to be problematic for the proposed project. It should be noted that settlement of the embankment soils under their own weight was on the order of ¼ to ½ of the total calculated settlement indicated in the above table. Some of this embankment settlement will occur during placement of the fill. Additionally, field observations of actual settlement generally tend to be less in magnitude than the theoretical calculated settlement.

Based on consolidation test results and correlations with soil index properties, as well as the indicated fill heights and range of compressible cohesive soil layer thicknesses, the time required to achieve 90 percent consolidation was calculated to be generally on the order of 1 to 2weeks. It should be noted for the embankment heights and settlement magnitudes indicated above, after 90 percent consolidation, the remaining foundation/embankment settlement would be less than ½ inch for even the higher embankment fills. For portions of the project where waiting periods are being considered, settlement platforms can be installed to evaluate the magnitude and rate of settlement to facilitate decisions regarding completion of the waiting period.

## 5.2 Bridge Foundations

This project includes foundation evaluations and recommendations for three bridges, as described in the following sections. The first two sections include recommendations for widening of the SR 51 bridge over US 23 to the right (south). The widened substructures of the four-span structure will include abutments supported by driven piles end-bearing on bedrock (Section 5.2.1) and three piers supported by footings bearing on bedrock (Section 5.2.2). The following section (Section 5.2.3) includes recommendations for re-alignment of Ramp A over

Ottawa River and Ramp D over Ottawa River. These bridges will be three-span structures with abutments and pier wall footings supported by drilled shafts socketed into bedrock.

### 5.2.1 SR 51 Bridge Widening – Pile-Supported Abutments

The proposed widened abutments for the SR 51 bridge over US 23 are planned to be supported by driven piles end-bearing on bedrock. The existing bridge is supported by HP 12x53 piles. However, depending on design loads, an alternate pile size may be utilized. The bottoms of the abutments are planned at approximate Elev. 640 for both abutments. Preliminary plans indicated that there will be 1 foot of stickup into the abutments.

For piles end-bearing on bedrock, the ODOT Bridge Design Manual (BDM) indicates that piles should be specified as H-piles. We understand that the bridge will be designed using LRFD specifications. The factored resistance for piles driven to refusal on bedrock is typically governed by structural resistance. The total factored load for any single pile shall not exceed the maximum factored structural resistance (Pr). The ODOT prescribed maximum Pr for common pile sizes is presented in the following table.

**Table 5.2.1.A. ODOT Prescribed Maximum Factored Structural Resistance (Pr) for Common Pile Sizes**

| Pile Type/Size | Maximum Pr (kips) |
|---|---|
| HP 10x42 H-pile | 310 |
| HP 12x53 H-pile | 380 |
| HP 14x73 H-pile | 530 |

The Pr values assume:

- an axially loaded pile with negligible moment;
- no appreciable loss of section due to deterioration throughout the life of the structure;
- a steel yield strength of 50 kips per square inch (ksi);
- a structural resistance factor for H-piles subject to damage due to severe driving conditions (AASHTO LRFD Bridge Design Specifications 6.5.4.2: $\phi_c = 0.50$); and
- a pile fully braced along its length.

The indicated Pr values should not be used for piles that are subjected to significant bending moments or are not supported by soil for their entire length. Examples of the latter condition include piles for capped pile piers and piles in soils subject to scour. For the abutments associated with the proposed roadway overpass bridge, these would not be design constraints.

Consideration should be given to downdrag load on piles due to the settlement associated with the new embankment fill at the abutments. As indicated in Section 5.1.3, the time required for 90 percent consolidation may be on the order of 1 to 2 weeks. If a waiting period is allotted prior to driving piles, downdrag loads do not need to be incorporated into design (reduction in available bridge structure factored load per pile). If a waiting period is not allotted, TTL should be consulted to evaluate downdrag associated with consolidation/settlement of the existing overburden soils present prior to placement of embankment fill. In this case, we assume sleeves would be provided for the embankment portion of the pile installation to avoid downdrag associated with the embankment fill itself.

Each pile must be driven to refusal as defined by ODOT as being met during driving when the pile penetration is 1 inch or less after receiving at least 20 blows from the pile hammer. ODOT indicates that, when estimating pile length, the depth to refusal shall be assumed as the elevation where the rock core begins in the nearest test boring.

The following table includes the estimated pile length and order length for each substructure. The estimated pile length includes the calculated length from anticipated pile cut-off elevation (including embedment into pile cap) to pile tip elevation, rounded up to the nearest 5 feet. If rounding up to the nearest 5 foot for estimated length adds less than one foot, increase to the nearest 5 foot interval. The order length is the estimated length plus 5 feet. These lengths will be valid regardless of which type of H-pile is selected.

**Table. 5.2.1.B. H-Pile Estimated Lengths and Order Lengths**

| Location | Boring Number | Bottom of Pile Cap Elevation (feet) | Pile Cut-Off Elevation (feet) | Anticipated Pile Tip Elevation (feet) | Estimated Pile Length (feet) | Order Pile Length (feet) |
|---|---|---|---|---|---|---|
| Rear (West) Abutment | B-006-1 | 640 | 641 | 614(1) | 30 | 35 |
| Forward (East) Abutment | B-010-0 | 640 | 641 | 615 | 30 | 35 |

(1)Note that augerable weathered bedrock was encountered at Elev. 623.

The maximum center-to-center spacing of driven piles should be 8 feet for capped pile abutments and the front row of stub abutments per ODOT BDM specifications. The maximum center-to-center spacing of driven piles should be 7 feet for the front row of wall-type abutments and retaining walls.

Cobbles or boulders were not encountered in the borings. However, it should be noted that the existence of cobbles or boulders within the glacial till subsoils is not unusual for this region. These conditions, if encountered, could hamper pile-driving operations and possibly damage some piles. If some piles are observed to meet refusal at depths markedly less than those indicated by the borings, boulder obstruction or pre-mature "fetching" may be indicated. If these conditions are indicated, a pile load test should be performed to evaluate the capacity of the pile. Alternately, for a modest-sized project such as this, one or more replacement piles could be driven, probably at less expense than the cost of a load test.

Based on the bedrock depth and strength, steel pile points should be utilized for this project to protect the tips of the piles. Additionally, if piles will be driven through 15 feet or more of embankment fill (should pile sleeves not be included), pre-boring should be performed per ODOT BDM 305.3.5.7.

### 5.2.2 SR 51 Bridge Widening – Footing-Supported Piers

For the SR 51 bridge widening, it is planned to support the piers using footings bearing on bedrock. Preliminary plans indicate a footing size of 8 feet by 8 feet. For footings located outside the limits of 100 year flood plain (such as this structure) that are founded on rock, the bottom of footing must be keyed at least 3 inches into rock.

Based on the conditions encountered in the borings, the foundation bearing information is summarized in the following table.

**Table 5.2.2.A. Pier Foundations Bearing Conditions**

| Substructure | Boring Number | Rock Bearing Conditions | Top of Bedrock Elevation (feet) | Auger Refusal Elevation (feet) | Anticipated Bearing Elevation (feet) |
|---|---|---|---|---|---|
| West Pier (Pier 1) | B-006-1-21 | Weathered/Fractured Augerable Rock | 623 | 614 | 622.7 |
| Intermediate Pier (Pier 2) | B-008-0-21 | Cored Dolomite Bedrock | 617.5 | 617 | 617[1] |
| East Pier (Pier 3) | B-010-0-21 | Core Dolomite Bedrock | 615.6 | 615.6 | 615.3 |

[1]Recommend extending slightly more than the minimum 3 inches to extend to auger refusal elevation.

We understand that the headwall foundations will be designed using LRFD specifications. At the service limit state and strength limit state, the resistance factor ($\phi_b$) values are 1.0 and 0.45, respectively. The recommended nominal and factored bearing resistance at the service limit state and strength limit state for each substructure are summarized in the following table.

**Table 5.2.2.B. Pier Foundations Bearing Resistance**

| **Substructure** | **Boring Number** | **Service Limit State Bearing Resistance** | | **Strength Limit State Bearing Resistance** | |
|---|---|---|---|---|---|
| | | **Nominal, qn (ksf)** | **Factored, qr (ksf)** | **Nominal, qn (ksf)** | **Factored, qr (ksf)** |
| West Pier (Pier 1) | B-006-1-21 | 20 | 20 | 41 | 18 |
| Intermediate Pier (Pier 2) | B-008-0-21 | 20 | 20 | 1013 | 456 |
| East Pier (Pier 3) | B-010-0-21 | 20 | 20 | 1138 | 512 |

The structural engineer should verify suitable stress associated with the concrete when considering the factored bearing resistance to be utilized for design. Settlement of foundations bearing on cored rock is expected to be negligible, with settlement on the order of ½ inch or less calculated for foundations bearing on weathered bedrock with pressures at the service limit state factored bearing resistance of 20 ksf.

Headwall footings should also be checked for sliding stability. We recommend that passive pressure be considered negligible at the toe of the wall due to the potential for erosion and/or freeze-thaw behavior that would significantly reduce reliance on passive earth pressure. As such, the LRFD nominal 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. Nominal sliding resistance $R_T$ is calculated as V tan $\delta$, where V is the vertical axial load acting on the foundation, and tan $\delta$ is the friction factor on the base. For cast-in-place concrete footings bearing on dolomite bedrock, ODOT GDM 1303.3.5 indicates use of 35 degrees for $\delta$, such that tan $\delta$ is 0.7. For sliding resistance on rock, the resistance factor $\phi_T$ should be taken as 0.9 for the weathered rock at the West Pier (Pier 1), and 1.0 for the cored rock bearing material at the Intermediate Pier (Pier 2) and East Pier (Pier 3).

### 5.2.3 Ramp A and Ramp B Bridges over Ottawa River – Socketed Drilled Shafts

Consideration was given to spread foundations bearing on bedrock for the Ramp A and Ramp D bridges over Ottawa River. However, Based on our evaluations, none of the samples of the upper potential bearing rock met all of the criterion required to be considered scour-resistant rock in accordance with ODOT Bridge Design Manual (BDM) Section 305.2.1.2.b. The RQD values, RMR values, and GSI values were lower than the minimum requirements. Results of these evaluations are presented in Appendices C and D for Ramp A and Ramp D, respectively. These structures are now planned to be supported by drilled shafts socketed into bedrock. Preliminary recommendations for vertical resistance and lateral load-deflection soil and rock parameters have been provided to the structural engineer. While the vertical resistance was suitable for a design using three drilled shafts per substructure, it was found that four drilled shafts per substructure were required for suitable lateral resistance while maintaining a relatively shallow socket. The bottom of footing / pier cap elevations, relevant borings and encountered bedrock conditions for the substructures, as well as indicated maximum vertical and lateral loads considering four drilled shafts per substructure are summarized in the following table.

**Table 5.2.3.A. Substructure Load, Footing, Scour, and Rock Data**

| Bridge | Substructure | Footing Elev. | Boring | Top of Rock Elev. (feet) | Provided Scour Elev. (feet) | Maximum Factored Vertical Load (kips) | Maximum Factored Moment (ft-kips) |
|---|---|---|---|---|---|---|---|
| Ramp A | Rear Abutment | 613.5 | B-028-0 | 609.3 | 598.3 | 203.05 | 923.76 |
| | Pier 1 | 610.0 | B-028-1 | 605.6 | 603.02 | 315.21 | 702.52 |
| | Pier 2 | 608.0 | B-028-2 | 608.1 | 605.72 | 315.21 | 702.52 |
| | Forward Abutment | 615.0 | B-029-0 | 609.0 | 607.7 | 203.05 | 923.76 |
| Ramp D | Rear Abutment | 612.5 | B-022-0 | 607.1 | 610.21 | 322.35 | -595.38 |
| | Pier 1 | 610.79 | B-022-1 | 609.1 | 605.61 | 460.86 | 551.86 |
| | Pier 2 | 605.14 | B-022-3 | 610.0 | 605.67 | 464.72 | 512.59 |
| | Forward Abutment | 614.0 | B-023-0 | 608.2 | 604.42 | 290.03 | 1082.13 |

<u>Drilled Shaft Rock Socket Vertical Resistance</u>

We understand that the bridge foundations will be designed using LRFD methods. The minimum diameter for drilled shafts that support pier columns is 42 inches. However, the piers for these structures are planned to be supported on strip footings. Therefore, the minimum diameter of 30 inches for drilled shafts was initially considered for both the abutment and pier shafts. The diameter of bedrock sockets for drilled shafts is generally 6 inches less than the diameter of the shaft above the bedrock elevation. Regardless of shaft diameter, reinforcing steel cages should be based on the bedrock socket diameter.

For the abutments and piers, initial considerations are based on the minimum 36-inch diameter shafts above bedrock and a socket diameter of 30 inches. It was then found that 42-inch diameter shafts with 36-inch diameter sockets were found to be required for lateral load resistance based on the factored loads presented in Table 5.2.3.A and the design soil/rock parameters in the following section. Finally, the structural engineer planned for 42-inch straight shafts in soil and bedrock based on scour considerations.

For end-bearing evaluation considerations, the minimum prescribed rock socket length is 1.5B, where B is the socket diameter. However, per ODOT BDM 305.4.4.4, a minimum 5-foot socket is prescribed with footings or ground surface within 10 feet of bedrock. All of the footings/bottom of pier caps for The Ramp A and Ramp D bridges are within 10 feet of bedrock. As such, the minimum rock socket length is then considered 5 feet. Furthermore, the minimum rock socket length is also governed by the scour elevation. Per ODOT BDM 305.4.1.1, for non-friction drilled shafts, they must penetrate a minimum of 10 feet below the controlling scour elevation. Based on the provided scour elevations in Table 5.2.3.A of this report, this was found to be the governing criteria for minimum rock socket tip elevation (pending suitable resistance also for lateral load-deflection evaluations described below). Depending on final design considerations, the initially planned 42-inch straight shafts may be utilized, or a 6-inch reduction in diameter for sockets may be used below top of rock (or below scour elevation), as appropriate.

Evaluations for factored unit tip resistance presented below are based on bearing in competent rock that does not contain adverse jointing, open solution cavities, or joints that are filled with weathered material that would affect the bearing resistance of the rock, within a distance equal to two socket diameters below the tip of the drilled shaft rock socket. In any case, any structural requirement for the drilled shaft foundations to resist lateral loads or moments may increase the socket depth or diameter and should be evaluated on an individual shaft basis by the structural engineer along with TTL.

Based on the rock conditions encountered at each substructure location in the borings summarized in Table 5.2.3.A, an unfactored unit tip resistance ($q_p$) was calculated. Based on the design methodologies utilized to evaluate unfactored unit tip resistance and AASHTO LRFD Table 10.5.5.2.4-1, a resistance factor of 0.50 should be utilized for design for tip resistance. The calculated unfactored tip resistance and factored unit tip resistance values are summarized in the following table.

| Table 5.2.3.B. Unfactored and Factored Unit Tip Resistance | | | | | | |
|---|---|---|---|---|---|---|
| **Bridge** | **Substructure** | **Boring** | **Unfactored Unit Tip Resistance, qp (ksf)** | **Factored Unit Tip Resistance (ksf)** | **Maximum Factored Vertical Load (kips)** | **Calculated Factored Vertical Resistance(1) (kips)** |
| Ramp A | Rear Abutment | B-028-0 | 6,150 | 3,075 | 203.05 | 29,585 |
| | Pier 1 | B-028-1 | 6,995 | 3,495 | 315.21 | 33,626 |
| | Pier 2 | B-028-2 | 6,340 | 3,170 | 315.21 | 30,499 |
| | Forward Abutment | B-029-0 | 4,575 | 2,285 | 203.05 | 21,984 |
| Ramp D | Rear Abutment | B-022-0 | 3,605 | 1,800 | 322.35 | 17,318 |
| | Pier 1 | B-022-1 | 4,285 | 2,140 | 460.86 | 20,589 |
| | Pier 2 | B-022-3 | 8,595 | 4,295 | 464.72 | 41,323 |
| | Forward Abutment | B-023-0 | 5,455 | 2,725 | 290.03 | 26,218 |

(1)For 3.5 feet diameter straight shaft in soil and end-bearing in rock.

Based on the planned shaft diameter of 42 inches and the factored unit tip resistance indicated above for each substructure, the resistance is suitable for the indicated factored loads when using the planned 4 drilled shafts per substructure. Even if a 6-inch reduction in diameter was considered for the rock socket portion of the drilled shaft foundation, the end-bearing resistance would be suitable for the provided factored loads.

A summary of the recommended rock socket lengths based on vertical resistance evaluations is provided in the following table.

| Table 5.2.3.C. Minimum Rock Socket Length Based on Vertical Load Considerations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Bridge** | **Sub-structure** | **Boring** | **Footing Elev. (feet)** | **Scour Elev. (feet)** | **Bottom of Rock Socket Elev. (feet)** | **Top of Rock Elev. (feet)** | **Calculated Rock Socket Length (feet)** | **Recommended Minimum Rock Socket Length(1)(2)** |
| Ramp A | Rear Abutment | B-028-0 | 613.5 | 605.9 | 595.9 | 609.3 | 13.4 | 13.5 |
| | Pier 1 | B-028-1 | 610.0 | 603.02 | 591.7(4) | 605.6 | 13.9 | 14 |
| | Pier 2 | B-028-2 | 608.0 | 605.72 | 595.72 | 608.1 | 12.28 | 12.5 |
| | Forward Abutment | B-029-0 | 615.0 | 607.7 | 597.7 | 609.0 | 11.3 | 11.5 |
| Ramp D | Rear Abutment | B-022-0 | 612.5 | 610.21 | 600.21 | 607.1 | 6.89 | 7 |
| | Pier 1 | B-022-1 | 610.79 | 605.61 | 595.61 | 609.1 | 13.49 | 13.5 |
| | Pier 2 | B-022-3 | 605.14 | 605.67 | 595.67 | 610.0 | 9.47(3) | 9.5 |
| | Forward Abutment | B-023-0 | 614.0 | 604.42 | 594.42 | 608.2 | 13.78 | 14 |

[(1)] Based on minimum 5-ft requirement for rock present within 10 feet of bottom of footing, as well as further governing extending at least 10 feet below scour elevation.
[(2)] Rock socket length may need to be increased if lateral load considerations govern design.
[(3)] Footing elevation is below top of rock, so of socket length is based on bottom of footing instead of top of rock.
[(4)] The end-bearing elevation associated with the extension of the shaft/socket 10 feet below the scour elevation was just above a highly fractured zone with open fractures at Elev. 592.7. At this elevation, the driller noted loss of water during coring. Due to suspect end-bearing of this material, we recommend the shaft/socket extend deeper. The driller noted 50% water return and we encountered more intact rock at Elev. 591.7. Therefore, use a tip elevation of Elev. 591.7.

The factored unit tip resistance was based on rock conditions. We recommend the structural engineer also consider any limiting conditions associated with the stress limitations of the concrete.

It should be noted that the provided factored unit bearing resistance reflects end-bearing conditions only. Typically, design based on end-bearing alone is considered when sound bedrock underlies highly weathered rock. Conversely, design based on side shear resistance alone is considered when the drilled shaft cannot be adequately cleaned, or where large movement of the shaft would be required to mobilize the end bearing. For this project, significant movement is not expected to be required to mobilize the end bearing (for shafts installed beyond the less competent upper bedrock profile), and it is assumed that due diligence will be exercised to install the shafts in a cleaned drill hole.

Consideration was given to downdrag on the drilled shafts due to the embankment fill that will be placed at the abutment locations. Based on the settlement calculations included in Appendix A, the settlement calculated for the soil portion below the footing elevation at the Ramp A forward abutment and Ramp D rear abutment was 0.4 inches or less. For foundations extending to bedrock, the neutral plane is considered the bedrock elevation, and downdrag is considered for the portion of the soil above the elevation where 0.4 inches of settlement is calculated immediately above the bedrock. As such, no downdrag loads are required for these two substructures. Settlement of more than 0.4 inch was calculated for the soil portion below the footing at the other two abutment locations. Side friction was evaluated for the portions of the foundations below the footing to the elevation where 0.4 inches of settlement was calculated immediately above the bedrock. Those results are provided in Appendices C and D, and are summarized in the following table.

**Table 5.2.3.D. Downdrag Load Considerations**

| Bridge | Sub-structure | Borings | Footing Elev. (feet) | Downdrag Zone | Downdrag Zone Thickness (feet) | Adhesion (ksf) | Calculated <u>Unfactored</u> Downdrag Load[(1)] (kips) |
|---|---|---|---|---|---|---|---|
| Ramp A | Rear Abutment | B-028-0/ B-028-1 | 613.5 | 613.5-612.6 | 0.9 | 0.75 | 7 |
| | Forward Abutment | B-029-0 | 615.0 | None | - | - | - |
| Ramp D | Rear Abutment | B-022-0 | 612.5 | None | - | - | - |
| | Forward Abutment | B-023-0 | 614.0 | 614.0-613.2 | 0.8 | 0.62 | 5.5 |
| | | | | 613.2-611 | 2.2 | 1.3 | 31 |
| | | | | | | Total: | 37 |

(1) Based on 3.5-ft diameter drilled shaft in soil.

In addition to the downdrag loads on the drilled shaft foundations, the embankment fill placed behind the abutment walls and drilled shaft caps will experience settlement that could cause downdrag loads on the walls. We recommend coating these portions of the abutment substructures that are above existing grade with low viscosity bituminous asphalt and then covering or wrapping those components with a durable thick plastic visqueen to avoid additional downdrag loads on these exposed elements. Otherwise, alternative methods to avoid downdrag on the walls and footings could be considered. To reduce potential downdrag, embankment should be constructed to as close as possible to the structure location and a waiting period could be utilized to allow for settlement under that embankment load. As discussed in Section 5.1.3, this period may be on the order of 1 to 2 weeks for 90 percent consolidation to occur.

Drilled shafts should be constructed in accordance with ODOT Construction and Material Specifications (CMS) Item 524. It is also recommended that the center-to-center spacing between adjacent shafts be no less than 2 shaft diameters. However, as discussed below, group effects within the soil would need to be considered for lateral load evaluations with a center-to-center spacing of drilled shafts of less than 3.75 shaft diameters.

Due to the presence of groundwater, as well as the granular soils encountered in the borings, it is likely that temporary steel casing will be required to support the walls of the shaft and to control groundwater seepage. If significant seepage is encountered and cannot be suitably pumped to dewater the drilled shaft, concrete will require placement by tremie methods. As the steel casing is withdrawn during concreting, sufficient concrete should be maintained above the bottom of the casing to counteract any hydrostatic head. Care must be taken during concreting and removal of any temporary liner so as to avoid the possibility of soil intrusions. The contractor should submit procedures for installation prior to the start of work.

Although cobbles or boulders were not noted in the borings performed for this exploration, they may be encountered at this site. Therefore, provisions should be made by the contractor to remove any obstructions, including cobbles or boulders, if they are encountered during the drilling operations.

Drilled shafts should be clean and free of all loose material prior to the placement of concrete. A TTL representative should verify that shafts are bearing on competent materials and that installation procedures meet specifications.

Lateral Load Soil and Rock Design Parameters

For lateral load-deflection evaluations using software, such as LPILE, recommended design parameters are summarized in the following tables based on the conditions encountered in the borings. It was indicated that the center-to-center spacing for a single row of 3.5 feet diameter drilled shafts was 8 feet. With the spacing of less than 3.75 shaft diameters, a p-multiplier of 0.85 was calculated per ODOT BDM Section 305.1.2, for consideration of group effects. The p-multiplier should be applied only for the soil portion of the shaft, not the socket in rock.

Per ODOT BDM Section 305.4.1.1 “Scour”, structural capacity of the shaft should be evaluated considering the depth of scour as an unbraced length since the drilled shaft will lose support along the scour depth. Additionally, a p-y analysis on the drilled shaft would need to be performed according to BDM Section 305.1.2 to demonstrate lateral stability against overturning at various design states and excessive deflection at the Service Limit State.

Initial LPILE files were setup using the provided factored vertical loads and moments, along with the parameters in the following tables. The files were then provided to the structural engineer to confirm that the steel reinforcement and drilled shafts (length and diameter) were suitable for the resulting shear, moment, and deflection from the LPILE evaluations. Otherwise, modification may include increased steel reinforcement, deeper sockets, or larger diameter drilled shafts/sockets. If larger diameter shafts are utilized, the p-multiplier would need to be modified accordingly.

*Ramp A Lateral Load – Deflection Parameters*

| Table 5.2.3.E. Subsurface Conditions and Recommended Lateral Load-Deflection Parameters – Ramp A Rear Abutment (Boring B-028-0-21) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Depth Below Existing Grade (feet)** | **Elevation (feet)** | **Generalized Layer Description** | **Approximate Total Unit Weight[1] (pcf)** | **Average Undrained Shear Strength, Su (psf)** | **Strain at 50% Maximum Stress, $\varepsilon_{50}$** | **Young's Modulus, Er (psi)** | **Rock Uniaxial Compressive Strength (psi)** | **$k_{rm}$** |
| 0 to 4 | 620.3 to 616.3 | Medium Dense A-3a | 125 | $\phi$=37.5º | k=25 pci | – | – | – |
| 4 to 6 | 616.3 to 614.3 | Very Stiff A-4a | 120 | 2,250 | 0.005 | – | – | – |
| 6 to 8 | 614.3 to 612.3 | Stiff to Very Stiff A-6a | 125 | 940 | 0.010 | – | – | – |
| 8 to 11 | 612.3 to 609.3 | Loose A-3a | 120 | $\phi$=32º | k=5 pci | – | – | – |
| 11 to 13 | 609.3 to 607.3 | Weathered Dolomite | 160 | – | – | 18,000 | 95.8 | 0.000027 |
| 13 to 14.4 | 607.3 to 605.9 | Dolomite Bedrock RQD = 65% | 160 | – | – | 900,000 | 10,750 | 0.000060 |
| 14.4 to 21 | 605.9 to 599.3 | Dolomite Bedrock RQD = 72% | 160 | – | – | 1,800,000 | 21,100 | 0.000059 |
| 21 to 23.9 | 599.3 to 596.4 | Dolomite Bedrock RQD = 34% | 160 | – | – | 1,800,000 | 20,200 | 0.000056 |
| 23.9 to 25 | 596.4 to 595.3 | Dolomite Bedrock RQD = 38% | 160 | – | – | 680,000 | 7,500 | 0.000055 |
| 25 to 26.8 | 595.3 to 593.5 | Dolomite Bedrock RQD = 77% | 160 | – | – | 1,400,000 | 17,090 | 0.000061 |
| 26.8 to 31 | 593.5 to 589.3 | Dolomite Bedrock RQD = 0% | 160 | – | – | 900,000 | 12,700 | 0.000071 |
| 31 to 33 | 589.5 to 587.3 | Dolomite Bedrock RQD = 24% | 160 | – | – | 900,000 | 12,700 | 0.000071 |

[1]Effective unit weight should be used below a depth of 16 feet (reduce by unit weight of water – 62.4 pcf).

| Table 5.2.3.F. Subsurface Conditions and Recommended Lateral Load-Deflection Parameters – Ramp A Pier 1 (Boring B-028-1-21) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Depth Below Existing Grade (feet)** | **Elevation (feet)** | **Generalized Layer Description** | **Approximate Total Unit Weight[1] (pcf)** | **Average Undrained Shear Strength, Su (psf)** | **Strain at 50% Maximum Stress, $\varepsilon_{50}$** | **Young's Modulus, Er (psi)** | **Rock Uniaxial Compressive Strength (psi)** | **$k_{rm}$** |
| 0 to 3 | 616.6 to 613.6 | Very Stiff A-4b | 125 | 2625 | 0.005 | – | – | – |
| 3 to 6 | 613.6 to 610.6 | Medium Stiff to Stiff A-4a | 115 | 1000 | 0.007 | – | – | – |
| 6 to 8 | 610.6 to 608.6 | Medium Dense A-2-4 | 125 | $\phi$=36° | k=23 pci | – | – | – |
| 8 to 11 | 608.6 to 605.6 | Very Dense A-2-4 | 140 | $\phi$=41° | k=64 pci | – | – | – |
| 11 to 11.4 | 605.6 to 605.2 | Dolomite Bedrock RQD = 0% | 160 | – | – | 900,000 | 10,750 | 0.000060 |
| 11.4 to 21.1 | 605.2 to 595.5 | Dolomite Bedrock RQD = 43% | 160 | – | – | 1,400,000 | 17,330 | 0.000062 |
| 21.1 to 21.9 | 595.5 to 594.7 | Dolomite Bedrock RQD = 0% | 160 | – | – | 680,000 | 7,500 | 0.000055 |
| 21.9 to 23.9 | 594.7 to 592.7 | Dolomite Bedrock RQD = 17% | 160 | – | – | 680,000 | 7,500 | 0.000055 |
| 23.9 to 24.9 | 592.7 to 591.7 | Dolomite Bedrock RQD = 0% | 160 | – | – | 680,000 | 7,500 | 0.000055 |
| 24.9 to 31.1 | 591.7 to 585.5 | Dolomite Bedrock RQD = 28% | 165 | – | – | 1,800,000 | 19,440 | 0.000054 |

[1]Effective unit weight should be used below a depth of 16 feet (reduce by unit weight of water – 62.4 pcf).

| Table 5.2.3.G. Subsurface Conditions and Recommended Lateral Load-Deflection Parameters – Ramp A Pier 2 (Boring B-028-2-21) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Depth Below Existing Grade (feet)** | **Elevation (feet)** | **Generalized Layer Description** | **Approximate Total Unit Weight[1] (pcf)** | **Average Undrained Shear Strength, Su (psf)** | **Strain at 50% Maximum Stress, $\varepsilon_{50}$** | **Young's Modulus, Er (psi)** | **Rock Uniaxial Compressive Strength (psi)** | **$k_{rm}$** |
| 0 to 0.9 | 609.0 to 608.1 | Very Dense A-1-b | 130 | $\phi$=42° | k=64 pci | – | – | – |
| 0.9 to 1.5 | 608.1 to 607.5 | Weathered Dolomite | 160 | – | – | 18,000 | 127.8 | 0.000035 |
| 1.5 to 8.5 | 607.5 to 600.5 | Dolomite Bedrock RQD = 60% | 165 | – | – | 1,400,000 | 14,990 | 0.000054 |
| 8.5 to 12.6 | 600.5 to 596.4 | Dolomite Bedrock RQD = 0% | 160 | – | – | 1,400,000 | 14,990 | 0.000054 |
| 12.6 to 20 | 596.4 to 589 | Dolomite Bedrock RQD = 4% | 165 | – | – | 1,400,000 | 17,610 | 0.000063 |
| 20 to 22 | 589 to 587 | Dolomite Bedrock RQD = 0% | 160 | – | – | 680,000 | 7,500 | 0.000055 |

[1]Effective unit weight should be used below a depth of 16 feet (reduce by unit weight of water – 62.4 pcf).

| Table 5.2.3.H. Subsurface Conditions and Recommended Lateral Load-Deflection Parameters – Ramp A Forward Abutment (Boring B-029-0-21) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Depth Below Existing Grade (feet)** | **Elevation (feet)** | **Generalized Layer Description** | **Approximate Total Unit Weight[1] (pcf)** | **Average Undrained Shear Strength, Su (psf)** | **Strain at 50% Maximum Stress, $\varepsilon_{50}$** | **Young's Modulus, Er (psi)** | **Rock Uniaxial Compressive Strength (psi)** | **$k_{rm}$** |
| 0 to 3 | 620.5 to 617.5 | Medium Dense A-3a | 125 | $\phi$=39° | k=31 pci | – | – | – |
| 3 to 9 | 617.5 to 611.5 | Very Stiff A-4a | 125 | 3,125 | 0.005 | – | – | – |
| 9 to 11.5 | 611.5 to 609 | Loose A-3a | 120 | $\phi$=32° | k=6 pci | – | – | – |
| 11.5 to 13.5 | 609 to 607 | Weathered Dolomite | 160 | – | – | 18,000 | 25.6 | 0.000007 |
| 13.5 to 16 | 607 to 604.5 | Weathered Dolomite | 160 | – | – | 18,000 | 76.7 | 0.000021 |
| 16 to 17.7 | 604.5 to 602.8 | Dolomite Bedrock RQD = 43% | 160 | – | – | 1,400,000 | 17,720 | 0.000063 |
| 17.7 to 23 | 602.5 to 597.5 | Dolomite Bedrock RQD = 81% | 160 | – | – | 1,400,000 | 17,720 | 0.000063 |
| 23 to 26 | 597.5 to 594.5 | Dolomite Bedrock RQD = 28% | 160 | – | – | 900,000 | 12,710 | 0.000071 |
| 26 to 26.6 | 594.5 to 593.9 | Dolomite Bedrock RQD = 0% | 160 | – | – | 680,000 | 7,500 | 0.000055 |
| 26.6 to 36 | 593.9 to 584.5 | Dolomite Bedrock RQD = 25% | 160 | – | – | 1,400,000 | 14,980 | 0.000054 |

[1]Effective unit weight should be used below a depth of 16 feet (reduce by unit weight of water – 62.4 pcf).

*Ramp D Lateral Load – Deflection Parameters*

**Table 5.2.3.I. Subsurface Conditions and Recommended Lateral Load-Deflection Parameters – Ramp D Rear Abutment (Boring B-022-0-21)**

| Depth Below Existing Grade (feet) | Elevation (feet) | Generalized Layer Description | Approximate Total Unit Weight[1] (pcf) | Average Undrained Shear Strength, Su (psf) | Strain at 50% Maximum Stress, $\varepsilon_{50}$ | Young's Modulus, Er (psi) | Rock Uniaxial Compressive Strength (psi) | $k_{rm}$ |
|---|---|---|---|---|---|---|---|---|
| 0 to 3.5 | 615.1 to 611.6 | Medium Stiff A-6a | 120 | 1,000 | 0.005 | – | – | – |
| 3.5 to 6 | 611.6 to 609.1 | Medium Dense A-2-4 | 125 | $\phi$=39.5º | k=23 pci | – | – | – |
| 6 to 8 | 609.1 to 607.1 | Very Dense A-3a | 140 | $\phi$=40º | k=64 pci | – | – | – |
| 8 to 10.3 | 607.1 to 604.8 | Dolomite Bedrock RQD = 29% | 160 | – | – | 450,000 | 6,250 | 0.000069 |
| 10.3 to 16.5 | 604.8 to 598.6 | Dolomite Bedrock RQD = 42% | 160 | – | – | 900,000 | 10,020 | 0.000056 |
| 16.5 to 18 | 598.6 to 597.1 | Dolomite Bedrock RQD = 24% | 160 | – | – | 900,000 | 10,020 | 0.000056 |
| 18 to 21 | 597.1 to 594.1 | Dolomite Bedrock RQD = 0% | 160 | – | – | 900,000 | 10,020 | 0.000056 |
| 21 to 28 | 594.1 to 587.1 | Dolomite Bedrock RQD = 31% | 160 | – | – | 1,400,000 | 15,030 | 0.000054 |

[1]Effective unit weight should be used below a depth of 16 feet (reduce by unit weight of water – 62.4 pcf).

**Table 5.2.3.J. Subsurface Conditions and Recommended Lateral Load-Deflection Parameters – Ramp D Pier 1 (Boring B-022-1-21)**

| Depth Below Existing Grade (feet) | Elevation (feet) | Generalized Layer Description | Approximate Total Unit Weight[1] (pcf) | Average Undrained Shear Strength, Su (psf) | Strain at 50% Maximum Stress, $\varepsilon_{50}$ | Young's Modulus, Er (psi) | Rock Uniaxial Compressive Strength (psi) | $k_{rm}$ |
|---|---|---|---|---|---|---|---|---|
| 0 to 4.5 | 616.1 to 611.6 | Stiff A-4a | 120 | 1,750 | 0.007 | – | – | – |
| 4.5 to 6 | 611.6 to 610.1 | Medium Stiff A-4a | 120 | 1,000 | 0.007 | – | – | – |
| 6 to 7 | 610.1 to 609.1 | Loose A-3a | 120 | $\phi$=32.5º | k=5 pci | – | – | – |
| 7 to 8.6 | 609.1 to 607.5 | Weathered Dolomite | 160 | – | – | 18,000 | 128 | 0.000035 |
| 8.6 to 18.5 | 607.5 to 597.6 | Dolomite Bedrock RQD = 17% | 160 | – | – | 1,400,000 | 19,275 | 0.000069 |
| 18.5 to 23.6 | 597.6 to 592.5 | Dolomite Bedrock RQD = 12% | 160 | – | – | 680,000 | 7,350 | 0.000054 |
| 23.6 to 28.6 | 592.5 to 587.5 | Dolomite Bedrock RQD = 22% | 165 | – | – | 1,400,000 | 16,420 | 0.000059 |

[1]Effective unit weight should be used below a depth of 16 feet (reduce by unit weight of water – 62.4 pcf).

| Table 5.2.3.K. Subsurface Conditions and Recommended Lateral Load-Deflection Parameters – Ramp D Pier 2 (Borings B-022-2-21 and B-022-3-21) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Depth Below Existing Grade (feet)** | **Elevation (feet)** | **Generalized Layer Description** | **Approximate Total Unit Weight[1] (pcf)** | **Average Undrained Shear Strength, Su (psf)** | **Strain at 50% Maximum Stress, $\varepsilon_{50}$** | **Young's Modulus, Er (psi)** | **Rock Uniaxial Compressive Strength (psi)** | **$k_{rm}$** |
| 0 to 6 | 616 to 610 | Very Stiff A-4a | 120 | 2,125 | 0.005 | – | – | – |
| 6 to 8.5 | 610 to 607.5 | Weathered Dolomite | 160 | – | – | 18,000 | 96 | 0.000027 |
| 8.5 to 9.3 | 607.5 to 606.7 | Weathered Dolomite | 160 | – | – | 18,000 | 192 | 0.000053 |
| 9.3 to 14.3 | 606.7 to 601.7 | Dolomite Bedrock RQD = 45% | 160 | – | – | 1,400,000 | 17,840 | 0.000064 |
| 14.3 to 19.3 | 601.7 to 596.7 | Dolomite Bedrock RQD = 0% | 160 | – | – | 1,400,000 | 17,840 | 0.000064 |
| 19.3 to 23.2 | 596.7 to 592.8 | Dolomite Bedrock RQD = 65% | 165 | – | – | 1,800,000 | 23,820 | 0.000066 |
| 23.2 to 26.3 | 592.8 to 589.7 | Dolomite Bedrock RQD = 18% | 165 | – | – | 1,800,000 | 23,930 | 0.000066 |
| 26.3 to 29.3 | 589.7 to 586.7 | Dolomite Bedrock RQD = 36% | 165 | – | – | 1,800,000 | 23,930 | 0.000066 |

[1]Effective unit weight should be used below a depth of 16 feet (reduce by unit weight of water – 62.4 pcf).

| Table 5.2.3.L. Subsurface Conditions and Recommended Lateral Load-Deflection Parameters – Ramp D Forward Abutment (Boring B-023-0-21) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Depth Below Existing Grade (feet)** | **Elevation (feet)** | **Generalized Layer Description** | **Approximate Total Unit Weight[1] (pcf)** | **Average Undrained Shear Strength, Su (psf)** | **Strain at 50% Maximum Stress, $\varepsilon_{50}$** | **Young's Modulus, Er (psi)** | **Rock Uniaxial Compressive Strength (psi)** | **$k_{rm}$** |
| 0 to 3.5 | 624.2 to 620.7 | Medium Dense A-2-4 | 120 | $\phi$=35.5º | k=14 pci | – | – | – |
| 3.5 to 8 | 620.7 to 616.2 | Medium Dense A-3a | 125 | $\phi$=34.5º | k=19 pci | – | – | – |
| 8 to 11 | 616.2 to 613.2 | Medium Stiff A-6b | 115 | 750 | 0.010 | – | – | – |
| 11 to 16 | 613.2 to 608.2 | Hard A-4a | 130 | 4,250 | 0.004 | – | – | – |
| 16 to 16.5 | 608.2 to 607.7 | Weathered Dolomite | 160 | – | – | 32,000 | 383 | 0.000060 |
| 16.5 to 24.3 | 607.7 to 599.9 | Dolomite Bedrock RQD = 70% | 160 | – | – | 1,400,000 | 16,490 | 0.000059 |
| 24.3 to 25.3 | 599.9 to 598.9 | Dolomite Bedrock RQD = 50% | 160 | – | – | 900,000 | 12,130 | 0.000067 |
| 25.3 to 29.5 | 598.9 to 594.7 | Dolomite Bedrock RQD = 24% | 160 | – | – | 900,000 | 12,130 | 0.000067 |
| 29.5 to 36.5 | 594.7 to 587.7 | Dolomite Bedrock RQD = 15% | 160 | – | – | 1,400,000 | 15,160 | 0.000054 |

[1]Effective unit weight should be used below a depth of 16 feet (reduce by unit weight of water – 62.4 pcf).

## 5.3 Soil Nail Wall Design Soil Parameters

A new retaining wall is planned to facilitate routing of Ramp B immediately west of the forward (East) abutment for the SR 51 Bridge over US 23. The planned retaining wall will wrap around the forward (East) abutment, and will be on the order of 240 lineal feet in length. Top of coping along the highest portion of the wall will generally range from approximate Elevs. 642 to 640, with toe elevations on the order of Elevs. 632 to 630, resulting in maximum exposed height of approximately 10 feet.

The wall is preliminarily planned as a soil nail wall with shotcrete facing covered by a cast-in-place concrete facing. A soil nail inclination of 15% from horizontal is being considered. The leveling pad elevation is indicated at Elev. 626. For the maximum top of coping elevation of Elev. 642±, this results in a maximum height of wall of approximately 16 feet. A perforated drain pipe is planned in front of the face of the wall, just above leveling pad elevation, to be fed by weep holes in the wall that are connected to a geocomposite strip drain along the back of the wall.

A paved gutter is planned behind the top of the wall for drainage. Grades above the top of wall will be on the order of 2 horizontal to 1 vertical (2H:1V) beneath the bridge overpass, and 4H:1V beyond the extents of the overpass.

### 5.3.1 Retaining Wall Design Soil Parameters

Based on the proposed location of the wall, nearby Borings B-010-0-21 behind the wall and B-008-0-21 in front of the wall were considered for design soil parameters. Based on these borings, the retained soils, soils in the sloped portion above the wall, and underlying soils are anticipated to be predominantly cohesive soils. A granular soil zone may be present near the maximum top of coping elevation/in the lower portion of the sloped portion above the wall. The soil properties associated with these soils are summarized in the following table.

| Table 5.3.1. Retaining Wall Design Parameters | | | | | |
|---|---|---|---|---|---|
| **Approximate Elevation (ft)** | **Layer No.** | **Soil Type** | **Total Unit Weight (pcf)** | **Undrained Shear Strength, Su (ksf)** | **Internal Angle of Friction, ϕ (degrees)** |
| 651 – 646 | 1 | Stiff to Very Stiff Cohesive Embankment Fill | 120 | 1.5 | - |
| 646 – 643 | 2 | Very Stiff Cohesive Embankment Fill | 130 | 2.6 | - |
| 643 – 640 | 3 | Medium Dense Granular Embankment Fill | 130 | - | 37.5 |
| 640 – 625 | 4 | Stiff to Very Stiff Cohesive | 125 | 1.4 | - |
| 625 – 623 | 5 | Very Stiff Cohesive | 135 | 2.9 | - |
| 623 – 616 | 6 | Hard Cohesive | 140 | 7.5 | - |
| 616- | 7 | Bedrock | Soil nails not anticipated to extend into bedrock. | | |

For design considerations, the “normal” groundwater level may be considered at Elev. 623±.

### 5.3.2 Lateral Earth Pressures

If needed for design, recommended lateral earth pressure values are provided in this section. Retaining structures and walls that are restrained from rotation and are considered rigid and non-yielding should be designed for “at-rest” earth pressure conditions. Based on the elevation range for the exposed wall height, it is anticipated that the retained soils will predominantly consist of Layer No. 4 soils presented in Table 5.3.1. Based on the properties for Layer No. 4 soils, an at-rest earth pressure coefficient ($k_o$) of 0.5 may be used for design, along with a soil unit weight of 125 pounds per cubic foot (pcf). Alternatively, an equivalent fluid weight of 65 pcf may be used for the at-rest case design.

If the retaining structure is not considered restrained at the top of the wall, design may be based on active lateral earth pressure conditions. Based on the properties for Layer No. 4 soils, an active earth pressure coefficient ($k_a$) of 0.33 may be used for design, along with a soil unit weight of 125 pcf. Alternatively, an equivalent fluid weight of 45 pcf may be used for the active case design.

It should be noted that some wall/foundation movement or horizontal displacement is needed to mobilize the full passive pressure of the soil. Additionally, passive pressure is typically ignored within the depth of potential frost penetration (3½ feet below toe grade for this site). Because of these considerations, and depending on the design methodology used for the soil nail wall, passive pressure is expected to be neglected for soil nail wall design.

It should also be noted that the earth pressures presented above do not include hydrostatic pressures that may result from elevated groundwater conditions. For this reason, the use of the currently planned geocomposite strip drain and overlying paved gutter should remain to alleviate hydrostatic conditions on the wall. In addition, the earth pressures indicated above are based on a level backfill condition behind the retaining wall. For the planned areas of appreciable sloping backfill 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 should be used for lateral loading in the design of the wall. Additionally, depending on the proximity of the wall, traffic surcharge may need to be incorporated into design.

### 5.4 GB-1 "Plan Subgrades" Evaluation

Where embankments are constructed for the project, the new embankment fill is anticipated to be suitable for pavement subgrade support. For portions of the project where pavement subgrade borings were performed for new roadway and ramp alignment that will approximate existing roadway alignment without significant grade change, an evaluation of the subgrade soils was completed in general accordance with ODOT Geotechnical Bulletin GB-1 "Plan Subgrades" (Now ODOT GDM Section 600). As part of this evaluation, ODOT a "Subgrade Analysis" worksheet (V14.6, 02/11/22) was completed for the entire project area, and it is attached in Appendix F.

Based on "Typical Sections" sheets for the project provided with the Stage 1 Submittal, our evaluations considered pavement cross-sections of approximately 18 inches to determine subgrade elevation below planned finished grades. Anticipated cut and fill to achieve subgrade elevation at the boring locations is presented in the "Subgrade Analysis" worksheet.

Based on GB-1, soils classified as ODOT A-4b, A-2-5, A-5, A-7-5, A-8a, A-8b, or rock have been designated as being problematic with respect to pavement subgrade support. Of these soil types, only one sample classified as A-4b (Boring B-032-0) was encountered at planned subgrade elevation in the borings performed for this exploration. Where A-4b soils are encountered within the upper 3 feet of the subgrade, ODOT generally requires that these soils be undercut to 36 inches or chemically stabilized to a depth of 14 inches.

The subgrade soils encountered during this exploration consisted of predominantly A-4a soils, but also included granular soils (generally consisting of A-3a soils) for approximately ¼ of the evaluated subgrade samples and cohesive A-6a soils for approximately 1/8 of the samples.

Based on GB-1 criteria, subgrade soils with moisture contents greater than 3 percent above optimum likely indicate the presence of unstable subgrade that may require some form of subgrade modification. Approximately half of the evaluated samples exhibited moisture contents greater than 3 percent above the optimum as determined using GB-1 criteria. It should be noted that approximately 80 percent of the samples with moisture contents greater than 3 percent above optimum had moisture contents greater than or equal to 5 percent above optimum. Thus, where moisture contents were wet of optimum, they were appreciably wet of optimum. These data indicate that scarification and aeration methods may not be feasible to achieve satisfactory proof rolling and stabilization of the predominantly cohesive subgrades. However, scarification and aeration methods may be utilized in areas where granular subgrades wet of optimum are present, provided weather conditions and construction schedule will allow such soil modification.

The type and thickness of subgrade modification is determined by GB-1 criteria based on the average, low SPT $N_{60}$-value ($N_{60L}$) and hand penetrometer results for the subgrade soils, soil type, and moisture content. Based on these criteria, 1 boring each along Harroun Road, Ramp B, Ramp C, and SR 184 contained cohesive subgrade soils which indicated subgrade modification is likely to be required. Granular soils with potential need for recompaction were encountered in three borings performed along SR 51 and two borings along Ramp B.

Based on the GB-1 analysis results, subgrade modification may consider global chemical stabilization using cement to a depth of 12 inches, or over-excavation and replacement with new granular engineered fill. With more than 30 percent of the project indicating likely need for modification, ODOT GB-1 indicates that global chemical stabilization will likely be the more economical method of modification. However, consideration should be given to construction phases that may require multiple mobilizations of the chemical stabilization equipment that may negatively affect the economical nature of this method of subgrade modification.

As required by GB-1, sulfate content tests (ODOT Supplement 1122) were performed on a sample within the upper 3 feet of anticipated subgrade elevation. The sulfate content test results ranged from 350 parts per million (ppm) to less than 100 ppm. The results are summarized on the Logs of Test Borings and in the GB-1 Subgrade Analysis spreadsheet.

GB-1 indicates that chemical stabilization cannot be utilized when sulfate contents for the majority of the samples exceed 3,000 parts per million (ppm), or individual soil samples exhibit sulfate contents of greater than 5,000 ppm. All tested samples had a sulfate content on the order of 350 ppm or less. Based on GB-1 criteria, sulfate content would not be restrictive to considering global chemical stabilization.

If it is instead desired that subgrade modification consist of excavation and replacement with new granular engineered fill, a summary of the depths of undercut indicated by GB-1 analyses is presented in the following tables.

**Table 5.4. GB-1 Recommended Depth of Undercut and Replacement with Granular Engineered Fill**

| Boring Number | GB-1 Recommended Depth of Undercut and Replacement with Granular Engineered Fill (inches) | Recommended Subgrade Modification Extents | Approximate Project Segment Length (feet) |
|---|---|---|---|
| **Harroun Road** | | | |
| B-002-0 | 12 | Southern Project Extent to Northern Project Extent of Harroun Road | 100 |
| **SR 51** | | | |
| B-004-0 | None (Re-Compact In-Place) | Half Way Between B-003-0 and B-004-0 to Half Way Between B-004-0 and B-006-0 | 600 |
| B-010-0 & B-011-0 | None (Re-Compact In-Place) | West extent of approach to SR 51 over US 23 to Half Way Between B-011-0 and B-012-0 | 350 |
| **Ramp B** | | | |
| B-014-0 | 12 | Half Way Between B-012-0 and B-014-0 to Half Way Between B-014-0 and B-039-0 | 700 |
| B-040-0 & B-041-0 | None (Re-Compact In-Place) | Half Way Between B-039-0 and B-040-0 to Northern Project Extent of Ramp B | 550 |
| **Ramp C** | | | |
| B-017-0 | 15 | Entire Ramp C alignment 10+63 to 16+60 | 600 |
| **SR 184** | | | |
| B-032-0 | 22 | Half Way Between B-031-0 and B-032-0 to Half Way Between B-032-0 and B-033-0 | 250 |

It should be noted that, in the above tables, transitions were based on the location approximately half way between borings indicating areas of recommended treatment and borings indicating no treatment or varying undercut depth was required by GB-1 analyses.

Where undercut and replacement is utilized, all fill should consist of ODOT Item 304 Aggregate Base or Item 703.16C, Granular Material Type B or Type C. It is recommended that geotextile fabric (referenced in ODOT Item 204, and specified as ODOT Item 712.09, Type D) be utilized on the subgrade at the bottom of the undercut zone. If particularly unstable subgrades are encountered during construction, or undercuts are on the order of 18 inches or greater, a geogrid could be used to reduce the total undercut and replacement of the unsuitable soils by 6 inches.

It should be noted that GB-1 analyses are used as a pre-construction tool to plan subgrade modification alternatives. **Actual subgrade modification will depend on field observations of proof-rolling conditions at the time of construction.** Changes in soil moisture content could create more or less favorable subgrade conditions that may result in adjustments to subgrade modification or soil stabilization requirements at the time of construction.

### 5.5 Flexible (Asphalt) Pavement Design

The ODOT "Subgrade Analysis" worksheet for the entire project site resulted in a CBR value of 8 percent. It should be noted that the CBR determination by the GB-1 spreadsheet is based on an average Group Index (GI) of all the evaluated samples. The indicated average GI of 6 would correlate with a CBR of 7 percent, so the worksheet indicated CBR of 8 percent may be based on a slightly lower average GI that was rounded up to 6. With the average GI calculation resulting in correlation approximately half way between a CBR of 7 and 8 on the correlation chart above, **we recommend use of a CBR value of 7 percent for design.**

If global chemical stabilization is planned, a higher CBR value could be considered for design. However, we anticipate that the various phases of the project may not be conducive for global chemical stabilization. In this case, multiple mobilizations of the stabilization equipment would be required which could reduce the economic benefit of this method of modification. As such, design based on the CBR value of 7 percent should be utilized, considering subgrade modification may consist of over-excavation and replacement with new engineered fill.

It should also be noted that the design CBR value is based on subgrades compacted to at least 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor) or verified as stable through proof-rolling in accordance with Section 5.8.2 of this report.

All pavement design and paving operations should conform to ODOT specifications. The pavement and subgrade preparation procedures outlined in this report should result in a reasonably workable and satisfactory pavement. It should be recognized, however, that all pavements need repairs or overlays over time as a result of progressive yielding under repeated loading for a prolonged period.

It is recommended that proof rolling, placement of aggregate base, and placement of asphalt be performed within as short a time period as possible. Exposure of the aggregate base to rain, snow, or freezing conditions may lead to deterioration of the subgrade and/or base materials due to excessive moisture conditions and to difficulties in achieving the required compaction.

## 5.6 Rigid (Concrete) Pavement

We understand that rigid concrete pavement may be considered for ramps. For properly prepared subgrade soils, a modulus of subgrade reaction (k) of 165 pounds per cubic inch (pci) may be used for rigid pavement design (equivalent to the recommended design CBR of 7 presented in Section 5.5). This section should consist of a minimum of 6 inches of reinforced, air-entrained concrete with a minimum compressive strength of 4,000 pounds per square inch (psi) underlain by a minimum of 6 inches of a dense-graded aggregate base (ODOT Item 304). The pavement section should be supported on subgrade compacted to at least 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor) or verified as stable through proof rolling.

## 5.7 Construction Dewatering and Groundwater Control

Groundwater conditions encountered in the borings were summarized in Section 4.4. Based on the soil characteristics and moisture conditions encountered in the borings, it is our opinion that "normal" groundwater levels in the vicinity of Ottawa River will generally occur at Elevs. 612±, corresponding to depths at or slightly above the "normal" flow levels in Ottawa River. Transitioning to the northern portion of the site, near the SR 51 overpass of US 23, "normal" groundwater levels may be on the order of Elev. 623±. It should be noted that groundwater elevations can also fluctuate with seasonal and climatic influences, as well as streamflow conditions in the river. Additionally, perched water may be present in granular soils that are underlain by relatively impermeable cohesive soils.

Groundwater seepage, perched water, and surface water runoff into shallow excavations in predominantly cohesive soils should be controllable by pumping from prepared sumps. If excavations extend below the groundwater level in granular soils, installation of multiple well points may be required in addition to pumping from prepared sumps. Installation of the intermediate piers in Ottawa River may require temporary cofferdams to divert streamflow to manage groundwater in addition to pumping from prepared sumps. Otherwise, steel casing may also be used to help facilitate groundwater control. In any case, as mentioned in Section 5.2.3, it is likely that temporary steel casing will be required to support the walls of the drilled shafts, in addition to facilitating control groundwater seepage. In the event excessive seepage is encountered during construction, TTL should be notified to evaluate whether other dewatering methods are required.

## 5.8 Construction

### 5.8.1 Sediment 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.

### 5.8.2 Site and Subgrade Preparation

Site and subgrade preparation activities should conform to ODOT CMS Item 204 specifications. Prior to proceeding with construction operations, all structures, pavements, topsoil, root systems, vegetation, and other deleterious non-soil materials should be removed from the proposed construction areas.

Upon completion of the clearing and undercutting activities, all areas that are to receive fill, or that have been excavated to proposed final subgrade elevation, should be inspected by a geotechnical engineer.

Pavement subgrades should be proof rolled in accordance with ODOT CMS 204.06. The GB-1 analysis for areas where new roadway and ramp alignment approximate existing roadway alignment without significant grade change indicates that modification should be anticipated to be required. GB-1 evaluations indicate areas of re-compaction of granular soils as well as areas of undercuts generally on the order of 12 to 15 inches, and replacement with new granular engineered fill. Based on encountered A-4b soils at subgrade elevation in Boring B-032-0, deeper over-excavation should be planned in this area. Alternatively, global chemical stabilization using cement and extending to a depth of 12 inches may be an economical alternative.

With more than 30 percent of the project indicating likely need for modification, ODOT GB-1 indicates that global chemical stabilization will likely be the more economical method of modification. However, consideration should be given to construction phases that may require multiple mobilizations of the chemical stabilization equipment that may negatively affect the economical nature of this method of subgrade modification.

Where new embankment fill is placed to achieve pavement subgrade elevations, the subgrade soils should be suitable for support of the new pavements unless they are disturbed by weather or construction traffic.

#### 5.8.3 Fill

Material for engineered fill or backfill required to achieve design grades should meet ODOT Item 203 "Embankment Fill" placement and compaction requirements. Borrow materials used for fill at subgrade elevations should be similar to the encountered existing subgrade soils to maintain the subgrade support properties associated with the recommended design CBR value and k-value for pavement design.

The upper profile on-site soils predominantly consist of cohesive soils, although granular soils were also encountered at pavement subgrade elevations. For the cohesive soils, a sheepsfoot roller should provide the most effective soil compaction. Where granular soils are encountered or new dense-graded aggregate pavement base materials are placed, a vibratory smooth-drum roller would be required to provide effective compaction.

#### 5.8.4 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. In any case, applicable Occupational Safety and Health Administration (OSHA) safety standards must be followed.

Based on the encountered soils, excavation may encounter the following OSHA type soils:

- Type A soils (native cohesive soils with unconfined compressive strengths of 3,000 pounds per square foot (psf) or greater),
- Type B soils (native cohesive soils with unconfined compressive strengths greater than 1,000 psf but less than 3,000 psf, cohesive embankment fill, as well as dry rock that is not stable), and
- Type C soils (granular soils, submerged soil, as well as submerged rock).

For temporary excavations in Type A, B, and C soils, side slopes must be no steeper than ¾ horizontal to 1 vertical (¾H:1V), 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.

For permanent excavations and slopes, we recommend that grades generally be no steeper than 3H:1V. Based on the provided plans, embankment slopes are generally planned to be 2H:1V. It should be noted that ODOT routinely uses 2H:1V slopes for roadway embankments. While these steeper slopes may used, it should be noted that the embankment faces are more prone to erosion and sloughing. Additional discussions regarding GB-2 "Special Benching" and slope stability were presented in Sections 5.1.1 and 5.1.2, respectively.

## 6.0 QUALIFICATION OF RECOMMENDATIONS

Our evaluation of the embankment fill, foundation, retaining wall, and pavement design and construction conditions has been based on the data obtained during our field investigation, criteria in ODOT Geotechnical Bulletins GB-1 "Plan Subgrades" and GB-2 "Special Benching and Sidehill Embankment Fills," as well as furnished information about the proposed project. The general subsurface conditions were based on interpretation of the data obtained at specific boring locations. Regardless of the thoroughness of a subsurface exploration, 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. This potential is increased for previously developed sites. Therefore, experienced geotechnical engineers should observe earthwork and foundation construction to confirm that the conditions anticipated in design are noted. Otherwise, TTL 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. TTL is not responsible for the conclusions, opinions, or recommendations of others based on this data.

## Plates


## LEGEND

APPROXIMATE SITE LOCATION

N

APPROXIMATE SCALE – FEET

0 1,700 3,400

PLATE 1.0
SITE LOCATION MAP
PROPOSED INTERSECTION IMPROVEMENTS
LUC–023–11.75, PID 105889
SYLVANIA, LUCAS COUNTY, OHIO

PREPARED FOR
ARCADIS U.S., INC.
CLEVELAND, OHIO

| | | | |
|---|---|---|---|
| DRAWN | TRR/6–12–23 | CHECKED | CPI/6–18–23 |
| REVISED | TMK/6–19–23 | APPROVED | |
| JOB NO. | 2062501 | | |
| DRAWING NUMBER | 2065201–01G | | |

TTL associates inc
Environmental Geotechnical Engineering & Testing


N

MATCHLINE – SEE DRAWING NUMBER 2065201 -02.3G

LEGEND

B-001-0-21 APPROXIMATE TEST BORING LOCATION

B-003-0-19 APPROXIMATE HISTORIC BORING LOCATION

APPROXIMATE SCALE – FEET

0 220 440

PLATE 2.1

TEST BORING LOCATION PLAN – WEST

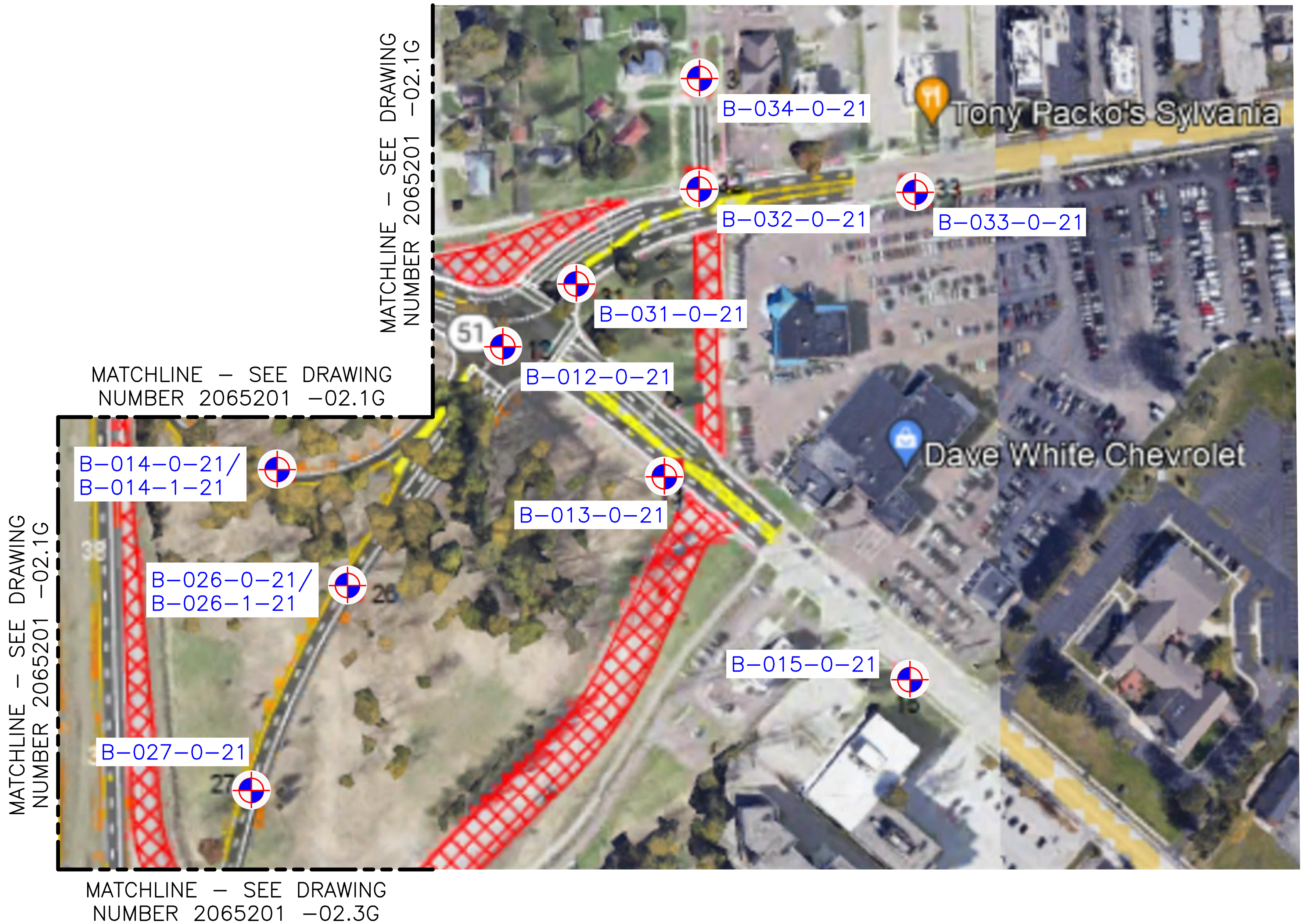
PROPOSED INTERSECTION IMPROVEMENTS
LUC-023-11.75, PID 105889
SYLVANIA, LUCAS COUNTY, OHIO

PREPARED FOR
ARCADIS U.S., INC.
CLEVELAND, OHIO

| | | | |
|---|---|---|---|
| DRAWN | TRR/6-13-23 | CHECKED | CPI/6-19-23 |
| REVISED | TMK/6-19-23 | APPROVED | |
| JOB NO. | 2065201 | | |
| DRAWING NUMBER | 2065201-02.1G | | |

TTL associates inc

BASE PLAN FOR IMAGE INCLUDING BORING B-004-0-21 TO THE WEST "LUC-23 PROPOSAL DISTANCES" PROVIDED VIA EMAIL FROM ARCADIS ON MARCH 28, 2021.
BASE PLAN FOR IMAGE EAST OF BORING B-004 -0-21 "LUC-23-11.75 – ALTERNATIVE B" PROVIDED VIA EMAIL FROM ARCADIS ON MARCH 21, 2022




N

LEGEND

B–012–0–21 APPROXIMATE TEST BORING LOCATION

APPROXIMATE SCALE – FEET
0 220 440

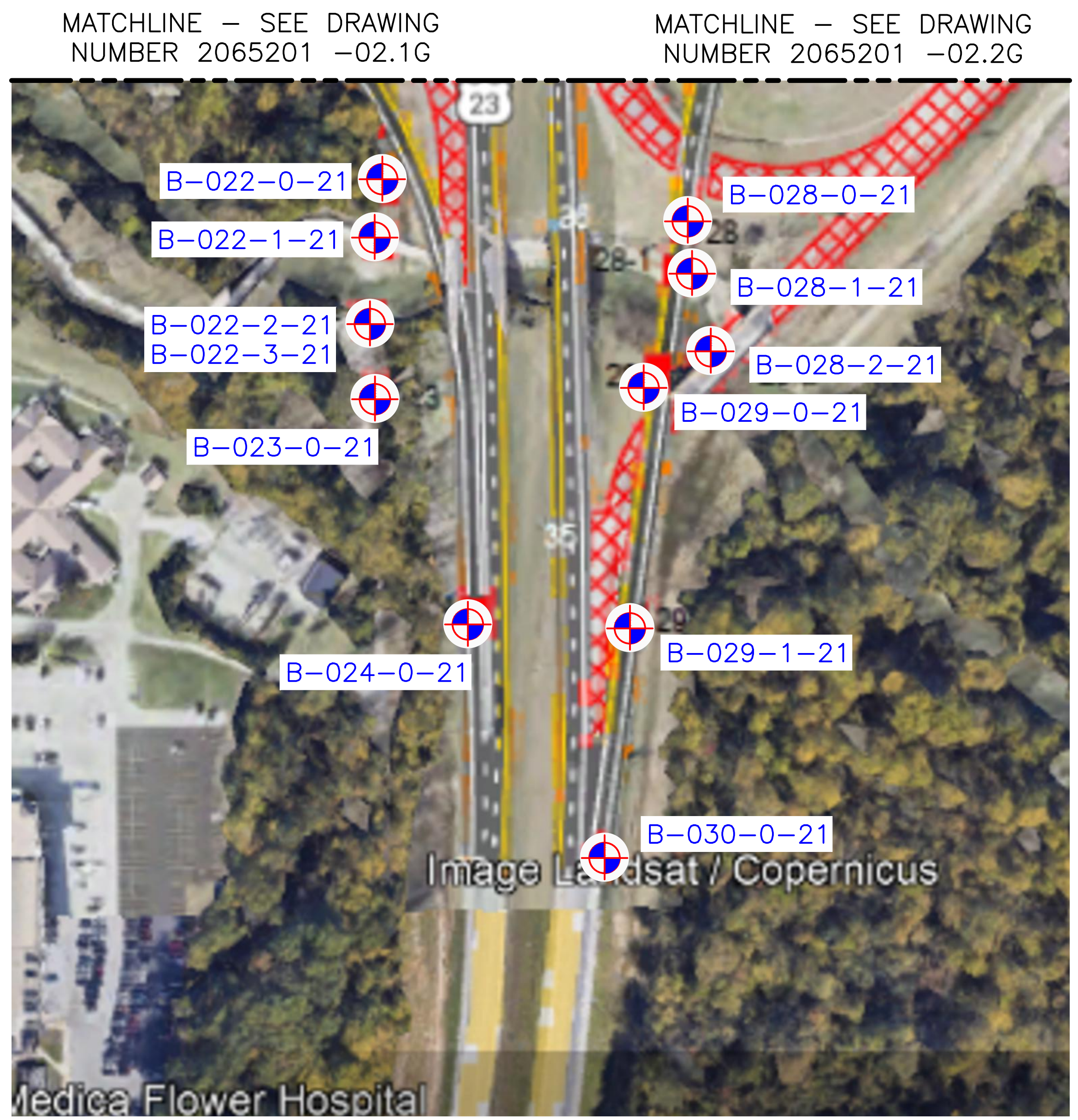
PLATE 2.2
TEST BORING LOCATION PLAN – EAST
PROPOSED INTERSECTION IMPROVEMENTS
LUC–023–11.75, PID 105889
SYLVANIA, LUCAS COUNTY, OHIO

PREPARED FOR
ARCADIS U.S., INC.
CLEVELAND, OHIO

| | | | |
|---|---|---|---|
| DRAWN | TRR/6–13–23 | CHECKED | CPI/6–19–23 |
| REVISED | TMK/6–19–23 | APPROVED | |
| JOB NO. | 2065201 | | |
| DRAWING NUMBER | 2065201–02.2G | | |

TTL associates inc

BASE PLAN FOR IMAGE "LUC–23–11.75 – ALTERNATIVE B" PROVIDED VIA EMAIL FROM ARCADIS ON MARCH 21, 2022.




LEGEND

B–022–0–21 APPROXIMATE TEST BORING LOCATION

APPROXIMATE SCALE – FEET
0 220 440

PLATE 2.3
TEST BORING LOCATION PLAN – SOUTH
PROPOSED INTERSECTION IMPROVEMENTS
LUC–023–11.75, PID 105889
SYLVANIA, LUCAS COUNTY, OHIO

PREPARED FOR
ARCADIS U.S., INC.
CLEVELAND, OHIO

| | | | |
|---|---|---|---|
| DRAWN | TMK/6–19–23 | CHECKED | CPI/6–19–23 |
| REVISED | | APPROVED | |
| JOB NO. | 2065201 | | |
| DRAWING NUMBER | 2065201–02.3G | | |

BASE PLAN FOR IMAGE "LUC–23–11.75 – ALTERNATIVE B" PROVIDED VIA EMAIL FROM ARCADIS ON MARCH 21, 2022.

# Figures

## Logs of Test Borings
## Legend Key

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-001-0-21 |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR51 | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 3/15/21 | ELEVATION: 644.1 (NAVD88) EOB: 8.5 ft. | PAGE 1 OF 1 |
| START: 11/1/21 END: 11/1/21 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 66 | COORD: 748612.8030 N, 1642099.9360 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 644.1 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 3.75 INCHES | 643.8 | | | | | | | | | | | | | | | | | | |
| CONCRETE - 9.75 INCHES | 643.0 | 1 | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 5.5 INCHES | 642.5 | 2 | 6 6 13 | 21 | 89 | SS-1 | 2.00 | 0 | 2 | 10 | 44 | 44 | 25 | 23 | 2 | 20 | A-4a (8) | 350 | |
| VERY STIFF, BROWN, **SANDY SILT**, "AND" CLAY, TRACE IRON OXIDE STAIN SEAM, DAMP<br>@2.5': LITTLE CLAY<br>@4': BROWN/GRAY, "AND" CLAY, MOIST | 638.8 | 3<br>4<br>5 | 10 16 18<br>14 16 18 | 37<br>37 | 100<br>100 | SS-2<br>SS-3 | -<br>3.50 | -<br>0 | -<br>1 | -<br>7 | -<br>38 | -<br>54 | -<br>27 | -<br>20 | -<br>7 | 18<br>21 | A-4a (V)<br>A-4a (8) | -<br>- | |
| VERY STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, MOIST | 636.9 | 6<br>7 | 7 8 12 | 22 | 100 | SS-4 | 2.50 | - | - | - | - | - | - | - | - | 20 | A-6a (V) | - | |
| HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP | 635.6 | 8<br>EOB | 11 17 22 | 43 | 100 | SS-5 | 4.25 | - | - | - | - | - | - | - | - | 12 | A-6a (V) | - | |



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75<br>TYPE: ROADWAY<br>PID: 105889 SFN: N/A<br>START: 11/1/21 END: 11/1/21 | DRILLING FIRM / OPERATOR: TTL / CW<br>SAMPLING FIRM / LOGGER: TTL / KKC<br>DRILLING METHOD: 3.5" SSA<br>SAMPLING METHOD: SPT | DRILL RIG: CME 75 TRUCK 844<br>HAMMER: CME AUTOMATIC<br>CALIBRATION DATE: 3/15/21<br>ENERGY RATIO (%): 66 | STATION / OFFSET:<br>ALIGNMENT: HARROUN RD<br>ELEVATION: 638.1 (NAVD88) EOB: 8.5 ft.<br>COORD: 748468.3670 N, 1642323.6210 E | EXPLORATION ID<br>B-002-0-21<br>PAGE<br>1 OF 1 |
|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 638.1 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 7.75 INCHES | 637.5 | | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 8.25 INCHES | 636.8 | 1 | | | | | | | | | | | | | | | | | |
| STIFF, BROWN, **SANDY SILT**, WITH CLAY, TRACE IRON OXIDE STAIN SEAM, DAMP | | 2 | 6 7 23 | 33 | 100 | SS-1 | 1.50 | 0 | 3 | 9 | 44 | 44 | 27 | 24 | 3 | 21 | A-4a (8) | - | |
| HARD, BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, TRACE IRON OXIDE STAIN SEAM, DAMP | 635.1 | 3 4 | 9 12 15 | 30 | 100 | SS-2 | >4.5 | 1 | 2 | 5 | 24 | 68 | 31 | 20 | 11 | 20 | A-6a (8) | 310 | |
| | | 5 | 7 15 17 | 35 | 100 | SS-3 | >4.5 | - | - | - | - | - | - | - | - | 14 | A-6a (V) | - | |
| | | 6 7 | 12 15 16 | 34 | 100 | SS-4 | >4.5 | - | - | - | - | - | - | - | - | 14 | A-6a (V) | - | |
| | 629.6 | 8 EOB | 10 12 18 | 33 | 100 | SS-5 | >4.5 | - | - | - | - | - | - | - | - | 14 | A-6a (V) | - | |

DRAFT

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-003-0-21 |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR51 | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 641.7 (NAVD88) EOB: 7.5 ft. | PAGE 1 OF 1 |
| START: 1/27/23 END: 1/27/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 748576.6860 N, 1642613.9040 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 641.7 |
|---|---|
| ASPHALT - 6 INCHES | 641.2 |
| CONCRETE - 10 INCHES | 640.4 |
| MEDIUM DENSE, BROWN, **FINE SAND**, TRACE SILT, TRACE CLAY, DAMP (FILL) | 637.7 |
| VERY STIFF, BROWN, **SANDY SILT**, LITTLE GRAVEL (CRUSHED STONE), TRACE CLAY, DAMP (FILL) | 637.2 |
| MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, MOIST (FILL) | 635.2 |
| MEDIUM STIFF, BLACK/BROWN, **SILTY CLAY**, SOME ASPHALT FRAGMENTS, LITTLE SAND, TRACE GRAVEL (CRUSHED STONE), MOIST (FILL) | 634.2 |

EOB

| DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 - 3 | 7 13 11 | 29 | 100 | SS-1 | - | 0 | 7 | 83 | 8 | 2 | NP | NP | NP | 5 | A-3 (0) | <100 | |
| 3 - 4.5 | 11 6 6 | 15 | 89 | SS-2A | - | - | - | - | - | - | - | - | - | - | A-3 (V) | - | |
| | | | | SS-2B | 2.75 | 8 | 12 | 33 | 42 | 5 | 20 | 15 | 5 | 15 | A-4a (2) | - | |
| 4.5 - 6 | 4 5 8 | 16 | 100 | SS-3 | - | - | - | - | - | - | - | - | - | 18 | A-3a (V) | - | |
| 6 - 7.5 | 5 5 3 | 10 | 100 | SS-4A | - | - | - | - | - | - | - | - | - | 11 | A-3a (V) | - | |
| | | | | SS-4B | 0.75 | - | - | - | - | - | - | - | - | 21 | A-6b (V) | - | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-004-0-21 |
|---|---|---|---|---|
| TYPE: LIGHT TOWER | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR51 | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 643.6 (NAVD88) EOB: 18.8 ft. | PAGE 1 OF 1 |
| START: 1/27/23 END: 1/27/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 748561.9540 N, 1643263.3670 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 643.6 | DEPTHS |
|---|---|---|
| ASPHALT - 6.5 INCHES | 643.1 | |
| CONCRETE - 9.5 INCHES | 642.3 | |
| MEDIUM DENSE, GRAY/BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE GRAVEL (CRUSHED STONE), TRACE CLAY, DAMP (FILL) | 639.6 | |
| STIFF, BROWN/GRAY, **SANDY SILT**, SOME GRAVEL (CRUSHED STONE), LITTLE CLAY, DAMP (FILL) | 639.1 | |
| STIFF, BROWN, **SANDY SILT**, AND CLAY, TRACE GRAVEL, MOIST<br>@6': WET<br>@8.5': BROWN/GRAY | 633.2 | W 633.2 |
| STIFF, GRAY, **SANDY SILT**, "AND" CLAY, MOIST<br>@13': VERY STIFF, TRACE GRAVEL, DAMP | 627.6 | |
| HARD, GRAY, **SILT AND CLAY**, LITTLE GRAVEL, LITTLE SAND, DAMP | 626.1 | TR |
| GRAY, **WEATHERED DOLOMITE** | 624.8 | EOB |

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 4 6 | 12 | 100 | SS-1 | - | 6 | 8 | 65 | 19 | 2 | NP | NP | NP | 10 | A-3a (0) | - |
| 3 12 13 | 30 | 100 | SS-2A | - | - | - | - | - | - | - | - | - | 10 | A-3a (V) | - |
| | | | SS-2B | 1.75 | 28 | 5 | 16 | 37 | 14 | 24 | 18 | 6 | 14 | A-4a (3) | 290 |
| 7 12 12 | 29 | 100 | SS-3 | 3.00 | 2 | 1 | 3 | 44 | 50 | 25 | 18 | 7 | 20 | A-4a (8) | - |
| 12 10 9 | 23 | 100 | SS-4 | 1.50 | - | - | - | - | - | - | - | - | 22 | A-4a (V) | - |
| 5 6 7 | 16 | 100 | SS-5 | 1.25 | - | - | - | - | - | - | - | - | 23 | A-4a (V) | - |
| 6 7 7 | 17 | 100 | SS-6 | 1.50 | 0 | 2 | 4 | 37 | 57 | 26 | 18 | 8 | 22 | A-4a (8) | - |
| 4 5 7 | 15 | 100 | SS-7 | 2.50 | - | - | - | - | - | - | - | - | 14 | A-4a (V) | - |
| 13 15 32 | 57 | 100 | SS-8 | 4.50 | - | - | - | - | - | - | - | - | 11 | A-6a (V) | - |
| 50/1" | - | 100 | SS-9 | - | - | - | - | - | - | - | - | - | 3 | Rock (V) | - |

NOTES: AUGER REFUSAL AT 18.8 FT.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

| | | | |
|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: |
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR51 |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 3/15/21 | ELEVATION: 650.9 (NAVD88) EOB: 4.5 ft. |
| START: 11/10/21 END: 11/10/21 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 66 | COORD: 748547.3130 N, 1643889.3010 E |

EXPLORATION ID B-006-0-21



| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 650.9 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 2 INCHES | 650.7 | | | | | | | | | | | | | | | | | | |
| CONCRETE - 13.5 INCHES | 649.6 | 1 | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 5.5 INCHES | 649.1 | 2 | 10 7 7 | 15 | 83 | SS-1 | 1.00 | - | - | - | - | - | - | - | - | 17 | A-4a (V) | - | |
| STIFF, BROWN/GRAY, **SANDY SILT**, "AND" CLAY, DAMP (EMBANKMENT FILL) | 646.4 | 3 4 EOB | 4 6 7 | 14 | 100 | SS-2 | 2.00 | 0 | 3 | 11 | 42 | 44 | 24 | 20 | 4 | 19 | A-4a (8) | 320 | |



NOTES: BORING TERMINATED AT 4.5' DUE TO CONCRETE AND REINFORCEMENT STEEL. SEE B-006-1-21 FOR OFFSET BORING.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-006-1-21 |
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR51 | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ2 | CALIBRATION DATE: 3/15/21 | ELEVATION: 652.0 (NAVD88) EOB: 58.8 ft. | PAGE 1 OF 2 |
| START: 11/10/21 END: 11/10/21 | SAMPLING METHOD: SPT / ST / NQ2 | ENERGY RATIO (%): 66 | COORD: 748545.1510 N, 1643880.0160 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 652.0 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEE B-006-0-21 | 647.5 | 1–4 | | | | | | | | | | | | | | | | | |
| VERY STIFF, GRAY, **SANDY SILT**, LITTLE CLAY, DAMP (EMBANKMENT FILL) | 646.0 | 5 | 10 18 22 | 44 | 89 | SS-1 | 2.00 | - | - | - | - | - | - | - | - | 15 | A-4a (V) | - | |
| VERY STIFF, GRAY, **SANDY SILT**, "AND" CLAY, DAMP (EMBANKMENT FILL) | 644.0 | 7 | 7 7 14 | 23 | 89 | SS-2 | 3.50 | 0 | 2 | 7 | 44 | 47 | 25 | 21 | 4 | 16 | A-4a (8) | - | |
| HARD, GRAY, **SANDY SILT**, "AND" CLAY, DAMP | 642.0 | 9 | 8 15 11 | 29 | 100 | SS-3 | >4.5 | - | - | - | - | - | - | - | - | 18 | A-4a (V) | - | |
| MEDIUM STIFF TO STIFF, GRAY, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, DAMP<br>@11': Qu = 8.5 PSI = 0.61 TSF | 639.0 | 12 | 8 4 3 | 8 | 100 | SS-4 | 1.25 | - | - | - | - | - | - | - | - | 19 | A-4a (V) | - | |
| STIFF, BROWN, **SANDY SILT**, "AND" CLAY, TRACE IRON OXIDE STAIN SEAM, DAMP | 636.0 | 14 | 11 19 21 | 44 | 100 | SS-5 | 1.50 | 0 | 2 | 6 | 40 | 52 | 26 | 23 | 3 | 16 | A-4a (8) | - | |
| HARD, GRAY, **SANDY SILT**, "AND" CLAY, DAMP | 634.0 | 17 | 6 12 12 | 26 | 100 | SS-6 | >4.5 | - | - | - | - | - | - | - | - | 18 | A-4a (V) | - | |
| VERY STIFF, GRAY, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, MOIST | 631.0 | 19 | 6 6 3 | 10 | 100 | SS-7 | 2.50 | 1 | 1 | 4 | 21 | 73 | 51 | 26 | 25 | 31 | A-7-6 (16) | - | |
| STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST | | 22 | 1 3 4 | 8 | 100 | SS-8 | 1.75 | - | - | - | - | - | - | - | - | 17 | A-6a (V) | - | |
| @23': VERY STIFF, SOME SAND, Qu = 33.8 PSI = 2.43 TSF | 626.0 | 24 | | | 96 | ST-9 | 3.50 | 9 | 6 | 14 | 27 | 44 | 25 | 14 | 11 | 14 | A-6a (8) | - | |
| HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST | 623.0 | 27 | 8 18 32 | 55 | 89 | SS-10 | >4.5 | - | - | - | - | - | - | - | - | 11 | A-6a (V) | - | |
| GRAY, **WEATHERED DOLOMITE WITH SAND, SILT, AND CLAY** | | TR 29 | 11 50/5" | - | 36 | SS-11 | - | - | - | - | - | - | - | - | - | 10 | A-2-6 (V) | - | |

| PID: 105889 | SFN: N/A | PROJECT: LUC-23-11.75 | STATION / OFFSET: | START: 11/10/21 | END: 11/10/21 | PG 2 OF 2 | B-006-1-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 621.0 |
|---|---|
| GRAY, **WEATHERED DOLOMITE WITH SAND, SILT, AND CLAY** *(continued)* | 614.0 |
| **DOLOMITE**, GRAY, HIGHLY TO SLIGHTLY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, OPEN; RQD 0%, REC 100%. | 612.6 |
| **DOLOMITE**, GRAY, SEVERELY TO HIGHLY WEATHERED, STRONG, VUGGY, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 14%, REC 51%. @39.7': Qu = 11920 PSI | 609.6 |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, OPEN TO NARROW; RQD 0%, REC 20%. | 604.6 |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, OPEN TO NARROW; RQD 0%, REC 61%. | 601.5 |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO TIGHT; RQD 42%, REC 100%. @50.9' Qu = 14280 PSI | 600.5 |
| **DOLOMITE**, GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED AND SLIGHTLY FRACTURED, OPEN TO TIGHT; RQD 31%, REC 33%. @51.6' Qu = 11110 PSI | 597.0 |
| **DOLOMITE**, GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, STRONG, VUGGY, JOINTED - SLIGHTLY FRACTURED, TIGHT; RQD 100%, REC 100%. | 595.0 |
| **LIMESTONE**, GRAY, HIGHLY WEATHERED, STRONG, VUGGY, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN; RQD 19%, REC 100%. | 593.2 |

DEPTHS: 32 – 58; W 614.0; EOB

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 50/5" | - | 36 | SS-12 | - | - | - | - | - | - | - | - | - | 5 | A-2-6 (V) | - | |
| 9 | | 65 | NQ-1 | | | | | | | | | | | CORE | | |
| 0 | | 20 | NQ-2 | | | | | | | | | | | CORE | | |
| 0 | | 61 | NQ-3 | | | | | | | | | | | CORE | | |
| 33 | | 48 | NQ-4 | | | | | | | | | | | CORE | | |
| 62 | | 100 | NQ-5 | | | | | | | | | | | CORE | | |

NOTES: BORING MOVED 8' WEST OF B-006-0-21.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 12 CF CEMENT-BENTONITE GROUT

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / JW | DRILL RIG: CME 550X ATV | STATION / OFFSET: | EXPLORATION ID B-008-0-21 |
|---|---|---|---|---|
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR51 | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ | CALIBRATION DATE: 2/20/23 | ELEVATION: 630.8 (NAVD88) EOB: 30.8 ft. | PAGE 1 OF 2 |
| START: 4/12/23 END: 4/12/23 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 75.2 | COORD: 748523.6960 N, 1644052.5540 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 630.8 | DEPTHS |
|---|---|---|
| TOPSOIL - 5 INCHES | 630.4 | |
| VERY STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, TRACE ORGANICS, MOIST | 627.3 | ▼ |
| STIFF, BROWN, **SANDY SILT**, "AND" CLAY, MOIST | 624.3 | |
| HARD, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP | 622.8 | |
| HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP | 619.3 | |
| VERY DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, LITTLE DOLOMITE FRAGMENTS, TRACE CLAY, DAMP | 617.3 | |
| GRAY, **WEATHERED DOLOMITE WITH SAND AND SILT** | 616.8 | W TR 616.8 |
| **DOLOMITE**, GRAY, MODERATELY TO HIGHLY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW TO TIGHT; RQD 0%, REC 100%.<br>@16.8': Qu = 18780 PSI<br>@17' TO 17.8': VUGGY | 611.9 | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 22%, REC 76%. @18.9': Qu = 19980 PSI | 607.8 | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW TO TIGHT; RQD 14%, REC 49%. | 604.9 | |
| **DOLOMITE**, GRAY, HIGHLY WEATHERED, MODERATELY STRONG TO STRONG, JOINTED - HIGHLY FRACTURED, NARROW TO TIGHT; RQD 0%, REC 100%. | 602.9 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 80%, REC 100%. | 601.6 | |
| | 599.9 | EOB |

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 3 4 | 9 | 78 | SS-1 | 2.50 | - | - | - | - | - | - | - | - | 18 | A-4a (V) | - | |
| 2 2 2 | 5 | 100 | SS-2 | 1.75 | 0 | 3 | 12 | 44 | 41 | 21 | 18 | 3 | 22 | A-4a (8) | - | |
| 2 10 21 | 39 | 89 | SS-3A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| | | | SS-3B | 4.50 | - | - | - | - | - | - | - | - | 12 | A-4a (V) | - | |
| 7 19 20 | 49 | 89 | SS-4 | 4.50 | 1 | 7 | 12 | 22 | 58 | 26 | 15 | 11 | 10 | A-6a (8) | - | |
| 17 50 | - | 83 | SS-5A | - | - | - | - | - | - | - | - | - | - | A-6a (V) | - | |
| | | | SS-5B | - | - | - | - | - | - | - | - | - | 7 | A-3a (V) | - | |
| 50/5" | - | 100 | SS-6 | - | - | - | - | - | - | - | - | - | 4 | A-2-4 (V) | - | |
| 0 | | 100 | NQ-1 | | | | | | | | | | | CORE | | |
| 18 | | 80 | NQ-2 | | | | | | | | | | | CORE | | |
| 15 | | 52 | NQ-3 | | | | | | | | | | | CORE | | |
| 20 | | 90 | NQ-4 | | | | | | | | | | | CORE | | |

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 6/29/23 13:54 - S:\PROJECTS\2065201.GPJ

| PID: 105889 | SFN: N/A | PROJECT: LUC-23-11.75 | STATION / OFFSET: | START: 4/12/23 | END: 4/12/23 | PG 2 OF 2 | B-008-0-21 |
|---|---|---|---|---|---|---|---|

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 599.8 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| @28': Qu = 17720 PSI | | | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, MODERATELY TO HIGHLY WEATHERED, MODERATELY STRONG TO STRONG, JOINTED - HIGHLY FRACTURED, NARROW; RQD 0%, REC 75%. | | | | | | | | | | | | | | | | | | | |

DRAFT

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 5 CF CEMENT-BENTONITE GROUT

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 6/29/23 13:54 - S:\PROJECTS\2065201.GPJ

| | | | |
|---|---|---|---|
| PROJECT: LUC-23-11.75<br>TYPE: BRIDGE<br>PID: 105889 SFN: N/A<br>START: 11/11/21 END: 11/11/21 | DRILLING FIRM / OPERATOR: TTL / TB<br>SAMPLING FIRM / LOGGER: TTL / KKC<br>DRILLING METHOD: 3.25" HSA / NQ2<br>SAMPLING METHOD: SPT / ST / NQ2 | DRILL RIG: CME 75 TRUCK 844<br>HAMMER: CME AUTOMATIC<br>CALIBRATION DATE: 3/15/21<br>ENERGY RATIO (%): 66 | STATION / OFFSET:<br>ALIGNMENT: SR51<br>ELEVATION: 651.0 (NAVD88) EOB: 55.2 ft.<br>COORD: 748529.7590 N, 1644265.8640 E |

EXPLORATION ID B-010-0-21



| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 651.0 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 2.5 INCHES | 650.8 | | | | | | | | | | | | | | | | | | |
| CONCRETE - 9 INCHES | 650.1 | 1 | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 9 INCHES | 649.3 | 2 | 3-5-6 | 12 | 78 | SS-1 | 1.50 | 0 | 1 | 6 | 43 | 50 | 23 | 21 | 2 | 20 | A-4a (8) | 320 | |
| STIFF, BROWN/GRAY, **SANDY SILT**, "AND" CLAY, MOIST (EMBANKMENT FILL)<br>@3': VERY STIFF, GRAY, SOME CLAY, DAMP | | 3-4 | 1-1-11 | 13 | 83 | SS-2 | 3.00 | - | - | - | - | - | - | - | - | 14 | A-4a (V) | - | |
| @4.5': "AND" CLAY, TRACE GRAVEL | | 5-6 | 15-18-19 | 41 | 100 | SS-3 | 2.50 | 1 | 0 | 7 | 41 | 51 | 24 | 21 | 3 | 14 | A-4a (8) | - | |
| | 643.0 | 7-8 | 9-14-13 | 30 | 100 | SS-4 | 2.75 | - | - | - | - | - | - | - | - | 13 | A-4a (V) | - | |
| MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, MOIST (EMBANKMENT FILL) | 640.0 | 9-10 | 5-12-14 | 29 | 100 | SS-5 | - | - | - | - | - | - | - | - | - | 11 | A-3a (V) | - | |
| VERY STIFF, BROWN, **SANDY SILT**, "AND" CLAY, TRACE ORGANICS, DAMP | 638.0 | 11-12 | 2-4-7 | 12 | 83 | SS-6 | 3.00 | 0 | 2 | 15 | 39 | 44 | 26 | 22 | 4 | 20 | A-4a (8) | - | |
| STIFF, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP Qu = 15.0 PSI = 1.08 TSF<br>@14.8': GRAY | 635.0 | 13-15 | 1-2-3 | 6 | 94 | SS-7 | 1.25 | - | - | - | - | - | - | - | - | 20 | A-6a (V) | - | |
| MEDIUM STIFF, BROWN/GRAY, **SANDY SILT**, SOME CLAY, MOIST | 633.0 | W 635.0 ▼ 16-17 | 2-4-7 | 12 | 100 | SS-8 | 0.50 | - | - | - | - | - | - | - | - | 22 | A-4a (V) | - | |
| STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, MOIST | 630.0 | 18-20 | 6-6-3 | 10 | 100 | SS-9 | 1.50 | - | - | - | - | - | - | - | - | 26 | A-6a (V) | - | |
| STIFF, GRAY, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, MOIST | | 21-22 | 2-3-2 | 6 | 100 | SS-10 | 1.50 | 1 | 1 | 4 | 21 | 73 | 41 | 22 | 19 | 30 | A-7-6 (12) | - | |
| @23.5': VERY STIFF, DAMP | 625.0 | 23-25 | 2-3-4 | 8 | 100 | SS-11 | 2.50 | - | - | - | - | - | - | - | - | 17 | A-7-6 (V) | - | |
| VERY STIFF, BROWN/GRAY, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, MOIST Qu = 36.1 PSI = 2.60 TSF | 623.0 | 26-27 | | | 88 | ST-12 | 3.25 | 10 | 6 | 18 | 25 | 41 | 25 | 13 | 12 | 13 | A-6a (7) | - | |
| HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP | | 28-30 | 16-33-31 | 70 | 100 | SS-13 | >4.5 | - | - | - | - | - | - | - | - | 10 | A-6a (V) | - | |

| PID: 105889 | SFN: N/A | PROJECT: LUC-23-11.75 | STATION / OFFSET: | START: 11/11/21 | END: 11/11/21 | PG 2 OF 2 | B-010-0-21 |
|---|---|---|---|---|---|---|---|

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 620.0 | DEPTHS |
|---|---|---|
| HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP *(continued)*<br>@34': SOME SAND, TRACE DOLOMITE FRAGMENTS | 615.6 | TR |
| **DOLOMITE**, GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 52%, REC 100%. | 614.7 | |
| **DOLOMITE**, GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 67%, REC 100%.<br>@36.9': Qu = 18020 PSI | 613.6 | |
| **DOLOMITE**, GRAY, MODERATELY TO SLIGHTLY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO TIGHT; RQD 19%, REC 45%. | 610.8 | |
| **DOLOMITE**, GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY STRONG, SHALEY LAMINAE, JOINTED - HIGHLY FRACTURED AND MODERATELY FRACTURED, OPEN TO TIGHT; RQD 67%, REC 100%.<br>@40.4': Qu = 19190 PSI | 609.3 | |
| **DOLOMITE**, GRAY, HIGHLY TO MODERATELY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN; RQD 24%, REC 74%. | 605.8 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN AND TIGHT; RQD 65%, REC 100%.<br>@45.4': Qu = 17110 PSI | 603.2 | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY STRONG, SHALEY LAMINAE, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO NARROW; RQD 31%, REC 79%. | 600.8 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, STRONG, VUGGY, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 48%, REC 100%.<br>@50.3': Qu = 12270 PSI | 598.6 | |
| **DOLOMITE**, GRAY, MODERATELY TO HIGHLY WEATHERED, STRONG, VUGGY, JOINTED - HIGHLY FRACTURED TO FRACTURED, OPEN TO NARROW; RQD 29%, REC 100%. | 597.4 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, STRONG, VUGGY, JOINTED - MODERATELY FRACTURED, TIGHT; RQD 58%, REC 58%. | 595.8 | EOB |

| DEPTH | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | 35<br>50/3" | - | 89 | SS-14 | >4.5 | - | - | - | - | - | - | - | - | 7 | A-6a (V) | - | |
| 35–40 | 36 | | 69 | NQ-1 | | | | | | | | | | | CORE | | |
| 40–45 | 37 | | 82 | NQ-2 | | | | | | | | | | | CORE | | |
| 45–50 | 48 | | 90 | NQ-3 | | | | | | | | | | | CORE | | |
| 50–55 | 48 | | 87 | NQ-4 | | | | | | | | | | | CORE | | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 11 CF CEMENT-BENTONITE GROUT

| | | | |
|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR51 |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 648.1 (NAVD88) EOB: 6.4 ft. |
| START: 2/1/23 END: 2/1/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 748499.6340 N, 1644465.8300 E |

EXPLORATION ID B-011-0-21

PAGE 1 OF 1

| MATERIAL DESCRIPTION AND NOTES | ELEV. 648.1 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 6 INCHES | 647.6 | | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 11 INCHES | 646.7 | 1 | | | | | | | | | | | | | | | | | |
| HARD, GRAY, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, DAMP (EMBANKMENT FILL) | | 2 | 9 12 15 | 33 | 100 | SS-1 | - | 1 | 2 | 10 | 43 | 44 | 23 | 19 | 4 | 15 | A-4a (8) | 200 | |
| HARD, BROWN/GRAY, **SANDY SILT**, "AND" CLAY, MOIST @3': BROWN/GRAY | | 3, 4 | 13 15 17 | 39 | 100 | SS-2 | - | 0 | 4 | 14 | 41 | 41 | 23 | 19 | 4 | 14 | A-4a (8) | - | |
| | 642.6 | 5 | 17 19 24 | 52 | 100 | SS-3A | - | - | - | - | - | - | - | - | - | 14 | A-4a (V) | - | |
| VERY DENSE, BROWN, **FINE SAND**, TRACE GRAVEL AND ROCK FRAGMENTS, TRACE SILT, TRACE CLAY, MOIST | 641.7 | 6 | | | | SS-3B | - | - | - | - | - | - | - | - | - | - | A-3 (V) | - | |
| | | EOB | 50/5" | - | 100 | SS-4 | - | - | - | - | - | - | - | - | - | 12 | A-3 (V) | - | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-012-0-21 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR51 | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 645.4 (NAVD88) EOB: 10.0 ft. | PAGE 1 OF 1 |
| START: 2/1/23 END: 2/1/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 748442.5000 N, 1644715.4850 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 645.4 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 6 INCHES | 644.9 | | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 11 INCHES | 644.0 | 1 | | | | | | | | | | | | | | | | | |
| VERY STIFF, BROWN/GRAY, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, DAMP (EMBANKMENT FILL) | | 2 | 19 9 13 | 27 | 100 | SS-1 | - | 8 | 1 | 9 | 41 | 41 | 23 | 18 | 5 | 15 | A-4a (8) | 190 | |
| | | 3 | | | | | | | | | | | | | | | | | |
| @3.5': GRAY, SOME CLAY, TRACE WOOD (ORGANIC CONTENT = 2.0%) | 640.4 | 4 | 10 11 13 | 29 | 100 | SS-2 | - | 1 | 3 | 18 | 43 | 35 | 22 | 18 | 4 | 17 | A-4a (8) | - | |
| VERY STIFF, BROWN, **SILT AND CLAY**, TRACE SAND, MOIST | | 5 | | | | | | | | | | | | | | | | | |
| | | 6–7 | 13 12 12 | 29 | 100 | SS-3A | - | - | - | - | - | - | - | - | - | 24 | A-6a (V) | - | |
| | | | | | | SS-3B | 2.00 | - | - | - | - | - | - | - | - | 22 | A-6a (V) | - | |
| | | 8 | | | | | | | | | | | | | | | | | |
| @8.5': STIFF | 635.4 | 9 | 5 4 4 | 10 | 100 | SS-4 | 1.25 | - | - | - | - | - | - | - | - | 24 | A-6a (V) | - | |
| | | EOB 10 | | | | | | | | | | | | | | | | | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| | | | |
|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: |
| TYPE: LIGHT TOWER | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR51 |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 643.3 (NAVD88) EOB: 25.0 ft. |
| START: 2/1/23 END: 2/1/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 748256.3160 N, 1644964.6350 E |

EXPLORATION ID B-013-0-21

PAGE 1 OF 1

| MATERIAL DESCRIPTION AND NOTES | ELEV. 643.3 |
|---|---|
| ASPHALT - 3 INCHES | 643.0 |
| CONCRETE - 9 INCHES | 642.3 |
| VERY STIFF, GRAY, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, DAMP<br>@3': LITTLE CLAY | 638.3 |
| DENSE, GRAY, **FINE SAND**, LITTLE ROCK FRAGMENTS, TRACE SILT, TRACE CLAY, MOIST | 637.3 |
| LOOSE, GRAY, **COARSE AND FINE SAND**, LITTLE SILT, TRACE GRAVEL, TRACE CLAY, MOIST | 634.3 |
| STIFF, BROWN, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, WET<br>@11': VERY STIFF | 630.3 |
| DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, MOIST | 627.3 |
| STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST Qu = 14.6 PSI = 1.05 TSF<br>@18.5': DAMP | 622.3 |
| STIFF, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP | 620.3 |
| HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP | 618.3 |

DEPTHS: 1–25; EOB

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 6 8 | 17 | 100 | SS-1 | - | 4 | 1 | 10 | 42 | 43 | 23 | 18 | 5 | 14 | A-4a (8) | - |
| 7 9 14 | 28 | 100 | SS-2 | - | 7 | 4 | 28 | 43 | 18 | 17 | 15 | 2 | 13 | A-4a (5) | 240 |
| 17 20 15 | 43 | 94 | SS-3 | - | - | - | - | - | - | - | - | - | 12 | A-3 (V) | - |
| 2 3 4 | 9 | 100 | SS-4 | - | - | - | - | - | - | - | - | - | 19 | A-3a (V) | - |
| 3 4 4 | 10 | 100 | SS-5 | - | 1 | 3 | 25 | 47 | 24 | 20 | 18 | 2 | 24 | A-4a (7) | - |
| 5 7 12 | 23 | 100 | SS-6 | - | - | - | - | - | - | - | - | - | 20 | A-4a (V) | - |
| 11 17 17 | 41 | 100 | SS-7 | - | - | - | - | - | - | - | - | - | 18 | A-3a (V) | - |
| 3 4 4 | 10 | 100 | SS-8 | 1.25 | 4 | 3 | 8 | 20 | 65 | 30 | 16 | 14 | 22 | A-6a (10) | - |
| 2 2 4 | 7 | 100 | SS-9 | 1.25 | - | - | - | - | - | - | - | - | 15 | A-6a (V) | - |
| 7 9 11 | 24 | 100 | SS-10 | 1.75 | - | - | - | - | - | - | - | - | 15 | A-6b (V) | - |
| 20 40 50 | 109 | 100 | SS-11 | - | 5 | 6 | 12 | 20 | 57 | 25 | 14 | 11 | 9 | A-6a (8) | - |

BACK FILL



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / JW | DRILL RIG: CME 550X ATV | STATION / OFFSET: | EXPLORATION ID B-014-0-21 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP B | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 634.8 (NAVD88) EOB: 15.0 ft. | PAGE 1 OF 1 |
| START: 4/11/23 END: 4/11/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 75.2 | COORD: 748227.7220 N, 1644385.4150 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 634.8 | DEPTHS |
|---|---|---|
| TOPSOIL - 5 INCHES | 634.4 | |
| MEDIUM STIFF, BROWN, **SANDY SILT**, "AND" CLAY, MOIST<br>@3.5': VERY STIFF | 628.1 | |
| STIFF TO VERY STIFF, BROWN, **SILTY CLAY**, TRACE SAND, MOIST Qu = 16.0 PSI = 1.15 TSF | 626.8 | |
| HARD, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST<br>@11.8': STIFF, GRAY, DAMP, Qu = 18.0 PSI = 1.30 TSF | 621.0 | |
| HARD, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP | 619.8 | EOB 15 |

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 4 5 | 11 | 78 | SS-1 | 0.75 | 0 | 2 | 6 | 48 | 44 | 24 | 19 | 5 | 21 | A-4a (8) | - | |
| 4 7 7 | 18 | 89 | SS-2 | 2.25 | - | - | - | - | - | - | - | - | 19 | A-4a (V) | - | |
| 2 4 5 | 11 | 83 | SS-3A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| | | | SS-3B | 2.50 | 0 | 5 | 3 | 24 | 68 | 40 | 19 | 21 | 24 | A-6b (12) | 250 | |
| 3 7 10 | 21 | 100 | SS-4 | 4.25 | 4 | 7 | 11 | 22 | 56 | 31 | 16 | 15 | 17 | A-6a (10) | - | |
| 5 6 8 | 18 | 100 | SS-5 | 2.00 | - | - | - | - | - | - | - | - | 14 | A-6a (V) | - | |
| 6 24 48 | 90 | 89 | SS-6A | - | - | - | - | - | - | - | - | - | - | A-6a (V) | - | |
| | | | SS-6B | 4.50 | - | - | - | - | - | - | - | - | 8 | A-4a (V) | - | |

NOTES: SEE LOG FOR B-014-1-21 FOR OFFSET BORING TO OBTAIN SHELBY TUBE SAMPLES.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 4 CF CEMENT-BENTONITE GROUT

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / JW | DRILL RIG: CME 550X ATV | STATION / OFFSET: | EXPLORATION ID B-014-1-21 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP B | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 635.5 (NAVD88) EOB: 12.0 ft. | PAGE |
| START: 4/19/23 END: 4/19/23 | SAMPLING METHOD: ST | ENERGY RATIO (%): 75.2 | COORD: 748231.8050 N, 1644382.0930 E | 1 OF 1 |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 635.5 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEE LOG FOR B-014-0-21 | 631.5 | 0–4 | | | | | | | | | | | | | | | | | |
| MEDIUM STIFF, BROWN, **SANDY SILT**, "AND"CLAY, MOIST | | 4–6 | | | 92 | ST-1 | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| STIFF TO VERY STIFF, BROWN, **SANDY SILT**, "AND"CLAY, MOIST @6': CU: c' = 0 PSI, PHI = 30.8 DEGREES | | 6–8 | | | 100 | ST-2 | - | 0 | 3 | 11 | 45 | 41 | 26 | 24 | 2 | 18 | A-4a (8) | - | |
| | 625.5 | 8–10 | | | | | | | | | | | | | | | | | |
| HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST @10' HARD, DAMP | 623.5 | 10–12 EOB | | | 100 | ST-3 | - | - | - | - | - | - | - | - | - | - | A-6b (V) | - | |

NOTES: OFFSET BORING TO OBTAIN SHELBY TUBE SAMPLES.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| | | | |
|---|---|---|---|
| PROJECT: LUC-23-11.75<br>TYPE: ROADWAY<br>PID: 105889 SFN: N/A<br>START: 11/1/21 END: 11/1/21 | DRILLING FIRM / OPERATOR: TTL / CW<br>SAMPLING FIRM / LOGGER: TTL / KKC<br>DRILLING METHOD: 3.5" SSA<br>SAMPLING METHOD: SPT | DRILL RIG: CME 75 TRUCK 844<br>HAMMER: CME AUTOMATIC<br>CALIBRATION DATE: 3/15/21<br>ENERGY RATIO (%): 66 | STATION / OFFSET:<br>ALIGNMENT: SR51<br>ELEVATION: 648.2 (NAVD88) EOB: 8.5 ft.<br>COORD: 747932.4360 N, 1645346.6020 E |

EXPLORATION ID B-015-0-21

PAGE 1 OF 1

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 648.2 |
|---|---|
| ASPHALT - 3.5 INCHES | 647.9 |
| CONCRETE - 9 INCHES | 647.2 |
| AGGREGATE BASE - 5.5 INCHES | 646.7 |
| STIFF, BROWN, **SANDY SILT**, SOME CLAY, DAMP<br>@2.8': 2-INCH BROWN SAND SEAM, WET<br>@3': BROWN/GRAY, "AND" CLAY, MOIST | 644.0 |
| LOOSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, MOIST | 642.5 |
| VERY STIFF, GRAY, **SANDY SILT**, SOME CLAY, MOIST | 639.7 |

DEPTHS: W 645.4; EOB

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 7 7 | 15 | 100 | SS-1 | 2.00 | 0 | 2 | 23 | 45 | 30 | 28 | 25 | 3 | 21 | A-4a (8) | 330 |
| 9 10 14 | 26 | 100 | SS-2 | 1.00 | 0 | 3 | 15 | 43 | 39 | 21 | 19 | 2 | 21 | A-4a (8) | - |
| 2 4 4 | 9 | 100 | SS-3 | - | - | - | - | - | - | - | - | - | 16 | A-3a (V) | - |
| 6 6 10 | 18 | 100 | SS-4 | 3.50 | - | - | - | - | - | - | - | - | 19 | A-4a (V) | - |
| 11 12 13 | 28 | 100 | SS-5 | 4.00 | - | - | - | - | - | - | - | - | 18 | A-4a (V) | - |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-016-0-21 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: GLASGOW RD | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 3/15/21 | ELEVATION: 645.9 (NAVD88) EOB: 8.5 ft. | PAGE 1 OF 1 |
| START: 11/1/21 END: 11/1/21 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 66 | COORD: 748695.9950 N, 1643574.6360 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 645.9 | DEPTHS |
|---|---|---|
| ASPHALT - 4.5 INCHES | 645.5 | |
| HARD, GRAY, **SILT AND CLAY**, SOME SAND, LITTLE CRUSHED STONE, DAMP (FILL) | 643.6 | |
| VERY STIFF, BROWN, **SANDY SILT**, "AND" CLAY, TRACE IRON OXIDE STAIN SEAM, DAMP | | |
| | W 640.9 | |
| **SANDY SILT** @5': MEDIUM STIFF | | |
| @8.2': BROWN/GRAY | 637.4 | EOB |

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 10 26 | 40 | 89 | SS-1A | >4.5 | - | - | - | - | - | - | - | - | 9 | A-6a (V) | - | |
| | | | SS-1B | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| 42 24 17 | 45 | 89 | SS-2 | 3.25 | 0 | 2 | 6 | 40 | 52 | 24 | 21 | 3 | 16 | A-4a (8) | 340 | |
| 18 18 18 | 40 | 100 | SS-3 | 3.00 | 0 | 3 | 11 | 42 | 44 | 26 | 23 | 3 | 20 | A-4a (8) | - | |
| 5 6 6 | 13 | 100 | SS-4 | 1.00 | - | - | - | - | - | - | - | - | 22 | A-4a (V) | - | |
| 7 7 7 | 15 | 100 | SS-5 | - | - | - | - | - | - | - | - | - | 22 | A-4a (V) | - | |



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 6/29/23 13:54 - S:\PROJECTS\2065201.GPJ

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-017-0-21 |
| TYPE: LIGHT TOWER | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP C | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 638.0 (NAVD88) EOB: 24.8 ft. | PAGE 1 OF 1 |
| START: 2/23/23 END: 2/23/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 748211.6050 N, 1643455.7860 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 638.0 |
|---|---|
| ASPHALT - 8 INCHES | 637.3 |
| AGGREGATE BASE - 7 INCHES | 636.7 |
| WET SAND - 2 INCHES | 636.5 |
| AGGREGATE BASE - 8 INCHES | 635.8 |
| MEDIUM STIFF, BROWN, **SANDY SILT**, SOME GRAVEL, SOME CLAY, MOIST (EMBANKMENT FILL) | 633.5 |
| STIFF TO VERY STIFF, BROWN, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, DAMP Qu = 19.8 PSI = 1.43 TSF<br>@6': VERY STIFF, GRAY/BROWN<br>@8.5': BROWN/GRAY | 626.0 |
| VERY STIFF, GRAY/BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST<br>@13.5': HARD, GRAY, SOME SAND, DAMP<br>@16': LITTLE GRAVEL | 618.5 |
| HARD, GRAY, **SANDY SILT**, SOME ROCK FRAGMENTS, TRACE CLAY, DAMP | 613.2 |

DEPTHS: W 617.0; EOB

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 2 4 | 7 | 56 | SS-1A | - | - | - | - | - | - | - | - | - | - | A-1-b (V) | - | |
| | | | SS-1B | 1.00 | 25 | 7 | 16 | 29 | 23 | 18 | 13 | 5 | 14 | A-4a (3) | - | |
| 5 6 9 | 18 | 78 | SS-2A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | 220 | |
| | | | SS-2B | 3.50 | - | - | - | - | - | - | - | - | 18 | A-4a (V) | - | |
| 8 9 12 | 26 | 89 | SS-3 | 3.75 | 2 | 0 | 6 | 41 | 51 | 24 | 19 | 5 | 17 | A-4a (8) | - | |
| 9 9 13 | 27 | 89 | SS-4 | 2.75 | 3 | 5 | 15 | 42 | 35 | 25 | 18 | 7 | 16 | A-4a (8) | - | |
| 8 10 16 | 32 | 78 | SS-5A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| | | | SS-5B | 4.00 | - | - | - | - | - | - | - | - | 18 | A-6a (V) | - | |
| 26 38 50/5" | - | 94 | SS-6 | - | 2 | 7 | 13 | 21 | 57 | 25 | 14 | 11 | 11 | A-6a (8) | - | |
| 16 28 35 | 77 | 89 | SS-7 | 4.50 | - | - | - | - | - | - | - | - | 11 | A-6a (V) | - | |
| 50/4" | - | 100 | SS-8 | - | - | - | - | - | - | - | - | - | 7 | A-6a (V) | - | |
| 33 29 16 | 55 | 78 | SS-9 | - | 24 | 24 | 11 | 33 | 8 | 16 | 14 | 2 | 11 | A-4a (1) | - | |
| 26 26 50/3" | - | 93 | SS-10 | - | - | - | - | - | - | - | - | - | 12 | A-4a (V) | - | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

| | | | |
|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: DIEDRICH D70 TRACK | STATION / OFFSET: |
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: RAMP D |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 4/13/22 | ELEVATION: 615.9 (NAVD88) EOB: 6.4 ft. |
| START: 3/22/23 END: 3/22/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 90 | COORD: 747822.9970 N, 1643718.2490 E |

EXPLORATION ID B-021-0-21

PAGE 1 OF 1

| MATERIAL DESCRIPTION AND NOTES | ELEV. 615.9 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL - 5 INCHES | 615.5 | | | | | | | | | | | | | | | | | | |
| VERY STIFF, BROWN, **SANDY SILT**, "AND" CLAY, TRACE ORGANICS, MOIST (ORGANIC CONTENT = 1.7%) | | 1 – 2; W 612.5 | 3 4 4 | 12 | 89 | SS-1 | 2.50 | 0 | 3 | 32 | 28 | 37 | 25 | 15 | 10 | 17 | A-4a (6) | - | |
| @3.5': SOME DOLOMITE FRAGMENTS, LITTLE CLAY, DAMP | | 4 – 5 | 5 3 4 | 11 | 78 | SS-2 | - | 30 | 16 | 11 | 30 | 13 | 19 | 14 | 5 | 13 | A-4a (2) | - | |
| | 609.9 | 6 TR | | | | | | | | | | | | | | | | | |
| GRAY, **WEATHERED DOLOMITE**, LITTLE SAND, LITTLE SILT, TRACE CLAY | 609.5 | EOB | 50/3" | - | 67 | SS-3 | - | - | - | - | - | - | - | - | - | 12 | Rock (V) | - | |



NOTES: AUGER REFUSAL AT 6.4 FT.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: DIEDRICH D70 TRACK | STATION / OFFSET: | EXPLORATION ID B-022-0-21 |
|---|---|---|---|---|
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: RAMP D | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ | CALIBRATION DATE: 4/13/22 | ELEVATION: 615.1 (NAVD88) EOB: 28.0 ft. | PAGE |
| START: 3/22/23 END: 3/22/23 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 90 | COORD: 747502.4980 N, 1643911.0480 E | 1 OF 1 |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 615.1 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL - 8 INCHES | 614.4 | | | | | | | | | | | | | | | | | | |
| MEDIUM STIFF, BROWN, **SILT AND CLAY**, AND SAND, TRACE GRAVEL, WET (TRACE WOOD TO 1.5 FT) | 611.6 | 611.6 | 2 1 2 | 5 | 100 | SS-1 | 1.00 | 1 | 8 | 27 | 27 | 37 | 25 | 14 | 11 | 22 | A-6a (6) | - | |
| MEDIUM DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, WET | 609.1 | | 5 11 6 | 26 | 100 | SS-2 | - | 23 | 12 | 35 | 27 | 3 | 17 | 13 | 4 | 22 | A-2-4 (0) | - | |
| VERY DENSE, GRAY, **COARSE AND FINE SAND**, SOME CLAY, LITTLE ROCK FRAGMENTS, MOIST | 607.1 | TR | 50 | - | 100 | SS-3 | - | - | - | - | - | - | - | - | - | 14 | A-3a (V) | - | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, MODERATELY STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW; RQD 29%, REC 100%. | 604.8 | | 28 | | 73 | NQ-1 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, MODERATELY TO HIGHLY WEATHERED, MODERATELY STRONG, SHALEY LAMINAE, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 42%, REC 78%. @12.3': VERTICAL SEAM, Qu = 6250 PSI @14.5': Qu = 13790 PSI | 598.6 | | 45 | | 92 | NQ-2 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, SHALEY LAMINAE, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 24%, REC 69%. | 597.1 | | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, VERTICAL FRACTURES, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW; RQD 0%, REC 100%. | 595.9 | | 12 | | 67 | NQ-3 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED, NARROW TO OPEN; RQD 0%, REC 100%. | 594.1 | | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, TIGHT; RQD 31%, REC 93%. @21': Qu = 15030 PSI | 587.1 | EOB | 32 | | 95 | NQ-4 | | | | | | | | | | | CORE | | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 2 CF CEMENT-BENTONITE GROUT

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: DIEDRICH D70 TRACK | STATION / OFFSET: | EXPLORATION ID B-022-1-21 |
|---|---|---|---|---|
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: RAMP D | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ | CALIBRATION DATE: 4/13/22 | ELEVATION: 616.1 (NAVD88) EOB: 28.6 ft. | PAGE |
| START: 3/21/23 END: 3/22/23 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 90 | COORD: 747459.1740 N, 1643912.2880 E | 1 OF 1 |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 616.1 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL - 3 INCHES | 615.8 | | | | | | | | | | | | | | | | | | |
| STIFF, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, TRACE ORGANICS, MOIST | | 1–3 | 1 3 6 | 14 | 89 | SS-1 | - | 1 | 8 | 47 | 40 | 4 | 22 | 14 | 8 | 17 | A-4a (2) | - | |
| | 611.6 | W 611.6; 4 | 2 2 3 | 8 | 100 | SS-2 | - | 6 | 14 | 31 | 42 | 7 | 20 | 11 | 9 | 19 | A-4a (3) | - | |
| MEDIUM STIFF, GRAY/BROWN, **SANDY SILT**, TRACE CLAY, TRACE ROCK FRAGMENTS, WET | 610.1 | 5–6 | | | | | | | | | | | | | | | | | |
| LOOSE, GRAY, **COARSE AND FINE SAND**, SOME ROCK FRAGMENTS, SOME SILT, LITTLE ORGANICS, TRACE CLAY, WET<br>@6.0' TO 7.0': ORGANIC CONTENT = 10.1%, HIGHLY ORGANIC | 609.1 | TR; 7 | 3 3 50/3" | - | 93 | SS-3A | - | 24 | 20 | 32 | 20 | 4 | NP | NP | NP | 68 | A-3a (0) | - | |
| GRAY, **WEATHERED DOLOMITE**, LITTLE SAND, LITTLE SILT, TRACE CLAY | 607.5 | 8 | | | | SS-3B | - | - | - | - | - | - | - | - | - | - | A-2-4 (V) | - | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, TIGHT; RQD 17.5%, REC 78%.<br>@9.2' TO 10.1': SDI = 99.2%<br>@10.1' TO 10.3': VUGGY<br>@11.6': MODERATELY FRACTURED SEGMENT<br>@11.8' TO 12.3': Qu = 15,630 PSI<br>@12.3' TO 12.5': SHALEY LAMINAE<br>@13.8' TO 14.2': Qu = 22,920 PSI | | 9–13 | 22 | | 85 | NQ-1 | | | | | | | | | | | CORE | | |
| | 597.5 | 14–18 | 13 | | 72 | NQ-2 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, BROWN, MODERATELY WEATHERED, MODERATELY STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, TIGHT; RQD 12%, REC 80%.<br>@18.6' TO 19.2': MODERATELY FRACTURED SEGMENT, Qu = 7,350 PSI<br>@22': GRAY | 592.5 | 19–23 | 12 | | 80 | NQ-3 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, TIGHT; RQD 22%, REC 100%.<br>@23.6' TO 24.3': Qu = 16,470 PSI | 587.5 | 24–28; EOB | 22 | | 100 | NQ-4 | | | | | | | | | | | CORE | | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 2 CF CEMENT-BENTONITE GROUT

| | | | |
|---|---|---|---|
| PROJECT: LUC-23-11.75<br>TYPE: BRIDGE<br>PID: 105889 SFN: N/A<br>START: 3/11/23 END: 3/11/23 | DRILLING FIRM / OPERATOR: TTL / CW<br>SAMPLING FIRM / LOGGER: TTL / KKC<br>DRILLING METHOD: 3.25" HSA<br>SAMPLING METHOD: SPT | DRILL RIG: GEOPROBE 7822DT<br>HAMMER: AUTOMATIC HAMMER<br>CALIBRATION DATE: 3/16/22<br>ENERGY RATIO (%): 90* | STATION / OFFSET:<br>ALIGNMENT: RAMP D<br>ELEVATION: 616.1 (NAVD88) EOB: 6.7 ft.<br>COORD: 747347.2390 N, 1643885.7520 E |

EXPLORATION ID B-022-2-21

PAGE 1 OF 1

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 616.1 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AGGREGATE - 18 INCHES | 614.6 | 1 | 3 / 4 / 7 | 17 | 44 | SS-1A | - | - | - | - | - | - | - | - | - | - | A-1-b (V) | - | |
| VERY STIFF, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, MOIST | | 2 | | | | SS-1B | - | - | - | - | - | - | - | - | - | 16 | A-4a (V) | - | |
| | | W 612.8 — 3 | | | | | | | | | | | | | | | | | |
| @3.5': BROWN/GRAY | | 4 | 5 / 6 / 5 | 17 | 56 | SS-2 | - | 3 | 14 | 33 | 44 | 6 | 24 | 15 | 9 | 19 | A-4a (3) | - | |
| | 610.1 | 5 | | | | | | | | | | | | | | | | | |
| GRAY, **WEATHERED DOLOMITE**, LITTLE SAND, LITTLE SILT, TRACE CLAY | 609.4 | TR — 6 — EOB | 50/2" | - | 100 | SS-3 | - | 72 | 8 | 6 | 14 | | NP | NP | NP | 7 | A-1-a (0) | - | |

NOTES: BORING TERMINATED UPON AUGER REFUSAL AT 6.7 FEET. OFFSET 15 FEET SOUTH (SEE B-022-3-21) DUE TO PROXIMITY TO UTILITY.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 2 CF CEMENT-BENTONITE GROUT

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: DIEDRICH D70 TRACK | STATION / OFFSET: | EXPLORATION ID B-022-3-21 |
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: RAMP D | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ | CALIBRATION DATE: 4/13/22 | ELEVATION: 616.0 (NAVD88) EOB: 29.3 ft. | PAGE |
| START: 3/20/23 END: 3/20/23 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 90 | COORD: 747330.8050 N, 1643885.2250 E | 1 OF 1 |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 616.0 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AGGREGATE - 18 INCHES | 614.5 | | | | | | | | | | | | | | | | | | |
| BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, MOIST (SEE LOG FOR B-022-2-21) | 610.0 | ▼ 5; TR 6 | | | | | | | | | | | | | | | | | |
| GRAY, **WEATHERED DOLOMITE WITH SAND AND SILT**, TRACE CLAY | 606.7 | W 608.0 | 13 31 50/4" | - | 100 | SS-1 | - | 44 | 13 | 12 | - 31 - | | NP | NP | NP | 9 | A-2-4 (0) | - | |
| | | | 50/2" | - | 0 | SS-2 | - | - | - | - | - | - | - | - | - | - | A-2-4 (V) | - | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, TIGHT; RQD 45%, REC 100%. @10.0' TO 11.0': SDI = 99.7% @13.4' TO 13.9': Qu = 17,840 PSI | 601.7 | | 45 | | 100 | NQ-1 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED, NARROW; RQD 0%, REC 33%. | 596.7 | | 0 | | 33 | NQ-2 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, TIGHT; RQD 65%, REC 100%. @19.3' TO 19.7': Qu = 23,820 PSI | 592.8 | | 50 | | 87 | NQ-3 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, SHALEY LAMINAE, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW; RQD 18%, REC 100%. @23.2' TO 23.4': HIGHLY WEATHERED @24.3' TO 24.9': Qu = 23,930 PSI | 589.7 | | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, TIGHT; RQD 36%, REC 67%. | 586.7 | EOB | 33 | | 80 | NQ-4 | | | | | | | | | | | CORE | | |

NOTES: OFFSET 15 FEET SOUTH OF B-022-2-21 TO CONTINUE BORING BELOW A DEPTH OF 6 FEET.

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

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75<br>TYPE: BRIDGE<br>PID: 105889 SFN: N/A<br>START: 4/4/23 END: 4/4/23 | DRILLING FIRM / OPERATOR: TTL / TB<br>SAMPLING FIRM / LOGGER: TTL / KKC<br>DRILLING METHOD: 3.25" HSA / NQ<br>SAMPLING METHOD: SPT / ST / NQ | DRILL RIG: DIEDRICH D70 TRACK<br>HAMMER: DIEDRICH AUTOMATIC<br>CALIBRATION DATE: 4/13/22<br>ENERGY RATIO (%): 90 | STATION / OFFSET:<br>ALIGNMENT: RAMP D<br>ELEVATION: 624.2 (NAVD88) EOB: 36.5 ft.<br>COORD: 747237.6920 N, 1643883.4630 E | EXPLORATION ID<br>B-023-0-21<br>PAGE<br>1 OF 2 |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 624.2 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AGGREGATE - 6 INCHES | 623.7 | | | | | | | | | | | | | | | | | | |
| MULCH - 8 INCHES | 623.0 | | | | | | | | | | | | | | | | | | |
| MEDIUM DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP (EMBANKMENT FILL) | 620.7 | 1–3 | 5 4 4 | 12 | 67 | SS-1 | - | 36 | 11 | 36 | 15 | 2 | NP | NP | NP | 6 | A-2-4 (0) | - | |
| MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE GRAVEL, TRACE CLAY, DAMP | | 4–5 | 5 7 5 | 18 | 67 | SS-2 | - | - | - | - | - | - | - | - | - | 8 | A-3a (V) | - | |
| @6.8': TRACE ORGANICS | 616.2 | 6–8 | 4 4 4 | 12 | 89 | SS-3 | - | - | - | - | - | - | - | - | - | 15 | A-3a (V) | - | |
| **PEAT** | 615.3 | 9 | 2 2 2 | 6 | 100 | SS-4A | - | - | - | - | - | - | - | - | - | - | Peat (V) | - | |
| MEDIUM STIFF, DARK BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, TRACE PEAT, MOIST | | | | | | SS-4B | 0.75 | - | - | - | - | - | - | - | - | 25 | A-6b (V) | - | |
| @9.5': VERY STIFF, BROWN | | 10 W 613.2 | | | | SS-4C | 2.25 | - | - | - | - | - | - | - | - | 23 | A-6b (V) | - | |
| @10': BROWN/GRAY, SOME SAND | 613.2 | 11–12 | | | 21 | ST-5 | - | 3 | 6 | 15 | 27 | 49 | 39 | 19 | 20 | 27 | A-6b (12) | - | |
| VERY STIFF, GRAY, **SANDY SILT**, AND CLAY, MOIST | 608.2 | 13–15 | 5 8 16 | 36 | 89 | SS-6 | 4.25 | 0 | 2 | 8 | 38 | 52 | 25 | 17 | 8 | 23 | A-4a (8) | - | |
| GRAY, **WEATHERED DOLOMITE WITH SAND AND SILT**, TRACE CLAY | 607.7 | 16 TR | 50/1" | - | 100 | SS-7 | - | - | - | - | - | - | - | - | - | 7 | Rock (V) | - | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 70%, REC 94%. @16.5': 5-INCH VERTICAL FRACTURE ZONE<br>@18.4': Qu = 20850 PSI | | 17–21 | 65 | | 92 | NQ-1 | | | | | | | | | | | CORE | | |
| @23.2': Qu = 12130 PSI | 599.9 | 22–24 | 53 | | 90 | NQ-2 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW; RQD 50%, REC 100%. | 598.9 | 25–26 | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, VUGGY, JOINTED - HIGHLY FRACTURED TO FRACTURED, OPEN TO NARROW; RQD 10%, REC 90%. | 594.7 | 27–30 | 8 | | 83 | NQ-3 | | | | | | | | | | | CORE | | |

| PID: 105889 | SFN: N/A | PROJECT: LUC-23-11.75 | STATION / OFFSET: | START: 4/4/23 | END: 4/4/23 | PG 2 OF 2 | B-023-0-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 593.2 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, VERTICAL FRACTURES, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 15%, REC 87%. *(continued)*<br>@33.3': VERY STRONG, Qu = 15160 PSI | 587.7 | 32<br>33<br>34<br>35<br>36<br>EOB | 22 | | 98 | NQ-4 | | | | | | | | | | | CORE | | |

DRAFT

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 5 CF CEMENT-BENTONITE GROUT

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 6/29/23 13:54 - S:\PROJECTS\2065201.GPJ

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-024-0-21 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP D | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 629.3 (NAVD88) EOB: 7.5 ft. | PAGE 1 OF 1 |
| START: 2/24/23 END: 2/24/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 746986.6470 N, 1643999.0880 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 629.3 | DEPTHS |
|---|---|---|
| ASPHALT - 11 INCHES | 628.4 | |
| AGGREGATE BASE - 8 INCHES | 627.7 | |
| MEDIUM DENSE, BROWN, **FINE SAND**, TRACE SILT, TRACE CLAY, MOIST (EMBANKMENT FILL) | 626.3 | |
| MEDIUM DENSE, BROWN/GRAY, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, MOIST (EMBANKMENT FILL) | 624.1 | |
| VERY STIFF, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP (EMBANKMENT FILL) | 622.8 | |
| VERY DENSE, BROWN/GRAY, **COARSE AND FINE SAND**, SOME SILT, TRACE GRAVEL, TRACE CLAY, MOIST (EMBANKMENT FILL) | 622.4 | |
| HARD, GRAY/BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL (EMBANKMENT FILL) | 621.8 | EOB |

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 6 7 | 16 | 72 | SS-1 | - | 0 | 4 | 86 | 8 | 2 | NP | NP | NP | 11 | A-3 (0) | <100 |
| 9 9 12 | 26 | 83 | SS-2 | - | 0 | 12 | 59 | 27 | 2 | NP | NP | NP | 10 | A-3a (0) | - |
| 11 9 13 | 27 | 100 | SS-3A | - | - | - | - | - | - | - | - | - | - | A-3a (V) | - |
| | | | SS-3B | 4.00 | - | - | - | - | - | - | - | - | 14 | A-4a (V) | - |
| 15 26 28 | 66 | 89 | SS-4A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - |
| | | | SS-4B | - | - | - | - | - | - | - | - | - | 12 | A-3a (V) | - |
| | | | SS-4C | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - |



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / JP | DRILL RIG: GEOPROBE 7822DT | STATION / OFFSET: | EXPLORATION ID B-026-0-21 |
|---|---|---|---|---|
| TYPE: LIGHT TOWER | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: AUTOMATIC HAMMER | ALIGNMENT: RAMP A | |
| PID: 105889 SFN: N/A | DRILLING METHOD: HSA | CALIBRATION DATE: 3/16/22 | ELEVATION: 622.7 (NAVD88) EOB: 8.3 ft. | PAGE 1 OF 1 |
| START: 3/8/23 END: 3/8/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 90* | COORD: 748090.5860 N, 1644510.8720 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 622.7 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL - 10 INCHES | 621.9 | | | | | | | | | | | | | | | | | | |
| STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE ORGANICS, WET | 618.7 | 1, 2, 3 | 2 3 3 | 9 | 100 | SS-1 | - | 0 | 4 | 48 | 37 | 11 | NP | NP | NP | 25 | A-4a (3) | - | |
| HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP | | 4, 5 | 10 20 25 | 68 | 100 | SS-2A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| | | | | | | SS-2B | 4.50 | 7 | 6 | 10 | 20 | 57 | 25 | 14 | 11 | 9 | A-6a (8) | - | |
| @6': Qu = 159 PSI = 11.45 TSF | 614.4 | 6, 7, 8 ETR3 | 15 25 35 | 90 | 100 | SS-3 | 4.50 | 2 | 3 | 7 | 21 | 67 | 26 | 14 | 12 | 10 | A-6a (9) | - | |

NOTES: AUGER REFUSAL AT 8.3 FT. OFFSET BORING WITH DIFFERENT RIG UTILIZED FOR ROCK CORING. SEE LOG FOR B-026-1-21.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: DIEDRICH D70 TRACK | STATION / OFFSET: | EXPLORATION ID B-026-1-21 |
|---|---|---|---|---|
| TYPE: LIGHT TOWER | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: RAMP A | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 4.25" HSA | CALIBRATION DATE: 4/13/22 | ELEVATION: 623.1 (NAVD88) EOB: 16.0 ft. | PAGE |
| START: 3/20/23 END: 3/20/23 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 90 | COORD: 748076.1350 N, 1644511.8220 E | 1 OF 1 |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 623.1 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEE LOG FOR B-026-0-21 | 615.1 | 0 – 8 | | | | | | | | | | | | | | | | | |
| HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP<br>@9.3': SOME ROCK FRAGMENTS | 612.1 | 8 – 11 (TR) | 35 43 50/3" | - | 93 | SS-1 | - | - | - | - | - | - | - | - | - | - | A-6a (V) | - | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, STRONG, JOINTED-SLIGHTLY FRACTURED, TIGHT; RQD 100%, REC 100%. | 610.8 | 11 – 12.3 | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, JOINTED-HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 73%, REC 91%. | 607.1 | 12.3 – 16 (EOB) | 80 | | 93 | NQ2-1 | | | | | | | | | | | CORE | | |

NOTES: OFFSET BORING FOR ROCK CORING.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 1 CF CEMENT-BENTONITE GROUT

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / JP | DRILL RIG: GEOPROBE 7822DT | STATION / OFFSET: | EXPLORATION ID B-027-0-21 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: AUTOMATIC HAMMER | ALIGNMENT: RAMP A | |
| PID: 105889 SFN: N/A | DRILLING METHOD: HSA | CALIBRATION DATE: 3/16/22 | ELEVATION: 622.9 (NAVD88) EOB: 2.7 ft. | PAGE 1 OF 1 |
| START: 3/8/23 END: 3/8/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 90* | COORD: 747755.6880 N, 1644342.6320 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 622.9 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) | | | | | ATTERBERG | | | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | GR | CS | FS | SI | CL | LL | PL | PI | | | | |
| TOPSOIL - 10 INCHES | 622.1 | | | | | | | | | | | | | | | | | | |
| STIFF TO VERY STIFF, BROWN, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, TRACE ORGANICS, MOIST Qu = 14.1 PSI = 1.02 TSF | 620.2 | 1<br>2<br>ETR 3 | 3<br>4<br>8 | 18 | 89 | SS-1 | 3.00 | 1 | 3 | 6 | 23 | 67 | 34 | 16 | 18 | 20 | A-6b (11) | - | |

NOTES: AUGER REFUSAL AT 2.7 FT.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: DIEDRICH D70 TRACK | STATION / OFFSET: | EXPLORATION ID B-028-0-21 |
|---|---|---|---|---|
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: RAMP A | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ | CALIBRATION DATE: 4/13/22 | ELEVATION: 620.3 (NAVD88) EOB: 33.0 ft. | PAGE 1 OF 2 |
| START: 4/10/23 END: 4/10/23 | SAMPLING METHOD: SPT / ST / NQ | ENERGY RATIO (%): 90 | COORD: 747474.8920 N, 1644274.2750 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 620.3 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL - 2 INCHES | 620.1 | | | | | | | | | | | | | | | | | | |
| MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, MOIST (EMBANKMENT FILL) | 616.3 | 1–3 | 8 7 6 | 20 | 100 | SS-1 | - | 0 | 8 | 72 | 18 | 2 | NP | NP | NP | 12 | A-3a (0) | <100 | |
| VERY STIFF, GRAY, **SANDY SILT**, SOME CLAY, MOIST (EMBANKMENT FILL) | 614.3 | 4–5; W 614.3 | 7 6 6 | 18 | 72 | SS-2 | - | 0 | 10 | 38 | 29 | 23 | 19 | 13 | 6 | 13 | A-4a (3) | - | |
| STIFF TO VERY STIFF, GRAY, **SILT AND CLAY**, SOME SAND, MOIST<br>@7': TRACE ORGANICS, Qu: 13.0 PSI = 0.94 TSF, CONSOLIDATION: Cc = 0.23, Cr = 0.034, eo = 0.85, pc = 2.7 TSF | 612.3 | 6–8 | | | 92 | ST-3 | 3.25 | 0 | 5 | 27 | 25 | 43 | 34 | 21 | 13 | 27 | A-6a (8) | - | |
| LOOSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, LITTLE ROCK FRAGMENTS, TRACE CLAY, WET | 609.3 | 9–10 | 2 2 3 | 8 | 89 | SS-4 | - | 13 | 15 | 39 | 26 | 7 | NP | NP | NP | 21 | A-3a (0) | - | |
| GRAY, **WEATHERED DOLOMITE WITH SAND AND SILT**, TRACE CLAY | 607.3 | TR 11–12 | 11 50/4" | - | 80 | SS-5 | - | - | - | - | - | - | - | - | - | 10 | A-2-4 (V) | - | |
| **DOLOMITE**, LIGHT GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, VUGGY, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 65%, REC 100%. | 605.9 | 13–14 | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 72%, REC 96%.<br>@17': Qu = 22000 PSI | | 15–18 | 68 | | 95 | NQ-1 | | | | | | | | | | | CORE | | |
| @20.2': Qu = 20200 PSI | 599.3 | 19–22 | 53 | | 100 | NQ-2 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 34%, REC 100%. | 596.4 | 23–24 | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, MODERATELY STRONG TO STRONG, VUGGY, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 38%, REC 100%. | 595.3<br>593.5 | 25–27 | 45 | | 97 | NQ-3 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 77%, REC 100%.<br>@26.1': Qu = 17090 PSI | 590.8 | 28–29 | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, | | 30 | 17 | | 98 | NQ-4 | | | | | | | | | | | CORE | | |

| PID: 105889 | SFN: N/A | PROJECT: LUC-23-11.75 | STATION / OFFSET: | START: 4/10/23 | END: 4/10/23 | PG 2 OF 2 | B-028-0-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 589.3 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW TO TIGHT; RQD 0%, REC 94%. | | 32 | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 24%, REC 98%. *(continued)* | 587.3 | EOB 33 | | | | | | | | | | | | | | | | | |



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 4 CF CEMENT-BENTONITE GROUT

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: DIEDRICH D70 TRACK | STATION / OFFSET: | EXPLORATION ID B-028-1-21 |
|---|---|---|---|---|
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: RAMP A | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ | CALIBRATION DATE: 4/13/22 | ELEVATION: 616.6 (NAVD88) EOB: 31.1 ft. | PAGE 1 OF 2 |
| START: 3/21/23 END: 3/21/23 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 90 | COORD: 747416.7470 N, 1644288.8740 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 616.6 | DEPTHS |
|---|---|---|
| TOPSOIL - 3 INCHES | 616.3 | |
| VERY STIFF, GRAY, **SILT**, LITTLE CLAY, TRACE SAND, MOIST | 613.6 | |
| MEDIUM STIFF TO STIFF, GRAY, **SANDY SILT**, TRACE CLAY, WET | 610.6 | ▼ |
| MEDIUM DENSE, GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP | 608.6 | W 608.6 |
| VERY DENSE, GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP | 605.6 | TR |
| **WEATHERED DOLOMITE WITH SAND AND SILT**, TRACE CLAY | 605.5 | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, FAULTED - HIGHLY FRACTURED, OPEN; RQD 0%, REC 100%. | 605.2 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, VUGGY, JOINTED - FRACTURED TO MODERATELY FRACTURED, TIGHT; RQD 43%, REC 89%.<br>@11.4' TO 12.4': SDI = 99.6%<br>@12.4' TO 13.1': Qu = 21,510 PSI<br>@17.2' TO 17.5': Qu = 13,150 PSI<br>@17.2': STRONG | 595.5 | |
| **DOLOMITE**, GRAY, HIGHLY WEATHERED, STRONG, FAULTED - HIGHLY FRACTURED, OPEN; RQD 0%, REC 100%. | 594.7 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, TIGHT; RQD 17%, REC 100%. | 592.7 | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, FAULTED - HIGHLY FRACTURED, OPEN; RQD 0%, REC 33%.<br>@23.9': DRILLERS NOTED LOSS OF RETURN WATER DURING CORING OPERATIONS | 591.7 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, TIGHT; RQD 28%, REC 85%.<br>@24.9': DRILLERS NOTED 50% RETURN WATER DURING CORING OPERATIONS | | |

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 8 6 | 21 | 89 | SS-1 | - | - | - | - | - | - | - | - | - | 19 | A-4b (V) | - | |
| 2 2 2 | 6 | 100 | SS-2 | 1.00 | 0 | 21 | 25 | 46 | 8 | 21 | 16 | 5 | 22 | A-4a (4) | - | |
| 4 6 6 | 18 | 100 | SS-3 | - | 48 | 0 | 27 | 23 | 2 | 22 | 16 | 6 | 11 | A-2-4 (0) | - | |
| 15 18 42 | 90 | 89 | SS-4 | - | 45 | 12 | 12 | 28 | 3 | 21 | 17 | 4 | 12 | A-2-4 (0) | - | |
| 50/1" | - | 100 | SS-5 | - | 28 | 17 | 24 | 31 | | NP | NP | NP | - | A-2-4 (0) | - | |
| 77 | | 80 | NQ-1 | | | | | | | | | | | CORE | | |
| 57 | | 98 | NQ-2 | | | | | | | | | | | CORE | | |
| 7 | | 72 | NQ-3 | | | | | | | | | | | CORE | | |
| 35 | | 95 | NQ-4 | | | | | | | | | | | CORE | | |



STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 6/29/23 13:54 - S:\PROJECTS\2065201.GPJ

| PID: 105889 | SFN: N/A | PROJECT: LUC-23-11.75 | STATION / OFFSET: | START: 3/21/23 | END: 3/21/23 | PG 2 OF 2 | B-028-1-21 |
|---|---|---|---|---|---|---|---|

| *MATERIAL DESCRIPTION AND NOTES* | ELEV. 585.6 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| @27.0' TO 27.4': Qu = 19,440 PSI | 585.5 | EOB | | | | | | | | | | | | | | | | | |

DRAFT

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 4 CF CEMENT-BENTONITE GROUT

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 6/29/23 13:54 - S:\PROJECTS\2065201.GPJ

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: DIEDRICH D70 TRACK | STATION / OFFSET: | EXPLORATION ID B-028-2-21 |
|---|---|---|---|---|
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: RAMP A | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ | CALIBRATION DATE: 4/13/22 | ELEVATION: 609.0 (NAVD88) EOB: 22.0 ft. | PAGE |
| START: 3/23/23 END: 3/24/23 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 90 | COORD: 747306.1340 N, 1644304.9880 E | 1 OF 1 |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 609.0 | DEPTHS |
|---|---|---|
| BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY | 608.1 | 609.0 TR |
| GRAY, **WEATHERED DOLOMITE**, LITTLE SAND, LITTLE SILT, TRACE CLAY | 607.5 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, STRONG, VUGGY, JOINTED - FRACUTRED TO MODERATELY FRACTURED, TIGHT; RQD 60%, REC 99%.<br>@2.2' TO 2.7': Qu = 10,750 PSI<br>@3.7' TO 4.7': SDI = 99.6%<br>@6.1' TO 7.0': Qu = 19,230 PSI<br>@6.1': VERY STRONG | 600.5 | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED, OPEN; RQD 0%, REC 88%. | 596.4 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED, TIGHT; RQD 4%, REC 76%.<br>@16.8' TO 17.1': Qu = 17,610 PSI | 589.0 | |
| **DOLOMITE**, BROWN/GRAY, MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED, OPEN; RQD 0%, REC 67%. | 587.0 | EOB 22 |

| SPT/RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 26 50/3" | - | 67 | SS-1 | - | 62 | 10 | 8 | - 20 - | | NP | NP | NP | - | A-1-b (0) | - | |
| 67 | | 98 | NQ-1 | | | | | | | | | | | CORE | | |
| 37 | | 90 | NQ-2 | | | | | | | | | | | CORE | | |
| 0 | | 63 | NQ-3 | | | | | | | | | | | CORE | | |
| 7 | | 97 | NQ-4 | | | | | | | | | | | CORE | | |
| 0 | | 67 | NQ-5 | | | | | | | | | | | CORE | | |

NOTES: BRIDGE DECK WAS 22 INCHES, BRIDGE SURFACE ELEV. 629.5, WATER SURFACE ELEV. 611.5.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 1 CF CEMENT-BENTONITE GROUT

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: DIEDRICH D70 TRACK | STATION / OFFSET: | EXPLORATION ID B-029-0-21 |
|---|---|---|---|---|
| TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: RAMP A | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ | CALIBRATION DATE: 4/13/22 | ELEVATION: 620.5 (NAVD88) EOB: 36.0 ft. | PAGE 1 OF 2 |
| START: 4/7/23 END: 4/7/23 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 90 | COORD: 747290.2960 N, 1644227.5050 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 620.5 | DEPTHS |
|---|---|---|
| TOPSOIL - 5 INCHES | 620.1 | |
| MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, DAMP (EMBANKMENT FILL) | 617.5 | |
| VERY STIFF, GRAY, **SANDY SILT**, SOME CLAY, DAMP (EMBANKMENT FILL)<br>@6': MOIST | 611.5 | |
| LOOSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, TRACE ROCK FRAGMENTS, TRACE CLAY, TRACE ORGANICS, WET | 609.0 | TR |
| GRAY, **WEATHERED DOLOMITE WITH SAND AND SILT**, TRACE CLAY | 604.5 | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY STRONG, JOINTED - HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 43%, REC 100%.<br>@16.9': Qu = 17720 PSI | 602.8 | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, TIGHT; RQD 81%, REC 92%.<br>@18.9' to 20': SLIGHTLY FRACTURED SEGMENT<br>@22.6': 4-INCH VERTICAL FRACTURE ZONE | 597.5 | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, STRONG, JOINTED - FRACTURED, NARROW TO TIGHT; RQD 28%, REC 97%.<br>@24': Qu = 12710 PSI | 594.5 | |
| **LIMESTONE**, GRAY, MODERATELY WEATHERED, MODERATELY STRONG TO STRONG, VUGGY, SHALEY LAMINAE, JOINTED - HIGHLY FRACTURED TO FRACTURED, OPEN TO NARROW; RQD 0%, REC 100%. | 593.9 | |

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 7 9 | 24 | 100 | SS-1 | - | 0 | 16 | 59 | 23 | 2 | NP | NP | NP | 10 | A-3a (0) | 120 | |
| 5 9 9 | 27 | 100 | SS-2 | - | 0 | 5 | 40 | 28 | 27 | 17 | 14 | 3 | 11 | A-4a (4) | - | |
| 8 8 7 | 23 | 100 | SS-3 | - | 0 | 6 | 31 | 29 | 34 | 21 | 16 | 5 | 17 | A-4a (6) | - | |
| 1 3 3 | 9 | 100 | SS-4A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| | | | SS-4B | - | 8 | 21 | 48 | 21 | 2 | NP | NP | NP | 24 | A-3a (0) | - | |
| 20 15 25 | 60 | 83 | SS-5A | - | - | - | - | - | - | - | - | - | - | A-3a (V) | - | |
| | | | SS-5B | - | - | - | - | - | - | - | - | - | 10 | A-2-4 (V) | - | |
| 50/5" | - | 100 | SS-6 | - | - | - | - | - | - | - | - | - | 8 | A-2-4 (V) | - | |
| 70 | | 98 | NQ-1 | | | | | | | | | | | CORE | | |
| 50 | | 98 | NQ-2 | | | | | | | | | | | CORE | | |
| 18 | | 95 | NQ-3 | | | | | | | | | | | CORE | | |

| PID: 105889 | SFN: N/A | PROJECT: LUC-23-11.75 | STATION / OFFSET: | START: 4/7/23 | END: 4/7/23 | PG 2 OF 2 | B-029-0-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 589.5 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, OPEN TO NARROW; RQD 25%, REC 97%. *(continued)*<br>@32.3': Qu = 14980 PSI<br>@34': 3-INCH VERTICAL FRACTURE ZONE | 584.5 | 32<br>33<br>34<br>35<br>EOB 36 | 28 | | 100 | NQ-4 | | | | | | | | | | | CORE | | |



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 5 CF CEMENT-BENTONITE GROUT

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75<br>TYPE: LIGHT TOWER<br>PID: 105889 SFN: N/A<br>START: 2/23/23 END: 2/23/23 | DRILLING FIRM / OPERATOR: TTL / TB<br>SAMPLING FIRM / LOGGER: TTL / KKC<br>DRILLING METHOD: 3.25" HSA / NQ2<br>SAMPLING METHOD: SPT / NQ2 | DRILL RIG: CME 75 TRUCK 844<br>HAMMER: CME AUTOMATIC<br>CALIBRATION DATE: 2/20/23<br>ENERGY RATIO (%): 72.9 | STATION / OFFSET:<br>ALIGNMENT: RAMP A<br>ELEVATION: 630.7 (NAVD88) EOB: 27.5 ft.<br>COORD: 746975.5320 N, 1644188.2630 E | EXPLORATION ID<br>B-029-1-21<br>PAGE<br>1 OF 1 |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 630.7 | DEPTHS | SPT/RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 16 INCHES | 629.4 | | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 5 INCHES | 628.9 | | 50/2" | - | 100 | SS-1 | - | - | - | - | - | - | - | - | - | 2 | A-1-b (V) | - | |
| DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, MOIST (EMBANKMENT FILL) | | | 7 12 14 | 32 | 89 | SS-2 | - | 0 | 9 | 59 | 28 | 4 | NP | NP | NP | 11 | A-3a (0) | <100 | |
| | | | 13 13 18 | 38 | 100 | SS-3 | - | 0 | 7 | 58 | 31 | 4 | NP | NP | NP | 11 | A-3a (0) | - | |
| | | | 11 11 19 | 36 | 100 | SS-4 | - | 0 | 8 | 58 | - 34 - | | NP | NP | NP | 11 | A-3a (0) | - | |
| @11': BROWN/GRAY, TRACE WOOD | | | 16 14 17 | 38 | 100 | SS-5 | - | - | - | - | - | - | - | - | - | 10 | A-3a (V) | - | |
| | 616.7 | ▼ | 2 | | | SS-6A | - | - | - | - | - | - | - | - | - | - | A-3a (V) | - | |
| MEDIUM STIFF TO STIFF, BROWN, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, MOIST Qu = 7.9 PSI = 0.57 TSF | 615.4 | | 4 7 | 13 | 100 | SS-6B | 3.50 | 2 | 5 | 15 | 28 | 50 | 34 | 17 | 17 | 20 | A-6b (11) | - | |
| MEDIUM DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, MOIST | | | 7 6 8 | 17 | 100 | SS-7 | - | 0 | 4 | 61 | 31 | 4 | 21 | 15 | 6 | 17 | A-3a (0) | - | |
| | | | 2 7 10 | 21 | 78 | SS-8 | - | - | - | - | - | - | - | - | - | 16 | A-3a (V) | - | |
| @19.7': LITTLE DOLOMITE FRAGMENTS | 610.4 | W 610.4 TR | | | | | | | | | | | | | | | | | |
| GRAY, **WEATHERED DOLOMITE WITH SAND AND SILT**, TRACE CLAY | 608.2 | | 17 19 34 | 64 | 67 | SS-9 | - | 35 | 11 | 20 | - 34 - | | NP | NP | NP | 10 | A-2-4 (0) | - | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW TO TIGHT; RQD 7%, REC 67%. | 603.2 | EOB | 7 | | 67 | NQ-1 | | | | | | | | | | | CORE | | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; PUMPED 6 CF CEMENT-BENTONITE GROUT

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-030-0-21 |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP A | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 633.3 (NAVD88) EOB: 7.5 ft. | PAGE |
| START: 2/21/23 END: 2/21/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 746722.8750 N, 1644164.4750 E | 1 OF 1 |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 633.3 |
|---|---|
| ASPHALT - 10 INCHES | 632.5 |
| AGGREGATE BASE - 8 INCHES | 631.8 |
| MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, DAMP (EMBANKMENT FILL) | 629.9 |
| MEDIUM DENSE, BROWN/GRAY, **SANDY SILT**, TRACE CLAY, MOIST (EMBANKMENT FILL) @4.5': DENSE | 627.8 |
| DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, MOIST (EMBANKMENT FILL) | 625.8 |

DEPTHS: 1, 2, 3, 4, 5, 6, 7 — EOB

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 5 5 | 12 | 100 | SS-1 | - | 0 | 8 | 77 | 13 | 2 | NP | NP | NP | 8 | A-3a (0) | <100 | |
| | | | SS-2A | - | - | - | - | - | - | - | - | - | - | A-3a (V) | - | |
| 8 10 14 | 29 | 100 | SS-2B | 3.50 | 0 | 11 | 46 | 39 | 4 | NP | NP | NP | 12 | A-4a (2) | - | |
| 18 16 14 | 36 | 100 | SS-3A | 3.25 | - | - | - | - | - | - | - | - | 10 | A-4a (V) | - | |
| | | | SS-3B | - | - | - | - | - | - | - | - | - | 11 | A-3a (V) | - | |
| 14 18 20 | 46 | 100 | SS-4 | - | - | - | - | - | - | - | - | - | 18 | A-3a (V) | - | |



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / JW | DRILL RIG: CME 550X ATV | STATION / OFFSET: | EXPLORATION ID B-031-0-21 |
| TYPE: LIGHT TOWER | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR184 | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 646.5 (NAVD88) EOB: 25.0 ft. | PAGE 1 OF 1 |
| START: 4/11/23 END: 4/11/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 75.2 | COORD: 748535.3990 N, 1644847.7740 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 646.5 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL - 10 INCHES | 645.7 | | | | | | | | | | | | | | | | | | |
| VERY STIFF, GRAY/BROWN, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, DAMP (EMBANKMENT FILL) | | 1 – 2 | 5 9 10 | 24 | 89 | SS-1 | 2.75 | 2 | 2 | 16 | 40 | 40 | 22 | 18 | 4 | 13 | A-4a (8) | 140 | |
| | 642.0 | 3 – 5 | 6 5 5 | 13 | 89 | SS-2A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| VERY STIFF, BROWN/GRAY, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, TRACE ORGANICS, MOIST | | | | | | SS-2B | 2.25 | 1 | 3 | 16 | 45 | 35 | 21 | 17 | 4 | 17 | A-4a (8) | - | |
| | 640.0 | 6 – 7 | 2 3 2 | 6 | 100 | SS-3A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| MEDIUM STIFF, BROWN/GRAY, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, MOIST | | | | | | SS-3B | - | 1 | 2 | 9 | 40 | 48 | 21 | 18 | 3 | 19 | A-4a (8) | - | |
| @8': GRAY | | 8 – 10 | 3 1 2 | 4 | 100 | SS-4 | 0.75 | - | - | - | - | - | - | - | - | 22 | A-4a (V) | - | |
| | 634.5 | 11 – 12 W 634.5 | 1 1 2 | 4 | 100 | SS-5A | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| SOFT, BROWN, **SILT**, SOME CLAY, TRACE SAND, MOIST | 633.5 | | | | | SS-5B | - | - | - | - | - | - | - | - | - | 24 | A-4b (V) | - | |
| MEDIUM STIFF, GRAY, **SILTY CLAY**, LITTLE SAND, LITTLE GRAVEL, DAMP | | 13 – 15 | 2 3 3 | 8 | 33 | SS-6 | - | - | - | - | - | - | - | - | - | 13 | A-6b (V) | - | |
| @16': STIFF, TRACE GRAVEL, MOIST | | 16 – 17 | 2 3 4 | 9 | 100 | SS-7 | 1.25 | - | - | - | - | - | - | - | - | 22 | A-6b (V) | - | |
| | | 18 – 20 | 2 3 4 | 9 | 100 | SS-8 | 2.00 | - | - | - | - | - | - | - | - | 20 | A-6b (V) | - | |
| | | 21 – 22 | 2 4 6 | 13 | 100 | SS-9 | 1.50 | - | - | - | - | - | - | - | - | 16 | A-6b (V) | - | |
| @23.5': VERY STIFF | 621.5 | 23 – 25 EOB | 3 5 6 | 14 | 100 | SS-10 | 2.50 | - | - | - | - | - | - | - | - | 15 | A-6b (V) | - | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 7 CF CEMENT-BENTONITE GROUT

| | | | |
|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR184 |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 3/15/21 | ELEVATION: 645.3 (NAVD88) EOB: 8.5 ft. |
| START: 11/1/21 END: 11/1/21 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 66 | COORD: 748711.9400 N, 1645013.5690 E |

EXPLORATION ID B-032-0-21



| MATERIAL DESCRIPTION AND NOTES | ELEV. 645.3 | DEPTHS |
|---|---|---|
| ASPHALT - 10.75 INCHES | 644.4 | |
| AGGREGATE BASE - 9.25 INCHES | 643.6 | |
| MEDIUM STIFF, BROWN, **SILT**, SOME SAND, TRACE CLAY, TRACE CRUSHED STONE, TRACE IRON OXIDE STAIN SEAM, MOIST (FILL) | 642.0 | |
| MEDIUM DENSE, BROWN/GRAY, **STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, MOIST (CRUSHED STONE FILL) | 641.1 | W 641.1 |
| VERY STIFF, GRAY, **SANDY SILT**, SOME CLAY, DAMP (FILL)<br>@5.3': HARD, SOME GRAVEL (CRUSHED STONE)<br>@6': GRAY/BROWN<br>@7.3': VERY STIFF | 636.8 | EOB |

| SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 2 3 | 6 | 100 | SS-1 | 0.50 | 2 | 5 | 27 | 58 | 8 | 26 | 24 | 2 | 24 | A-4b (6) | 340 | |
| 4 4 10 | 15 | 100 | SS-2A | - | - | - | - | - | - | - | - | - | - | A-4b (V) | - | |
| | | | SS-2B | - | - | - | - | - | - | - | - | - | 9 | A-2-6 (V) | - | |
| 8 8 14 | 24 | 100 | SS-3 | 4.00 | - | - | - | - | - | - | - | - | 17 | A-4a (V) | - | |
| 13 5 4 | 10 | 100 | SS-4 | >4.5 | 27 | 4 | 4 | 33 | 32 | 25 | 23 | 2 | 17 | A-4a (6) | - | |
| 20 22 24 | 51 | 100 | SS-5 | 4.00 | - | - | - | - | - | - | - | - | 16 | A-4a (V) | - | |



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 6/29/23 13:55 - S:\PROJECTS\2065201.GPJ

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-033-0-21 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: SR184 | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 3/15/21 | ELEVATION: 646.4 (NAVD88) EOB: 8.5 ft. | PAGE 1 OF 1 |
| START: 11/1/21 END: 11/1/21 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 66 | COORD: 748675.8700 N, 1645349.2310 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 646.4 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 2.5 INCHES | 646.2 | | | | | | | | | | | | | | | | | | |
| CONCRETE - 9 INCHES | 645.4 | 1 | | | | | | | | | | | | | | | | | |
| HARD, BROWN, **SANDY SILT**, WITH CLAY, TRACE IRON OXIDE STAIN SEAM, DAMP | | 2 | 9 8 9 | 19 | 94 | SS-1 | >4.5 | 0 | 1 | 15 | 43 | 41 | 26 | 22 | 4 | 16 | A-4a (8) | - | |
| @3': WET | | W 643.4 3 | 11 13 13 | 29 | 100 | SS-2 | - | 0 | 2 | 6 | 40 | 52 | 28 | 25 | 3 | 26 | A-4a (8) | 350 | |
| | 641.7 | 4 | | | | | | | | | | | | | | | | | |
| HARD, BROWN/GRAY, **SILT AND CLAY**, LITTLE SAND, DAMP | | 5 | 10 12 14 | 29 | 100 | SS-3 | 4.25 | - | - | - | - | - | - | - | - | 18 | A-6a (V) | - | |
| | 639.9 | 6 | 6 8 10 | 20 | 100 | SS-4A | 4.25 | - | - | - | - | - | - | - | - | 19 | A-6a (V) | - | |
| VERY STIFF, BROWN/GRAY, **SANDY SILT**, SOME CLAY, DAMP | | 7 | | | | SS-4B | - | - | - | - | - | - | - | - | - | - | A-4a (V) | - | |
| | 637.9 | 8 EOB | 8 10 10 | 22 | 100 | SS-5 | 2.50 | - | - | - | - | - | - | - | - | 18 | A-4a (V) | - | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-034-0-21 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: ACRES RD | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 3/15/21 | ELEVATION: 649.0 (NAVD88) EOB: 8.5 ft. | PAGE 1 OF 1 |
| START: 11/1/21 END: 11/1/21 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 66 | COORD: 748851.1870 N, 1645042.3370 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 649.0 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 9.5 INCHES | 648.2 | | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 6.5 INCHES | 647.7 | 1 | | | | | | | | | | | | | | | | | |
| VERY STIFF, BROWN, **SANDY SILT**, TRACE CLAY, MOIST | | 2 | 9 9 7 | 18 | 89 | SS-1 | - | 0 | 6 | 45 | 45 | 4 | 25 | 23 | 2 | 23 | A-4a (3) | 350 | |
| @2.8': STIFF, "AND" CLAY, TRACE IRON OXIDE STAIN SEAM, DAMP | | 3 | 6 10 10 | 22 | 100 | SS-2 | 1.50 | 0 | 2 | 7 | 41 | 50 | 24 | 22 | 2 | 19 | A-4a (8) | - | |
| @4.1': VERY STIFF, BROWN/GRAY | | 4, 5 | 8 14 14 | 31 | 100 | SS-3 | 3.00 | - | - | - | - | - | - | - | - | 18 | A-4a (V) | - | |
| | | 6, W 642.0 | 11 15 21 | 40 | 100 | SS-4 | 4.00 | - | - | - | - | - | - | - | - | 17 | A-4a (V) | - | |
| @7': GRAY | 640.5 | 7, 8, EOB | 6 12 22 | 37 | 100 | SS-5 | 3.50 | - | - | - | - | - | - | - | - | 18 | A-4a (V) | - | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-039-0-21 |
|---|---|---|---|---|
| TYPE: RETAINING WALL | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP B | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ2 | CALIBRATION DATE: 2/20/23 | ELEVATION: 636.2 (NAVD88) EOB: 35.0 ft. | PAGE 1 OF 2 |
| START: 2/24/23 END: 2/24/23 | SAMPLING METHOD: SPT / ST / NQ2 | ENERGY RATIO (%): 72.9 | COORD: 748905.2610 N, 1644118.7100 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 636.2 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 5.5 INCHES | 635.7 | | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 11.5 INCHES | 634.8 | 1 | | | | | | | | | | | | | | | | | |
| MEDIUM DENSE, BROWN, **FINE SAND**, TRACE SILT, TRACE CLAY, MOIST | | 2 | 6 9 8 | 21 | 78 | SS-1 | - | - | - | - | - | - | - | - | - | 12 | A-3 (V) | - | |
| | 632.0 | 3–4 | | | | | | | | | | | | | | | | | |
| STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, WET | | 4–5 | 4 3 4 | 9 | 100 | SS-2 | 1.50 | - | - | - | - | - | - | - | - | 23 | A-6b (V) | - | |
| @7': VERY STIFF | | 6–7 | 5 5 7 | 15 | 100 | SS-3 | 2.25 | 0 | 6 | 31 | 44 | 19 | 20 | 14 | 6 | 24 | A-4a (6) | - | |
| | 627.8 | 8 | | | | | | | | | | | | | | | | | |
| VERY STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST | | 9–10 | 4 5 6 | 13 | 100 | SS-4 | 2.50 | - | - | - | - | - | - | - | - | 15 | A-6a (V) | - | |
| @11': BROWN/GRAY, DAMP, Qu = 32.5 PSI = 2.34 TSF | | 11–12 | | | 29 | ST-5 | 2.75 | 6 | 8 | 10 | 26 | 50 | 26 | 15 | 11 | 13 | A-6a (8) | - | |
| | 622.7 | 13 | | | | | | | | | | | | | | | | | |
| HARD, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE ROCK FRAGMENTS, DAMP | 621.2 | 14 W 621.2 TR | 46 50/2" | - | 25 | SS-6 | - | - | - | - | - | - | - | - | - | 8 | A-4a (V) | - | |
| **DOLOMITE**, GRAY, MODERATELY TO HIGHLY WEATHERED, MODERATELY STRONG, VERTICAL FRACTURES, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW TO TIGHT; RQD 0%, REC 100%. | 619.5 | 15–17 | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 81%, REC 100%. @16.7': Qu - 16,730 PSI @20': Qu - 15,670 PSI | 614.7 | 18–21 | 48 | | 100 | NQ2-1 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW TO TIGHT; RQD 0%, REC 100%. | 613.4 | 22–23 | 47 | | 90 | NQ2-2 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 59%, REC 93%. @27': Qu - 19,820 PSI | 607.7 | 24–28 | 58 | | 100 | NQ2-3 | | | | | | | | | | | CORE | | |
| **DOLOMITE**, GRAY, MODERATELY WEATHERED, STRONG, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROT TO TIGHT; RQD 28%, REC 100%. | 606.2 | 29–30 | | | | | | | | | | | | | | | | | |

| PID: 105889 | SFN: N/A | PROJECT: LUC-23-11.75 | STATION / OFFSET: | START: 2/24/23 | END: 2/24/23 | PG 2 OF 2 | B-039-0-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 605.2 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROT TO TIGHT; RQD 58%, REC 85%. *(continued)* @32.2': Qu - 17,910 PSI | 601.2 | 32, 33, 34, EOB 35 | 58 | | 85 | NQ2-4 | | | | | | | | | | | CORE | | |

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 6/29/23 13:55 - S:\PROJECTS\2065201.GPJ



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; PUMPED 5 CF CEMENT-BENTONITE GROUT

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-039-1-21 |
|---|---|---|---|---|
| TYPE: RETAINING WALL | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP B | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 636.4 (NAVD88) EOB: 11.0 ft. | PAGE 1 OF 1 |
| START: 2/24/23 END: 2/24/23 | SAMPLING METHOD: ST | ENERGY RATIO (%): 72.9 | COORD: 748911.4670 N, 1644119.1590 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 636.4 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEE LOG FOR B-039-0-21 | 628.0 | 1 – 8 | | | | | | | | | | | | | | | | | |
| VERY STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST<br>@10.0-10.5': UU TRIAXIAL: C = 18.5 PSI = 1.33 TSF<br>@10.5-11.0': CONSOLIDATION: Cc = 0.09, Cr = 0.018, eo = 0.44, pc = 2.9 TSF | 625.4 | 9 – 11 EOB | | | 92 | ST-1 | 3.50 | 4 | 5 | 12 | 22 | 57 | 26 | 14 | 12 | 14 | A-6a (9) | - | |

NOTES: OFFSET 5 FT NORTH OF B-039-0-21 TO OBTAIN A SHELBY TUBE SAMPLE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; PUMPED 3 CF CEMENT-BENTONITE GROUT

| | | | |
|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP B |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 641.1 (NAVD88) EOB: 7.5 ft. |
| START: 2/21/23 END: 2/21/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 749267.2530 N, 1644133.1040 E |

EXPLORATION ID B-040-0-21

PAGE 1 OF 1

| MATERIAL DESCRIPTION AND NOTES | ELEV. 641.1 | DEPTHS | SPT/RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 8 INCHES | 640.4 | | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 9 INCHES | 639.7 | 1 | | | | | | | | | | | | | | | | | |
| LOOSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, MOIST | | 2 | 3 4 4 | 10 | 89 | SS-1 | - | 0 | 6 | 76 | 16 | 2 | NP | NP | NP | 18 | A-3a (0) | <100 | |
| @3.5': MEDIUM DENSE, DAMP | | 3 – 4 | 5 7 7 | 17 | 100 | SS-2 | - | - | - | - | - | - | - | - | - | 8 | A-3a (V) | - | |
| @4.4': 3 INCH GRAVEL WITH SAND SEAM | 636.4 | | | | | SS-3A | - | - | - | - | - | - | - | - | - | - | A-3a (V) | - | |
| STIFF, GRAY, **SANDY SILT**, SOME GRAVEL, LITTLE CLAY, MOIST | | 5 | 7 7 11 | 22 | 100 | SS-3B | 1.50 | 21 | 8 | 8 | 46 | 17 | 21 | 18 | 3 | 18 | A-4a (6) | - | |
| @6': VERY STIFF | 633.6 | 6 – 7 EOB | 9 4 5 | 11 | 100 | SS-4 | 2.50 | - | - | - | - | - | - | - | - | 22 | A-4a (V) | - | |



NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / TB | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-041-0-21 |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP B | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.5" SSA | CALIBRATION DATE: 2/20/23 | ELEVATION: 646.8 (NAVD88) EOB: 7.5 ft. | PAGE 1 OF 1 |
| START: 2/21/23 END: 2/21/23 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 72.9 | COORD: 749650.2750 N, 1644117.8320 E | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 646.8 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 10 INCHES | 646.0 | | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 7 INCHES | 645.4 | 1 | | | | | | | | | | | | | | | | | |
| LOOSE, GRAY/BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, MOIST | | 2 | 3 4 4 | 10 | 83 | SS-1 | - | - | - | - | - | - | - | - | - | 13 | A-3a (V) | - | |
| @3.3': MEDIUM DENSE, BROWN, TRACE GRAVEL | | 3 4 | 6 5 5 | 12 | 100 | SS-2 | - | 1 | 22 | 56 | 19 | 2 | NP | NP | NP | 10 | A-3a (0) | 170 | |
| @4.4': 3-INCH GRAVEL SEAM | 642.1 | W 642.1 | | | | SS-3A | - | - | - | - | - | - | - | - | - | - | A-3a (V) | - | |
| VERY STIFF, GRAY, **SANDY SILT**, SOME GRAVEL, SOME CLAY, MOIST | | 5 6 | 6 9 13 | 27 | 72 | SS-3B | 2.00 | 33 | 7 | 4 | 26 | 30 | 23 | 19 | 4 | 20 | A-4a (4) | - | |
| @6': BROWN/GRAY | 639.3 | 7 EOB | 15 14 14 | 34 | 94 | SS-4 | 3.50 | - | - | - | - | - | - | - | - | 22 | A-4a (V) | - | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

| PROJECT: LUC-23-11.75 | DRILLING FIRM / OPERATOR: TTL / CW | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: | EXPLORATION ID B-043-0-21 |
|---|---|---|---|---|
| TYPE: RETAINING WALL | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: RAMP B | |
| PID: 105889 SFN: N/A | DRILLING METHOD: 3.25" HSA / NQ2 | CALIBRATION DATE: 2/20/23 | ELEVATION: 647.6 (NAVD88) EOB: 37.7 ft. | PAGE 1 OF 2 |
| START: 3/9/23 END: 3/9/23 | SAMPLING METHOD: SPT / ST / NQ2 | ENERGY RATIO (%): 72.9 | COORD: 748732.3960 N, 1644211.9050 E | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 647.6 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 9 INCHES | 646.8 | | | | | | | | | | | | | | | | | | |
| AGGREGATE BASE - 7 INCHES | 646.3 | 1 | | | | | | | | | | | | | | | | | |
| MEDIUM DENSE, GRAY/BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, MOIST | 644.6 | 2 – 3 | 5 5 6 | 13 | 100 | SS-1 | - | - | - | - | - | - | - | - | - | 14 | A-3a (V) | - | |
| HARD, GRAY/BROWN, **SANDY SILT**, "AND" CLAY, DAMP | 641.6 | 4 – 6 | 12 22 22 | 53 | 100 | SS-2 | - | 0 | 1 | 9 | 38 | 52 | 22 | 17 | 5 | 11 | A-4a (8) | - | |
| VERY STIFF, BROWN/GRAY, **SILT**, SOME SAND, LITTLE CLAY, TRACE GRAVEL, DAMP | 639.1 | 7 – 8 | 8 10 8 | 22 | 100 | SS-3 | - | 1 | 2 | 19 | 59 | 19 | 21 | 18 | 3 | 16 | A-4b (8) | - | |
| MEDIUM STIFF, GRAY, **SANDY SILT**, "AND" CLAY, WET | 636.6 | 9 – 10 | 1 1 2 | 4 | 100 | SS-4 | 0.50 | 0 | 2 | 10 | 44 | 44 | 29 | 21 | 8 | 27 | A-4a (8) | - | |
| DENSE, GRAY/BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE GRAVEL, TRACE CLAY, WET | 634.6 | ▼ 11 – 13 | 9 12 15 | 33 | 94 | SS-5 | - | - | - | - | - | - | - | - | - | 20 | A-3a (V) | - | |
| VERY STIFF, BROWN, **SANDY SILT**, "AND" CLAY, MOIST | 631.6 | 14 – 15 | 7 11 14 | 30 | 100 | SS-6 | 3.50 | 0 | 2 | 6 | 40 | 52 | 25 | 19 | 6 | 19 | A-4a (8) | - | |
| MEDIUM STIFF, GRAY, **SANDY SILT**, "AND" CLAY, MOIST Qu = 7.7 PSI = 0.55 TSF | 629.6 | 16 – 18 | 6 6 5 | 13 | 100 | SS-7 | 0.75 | 0 | 2 | 6 | 40 | 52 | 24 | 18 | 6 | 21 | A-4a (8) | - | |
| STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, MOIST | 626.9 | 19 – 20 W 627.0 | 2 4 6 | 12 | 100 | SS-8 | 1.75 | 0 | 4 | 12 | 28 | 56 | 30 | 19 | 11 | 22 | A-6a (8) | - | |
| GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, WET | 626.2 | 21 | | | 100 | ST-9A | - | - | - | - | - | - | - | - | - | 23 | A-4a (V) | - | |
| VERY STIFF, GRAY, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, MOIST | 624.1 | 22 – 23 | | | | ST-9B | 3.00 | 1 | 2 | 5 | 24 | 68 | 42 | 22 | 20 | 30 | A-7-6 (12) | - | |
| HARD, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, DAMP | | 24 – 25 | 9 22 33 | 67 | 100 | SS-10 | 4.50 | 4 | 6 | 15 | 26 | 49 | 32 | 19 | 13 | 12 | A-6a (9) | - | |
| | 619.9 | 26 – 27 TR | 11 22 50/2" | - | 100 | SS-11 | 4.50 | - | - | - | - | - | - | - | - | 11 | A-6a (V) | - | |
| **DOLOMITE**, GRAY, MODERATELY TO HIGHLY WEATHERED, STRONG, VUGGY, JOINTED - HIGHLY FRACTURED TO FRACTURED, NARROW TO TIGHT; RQD 27%, REC 100%. | 618.1 | 28 – 30 | 30 | | 75 | NQ2-1 | | | | | | | | | | | CORE | | |
| @30.3': Qu - 21,350 PSI | | | | | | | | | | | | | | | | | | | |



STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 6/29/23 13:55 - S:\PROJECTS\2065201.GPJ

| PID: 105889 | SFN: N/A | PROJECT: LUC-23-11.75 | STATION / OFFSET: | START: 3/9/23 | END: 3/9/23 | PG 2 OF 2 | B-043-0-21 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 616.6 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | SO4 ppm | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DOLOMITE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED - FRACTURED TO MODERATELY FRACTURED, NARROW TO TIGHT; RQD 32%, REC 61%. *(continued)* | 614.9 | 32, 33 | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY STRONG, SHALEY LAMINAE, JOINTED - FRACTURED TO MODERATLEY FRACTED (WITH HIGHLY FRACTURED ZONES), NARROW TO TIGHT; RQD 28%, REC 55%. @32.7': Qu - 22,330 PSI | 609.9 | 34, 35, 36, 37 EOB | 28 | | 55 | NQ2-2 | | | | | | | | | | | CORE | | |

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; PUMPED 8 CF BENTONITE GROUT

# LEGEND KEY

## Ohio Department of Transportation Soil Symbols

A-1-a - Gravel and/or Stone Fragments

A-1-b - Gravel and/or Stone Fragments with Sand

A-2-4,A-2-5 - Gravel and/or Stone Fragments with Sand and Silt

A-2-6,A-2-7 - Gravel and/or Stone Fragments with Sand, Silt and Clay

A-3 - Fine Sand

A-3a - Coarse and Fine Sand

A-4a - Sandy Silt

A-4b - Silt

A-5 - Elastic Silt and Clay

A-6a - Silt and Clay

A-6b - Silty Clay

A-7-5 - Elastic Clay

A-7-6 - Clay

A-8a - Organic Silt

A-8b - Organic Clay

Asphalt

Sod and/or Topsoil

Concrete

Random Fill

Peat

Dolomite

Weathered Dolomite

Limestone

Weathered Limestone

Sandstone

Weathered Sandstone

Shale

Weathered Shale

## Sample Symbols

SS - Split Spoon

ST - Shelby Tube

RC - Rock Core

GS - Geoprobe Sleeve

AU - Auger Cuttings

GB - Grab

Notes:

1. Exploratory borings were drilled during the periods of November 2021, as well as January through April, 2023, using 3¼-inch and 4¼-inch inside diameter hollow-stem augers, as well as 3½-inch diameter solid-stem augers.

2. These logs are subject to the limitations, conclusions, and recommendations in the report and should not be interpreted separate from the report.

3. The boring locations were established in the field by TTL Associates, Inc. (TTL) based on site plans provided by ARCADIS U.S., Inc. Ground surface elevations at the boring locations were obtained by TTL using a handheld GPS unit.

# APPENDIX A

## Embankment Evaluations

## (Including GB-2 Special Benching Diagrams)

**TTL Project No. 2065201**
**LUC-23-11.75**
**Max New Embankment Heights**
**CPI - 5/8/23**

| Algnment | Approximate Station | Nearest Boring(s) | Fill Height (ft) | Notes | GSE (ft) | Rock Elev. (ft) | Depth to Rock (ft) |
|---|---|---|---|---|---|---|---|
| Monroe St | 178+00 | B-006-0/B-006-1 Crest B-008-0 Toe | 7 | Rear Abut: Embankment widening/sidehill fill. New 4:1 Slopes | 640 | 617.5 | 22.5 |
| Monroe St | 183+00 | B-010 Crest B-008-0/ B-014-0/ B-014-1 Toe | 7 | Fwd Abut: Embankment widening/sidehill fill. New 4:1 Slopes | 644 | 615.5 | 28.5 |
| Monroe St | 190+00 | B-013-0/B-026-0/ B-026-1 | 10 | Max Fill: Embankment widening/sidehill fill. New 4:1 Slopes | 626 | 613 | 13 |
| Ramp A | 24+00 | B-026-0/B-026-1/ B-014-0/B-014-1 | 16 | Max Fill: Full Width Embankment with 4:1 Slopes to left and 2:1 Slopes to right | 621 | 613 | 8 |
| Ramp A | 31+45 | B-028-0/B-028-1 | 13 | Rear Abut: Full Width Embankment with 6:1 Slopes to left and 2:1 slopes to right | 618 | 608 | 10 |
| Ramp A | 32+75 | B-029-0 | 10 | Fwd Abut: Full Width Embankment with 2:1 slopes to left and right | 620 | 609.5 | 10.5 |
| Ramp B | 23+00 | B-026-0/B-026-1/ B-014-0/B-014-1 | 8 | Max Fill: Full Width Embankment with 2:1 Slopes to left and 6:1 Slopes to right | 630 | 613 | 17 |
| Ramp C/D | 15+00 | B-017-0 Crest B-021-0 Toe | 12 | Sliver fill left side. Embankment widening/sidehill fill to right with 2:1 slope | 624 | 612 | 12 |
| Ramp D | 21+50 | B-021-0 and B-022-0 | 20 | Max Fill: Full Width Embankment with 8:1 slope to left and 2:1 slope to right | 615 | 608 | 7 |
| Ramp D | 22+97 | B-022-0 and B-022-1 | 18 | Rear Abut: Full Width Embankment with flat slopes to left and 2:1 slopes to right | 618 | 608 | 10 |
| Ramp D | 24+87 | B-022-2/B-022-3 and B-023-0 | 19 | Fwd Abut: Widen of Mainline/Ramp D to Right with flat slope to left to upper elevation and then 2:1 Slope to right | 615 | 603 | 12 |

# SUBSURFACE DIAGRAM

OHIO DEPARTMENT OF TRANSPORTATION
OFFICE OF GEOTECHNICAL ENGINEERING

Monroe St. 183+00, 7' Fill, 28.5' to Rock

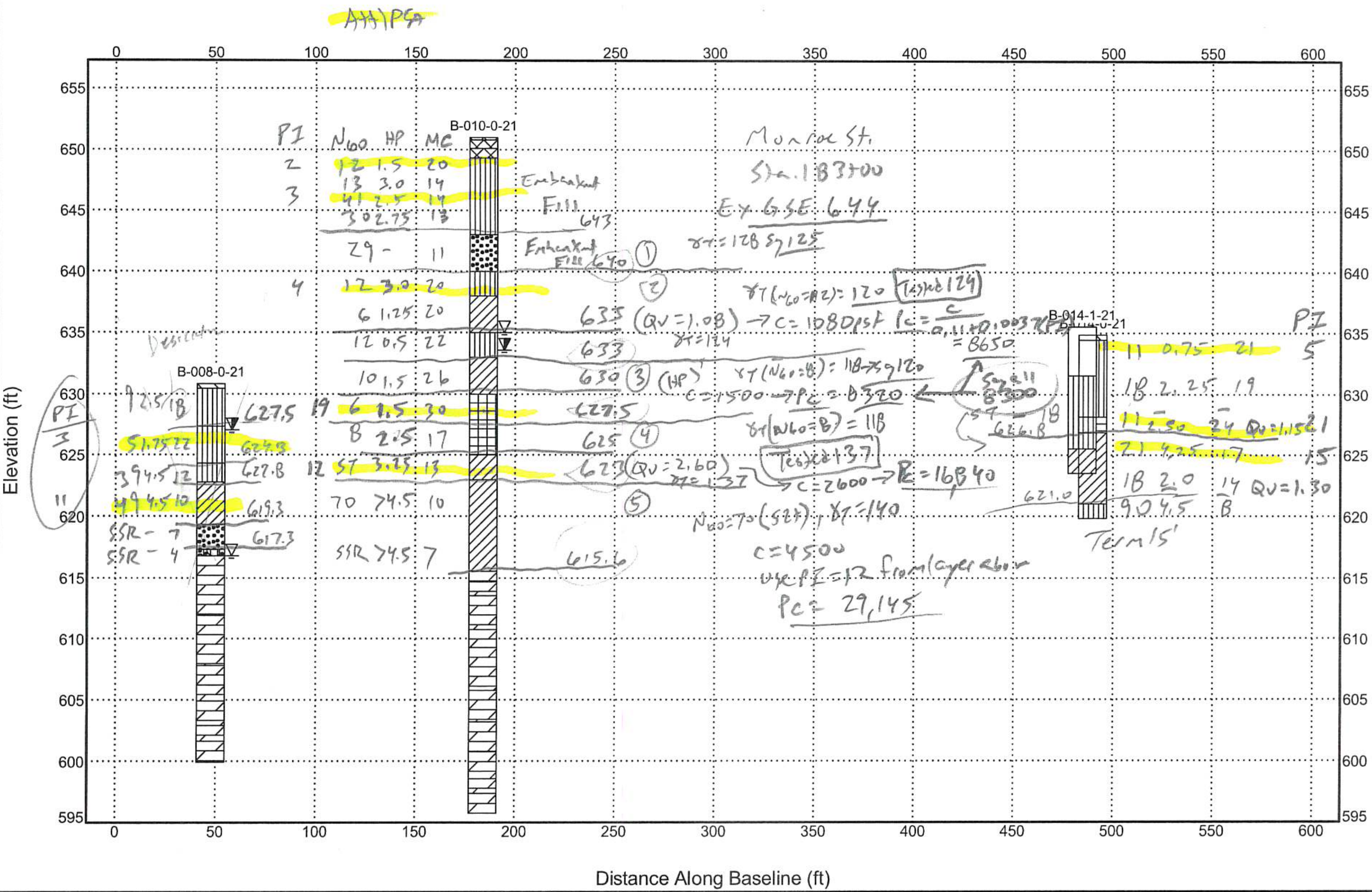
CLIENT ______

PROJECT NUMBER 105889

γT from GDM Table 400-4

PROJECT NAME ______

PROJECT LOCATION N/A




STRATIGRAPHY & GW - A SIZE - OH DOT.GDT - 6/16/23 13:33 - S:\PROJECTS\2065201.GPJ

**TTL Project No. 2065201**
**LUC-23-11.75**
**Monroe St 183+00 (Forward Abutment) Settlement due to Self Weight**
**CPI - 6/28/23**

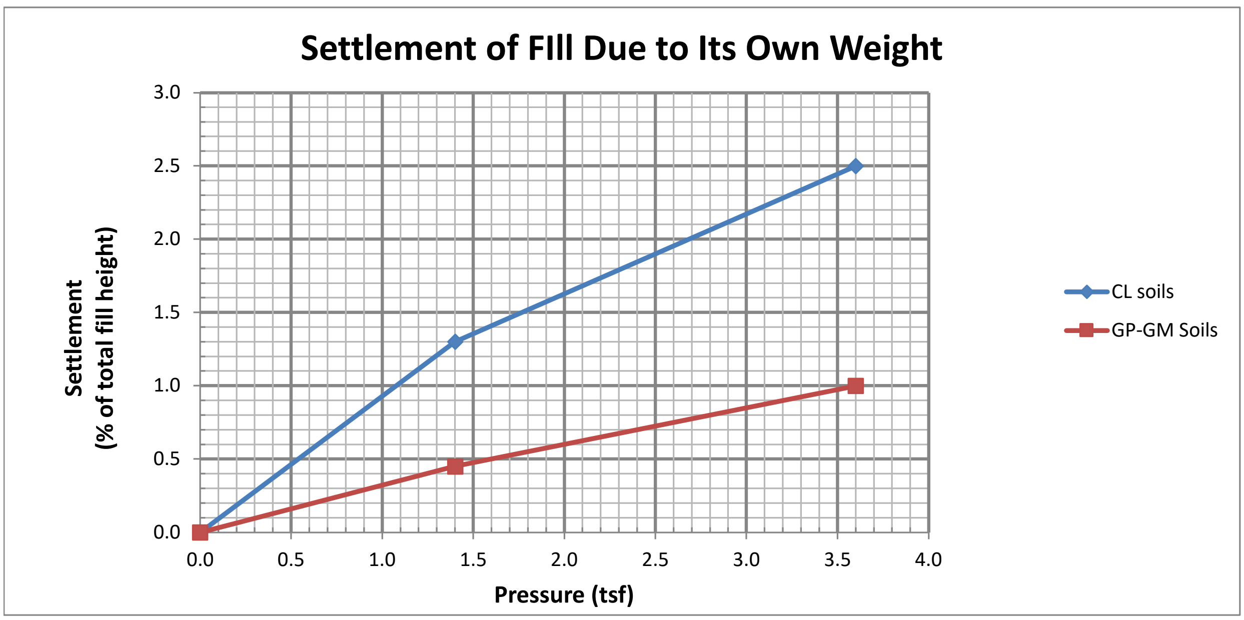
| | |
|---|---|
| Fill Ht (ft): | 7 |
| **Clay** Fill Unit Wt (pcf): | 130 |
| Average pressure (at center of fill height) (psf): | 455 |
| Average pressure (at center of fill height) (tsf): | 0.23 |
| Settlement (% of original Height): | 0.21 |
| Settlement (fraction of original height): | 0.002113 |
| Settlement (inches): | 0.18 |

clays of low to medium plasticity (CL)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 1.3 |
| 3.6 | 2.5 |

Poorly Graded Gravel with sand and silt (GP-GM)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 0.45 |
| 3.6 | 1 |



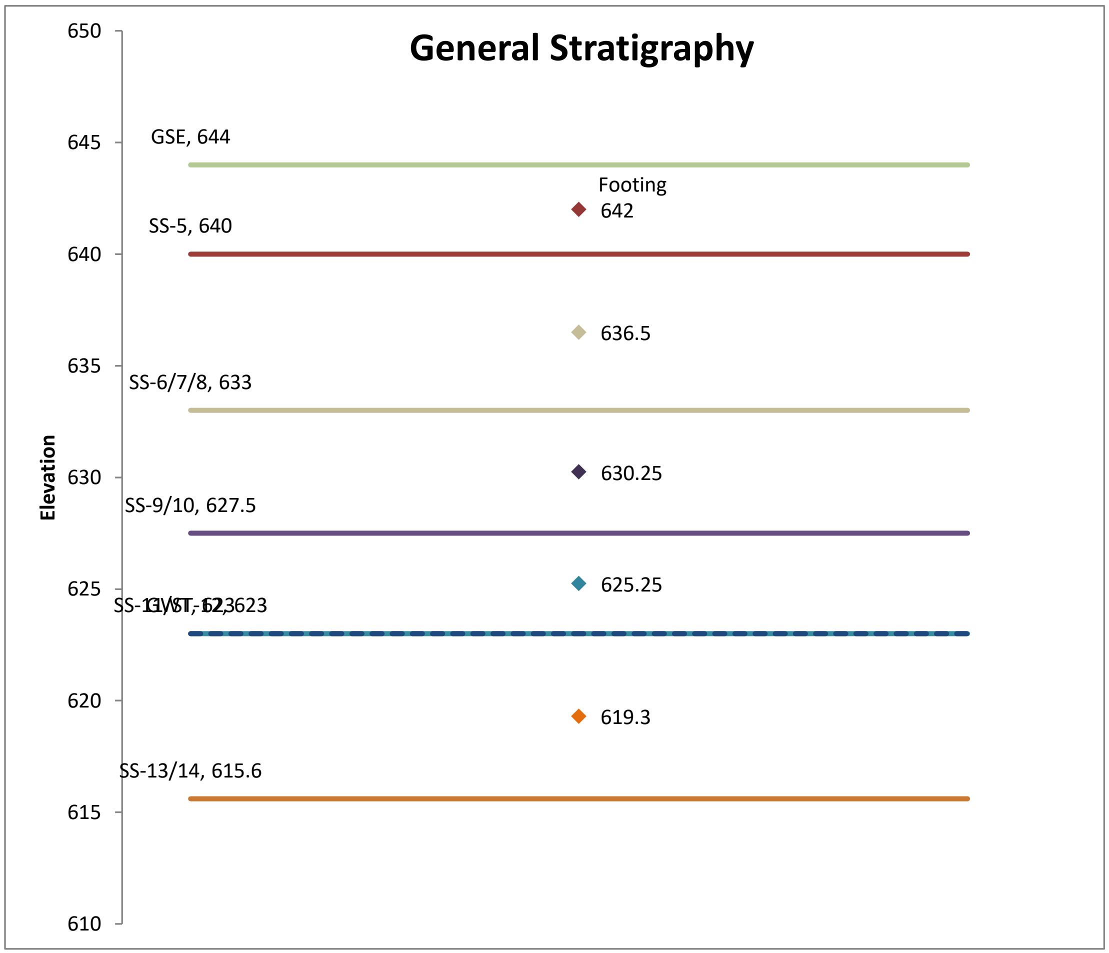
| | | | |
|---|---|---|---|
| Project Name: | 2065201 | Boring Number | B-010-0-21 |
| Project Number: | LUC-023-11 75 | Analysis Type | 0 |
| Calculated by: | CPI | | Consol Results |

For pc, see subsurface diagram and hand calcs.

| Layer | H (feet) | $C_r$ | $e_o$ | sigma v (psf) | z (feet) | b (feet) | (z-Df) / b | $I_z$ | delta p@ | 910 psf | (check) sigma v+ΔP | delta H (inches) | | C' | delta H w/C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS-5 | 4 | 0.011 | 0.50 | 250 | 2 | 0 | #DIV/0! | 1 | 910 | | 1160 | | | 250 | 0.13 |
| SS-6/7/8 | 7 | 0.022 | 0.67 | 934 | 7.5 | 0 | #DIV/0! | 1 | 910 | pc=8300 psf | 1844 | 0.33 | | 0 | #DIV/0! |
| SS-9/10 | 5.5 | 0.028 | 0.81 | 1698 | 13.75 | 0 | #DIV/0! | 1 | 910 | pc=8300 psf | 2608 | 0.19 | | 0 | #DIV/0! |
| SS-11/ST-12 | 4.5 | 0.015 | 0.42 | 2336 | 18.75 | 0 | #DIV/0! | 1 | 910 | pc=16,800 psf | 3246 | 0.08 | | 0 | #DIV/0! |
| SS-13/14 | 7.4 | 0.009 | 0.32 | 2932 | 24.7 | 0 | #DIV/0! | 1 | 910 | pc=29,000 psf | 3842 | 0.07 | | 0 | #DIV/0! |
| | | | | | | | | | | | | | | | |

| | | | | |
|---|---|---|---|---|
| Total delta H (in.) | 0.80 | | | #DIV/0! |
| +15% | 0.92 | | | #DIV/0! |
| -15% | 0.68 | | | #DIV/0! |
| | OKAY | | | |

Total Settlement
3/4 to 1 inch



| | | | |
|---|---|---|---|
| Project Number: | 2065201 | Boring Number | B-010-0-21 |
| Project Name: | LUC-023-11 75 | Analysis Type | |
| Calculated by: | CPI 6/18/2023 | | Embankment Fill |

T:\Projects\2065201 - Arcadis - LUC-023-11 75 - Sylvania Ohio\Evaluations\Embankment Settlement\[04 2065201 Monroe Street 183+00 B-010-0.xlsx]output

| | | |
|---|---|---|
| G (assumed) | 2.7 | |
| GSE | 644 | |
| GWT | 623 | |
| Bearing Elev | 644 | Embankment fill "Bearing" on existing GSE |
| $D_f$ | | 130 pcf Material |
| | | 7 ft Fill |
| P | 910 psf | |
| Rig | | ER 66 |

| $\gamma_T$ (pcf) | $\gamma_d$ (pcf) |
|---|---|
| | 0 |
| 0 | |

| | Bot. Elev. | Centroid (C) Elev. | H (ft) | z below footing | z below GSE | $\gamma_T$ (pcf) | $\gamma_d$ (pcf) | $H_{GWT-C}$ | w at C (%) (or $C_r$x1000) | $e_o$ | Depth of Influence = $(z-D_f)/B$ | $I_z$ | $\sigma_v'$ (psf) | N'/N | $N_m$ | N60 | N' | C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS-5 | 640 | 642 | 4 | 2 | 2 | 125 | 113 | -19 | 11 | 0.50 | #DIV/0! | 1 | 250 | 2.57 | 26 | 29 | 75 | 250 |
| SS-6/7/8 | 633 | 636.5 | 7 | 7.5 | 7.5 | 124 | 102 | -13.5 | 22 | 0.67 | #DIV/0! | 1 | 934 | 1.39 | | | 0 | |
| SS-9/10 | 627.5 | 630.25 | 5.5 | 13.75 | 13.75 | 120 | 94 | -7.25 | 28 | 0.81 | #DIV/0! | 1 | 1698 | 0.97 | | | 0 | |
| SS-11/ST-12 | 623 | 625.25 | 4.5 | 18.75 | 18.75 | 137 | 119 | -2.25 | 15 | 0.42 | #DIV/0! | 1 | 2336 | 0.89 | | | 0 | |
| SS-13/14 | 615.6 | 619.3 | 7.4 | 24.7 | 24.7 | 140 | 128 | 3.7 | 9 | 0.32 | #DIV/0! | 1 | 2932 | 0.82 | | | 0 | |

**TTL Project No. 2065201**
**LUC-23-11.75**
**Ramp A Rear Abutment Settlement due to Self Weight**
**CPI - 6/25/23**

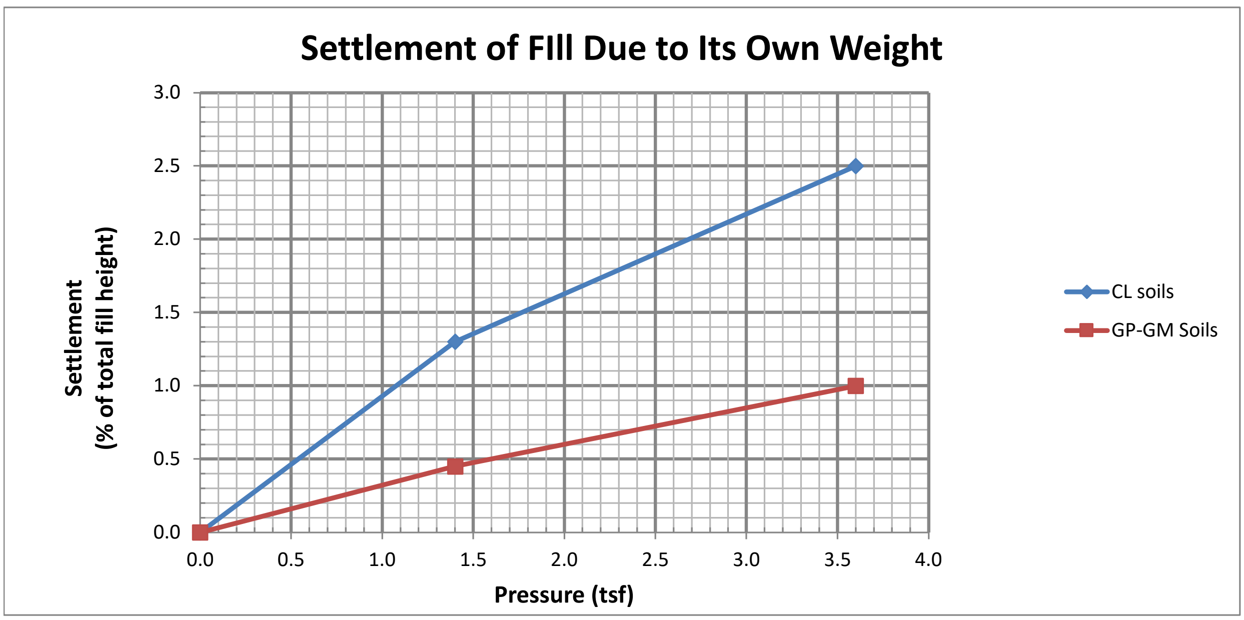
| | |
|---|---|
| Fill Ht (ft): | 13 |
| **Clay** Fill Unit Wt (pcf): | 130 |
| Average pressure (at center of fill height) (psf): | 845 |
| Average pressure (at center of fill height) (tsf): | 0.42 |
| Settlement (% of original Height): | 0.39 |
| Settlement (fraction of original height): | 0.003923 |
| Settlement (inches): | 0.61 |

clays of low to medium plasticity (CL)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 1.3 |
| 3.6 | 2.5 |

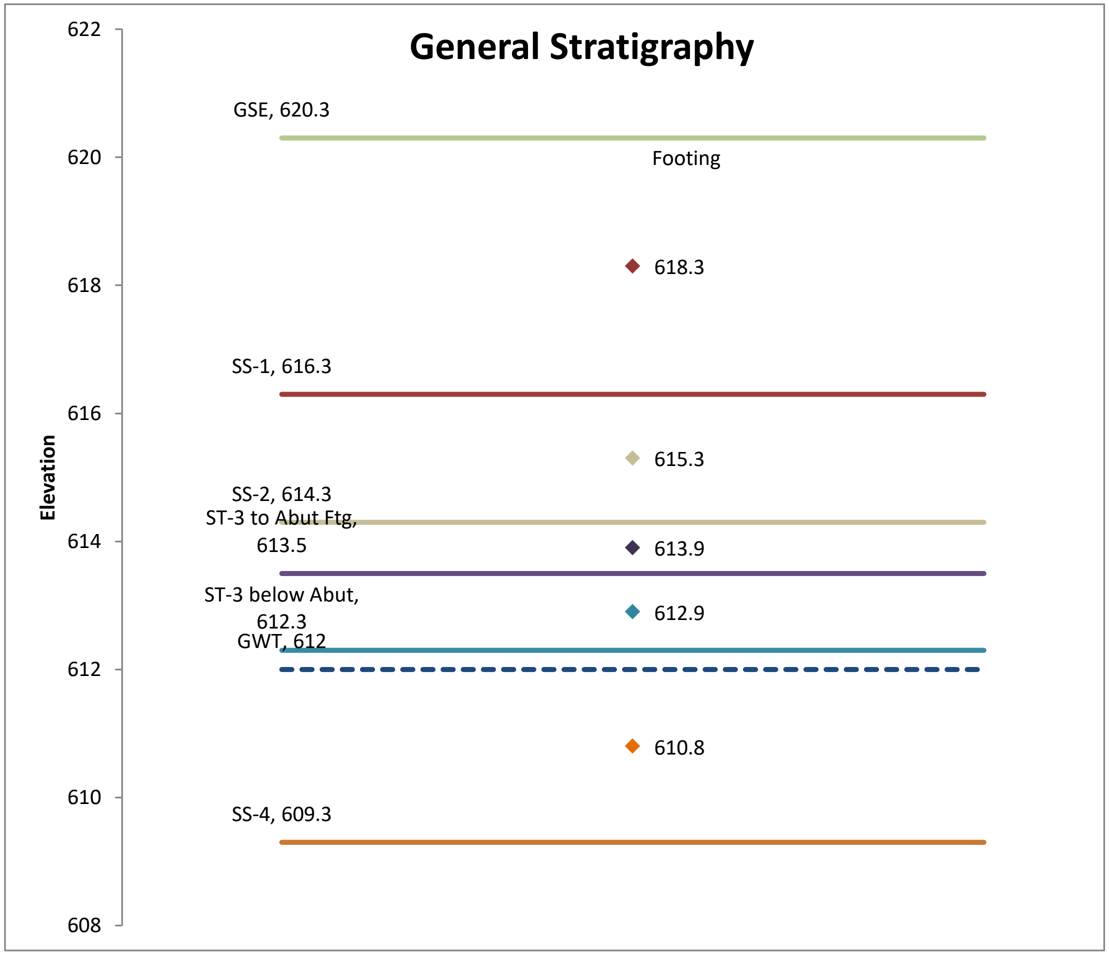
Poorly Graded Gravel with sand and silt (GP-GM)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 0.45 |
| 3.6 | 1 |



| | | | |
|---|---|---|---|
| Project Name: | 2065201 | Boring Number | B-028-0-21 |
| Project Number: | LUC-023-11 75 | Analysis Type | 0 |
| Calculated by: | CPI | | Consol Results |

| Layer | H (feet) | $C_r$ | $e_o$ | sigma v (psf) | z (feet) | b (feet) | (z-Df) / b | $I_z$ | delta p@ | 1690 psf | (check) sigma v+ΔP | delta H (inches) | | C' | delta H w/C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS-1 | 4 | 0.012 | 0.52 | 250 | 2 | 0 | #DIV/0! | 1 | 1690 | | 1940 | 0.34 | | 156 | 0.27 |
| SS-2 | 2 | 0.013 | 0.59 | 620 | 5 | 0 | #DIV/0! | 1 | 1690 | | 2310 | 0.11 | | 0 | #DIV/0! |
| -3 to Abut F | 0.8 | 0.034 | 0.85 | 790 | 6.4 | 0 | #DIV/0! | 1 | 1690 | pc=5400 psf | 2480 | 0.09 | | 0 | #DIV/0! |
| -3 below Ab | 1.2 | 0.034 | 0.85 | 915 | 7.4 | 0 | #DIV/0! | 1 | 1690 | pc=5400 psf | 2605 | 0.12 | | 0 | #DIV/0! |
| SS-4 | 3 | 0.021 | 0.70 | 1095 | 9.5 | 0 | #DIV/0! | 1 | 1690 | | 2785 | 0.18 | | 46 | 0.32 |




| | | | |
|---|---|---|---|
| Total delta H (in.) | 0.91 | | #DIV/0! |
| +15% | 1.05 | | #DIV/0! |
| -15% | 0.77 | | #DIV/0! |
| | OKAY | | |

Total Settlement
3/4 to 1 inch

Below Abutment Footing
0.44 in.
0.50 +15%
0.37 -15%

Essentially 0.4 inch or less, so no downdrag

| | | | |
|---|---|---|---|
| Project Number: | 2065201 | Boring Number | B-028-0-21 |
| Project Name: | LUC-023-11 75 | Analysis Type | |
| Calculated by: | CPI 5/30/2023 | | Embankment Fill |

T:\Projects\2065201 - Arcadis - LUC-023-11 75 - Sylvania Ohio\Evaluations\Embankment Settlement\[06 2065201 Ramp A Rear Abutment B-028-0.xlsx]output

| | | |
|---|---|---|
| G (assumed) | 2.7 | |
| GSE | 620.3 | |
| GWT | 612 | |
| Bearing Elev | 620.3 | Embankment fill "Bearing" on existing GSE |
| $D_f$ | | 130 pcf Material |
| | | 13 ft Fill |
| P | 1690 psf | |
| Rig | | ER 90 |

Consol Test Results

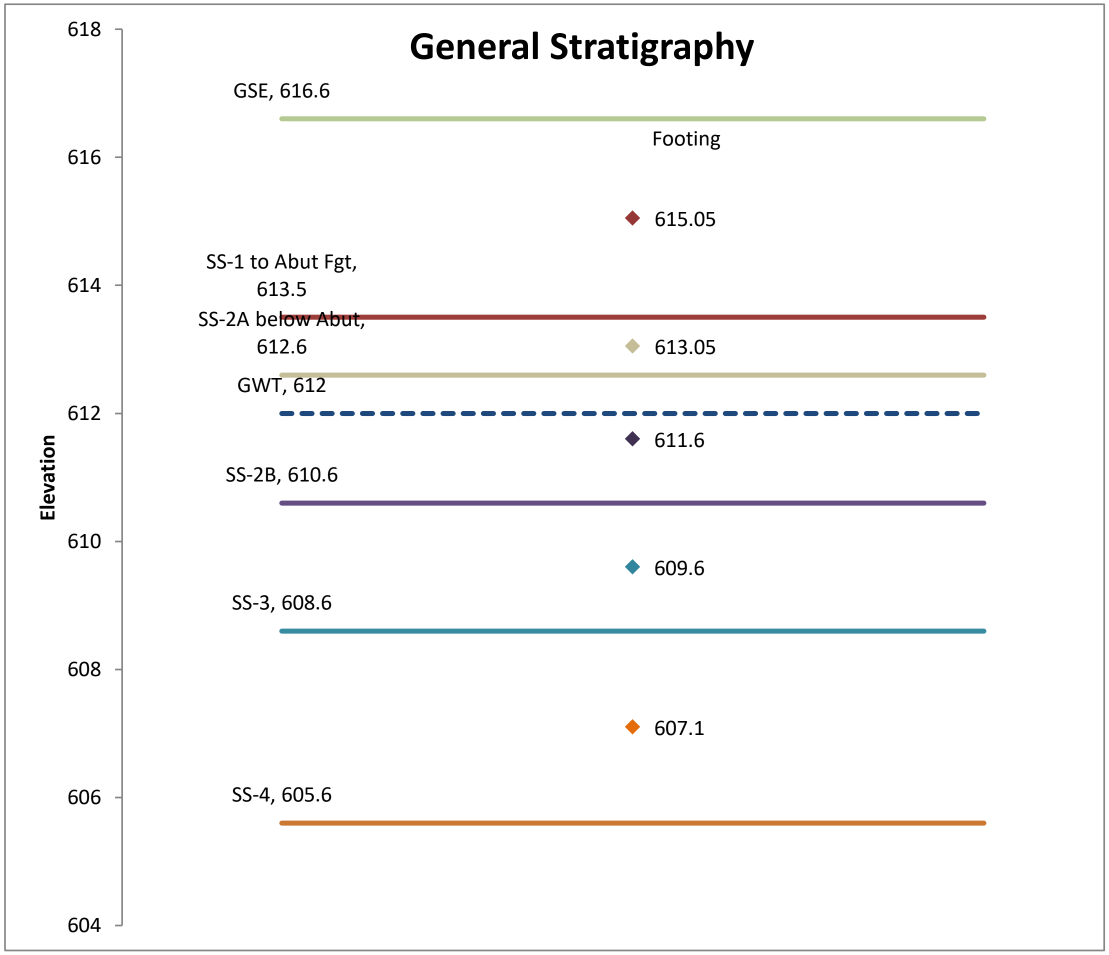
| $\gamma_T$ (pcf) | $\gamma_d$ (pcf) |
|---|---|
| | 0 |
| 0 | |

| | Bot. Elev. | Centroid (C) Elev. | H (ft) | z below footing | z below GSE | $\gamma_T$ (pcf) | $\gamma_d$ (pcf) | $H_{GWT-C}$ | w at C (%) (or $C_r$x1000) | $e_o$ | Depth of Influence = $(z-D_f)/B$ | $I_z$ | $\sigma_v'$ (psf) | N'/N | $N_m$ | N60 | N' | C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS-1 | 616.3 | 618.3 | 4 | 2 | 2 | 125 | 112 | -6.3 | 12 | 0.52 | #DIV/0! | 1 | 250 | 2.57 | 13 | 20 | 50 | 156 |
| SS-2 | 614.3 | 615.3 | 2 | 5 | 5 | 120 | 106 | -3.3 | 13 | 0.59 | #DIV/0! | 1 | 620 | 1.76 | | | 0 | |
| ST-3 to Abut Ftg | 613.5 | 613.9 | 0.8 | 6.4 | 6.4 | 125 | 98 | -1.9 | 27 | 0.85 | #DIV/0! | 1 | 790 | 1.54 | | | 0 | |
| ST-3 below Abut | 612.3 | 612.9 | 1.2 | 7.4 | 7.4 | 125 | 98 | -0.9 | 27 | 0.85 | #DIV/0! | 1 | 915 | 1.41 | | | 0 | |
| SS-4 | 609.3 | 610.8 | 3 | 9.5 | 9.5 | 120 | 99 | 1.2 | 21 | 0.70 | #DIV/0! | 1 | 1095 | 1.25 | 5 | 8 | 9.4 | 46 |

Project Name: 2065201
Project Number: LUC-023-11 75
Calculated by: CPI

Boring Number B-028-1-21
Analysis Type 0

| Layer | H (feet) | $C_r$ | $e_o$ | sigma v (psf) | z (feet) | b (feet) | (z-Df) / b | $I_z$ | delta p@ | 1690 psf | (check) sigma v+ΔP | delta H (inches) | | C' | delta H w/C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -1 to Abut F | 3.1 | 0.019 | 0.60 | 194 | 1.55 | 0 | #DIV/0! | 1 | 1690 | | 1884 | 0.44 | | 0 | #DIV/0! |
| 2A below A | 0.9 | 0.022 | 0.79 | 439 | 3.55 | 0 | #DIV/0! | 1 | 1690 | | 2129 | 0.09 | | 0 | #DIV/0! |
| SS-2B | 2 | 0.034 | 0.79 | 581 | 5 | 0 | #DIV/0! | 1 | 1690 | | 2271 | 0.27 | | 0 | #DIV/0! |
| SS-3 | 2 | 0.034 | 0.50 | 696 | 7 | 0 | #DIV/0! | 1 | 1690 | | 2386 | 0.29 | | 92 | 0.14 |
| SS-4 | 3 | 0.012 | 0.36 | 875 | 9.5 | 0 | #DIV/0! | 1 | 1690 | | 2565 | 0.15 | | ### | 0.01 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | Total delta H (in.) | 0.94 | | | #DIV/0! |
| | | | | | | | | | | | +15% | 1.08 | | | #DIV/0! |
| | | | | | | | | | | | -15% | 0.80 | | | #DIV/0! |
| | | | | | | | | | | | | OKAY | | | |




Total Settlement
3/4 to 1 inch

Below Abutment Footing
0.50 in.
0.58 +15%
0.43 -15%

Downdrag for soil above settlement of 0.4" coming up from bedrock:
Downdrag for Layer SS-2A Below Footing
Elevs 613.5 to 612.6 - 1 ft Zone

From LPILE Analysis, c = 1 ksf
NAVFAC Figure 2 (pg 7.2-196)
Adhesion (cA) = 750 psf = 0.75 ksf

| | | | |
|---|---|---|---|
| Project Number: | 2065201 | Boring Number | B-028-1-21 |
| Project Name: | LUC-023-11 75 | Analysis Type | |
| Calculated by: | CPI 5/30/2023 | | Embankment Fill |

T:\Projects\2065201 - Arcadis - LUC-023-11 75 - Sylvania Ohio\Evaluations\Embankment Settlement\[07 2065201 Ramp A Rear Abutment B-028-1.xlsx]output

| | | | |
|---|---|---|---|
| G (assumed) | 2.7 | | |
| GSE | 616.6 | | |
| GWT | 612 | | |
| Bearing Elev | 616.6 | | Embankment fill "Bearing" on existing GSE |
| $D_f$ | | 130 | pcf Material |
| | | 13 | ft Fill |
| P | 1690 psf | | |
| Rig | | ER 90 | |

| $\gamma_T$ (pcf) | $\gamma_d$ (pcf) |
|---|---|
| | 0 |
| 0 | |

| | Bot. Elev. | Centroid (C) Elev. | H (ft) | z below footing | z below GSE | $\gamma_T$ (pcf) | $\gamma_d$ (pcf) | $H_{GWT-C}$ | w at C (%) (or $C_r$x1000) | $e_o$ | Depth of Influence = (z-$D_f$)/B | $I_z$ | $\sigma_v$' (psf) | N'/N | $N_m$ | N60 | N' | C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS-1 to Abut Fgt | 613.5 | 615.05 | 3.1 | 1.55 | 1.55 | 125 | 105 | -3.05 | 19 | 0.60 | #DIV/0! | 1 | 194 | 2.8 | | 0 | 0 | |
| SS-2A below Abut | 612.6 | 613.05 | 0.9 | 3.55 | 3.55 | 115 | 94 | -1.05 | 22 | 0.79 | #DIV/0! | 1 | 439 | 2.07 | | | 0 | |
| SS-2B | 610.6 | 611.6 | 2 | 5 | 5 | 115 | 94 | 0.4 | 22 | 0.79 | #DIV/0! | 1 | 581 | 1.82 | | | 0 | |
| SS-3 | 608.6 | 609.6 | 2 | 7 | 7 | 125 | 113 | 2.4 | 11 | 0.50 | #DIV/0! | 1 | 696 | 1.66 | 12 | 18 | 20 | 92 |
| SS-4 | 605.6 | 607.1 | 3 | 9.5 | 9.5 | 140 | 125 | 4.9 | 12 | 0.36 | #DIV/0! | 1 | 875 | 1.45 | 60 | 90 | 131 | ### |

**TTL Project No. 2065201**
**LUC-23-11.75**
**Ramp A Forward Abutment Settlement due to Self Weight**
**CPI - 6/25/23**

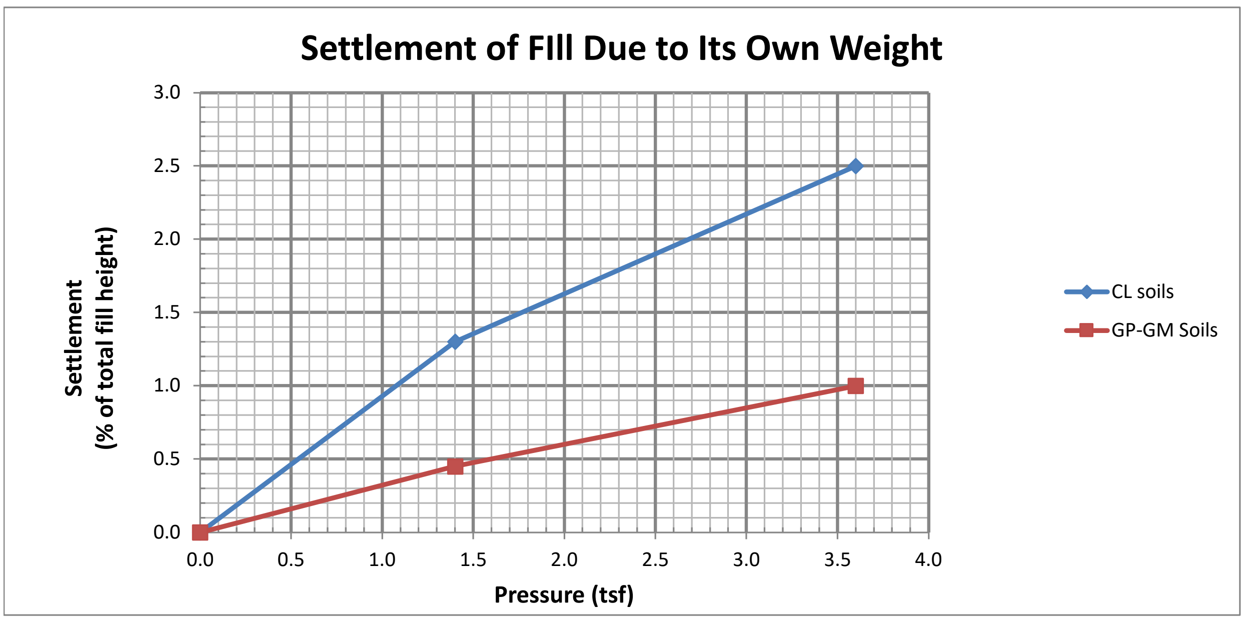
| | |
|---|---|
| Fill Ht (ft): | 10 |
| **Clay** Fill Unit Wt (pcf): | 130 |
| Average pressure (at center of fill height) (psf): | 650 |
| Average pressure (at center of fill height) (tsf): | 0.33 |
| Settlement (% of original Height): | 0.30 |
| Settlement (fraction of original height): | 0.003018 |
| Settlement (inches): | 0.36 |

clays of low to medium plasticity (CL)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 1.3 |
| 3.6 | 2.5 |

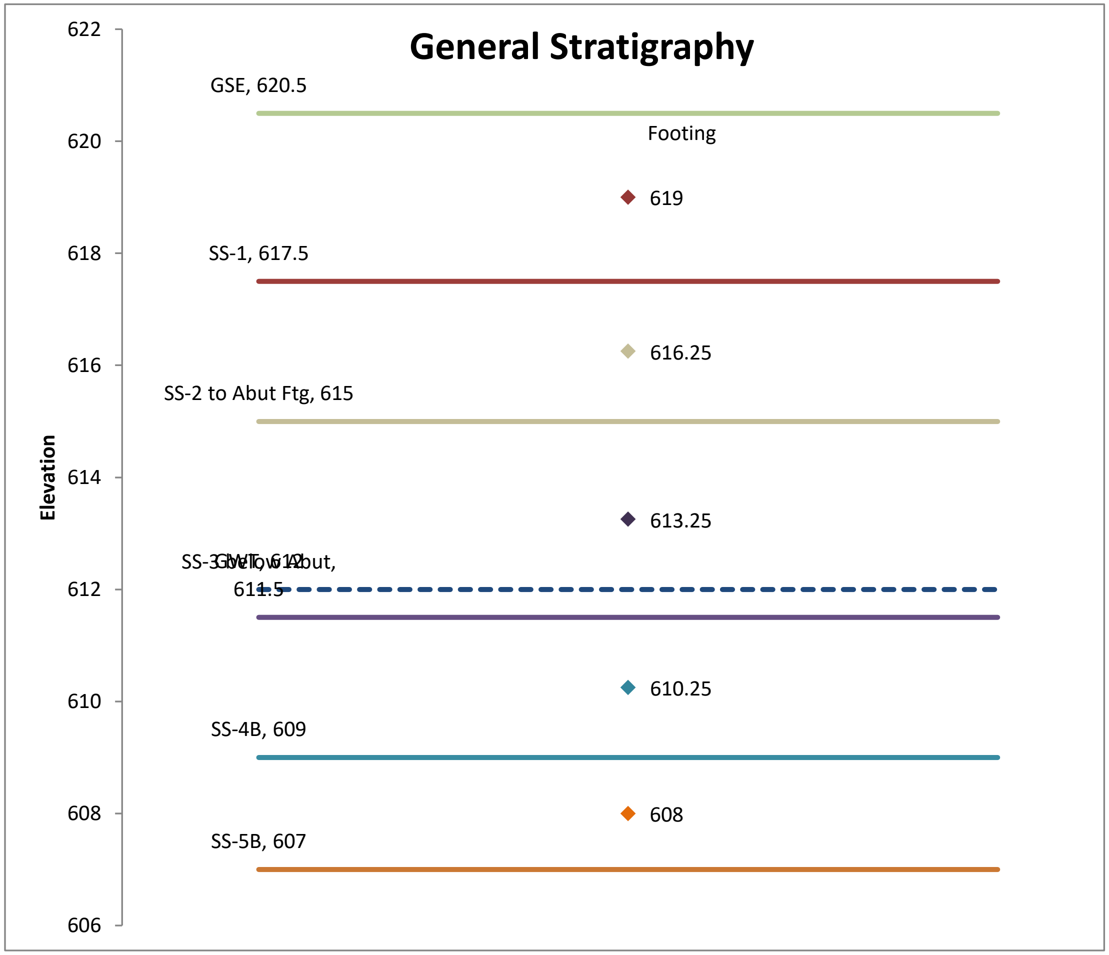
Poorly Graded Gravel with sand and silt (GP-GM)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 0.45 |
| 3.6 | 1 |



| | | | |
|---|---|---|---|
| Project Name: | 2065201 | Boring Number | B-029-0-21 |
| Project Number: | LUC-023-11 75 | Analysis Type | 0 |
| Calculated by: | CPI | | |

| Layer | H (feet) | $C_r$ | $e_o$ | sigma v (psf) | z (feet) | b (feet) | (z-Df) / b | $I_z$ | delta p@ | 1300 psf | (check) sigma v+ΔP | delta H (inches) | | C' | delta H w/C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS-1 | 3 | 0.01 | 0.49 | 188 | 1.5 | 0 | #DIV/0! | 1 | 1300 | | 1488 | 0.22 | | 221 | 0.15 |
| -2 to Abut F | 2.5 | 0.011 | 0.50 | 531 | 4.25 | 0 | #DIV/0! | 1 | 1300 | | 1831 | 0.12 | | 0 | #DIV/0! |
| -3 below Ab | 3.5 | 0.017 | 0.59 | 906 | 7.25 | 0 | #DIV/0! | 1 | 1300 | | 2206 | 0.17 | | 0 | #DIV/0! |
| SS-4B | 2.5 | 0.024 | 0.76 | 1166 | 10.25 | 0 | #DIV/0! | 1 | 1300 | | 2466 | | | 49 | 0.20 |
| SS-5B | 2 | 0.01 | 0.20 | 1335 | 12.5 | 0 | #DIV/0! | 1 | 1300 | | 2635 | 0.06 | | 206 | 0.03 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | Total delta H (in.) | 0.67 | | | #DIV/0! |
| | | | | | | | | | | | +15% | 0.77 | | | #DIV/0! |
| | | | | | | | | | | | -15% | 0.57 | | | #DIV/0! |
| | | | | | | | | | | | | OKAY | | | |




Total Settlement
1/2 to 3/4 inch

Below Abutment Footing
0.41 in.
0.47 +15%
0.35 -15%

Essentially 0.4 inch or less, so no downdrag

**NAVFAC**
**pc=c/(0.11+(0.0037PI))**

| | | |
|---|---|---|
| pc SS-2 | | |
| c (ksf)= | 3.125 | |
| PI= | 3 | |
| pc (ksf)= | 25.8 | >1.8 ksf so Cr |
| pc SS-3 | | |
| c (ksf)= | 3.125 | |
| PI= | 5 | |
| pc (ksf)= | 24.3 | >2.2 ksf so Cr |

Project Number: 2065201 Boring Number B-029-0-21
Project Name: LUC-023-11 75 Analysis Type
Calculated by: CPI 6/25/2023 Embankment Fill

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G (assumed) 2.7
GSE 620.5
GWT 612
Bearing Elev 620.5 Embankment fill "Bearing" on existing GSE
$D_f$ 130 pcf Material
10 ft Fill
P 1300 psf

| $\gamma_T$ (pcf) | $\gamma_d$ (pcf) |
|---|---|
| | 0 |
| 0 | |

Rig ER 90

| | Bot. Elev. | Centroid (C) Elev. | H (ft) | z below footing | z below GSE | $\gamma_T$ (pcf) | $\gamma_d$ (pcf) | $H_{GWT-C}$ | w at C (%) (or $C_r$x1000) | $e_o$ | Depth of Influence = $(z-D_f)/B$ | $I_z$ | $\sigma_v'$ (psf) | N'/N | $N_m$ | N60 | N' | C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS-1 | 617.5 | 619 | 3 | 1.5 | 1.5 | 125 | 114 | -7 | 10 | 0.49 | #DIV/0! | 1 | 188 | 2.83 | 16 | 24 | 68 | 221 |
| SS-2 to Abut Ftg | 615 | 616.25 | 2.5 | 4.25 | 4.25 | 125 | 113 | -4.25 | 11 | 0.50 | #DIV/0! | 1 | 531 | 1.9 | | | 0 | |
| SS-3 below Abut | 611.5 | 613.25 | 3.5 | 7.25 | 7.25 | 125 | 107 | -1.25 | 17 | 0.59 | #DIV/0! | 1 | 906 | 1.42 | | | 0 | |
| SS-4B | 609 | 610.25 | 2.5 | 10.25 | 10.25 | 120 | 97 | 1.75 | 24 | 0.76 | #DIV/0! | 1 | 1166 | 1.19 | 6 | 9 | 11 | 49 |
| SS-5B | 607 | 608 | 2 | 12.5 | 12.5 | 160 | 145 | 4 | 10 | 0.20 | #DIV/0! | 1 | 1335 | 1.07 | 40 | 60 | 64 | 206 |

**TTL Project No. 2065201**
**LUC-23-11.75**
**Ramp D Rear Abutment Settlement due to Self Weight**
**CPI - 6/25/23**

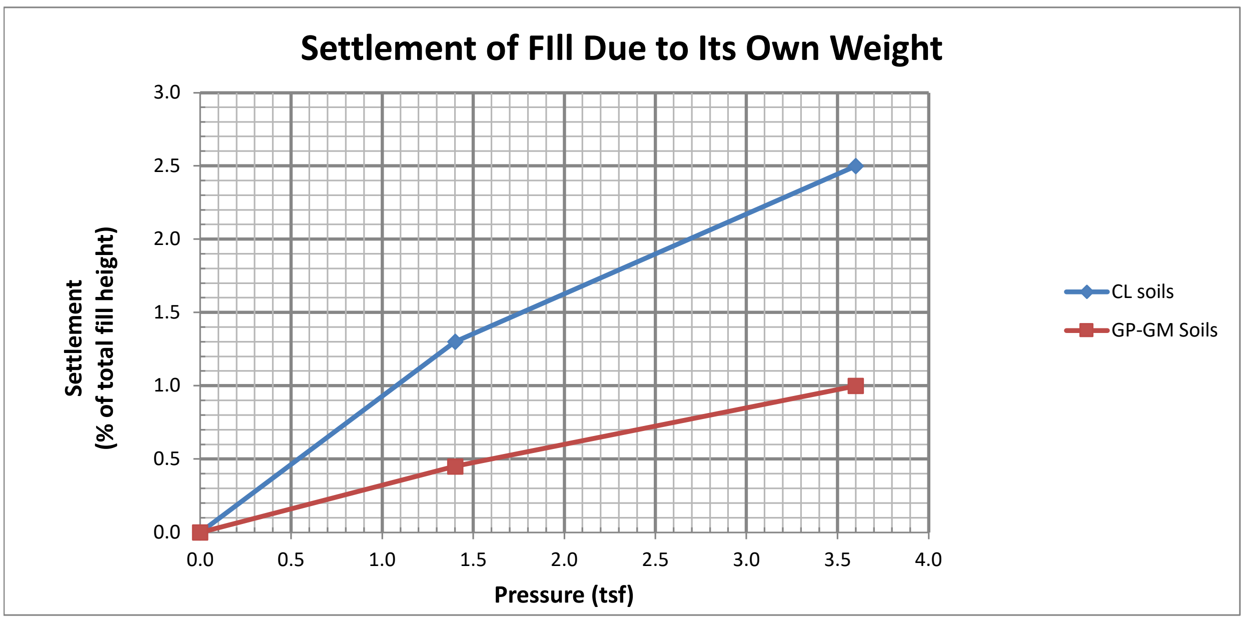
| | |
|---|---|
| Fill Ht (ft): | 18 |
| **Clay** Fill Unit Wt (pcf): | 130 |
| Average pressure (at center of fill height) (psf): | 1170 |
| Average pressure (at center of fill height) (tsf): | 0.59 |
| Settlement (% of original Height): | 0.54 |
| Settlement (fraction of original height): | 0.005432 |
| Settlement (inches): | 1.17 |

clays of low to medium plasticity (CL)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 1.3 |
| 3.6 | 2.5 |

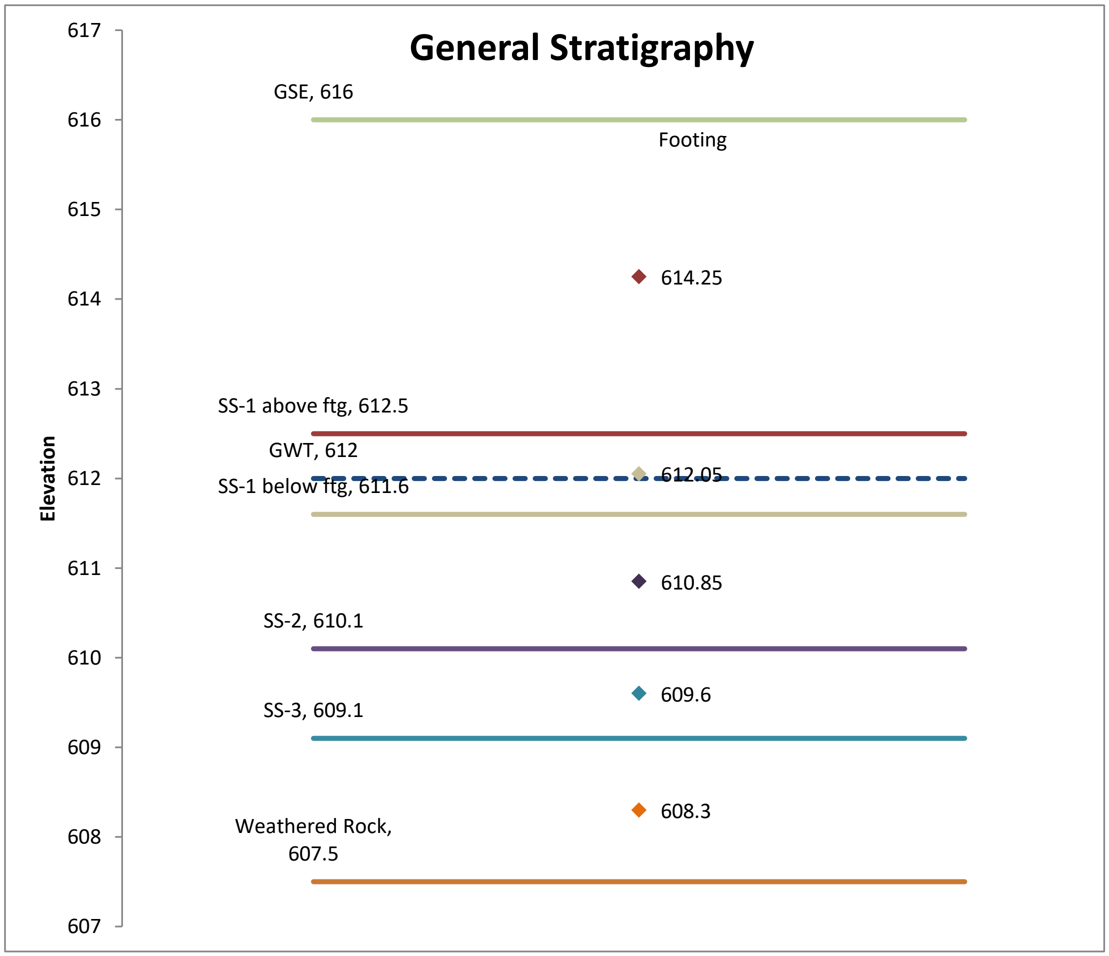
Poorly Graded Gravel with sand and silt (GP-GM)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 0.45 |
| 3.6 | 1 |



| | | | |
|---|---|---|---|
| Project Name: | 2065201 | Boring Number | B-022-1-21 |
| Project Number: | LUC-023-11 75 | Analysis Type | 0 |
| Calculated by: | CPI | | Consol Results |

| Layer | H (feet) | $C_r$ | $e_o$ | sigma v (psf) | z (feet) | b (feet) | (z-Df) / b | $I_z$ | delta p@ | 2340 psf | (check) sigma v+ΔP | delta H (inches) | C' | delta H w/C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S-1 above ft | 3.5 | 0.017 | 0.65 | 210 | 1.75 | 0 | #DIV/0! | 1 | 2340 | | 2550 | 0.47 | 0 | #DIV/0! |
| S-1 below ft | 0.9 | 0.017 | 0.65 | 474 | 3.95 | 0 | #DIV/0! | 1 | 2340 | | 2814 | 0.09 | 0 | #DIV/0! |
| SS-2 | 1.5 | 0.019 | 0.68 | 546 | 5.15 | 0 | #DIV/0! | 1 | 2340 | | 2886 | 0.15 | 0 | #DIV/0! |
| SS-3 | 1 | 0.068 | 1.37 | 618 | 6.4 | 0 | #DIV/0! | 1 | 2340 | | 2958 | 0.23 | 60 | 0.14 |
| eathered Rc | 1.6 | 0 | 0.20 | 725 | 7.7 | 0 | #DIV/0! | 1 | 2340 | | 3065 | | 0 | #DIV/0! |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | Total delta H (in.) | 0.84 | | #DIV/0! |
| | | | | | | | | | | | +15% | 0.96 | | #DIV/0! |
| | | | | | | | | | | | -15% | 0.71 | | #DIV/0! |
| | | | | | | | | | | | | OKAY | | |




Total Settlement
3/4 to 1 inch

Below Abutment Footing
0.37 in.
0.42 +15%
0.31 -15%

Settlement below the footing of approximately 0.4" or less so no downdrag.

**NAVFAC**
**pc=c/(0.11+(0.0037PI))**

| | | |
|---|---|---|
| pc SS-1 | | |
| c (ksf)= | 1.75 | |
| PI= | 8 | |
| pc (ksf)= | 12.5 | >2.8 ksf so Cr |
| pc SS-2 | | |
| c (ksf)= | 1 | |
| PI= | 9 | |
| pc (ksf)= | 7.0 | >2.9 ksf so Cr |

| | | | |
|---|---|---|---|
| Project Number: | 2065201 | Boring Number | B-022-1-21 |
| Project Name: | LUC-023-11 75 | Analysis Type | |
| Calculated by: | CPI 6/26/2023 | | Embankment Fill |

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| | | | |
|---|---|---|---|
| G (assumed) | 2.7 | | |
| GSE | 616 | | |
| GWT | 612 | | |
| Bearing Elev | 616 | | Embankment fill "Bearing" on existing GSE |
| $D_f$ | | 130 | pcf Material |
| | | 18 | ft Fill |
| P | 2340 psf | | |
| Rig | | ER 90 | |

| $\gamma_T$ (pcf) | $\gamma_d$ (pcf) |
|---|---|
| | 0 |
| 0 | |

| | Bot. Elev. | Centroid (C) Elev. | H (ft) | z below footing | z below GSE | $\gamma_T$ (pcf) | $\gamma_d$ (pcf) | $H_{GWT-C}$ | w at C (%) (or $C_r$x1000) | $e_o$ | Depth of Influence = (z-$D_f$)/B | $I_z$ | $\sigma_v$' (psf) | N'/N | $N_m$ | N60 | N' | C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS-1 above ftg | 612.5 | 614.25 | 3.5 | 1.75 | 1.75 | 120 | 103 | -2.25 | 17 | 0.65 | #DIV/0! | 1 | 210 | 2.73 | | | 0 | |
| SS-1 below ftg | 611.6 | 612.05 | 0.9 | 3.95 | 3.95 | 120 | 103 | -0.05 | 17 | 0.65 | #DIV/0! | 1 | 474 | 2 | | | 0 | |
| SS-2 | 610.1 | 610.85 | 1.5 | 5.15 | 5.15 | 120 | 101 | 1.15 | 19 | 0.68 | #DIV/0! | 1 | 546 | 1.87 | | | 0 | |
| SS-3 | 609.1 | 609.6 | 1 | 6.4 | 6.4 | 120 | 71 | 2.4 | 68 | 1.37 | #DIV/0! | 1 | 618 | 1.76 | 6 | 9 | 16 | 60 |
| Weathered Rock | 607.5 | 608.3 | 1.6 | 7.7 | 7.7 | 160 | 160 | 3.7 | 0 | 0.20 | #DIV/0! | 1 | 725 | 1.62 | | | 0 | |

# SUBSURFACE DIAGRAM

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

Ramp D 24+87, 19' Fill, 12' to Rock

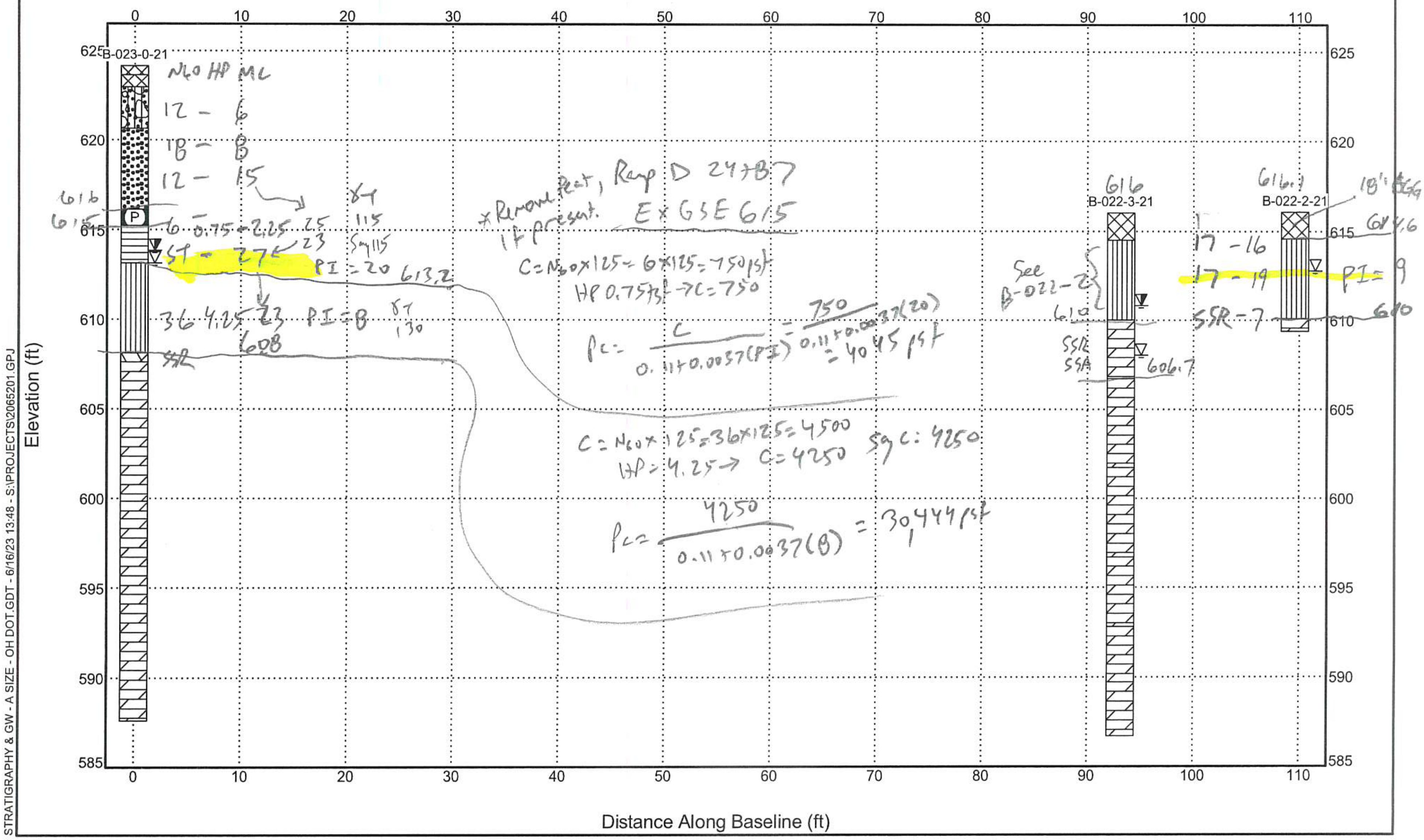
γT GDM Table 400-4

CLIENT ______________________

PROJECT NUMBER 105889

PROJECT NAME ______________________

PROJECT LOCATION N/A



**TTL Project No. 2065201**
**LUC-23-11.75**
**Ramp D Forward Abutment Settlement due to Self Weight**
**CPI - 6/25/23**

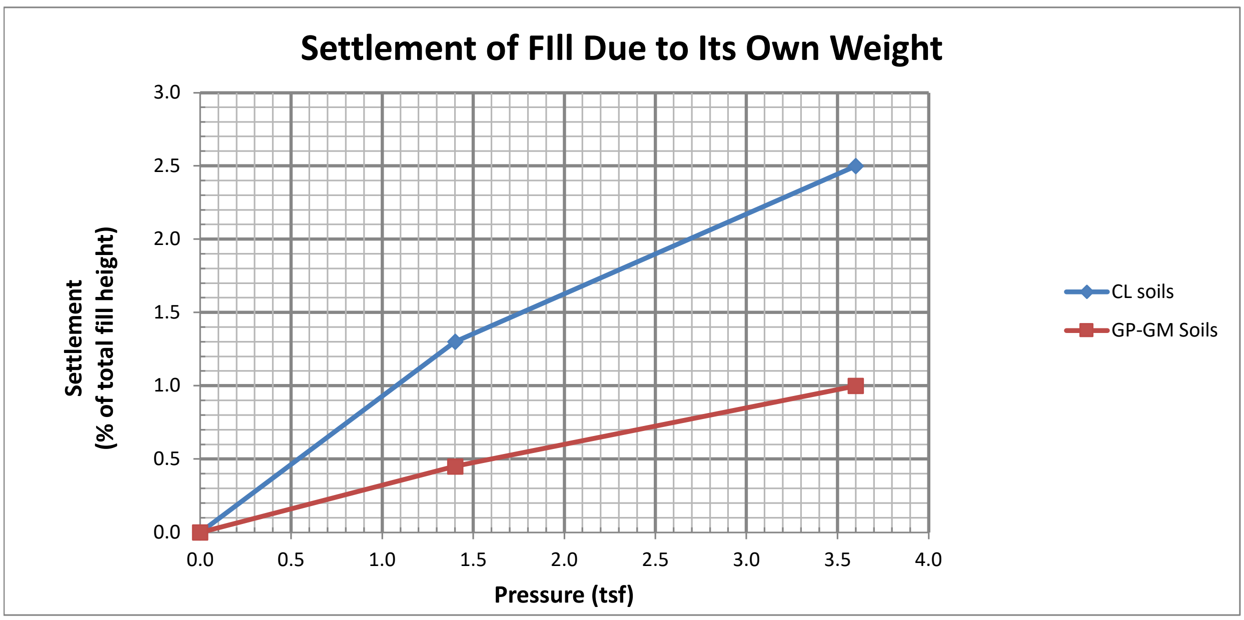
| | |
|---|---|
| Fill Ht (ft): | 19 |
| **Clay** Fill Unit Wt (pcf): | 130 |
| Average pressure (at center of fill height) (psf): | 1235 |
| Average pressure (at center of fill height) (tsf): | 0.62 |
| Settlement (% of original Height): | 0.57 |
| Settlement (fraction of original height): | 0.005734 |
| Settlement (inches): | 1.31 |

clays of low to medium plasticity (CL)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 1.3 |
| 3.6 | 2.5 |

Poorly Graded Gravel with sand and silt (GP-GM)

| pressure | typical value of compression - (percent of total fill height) |
|---|---|
| 0 | 0 |
| 1.4 | 0.45 |
| 3.6 | 1 |

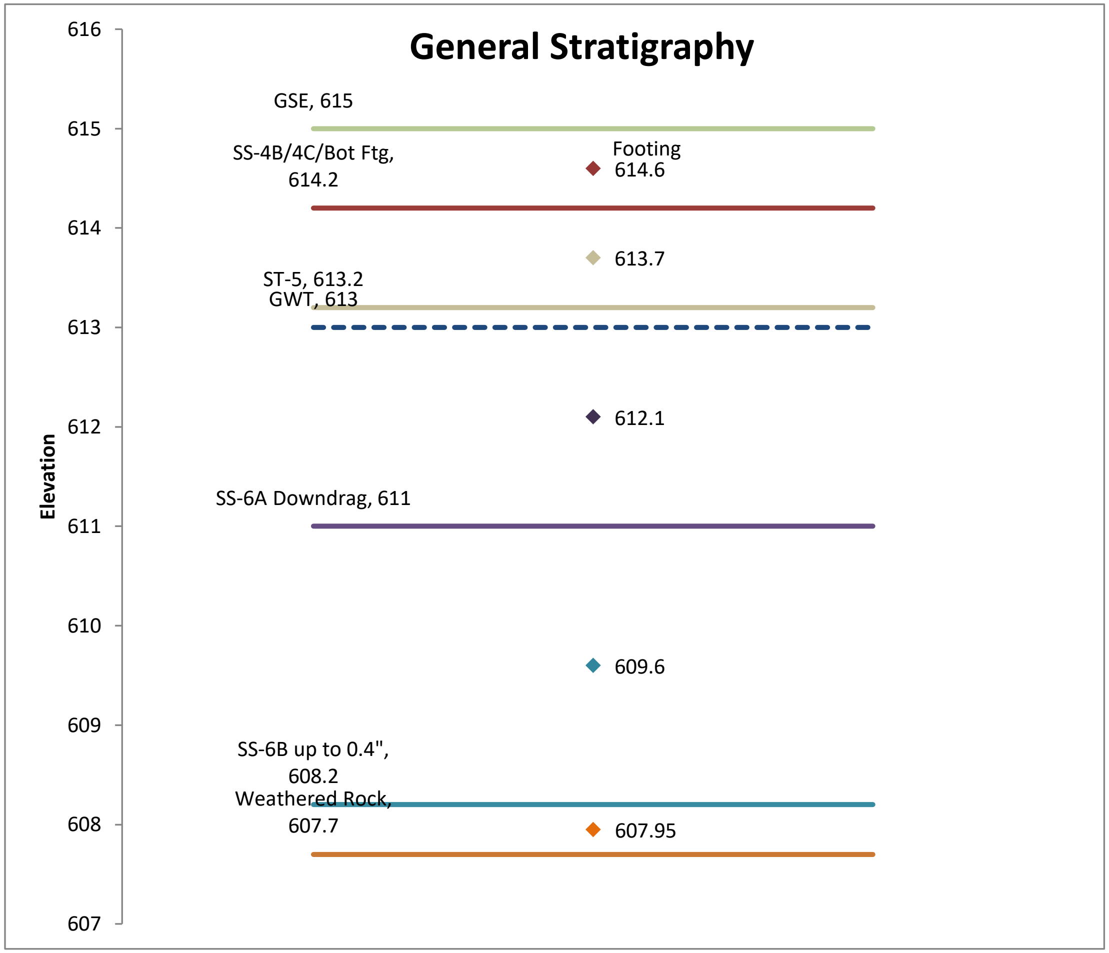


| | | | |
|---|---|---|---|
| Project Name: | 2065201 | Boring Number | B-023-0-21 |
| Project Number: | LUC-023-11 75 | Analysis Type | 0 |
| Calculated by: | CPI | | Consol Results |

For pc, see subsurface diagram and hand calcs.

| Layer | H (feet) | $C_r$ | $e_o$ | sigma v (psf) | z (feet) | b (feet) | (z-Df) / b | $I_z$ | delta p@ | 2470 psf | (check) sigma v+ΔP | delta H (inches) | | C' | delta H w/C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4B/4C/Bot | 0.8 | 0.025 | 0.83 | 46 | 0.4 | 0 | #DIV/0! | 1 | 2470 | pc=4045 psf | 2516 | 0.23 | | 0 | #DIV/0! |
| ST-5 | 1 | 0.027 | 0.87 | 149 | 1.3 | 0 | #DIV/0! | 1 | 2470 | pc=4045 psf | 2619 | 0.22 | | 0 | #DIV/0! |
| -6A Downdr | 2.2 | 0.023 | 0.60 | 294 | 2.9 | 0 | #DIV/0! | 1 | 2470 | pc=30,000 psf | 2764 | 0.37 | | 0 | #DIV/0! |
| -6B up to 0. | 2.8 | 0.023 | 0.60 | 463 | 5.4 | 0 | #DIV/0! | 1 | 2470 | pc=30,000 psf | 2933 | 0.39 | | 0 | #DIV/0! |
| eathered Ro | 0.5 | 0 | 0.20 | 582 | 7.05 | 0 | #DIV/0! | 1 | 2470 | Rock | 3052 | | | 0 | #DIV/0! |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | Total delta H (in.) | 1.20 | | | #DIV/0! |
| | | | | | | | | | | | +15% | 1.38 | | | #DIV/0! |
| | | | | | | | | | | | -15% | 1.02 | | | #DIV/0! |

OKAY




Total Settlement
1 to 1-1/2 inch

Below Abutment Footing
0.97 in.
1.12 +15%
0.82 -15%

Downdrag for soil above settlement of 0.4"
coming up from bedrock:
ST-5 and SS-6A Below Footing

Layer ST-5
Elevs 614.0 to 613.2 - 0.8 ft Zone
From LPILE Analysis, c = 0.75 ksf
NAVFAC Figure 2 (pg 7.2-196)
Adhesion (cA) = 615 psf = 0.62 ksf

Layer SS-6A
Elevs 613.2 to 611 - 2.2 ft Zone
From LPILE Analysis, c = 4.25 ksf
NAVFAC Figure 2 (pg 7.2-196)
Adhesion (cA) = 1,300 psf = 1.30 ksf

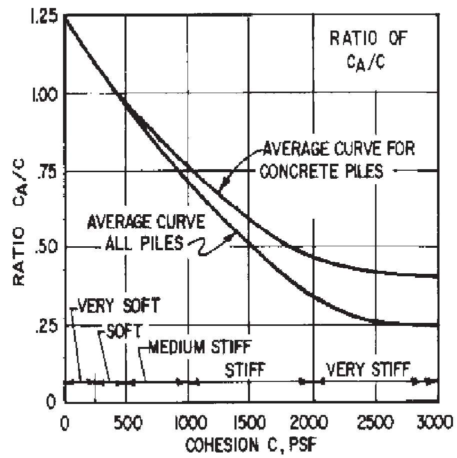
| | | | |
|---|---|---|---|
| Project Number: | 2065201 | Boring Number | B-023-0-21 |
| Project Name: | LUC-023-11 75 | Analysis Type | |
| Calculated by: | CPI 6/18/2023 | | Embankment Fill |

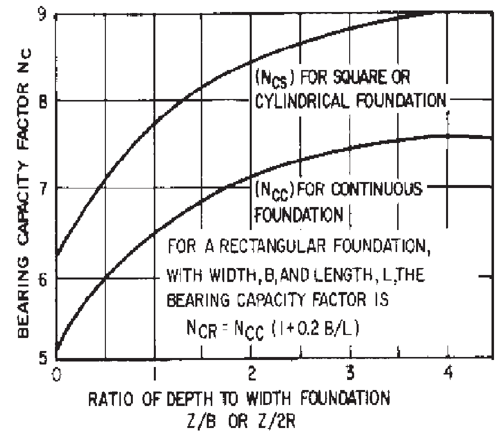
T:\Projects\2065201 - Arcadis - LUC-023-11 75 - Sylvania Ohio\Evaluations\Embankment Settlement\[14 2065201 Ramp D Fwd Abutment B-023-0.xlsx]output

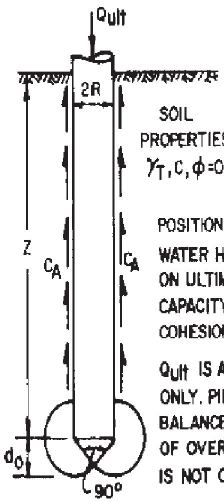
| | | |
|---|---|---|
| G (assumed) | 2.7 | |
| GSE | 615 | |
| GWT | 613 | |
| Bearing Elev | 615 | Embankment fill "Bearing" on existing GSE |
| $D_f$ | | 130 pcf Material |
| | | 19 ft Fill |
| P | 2470 psf | |
| Rig | | ER 90 |

| $\gamma_T$ (pcf) | $\gamma_d$ (pcf) |
|---|---|
| | 0 |
| 0 | |

| | Bot. Elev. | Centroid (C) Elev. | H (ft) | z below footing | z below GSE | $\gamma_T$ (pcf) | $\gamma_d$ (pcf) | $H_{GWT-C}$ | w at C (%) (or $C_r$x1000) | $e_o$ | Depth of Influence = (z-$D_f$)/B | $I_z$ | $\sigma_v$' (psf) | N'/N | $N_m$ | N60 | N' | C' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS-4B/4C/Bot Ftg | 614.2 | 614.6 | 0.8 | 0.4 | 0.4 | 115 | 92 | -1.6 | 25 | 0.83 | #DIV/0! | 1 | 46 | 4.08 | | | 0 | |
| ST-5 | 613.2 | 613.7 | 1 | 1.3 | 1.3 | 115 | 91 | -0.7 | 27 | 0.87 | #DIV/0! | 1 | 149 | 3.03 | | | 0 | |
| SS-6A Downdrag | 611 | 612.1 | 2.2 | 2.9 | 2.9 | 130 | 106 | 0.9 | 23 | 0.60 | #DIV/0! | 1 | 294 | 2.43 | | | 0 | |
| SS-6B up to 0.4" | 608.2 | 609.6 | 2.8 | 5.4 | 5.4 | 130 | 106 | 3.4 | 23 | 0.60 | #DIV/0! | 1 | 463 | 2.02 | | | 0 | |
| Weathered Rock | 607.7 | 607.95 | 0.5 | 7.05 | 7.05 | 160 | 160 | 5.05 | 0 | 0.20 | #DIV/0! | 1 | 582 | 1.82 | | | 0 | |




SOIL PROPERTIES
$\gamma_T, C, \phi = 0$

POSITION OF GROUND-WATER HAS NO EFFECT ON ULTIMATE LOAD CAPACITY UNLESS COHESION IS CHANGED.

$Q_{ult}$ IS APPLIED LOAD ONLY. PILE WEIGHT IS BALANCED BY WEIGHT OF OVERBURDEN AND IS NOT CONSIDERED.

ULTIMATE LOAD CAPACITY IN COMPRESSION

$$Q_{ult} = C \underset{(N_{CC})}{(N_{CS})} \pi R^2 + C_A 2\pi RZ$$

RECOMMENDED VALUES OF ADHESION

| PILE TYPE | CONSISTENCY OF SOIL | COHESION, C PSF | ADHESION, $C_A$ PSF |
|---|---|---|---|
| TIMBER AND CONCRETE | VERY SOFT | 0 - 250 | 0 - 250 |
| | SOFT | 250 - 500 | 250 - 480 |
| | MED. STIFF | 500 - 1000 | 480 - 750 |
| | STIFF | 1000 - 2000 | 750 - 950 |
| | VERY STIFF | 2000 - 4000 | 950 - 1300 |
| STEEL | VERY SOFT | 0 - 250 | 0 - 250 |
| | SOFT | 250 - 500 | 250 - 460 |
| | MED. STIFF | 500 - 1000 | 460 - 700 |
| | STIFF | 1000 - 2000 | 700 - 720 |
| | VERY STIFF | 2000 - 4000 | 720 - 750 |

ULTIMATE LOAD CAPACITY IN TENSION

$T_{ult} = C_A 2\pi RZ$

$T_{ult}$ UNDER SUSTAINED LOAD MAY BE LIMITED BY OTHER FACTORS, SEE TEXT.

FIGURE 2
Ultimate Load Capacity of Single Pile or Pier in Cohesive Soils

(3) Drilled Piers. For drilled piers greater than 24 inches in diameter settlement rather than bearing capacity may control. A reduced end bearing resistance may result from entrapment of bentonite slurry if used to maintain an open excavation to the pier's tip. Bells, or enlarged bases, are usually not stable in granular soils.

(4) Piles and Drilled Piers in Cohesive Soils. See Figure 2 and Table 3. Experience demonstrates that pile driving permanently alters surface adhesion of clays having a shear strength greater than 500 psf (see Figure 2). In softer clays the remolded material consolidates with time, regaining adhesion approximately equal to original strength. Shear strength for point-bearing resistance is essentially unchanged by pile driving. For drilled piers, use Table 3 from Reference 4, Soils and Geology, Procedures for Foundation Design of Buildings and Other Structures, by lie Departments of Army and Air Force, for determining side friction. Ultimate resistance to pullout cannot exceed the total resistance of reduced adhesion acting over the pile surface or the effective weight of the soil mass which is available to react against pullout. The allowable sustained pullout load usually is limited by the tendency for the pile to move upward gradually while mobilizing an adhesion less than the failure value.

Adhesion factors in Figure 2 may be very conservative for evaluating piles driven into stiff but normally consolidated clays. Available data suggests that for piles driven into normally to slightly overconsolidated clays, the side friction is about 0.25 to 0.4 times the effective overburden.

(5) Piles Penetrating Multi-layered Soil Profile. Where piles penetrate several different strata, a simple approach is to add supporting capacity of the individual layers, except where a soft layer may consolidate and relieve load or cause drag on the pile. For further guidance on bearing capacity when a pile penetrates layered soil and terminates in granular strata see Reference 5, Ultimate Bearing Capacity of Foundations on Layered Soils Under Inclined Loads, by Meyer off and Hanna, which consides the ultimate bearing capacity of a deep member in sand underlying a clay layer and for the case of a sand bearing stratum overlying a weak clay layer.

(6) Pile Buckling. For fully embedded piles, buckling usually is not a problem. For a fully embedded, free headed pile with length equal to or greater than 4T, the critical load for buckling is as follows (after Reference 6, Design of Pile Foundations, by Vesic):

P+crit, = 0.78 T.3-f    for L>/= 4T

where: P+crit, = critical load for buckling

f = coefficient of variation of lateral subgrade reaction (see Figure 10)

T = relative stiffness factor (see Figure 10)

L = length of pile.

Project Name: LUC-023-11.75, Ramp A Rear Abutment
Project Number: 2065201
Calculated by: CPI 06/18/2023

**Embankment Parameters** Look at B-028-0

| Height | Pressure @ 125 pcf | |
|---|---|---|
| 13 feet | 1625 psf | 0.8125 tsf |

**Coefficient of Consolidation from NAVFAC Figure 4 (7.1-144)**

| Stratum | LL | Virgin Compression | | Recompression | |
|---|---|---|---|---|---|
| | | $C_v$ ($cm^2$/sec) | $C_v$ ($ft^2$/day) | $C_v$ ($cm^2$/sec) | $C_v$ ($ft^2$/day) |
| 2 | 19 | >0.005 | >0.5 | >0.03 | >2.79 |
| 3 | 34 | 0.004 | 0.37 | 0.028 | 2.56 |
| | | | | | |
| | | | | | |
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| | | | | | |
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| | | | | | |
| | | | | | |

| Virgin Average |
|---|
| $C_v$ ($ft^2$/day) |
| 0.50 |
| 0.37 |
| |
| |
| |
| |
| |
| |
| |
| |
| |

**Coefficient of Consolidation from Tested Values**

| Sample | Pressure (tsf) | Virgin Compression | | Recompression | |
|---|---|---|---|---|---|
| | | $C_v$ ($cm^2$/sec) | $C_v$ ($ft^2$/day) | $C_v$ ($cm^2$/sec) | $C_v$ ($ft^2$/day) |
| B-028-0 ST-3 | 0.5 | - | | - | 0.28 |
| | 1.0 | - | | - | 0.60 |

| Interpolate Cv for 0.8125 tsf |
|---|
| 0.48 |

Project Nai LUC-023-11.75, Ramp A Rear Abutment
Project Nui 2065201
Calculated CPI 06/18/2023



**Encountered Conditions**

| | H (feet) | |
|---|---|---|
| Stratum 2 Layer Thickness | 2 | |
| Stratum 3 Layer Thickness | 2 | |
| | | |

**Assume double drainage between strata layers**

| $H_{dr}$ (feet) | |
|---|---|
| 1 | |
| 1 | |
| | |

**Time for 90% Consolidation**

$$t = \frac{T\ (H_{dr})^2}{C_v}$$

where T = 0.848 for 90% consolidation

Results Based on $H_{dr}$

| Stratum | From NAVFAC Cv Values | | | From Lab Cv Values | | |
|---|---|---|---|---|---|---|
| | t (days) | t (weeks) | t (months) | t (days) | t (weeks) | t (months) |
| **2** | 1.7 | 0.24 | 0.1 | | | |
| **3** | 2.3 | 0.33 | 0.1 | 2 | 0.3 | 0.1 |
| | | | | | | |

**Final Conclusions**

Time for 90 % Consolicatoin may be on the order of a week or less.

Project Name: LUC-023-11.75, Ramp D Fwd Abutment
Project Number: 2065201
Calculated by: CPI 06/21/2023

**Embankment Parameters**

Look at B-023-0 (Clay and Silt underlyng Gravel and Sand)

| Height | | Pressure @ 125 pcf | |
|---|---|---|---|
| 19 | feet | 2375 psf | 1.1875 tsf |

**Coefficient of Consolidation from NAVFAC Figure 4 (7.1-144)**

| Stratum | LL | Virgin Compression | | Recompression | |
|---|---|---|---|---|---|
| | | $C_v$ ($cm^2$/sec) | $C_v$ ($ft^2$/day) | $C_v$ ($cm^2$/sec) | $C_v$ ($ft^2$/day) |
| 3 | 39 | 0.003 | 0.28 | 0.018 | 1.63 |
| 4 | 25 | >0.005 | >0.5 | >0.03 | >2.79 |
| | | | | | |
| | | | | | |
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| | | | | | |
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| | | | | | |
| | | | | | |

| Virgin Average |
|---|
| $C_v$ ($ft^2$/day) |
| 0.28 |
| 0.50 |
| |
| |
| |
| |
| |
| |
| |
| |
| |

**Coefficient of Consolidation from Tested Values**

| Sample | Pressure (tsf) | Virgin Compression | | Recompression | |
|---|---|---|---|---|---|
| | | $C_v$ ($cm^2$/sec) | $C_v$ ($ft^2$/day) | $C_v$ ($cm^2$/sec) | $C_v$ ($ft^2$/day) |
| Across US-23, B-028-0 ST-3 | 1.0 | - | | - | 0.60 |
| | 2.0 | - | | - | 0.25 |

| Interpolate Cv for 1.1875 tsf |
|---|
| 0.53 |

Project Nai LUC-023-11.75, Ramp D Fwd Abutment
Project Nui 2065201
Calculated CPI 06/21/2023



**Encountered Conditions**

Stratum 2 Layer Thickness
Stratum 3 Layer Thickness

| H (feet) | |
|---|---|
| 2 | |
| 5 | |
| | |

**Assume double drainage between strata layers**

| $H_{dr}$ (feet) | |
|---|---|
| 1 | |
| 2.5 | |
| | |

**Time for 90% Consolidation**

$$t = \frac{T\,(H_{dr})^2}{C_v}$$

where T = 0.848 for 90% consolidation

Results Based on $H_{dr}$

| Stratum | From NAVFAC Cv Values | | | From Lab Cv Values | | |
|---|---|---|---|---|---|---|
| | t (days) | t (weeks) | t (months) | t (days) | t (weeks) | t (months) |
| **2** | 3.0 | 0.43 | 0.1 | 2 | 0.2 | 0.1 |
| **3** | 10.6 | 1.51 | 0.4 | 10 | 1.4 | 0.3 |
| | | | | | | |

**Final Conclusions**

Time for 90 % Consolicatoin may be on the order of 2 weeks or less.

LUC-23-11.75

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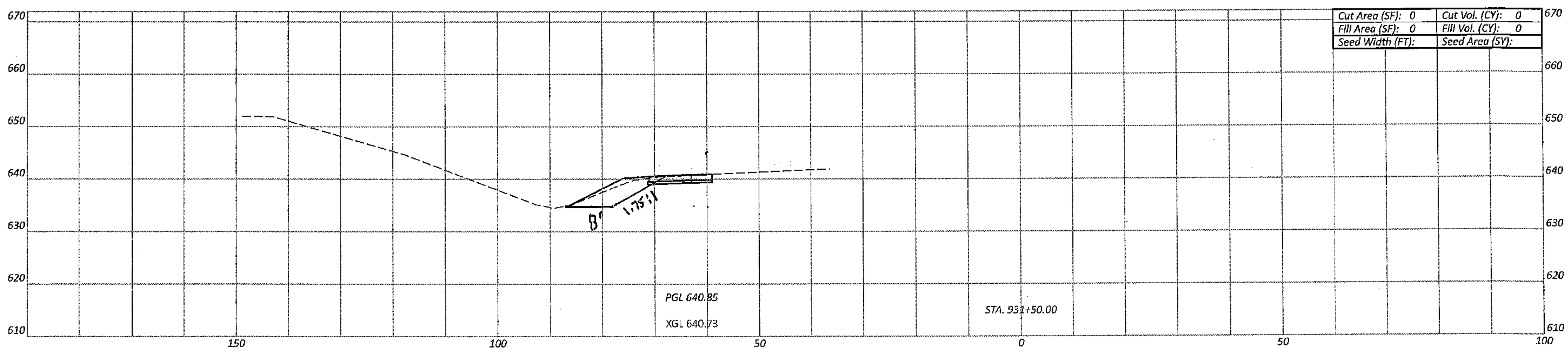


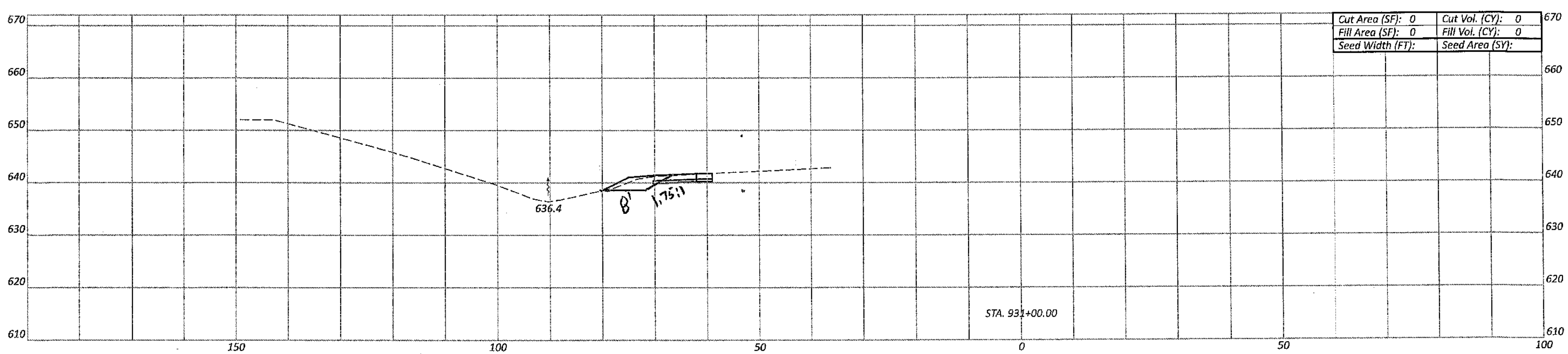


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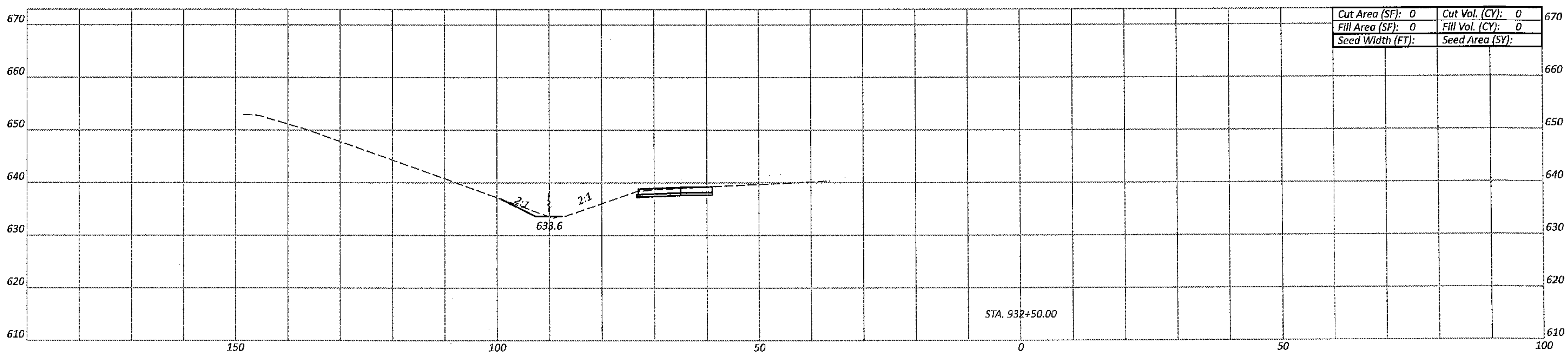


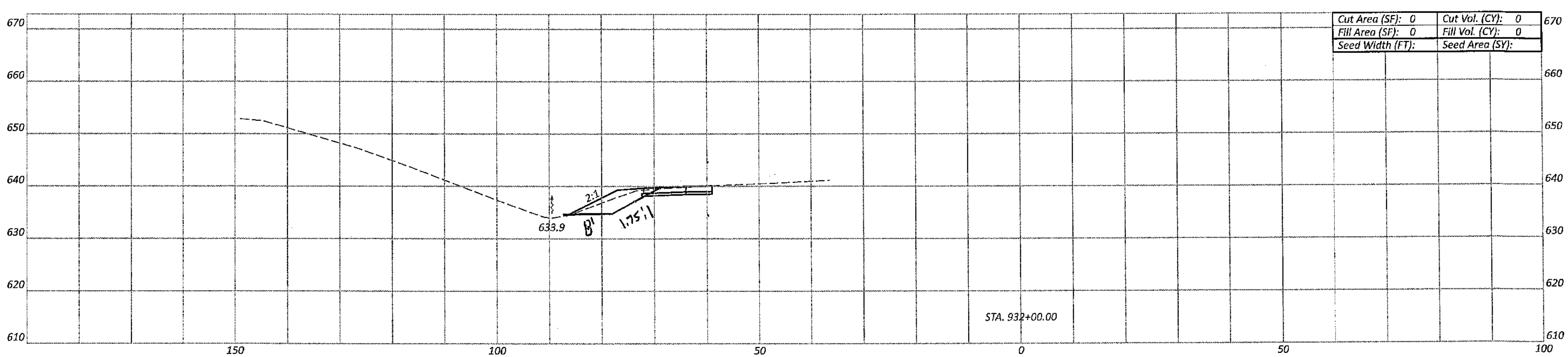


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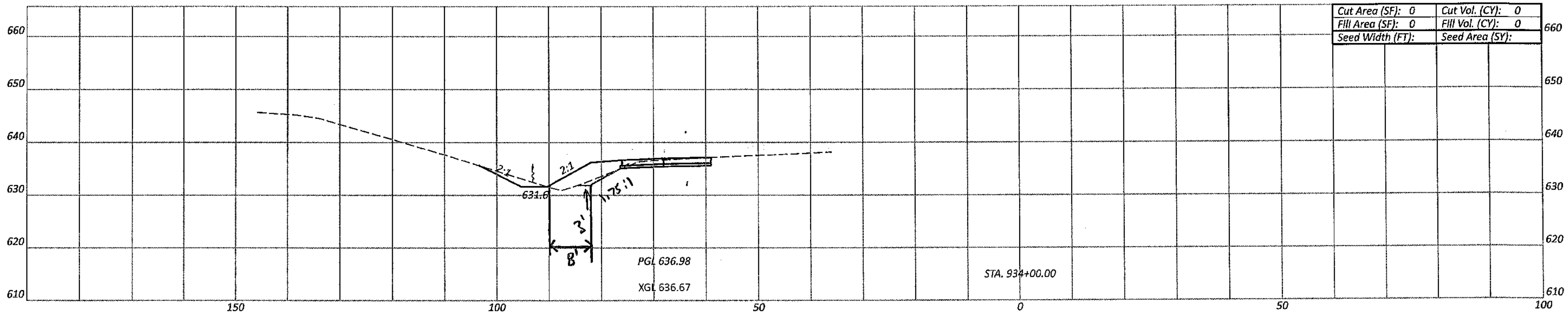


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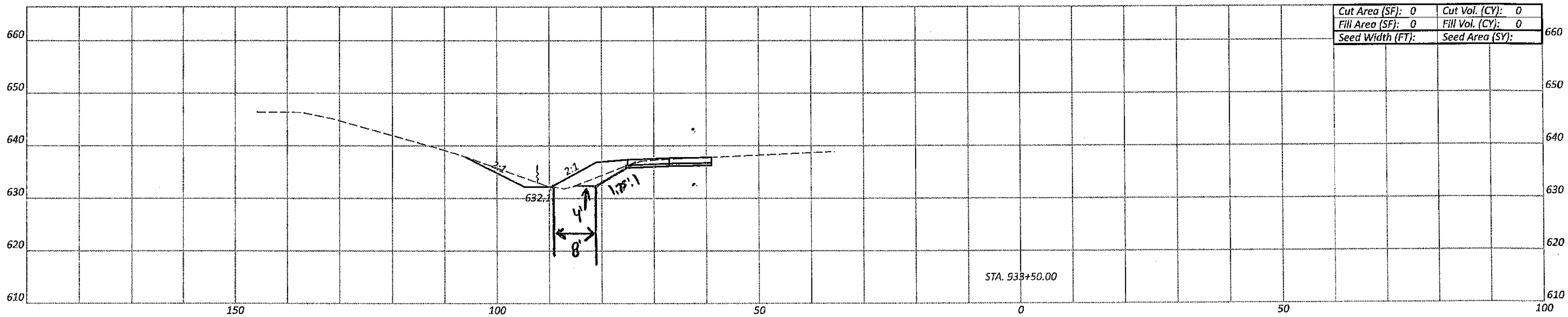


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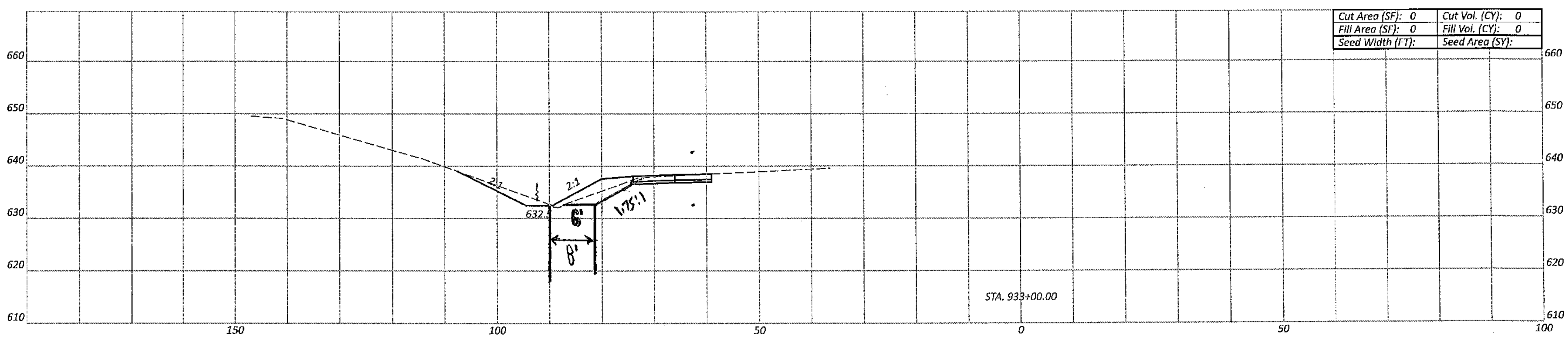


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# CROSS SECTIONS - US-23
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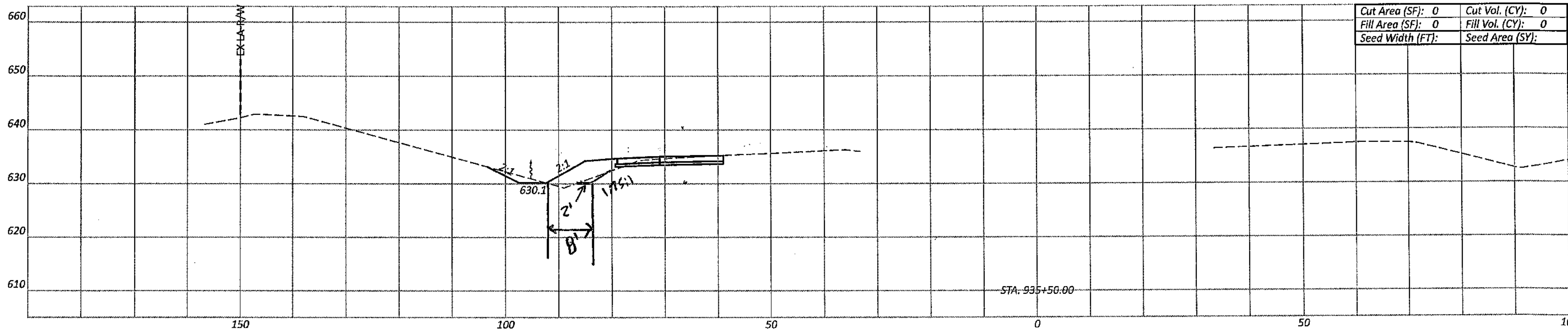


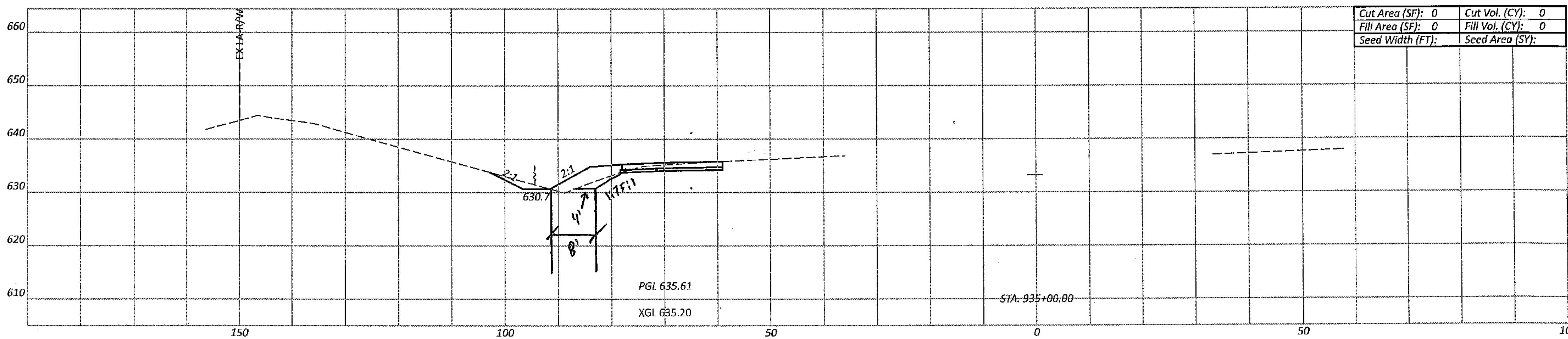


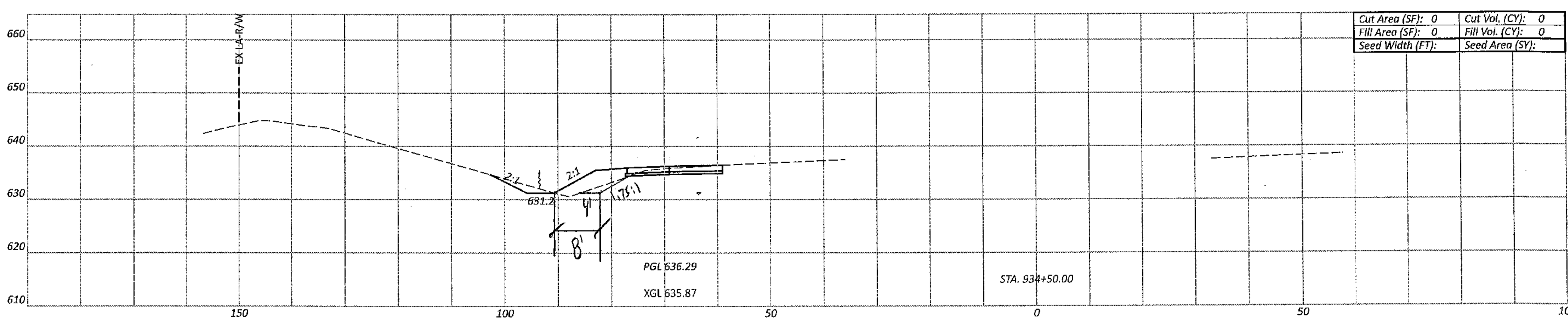


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|---|---|---|
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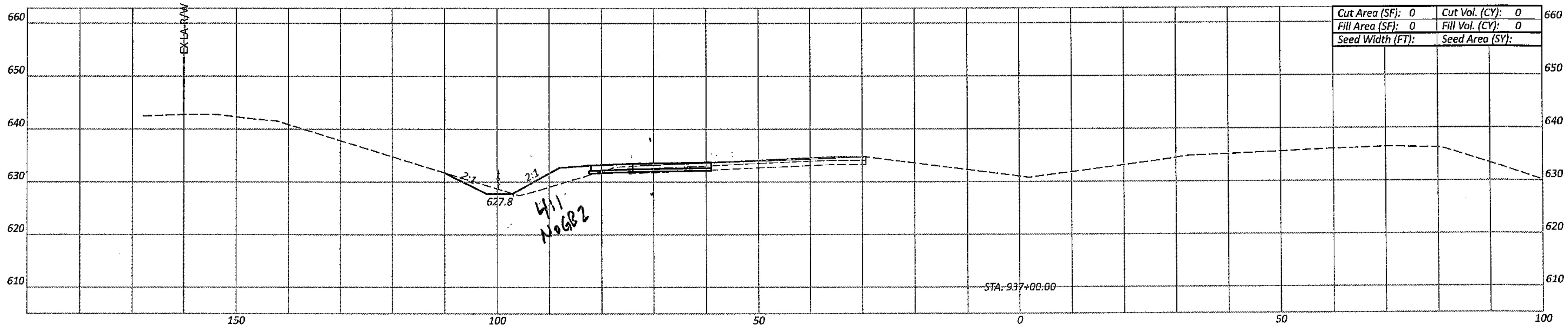


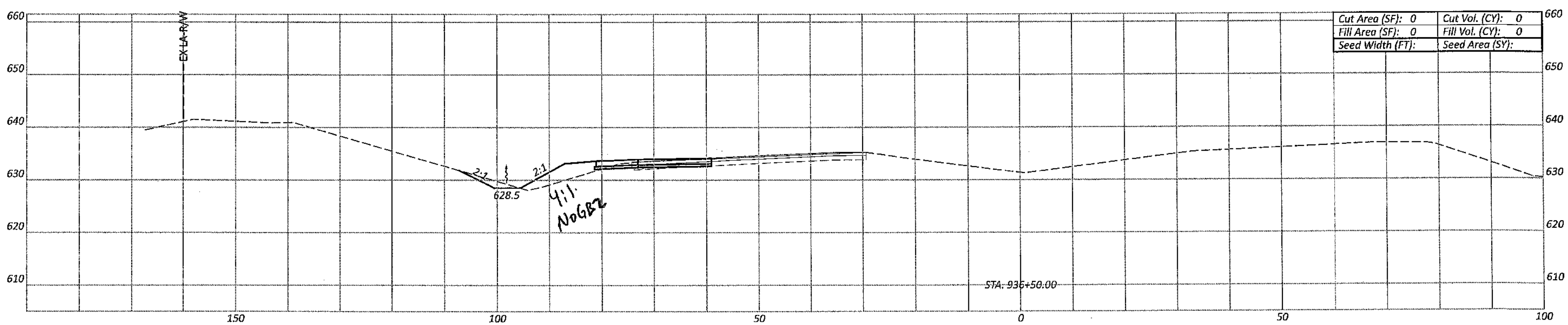


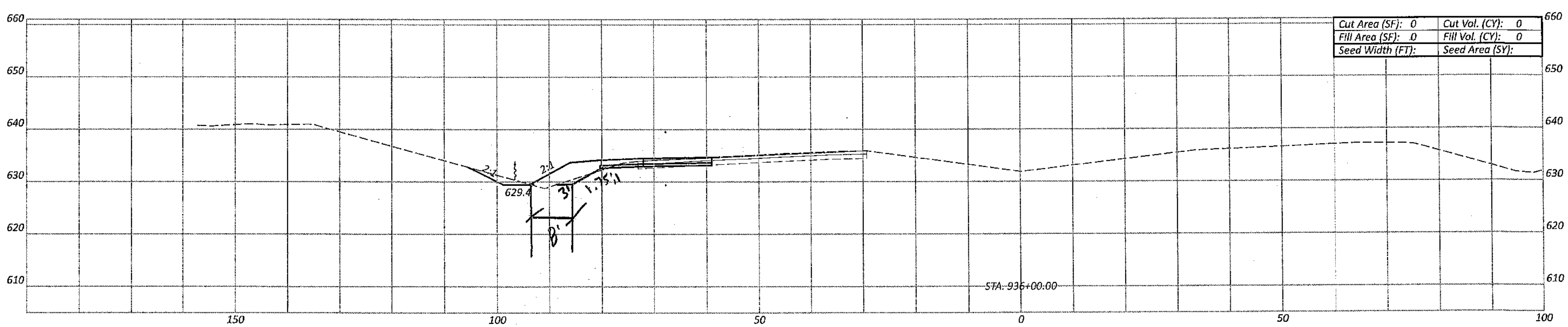


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# CROSS SECTIONS - US-23
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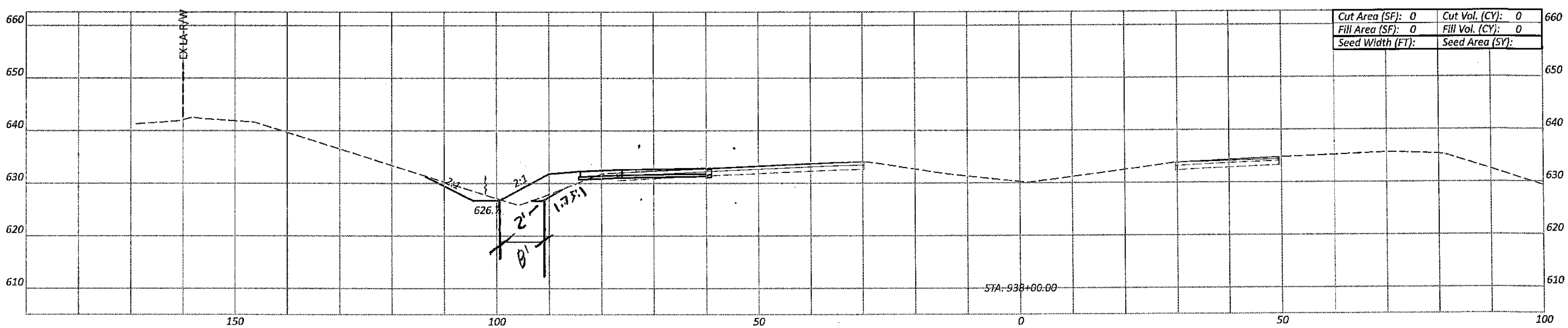


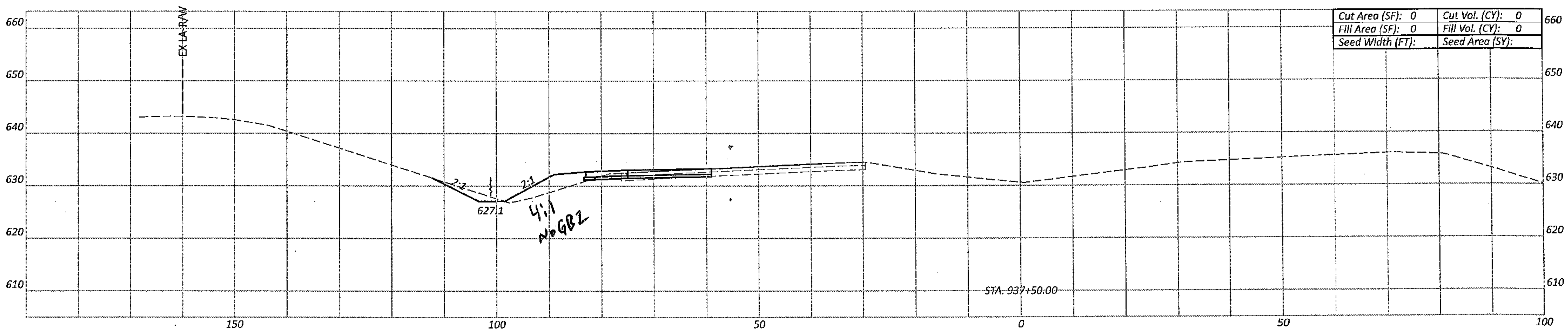


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# CROSS SECTIONS - US-23
# STA. 937+50 TO STA. 938+00

| Sheet Totals | | |
|---|---|---|
| Seeding | Cut | Fill |
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| 51 | |

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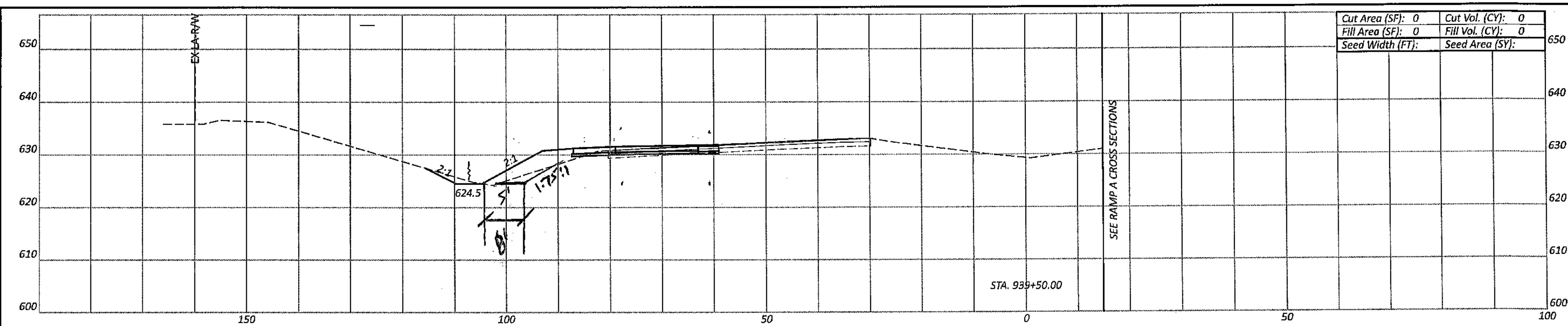


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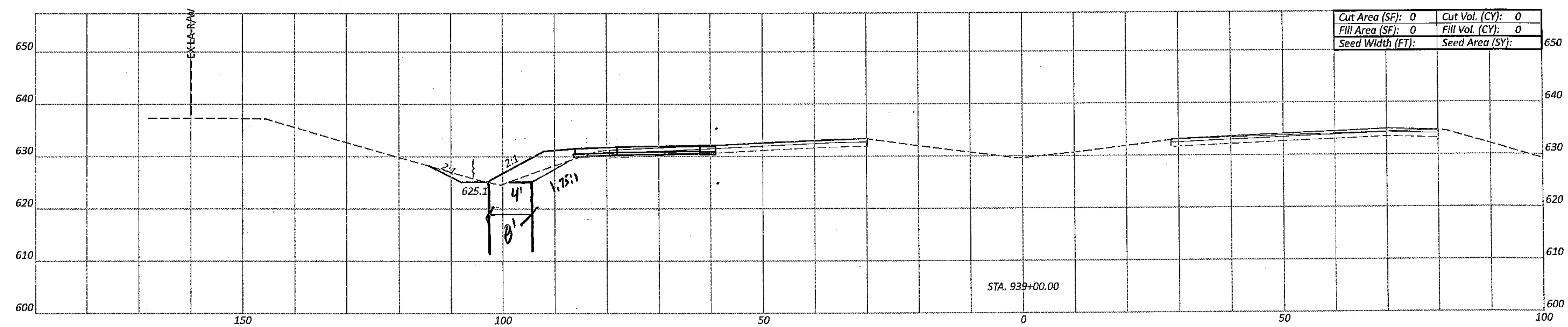
|---|---|
| Fill Area (SF): 0 | Fill Vol. (CY): 0 |
| Seed Width (FT): | Seed Area (SY): |

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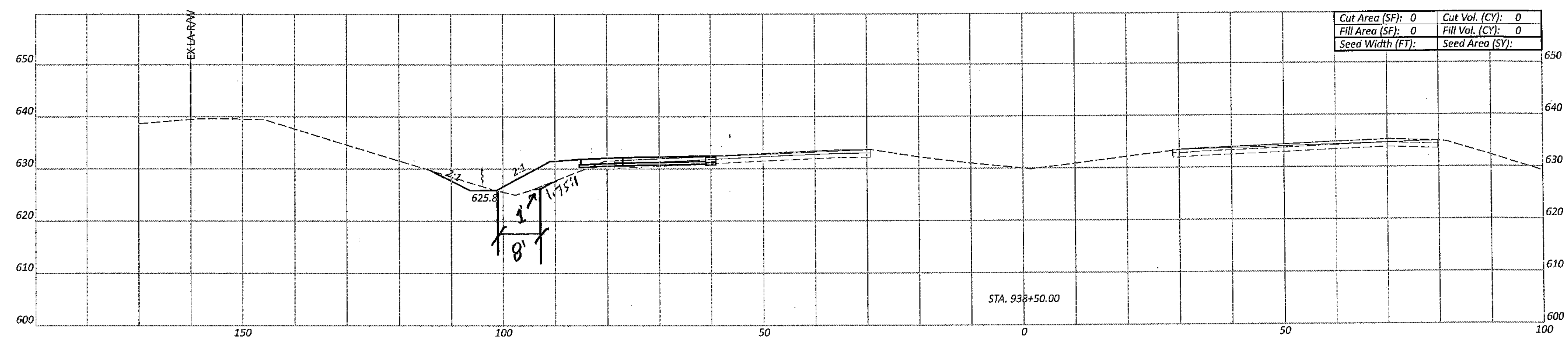


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|---|---|
| Fill Area (SF): 0 | Fill Vol. (CY): 0 |
| Seed Width (FT): | Seed Area (SY): |

| Sheet Totals | | |
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| Seeding | Cut | Fill |
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# CROSS SECTIONS - US-23
## STA. 938+50 TO STA. 939+50

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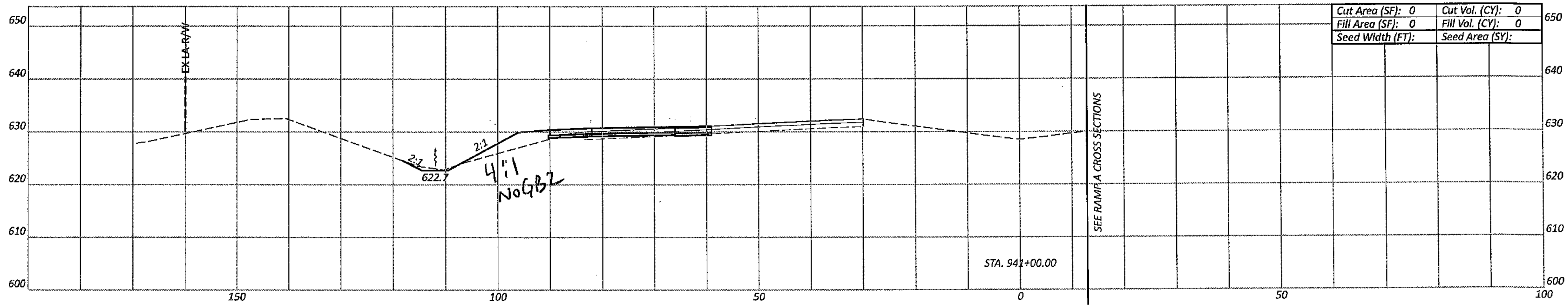
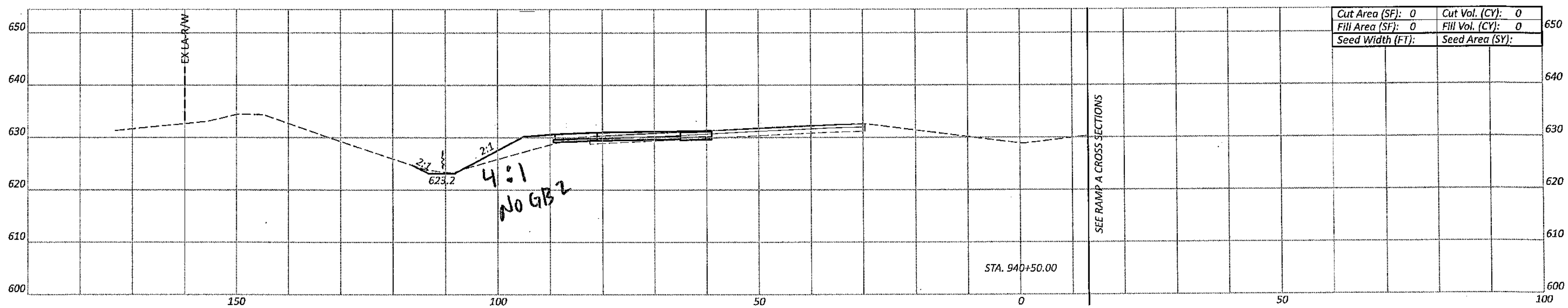
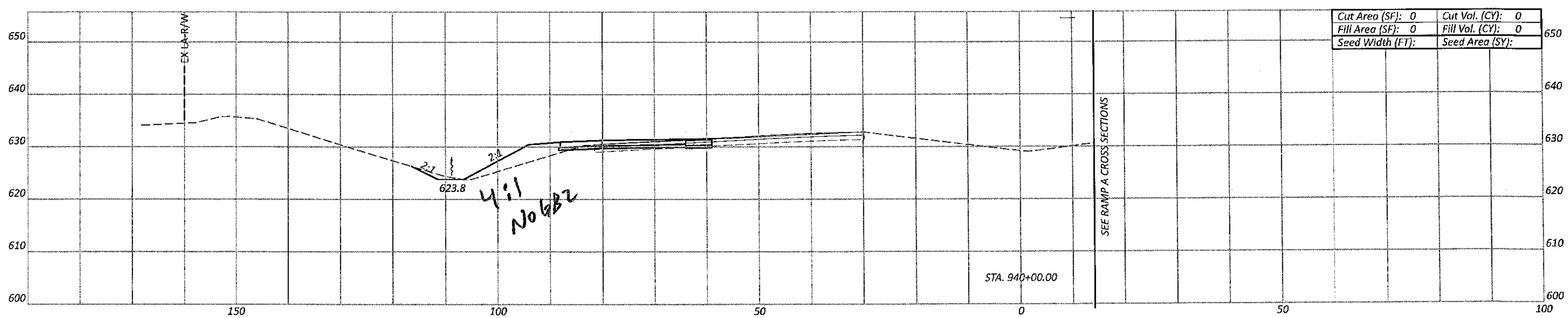
SHEET 52 TOTAL

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| Seeding | Cut | Fill |
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| SHEET | TOTAL |
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| 53 | |

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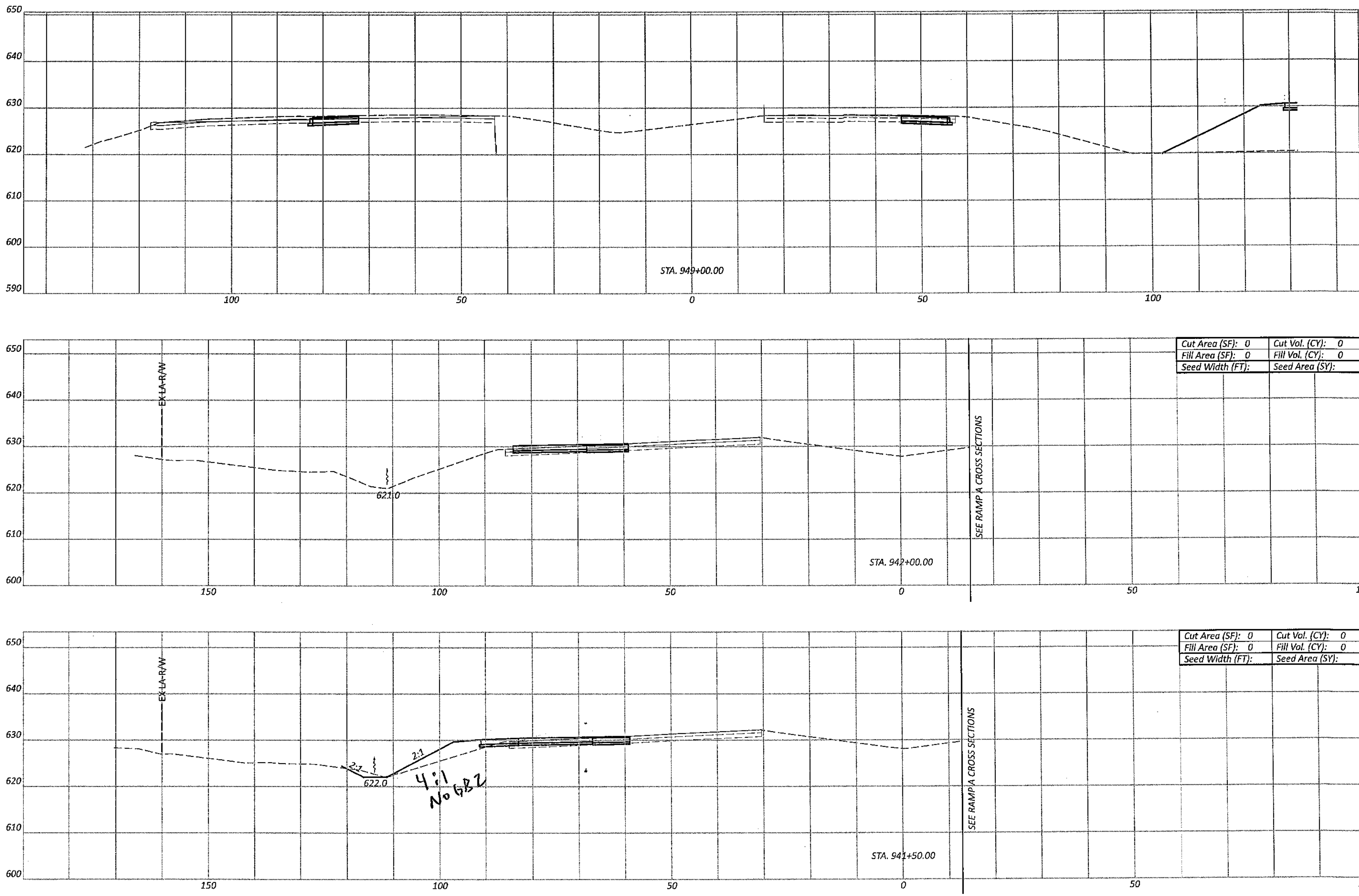


| | | | |
|---|---|---|---|
| Cut Area (SF): 0 | | Cut Vol. (CY): 0 | |
| Fill Area (SF): 0 | | Fill Vol. (CY): 0 | |
| Seed Width (FT): | | Seed Area (SY): | |

| | | | |
|---|---|---|---|
| Cut Area (SF): 0 | | Cut Vol. (CY): 0 | |
| Fill Area (SF): 0 | | Fill Vol. (CY): 0 | |
| Seed Width (FT): | | Seed Area (SY): | |

# CROSS SECTIONS - US-23
# STA. 941+50 TO STA. 949+00

LUC-23-11.75

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| Sheet Totals | | |
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| Seeding | Cut | Fill |
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SHEET 54 TOTAL

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MODEL: CLP_NB_ENT - 27+00.00 [Sheet] PAPERSIZE: 17x11 (in.) DATE: 11/4/2022 TIME: 4:23:20 PM USER: SMaag
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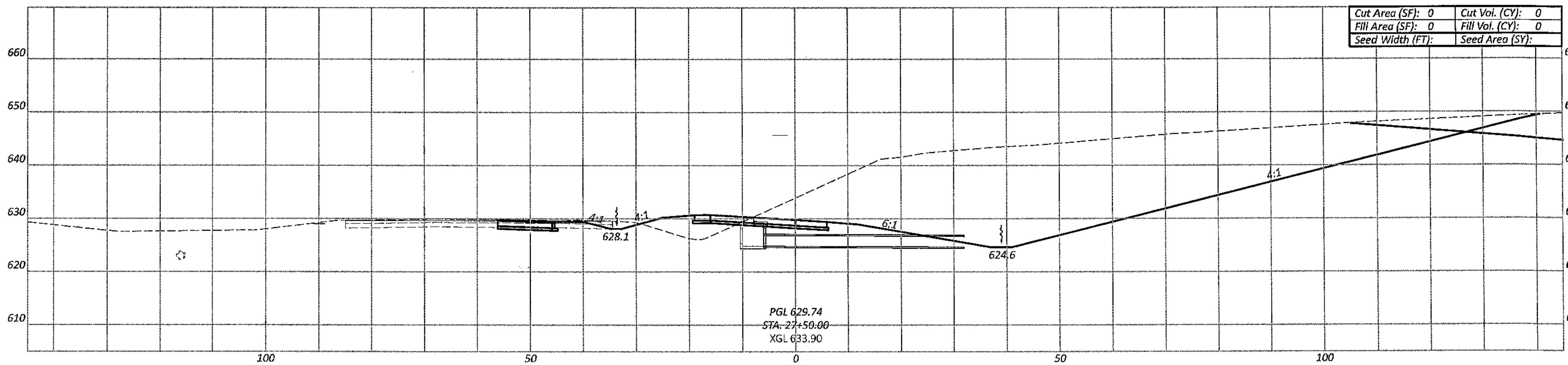
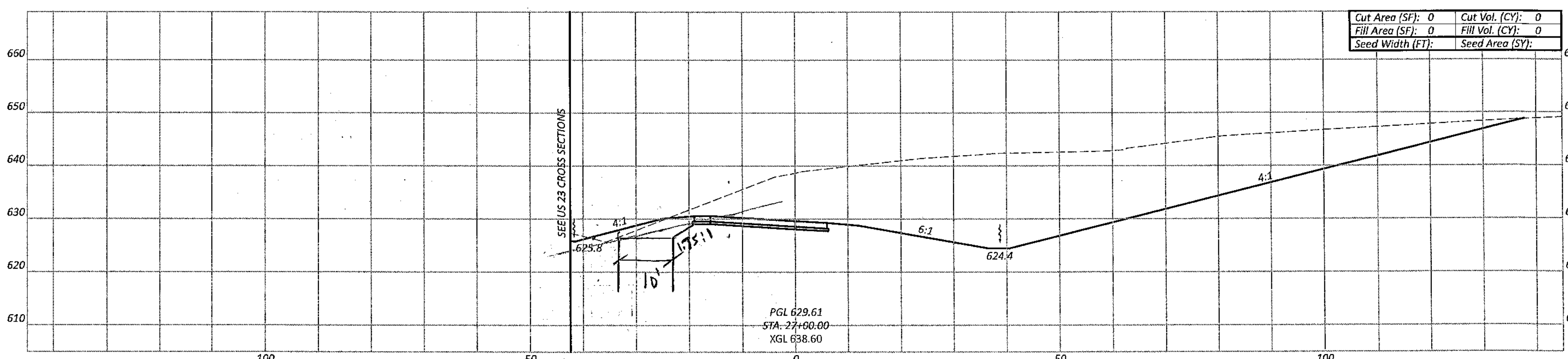
# CROSS SECTIONS - RAMP B
# STA. 27+00 TO STA. 27+50




| Sheet Totals | | |
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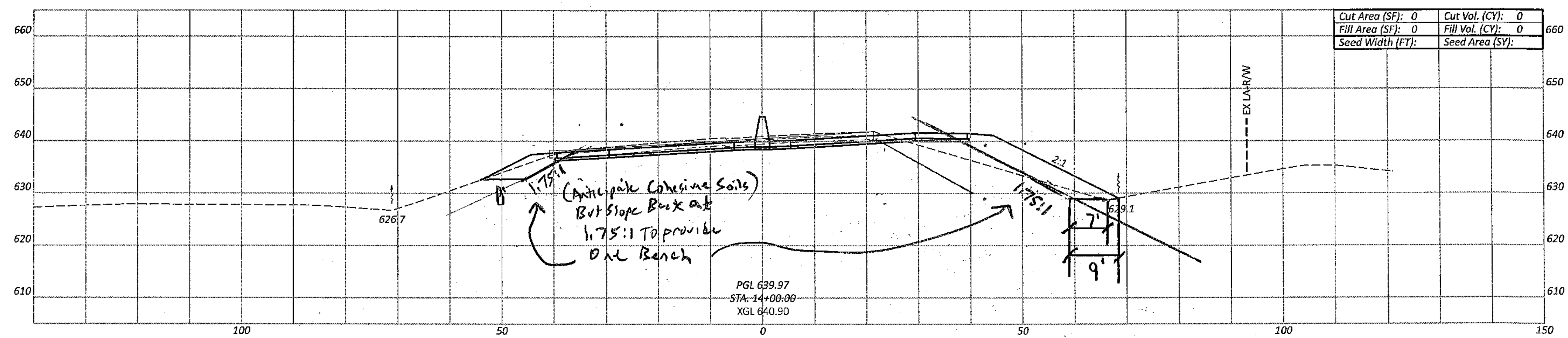


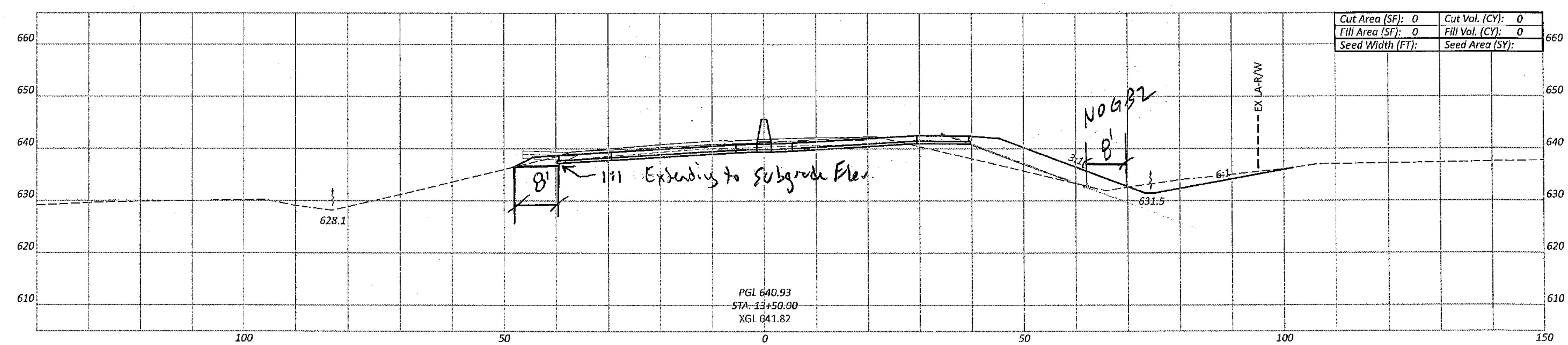


CROSS SECTIONS - RAMP C-D
STA. 13+50 TO STA. 14+00

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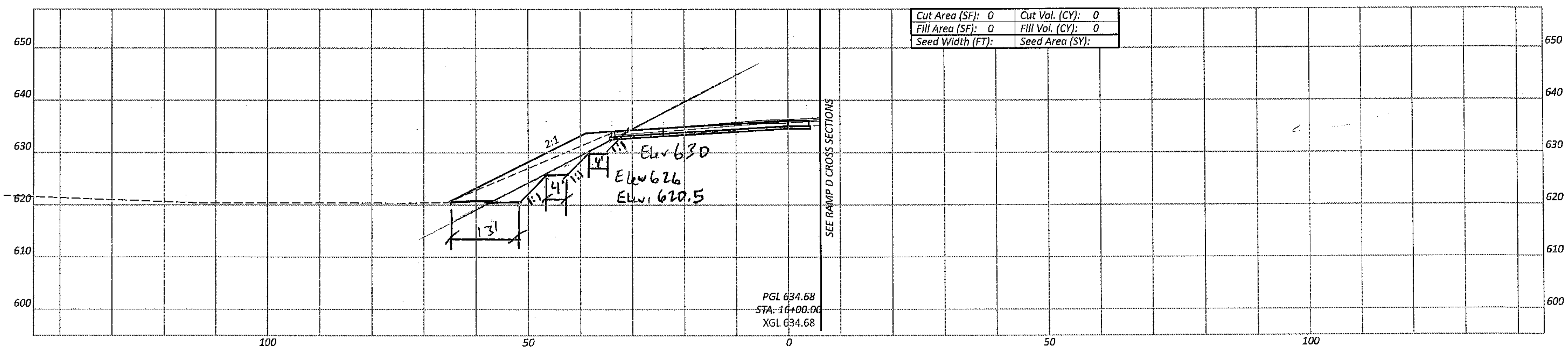
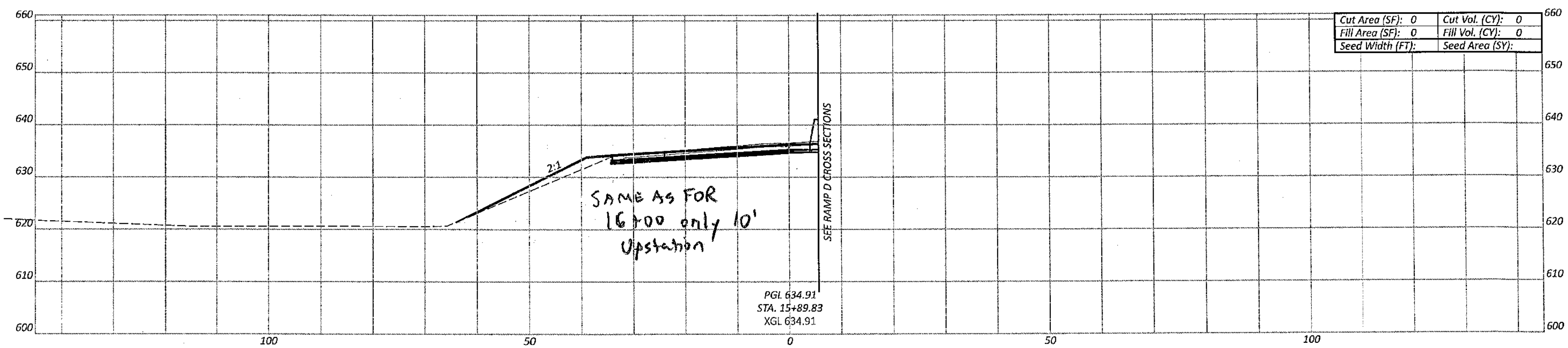
# CROSS SECTIONS - RAMP C
STA. 15+89.83 TO STA. 16+00.00




| Sheet Totals | | |
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SHEET 130 TOTAL

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MODEL: CLP_SB_EXT - 15+89.83 [Sheet] PAPERSIZE: 17x11 (in.) DATE: 11/4/2022 TIME: 4:24:42 PM USER: SMeae
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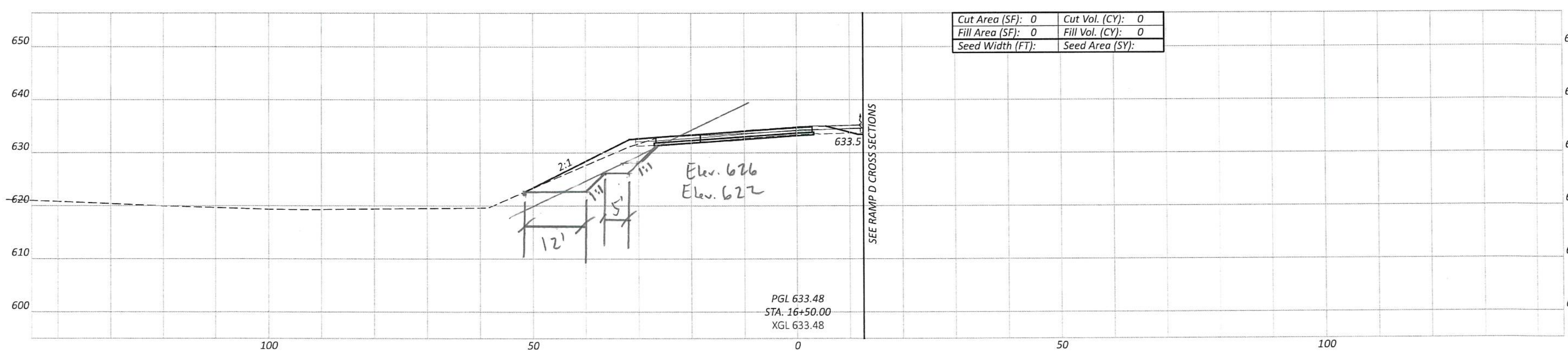
# CROSS SECTIONS - RAMP C
## STA. 16+50 TO STA. 16+60


| Sheet Totals | | |
|---|---|---|
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SHEET 131
TOTAL

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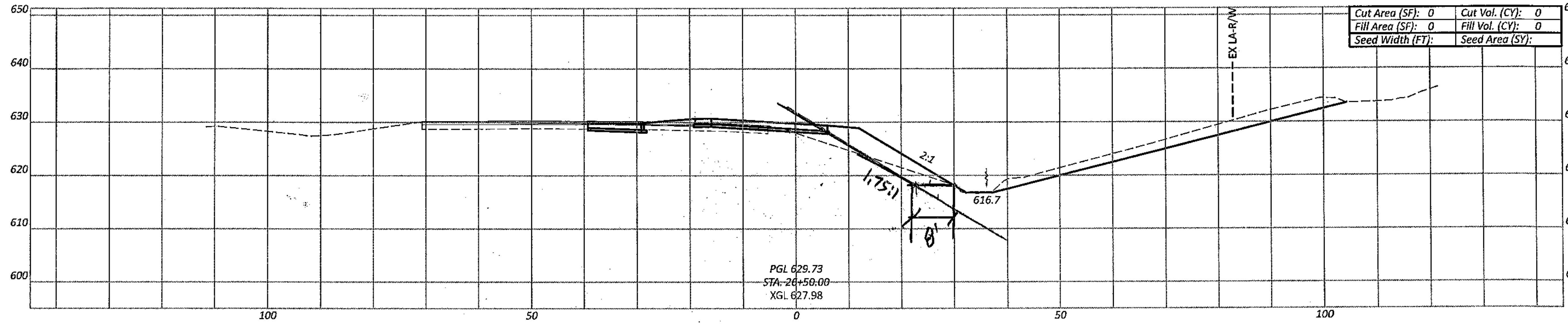


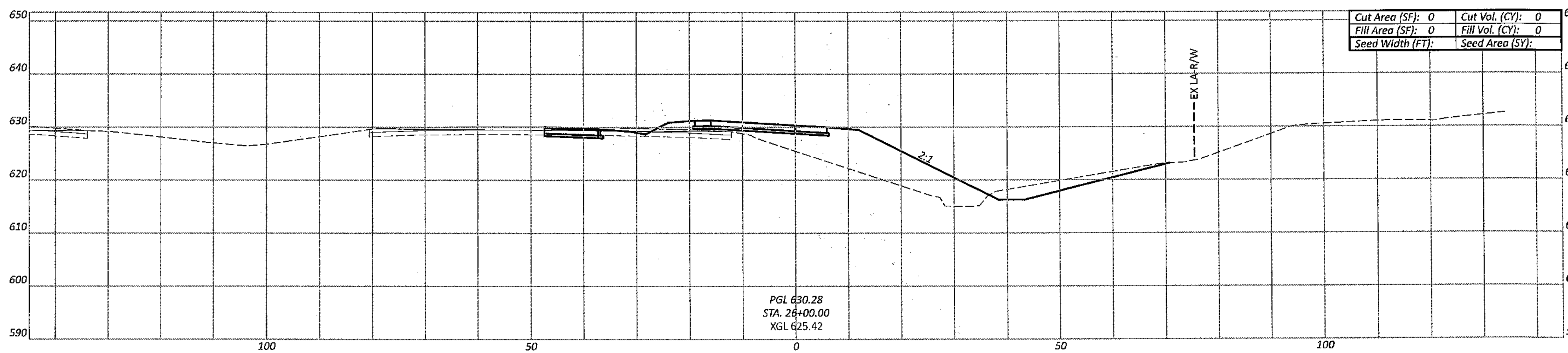


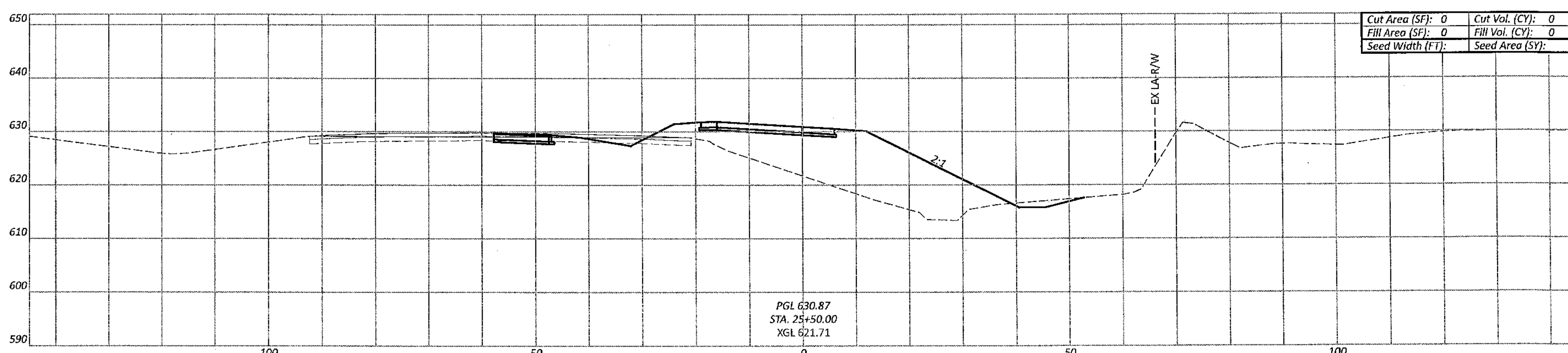


| Sheet Totals | | |
|---|---|---|
| Seeding | Cut | Fill |
| | | |

# CROSS SECTIONS - RAMP D
# STA. 25+50 TO STA. 26+50

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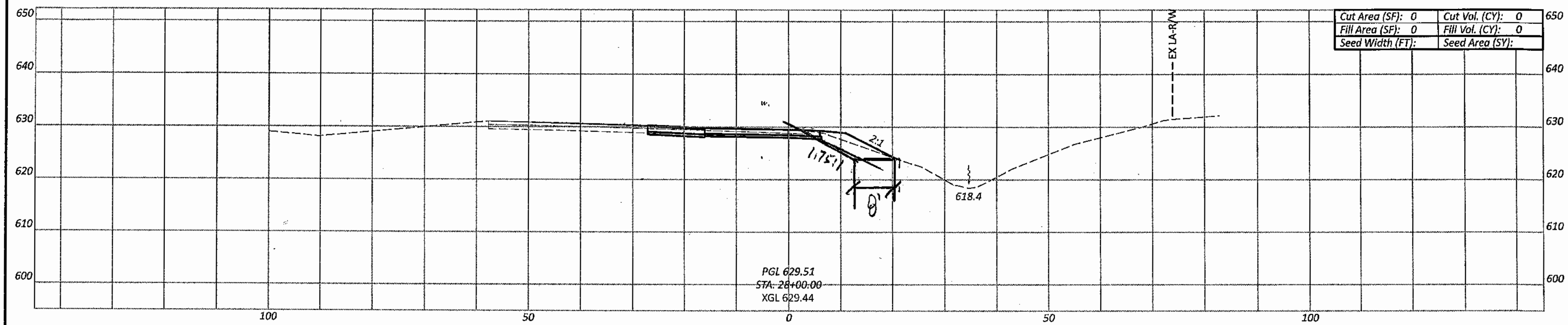
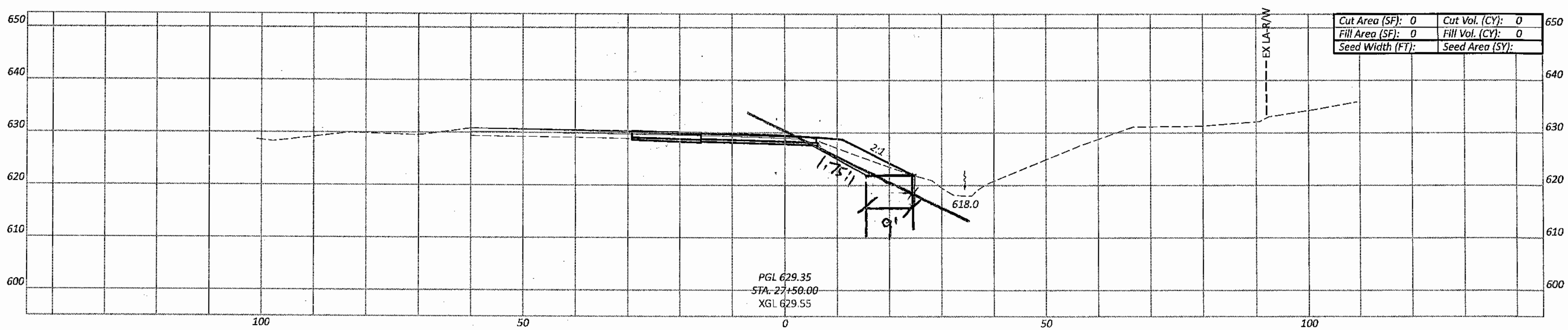
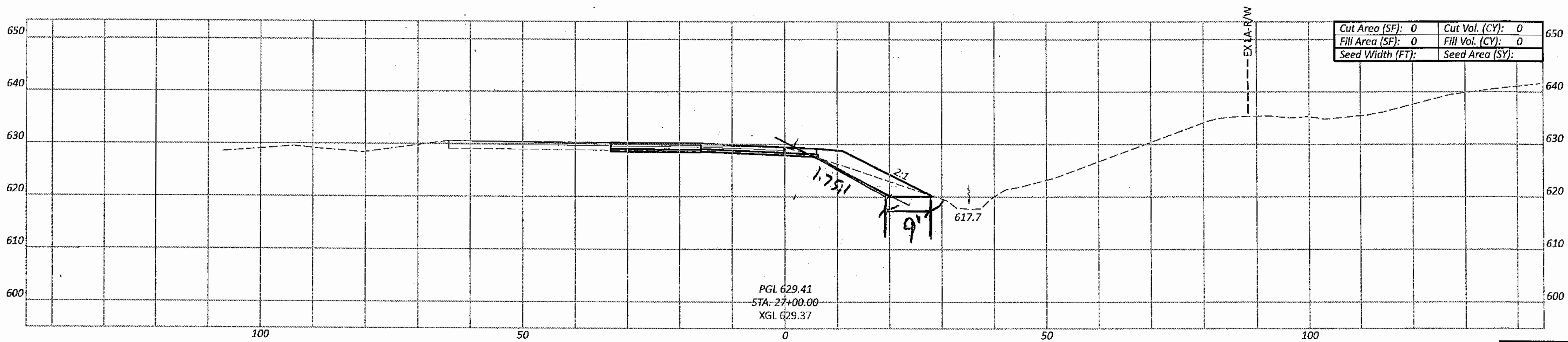
SHEET 142
TOTAL




# CROSS SECTIONS - RAMP D
## STA. 27+00 TO STA. 28+00

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| Sheet Totals | | |
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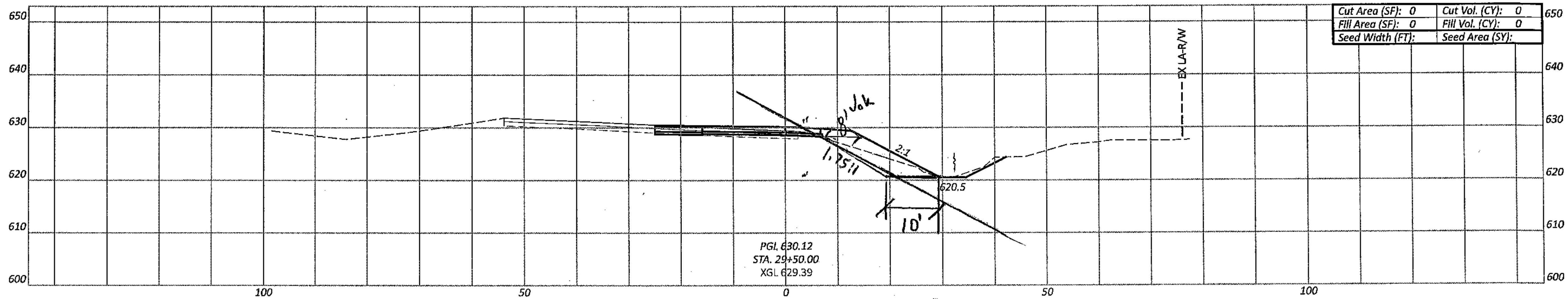
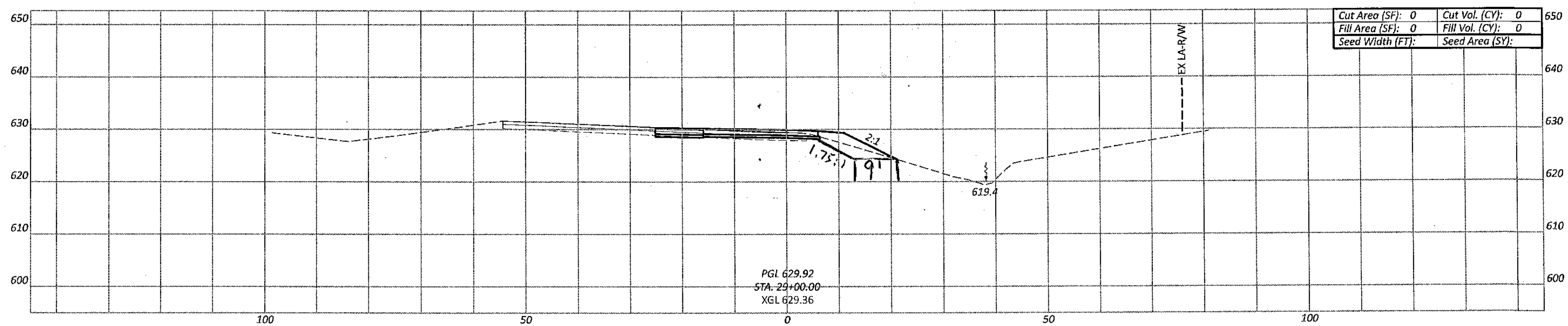
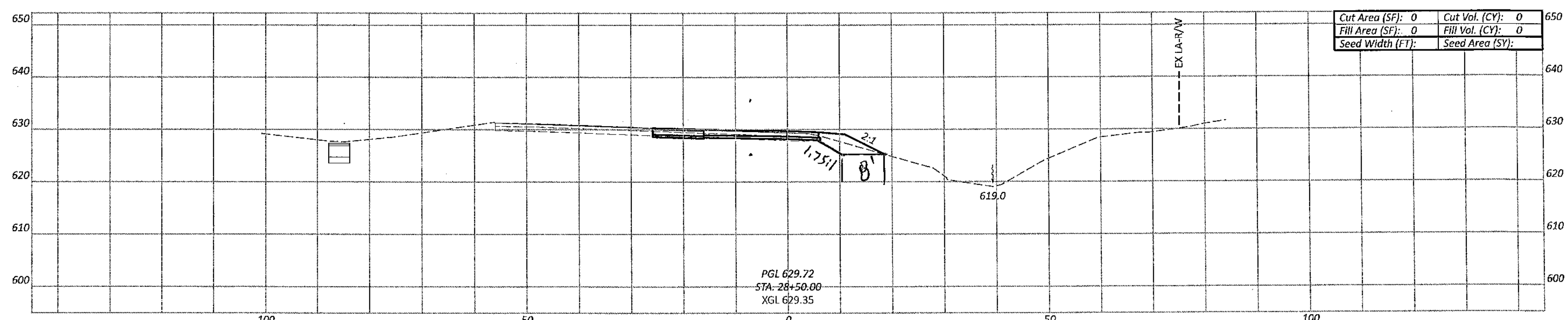
SHEET 143
TOTAL




# CROSS SECTIONS - RAMP D
## STA. 28+50 TO STA. 29+50

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|---|---|---|
| Seeding | Cut | Fill |
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SHEET 144 | TOTAL

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**APPENDIX B**

**State Route 51 Bridge Foundation Evaluations**

| | | | |
|---|---|---|---|
| **TTL Project No.:** | **2065201** | | |
| **Project:** | **LUC-23-11.75** | | |
| **Calcs by:** | **CPI** | | |
| **Date:** | **6/1/2023** | | |
| | | | |
| **Calcs:** | **Abutment Driven Piles to Bedrock** | | |
| **Location:** | **SR 51 Rear and Forward Abutments** | | |
| | | | |
| **Substructure:** | **Rear Abutment** | | |
| Boring: | B-006-1-21 | | |
| Bottom of Pile Cap Elev. (ft): | 640 | | |
| Pile Stickup (ft): | 1 | | |
| Pile Cut-Off Elev. (ft): | 641 | | |
| Auger Refusal/Top of Coring Elev. (ft): | 614 | | |
| Calculated Length (ft): | 27 | | |
| Estimated Length (ft): | 30 | | |
| Order Length (ft): | 35 | | |
| | | | |
| **Substructure:** | **Forward Abutment** | | |
| Boring: | B-010-0-21 | | |
| Bottom of Pile Cap Elev. (ft): | 640 | | |
| Pile Stickup (ft): | 1 | | |
| Pile Cut-Off Elev. (ft): | 641 | | |
| Auger Refusal/Top of Coring Elev. (ft): | 615.6 | | |
| Calculated Length (ft): | 25.4 | | |
| Estimated Length (ft): | 30 | | |
| Order Length (ft): | 35 | | |

| | | | |
|---|---|---|---|
| **TTL Project No.:** | **2065201** | | |
| **Project:** | **LUC-23-11.75** | | |
| **Calcs by:** | **CPI** | | |
| **Date:** | **5/23/2023** | | |
| | | | |
| **Calcs:** | **Footings on Rock** | | |
| **Location:** | **SR 51 over US 23** | | |
| **Substructure:** | **Western Pier (Pier 1)** | | |
| | | | |
| Boring: | B-006-1-21 | | |
| GSE (ft): | 652 | | |
| Long-Term GWT (ft): | 623 | | |
| | | | |
| Top of Weathered Rock Depth (ft): | 29 | | |
| Top of Weathered Rock Elev. (ft): | 623 | | |
| Footing keyed 3" into Rock at | | | |
| Bearing Elev. (ft): | 622.7 | | |
| | | | |
| Auger Refusal Depth (ft): | 38 | | |
| Auger Refusal Elev. (ft): | 614 | | |
| | | | |
| Prelim Footing Size: | L (ft)= | 8 | |
| | B (ft)= | 8 | |

**Service Limit State**

AASHTO LRFD Bridge Design Spec Table C10.6.2.5.1-1

| | | Bearing Resistance (ksf) | |
|---|---|---|---|
| **Type of Bearing Material** | **Consistency** | **Ordinary Range** | **Recommended Value** |
| Weathered / Broken Rock (except shale) | Medium Hard Rock | 16-24 | 20 |

| | |
|---|---|
| Resistance Factor: | 1.0 |
| Factored Resistance (ksf): | 20 |

**Settlement**

AASHTO LRFD Bridge Design Specification 10.6.2.4.4

| | | |
|---|---|---|
| For Circular or Square Footings, | | |
| Delta=qo(1-v^2)*((r*Ip)/(144Em))= | 0.56 | inch |
| qo (ksf)= | 20 | |
| v from AASHTO LRFD Table C10.4.6.5-2 | | |
| v, Mean Value for Dolostone: | 0.29 | |
| r = raidus for circular or B/2 for square | | |
| r (ft): | 4 | |
| Ip=(pi^(1/2))/Bz = | 1.64 | |
| Bz per Table 10.6.2.4.2-1 | | |
| L/B: | 1 | |
| Bz (Rigid Footing): | 1.08 | |
| Em per AASHTO LRFD 10.4.6.5 | | |
| Em = lesser of | | |
| Ei or | 18 | |
| Em=145*(10^((RMR-10)/40)) or | 386 | |
| Em=(Em/Ei)*Ei | 386 | |
| Em (ksi)= | 18 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Calcs:** | **Footings on Rock** | | | | | | |
| **Location:** | **SR 51 over US 23** | | | | | | |
| **Substructure:** | **Western Pier (Pier 1)** | | | | | | |
| | | | | | | | |
| Ei From GDM Table 400-6 | | | | | | | |
| From Below for | | | | | | | |
| Strength Limit State, Qu (psi)= | 56.2 | | | | | | |
| Very Weak Qu of 200 psi or less | | | | | | | |
| Ei(psi)= | 18000 | | | | | | |
| Ei(ksi)= | 18 | | | | | | |
| | | | | | | | |
| **RMR Calculations** | | | | | | | |
| | | | | | | | |
| **Parameter** | **Value** | **Note** | **See ODOT GDM 1303.3.3 for guidance on RMR Parameters** | | | | |
| 1 | 0 | Qu =8 ksf | | | | | |
| 2 | 3 | RQD=0% | | | | | |
| 3 | 5 | <2" spacing of joints, Highly Fractured | | | | | |
| 4 | 12 | Slightly rough, Separateion <0.05in, Soft Joint Wall | | | | | |
| 5 | 7 | Moist Only | | | | | |
| **RMR =** | **27** | | | | | | |
| | | | | | | | |
| **Strength Limit State** | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| **Augerable Weathered Bedrock** | | | | | | | |
| **Rock Type** | **SPT Results** | | | | | | |
| **Weathered Dolomite** | 11-50/5" | 38-50/5" | | | | | |
| | | | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | |
| | 162 | Average of Tested Values for the project. | | | | | |
| Qu based on SPT Results per GDM 404.3 | | | | | | | |
| Qu (ksf)=0.092x(Nrate)90 (bpf) | | | | | | | |
| ER(%)= | 66 | | | | | | |
| N66=50/5" x 12" = | 120 | bpf | | | | | |
| N90 = 66/90 x 120 bpf = | 88 | bpf | | | | | |
| Qu (ksf) = | 8.096 | =Co | | | | | |
| Qu (psi) = | 56.2 | =Co | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| **Due to weathered nature of rock at bearing elevation, consider the following method of analysis:** | | | | | | | |
| **Per ODOT GDM 1303.3.3, Rock meets all three criteria of:** | | | | | | | |
| 1. Bedrock under footing not steeply sloping (2H:1V or less), which is case for rock at this site. | | | | | | | |
| 2. RMR ≤ 70 | RMR = | 27 | | | | | |
| 3. Moderately Strong or less (Qu≤7500 psi) | Qu (psi)= | 56 | | | | | |
| | | | | | | | |
| c' (ksf)= 0.104*RMR= | 2.808 | | | | | | |
| ϕ' (deg)=(RMR/2)+5 = | 18.5 | | | | | | |
| | | | | | | | |
| Table 10.6.3.1.2a-1 | | | | | | | |
| For ϕ' (deg) of | 18 | | | | | | |
| Nc | 13.1 | | | | | | |
| Nq | 5.3 | | | | | | |
| Ngamma | 4.1 | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Calcs:** | **Footings on Rock** | | | | | | |
| **Location:** | **SR 51 over US 23** | | | | | | |
| **Substructure:** | **Western Pier (Pier 1)** | | | | | | |
| | | | | | | | |
| AASHTO LRFD Eqn.: 10.6.3.1.2a-1 | | | | | | | |
| qn=CNc+Gamma*Df*Nq*Cwq+0.5 Gamma B Ngamma Cwgamma | | | | | | | |
| c' (psf)= | 2808 | | | | | | |
| Dw = 0 (above Df) so Cwq= | 0.5 | | | | | | |
| Cwgamma= | 0.5 | | | | | | |
| Gamma Df based on Grade at Toe of existing overpass embankment, not GSE at B-006-1 | | | | | | | |
| Toe Elev | 631 | | | | | | |
| Bearing Elev | 622.7 | | | | | | |
| Df (ft): | 8.3 | | | | | | |
| Overburden Average Gamma (pcf): | 129 | | | | | | |
| Bearing Gamma (pcf): | 160 | | | | | | |
| Term 1 | 36785 | psf | | | | | |
| Term 2 | 2837 | psf | | | | | |
| Term 3 | 1312 | psf | | | | | |
| qn (psf)= | 40934 | | | | | | |
| qn (ksf)= | 41 | | | | | | |
| Table 10.5.5.2.2-1 Resistance Factor (Sand SPT or on Rock) | | | | | | | |
| Bearing on rock, ϕb= | 0.45 | | | | | | |
| qr (ksf)= | 18 | | | | | | |

| | | | | |
|---|---|---|---|---|
| **TTL Project No.:** | **2065201** | | | |
| **Project:** | **LUC-23-11.75** | | | **Reviewed by:** |
| **Calcs by:** | **CPI** | | | **KCH** |
| **Date:** | **5/25/2023** | **to** | **6/2/2023** | **6/2/2023** |
| | | | | |
| **Calcs:** | **Footings on Rock** | | | |
| **Location:** | **SR 51 over US 23** | | | |
| **Substructure:** | **Intermediate Pier (Pier 2)** | | | |
| | | | | |
| Boring: | B-008-0-21 | | | |
| GSE (ft): | 631 | Based on Google Earth. | | |
| Long-Term GWT (ft): | 623 | | Will be re-surveying with Handheld GPS. | |
| | | | | |
| Top of Weathered Rock Depth (ft): | 13.5 | | | |
| Top of Weathered Rock Elev. (ft): | 617.5 | | | |
| Footing keyed 3" into Rock at | | | | |
| Bearing Elev. (ft): | 617.2 | See note below regarding slightly deeper bearing. | | |
| | | | | |
| Auger Refusal Depth (ft): | 14 | | | |
| Auger Refusal Elev. (ft): | 617 | | | |
| | | | | |
| Extend Footing to AR Elev. (ft): | 617 | | | |
| | | | | |
| Prelim Footing Size: | L (ft)= | 8 | | |
| | B (ft)= | 8 | | |

**Service Limit State**

AASHTO LRFD Bridge Design Spec Table C10.6.2.5.1-1

| | | Bearing Resistance (ksf) | |
|---|---|---|---|
| **Type of Bearing Material** | **Consistency** | **Ordinary Range** | **Recommended Value** |
| Weathered / Broken Rock (except shale) | Medium Hard Rock | 16-24 | 20 |

| | |
|---|---|
| Resistance Factor: | 1.0 |
| Factored Resistance (ksf): | 20 |

**Settlement**

AASHTO LRFD Bridge Design Specification 10.6.2.4.4

| | | |
|---|---|---|
| For Circular or Square Footings, | | |
| Delta=qo(1-v^2)*((r*Ip)/(144Em))= | 0.14 | inch |
| qo (ksf)= | 20 | |
| v from AASHTO LRFD Table C10.4.6.5-2 | | |
| v, Mean Value for Dolostone: | 0.29 | |
| r = raidus for circular or B/2 for square | | |
| r (ft): | 4 | |
| Ip=(pi^(1/2))/Bz = | 1.64 | |
| Bz per Table 10.6.2.4.2-1 | | |
| L/B: | 1 | |
| Bz (Rigid Footing): | 1.08 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Calcs:** | **Footings on Rock** | | | | | | |
| **Location:** | **SR 51 over US 23** | | | | | | |
| **Substructure:** | **Intermediate Pier (Pier 2)** | | | | | | |
| | | | | | | | |
| Em per AASHTO LRFD 10.4.6.5 | | | | | | | |
| Em = lesser of | | | | | | | |
| Ei or | 1400 | | | | | | |
| Em=145*(10^((RMR-10)/40)) or | 1627 | | | | | | |
| Em=(Em/Ei)*Ei | 70 | | | | | | |
| Em/Ei | 0.05 | AASHTO LRFD Table C10.4.6.5-1 | | | | | |
| Em (ksi)= | 70 | | | | | | |
| | | | | | | | |
| Ei From GDM Table 400-6 based on Qu | | | | | | | |
| Qu (psi) within ~2B= | 18780 | 19980 | 17720 | | | | |
| Average Qu (psi)= | 18827 | = | 2711 | ksf | | | |
| for Very Strong Qu=15000 psi | (Not quite up to Qu=20,000 psi) | | | | | | |
| Ei(psi)= | 1400000 | | | | | | |
| Ei(ksi)= | 1400 | | | | | | |
| | | | | | | | |
| **RMR Calculations** | | | | | | | |
| | | | | | | | |
| **Parameter** | **Value** | **Note** | **See ODOT GDM 1303.3.3 for guidance on RMR Parameters** | | | | |
| 1 | 12 | Qu =2711 ksf | | | | | |
| 2 | 3 | RQD=0% | | | | | |
| 3 | 10 | 2"-12" spacing of joints, Highly Fractured to Fractured | | | | | |
| 4 | 20 | Slightly rough, Separateion <0.05in, hard joint wall | | | | | |
| 5 | 7 | Moist Only | | | | | |
| **RMR =** | **52** | | | | | | |
| | | | | | | | |
| **Strength Limit State** | | | | | | | |
| | | | | | | | |
| **Look at ODOT GDM 1303.3.3** | | | | | | | |
| Meeting any of the following three conditions: | | | | | Condition Met? | | |
| 1. Bedrock Surface under the footing lopes steeper than 2H:1V | | | | | No | | |
| 2. Foundaiton Bedrock Has RMR >70 | | RMR= | 52 | | No | | |
| 3. Foundation Bedrock is Strong or greater (Qu>7,500 psi) | | | Qu (psi)= | 18827 | Yes | | |
| | | | | | | | |
| qn=(sqrt(s)+((m*sqrt(s))+s)^0.5)*Qu = | 7032 | psi | | | | | |
| qn= | 1013 | ksf | | | | | |
| | | | | | | | |
| m=mi*exp((RMR-100)/28)= | 1.26 | | | | | | |
| For dolomite, mi = | 7 | | | | | | |
| | | | | | | | |
| s=exp((RMR-100)/9)= | 0.0048 | | | | | | |
| | | | | | | | |
| From Table 10.5.5.2.2-1, | | | | | | | |
| For footings on rock, | | | | | | | |
| $\phi$b= | 0.45 | | | | | | |
| | | | | | | | |
| qR=$\phi$b*qn (ksf)= | 456 | | | | | | |

| | | | |
|---|---|---|---|
| **TTL Project No.:** | **2065201** | | |
| **Project:** | **LUC-23-11.75** | | |
| **Calcs by:** | **CPI** | | |
| **Date:** | **5/25/2023** | **to** | **6/2/2023** |
| | | | |
| **Calcs:** | **Footings on Rock** | | |
| **Location:** | **SR 51 over US 23** | | |
| **Substructure:** | **East Pier (Pier 3)** | | |
| | | | |
| Boring: | B-010-0-21 | | |
| GSE (ft): | 651.0 | | |
| Long-Term GWT (ft): | 623 | | |
| | | | |
| No encountered weathered rock | | | |
| Auger Refusal Top of Rock Depth (ft): | 35.4 | | |
| Top of Weathered Rock Elev. (ft): | 615.6 | | |
| Footing keyed 3" into Rock at | | | |
| Bearing Elev. (ft): | 615.3 | | |
| | | | |
| Prelim Footing Size: | L (ft)= | 8 | |
| | B (ft)= | 8 | |

**Service Limit State**

AASHTO LRFD Bridge Design Spec Table C10.6.2.5.1-1

| | | Bearing Resistance (ksf) | |
|---|---|---|---|
| **Type of Bearing Material** | **Consistency** | **Ordinary Range** | **Recommended Value** |
| Weathered / Broken Rock (except shale) | Medium Hard Rock | 16-24 | 20 |

| | |
|---|---|
| Resistance Factor: | 1.0 |
| Factored Resistance (ksf): | 20 |

**Settlement**

AASHTO LRFD Bridge Design Specification 10.6.2.4.4

| | | |
|---|---|---|
| For Circular or Square Footings, | | |
| Delta=qo(1-v^2)*((r*Ip)/(144Em))= | 0.14 | inch |
| qo (ksf)= | 20 | |
| v from AASHTO LRFD Table C10.4.6.5-2 | | |
| v, Mean Value for Dolostone: | 0.29 | |
| r = raidus for circular or B/2 for square | | |
| r (ft): | 4 | |
| Ip=(pi^(1/2))/Bz = | 1.64 | |
| Bz per Table 10.6.2.4.2-1 | | |
| L/B: | 1 | |
| Bz (Rigid Footing): | 1.08 | |
| Em per AASHTO LRFD 10.4.6.5 | | |
| Em = lesser of | | |
| Ei or | 1400 | |
| Em=145*(10^((RMR-10)/40)) or | 2170 | |
| Em=(Em/Ei)*Ei | 70 | |
| Em/Ei | 0.05 | AASHTO LRFD Table C10.4.6.5-1 |
| Em (ksi)= | 70 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Calcs:** | **Footings on Rock** | | | | | | |
| **Location:** | **SR 51 over US 23** | | | | | | |
| **Substructure:** | **East Pier (Pier 3)** | | | | | | |
| | | | | | | | |
| Ei From GDM Table 400-6 based on Qu | | | | | | | |
| Qu (psi) within ~2B= | 18020 | 19190 | 17110 | 12270 | | | |
| Average Qu (psi)= | 16648 | = | 2397 | ksf | | | |
| for Very Strong Qu=15000 psi | (Not quite up to Qu=20,000 psi) | | | | | | |
| Ei(psi)= | 1400000 | | | | | | |
| Ei(ksi)= | 1400 | | | | | | |
| | | | | | | | |
| **RMR Calculations** | | | | | | | |
| | | | | | | | |
| **Parameter** | **Value** | **Note** | **See ODOT GDM 1303.3.3 for guidance on RMR Parameters** | | | | |
| 1 | 12 | Qu =2397 ksf | | | | | |
| 2 | 8 | RQD=36% | | | | | |
| 3 | 10 | 2"-12" spacing of joints, Highly Fractured to Moderately Fractured | | | | | |
| 4 | 20 | Slightly rough, Separateion <0.05in, hard joint wall | | | | | |
| 5 | 7 | Moist Only | | | | | |
| **RMR =** | **57** | | | | | | |
| | | | | | | | |
| **Strength Limit State** | | | | | | | |
| | | | | | | | |
| **Look at ODOT GDM 1303.3.3** | | | | | | | |
| Meeting any of the following three conditions: | | | | | Condition Met? | | |
| 1. Bedrock Surface under the footing lopes steeper than 2H:1V | | | | | No | | |
| 2. Foundaiton Bedrock Has RMR >70 | | RMR= | 57 | | No | | |
| 3. Foundation Bedrock is Strong or greater (Qu>7,500 psi) | | | Qu (psi)= | 16648 | Yes | | |
| | | | | | | | |
| qn=(sqrt(s)+((m*sqrt(s))+s)^0.5)*Qu = | 7903 | psi | | | | | |
| qn= | 1138 | ksf | | | | | |
| | | | | | | | |
| m=mi*exp((RMR-100)/28)= | 1.51 | | | | | | |
| For dolomite, mi = | 7 | | | | | | |
| | | | | | | | |
| s=exp((RMR-100)/9)= | 0.0084 | | | | | | |
| | | | | | | | |
| From Table 10.5.5.2.2-1, | | | | | | | |
| For footings on rock, | | | | | | | |
| ϕb= | 0.45 | | | | | | |
| | | | | | | | |
| qR=ϕb*qn (ksf)= | 512 | | | | | | |

# APPENDIX C

## Ramp A Bridge Foundation Evaluations

Project Name: LUC-023-11.75, PID 105889
Project Numbe 2065201
Calculated by: KCH 04/11/2023
Reviewed By: CPI 04/17/2023

**Scour Determination - Ramp A**

Upper Elevation Limit for Analysis = 621.79 feet, based on 100-year floodplain
Lower Elevation Limit for Analysis = 602.40 feet, based on 6 feet below bottom of river

**Table 3. Scour Parameters for Soils - Ramp A**

| Boring Number | Sample Number | Sample Depth (feet) | Sample Approximate Elevation (feet) | ODOT Soil Class | Fines (<75 µm) (percent) | PI (percent) | w (percent) | $q_u$[1] (psf) | $D_{50}$ (mm) | $D_{95}$ (mm) | Critical Shear Stress, $\tau_c$ (psf) | Critical Shear Stress, $\tau_c$ (Pa) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-028-1-21 | SS-2 | 3.5 - 5.0 | 613.5 - 612.0 | A-4a (4) | 54 | 5 | 22 | 2,000 | 0.0452 | 1.3659 | 0.026 | 1.21 |
| B-028-1-21 | SS-3 | 6.0 - 7.5 | 611.0 - 609.5 | A-2-4 (0) | 25 | 6 | 11 | - | 0.3939 | 23.785 | 0.008 | 0.39 |
| B-028-1-21 | SS-4 | 8.5 - 10 | 608.5 - 607.0 | A-2-4 (0) | 31 | 4 | 12 | - | 1.0692 | 23.894 | 0.022 | 1.07 |
| B-028-1-21 | SS-5 | 11 - 11.1 | 606.0 - 605.9 | A-2-4 (0) | 31 | 0 | - | - | 0.3334 | 9.9839 | 0.007 | 0.33 |
| B-028-2-21 | SS-1 | 0.0 - 0.9 | 609.5 - 608.6 | A-1-b (0) | 20 | 0 | - | - | 6.3707 | 23.5121 | 0.133 | 6.37 |

[1] For cohesive samples which were not intact for an unconfined compressive strength test or a hand penetrometer value, $q_u$ was estimated by $N_{60}$x250.

**Table 4. Scour Parameters for Rock - Ramp A**

| Boring Number | Sample Number | Sample Depth (feet) | Sample Approximate Elevation (feet) | Unconfined Compressive Strength, $Q_u$ (psi) | Slake Durability Index, $S_{DI}$ (percent) | Rock Quality Designation, RQD (percent) | Unit Weight (pcf) | Rock Mass Rating, RMR (Superseded by GSI) | Geologic Strength Index, GSI | Erodibility Index, K | Critical Shear Stress, $\tau_c$ (psf) | Critical Shear Stress, $\tau_c$ (Pa) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-028-1-21 | NQ-1 | 11.2 - 16.2 | 606.0 - 601.0 | 12,510 | 99.6 | 77 | 160.5 | 38 | 30 to 45 | 266 | 86.16 | 4,125.5 |
| B-028-2-21 | NQ-1 | 1.5 - 5.0 | 608.0 - 604.5 | 10,750 | 99.6 | 67 | 164.6 | 57 | 45 to 65 | 298 | 91.25 | 4,369.0 |
| B-028-2-21 | NQ-2 | 5.0 - 10.0 | 604.5 - 599.5 | 19,230 | - | 37 | 164.2 | 57 | 45 to 65 | 294 | 90.69 | 4,342.5 |

| | |
|---|---|
| **TTL Project No.:** | **2065201** |
| **Project:** | **LUC-23-11.75** |
| **Calcs by:** | **CPI** |
| **Date:** | **6/27/2023** |
| **Calcs:** | **Drilled Shaft Rock Socket Factored Loads** |
| **Location:** | **Ramp A over Ottawa River** |

**Provided Factored Loads - Per Shaft (4 shafts per footing)**

| **Substructure** | **Bottom of Footing Elev. (ft)** | **Provided P (kips)** | **Provided M (k-ft)** |
|---|---|---|---|
| Rear Abutment | 613.5 | 203.05 | 923.76 |
| Pier 1 | 610.0 | 315.21 | 702.52 |
| Pier 2 | 608.0 | 315.21 | 702.52 |
| Forward Abutment | 615.0 | 203.05 | 923.76 |

**Unit Conversion for input into LPILE**

**Provided Factored Loads - Per Shaft (4 shafts per footing)**

| **Substructure** | **Bottom of Footing Elev. (ft)** | **Provided P (lbs)** | **Provided M (in-lb)** |
|---|---|---|---|
| Rear Abutment | 613.5 | 203,050 | 11,085,120 |
| Pier 1 | 610.0 | 315,210 | 8,430,240 |
| Pier 2 | 608.0 | 315,210 | 8,430,240 |
| Forward Abutment | 615.0 | 203,050 | 11,085,120 |

| | |
|---|---|
| Indicated center-to-center spacing, S (ft): | 8 |
| Indicated shaft diameter, B (ft): | 3.5 |
| Spacing (S/B): | 2.29 |

ODOT BDM 305.1.2 Group Effects for single row with C-C <3.75 diameters

Pm = 0.64 (S/B)^0.34 for 1.0≤ S/B ≤ 3.75

Pm = 0.85

| | |
|---|---|
| **TTL Project No.:** | **2065201** |
| **Project:** | **LUC-23-11.75** |
| **Calcs by:** | **CPI** |
| **Date:** | **5/10/2023, 6/26&30/2023** |
| | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp A over Ottawa River** |
| **Substructure:** | **Rear Abutment** |
| | |
| Boring(s): | B-028-0-21 |
| Ground Surface Elevation (ft): | 620.3 |
| Bottom of Pier Cap Elev (ft): | 613.5 |
| Top of Rock Elevation (ft): | 609.3 |
| Length of Shaft in Soil (ft): | 4.2 |
| Shaft in Soil Diameter (in): | 36 |
| *(Minimum 42" for Pier Columns, and 36" for others.)* | |
| | |
| Shaft in Rock Diameter (in): | 30 |
| Shaft in Rock Diameter (ft): | 2.5 |
| End-Bearing at 1.5 x B | |
| Length of Socket (ft): | 3.75 |
| | |
| May increase Shaft in soil to 3.5 ft and socket to 3 ft diameter for lateral resistance | |
| Shaft in Rock Diameter (ft): | 3 |
| In this case, 1.5 x B | |
| Length of Socket (ft): | 4.5 |
| BDM 305.4.4.4, minimum 5' socket if rock within 10 ft of ground surface or bottom of shaft cap. | |
| As noted above, shaft in soil (ft): | 4.2 |
| Governing Length of Socket (ft): | 5 |
| End-Bearing Elev. (ft): | 604.3 |
| | |
| **Structural indicates Scour to Elev:** | **605.9** |
| BDM 305.4.1.1, for end-bearing shafts/sockets in non-scour resistant bedrock, | |
| extend socket to penetrate a minimum of 10 feet below scour elevation. | |
| Therefore, end-bearing elevation is 10 ft below scour elevation. | |
| End-Bearing Elev. (ft): | 595.9 |
| This is deeper than that determined with the 5 ft below top of rock requirement. | |
| **End-Bearing Elev. (ft):** | **595.9** |
| **Calculated Socket Length (ft):** | **13.4** |
| | |
| Look at RC Qu at bearing to | |
| 2B below bearing: | |
| 2B below bearing Elev.: | 589.9 |
| Qu (psi): | 17090 |
| | |
| | |
| Use Average Qu (psi): | 17090 |
| Average Qu (ksf): | 2461 |
| | |

| | |
|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp A over Ottawa River** |
| **Substructure:** | **Rear Abutment** |
| | |
| End-Bearing Resistance (AASHTO LRFD 10.8.3.5.4c-1) | |
| qp=2.5qu | |
| **(Unfactored) qp (ksf):** | **6152** |
| Resistance Factor (AASHTO LRFD Table 10.5.5.2.4-1) | |
| $\phi$= | 0.5 |
| **Factored Bearing Resistance (ksf)=** | **3076** |
| **Say, Factored Bearing Resistance (ksf)=** | **3075** |
| For 2.5 ft diameter socket, | |
| Available Resistance (kips)= | 15094 |
| For 4 Shafts in Footing, | |
| Indicated Total Factored Load (kips)= | 203.05 |
| **Suitable Vertical Resistance?** | **YES** |
| For 3 ft diameter socket, | |
| Available Resistance (kips)= | 21736 |
| For consideration of 3.5 ft dia shaft continued without 6" reduction, | |
| Available Resistance (kips)= | 29585 |
| | |
| This design is based on deepest Qu value in boring. If need to extend deeper for lateral purposes, | |
| would use same Qu. So still ok for vertical. | |
| | |
| Note there is downdrag at this location. | |
| Per settlement calc sheet, | |
| Adhesion (ksf)= | 0.75 |
| Top downdrag Elev / Footing Elev: | 613.5 |
| Elev of 0.4" settlement below to | |
| top of rock is Elev: | 612.6 |
| Downdrag Length of Shaft (ft) | 0.9 |
| For 3.5 ft shaft in soil, | |
| unfactored DD (kips)= | 7 |
| For factored DD, still pleanty of resistance available. | |
| If load is carried by additional shafts, should lateral loading govern, | |
| there would be even less vertical load and vertical resistance would be suitable. | |
| | |
| Use other methods to avoid downdrag on footing and abutment walls. | |

| | |
|---|---|
| **TTL Project No.:** | **2065201** |
| **Project:** | **LUC-23-11.75** |
| **Calcs by:** | **CPI** |
| **Date:** | **5/10/2023, 6/26&30/2023** |
| | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp A over Ottawa River** |
| **Substructure:** | **Pier 1** |
| | |
| Boring(s): | B-028-1-21 |
| Ground Surface Elevation (ft): | 616.6 |
| Bottom of Pier Cap Elev (ft): | 610 |
| Top of Rock Elevation (ft): | 605.6 |
| Length of Shaft in Soil (ft): | 4.4 |
| Shaft in Soil Diameter (in): | 36 |
| *(Minimum 42" for Pier Columns, and 36" for others.)* | |
| *Using footing instead of columns* | |
| Shaft in Rock Diameter (in): | 30 |
| Shaft in Rock Diameter (ft): | 2.5 |
| End-Bearing at 1.5 x B | |
| Length of Socket (ft): | 3.75 |
| May increase Shaft in soil to 3.5 ft and socket to 3 ft diameter for lateral resistance | |
| Shaft in Rock Diameter (ft): | 3 |
| In this case, 1.5 x B | |
| Length of Socket (ft): | 4.5 |
| BDM 305.4.4.4, minimum 5' socket if rock within 10 ft of ground surface or bottom of shaft cap. | |
| As noted above, shaft in soil (ft): | 4.4 |
| Governing Length of Socket (ft): | 5 |
| End-Bearing Elev. (ft): | 600.6 |
| | |
| **Structural indicates Scour to Elev:** | **603.02** |
| BDM 305.4.1.1, for end-bearing shafts/sockets in non-scour resistant bedrock, | |
| extend socket to penetrate a minimum of 10 feet below scour elevation. | |
| Therefore, end-bearing elevation is 10 ft below scour elevation. | |
| End-Bearing Elev. (ft): | 593.02 |
| This is deeper than that determined with the 5 ft below top of rock requirement. | |
| End-Bearing Elev. (ft): | 593.02 |
| This is just above highly fractured zone with open fractures at Elev. 592.7 where driller | |
| noted loss of water during coring. Due to suspect end-bearing on this material, extend | |
| deeper. Water 50% return and more intact rock at Elev. 591.7. Therefore, extend socket | |
| to end-bearing at this elevation. | |
| **End-Bearing Elev. (ft):** | **591.7** |
| **Calculated Socket Length (ft):** | **13.9** |
| | |

| | |
|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp A over Ottawa River** |
| **Substructure:** | **Pier 1** |
| | |
| Look at RC Qu at bearing to | |
| 2B below bearing: | |
| 2B below bearing Elev.: | 587.02 |
| Qu (psi): | 19440 |
| | |
| | |
| Use Average Qu (psi): | 19440 |
| Average Qu (ksf): | 2799 |
| | |
| End-Bearing Resistance (AASHTO LRFD 10.8.3.5.4c-1) | |
| qp=2.5qu | |
| **(Unfactored) qp (ksf):** | **6998** |
| Resistance Factor (AASHTO LRFD Table 10.5.5.2.4-1) | |
| $\phi$= | 0.5 |
| Factored Bearing Resistance (ksf)= | 3499 |
| **Say, Factored Bearing Resistance (ksf)=** | **3495** |
| For 2.5 ft diameter socket, | |
| Available Resistance (kips)= | 17156 |
| For 4 Shafts in Footing, | |
| Indicated Total Factored Load (kips)= | 315.21 |
| **Suitable Vertical Resistance?** | **YES** |
| For 3 ft diameter socket, | |
| Available Resistance (kips)= | 24705 |
| For consideration of 3.5 ft dia shaft continued without 6" reduction, | |
| Available Resistance (kips)= | 33626 |
| | |
| This is deepest cored rock layer in the boring, so deeper shaft for lateral, if needed, | |
| would be designed using same Qu. | |

TTL associates inc
Environmental, Geotechnical Engineering & Testing

| | |
|---|---|
| **TTL Project No.:** | **2065201** |
| **Project:** | **LUC-23-11.75** |
| **Calcs by:** | **CPI** |
| **Date:** | **5/10/2023, 6/26&30/2023** |
| | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp A over Ottawa River** |
| **Substructure:** | **Pier 2** |
| | |
| Boring(s): | B-028-2-21 |
| Ground Surface Elevation (ft): | 609 |
| Bottom of Pier Cap Elev (ft): | 608 |
| Note, Bottom of Pier Cap below Top of Rock | |
| Top of Rock Elevation (ft): | 608.1 |
| Length of Shaft in Soil (ft): | 0 |
| Shaft in Soil Diameter (in): | 36 |
| *(Minimum 42" for Pier Columns, and 36" for others.)* | |
| *Using footing instead of columns.* | |
| Shaft in Rock Diameter (in): | 30 |
| Shaft in Rock Diameter (ft): | 2.5 |
| End-Bearing at 1.5 x B | |
| Length of Socket (ft): | 3.75 |
| Note, Length below pier cap, not top of rock. | |
| May increase Shaft in soil to 3.5 ft and socket to 3 ft diameter for lateral resistance | |
| Shaft in Rock Diameter (ft): | 3 |
| In this case, 1.5 x B | |
| Length of Socket (ft): | 4.5 |
| Note, Length below pier cap, not top of rock. | |
| BDM 305.4.4.4, minimum 5' socket if rock within 10 ft of ground surface or bottom of shaft cap. | |
| As noted above, shaft in soil (ft): | 0 |
| Governing Length of Socket (ft): | 5 |
| Note, Length below pier cap, not top of rock. | |
| End-Bearing Elev. (ft): | 603 |
| | |
| **Structural indicates Scour to Elev:** | **605.72** |
| BDM 305.4.1.1, for end-bearing shafts/sockets in non-scour resistant bedrock, | |
| extend socket to penetrate a minimum of 10 feet below scour elevation. | |
| Therefore, end-bearing elevation is 10 ft below scour elevation. | |
| End-Bearing Elev. (ft): | 595.72 |
| This is deeper than that determined with the 5 ft below top of rock requirement. | |
| **End-Bearing Elev. (ft):** | **595.72** |
| Note, Length below pier cap, not top of rock. | |
| **Calculated Socket Length (ft):** | **12.28** |
| | |

| | |
|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp A over Ottawa River** |
| **Substructure:** | **Pier 2** |
| | |
| Look at RC Qu at bearing to | |
| 2B below bearing: | |
| 2B below bearing Elev.: | 589.72 |
| Qu (psi): | 17610 |
| | |
| | |
| | |
| Use Average Qu (psi): | 17610 |
| Average Qu (ksf): | 2536 |
| | |
| End-Bearing Resistance (AASHTO LRFD 10.8.3.5.4c-1) | |
| qp=2.5qu | |
| **(Unfactored) qp (ksf):** | **6340** |
| Resistance Factor (AASHTO LRFD Table 10.5.5.2.4-1) | |
| $\phi$= | 0.5 |
| Factored Bearing Resistance (ksf)= | 3170 |
| **Say, Factored Bearing Resistance (ksf)=** | **3170** |
| For 2.5 ft diameter socket, | |
| Available Resistance (kips)= | 15561 |
| For 4 Shafts in Footing, | |
| Indicated Total Factored Load (kips)= | 315.21 |
| **Suitable Vertical Resistance?** | **YES** |
| For 3 ft diameter socket, | |
| Available Resistance (kips)= | 22407 |
| For consideration of 3.5 ft dia shaft continued without 6" reduction, | |
| Available Resistance (kips)= | 30499 |
| | |
| This is deepest cored rock layer in the boring, so deeper shaft for lateral, if needed, | |
| would be designed using same Qu. | |

| | |
|---|---|
| **TTL Project No.:** | **2065201** |
| **Project:** | **LUC-23-11.75** |
| **Calcs by:** | **CPI** |
| **Date:** | **5/10/2023, 6/26&30/2023** |
| | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp A over Ottawa River** |
| **Substructure:** | **Forward Abutment** |
| | |
| Boring(s): | B-029-0-21 |
| Ground Surface Elevation (ft): | 620.5 |
| Bottom of Pier Cap Elev (ft): | 615 |
| Top of Rock Elevation (ft): | 609 |
| Length of Shaft in Soil (ft): | 6 |
| Shaft in Soil Diameter (in): | 36 |
| *(Minimum 42" for Pier Columns, and 36" for others.)* | |
| | |
| Shaft in Rock Diameter (in): | 30 |
| Shaft in Rock Diameter (ft): | 2.5 |
| End-Bearing at 1.5 x B | |
| Length of Socket (ft): | 3.75 |
| End-Bearing Elev. (ft): | 605.25 |
| ***Note that Auger Refusal at Elev. (ft):*** | *604.5* |
| *Extend End-Bearing to Elev. (ft):* | *604.5* |
| *Minimum Socket Length (ft):* | *4.5* |
| May increase Shaft in soil to 3.5 ft and socket to 3 ft diameter for lateral resistance | |
| Shaft in Rock Diameter (ft): | 3 |
| In this case, 1.5 x B | |
| Length of Socket (ft): | 4.5 |
| This meets minimum above to get into cored rock. | |
| BDM 305.4.4.4, minimum 5' socket if rock within 10 ft of ground surface or bottom of shaft cap. | |
| As noted above, shaft in soil (ft): | 6 |
| Governing Length of Socket (ft): | 5 |
| End-Bearing Elev. (ft): | 604 |
| | |
| **Structural indicates Scour to Elev:** | **607.7** |
| BDM 305.4.1.1, for end-bearing shafts/sockets in non-scour resistant bedrock, | |
| extend socket to penetrate a minimum of 10 feet below scour elevation. | |
| Therefore, end-bearing elevation is 10 ft below scour elevation. | |
| End-Bearing Elev. (ft): | 597.7 |
| This is deeper than that determined with the 5 ft below top of rock requirement. | |
| **End-Bearing Elev. (ft):** | **597.7** |
| **Calculated Socket Length (ft):** | **11.3** |
| | |

| | |
|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp A over Ottawa River** |
| **Substructure:** | **Forward Abutment** |
| | |
| Look at RC Qu at bearing to | |
| 2B below bearing: | |
| 2B below bearing Elev.: | 591.7 |
| Qu (psi): | 12710 |
| *No other tests within 2B* | |
| | |
| Use Average Qu (psi): | 12710 |
| Average Qu (ksf): | 1830 |
| | |
| End-Bearing Resistance (AASHTO LRFD 10.8.3.5.4c-1) | |
| qp=2.5qu | |
| **(Unfactored) qp (ksf):** | **4576** |
| Resistance Factor (AASHTO LRFD Table 10.5.5.2.4-1) | |
| $\phi$= | 0.5 |
| Factored Bearing Resistance (ksf)= | 2288 |
| **Say, Factored Bearing Resistance (ksf)=** | **2285** |
| For 2.5 ft diameter socket, | |
| Available Resistance (kips)= | 11216 |
| For 4 Shafts in Footing, | |
| Indicated Total Factored Load (kips)= | 203.05 |
| **Suitable Vertical Resistance?** | **YES** |
| For 3 ft diameter socket, | |
| Available Resistance (kips)= | 16152 |
| For consideration of 3.5 ft dia shaft continued without 6" reduction, | |
| Available Resistance (kips)= | 21984 |
| | |
| If extend deeper for lateral load considerations, the Qu at Elev. 588+/- is even higher | |
| than the value used for design. As such, vertical would still be suitable. | |
| | |
| No downdrag for this location with approximately 0.4 inch or less settlement | |
| calculated for soil zone from footing elevation to top of rock. | |
| Use other methods to avoid downdrag on footing and abutment walls. | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TTL Project No.: | 2065201 | | | | | | | |
| Project: | LUC-23-11.75 | | | | | | | |
| Calcs by: | CPI | | | | | | | |
| Date: | 5/15/2023 | | | | | | | |
| | | | | | | | | |
| Calcs: | Drilled Shaft Rock Sockets - Lateral Resistance | | | | | | | |
| Location: | Ramp A over Ottawa River | | | | | | | |
| Substructure: | Rear Abutment | | | | | | | |
| | | | | | | | | |
| Boring(s): | B-028-0-21 | | | | | | | |
| GSE (ft): | 620.3 | | | | | | | |
| Long-Term GWT (ft): | 612 | Approx. Normal River Elev. | | | | | | |
| Bottom of Pier Cap Elev. (ft): | 613.5 | | | | | | | |
| | | | | | | | | |
| **Soil** | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 1** | **Medium Dense A-3a** | 0 | 4 | 620.3 | 616.3 | 20 | - | - |
| | | | **Depth below bottom of Pier Cap:** | -6.8 | -2.8 | | | |
| **Total Unit Wt (pcf):** | 125 | GDM Table 400-4 | | **Use** | **125** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 2 | ft | | | | | | |
| sigma-v' (ksf): | 0.25 | | | | | | | |
| CN= | 1.7 | <2.0, use | 1.7 | | | | | |
| N160 (bpf)= | 34 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 30 | 37.5 | | | | | | | |
| 50 | 40.5 | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 34 | 38.09 | use | 38 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-3a | -0.5 | | | | | | | |
| **Phi (deg) =** | **37.5** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Medium Dense, Dry to Moist Sand | | | | | | | |
| Range of k-value (pci) = | 13.0 - 40.0 | | | | | | | |
| Med Dense range of N60 | k (pci) | | | | | | | |
| 11 | 13 | | | | | | | |
| 30 | 40 | | | | | | | |
| Interpolate for 20 bpf for this layer: | 25.8 | | | | | | | |
| **Say k (pci) =** | **25** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 2** | **Very Stiff A-4a** | 4 | 6 | 616.3 | 614.3 | 18 | - | - |
| | | | **Depth below bottom of Pier Cap:** | -2.8 | -0.8 | | | |
| **Total Unit Wt (pcf):** | 122 | GDM Table 400-4 | | **Use** | **120** | **pcf** | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | |
| **Su (ksf)=** | **2.25** | | | | | | | |
| | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | |
| **Su = 2-4 ksf, epsilon 50 =** | **0.005** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 3** | **Stiff to Very Stiff A-6a** | 6 | 8 | 614.3 | 612.3 | ST | 3.25 | 0.94 |
| | | | **Depth below bottom of Pier Cap:** | -0.8 | 1.2 | | | |
| **Total Unit Wt (pcf):** | 124 | Qu Specimen | | **Use** | **125** | **pcf** | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | Based on soil type and Unit Wt for A-4a above. | | | | |
| **Su (ksf)=** | **0.94** | Based on Qu test result. | | | | | | |
| | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | |
| epsilon 50 for Su = 1-2 ksf: 0.007, Medium Stiff: 0.010, Soft: 0.020 | | | | | | | | |
| **Su slightly <1 ksf, so use epsilon 50 =** | **0.010** | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | |
| **Location:** | **Ramp A over Ottawa River** | | | | | | | |
| **Substructure:** | **Rear Abutment** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 4** | **Loose A-3a** | 8 | 11 | 612.3 | 609.3 | 8 | - | - |
| | | | **Depth below bottom of Pier Cap:** | 1.2 | 4.2 | | | |
| **Total Unit Wt (pcf):** | 120 | GDM Table 400-4 | | **Use** | **120** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 9.5 | ft | | | | | | |
| sigma-v' (ksf): | 1.14 | | | | | | | |
| CN= | 1.2 | <2.0, use | 1.2 | | | | | |
| N160 (bpf)= | 10 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 10 | 32.5 | use | 32.5 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-3a | -0.5 | | | | | | | |
| **Phi (deg) =** | **32** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Loose, Submerged Sand | | | | | | | |
| Range of k-value (pci) = | 2.1 - 6.4 | | | | | | | |
| Med Dense range of N60 | k (pci) | | | | | | | |
| 5 | 2.1 | | | | | | | |
| 10 | 6.4 | | | | | | | |
| Interpolate for 8 bpf for this layer: | 4.7 | | | | | | | |
| **Say k (pci) =** | **5** | | | | | | | |
| | | | | | | | | |
| **Augerable Weathered Bedrock** | | | | | | | | |
| **Layer** | **Rock Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **SPT Result** | | |
| **Layer 5** | **Weathered Dolomite** | 11 | 13 | 609.3 | 607.3 | 11-50/4" | | |
| | | | **Depth below bottom of Pier Cap:** | 4.2 | 6.2 | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | |
| | 162 | Average of Tested Values for the project. | | | | | | |
| Qu based on SPT Results per GDM 404.3 | | | | | | | | |
| Qu (ksf)=0.092x(Nrate)90 (bpf) | | | | | | | | |
| ER(%)= | 90 | | | | | | | |
| N90=50/4" x 12" = | 150 | bpf | | | | | | |
| N90 = 90/90 x 150 bpf = | 150 | bpf | | | | | | |
| Qu (ksf) = | 13.8 | | | | | | | |
| Qu (psi) = | 95.8 | | | | | | | |
| | | | | | | | | |
| Estimate E based on GDM Table 400-6 | | | | | | | | |
| Lowest Qu = 200 psi, indicated as E = 18,000 psi | | | | | | | | |
| **Use E (psi) =** | **18000** | | | | | | | |
| | | | | | | | | |
| If Strain at 18,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | |
| Half max stress = Qu/2 = | 47.9 | psi | | | | | | |
| krm = 1% x (47.9 psi / 18,000 psi) = | 0.0027 | % | | | | | | |
| **krm (decimal format) =** | **0.000027** | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Calcs: | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| Location: | **Ramp A over Ottawa River** | | | | | | | | | |
| Substructure: | **Rear Abutment** | | | | | | | | | |

**Cored Bedrock**

| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Layer 6** | **Dolomite - Strong, Vuggy** | 13 | 14.4 | 607.3 | 605.9 | 65 | 100 | No Test | | |
| | **Frac. To Mod Frac.** | | | | | | | | | |
| | | **Depth below bottom of Pier Cap:** | | 6.2 | 7.6 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| **Qu (psi)=** | **10750** | Similar depth below top of rock from nearby B-028-2-21, and Strong | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| If Strain at 900,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 5375 | psi | | | | | | | | |
| krm = 1% x (5375 psi / 900,000 psi) = | 0.0060 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000060** | | | | | | | | | |

| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Layer 7** | **Dolomite - Very Strong** | 14.4 | 21 | 605.9 | 599.3 | 72 | 96 | 22000 | 164 | at 17 ft |
| | **Frac. To Mod Frac.** | | | | | | | 20200 | 161 | at 20.2 ft |
| | | **Depth below bottom of Pier Cap:** | | 7.6 | 14.2 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162.5 | Average of tested values within zone. | | | | | | | | |
| **Qu (psi)=** | **21100** | Average of tested values within zone. | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1800000** | | | | | | | | | |
| If Strain at 1,800,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 10550 | psi | | | | | | | | |
| krm = 1% x (10,550 psi / 1,800,000 psi) = | 0.0059 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000059** | | | | | | | | | |

| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Layer 8** | **Dolomite - Very Strong** | 21 | 23.9 | 599.3 | 596.4 | 34 | 100 | No Test | | |
| | **Highly Frac. To Mod Frac.** | | | | | | | | | |
| | | **Depth below bottom of Pier Cap:** | | 14.2 | 17.1 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| **Qu (psi)=** | **20200** | Lower-bound strength for layer above. | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1800000** | | | | | | | | | |
| If Strain at 1,800,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 10100 | psi | | | | | | | | |
| krm = 1% x (10,100 psi / 1,800,000 psi) = | 0.0056 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000056** | | | | | | | | | |

| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Layer 9** | **Dolomite - Mod. Strong to Strong** | 23.9 | 25 | 596.4 | 595.3 | 38 | 100 | No Test | | |
| | **Vuggy, Highly Frac. To Mod Frac.** | | | | | | | | | |
| | | **Depth below bottom of Pier Cap:** | | 17.1 | 18.2 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| **Qu (psi)=** | **7500** | Transition from Moderately Strong to Strong | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **680000** | | | | | | | | | |
| If Strain at 680,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 3750 | psi | | | | | | | | |
| krm = 1% x (3,750 psi / 680,000 psi) = | 0.0055 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000055** | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Calcs: | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| Location: | **Ramp A over Ottawa River** | | | | | | | | | |
| Substructure: | **Rear Abutment** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 10** | **Dolomite - Very Strong** | 25 | 26.8 | 595.3 | 593.5 | 77 | 100 | 17090 | 161 | at 26.1 ft |
| | **Frac. To Mod Frac.** | | | | | | | | | |
| | **Depth below bottom of Pier Cap:** | | | 18.2 | 20 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 161 | Average of tested values within zone. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **17090** | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at <u>1,400,000</u> psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 8545 | psi | | | | | | | | |
| krm = 1% x (<u>8545</u> psi / <u>1,400,000</u> psi) = | 0.0061 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000061** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 11** | **Dolomite - Strong** | 26.8 | 31 | 593.5 | 589.3 | 0 | 94 | No Test | | |
| | **Highly Frac. To Frac.** | | | | | | | | | |
| | **Depth below bottom of Pier Cap:** | | | 20 | 24.2 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **12700** | Average of Qu for specimens within strong range for the project. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at <u>900,000</u> psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 6350 | psi | | | | | | | | |
| krm = 1% x (<u>6,350</u> psi / <u>900,000</u> psi) = | 0.0071 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000071** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 12** | **Dolomite - Strong** | 31 | 33 | 589.3 | 587.3 | 24 | 98 | No Test | | |
| | **Highly Frac. To Mod. Frac.** | | | | | | | | | |
| | **Depth below bottom of Pier Cap:** | | | 24.2 | 26.2 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **12700** | Average of Qu for specimens within strong range for the project. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at <u>900,000</u> psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 6350 | psi | | | | | | | | |
| krm = 1% x (<u>6,350</u> psi / <u>900,000</u> psi) = | 0.0071 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000071** | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TTL Project No.:** | **2065201** | | | | | | | |
| **Project:** | **LUC-23-11.75** | | | | | | | |
| **Calcs by:** | **CPI** | | | | | | | |
| **Date:** | **5/15/2023** | | | | | | | |
| | | | | | | | | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | |
| **Location:** | **Ramp A over Ottawa River** | | | | | | | |
| **Substructure:** | **Pier 1** | | | | | | | |
| | | | | | | | | |
| Boring(s): | B-028-1-21 | | | | | | | |
| GSE (ft): | 616.6 | | | | | | | |
| Long-Term GWT (ft): | 612 | Approx. Normal River Elev. | | | | | | |
| Bottom of Pier Cap Elev. (ft): | 610 | | | | | | | |
| | | | | | | | | |
| **Soil** | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 1** | **Very Stiff A-4b** | 0 | 3 | 616.6 | 613.6 | 21 | - | - |
| | **Depth below bottom of Pier Cap:** | | | -6.6 | -3.6 | | | |
| **Total Unit Wt (pcf):** | 125 | GDM Table 400-4 | | **Use** | **125** | **pcf** | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | |
| **Su (ksf)=** | **2.625** | | | | | | | |
| | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | |
| **Su = 2-4 ksf, epsilon 50 =** | **0.005** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 2** | **Medium Stiff to Stiff A-4a** | 3 | 6 | 613.6 | 610.6 | 6 | 1.00 | No Test |
| | **Depth below bottom of Pier Cap:** | | | -3.6 | -0.6 | | | |
| **Total Unit Wt (pcf):** | 115 | GDM Table 400-4 | | **Use** | **115** | **pcf** | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | Based on soil type and Unit Wt for A-4a above. | | | | |
| Su (ksf)= | 750 | Based on N60 value. | | | | | | |
| Su (ksf)= | 1.00 | Based on HP result | | | | | | |
| Say Su (ksf)= | 1.00 | | | | | | | |
| | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | |
| epsilon 50 for Su = 1-2 ksf: 0.007, Medium Stiff: 0.010, Soft: 0.020 | | | | | | | | |
| **Say epsilon 50 =** | **0.007** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 3** | **Medium Dense A-2-4** | 6 | 8 | 610.6 | 608.6 | 18 | - | - |
| | **Depth below bottom of Pier Cap:** | | | -0.6 | 1.4 | | | |
| **Total Unit Wt (pcf):** | 125 | GDM Table 400-4 | | **Use** | **125** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 7 | ft | | | | | | |
| sigma-v' (ksf): | 0.845 | | | | | | | |
| CN= | 1.3 | <2.0, use | 1.3 | | | | | |
| N160 (bpf)= | 23 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 10 | 32.5 | | | | | | | |
| 30 | 37.5 | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 23 | 35.80 | use | 35.5 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-2-4 | +0.5 | | | | | | | |
| **Phi (deg) =** | **36** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Medium Dense, Dry to Moist Sand | | | | | | | |
| Range of k-value (pci) = | 13.0 - 40.0 | | | | | | | |
| Med Dense range of N60 | k (pci) | | | | | | | |
| 11 | 13 | | | | | | | |
| 30 | 40 | | | | | | | |
| Interpolate for 18 bpf for this layer: | 22.9 | | | | | | | |
| **Say k (pci) =** | **23** | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| **Location:** | **Ramp A over Ottawa River** | | | | | | | | | |
| **Substructure:** | **Pier 1** | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** | | |
| **Layer 4** | **Very Dense A-2-4** | 8 | 11 | 608.6 | 605.6 | 90 | - | - | | |
| | | | **Depth below bottom of Pier Cap:** | 1.4 | 4.4 | | | | | |
| **Total Unit Wt (pcf):** | 140 | GDM Table 400-4 | | **Use** | **140** | **pcf** | | | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | | | |
| CN at | 9.5 | ft | | | | | | | | |
| sigma-v' (ksf): | 1.024 | | | | | | | | | |
| CN= | 1.2 | <2.0, use | 1.2 | | | | | | | |
| N160 (bpf)= | 110 | | | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | | | |
| Highest is 50 bpf | 40.5 | | | | | | | | | |
| N160 | Phi (deg) | | | | | | | | | |
| 110 | 40.5 | use | 40.5 | deg | | | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | | | |
| A-2-4 | +0.5 | | | | | | | | | |
| **Phi (deg) =** | **41** | | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | | | |
| Parameters: | Dense, Submerged | | | | | | | | | |
| Range of k-value (pci) = | 32.0-64.0 | | | | | | | | | |
| For N60 of 90 bpf, V. Dense, use highest v | k (pci) | | | | | | | | | |
| **Say k (pci) =** | **64** | | | | | | | | | |
| **Bedrock** | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 5** | **Dolomite - Strong** | 11 | 11.4 | 605.6 | 605.2 | 0 | 100 | No Test | | |
| | **Highly Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 4.4 | 4.8 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| **Qu (psi)=** | **10750** | Similar depth below top of rock from nearby B-028-2-21, and Strong | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| If Strain at 900,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 5375 | psi | | | | | | | | |
| krm = 1% x (5375 psi / 900,000 psi) = | 0.0060 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000060** | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 6** | **Dolomite - Very Strong to Strong** | 11.4 | 21.1 | 605.2 | 595.5 | 43 | 89 | 21510 | 160 | at 12.4 ft |
| | **Vuggy, Frac. To Mod Frac.** | | | | | | | 13150 | 164 | at 17.2 ft |
| | | | **Depth below bottom of Pier Cap:** | 4.8 | 14.5 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of tested values within zone. | | | | | | | | |
| **Qu (psi)=** | **17330** | Average of tested values within zone. | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 8665 | psi | | | | | | | | |
| krm = 1% x (8,665 psi / 1,400,000 psi) = | 0.0062 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000062** | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| **Location:** | **Ramp A over Ottawa River** | | | | | | | | | |
| **Substructure:** | **Pier 1** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 7** | **Dolomite - Strong** | 21.1 | 21.9 | 595.5 | 594.7 | 0 | 100 | No Test | | |
| | **Highly Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 14.5 | 15.3 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **7500** | Transition from Moderately Strong to Strong | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **680000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 680,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 3750 | psi | | | | | | | | |
| krm = 1% x (3,750 psi / 680,000 psi) = | 0.0055 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000055** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 8** | **Dolomite - Strong** | 21.9 | 23.9 | 594.7 | 592.7 | 17 | 100 | No Test | | |
| | **Highly Frac. To Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 15.3 | 17.3 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **7500** | Transition from Moderately Strong to Strong | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **680000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 680,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 3750 | psi | | | | | | | | |
| krm = 1% x (3,750 psi / 680,000 psi) = | 0.0055 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000055** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 9** | **Dolomite - Strong** | 23.9 | 24.9 | 592.7 | 591.7 | 0 | 33 | No Test | | |
| | **Highly Frac. Driller noted loss of water return during coring.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 17.3 | 18.3 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **7500** | Transition from Moderately Strong to Strong | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **680000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 680,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 3750 | psi | | | | | | | | |
| krm = 1% x (3,750 psi / 680,000 psi) = | 0.0055 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000055** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 10** | **Dolomite - Very Strong** | 24.9 | 31.1 | 591.7 | 585.5 | 28 | 85 | 19440 | 164 | at 27 ft |
| | **Frac. To Mod Frac. Driller noted 50% return water during coring in this zone.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 18.3 | 24.5 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **165** | **pcf** | | | | |
| | 164 | Average of tested values within zone. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **19440** | Tested value | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1800000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,800,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 9720 | psi | | | | | | | | |
| krm = 1% x (9,720 psi / 1,800,000 psi) = | 0.0054 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000054** | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TTL Project No.:** | **2065201** | | | | | | | |
| **Project:** | **LUC-23-11.75** | | | | | | | |
| **Calcs by:** | **CPI** | | | | | | | |
| **Date:** | **5/15/2023** | | | | | | | |
| | | | | | | | | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | |
| **Location:** | **Ramp A over Ottawa River** | | | | | | | |
| **Substructure:** | **Pier 2** | | | | | | | |
| | | | | | | | | |
| Boring(s): | B-028-2-21 | | | | | | | |
| GSE (ft): | 609 | Performed from Bridge Deck into Ottawa River | | | | | | |
| Long-Term GWT (ft): | 612 | Approx. Normal River Elev. | | | | | | |
| Bottom of Pier Cap Elev. (ft): | 608 | | | | | | | |
| | | | | | | | | |
| **Soil** | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 1** | **Very Dense A-1-b** | 0 | 0.9 | 609 | 608.1 | 52 | - | - |
| | **Depth below bottom of Pier Cap:** | | | -1 | -0.1 | | | |
| **Total Unit Wt (pcf):** | 132 | GDM Table 400-4 | | **Use** | **130** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 0.45 | ft | | | | | | |
| sigma-v' (ksf): | 0.03042 | | | | | | | |
| CN= | 2.4 | >2.0, use | 2.0 | | | | | |
| N160 (bpf)= | 104 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| Highest is 50 bpf | 40.5 | | | | | | | |
| | | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 104 | 40.5 | use | 40.5 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-1-b | +1.5 | | | | | | | |
| **Phi (deg) =** | **42.0** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Dense, Submerged | | | | | | | |
| Range of k-value (pci) = | 32.0-64.0 | | | | | | | |
| For N60 of 52 bpf, V. Dense, use highest v | k (pci) | | | | | | | |
| **Say k (pci) =** | **64** | | | | | | | |
| | | | | | | | | |
| **Augerable Weathered Bedrock** | | | | | | | | |
| **Layer** | **Rock Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **SPT Result** | | |
| **Layer 2** | **Weathered Dolomite** | 0.9 | 1.5 | 608.1 | 607.5 | 50/3" | | |
| | **Depth below bottom of Pier Cap:** | | | -0.1 | 0.5 | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | |
| | 162 | Average of Tested Values for the project. | | | | | | |
| Qu based on SPT Results per GDM 404.3 | | | | | | | | |
| Qu (ksf)=0.092x(Nrate)90 (bpf) | | | | | | | | |
| ER(%)= | 90 | | | | | | | |
| N90=50/3" x 12" = | 200 | bpf | | | | | | |
| N90 = 90/90 x 200 bpf = | 200 | bpf | | | | | | |
| Qu (ksf) = | 18.4 | | | | | | | |
| Qu (psi) = | 127.8 | | | | | | | |
| | | | | | | | | |
| Estimate E based on GDM Table 400-6 | | | | | | | | |
| Lowest Qu = 200 psi, indicated as E = 18,000 psi | | | | | | | | |
| **Use E (psi) =** | **18000** | | | | | | | |
| | | | | | | | | |
| If Strain at 18,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | |
| Half max stress = Qu/2 = | 63.9 | psi | | | | | | |
| krm = 1% x (63.9 psi / 18,000 psi) = | 0.0035 | % | | | | | | |
| **krm (decimal format) =** | **0.000035** | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| **Location:** | **Ramp A over Ottawa River** | | | | | | | | | |
| **Substructure:** | **Pier 2** | | | | | | | | | |
| **Cored Bedrock** | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 3** | **Dolomite - Strong to Very Strong** | 1.5 | 8.5 | 607.5 | 600.5 | 60 | 99 | 10750 | 165 | at 2.2 ft |
| | **Frac. To Mod Frac.** | | | | | | | 19230 | 164 | at 6.1 ft |
| | | | **Depth below bottom of Pier Cap:** | 0.5 | 7.5 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **165** | **pcf** | | | | |
| | 164.5 | Average of tested values within zone. | | | | | | | | |
| **Qu (psi)=** | **14990** | Average of tested values within zone. | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 7495 | psi | | | | | | | | |
| krm = 1% x (7,495 psi / 1,400,000 psi) = | 0.0054 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000054** | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 4** | **Dolomite - Strong** | 8.5 | 12.6 | 600.5 | 596.4 | 0 | 88 | No Test | | |
| | **Highly Fractured** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 7.5 | 11.6 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| **Qu (psi)=** | **14990** | Conservatively same as layer above. | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 7495 | psi | | | | | | | | |
| krm = 1% x (7,495 psi / 1,400,000 psi) = | 0.0054 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000054** | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 5** | **Dolomite - Very Strong** | 12.6 | 20 | 596.4 | 589 | 4 | 76 | 17610 | 166 | at 16.8 ft |
| | **Fractured** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 11.6 | 19 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **165** | **pcf** | | | | |
| | 166 | Average of tested values within zone. | | | | | | | | |
| **Qu (psi)=** | **17610** | Tested value. | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 8805 | psi | | | | | | | | |
| krm = 1% x (8,805 psi / 1,400,000 psi) = | 0.0063 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000063** | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 6** | **Dolomite - Strong** | 20 | 22 | 589 | 587 | 0 | 67 | No Test | | |
| | **Highly Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 19 | 21 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| **Qu (psi)=** | **7500** | Transition from Moderately Strong to Strong | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **680000** | | | | | | | | | |
| If Strain at 680,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 3750 | psi | | | | | | | | |
| krm = 1% x (3,750 psi / 680,000 psi) = | 0.0055 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000055** | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TTL Project No.:** | **2065201** | | | | | | | |
| **Project:** | **LUC-23-11.75** | | | | | | | |
| **Calcs by:** | **CPI** | | | | | | | |
| **Date:** | **5/16/2023** | | | | | | | |
| | | | | | | | | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | |
| **Location:** | **Ramp A over Ottawa River** | | | | | | | |
| **Substructure:** | **Forward Abutment** | | | | | | | |
| | | | | | | | | |
| Boring(s): | B-029-0-21 | | | | | | | |
| GSE (ft): | 620.5 | | | | | | | |
| Long-Term GWT (ft): | 612 | Approx. Normal River Elev. | | | | | | |
| Bottom of Pier Cap Elev. (ft): | 615 | | | | | | | |
| | | | | | | | | |
| **Soil** | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 1** | **Medium Dense A-3a** | 0 | 3 | 620.5 | 617.5 | 24 | - | - |
| | | | **Depth below bottom of Pier Cap:** | -5.5 | -2.5 | | | |
| **Total Unit Wt (pcf):** | 125 | GDM Table 400-4 | | **Use** | **125** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 1.5 | ft | | | | | | |
| sigma-v' (ksf): | 0.1875 | | | | | | | |
| CN= | 1.8 | <2.0, use | 1.8 | | | | | |
| N160 (bpf)= | 43 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 30 | 37.5 | | | | | | | |
| 50 | 40.5 | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 43 | 39.46 | use | 39.5 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-3a | -0.5 | | | | | | | |
| **Phi (deg) =** | **39** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Medium Dense, Dry to Moist Sand | | | | | | | |
| Range of k-value (pci) = | 13.0 - 40.0 | | | | | | | |
| Med Dense range of N60 | k (pci) | | | | | | | |
| 11 | 13 | | | | | | | |
| 30 | 40 | | | | | | | |
| Interpolate for 24 bpf for this layer: | 31.5 | | | | | | | |
| **Say k (pci) =** | **31** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 2** | **Very Stiff A-4a** | 3 | 9 | 617.5 | 611.5 | 27 | - | - |
| | | | **Depth below bottom of Pier Cap:** | -2.5 | 3.5 | 23 | | |
| | | | | | **Average N60:** | **25** | | |
| **Total Unit Wt (pcf):** | 125 | GDM Table 400-4 | | **Use** | **125** | **pcf** | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | |
| **Su (ksf)=** | **3.125** | | | | | | | |
| | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | |
| **Su = 2-4 ksf, epsilon 50 =** | **0.005** | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | |
| **Location:** | **Ramp A over Ottawa River** | | | | | | | |
| **Substructure:** | **Forward Abutment** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 3** | **Loose A-3a** | 9 | 11.5 | 611.5 | 609 | 9 | - | - |
| | **Depth below bottom of Pier Cap:** | | | 3.5 | 6 | | | |
| **Total Unit Wt (pcf):** | 122 | GDM Table 400-4 | | **Use** | **120** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 10.25 | ft | | | | | | |
| sigma-v' (ksf): | 1.197 | | | | | | | |
| CN= | 1.2 | <2.0, use | 1.2 | | | | | |
| N160 (bpf)= | 11 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 10 | 32.5 | | | | | | | |
| 30 | 37.5 | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 11 | 32.64 | use | 32.5 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-3a | -0.5 | | | | | | | |
| **Phi (deg) =** | **32** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Loose, Saturated Sand | | | | | | | |
| Range of k-value (pci) = | 2.1 to 6.4 | | | | | | | |
| Med Dense range of N60 | k (pci) | | | | | | | |
| 1 | 2.1 | | | | | | | |
| 10 | 6.4 | | | | | | | |
| Interpolate for 9 bpf for this layer: | 5.9 | | | | | | | |
| **Say k (pci) =** | **6** | | | | | | | |
| | | | | | | | | |
| **Augerable Weathered Bedrock** | | | | | | | | |
| **Layer** | **Rock Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **Uncorrected N** | |
| **Layer 4A** | **Weathered Dolomite** | 11.5 | 13.5 | 609 | 607 | 60 | 40 | |
| | **Depth below bottom of Pier Cap:** | | | 6 | 8 | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | |
| | 162 | Average of Tested Values for the project. | | | | | | |
| Qu based on SPT Results per GDM 404.3 | | | | | | | | |
| Qu (ksf)=0.092x(Nrate)90 (bpf) | | | | | | | | |
| ER(%)= | 90 | | | | | | | |
| N90= | 40 | bpf | | | | | | |
| Qu (ksf) = | 3.68 | | | | | | | |
| Qu (psi) = | 25.6 | | | | | | | |
| | | | | | | | | |
| Estimate E based on GDM Table 400-6 | | | | | | | | |
| Lowest Qu = 200 psi, indicated as E = 18,000 psi | | | | | | | | |
| **Use E (psi) =** | **18000** | | | | | | | |
| | | | | | | | | |
| If Strain at 18,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | |
| Half max stress = Qu/2 = | 12.8 | psi | | | | | | |
| krm = 1% x (12.8 psi / 18,000 psi) = | 0.0007 | % | | | | | | |
| **krm (decimal format) =** | **0.000007** | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| **Location:** | **Ramp A over Ottawa River** | | | | | | | | | |
| **Substructure:** | **Forward Abutment** | | | | | | | | | |
| **Layer** | **Rock Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **SPT Result** | | | | |
| **Layer 4B** | **Weathered Dolomite** | 13.5 | 16 | 607 | 604.5 | 50/5" | | | | |
| | | | **Depth below bottom of Pier Cap:** | 8 | 10.5 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| Qu based on SPT Results per GDM 404.3 | | | | | | | | | | |
| Qu (ksf)=0.092x(Nrate)90 (bpf) | | | | | | | | | | |
| ER(%)= | 90 | | | | | | | | | |
| N90=50/5" x 12" = | 120 | bpf | | | | | | | | |
| N90 = 90/90 x 120 bpf = | 120 | bpf | | | | | | | | |
| Qu (ksf) = | 11.04 | | | | | | | | | |
| Qu (psi) = | 76.7 | | | | | | | | | |
| Estimate E based on GDM Table 400-6 | | | | | | | | | | |
| Lowest Qu = 200 psi, indicated as E = 18,000 psi | | | | | | | | | | |
| **Use E (psi) =** | **18000** | | | | | | | | | |
| If Strain at 18,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 38.3 | psi | | | | | | | | |
| krm = 1% x (38.3 psi / 18,000 psi) = | 0.0021 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000021** | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 5** | **Dolomite - Very Strong** | 16 | 17.7 | 604.5 | 602.8 | 43 | 100 | 17720 | 162 | at 16.9 ft |
| | **Highly Frac. To Mod Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 10.5 | 12.2 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Tested value | | | | | | | | |
| **Qu (psi)=** | **17720** | Tested value within zone. | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 8860 | psi | | | | | | | | |
| krm = 1% x (8860 psi / 1,400,000 psi) = | 0.0063 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000063** | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 6** | **Dolomite - Very Strong** | 17.7 | 23 | 602.8 | 597.5 | 81 | 92 | No Test | | |
| | **Frac. To Moderately Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 12.2 | 17.5 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| **Qu (psi)=** | **17720** | Same as layer above. | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 8860 | psi | | | | | | | | |
| krm = 1% x (8,860 psi / 1,400,000 psi) = | 0.0063 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000063** | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Calcs: | Drilled Shaft Rock Sockets - Lateral Resistance | | | | | | | | | |
| Location: | Ramp A over Ottawa River | | | | | | | | | |
| Substructure: | Forward Abutment | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 7** | **Dolomite - Strong** | 23 | 26 | 597.5 | 594.5 | 28 | 97 | 12710 | 159 | at 24 ft |
| | **Fractured** | | | | | | | | | |
| | | **Depth below bottom of Pier Cap:** | | 17.5 | 20.5 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 159 | Tested value | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **12710** | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 900,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 6355 | psi | | | | | | | | |
| krm = 1% x (6355 psi / 900,000 psi) = | 0.0071 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000071** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 8** | **Limestone - Mod Strong to Strong** | 26 | 26.6 | 594.5 | 593.9 | 0 | 100 | No Test | | |
| | **Highly Frac.** | | | | | | | | | |
| | | **Depth below bottom of Pier Cap:** | | 20.5 | 21.1 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **7500** | Transition from Moderately Strong to Strong | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **680000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 680,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 3750 | psi | | | | | | | | |
| krm = 1% x (3,750 psi / 680,000 psi) = | 0.0055 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000055** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 9** | **Dolomite - Strong** | 26.6 | 36 | 593.9 | 584.5 | 25 | 97 | 14980 | 161 | at 32.3 ft |
| | **Highly Frac. To Frac.** | | | | | | | | | |
| | | **Depth below bottom of Pier Cap:** | | 21.1 | 30.5 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 161 | Tested value | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **14980** | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 7490 | psi | | | | | | | | |
| krm = 1% x (7490 psi / 1,400,000 psi) = | 0.0054 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000054** | | | | | | | | | |

# APPENDIX D

## Ramp D Bridge Foundation Evaluations

Project Name: LUC-023-11.75, PID 105889
Project Numbe 2065201
Calculated by: KCH 04/11/2023
Reviewed By: CPI 04/17/2023

**Scour Determination - Ramp D**

Upper Elevation Limit for Analysis = 623.88 feet, based on 100-year floodplain
Lower Elevation Limit for Analysis = 602.46 feet, based on 6 feet below bottom of river

**Table 1. Scour Parameters for Soils - Ramp D**

| Boring Number | Sample Number | Sample Depth (feet) | Sample Approximate Elevation (feet) | ODOT Soil Class | Fines (<75 µm) (percent) | PI (percent) | w (percent) | $q_u$ [1] (psf) | $D_{50}$ (mm) | $D_{95}$ (mm) | Critical Shear Stress, $\tau_c$ (psf) | Critical Shear Stress, $\tau_c$ (Pa) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-022-1-21 | SS-1 | 1.0 - 2.5 | 615.0 - 613.5 | A-4a (2) | 44 | 8 | 17 | 3,500 | 0.0940 | 0.9801 | 0.066 | 3.09 |
| B-022-1-21 | SS-2 | 3.5 - 5.0 | 612.5 - 611.0 | A-4a (3) | 49 | 9 | 19 | 2,000 | 0.0791 | 9.7229 | 0.061 | 2.86 |
| B-022-1-21 | SS-3 | 6.0 - 7.3 | 610.0 - 608.7 | A-3 (0) | 24 | 0 | 68 | - | 0.2838 | 17.0339 | 0.006 | 0.28 |
| B-022-2-21 | SS-2 | 3.5 - 5.0 | 612.5 - 611.0 | A-4a (3) | 50 | 9 | 19 | 4,250 | 0.0707 | 1.4922 | 0.086 | 4.02 |
| B-022-2-21 | SS-3 | 6.0 - 6.2 | 610.0 - 609.8 | A-1-a (0) | 0 | 0 | 7 | - | 9.1626 | 17.9364 | 0.191 | 9.16 |
| B-022-3-21 | SS-1 | 6.0 - 7.3 | 610.0 - 608.7 | A-2-4 (0) | 0 | 0 | 9 | - | 1.0398 | 22.3951 | 0.022 | 1.04 |

[1] For cohesive samples which were not intact for an unconfined compressive strength test or a hand penetrometer value, $q_u$ was estimated by $N_{60}$x250.

**Table 2. Scour Parameters for Rock - Ramp D**

| Boring Number | Sample Number | Sample Depth (feet) | Sample Approximate Elevation (feet) | Unconfined Compressive Strength, $Q_u$ (psi) | Slake Durability Index, $S_{DI}$ (percent) | Rock Quality Designation, RQD (percent) | Unit Weight (pcf) | Rock Mass Rating, RMR (Superseded by GSI) | Geologic Strength Index, GSI | Erodibility Index, K | Critical Shear Stress, $\tau_c$ (psf) | Critical Shear Stress, $\tau_c$ (Pa) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-022-1-21 | NQ-1 | 8.6 - 13.6 | 607.4 - 602.4 | 15,630 | 99.2 | 22 | 163.5 | 47 | 35 to 55 | 142 | 63.05 | 3,018.8 |
| B-022-3-21 | NQ-1 | 9.3 - 14.3 | 606.7 - 601.7 | 17,840 | 99.7 | 45 | 159.5 | 57 | 45 to 65 | 332 | 96.34 | 4,612.6 |

| | | | | |
|---|---|---|---|---|
| **TTL Project No.:** | **2065201** | | | |
| **Project:** | **LUC-23-11.75** | | | |
| **Calcs by:** | **CPI** | | | |
| **Date:** | **6/27/2023** | | | |
| | | | | |
| **Calcs:** | **Drilled Shaft Rock Socket Factored Loads** | | | |
| **Location:** | **Ramp D over Ottawa River** | | | |

**Provided Factored Loads - Per Shaft (4 shafts per footing)**

| Substructure | Bottom of Footing Elev. (ft) | Provided P (kips) | Provided M (k-ft) |
|---|---|---|---|
| Rear Abutment | 612.50 | 322.35 | -595.38 |
| Pier 1 | 610.79 | 460.86 | 551.86 |
| Pier 2 | 605.14 | 464.72 | 512.59 |
| Forward Abutment | 614.00 | 290.03 | 1082.13 |

**Unit Conversion for input into LPILE**

**Provided Factored Loads - Per Shaft (4 shafts per footing)**

| Substructure | Bottom of Footing Elev. (ft) | Provided P (lbs) | Provided M (in-lb) |
|---|---|---|---|
| Rear Abutment | 613.5 | 322,350 | -7,144,560 |
| Pier 1 | 610.0 | 460,860 | 6,622,320 |
| Pier 2 | 608.0 | 464,720 | 6,151,080 |
| Forward Abutment | 615.0 | 290,030 | 12,985,560 |

| | |
|---|---|
| Indicated center-to-center spacing, S (ft): | 8 |
| Indicated shaft diameter, B (ft): | 3.5 |
| Spacing (S/B): | 2.29 |

ODOT BDM 305.1.2 Group Effects for single row with C-C <3.75 diameters

Pm = 0.64 (S/B)^0.34 for 1.0≤ S/B ≤ 3.75

Pm = 0.85

| | |
|---|---|
| **TTL Project No.:** | **2065201** |
| **Project:** | **LUC-23-11.75** |
| **Calcs by:** | **CPI** |
| **Date:** | **5/9/2023, 6/26&29/2023** |
| | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp D over Ottawa River** |
| **Substructure:** | **Rear Abutment** |
| | |
| Boring(s): | B-022-0-21 and B-022-1-21 |
| | *B-022-0-21 Governs* |
| Ground Surface Elevation (ft): | 615.1 |
| Bottom of Pier Cap Elev (ft): | 612.5 |
| Top of Rock Elevation (ft): | 607.1 |
| Length of Shaft in Soil (ft): | 5.4 |
| Shaft in Soil Diameter (in): | 36 |
| *(Minimum 42" for Pier Columns, and 36" for others.)* | |
| | |
| Shaft in Rock Diameter (in): | 30 |
| Shaft in Rock Diameter (ft): | 2.5 |
| End-Bearing at 1.5 x B | |
| Length of Socket (ft): | 3.75 |
| May increase Shaft in soil to 3.5 ft and socket to 3 ft diameter for lateral resistance | |
| Shaft in Rock Diameter (ft): | 3 |
| In this case, 1.5 x B | |
| Length of Socket (ft): | 4.5 |
| BDM 305.4.4.4, minimum 5' socket if rock within 10 ft of ground surface or bottom of shaft cap. | |
| As noted above, shaft in soil (ft): | 5.4 |
| Governing Length of Socket (ft): | 5 |
| End-Bearing Elev. (ft): | 602.1 |
| | |
| **Structural indicates Scour to Elev:** | **610.21** |
| BDM 305.4.1.1, for end-bearing shafts/sockets in non-scour resistant bedrock, | |
| extend socket to penetrate a minimum of 10 feet below scour elevation. | |
| Therefore, end-bearing elevation is 10 ft below scour elevation. | |
| End-Bearing Elev. (ft): | 600.21 |
| This is deeper than that determined with the 5 ft below top of rock requirement. | |
| **End-Bearing Elev. (ft):** | **600.21** |
| **Calculated Socket Length (ft):** | **6.89** |
| | |

| | |
|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp D over Ottawa River** |
| **Substructure:** | **Rear Abutment** |
| | |
| Look at RC Qu at bearing to | |
| 2B below bearing: | |
| 2B below bearing Elev.: | 594.21 |
| Qu (psi): | 6250 |
| | 13790 |
| | |
| Use Average Qu (psi): | 10020 |
| Average Qu (ksf): | 1443 |
| | |
| End-Bearing Resistance (AASHTO LRFD 10.8.3.5.4c-1) | |
| qp=2.5qu | |
| **(Unfactored) qp (ksf):** | **3607** |
| Resistance Factor (AASHTO LRFD Table 10.5.5.2.4-1) | |
| $\phi$= | 0.5 |
| Factored Bearing Resistance (ksf)= | 1804 |
| **Say, Factored Bearing Resistance (ksf)=** | **1800** |
| For 2.5 ft diameter socket, | |
| Available Resistance (kips)= | 8836 |
| For 4 Shafts in Footing, | |
| Indicated Total Factored Load (kips)= | 322.35 |
| **Suitable Vertical Resistance?** | **YES** |
| For 3 ft diameter socket, | |
| Available Resistance (kips)= | 12723 |
| For consideration of 3.5 ft dia shaft continued without 6" reduction, | |
| Available Resistance (kips)= | 17318 |
| | |
| | |
| If deeper socket for lateral, look at Qu only for deeper samples. | |
| At Elev. 594 +/-, Qu (psi): | 15030 |
| At Elev. 594 +/-, Qu (ksf): | 2164 |
| This Qu value is higher than average value used above. As such, the analysis above governs. | |
| No downdrag for this location with approximately 0.4 inch or less settlement | |
| calculated for soil zone from footing elevation to top of rock. | |
| Use other methods to avoid downdrag on footing and abutment walls. | |

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| **TTL Project No.:** | **2065201** |
| **Project:** | **LUC-23-11.75** |
| **Calcs by:** | **CPI** |
| **Date:** | **5/10/2023, 6/26&29/2023** |
| | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp D over Ottawa River** |
| **Substructure:** | **Pier 1** |
| | |
| Boring(s): | B-022-1-21 |
| Ground Surface Elevation (ft): | 616.1 |
| Bottom of Pier Cap Elev (ft): | 610.79 |
| Top of Rock Elevation (ft): | 609.1 |
| Length of Shaft in Soil (ft): | 1.69 |
| Shaft in Soil Diameter (in): | 36 |
| *(Minimum 42" for Pier Columns, and 36" for others.)* | |
| *Using footing instead of columns* | |
| Shaft in Rock Diameter (in): | 30 |
| Shaft in Rock Diameter (ft): | 2.5 |
| End-Bearing at 1.5 x B | |
| Length of Socket (ft): | 3.75 |
| May increase Shaft in soil to 3.5 ft and socket to 3 ft diameter for lateral resistance | |
| Shaft in Rock Diameter (ft): | 3 |
| In this case, 1.5 x B | |
| Length of Socket (ft): | 4.5 |
| BDM 305.4.4.4, minimum 5' socket if rock within 10 ft of ground surface or bottom of shaft cap. | |
| As noted above, shaft in soil (ft): | 1.69 |
| Governing Length of Socket (ft): | 5 |
| End-Bearing Elev. (ft): | 604.1 |
| | |
| **Structural indicates Scour to Elev:** | **605.61** |
| BDM 305.4.1.1, for end-bearing shafts/sockets in non-scour resistant bedrock, | |
| extend socket to penetrate a minimum of 10 feet below scour elevation. | |
| Therefore, end-bearing elevation is 10 ft below scour elevation. | |
| End-Bearing Elev. (ft): | 595.61 |
| This is deeper than that determined with the 5 ft below top of rock requirement. | |
| **End-Bearing Elev. (ft):** | **595.61** |
| **Calculated Socket Length (ft):** | **13.49** |
| | |

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|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp D over Ottawa River** |
| **Substructure:** | **Pier 1** |
| | |
| Look at RC Qu at bearing to | |
| 2B below bearing: | |
| 2B below bearing Elev.: | 589.61 |
| Qu (psi): | 7350 |
| | 16470 |
| | |
| Use Average Qu (psi): | 11910 |
| Average Qu (ksf): | 1715 |
| | |
| End-Bearing Resistance (AASHTO LRFD 10.8.3.5.4c-1) | |
| qp=2.5qu | |
| **(Unfactored) qp (ksf):** | **4288** |
| Resistance Factor (AASHTO LRFD Table 10.5.5.2.4-1) | |
| $\phi$= | 0.5 |
| Factored Bearing Resistance (ksf)= | 2144 |
| **Say, Factored Bearing Resistance (ksf)=** | **2140** |
| For 2.5 ft diameter socket, | |
| Available Resistance (kips)= | 10505 |
| For 4 Shafts in Footing, | |
| Indicated Total Factored Load (kips)= | 460.86 |
| **Suitable Vertical Resistance?** | **YES** |
| For 3 ft diameter socket, | |
| Available Resistance (kips)= | 15127 |
| For consideration of 3.5 ft dia shaft continued without 6" reduction, | |
| Available Resistance (kips)= | 20589 |
| | |
| This analysis incorporates lowest UCS for Rock in this boring. Therefore, if socket | |
| is required to extend deeper for lateral load consideraions, would still be ok for vertical. | |

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| **TTL Project No.:** | **2065201** |
| **Project:** | **LUC-23-11.75** |
| **Calcs by:** | **CPI** |
| **Date:** | **5/10/2023, 6/26&29/2023** |
| | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp D over Ottawa River** |
| **Substructure:** | **Pier 2** |
| | |
| Boring(s): | B-022-3-21 |
| Ground Surface Elevation (ft): | 616.0 |
| Bottom of Pier Cap Elev (ft): | 605.14 |
| Top of Rock Elevation (ft): | 610 |
| Length of Shaft in Soil (ft): | 0 |
| Shaft in Soil Diameter (in): | 36 |
| *(Minimum 42" for Pier Columns, and 36" for others.)* | |
| *Using footing instead of columns* | |
| Shaft in Rock Diameter (in): | 30 |
| Shaft in Rock Diameter (ft): | 2.5 |
| End-Bearing at 1.5 x B | |
| Length of Socket (ft): | 3.75 |
| Note, Length below pier cap, not top of rock. | |
| | |
| May increase Shaft in soil to 3.5 ft and socket to 3 ft diameter for lateral resistance | |
| Shaft in Rock Diameter (ft): | 3 |
| In this case, 1.5 x B | |
| Length of Socket (ft): | 4.5 |
| Note, Length below pier cap, not top of rock. | |
| | |
| BDM 305.4.4.4, minimum 5' socket if rock within 10 ft of ground surface or bottom of shaft cap. | |
| As noted above, shaft in soil (ft): | 0 |
| Governing Length of Socket (ft): | 5 |
| Note, Length below pier cap, not top of rock. | |
| End-Bearing Elev. (ft): | 600.14 |
| | |
| **Structural indicates Scour to Elev:** | **605.67** |
| BDM 305.4.1.1, for end-bearing shafts/sockets in non-scour resistant bedrock, | |
| extend socket to penetrate a minimum of 10 feet below scour elevation. | |
| Therefore, end-bearing elevation is 10 ft below scour elevation. | |
| End-Bearing Elev. (ft): | 595.67 |
| This is deeper than that determined with the 5 ft below top of rock requirement. | |
| **End-Bearing Elev. (ft):** | **595.67** |
| **Calculated Socket Length (ft):** | **9.47** |
| | |

| | |
|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp D over Ottawa River** |
| **Substructure:** | **Pier 2** |
| | |
| Look at RC Qu at bearing to | |
| 2B below bearing: | |
| 2B below bearing Elev.: | 589.67 |
| Qu (psi): | 23820 |
| | 23930 |
| | |
| Use Average Qu (psi): | 23875 |
| Average Qu (ksf): | 3438 |
| | |
| End-Bearing Resistance (AASHTO LRFD 10.8.3.5.4c-1) | |
| qp=2.5qu | |
| **(Unfactored) qp (ksf):** | **8595** |
| Resistance Factor (AASHTO LRFD Table 10.5.5.2.4-1) | |
| $\phi$= | 0.5 |
| Factored Bearing Resistance (ksf)= | 4298 |
| **Say, Factored Bearing Resistance (ksf)=** | **4295** |
| For 2.5 ft diameter socket, | |
| Available Resistance (kips)= | 21083 |
| For 4 Shafts in Footing, | |
| Indicated Total Factored Load (kips)= | 464.72 |
| **Suitable Vertical Resistance?** | **YES** |
| For 3 ft diameter socket, | |
| Available Resistance (kips)= | 30360 |
| For consideration of 3.5 ft dia shaft continued without 6" reduction, | |
| Available Resistance (kips)= | 41323 |
| | |
| Compressive strength of rock is higher as extend deeper. If this is suitable for | |
| vertical load, then we are ok should shafts extend deeper for lateral load considerations | |

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|---|---|
| **TTL Project No.:** | **2065201** |
| **Project:** | **LUC-23-11.75** |
| **Calcs by:** | **CPI** |
| **Date:** | **5/10/2023, 6/26&29/2023** |
| | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp D over Ottawa River** |
| **Substructure:** | **Forward Abutment** |
| | |
| Boring(s): | B-023-0-21 |
| Ground Surface Elevation (ft): | 624.2 |
| Bottom of Pier Cap Elev (ft): | 614.0 |
| Top of Rock Elevation (ft): | 608.2 |
| Length of Shaft in Soil (ft): | 5.8 |
| Shaft in Soil Diameter (in): | 36 |
| *(Minimum 42" for Pier Columns, and 36" for others.)* | |
| | |
| Shaft in Rock Diameter (in): | 30 |
| Shaft in Rock Diameter (ft): | 2.5 |
| End-Bearing at 1.5 x B | |
| Length of Socket (ft): | 3.75 |
| May increase Shaft in soil to 3.5 ft and socket to 3 ft diameter for lateral resistance | |
| Shaft in Rock Diameter (ft): | 3 |
| In this case, 1.5 x B | |
| Length of Socket (ft): | 4.5 |
| BDM 305.4.4.4, minimum 5' socket if rock within 10 ft of ground surface or bottom of shaft cap. | |
| As noted above, shaft in soil (ft): | 5.8 |
| Governing Length of Socket (ft): | 5 |
| End-Bearing Elev. (ft): | 603.2 |
| | |
| **Structural indicates Scour to Elev:** | **604.42** |
| BDM 305.4.1.1, for end-bearing shafts/sockets in non-scour resistant bedrock, | |
| extend socket to penetrate a minimum of 10 feet below scour elevation. | |
| Therefore, end-bearing elevation is 10 ft below scour elevation. | |
| End-Bearing Elev. (ft): | 594.42 |
| This is deeper than that determined with the 5 ft below top of rock requirement. | |
| **End-Bearing Elev. (ft):** | **594.42** |
| **Calculated Socket Length (ft):** | **13.78** |
| | |

| | |
|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp D over Ottawa River** |
| **Substructure:** | **Forward Abutment** |
| | |
| Look at RC Qu at bearing to | |
| 2B below bearing: | |
| 2B below bearing Elev.: | 588.42 |
| Qu (psi): | 15160 |
| | |
| | |
| Use Average Qu (psi): | 15160 |
| Average Qu (ksf): | 2183 |
| | |
| End-Bearing Resistance (AASHTO LRFD 10.8.3.5.4c-1) | |
| qp=2.5qu | |
| **(Unfactored) qp (ksf):** | **5458** |
| Resistance Factor (AASHTO LRFD Table 10.5.5.2.4-1) | |
| $\phi$= | 0.5 |
| Factored Bearing Resistance (ksf)= | 2729 |
| **Say, Factored Bearing Resistance (ksf)=** | **2725** |
| For 2.5 ft diameter socket, | |
| Available Resistance (kips)= | 13376 |
| For 4 shafts in substructure, | |
| Indicated Total Factored Load (kips)= | 290.03 |
| **Suitable Vertical Resistance?** | **YES** |
| For 3 ft diameter socket, | |
| Available Resistance (kips)= | 19262 |
| For consideration of 3.5 ft dia shaft continued without 6" reduction, | |
| Available Resistance (kips)= | 26218 |
| | |
| This analysis incorporates deepest rock cored for this location. | |
| If need to extend deeper for lateral load considerations, would also be ok for vertical. | |
| | |

| | |
|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Vertical Resistance** |
| **Location:** | **Ramp D over Ottawa River** |
| **Substructure:** | **Forward Abutment** |
| | |
| Note there is downdrag at this location. | |
| Per settlement calc sheet, | |
| Top downdrag Elev / Footing Elev: | 614.0 |
| Elev of 0.4" settlement below to | |
| top of rock is Elev: | 611 |
| Downdrag Length of Shaft (ft) | 3 |
| For zone from Elev. | 614.0 |
| to Elev. | 613.2 |
| Length (ft): | 0.8 |
| Adhesion (ksf): | 0.62 |
| For zone from Elev. | 613.2 |
| to Elev. | 611 |
| Length (ft): | 2.2 |
| Adhesion (ksf): | 1.3 |
| For 3.5 ft shaft in soil, | |
| Upper zone unfactored DD (kips)= | 5.5 |
| Lower zone unfactored DD (kips)= | 31 |
| Total unfactored DD (kips)= | 37 |
| For factored DD, still pleanty of resistance available. | |
| If load is carried by additional shafts, should lateral loading govern, | |
| there would be even less vertical load and vertical resistance would be suitable. | |
| | |
| Use other methods to avoid downdrag on footing and abutment walls. | |

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|---|---|---|---|---|---|---|---|---|
| **TTL Project No.:** | **2065201** | | | | | | | |
| **Project:** | **LUC-23-11.75** | | | | | | | |
| **Calcs by:** | **CPI** | | | | | | | |
| **Date:** | **6/21/2023 & 6/26/2023** | | | | | | | |
| | | | | | | | | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | |
| **Location:** | **Ramp D over Ottawa River** | | | | | | | |
| **Substructure:** | **Rear Abutment** | | | | | | | |
| | | | | | | | | |
| Boring(s): | B-022-0-21 | | | | | | | |
| GSE (ft): | 615.1 | | | | | | | |
| Long-Term GWT (ft): | 612 | Approx. Normal River Elev. | | | | | | |
| Bottom of Pier Cap Elev. (ft): | 612.5 | | | | | | | |
| | | | | | | | | |
| **Soil** | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 1** | **Medium Stiff A-6a** | 0 | 3.5 | 615.1 | 611.6 | 5 | 1.00 | - |
| | **Depth below bottom of Pier Cap:** | | | -2.6 | 0.9 | | | |
| **Total Unit Wt (pcf):** | 118 | GDM Table 400-4 | | **Use** | **120** | **pcf** | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | |
| Su via N60 (ksf)= | 0.625 | | | | | | | |
| Su via HP (ksf)= | 1.00 | | | | | | | |
| **Su (ksf)=** | **1.0** | | | | | | | |
| | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | |
| **Su = 1-2 ksf, epsilon 50 =** | **0.007** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 2** | **Medium Dense A-2-4** | 3.5 | 6 | 611.6 | 609.1 | 26 | - | - |
| | **Depth below bottom of Pier Cap:** | | | 0.9 | 3.4 | | | |
| **Total Unit Wt (pcf):** | 128 | GDM Table 400-4 | | **Use** | **125** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 4.75 | ft | | | | | | |
| sigma-v' (ksf): | 0.47 | | | | | | | |
| CN= | 1.5 | <2.0, use | 1.5 | | | | | |
| N160 (bpf)= | 39 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 30 | 37.5 | | | | | | | |
| 50 | 40.5 | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 39 | 38.79 | use | 39 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-2-4 | +0.5 | | | | | | | |
| **Phi (deg) =** | **39.5** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Medium Dense, Submerged | | | | | | | |
| Range of k-value (pci) = | 8.0 - 27.0 | | | | | | | |
| Med Dense range of N60 | k (pci) | | | | | | | |
| 11 | 8 | | | | | | | |
| 30 | 27 | | | | | | | |
| Interpolate for 26 bpf for this layer: | 23 | | | | | | | |
| **Say k (pci) =** | **23** | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| **Location:** | **Ramp D over Ottawa River** | | | | | | | | | |
| **Substructure:** | **Rear Abutment** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** | | |
| **Layer 3** | **Very Dense A-3a** | 6 | 8 | 609.1 | 607.1 | 50/6" | - | - | | |
| | | | **Depth below bottom of Pier Cap:** | 3.4 | 5.4 | | | | | |
| **Total Unit Wt (pcf):** | 140 | GDM Table 400-4 | | **Use** | **140** | **pcf** | | | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | | | |
| CN at | 7 | ft | | | | | | | | |
| sigma-v' (ksf): | 0.63 | | | | | | | | | |
| CN= | 1.4 | <2.0, use | 1.4 | | | | | | | |
| N160 (bpf)= | >50 (max in Table 10.4.6.2.4-1 | | | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | | | |
| 50 | 40.5 | use | 40.5 | deg | | | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | | | |
| A-3a | -0.5 | | | | | | | | | |
| **Phi (deg) =** | **40** | | | | | | | | | |
| | | | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | | | |
| Parameters: | Very Dense, Submerged | | | | | | | | | |
| Range of k-value (pci) = | 32.0 - 64.0 | | | | | | | | | |
| Dense range of N60 | k (pci) | | | | | | | | | |
| 31 | 32 | | | | | | | | | |
| 50 | 64 | | | | | | | | | |
| Interpolate for 50/6" bpf for this layer: | 64 | | | | | | | | | |
| **Say k (pci) =** | **64** | | | | | | | | | |
| | | | | | | | | | | |
| **Cored Bedrock** | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 4** | **Dolomite - Moderately Strong** | 8 | 10.3 | 607.1 | 604.8 | 29 | 100 | No Test | | |
| | **Highly Frac. To Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 5.4 | 7.7 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **6250** | Based on test result for underlying moderately strong layer. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **450000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at <u>450,000</u> psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 3125 | psi | | | | | | | | |
| krm = 1% x (<u>3125</u> psi / <u>450,000</u> psi) = | 0.0069 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000069** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 5** | **Dolomite - Moderately Strong** | 10.3 | 16.5 | 604.8 | 598.6 | 42 | 78 | 6250 | 159 | at 12.3' |
| | **Highly Frac. To Mod Frac.** | | | | | | | 13790 | 159 | at 14.5' |
| | | | **Depth below bottom of Pier Cap:** | 7.7 | 13.9 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 159 | Average of tested values in this zone | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **10020** | Average of tested values in this zone | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at <u>900,000</u> psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 5010 | psi | | | | | | | | |
| krm = 1% x (<u>5010</u> psi / <u>900,000</u> psi) = | 0.0056 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000056** | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| **Location:** | **Ramp D over Ottawa River** | | | | | | | | | |
| **Substructure:** | **Rear Abutment** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 6** | **Dolomite - Strong** | 16.5 | 18 | 598.6 | 597.1 | 24 | 69 | No Test | | |
| | **Highly Frac. To Mod Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 13.9 | 15.4 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **10020** | Value used for layer above. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 900,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 5010 | psi | | | | | | | | |
| krm = 1% x (5010 psi / 900,000 psi) = | 0.0056 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000056** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 7** | **Dolomite - Strong** | 18 | 19.2 | 597.1 | 595.9 | 0 | 100 | No Test | | |
| | **Highly Frac. To Mod Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 15.4 | 16.6 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **10020** | Value used for layer above. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 900,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 5010 | psi | | | | | | | | |
| krm = 1% x (5010 psi / 900,000 psi) = | 0.0056 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000056** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 8** | **Dolomite - Strong** | 19.2 | 21 | 595.9 | 594.1 | 0 | 100 | No Test | | |
| | **Highly Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 16.6 | 18.4 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **10020** | Value used for layer above. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 900,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 5010 | psi | | | | | | | | |
| krm = 1% x (5010 psi / 900,000 psi) = | 0.0056 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000056** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 9** | **Dolomite - Very Strong** | 21 | 28 | 594.1 | 587.1 | 31 | 93 | 15030 | 164 | at 21' |
| | **Highly Frac. To Mod Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 18.4 | 25.4 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 164 | Tested value in this zone | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **15030** | Tested value in this zone | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 7515 | psi | | | | | | | | |
| krm = 1% x (7515 psi / 1,400,000 psi) = | 0.0054 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000054** | | | | | | | | | |
| | | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TTL Project No.:** | **2065201** | | | | | | | |
| **Project:** | **LUC-23-11.75** | | | | | | | |
| **Calcs by:** | **CPI** | | | | | | | |
| **Date:** | **6/21/2023 & 6/26/23** | | | | | | | |
| | | | | | | | | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | |
| **Location:** | **Ramp D over Ottawa River** | | | | | | | |
| **Substructure:** | **Pier 1** | | | | | | | |
| | | | | | | | | |
| Boring(s): | B-022-1-21 | | | | | | | |
| GSE (ft): | 616.1 | | | | | | | |
| Long-Term GWT (ft): | 612 | Approx. Normal River Elev. | | | | | | |
| Bottom of Pier Cap Elev. (ft): | 610.79 | | | | | | | |
| | | | | | | | | |
| **Soil** | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 1** | **Stiff A-4a** | 0 | 4.5 | 616.1 | 611.6 | 14 | - | - |
| | | | **Depth below bottom of Pier Cap:** | -5.31 | -0.81 | | | |
| **Total Unit Wt (pcf):** | 122 | GDM Table 400-4 | | **Use** | **120** | **pcf** | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | |
| **Su (ksf)=** | **1.75** | | | | | | | |
| | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | |
| **Su = 1-2 ksf, epsilon 50 =** | **0.007** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 2** | **Medium Stiff A-4a** | 4.5 | 6 | 611.6 | 610.1 | 8 | - | - |
| | | | **Depth below bottom of Pier Cap:** | -0.81 | 0.69 | | | |
| **Total Unit Wt (pcf):** | 118 | GDM Table 400-4 | | **Use** | **120** | **pcf** | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | Based on soil type and Unit Wt for A-4a above. | | | | |
| Say Su (ksf)= | 1.0 | | | | | | | |
| | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | |
| **Su = 1-2 ksf, epsilon 50 =** | **0.007** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 3** | **Loose A-3a** | 6 | 7 | 610.1 | 609.1 | 9 | - | - |
| | | | **Depth below bottom of Pier Cap:** | 0.69 | 1.69 | | | |
| **Total Unit Wt (pcf):** | 122 | GDM Table 400-4 | | **Use** | **120** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 6.5 | ft | | | | | | |
| sigma-v' (ksf): | 0.66 | | | | | | | |
| CN= | 1.4 | <2.0, use | 1.4 | | | | | |
| N160 (bpf)= | 12 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 10 | 32.5 | | | | | | | |
| 30 | 37.5 | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 12 | 33.1 | use | 33 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-3a | -0.5 | | | | | | | |
| **Phi (deg) =** | **32.5** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Loose, submerged | | | | | | | |
| Range of k-value (pci) = | 2.1 - 6.4 | | | | | | | |
| Loose range of N60 | k (pci) | | | | | | | |
| 5 | 2.1 | | | | | | | |
| 10 | 6.4 | | | | | | | |
| Interpolate for 9 bpf for this layer: | 5.5 | | | | | | | |
| **Say k (pci) =** | **5** | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Calcs: | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| Location: | **Ramp D over Ottawa River** | | | | | | | | | |
| Substructure: | **Pier 1** | | | | | | | | | |

**Augerable Weathered Bedrock**

| Layer | Rock Type | Top Depth (ft) | Bottom Depth (ft) | Top Elev. (ft) | Bottom Elev. (ft) | SPT Result |
|---|---|---|---|---|---|---|
| **Layer 4** | **Weathered Dolomite** | 7 | 8.6 | 609.1 | 607.5 | 50/3" |
| | | **Depth below bottom of Pier Cap:** | | 1.69 | 3.29 | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** |
| | 162 | Average of Tested Values for the project. | | | | |

Qu based on SPT Results per GDM 404.3

Qu (ksf)=0.092x(Nrate)90 (bpf)

| | | |
|---|---|---|
| ER(%)= | 90 | |
| N90=50/3" x 12" = | 200 | bpf |
| N90 = 90/90 x 200 bpf = | 200 | bpf |
| Qu (ksf) = | 18.4 | |
| Qu (psi) = | 127.8 | |

Estimate E based on GDM Table 400-6

Lowest Qu = 200 psi, indicated as E = 18,000 psi

**Use E (psi) = 18000**

If Strain at 18,000 psi is 1%, then strain at half max stress (krm) is calculated by:

| | | |
|---|---|---|
| Half max stress = Qu/2 = | 63.9 | psi |
| krm = 1% x (63.9 psi / 18,000 psi) = | 0.0035 | % |
| **krm (decimal format) =** | **0.000035** | |

**Bedrock**

| Layer | Soil Type | Top Depth (ft) | Bottom Depth (ft) | Top Elev. (ft) | Bottom Elev. (ft) | RQD (%) | Rec (%) | Qu (psi) | Total Unit Wt (pcf) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Layer 5** | **Dolomite - Very Strong** | 8.6 | 18.5 | 607.5 | 597.6 | 17 | 78 | 15630 | 163 | at 11.8 ft |
| | **Highly Frac. To Frac.** | | | | | | | 22920 | 161 | at 13.8 ft |
| | | **Depth below bottom of Pier Cap:** | | 3.29 | 13.19 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of tested values within zone. | | | | | | | | |

| | | |
|---|---|---|
| **Qu (psi)=** | **19275** | Similar depth below top of rock from nearby B-028-2-21, and Strong |
| **From GDM Table 400-6, say E (psi) =** | **1,400,000** | |

If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by:

| | | |
|---|---|---|
| Half max stress = Qu/2 = | 9638 | psi |
| krm = 1% x (9638 psi / 1,400,000 psi) = | 0.0069 | % |
| **krm (decimal format) =** | **0.000069** | |

| Layer | Soil Type | Top Depth (ft) | Bottom Depth (ft) | Top Elev. (ft) | Bottom Elev. (ft) | RQD (%) | Rec (%) | Qu (psi) | Total Unit Wt (pcf) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Layer 6** | **Dolomite - Moderately Strong** | 18.5 | 23.6 | 597.6 | 592.5 | 12 | 80 | 7350 | 161 | at 18.6 ft |
| | **Highly Frac. To Frac.** | | | | | | | | | |
| | | **Depth below bottom of Pier Cap:** | | 13.19 | 18.29 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 161 | Tested value within zone. | | | | | | | | |

| | | |
|---|---|---|
| **Qu (psi)=** | **7350** | Tested value within zone. |
| **From GDM Table 400-6, say E (psi) =** | **680000** | |

If Strain at 680,000 psi is 1%, then strain at half max stress (krm) is calculated by:

| | | |
|---|---|---|
| Half max stress = Qu/2 = | 3675 | psi |
| krm = 1% x (3,675 psi / 680,000 psi) = | 0.0054 | % |
| **krm (decimal format) =** | **0.000054** | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| **Location:** | **Ramp D over Ottawa River** | | | | | | | | | |
| **Substructure:** | **Pier 1** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 7** | **Dolomite - Very Strong** | 23.6 | 28.6 | 592.5 | 587.5 | 22 | 100 | 16420 | 166 | at 23.6 ft |
| | **Frac. To Moderately Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 18.29 | 23.29 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **165** | **pcf** | | | | |
| | 166 | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **16420** | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 8210 | psi | | | | | | | | |
| krm = 1% x (8,210 psi / 1,400,000 psi) = | 0.0059 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000059** | | | | | | | | | |
| | | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TTL Project No.: | 2065201 | | | | | | | |
| Project: | LUC-23-11.75 | | | | | | | |
| Calcs by: | CPI | | | | | | | |
| Date: | 6/21/2023 &6/26/2023 | | | | | | | |
| Calcs: | Drilled Shaft Rock Sockets - Lateral Resistance | | | | | | | |
| Location: | Ramp D over Ottawa River | | | | | | | |
| Substructure: | Pier 2 | | | | | | | |
| Boring(s): | B-022-2-21 & B-022-3-21 | | | | | | | |
| GSE (ft): | 616.0 | | | | | | | |
| Long-Term GWT (ft): | 612 | Approx. Normal River Elev. | | | | | | |
| Bottom of Pier Cap Elev. (ft): | 605.14 | | | | | | | |

**Soil**

| Layer | Soil Type | Top Depth (ft) | Bottom Depth (ft) | Top Elev. (ft) | Bottom Elev. (ft) | N60 | HP (tsf) | Qu (tsf) |
|---|---|---|---|---|---|---|---|---|
| Layer 1 | Very Stiff A-4a | 0 | 6 | 616 | 610 | 17 | - | - |
| | | Depth below bottom of Pier Cap: | | -10.86 | -4.86 | | | |
| Total Unit Wt (pcf): | 122 | GDM Table 400-4 | | Use | 120 | pcf | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | |
| Su (ksf)= | 2.125 | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manua | | | | | | | | |
| Su = 2-4 ksf, epsilon 50 = | 0.005 | | | | | | | |

**Augerable Weathered Bedrock**

| Layer | Rock Type | Top Depth (ft) | Bottom Depth (ft) | Top Elev. (ft) | Bottom Elev. (ft) | SPT Result |
|---|---|---|---|---|---|---|
| Layer 2 | Weathered Dolomite | 6 | 8.5 | 610 | 607.5 | 50/4" |
| | | Depth below bottom of Pier Cap: | | -4.86 | -2.36 | |
| Total Unit Wt (pcf): | 165-175 | GDM Table 400-5 | | Use | 160 | pcf |
| | 162 | Average of Tested Values for the project. | | | | |
| Qu based on SPT Results per GDM 404.3 | | | | | | |
| Qu (ksf)=0.092x(Nrate)90 (bpf) | | | | | | |
| ER(%)= | 90 | | | | | |
| N90=50/4" x 12" = | 150 | bpf | | | | |
| N90 = 90/90 x 150 bpf = | 150 | bpf | | | | |
| Qu (ksf) = | 13.8 | | | | | |
| Qu (psi) = | 95.8 | | | | | |
| Estimate E based on GDM Table 400-6 | | | | | | |
| Lowest Qu = 200 psi, indicated as E = 18,000 ps | | | | | | |
| Use E (psi) = | 18000 | | | | | |
| If Strain at 18,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | |
| Half max stress = Qu/2 = | 47.9 | psi | | | | |
| krm = 1% x (47.9 psi / 18,000 psi) = | 0.0027 | % | | | | |
| krm (decimal format) = | 0.000027 | | | | | |

| Layer | Rock Type | Top Depth (ft) | Bottom Depth (ft) | Top Elev. (ft) | Bottom Elev. (ft) | SPT Result |
|---|---|---|---|---|---|---|
| Layer 3 | Weathered Dolomite | 8.5 | 9.3 | 607.5 | 606.7 | 50/2" |
| | | Depth below bottom of Pier Cap: | | -2.36 | -1.56 | |
| Total Unit Wt (pcf): | 165-175 | GDM Table 400-5 | | Use | 160 | pcf |
| | 162 | Average of Tested Values for the project. | | | | |
| Qu based on SPT Results per GDM 404.3 | | | | | | |
| Qu (ksf)=0.092x(Nrate)90 (bpf) | | | | | | |
| ER(%)= | 90 | | | | | |
| N90=50/2" x 12" = | 300 | bpf | | | | |
| N90 = 90/90 x 300 bpf = | 300 | bpf | | | | |
| Qu (ksf) = | 27.6 | | | | | |
| Qu (psi) = | 191.7 | | | | | |
| Estimate E based on GDM Table 400-6 | | | | | | |
| Lowest Qu = 200 psi, indicated as E = 18,000 ps | | | | | | |
| Use E (psi) = | 18000 | | | | | |
| If Strain at 18,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | |
| Half max stress = Qu/2 = | 95.8 | psi | | | | |
| krm = 1% x (95.8 psi / 18,000 psi) = | 0.0053 | % | | | | |
| krm (decimal format) = | 0.000053 | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Calcs: | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| Location: | **Ramp D over Ottawa River** | | | | | | | | | |
| Substructure: | **Pier 2** | | | | | | | | | |
| | | | | | | | | | | |
| **Bedrock** | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 4** | **Dolomite - Very Strong** | 9.3 | 14.3 | 606.7 | 601.7 | 45 | 100 | 17840 | 159 | at 13.4 ft |
| | **Frac. To Moderately Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | -1.56 | 3.44 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 159 | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **17840** | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1,400,000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 8920 | psi | | | | | | | | |
| krm = 1% x (8920 psi / 1,400,000 psi) = | 0.0064 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000064** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 5** | **Dolomite - Strong** | 14.3 | 19.3 | 601.7 | 596.7 | 0 | 33 | - | | |
| | **Highly Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 3.44 | 8.44 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **17840** | Tested Value for Layer above. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1400000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 8920 | psi | | | | | | | | |
| krm = 1% x (8,920 psi / 1,400,000 psi) = | 0.0064 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000064** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 6** | **Dolomite - Very Strong** | 19.3 | 23.2 | 596.7 | 592.8 | 65 | 100 | 23820 | 164 | at 19.3 ft |
| | **Frac. To Moderately Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 8.44 | 12.34 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **165** | **pcf** | | | | |
| | 164 | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **23820** | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1800000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,800,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 11910 | psi | | | | | | | | |
| krm = 1% x (11,920 psi / 1,800,000 psi) = | 0.0066 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000066** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 7** | **Dolomite - Very Strong** | 23.2 | 26.3 | 592.8 | 589.7 | 18 | 100 | 23930 | 165 | at 24.3 ft |
| | **Highly Frac. To Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 12.34 | 15.44 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **165** | **pcf** | | | | |
| | 165 | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **23930** | Tested value within zone. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1800000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,800,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 11965 | psi | | | | | | | | |
| krm = 1% x (11,965 psi / 1,800,000 psi) = | 0.0066 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000066** | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | |
| **Location:** | **Ramp D over Ottawa River** | | | | | | | |
| **Substructure:** | **Pier 2** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** |
| **Layer 8** | **Dolomite - Very Strong** | 26.3 | 29.3 | 589.7 | 586.7 | 36 | 67 | - |
| | **Frac. To Moderately Frac.** | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 15.44 | 18.44 | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **165** | **pcf** | | |
| | 162 | Average of Tested Values for the project. | | | | | | |
| | | | | | | | | |
| **Qu (psi)=** | **23930** | Tested value from layer above. | | | | | | |
| | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1800000** | | | | | | | |
| | | | | | | | | |
| If Strain at 1,800,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | |
| Half max stress = Qu/2 = | 11965 | psi | | | | | | |
| krm = 1% x (11,965 psi / 1,800,000 psi) = | 0.0066 | % | | | | | | |
| **krm (decimal format) =** | **0.000066** | | | | | | | |
| | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TTL Project No.:** | **2065201** | | | | | | | |
| **Project:** | **LUC-23-11.75** | | | | | | | |
| **Calcs by:** | **CPI** | | | | | | | |
| **Date:** | **6/21/2023 & 6/26/2023** | | | | | | | |
| | | | | | | | | |
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | |
| **Location:** | **Ramp D over Ottawa River** | | | | | | | |
| **Substructure:** | **Forward Abutment** | | | | | | | |
| | | | | | | | | |
| Boring(s): | B-023-0-21 | | | | | | | |
| GSE (ft): | 624.2 | | | | | | | |
| Long-Term GWT (ft): | 612 | Approx. Normal River Elev. | | | | | | |
| Bottom of Pier Cap Elev. (ft): | 614.0 | | | | | | | |
| | | | | | | | | |
| **Soil** | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 1** | **Medium Dense A-2-4** | 0 | 3.5 | 624.2 | 620.7 | 12 | - | - |
| | **Depth below bottom of Pier Cap:** | | | -10.2 | -6.7 | | | |
| **Total Unit Wt (pcf):** | 122 | GDM Table 400-4 | | **Use** | **120** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 1.75 | ft | | | | | | |
| sigma-v' (ksf): | 0.21 | | | | | | | |
| CN= | 1.8 | <2.0, use | 1.8 | | | | | |
| N160 (bpf)= | 21 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 10 | 32.5 | | | | | | | |
| 30 | 37.5 | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 21 | 35.3 | use | 35 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-2-4 | +0.5 | | | | | | | |
| **Phi (deg) =** | **35.5** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Medium Dense, Dry or Moist | | | | | | | |
| Range of k-value (pci) = | 13.0 - 40.0 | | | | | | | |
| Med Dense range of N60 | k (pci) | | | | | | | |
| 11 | 13 | | | | | | | |
| 30 | 40 | | | | | | | |
| Interpolate for 12 bpf for this layer: | 14 | | | | | | | |
| **Say k (pci) =** | **14** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **Avg. N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 2** | **Medium Dense A-3a** | 3.5 | 8 | 620.7 | 616.2 | 15 | - | - |
| | **Depth below bottom of Pier Cap:** | | | -6.7 | -2.2 | | | |
| **Total Unit Wt (pcf):** | 125 | GDM Table 400-4 | | **Use** | **125** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 5.75 | ft | | | | | | |
| sigma-v' (ksf): | 0.70 | | | | | | | |
| CN= | 1.4 | <2.0, use | 1.4 | | | | | |
| N160 (bpf)= | 20 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 10 | 32.5 | | | | | | | |
| 30 | 37.5 | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 20 | 35.1 | use | 35 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-3a | -0.5 | | | | | | | |
| **Phi (deg) =** | **34.5** | | | | | | | |
| | | | | | | | | |
| k Evaluation From LPILE 2018 Technical Manual | | | | | | | | |
| Parameters: | Medium Dense, Dry to Moist | | | | | | | |
| Range of k-value (pci) = | 13.0 - 40.0 | | | | | | | |
| Dense range of N60 | k (pci) | | | | | | | |
| 11 | 13 | | | | | | | |
| 30 | 40 | | | | | | | |
| Interpolate for 15 bpf for this layer: | 19 | | | | | | | |
| **Say k (pci) =** | **19** | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| **Location:** | **Ramp D over Ottawa River** | | | | | | | | | |
| **Substructure:** | **Forward Abutment** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** | | |
| **Layer 3** | **Medium Stiff A-6b w/Peat** | 8 | 11 | 616.2 | 613.2 | 6 | 0.75 | - | | |
| | | | **Depth below bottom of Pier Cap:** | -2.2 | 0.8 | | | | | |
| **Total Unit Wt (pcf):** | 115 | GDM Table 400-4 | | **Use** | **115** | **pcf** | | | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | | | |
| Su via N60 (ksf)= | 0.75 | | | | | | | | | |
| Su via HP (ksf)= | 0.75 | | | | | | | | | |
| **Su (ksf)=** | **0.75** | | | | | | | | | |
| | | | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | | | |
| **Medium Stiff, epsilon 50 =** | **0.010** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** | | |
| **Layer 4** | **Hard A-4a** | 11 | 16 | 613.2 | 608.2 | 36 | 4.25 | - | | |
| | | | **Depth below bottom of Pier Cap:** | 0.8 | 5.8 | | | | | |
| **Total Unit Wt (pcf):** | 130 | GDM Table 400-4 | | **Use** | **130** | **pcf** | | | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | | | |
| Su via N60 (ksf)= | 4.5 | | | | | | | | | |
| Su via HP (ksf)= | 4.25 | | | | | | | | | |
| **Su (ksf)=** | **4.25** | | | | | | | | | |
| | | | | | | | | | | |
| Evaluation of Strain at half stress (epsilon 50) from LPILE 2018 Technical Manual | | | | | | | | | | |
| **Su = 4-6 ksf, epsilon 50 =** | **0.004** | | | | | | | | | |
| | | | | | | | | | | |
| **Augerable Weathered Bedrock** | | | | | | | | | | |
| **Layer** | **Rock Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **SPT Result** | | | | |
| **Layer 5** | **Weathered Dolomite** | 16 | 16.5 | 608.2 | 607.7 | 50/1" | | | | |
| | | | **Depth below bottom of Pier Cap:** | 5.8 | 6.3 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| Qu based on SPT Results per GDM 404.3 | | | | | | | | | | |
| Qu (ksf)=0.092x(Nrate)90 (bpf) | | | | | | | | | | |
| ER(%)= | 90 | | | | | | | | | |
| N90=50/1" x 12" = | 600 | bpf | | | | | | | | |
| N90 = 90/90 x 600 bpf = | 600 | bpf | | | | | | | | |
| Qu (ksf) = | 55.2 | | | | | | | | | |
| Qu (psi) = | 383.3 | | | | | | | | | |
| | | | | | | | | | | |
| Estimate E based on GDM Table 400-6 | | | | | | | | | | |
| For Qu = 360 psi, indicated as E = 32,000 psi | | | | | | | | | | |
| **Use E (psi) =** | **32000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 32,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 191.7 | psi | | | | | | | | |
| krm = 1% x (191.7 psi / 32,000 psi) = | 0.0060 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000060** | | | | | | | | | |
| | | | | | | | | | | |
| **Cored Bedrock** | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 6** | **Dolomite - Very Strong to Strong** | 16.5 | 24.3 | 607.7 | 599.9 | 70 | 94 | 20850 | 162 | at 18.4' |
| | **Frac. To Moderately Frac.** | | | | | | | 12130 | 158 | at 23.2' |
| | | | **Depth below bottom of Pier Cap:** | 6.3 | 14.1 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 159 | Average of tested values in this zone | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **16490** | Average of tested values in this zone | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1,400,000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 8245 | psi | | | | | | | | |
| krm = 1% x (8245 psi / 1,400,000 psi) = | 0.0059 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000059** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 7** | **Dolomite - Strong** | 24.3 | 25.3 | 599.9 | 598.9 | 50 | 100 | - | | |
| | **Highly Frac. To Mod Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 14.1 | 15.1 | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Drilled Shaft Rock Sockets - Lateral Resistance** | | | | | | | | | |
| **Location:** | **Ramp D over Ottawa River** | | | | | | | | | |
| **Substructure:** | **Forward Abutment** | | | | | | | | | |
| | | | | | | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **12130** | Tested value at 23.2', just above this layer | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 900,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 6065 | psi | | | | | | | | |
| krm = 1% x (6065 psi / 900,000 psi) = | 0.0067 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000067** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | | |
| **Layer 8** | **Dolomite - Strong, Vuggy** | 25.3 | 29.5 | 598.9 | 594.7 | 24 | 69 | No Test | | |
| | **Highly Frac. To Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 15.1 | 19.3 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 162 | Average of Tested Values for the project. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **12130** | Value used for layer above. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **900000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 900,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 6065 | psi | | | | | | | | |
| krm = 1% x (6065 psi / 900,000 psi) = | 0.0067 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000067** | | | | | | | | | |
| | | | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **RQD (%)** | **Rec (%)** | **Qu (psi)** | **Total Unit Wt (pcf)** | |
| **Layer 9** | **Dolomite - Strong** | 29.5 | 36.5 | 594.7 | 587.7 | 15 | 87 | 15160 | 164 | at 33.3' |
| | **Frac. To Mod Frac.** | | | | | | | | | |
| | | | **Depth below bottom of Pier Cap:** | 19.3 | 26.3 | | | | | |
| **Total Unit Wt (pcf):** | 165-175 | GDM Table 400-5 | | **Use** | **160** | **pcf** | | | | |
| | 164 | Tested value for this layer. | | | | | | | | |
| | | | | | | | | | | |
| **Qu (psi)=** | **15160** | Tested value for this layer. | | | | | | | | |
| | | | | | | | | | | |
| **From GDM Table 400-6, say E (psi) =** | **1,400,000** | | | | | | | | | |
| | | | | | | | | | | |
| If Strain at 1,400,000 psi is 1%, then strain at half max stress (krm) is calculated by: | | | | | | | | | | |
| Half max stress = Qu/2 = | 7580 | psi | | | | | | | | |
| krm = 1% x (7580 psi / 1,400,000 psi) = | 0.0054 | % | | | | | | | | |
| **krm (decimal format) =** | **0.000054** | | | | | | | | | |

# APPENDIX E

## Ramp B Soil Nail Retaining Wall Evaluations

# SUBSURFACE DIAGRAM

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

At Max Sections, Toe/Ground @ 632 to 630
Top Wall = 642-640 ~10' Exposed Ht

* 2H:1V Slope Behind.

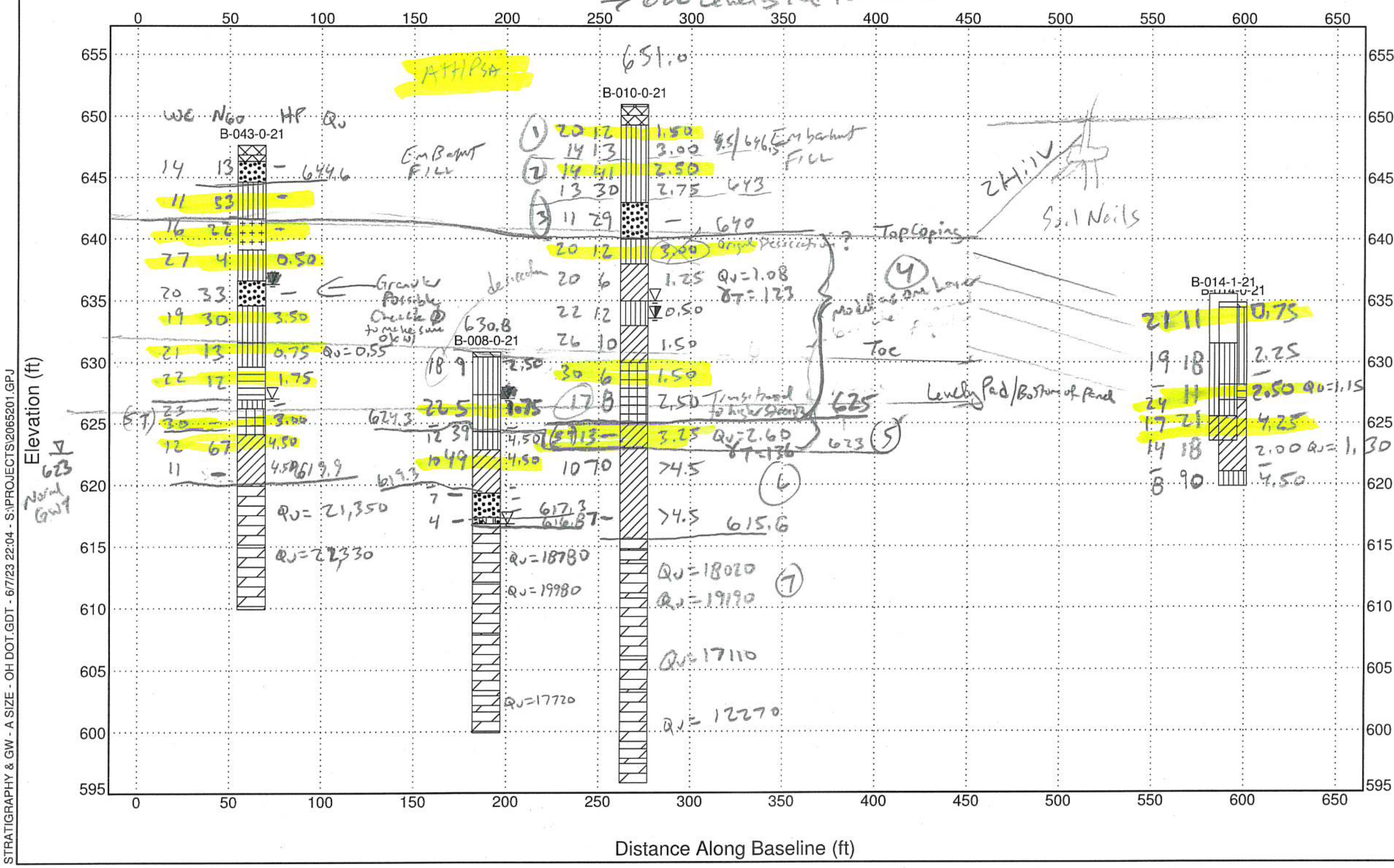
CLIENT ______

PROJECT NUMBER 105889

PROJECT NAME ______

PROJECT LOCATION N/A

~627 Perforated Pipe
→ 626 Leveling Pad For Conc Panel



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TTL Project No.:** | **2065201** | | | | | | | |
| **Project:** | **LUC-23-11.75** | | | | | | | |
| **Calcs by:** | **CPI** | | | | | | | |
| **Date:** | **6/7/2023** | | | | | | | |
| | | | | | | | | |
| **Calcs:** | **Ramp B Retaining Wall Design Soil Properties** | | | | | | | |
| **Location:** | **Ramp B Underpass of SR 51** | | | | | | | |
| | | | | | | | | |
| Boring(s): | B-010-0-21 (also reviewed B-008-0-21) | | | | | | | |
| GSE (ft): | 651.0 | | | | | | | |
| Long-Term GWT (ft): | 623 | | | | | | | |
| | | | | | | | | |
| **Soil generally above top of wall in 2H:1V slope back zone.** | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **Avg. N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 1** | **Stiff to Very Stiff A-4a** | 0 | 4.5 | 651 | 646.5 | 13 | 1.5 | - |
| | | | | | | | | |
| **Total Unit Wt (pcf):** | 120 | GDM Table 400-4 | | **Use** | **120** | **pcf** | | |
| | | | | | | | | |
| Su (ksf) from HP Results: | 1.5 | | | | | | | |
| | | | | | | | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | |
| Su (ksf)= | 1.6 | | | | | | | |
| | | | | | | | | |
| **Hand Pen or Qu values typically govern over estimation from N60.** | | | | | | | | |
| **Say Su (ksf) =** | **1.5** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **Avg. N60** | **Avg. HP (tsf)** | **Qu (tsf)** |
| **Layer 2** | **Very Stiff A-4a** | 4.5 | 8 | 646.5 | 643 | 36 | 2.63 | - |
| | | | | | | | | |
| **Total Unit Wt (pcf):** | 130 | GDM Table 400-4 | | **Use** | **130** | **pcf** | | |
| | | | | | | | | |
| Su (ksf) from HP Results: | 2.63 | | | | | | | |
| | | | | | | | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | |
| Su (ksf)= | 4.4 | | | | | | | |
| | | | | | | | | |
| **Hand Pen or Qu values typically govern over estimation from N60.** | | | | | | | | |
| **Say Su (ksf) =** | **2.6** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 3** | **Medium Dense A-3a** | 8 | 11 | 643 | 640 | 29 | - | - |
| | | | | | | | | |
| **Total Unit Wt (pcf):** | 128 | GDM Table 400-4 | | **Use** | **130** | **pcf** | | |
| **Internal Angle of Friction Determination (GDM 404.2):** | | | | | | | | |
| N160 (bpf)=CN*N60 | AASHTO LRFD 10.4.6.2.4 | | | | | | | |
| CN=0.77log(40/sigma-v'), with CN<2.0 | | | | | | | | |
| CN at | 9.5 | ft | | | | | | |
| sigma-v' (ksf): | 1.19 | | | | | | | |
| CN= | 1.2 | <2.0, use | 1.2 | | | | | |
| N160 (bpf)= | 34 | | | | | | | |
| AASHTO LRFD Table 10.4.6.2.4-1 | | | | | | | | |
| N160 | Mid-Range Phi (deg) | | | | | | | |
| 30 | 37.5 | | | | | | | |
| 50 | 40.5 | | | | | | | |
| N160 | Phi (deg) | | | | | | | |
| 34 | 38.1 | use | 38 | deg | | | | |
| GDM Table 400-3 phi Adjustment | | | | | | | | |
| A-3a | -0.5 | | | | | | | |
| **Phi (deg) =** | **37.5** | | | | | | | |
| | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Calcs:** | **Ramp B Retaining Wall Design Soil Properties** | | | | | | | |
| **Location:** | **Ramp B Underpass of SR 51** | | | | | | | |
| | | | | | | | | |
| Predominantly retained soil zone and extending below toe elevations. | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **Avg. N60** | **Avg. HP (tsf)** | **Qu (tsf)** |
| **Layer 4** | **Stiff to Very Stiff A-4a & A-6a** | 11 | 26 | 640 | 625 | 9 | 1.7 | 1.08 |
| **(Also consider B-008-0-21 from Elevs. 630.8 to 624.3)** | | | | | | | | |
| **Total Unit Wt (pcf):** | 118 | GDM Table 400-4 | | **Use** | **125** | **pcf** | | |
| **Tested ST Sample Total Unit Wt (pcf):** | 123 | | | | | | | |
| | | | | | | | | |
| Su (ksf) from Qu Results: | 1.08 | | | | | | | |
| | | | | | | | | |
| Su (ksf) from HP Results: | 1.7 | | | | | | | |
| | | | | | | | | |
| Su = N60 x 125 (N60<= 52 bpf) per GDM 404.1 | | | | | | | | |
| Su (ksf)= | 1.1 | | | | | | | |
| | | | | | | | | |
| **Hand Pen or Qu values typically govern over estimation from N60.** | | | | | | | | |
| **Use average of Su from Qu and HP. Note this is similar to, and slightly higher than, Su estimated using N60.** | | | | | | | | |
| **Say Su (ksf) =** | **1.4** | | | | | | | |
| | | | | | | | | |
| Soil generally below toe elevations. | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **Avg. N60** | **HP (tsf)** | **Qu (tsf)** |
| **Layer 5** | **Stiff to Very Stiff A-4a, A-6a, & A-7-6** | 26 | 28 | 625 | 623 | N/A ST | 3.25 | 2.60 |
| **(Also consider B-008-0-21 from Elevs. 630.8 to 624.3)** | | | | | | | | |
| **Tested ST Sample Total Unit Wt (pcf):** | 136 | | | **Use** | **135** | **pcf** | | |
| | | | | | | | | |
| Su (ksf) from Qu Results: | 2.60 | | | | | | | |
| | | | | | | | | |
| Su (ksf) from HP Results: | 3.25 | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Use average of Su from Qu and HP.** | | | | | | | | |
| **Say Su (ksf) =** | **2.9** | | | | | | | |
| | | | | | | | | |
| **Layer** | **Soil Type** | **Top Depth (ft)** | **Bottom Depth (ft)** | **Top Elev. (ft)** | **Bottom Elev. (ft)** | **Avg. N60** | **Avg. HP (tsf)** | **Qu (tsf)** |
| **Layer 6** | **Hard A-4a & A-6a** | 28 | 35.4 | 623 | 615.6 | 65 | 4.50 | - |
| **(Also consider B-008-0-21 from Elevs. 624.3 to 619.3)** | | | | | | | | |
| **Total Unit Wt (pcf):** | 140 | GDM Table 400-4 | | **Use** | **140** | **pcf** | | |
| | | | | | | | | |
| Su (ksf) from HP Results: | 4.50 | or greater with max of Hand Pen | | | | | | |
| | | | | | | | | |
| Su = f1 x N60 x pa/100 (N60> 52 bpf) per GDM 404.1 | | | | | | | | |
| pa(psf) is given as: | 2116.5 | | | | | | | |
| For PI of 12 for ST-12 in this zone, f1= | 5.5 | | | | | | | |
| Su (psf)= | 7508 | | | | | | | |
| Su (ksf)= | 7.5 | | | | | | | |
| | | | | | | | | |
| **With limitation of max of HP, use N60 estimation** | | | | | | | | |
| **Say Su (ksf) =** | **7.5** | | | | | | | |

# APPENDIX F

## Subgrade Evaluations
## (Including GB-1 Spreadsheet)

# OHIO DEPARTMENT OF TRANSPORTATION

## OFFICE OF GEOTECHNICAL ENGINEERING

## PLAN SUBGRADES
## Geotechnical Design Manual Section 600

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

**LUC-023-11.75**
**105889**

**US Route 23 at State Route 51 (Monroe St) Interchange Improvements, Sylvania, OH**

**TTL Associates, Inc.**

**Prepared By:** Christopher P. Iott, P.E.
**Date prepared:** Monday, May 1, 2023

Christopher P. Iott, P.E.
TTL Associates, Inc.
1915 N. 12th Street
Toledo, Ohio 43604
419-214-5020
ciott@ttlassoc.com

**NO. OF BORINGS:** 22

| # | Boring ID | Alignment | Station | Offset | Dir | Drill Rig | ER | Boring EL. | Proposed Subgrade EL | Cut Fill |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | B-001-0-21 | SR51 | | | | CME 75 Truck 844 \03 | 66 | 644.1 | 642.6 | 1.5 C |
| 2 | B-002-0-21 | Harroun Rd | | | | CME 75 Truck 844 \03 | 66 | 638.1 | 636.6 | 1.5 C |
| 3 | B-003-0-21 | SR51 | | | | CME 75 Truck 844 \04 | 72.9 | 641.7 | 640.2 | 1.5 C |
| 4 | B-004-0-21 | SR51 | | | | CME 75 Truck 844 \04 | 72.9 | 643.6 | 642.1 | 1.5 C |
| 5 | B-006-0-21 | SR51 | | | | CME 75 Truck 844 \03 | 66 | 650.9 | 650.4 | 0.5 C |
| 6 | B-010-0-21 | SR51 | | | | CME 75 Truck 844 \03 | 66 | 651 | 650.5 | 0.5 C |
| 7 | B-011-0-21 | SR51 | | | | CME 75 Truck 844 \04 | 72.9 | 648.1 | 647.6 | 0.5 C |
| 8 | B-012-0-21 | SR51 | | | | CME 75 Truck 844 \04 | 72.9 | 645.4 | 643.9 | 1.5 C |
| 9 | B-013-0-21 | SR51 | | | | CME 75 Truck 844 \04 | 72.9 | 643.3 | 641.8 | 1.5 C |
| 10 | B-014-0-21 | Ramp B | | | | CME 550x ATV \08 | 75.2 | 634.8 | 628.3 | 6.5 C |
| 11 | B-015-0-21 | SR51 | | | | CME 75 Truck 844 \03 | 66 | 648.2 | 646.7 | 1.5 C |
| 12 | B-016-0-21 | Glasgow Rd | | | | CME 75 Truck 844 \03 | 66 | 645.9 | 644.4 | 1.5 C |
| 13 | B-017-0-21 | Ramp C | | | | CME 75 Truck 844 \04 | 72.9 | 638 | 635.5 | 2.5 C |
| 14 | B-024-0-21 | Ramp D | | | | CME 75 Truck 844 \04 | 72.9 | 629.3 | 627.8 | 1.5 C |
| 15 | B-029-1-21 | Ramp A | | | | CME 75 Truck 844 \04 | 72.9 | 630.7 | 629.2 | 1.5 C |
| 16 | B-030-0-21 | Ramp A | | | | CME 75 Truck 844 \04 | 72.9 | 633.3 | 631.8 | 1.5 C |
| 17 | B-031-0-21 | SR184 | | | | CME 550x ATV \08 | 75.2 | 646.5 | 647.0 | 0.5 F |
| 18 | B-032-0-21 | SR184 | | | | CME 75 Truck 844 \03 | 66 | 645.3 | 643.8 | 1.5 C |
| 19 | B-033-0-21 | SR184 | | | | CME 75 Truck 844 \03 | 66 | 646.4 | 644.9 | 1.5 C |
| 20 | B-034-0-21 | Acres Rd | | | | CME 75 Truck 844 \03 | 66 | 649 | 647.5 | 1.5 C |
| 21 | B-040-0-21 | Ramp B | | | | CME 75 Truck 844 \04 | 72.9 | 641.1 | 639.6 | 1.5 C |
| 22 | B-041-0-21 | Ramp B | | | | CME 75 Truck 844 \04 | 72.9 | 646.8 | 645.3 | 1.5 C |

OHIO DEPARTMENT OF TRANSPORTATION

# Subgrade Analysis

V. 14.6 2/11/2022

| # | Boring | Sample | Sample Depth | | Subgrade Depth | | Standard Penetration | | HP (tsf) | Physical Characteristics | | | | | | Moisture | | Ohio DOT | | Sulfate Content (ppm) | Problem | | Excavate and Replace (Item 204) | | Recommendation (Enter depth in inches) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | From | To | From | To | $N_{60}$ | $N_{60L}$ | | LL | PL | PI | % Silt | % Clay | P200 | $M_C$ | $M_{OPT}$ | Class | GI | | Unsuitable | Unstable | Unsuitable | Unstable | |
| 1 | B | SS-1 | 1.6 | 2.5 | 0.1 | 1.0 | 21 | | 2 | 25 | 23 | 2 | 44 | 44 | 88 | 20 | 18 | A-4a | 8 | 350 | | | | | None |
| | 001-0 | SS-2 | 2.5 | 4.0 | 1.0 | 2.5 | 37 | | | | | | | | | 18 | 10 | A-4a | 8 | | | Mc | | | |
| | 21 | SS-3 | 4.0 | 5.3 | 2.5 | 3.8 | 37 | | 3.5 | 27 | 20 | 7 | 38 | 54 | 92 | 21 | 15 | A-4a | 8 | | | | | | |
| | | SS-4 | 5.3 | 7.2 | 3.8 | 5.7 | 22 | 21 | 2.5 | | | | | | | 20 | 14 | A-6a | 10 | | | | | | |
| 2 | B | SS-1 | 1.3 | 3.0 | -0.2 | 1.5 | 33 | | 1.5 | 27 | 24 | 3 | 44 | 44 | 88 | 21 | 19 | A-4a | 8 | | | HP | | 12" | 12" |
| | 002-0 | SS-2 | 3.0 | 4.0 | 1.5 | 2.5 | 30 | | 4.5 | 31 | 20 | 11 | 24 | 68 | 92 | 20 | 15 | A-6a | 8 | 310 | | Mc | | | 204 Geotextile |
| | 21 | SS-3 | 4.0 | 5.5 | 2.5 | 4.0 | 35 | | 4.5 | | | | | | | 14 | 14 | A-6a | 10 | | | | | | |
| | | SS-4 | 5.5 | 7.0 | 4.0 | 5.5 | 34 | 30 | 4.5 | | | | | | | 14 | 14 | A-6a | 10 | | | | | | |
| 3 | B | SS-1 | 1.3 | 3.0 | -0.2 | 1.5 | 29 | | | NP | NP | NP | 8 | 2 | 10 | 5 | 8 | A-3 | 0 | 100 | | | | | None |
| | 003-0 | SS-2A | 3.0 | 4.0 | 1.5 | 2.5 | 15 | | | | | | | | | | 8 | A-3 | 0 | | | | | | |
| | 21 | SS-2B | 4.0 | 4.5 | 2.5 | 3.0 | 15 | | 2.75 | 20 | 15 | 5 | 42 | 5 | 47 | 15 | 10 | A-4a | 2 | | | Mc | | | |
| | | SS-3/4A | 4.5 | 6.5 | 3.0 | 5.0 | 16 | 15 | | | | | | | | 18 | 8 | A-3a | 0 | | | | | | |
| 4 | B | SS-1 | 1.3 | 3.0 | -0.2 | 1.5 | 12 | | | NP | NP | NP | 19 | 2 | 21 | 10 | 8 | A-3a | 0 | | | | | | Recompact |
| | 004-0 | SS-2A | 3.0 | 4.0 | 1.5 | 2.5 | 30 | | | | | | | | | 10 | 8 | A-3a | 0 | | | | | | |
| | 21 | SS-2B | 4.0 | 4.5 | 2.5 | 3.0 | 30 | | 1.75 | 24 | 18 | 6 | 37 | 14 | 51 | 14 | 13 | A-4a | 3 | 290 | | | | | |
| | | SS-3 | 4.5 | 6.0 | 3.0 | 4.5 | 29 | 12 | 3 | 25 | 18 | 7 | 44 | 50 | 94 | 20 | 13 | A-4a | 8 | | | | | | |
| 5 | B | SS-1 | 1.8 | 3.0 | 1.3 | 2.5 | 15 | | 1 | | | | | | | 17 | 10 | A-4a | 8 | | | HP & Mc | | | None |
| | 006-0 | SS-2 | 3.0 | 4.5 | 2.5 | 4.0 | 14 | | 2 | 24 | 20 | 4 | 42 | 44 | 86 | 19 | 15 | A-4a | 8 | 320 | | | | | |
| | 21 | 6-1: SS-1 | 4.5 | 6.0 | 4.0 | 5.5 | 44 | | 2 | | | | | | | 15 | 10 | A-4a | 8 | | | | | | |
| | | 6-1: SS-2 | 6.0 | 8.0 | 5.5 | 7.5 | 23 | 14 | 3.5 | 25 | 21 | 4 | 44 | 47 | 91 | 16 | 16 | A-4a | | | | | | | |
| 6 | B | | 0.9 | 1.7 | 0.4 | 1.2 | | | | | | | | | | | 6 | A-1-b | 0 | | | | | | Recompact if need |
| | 010-0 | SS-1 | 1.7 | 3.0 | 1.2 | 2.5 | 12 | | 1.5 | 23 | 21 | 2 | 43 | 50 | 93 | 20 | 16 | A-4a | 8 | 320 | | HP & Mc | | | |
| | 21 | SS-2 | 3.0 | 4.5 | 2.5 | 4.0 | 13 | | 3 | | | | | | | 14 | 10 | A-4a | 8 | | | | | | |
| | | SS-3 | 4.5 | 6.0 | 4.0 | 5.5 | 41 | 12 | 2.5 | 24 | 21 | 3 | 41 | 51 | 92 | 14 | 16 | A-4a | 8 | | | | | | |
| 7 | B | | 0.5 | 1.4 | 0.0 | 0.9 | | | | | | | | | | | 6 | A-1-b | 0 | | | | | | Recompact if need |
| | 011-0 | SS-1 | 1.4 | 3.0 | 0.9 | 2.5 | 33 | | | 23 | 19 | 4 | 43 | 44 | 87 | 15 | 14 | A-4a | 8 | 200 | | | | | |
| | 21 | SS-2 | 3.0 | 4.5 | 2.5 | 4.0 | 39 | | | 23 | 19 | 4 | 41 | 41 | 82 | 14 | 14 | A-4a | 8 | | | | | | |
| | | SS-3A | 4.5 | 5.5 | 4.0 | 5.0 | 52 | 30 | | | | | | | | 14 | 10 | A-4a | 8 | | | | | | |
| 8 | B | SS-1 | 1.4 | 3.5 | -0.1 | 2.0 | 27 | | | 23 | 18 | 5 | 41 | 41 | 82 | 15 | 13 | A-4a | 8 | 190 | | | | | None |
| | 012-0 | SS-2 | 3.5 | 5.0 | 2.0 | 3.5 | 29 | | | 22 | 18 | 4 | 43 | 35 | 78 | 17 | 13 | A-4a | 8 | | | Mc | | | |
| | 21 | SS-3A/3B | 5.0 | 8.5 | 3.5 | 7.0 | 29 | | 2 | | | | | | | 24 | 14 | A-6a | 10 | | | | | | |
| | | SS-4 | 8.5 | 10.0 | 7.0 | 8.5 | 10 | 27 | 1.25 | | | | | | | 24 | 14 | A-6a | | | | | | | |
| 9 | B | SS-1 | 1.0 | 3.0 | -0.5 | 1.5 | 17 | | | 23 | 18 | 5 | 42 | 43 | 85 | 14 | 13 | A-4a | 8 | | | | | | None |
| | 013-0 | SS-2 | 3.0 | 5.0 | 1.5 | 3.5 | 28 | | | 17 | 15 | 2 | 43 | 18 | 61 | 13 | 10 | A-4a | 5 | 240 | | Mc | | | |
| | 21 | SS-3 | 5.0 | 6.0 | 3.5 | 4.5 | 43 | | | | | | | | | 12 | 8 | A-3 | 0 | | | | | | |
| | | SS-4 | 6.0 | 9.0 | 4.5 | 7.5 | 9 | 9 | | | | | | | | 19 | 8 | A-3a | 0 | | | | | | |

| # | Boring | Sample | Sample Depth | | Subgrade Depth | | Standard Penetration | | HP (tsf) | Physical Characteristics | | | | | | Moisture | | Ohio DOT | | Sulfate Content (ppm) | Problem | | Excavate and Replace (Item 204) | | Recommendation (Enter depth in inches) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | From | To | From | To | $N_{60}$ | $N_{60L}$ | | LL | PL | PI | % Silt | % Clay | P200 | $M_C$ | $M_{OPT}$ | Class | GI | | Unsuitable | Unstable | Unsuitable | Unstable | |
| 10 | B | SS-1/2/3A | 3.5 | 6.7 | -3.0 | 0.2 | 18 | | 2.25 | 24 | 19 | 5 | 44 | 24 | 68 | 19 | 14 | A-4a | 7 | | | Mc | | | 12" |
| | 014-0 | SS-3B | 6.7 | 8.0 | 0.2 | 1.5 | 11 | | 2.5 | 40 | 19 | 21 | 24 | 68 | 92 | 24 | 16 | A-6b | 12 | 250 | | $N_{60}$ & Mc | | 12" | 204 Geotextile |
| | 21 | SS-4 | 8.0 | 11.8 | 1.5 | 5.3 | 21 | | 4.25 | 31 | 16 | 15 | 22 | 56 | 78 | 17 | 14 | A-6a | 10 | | | | | | |
| | | SS-5 | 11.8 | 13.5 | 5.3 | 7.0 | 18 | 11 | 2 | | | | | | | 14 | 14 | A-6a | | | | | | | |
| 11 | B | SS-1 | 1.5 | 3.0 | 0.0 | 1.5 | 15 | | 2 | 28 | 25 | 3 | 45 | 30 | 75 | 21 | 20 | A-4a | 8 | 330 | | | | | None |
| | 015-0 | SS-2 | 3.0 | 4.0 | 1.5 | 2.5 | 26 | | 1 | 21 | 19 | 2 | 43 | 39 | 82 | 21 | 14 | A-4a | 8 | | | HP & Mc | | | |
| | 21 | SS-3 | 4.0 | 5.7 | 2.5 | 4.2 | 9 | | | | | | | | | 16 | 8 | A-3a | 0 | | | | | | |
| | | SS-4 | 5.7 | 7.0 | 4.2 | 5.5 | 18 | 9 | 3.5 | | | | | | | 19 | 10 | A-4a | 8 | | | | | | |
| 12 | B | SS-1A | 0.4 | 2.3 | -1.1 | 0.8 | 40 | | 4.5 | | | | | | | 9 | 14 | A-6a | 10 | | | | | | None |
| | 016-0 | SS-2 | 2.3 | 4.0 | 0.8 | 2.5 | 45 | | 3.25 | 24 | 21 | 3 | 40 | 52 | 92 | 16 | 16 | A-4a | 8 | 340 | | | | | |
| | 21 | SS-3 | 4.0 | 5.0 | 2.5 | 3.5 | 40 | | 3 | 26 | 23 | 3 | 42 | 44 | 86 | 20 | 18 | A-4a | 8 | | | | | | |
| | | SS-4 | 5.0 | 8.2 | 3.5 | 6.7 | 13 | 13 | 1 | | | | | | | 22 | 10 | A-4a | 8 | | | | | | |
| 13 | B | SS-1B/2A | 2.2 | 4.5 | -0.3 | 2.0 | 7 | | 1 | 18 | 13 | 5 | 29 | 23 | 52 | 14 | 10 | A-4a | 3 | 220 | | HP & Mc | | 15" | 15" |
| | 017-0 | SS-2B | 4.5 | 6.0 | 2.0 | 3.5 | 18 | | 3.5 | | | | | | | 18 | 10 | A-4a | 8 | | | Mc | | | 204 Geotextile |
| | 21 | SS-3 | 6.0 | 8.5 | 3.5 | 6.0 | 26 | | 3.75 | 24 | 19 | 5 | 41 | 51 | 92 | 17 | 14 | A-4a | 8 | | | | | | |
| | | SS-4/5A | 8.5 | 12.0 | 6.0 | 9.5 | 27 | 7 | 2.75 | 25 | 18 | 7 | 42 | 35 | 77 | 16 | 13 | A-4a | | | | | | | |
| 14 | B | SS-1 | 1.6 | 3.0 | 0.1 | 1.5 | 16 | | | NP | NP | NP | 8 | 2 | 10 | 11 | 8 | A-3 | 0 | 100 | | | | | None |
| | 024-0 | SS-2/3A | 3.0 | 5.2 | 1.5 | 3.7 | 26 | | | NP | NP | NP | 27 | 2 | 29 | 10 | 8 | A-3a | 0 | | | | | | |
| | 21 | SS-3B/4A | 5.2 | 6.5 | 3.7 | 5.0 | 27 | | 4 | | | | | | | 14 | 10 | A-4a | 8 | | | | | | |
| | | SS-4B | 6.5 | 6.9 | 5.0 | 5.4 | 66 | 16 | | | | | | | | 12 | 8 | A-3a | 0 | | | | | | |
| 15 | B | SS-2 | 1.8 | 6.0 | 0.3 | 4.5 | 32 | | | NP | NP | NP | 28 | 4 | 32 | 11 | 8 | A-3a | 0 | 100 | | | | | None |
| | 029-1 | SS-3 | 6.0 | 8.5 | 4.5 | 7.0 | 38 | | | NP | NP | NP | 31 | 4 | 35 | 11 | 8 | A-3a | 0 | | | | | | |
| | 21 | SS-4 | 8.5 | 11.0 | 7.0 | 9.5 | 36 | | | NP | NP | NP | 30 | 4 | 34 | 11 | 8 | A-3a | | | | | | | |
| | | SS-5 | 11.0 | 14.0 | 9.5 | 12.5 | 38 | 30 | | | | | | | | 10 | 8 | A-3a | | | | | | | |
| 16 | B | SS-1/2A | 1.5 | 3.4 | 0.0 | 1.9 | 12 | | | NP | NP | NP | 13 | 2 | 15 | 8 | 8 | A-3a | 0 | 100 | | | | | None |
| | 030-0 | SS-2B | 3.4 | 4.5 | 1.9 | 3.0 | 29 | | 3.5 | NP | NP | NP | 39 | 4 | 43 | 12 | 11 | A-4a | 2 | | | | | | |
| | 21 | SS-3A | 4.5 | 5.5 | 3.0 | 4.0 | 36 | | 3.25 | | | | | | | 10 | 10 | A-4a | 8 | | | | | | |
| | | SS-3B/4 | 5.5 | 7.5 | 4.0 | 6.0 | 46 | 12 | | | | | | | | 18 | 8 | A-3a | 0 | | | | | | |
| 17 | B | SS-1/2A | 0.8 | 4.5 | 1.3 | 5.0 | 24 | | 2.75 | 22 | 18 | 4 | 40 | 40 | 80 | 13 | 13 | A-4a | 8 | 140 | | | | | None |
| | 031-0 | SS-2B/3A | 4.5 | 6.5 | 5.0 | 7.0 | 13 | | 2.25 | 21 | 17 | 4 | 45 | 35 | 80 | 17 | 12 | A-4a | 8 | | | | | | |
| | 21 | SS-3B | 6.5 | 8.0 | 7.0 | 8.5 | 6 | | | 21 | 18 | 3 | 40 | 48 | 88 | 19 | 13 | A-4a | | | | | | | |
| | | SS-4 | 8.0 | 12.0 | 8.5 | 12.5 | 4 | 13 | 0.75 | | | | | | | 22 | 10 | A-4a | | | | | | | |
| 18 | B | SS-1/2A | 1.7 | 3.3 | 0.2 | 1.8 | 6 | | 0.5 | 26 | 24 | 2 | 58 | 8 | 66 | 24 | 19 | A-4b | 6 | 340 | A-4b | HP & Mc | 22" | 24" | 22" |
| | 032-0 | SS-2B | 3.3 | 4.2 | 1.8 | 2.7 | 15 | | | | | | | | | 9 | 10 | A-2-6 | 4 | | | | | | 204 Geotextile |
| | 21 | SS-3 | 4.2 | 5.3 | 2.7 | 3.8 | 24 | | 4 | | | | | | | 17 | 10 | A-4a | 8 | | | | | | |
| | | SS-4 | 5.3 | 7.3 | 3.8 | 5.8 | 10 | 6 | 4.5 | 25 | 23 | 2 | 33 | 32 | 65 | 17 | 18 | A-4a | 6 | | | | | | |

| # | Boring | Sample | Sample Depth | | Subgrade Depth | | Standard Penetration | | HP (tsf) | Physical Characteristics | | | | | | Moisture | | Ohio DOT | | Sulfate Content (ppm) | Problem | | Excavate and Replace (Item 204) | | Recommendation (Enter depth in inches) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | From | To | From | To | $N_{60}$ | $N_{60L}$ | | LL | PL | PI | % Silt | % Clay | P200 | $M_C$ | $M_{OPT}$ | Class | GI | | Unsuitable | Unstable | Unsuitable | Unstable | |
| 19 | B | SS-1 | 1.0 | 3.0 | -0.5 | 1.5 | 19 | | 4.5 | 26 | 22 | 4 | 43 | 41 | 84 | 16 | 17 | A-4a | 8 | | | | | | **None** |
| | 033-0 | SS-2 | 3.0 | 4.7 | 1.5 | 3.2 | 29 | | | 28 | 25 | 3 | 40 | 52 | 92 | 26 | 20 | A-4a | 8 | 350 | | Mc | | | |
| | 21 | SS-3/4A | 4.7 | 6.5 | 3.2 | 5.0 | 29 | | 4.25 | | | | | | | 19 | 14 | A-6a | 10 | | | | | | |
| | | SS-4B/5 | 6.5 | 8.5 | 5.0 | 7.0 | 20 | 19 | 2.5 | | | | | | | 18 | 10 | A-4a | 8 | | | | | | |
| 20 | B | SS-1 | 1.3 | 2.8 | -0.2 | 1.3 | 18 | | | 25 | 23 | 2 | 45 | 4 | 49 | 23 | 18 | A-4a | 3 | 350 | | Mc | | | **None** |
| | 034-0 | SS-2 | 2.8 | 4.1 | 1.3 | 2.6 | 22 | | 1.5 | 24 | 22 | 2 | 41 | 50 | 91 | 19 | 17 | A-4a | 8 | | | HP | | | |
| | 21 | SS-3 | 4.1 | 5.5 | 2.6 | 4.0 | 31 | | 3 | | | | | | | 18 | 10 | A-4a | 8 | | | | | | |
| | | SS-4 | 5.5 | 7.0 | 4.0 | 5.5 | 40 | 18 | 4 | | | | | | | 17 | 10 | A-4a | 8 | | | | | | |
| 21 | B | SS-1 | 1.4 | 3.5 | -0.1 | 2.0 | 10 | | | NP | NP | NP | 16 | 2 | 18 | 18 | 8 | A-3a | 0 | 100 | | | | | **Recompact** |
| | 040-0 | SS-2/3A | 3.5 | 4.7 | 2.0 | 3.2 | 17 | | | | | | | | | 8 | 8 | A-3a | 0 | | | | | | |
| | 21 | SS-3B | 4.7 | 6.0 | 3.2 | 4.5 | 22 | | 1.5 | 21 | 18 | 3 | 46 | 17 | 63 | 18 | 13 | A-4a | 6 | | | | | | |
| | | SS-4 | 6.0 | 7.5 | 4.5 | 6.0 | 11 | 10 | 2.5 | | | | | | | 22 | 10 | A-4a | 8 | | | | | | |
| 22 | B | SS-1 | 1.4 | 3.3 | -0.1 | 1.8 | 10 | | | | | | | | | 13 | 8 | A-3a | 0 | | | | | | **Recompact** |
| | 041-0 | SS-2/3A | 3.3 | 4.7 | 1.8 | 3.2 | 12 | | | NP | NP | NP | 19 | 2 | 21 | 10 | 8 | A-3a | 0 | 170 | | | | | |
| | 21 | SS-3B | 4.7 | 6.0 | 3.2 | 4.5 | 27 | | 2 | 23 | 19 | 4 | 26 | 30 | 56 | 20 | 14 | A-4a | 4 | | | | | | |
| | | SS-4 | 6.0 | 7.5 | 4.5 | 6.0 | 34 | 10 | 3.5 | | | | | | | 22 | 10 | A-4a | 8 | | | | | | |

**PID:** 105889

**County-Route-Section:** LUC-023-11.75
**No. of Borings:** 22

**Geotechnical Consultant:** TTL Associates, Inc.
**Prepared By:** Christopher P. Iott, P.E.
**Date prepared:** 5/1/2023

| Chemical Stabilization Options | | |
|---|---|---|
| 320 | Rubblize & Roll | Option |
| 206 | Cement Stabilization | Option |
| | Lime Stabilization | No |
| 206 | Depth | 12" |

| Excavate and Replace Stabilization Options | |
|---|---|
| Global Geotextile<br>Average(N60L):<br>Average(HP): | <br>12"<br>0" |
| Global Geogrid<br>Average(N60L):<br>Average(HP): | <br>0"<br>0" |

| | |
|---|---|
| Design CBR | 8 |

| % Samples within 6 feet of subgrade | | | |
|---|---|---|---|
| $N_{60} \leq 5$ | 0% | HP ≤ 0.5 | 1% |
| $N_{60} < 12$ | 11% | 0.5 < HP ≤ 1 | 5% |
| $12 \leq N_{60} < 15$ | 10% | 1 < HP ≤ 2 | 14% |
| $N_{60} \geq 20$ | 59% | HP > 2 | 41% |
| M+ | 18% | | |
| Rock | 0% | | |
| Unsuitable | 1% | | |

| Excavate and Replace at Surface | |
|---|---|
| Average | 15" |
| Maximum | 22" |
| Minimum | 12" |

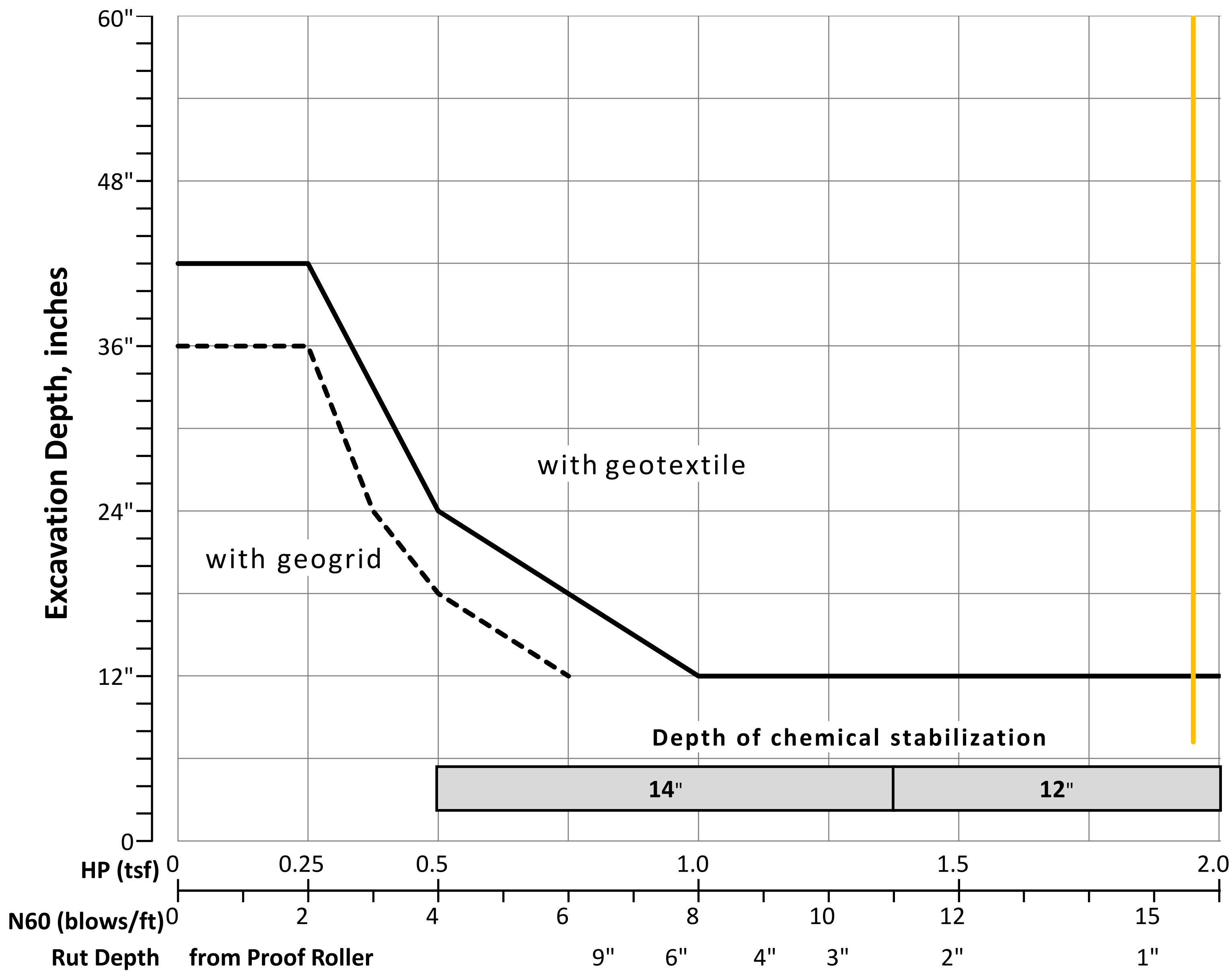
| % Proposed Subgrade Surface | |
|---|---|
| Unstable & Unsuitable | 34% |
| Unstable | 32% |
| Unsuitable | 2% |

| | $N_{60}$ | $N_{60L}$ | HP | LL | PL | PI | Silt | Clay | P 200 | $M_C$ | $M_{OPT}$ | GI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 25 | 16 | 2.72 | 24 | 20 | 5 | 36 | 31 | 67 | 16 | 12 | 6 |
| Maximum | 66 | 30 | 4.50 | 40 | 25 | 21 | 58 | 68 | 94 | 26 | 20 | 12 |
| Minimum | 4 | 6 | 0.50 | 17 | 13 | 2 | 8 | 2 | 10 | 5 | 6 | 0 |

**Classification Counts by Sample**

| ODOT Class | Rock | A-1-a | A-1-b | A-2-4 | A-2-5 | A-2-6 | A-2-7 | A-3 | A-3a | A-4a | A-4b | A-5 | A-6a | A-6b | A-7-5 | A-7-6 | A-8a | A-8b | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Count | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 4 | 17 | 52 | 1 | 0 | 10 | 1 | 0 | 0 | 0 | 0 | 88 |
| Percent | 0% | 0% | 2% | 0% | 0% | 1% | 0% | 5% | 19% | 59% | 1% | 0% | 11% | 1% | 0% | 0% | 0% | 0% | 100% |
| % Rock\|Granular\|Cohesive | 0% | 86% | | | | | | | | | 14% | | | | | | | | 100% |
| Surface Class Count | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 3 | 10 | 31 | 1 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 53 |
| Surface Class Percent | 0% | 0% | 4% | 0% | 0% | 2% | 0% | 6% | 19% | 58% | 2% | 0% | 8% | 2% | 0% | 0% | 0% | 0% | 100% |

**Fig. 600-1 – Subgrade Stabilization**

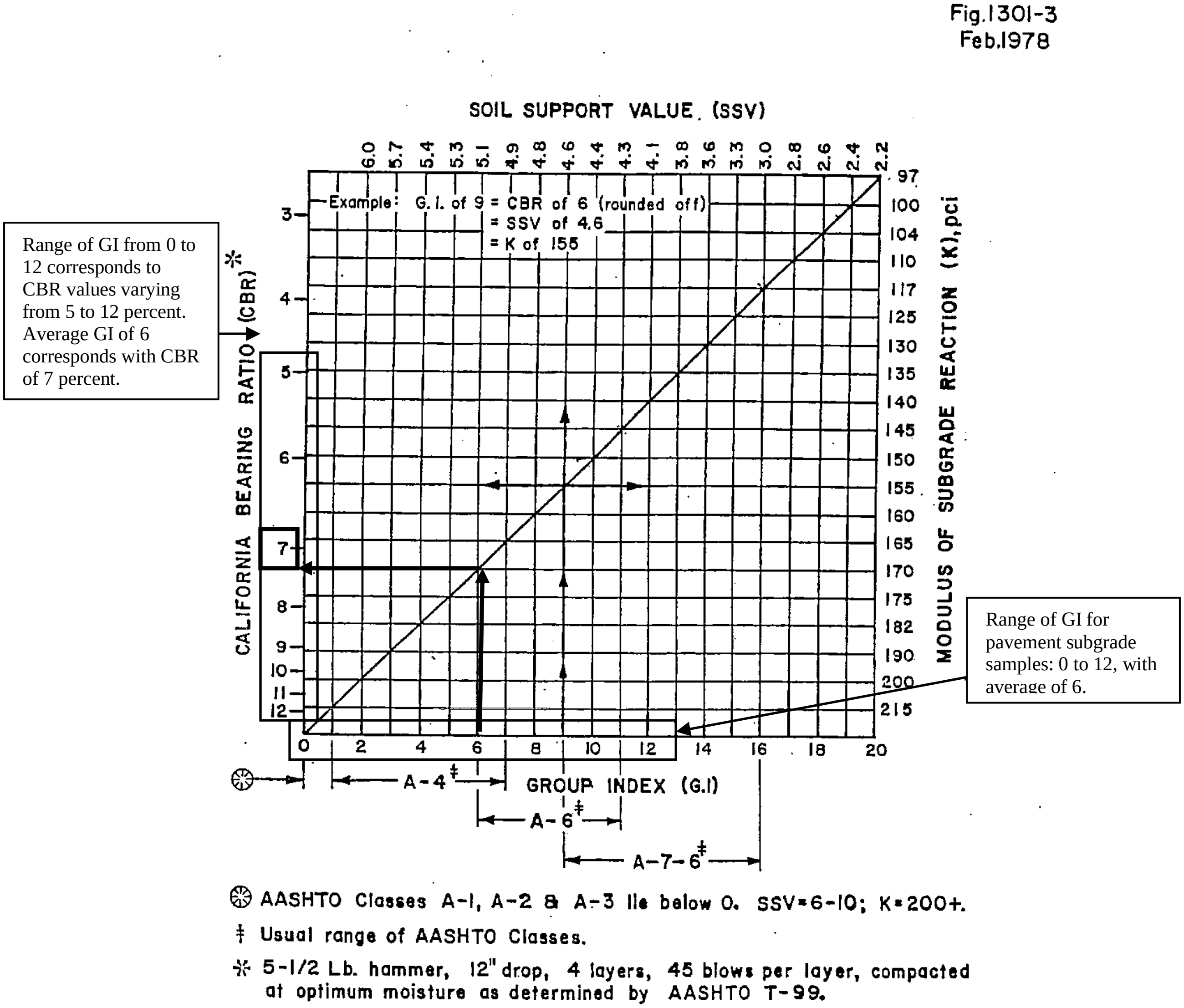



**OVERRIDE TABLE**

| Calculated Average | New Values | Check to Override |
|---|---|---|
| 2.72 | | ☐ HP |
| 15.64 | | ☐ N60L |

Average HP

Average $N_{60L}$




CORRELATION CHART FOR SUBGRADE STRENGTHS

The ODOT "Subgrade Analysis" worksheet for the entire project site resulted in a CBR value of 8 percent. It should be noted that the CBR determination by the GB-1 spreadsheet is based on an average Group Index (GI) of all the evaluated samples. The indicated average GI of 6 would correlate with a CBR of 7 percent, so the worksheet indicated CBR of 8 percent may be based on a slightly lower average GI that was rounded up to 6. With the average GI calculation resulting in correlation approximately half way between a CBR of 7 and 8 on the correlation chart above, **we recommend use of a CBR value of 7 percent for design.**

If global chemical stabilization is planned, a higher CBR value could be considered for design. However, we anticipate that the various phases of the project may not be conducive for global chemical stabilization. In this case, multiple mobilizations of the stabilization equipment would be required which could reduce the economic benefit of this method of modification. As such, design based on the CBR value of 7 percent should be utilized, considering subgrade modification may consist of over-excavation and replacement with new engineered fill.

# APPENDIX G

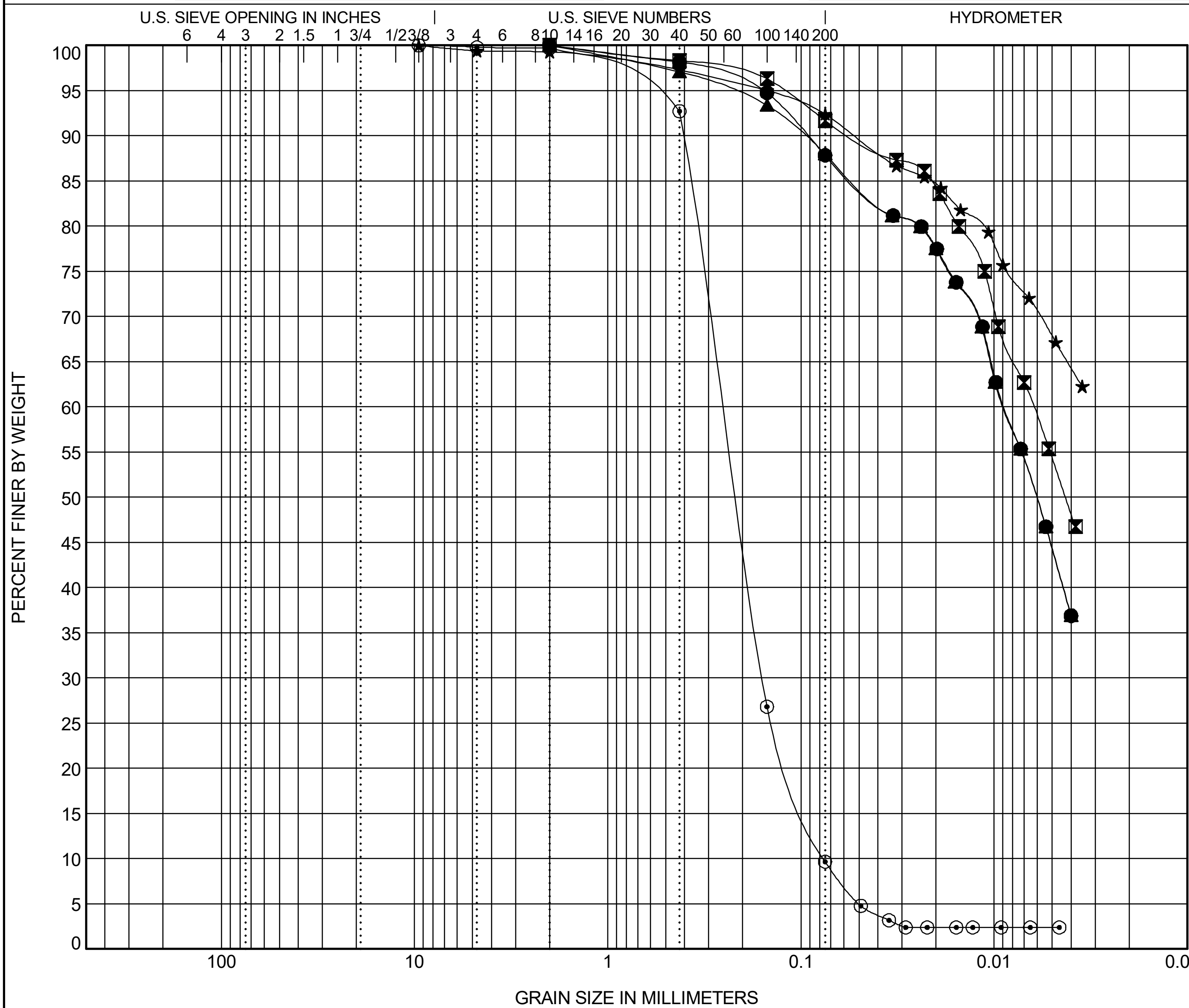
## Soils Laboratory Test Data

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| COBBLES | GRAVEL | SAND | | SILT | CLAY |
|---|---|---|---|---|---|
| | | coarse | fine | | |

| | Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-001-0-21** | **1.0** | **A-4a ~ SILT(ML)** | **25** | **23** | **2** |
| ⧗ | **B-001-0-21** | **4.0** | **A-4a ~ SILTY CLAY(CL-ML)** | **27** | **20** | **7** |
| ▲ | **B-002-0-21** | **1.0** | **A-4a ~ SILT(ML)** | **27** | **24** | **3** |
| ★ | **B-002-0-21** | **2.5** | **A-6a ~ LEAN CLAY(CL)** | **31** | **20** | **11** |
| ⊙ | **B-003-0-21** | **1.5** | **A-3 ~ POORLY GRADED SAND with SILT(SP-SM)** | **NP** | **NP** | **NP** |

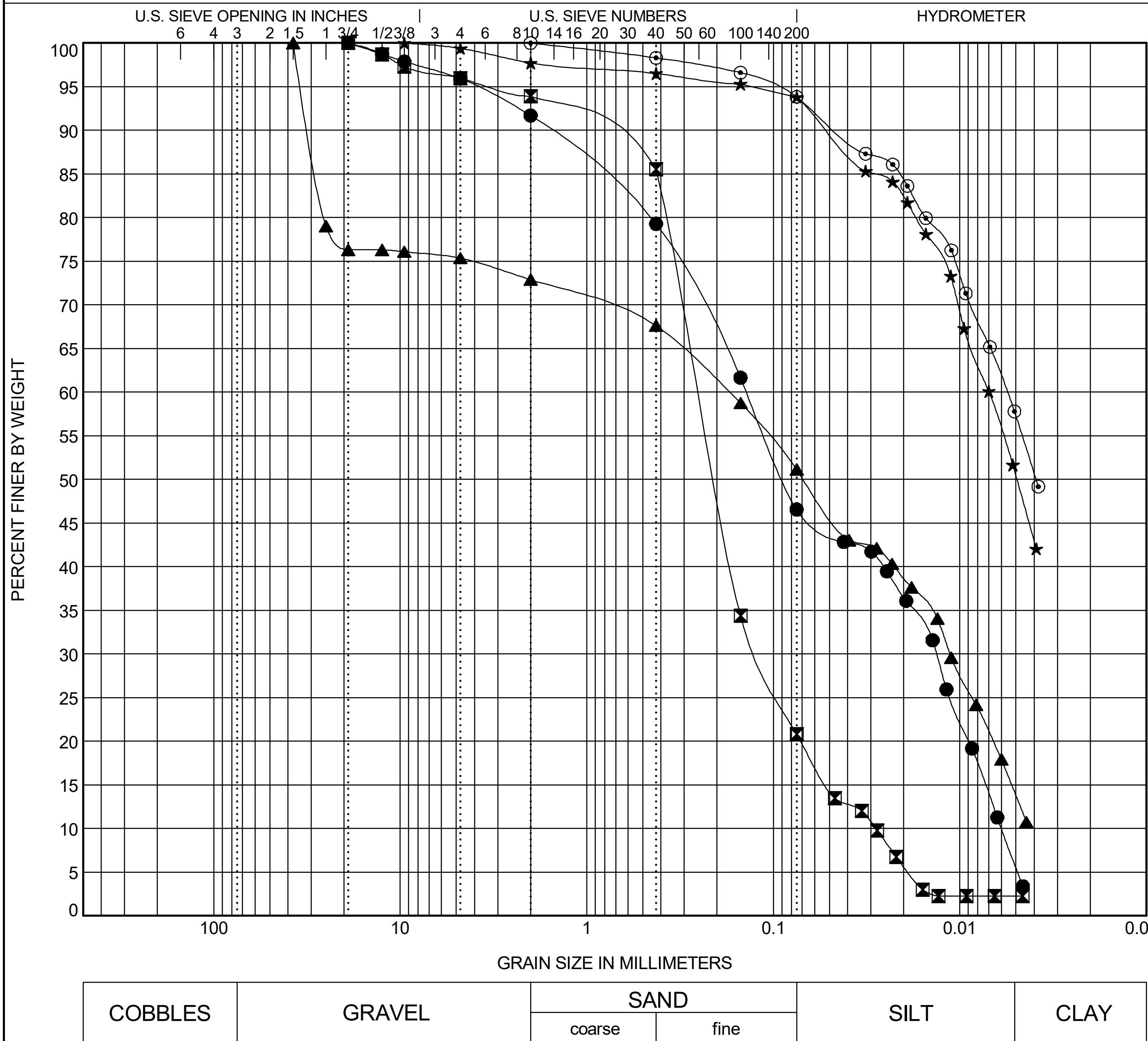
| | Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-001-0-21** | **1.0** | **0.093** | **0.006** | | | **0** | **2** | **10** | **44** | **44** | | |
| ⧗ | **B-001-0-21** | **4.0** | **0.054** | **0.004** | | | **0** | **1** | **7** | **38** | **54** | | |
| ▲ | **B-002-0-21** | **1.0** | **0.097** | **0.006** | | | **0** | **3** | **9** | **44** | **44** | | |
| ★ | **B-002-0-21** | **2.5** | **0.052** | | | | **1** | **2** | **5** | **24** | **68** | | |
| ⊙ | **B-003-0-21** | **1.5** | **0.407** | **0.216** | **0.158** | **0.076** | **0** | **7** | **83** | **8** | **2** | **1.29** | **3.33** |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-003-0-21 | 4.0 | **A-4a ~ SILTY, CLAYEY SAND(SC-SM)** | 20 | 15 | 5 |
| ⊠ B-004-0-21 | 1.5 | **A-3a ~ SILTY SAND(SM)** | NP | NP | NP |
| ▲ B-004-0-21 | 4.0 | **A-4a ~ GRAVELLY SILTY CLAY with SAND(CL-ML)** | 24 | 18 | 6 |
| ★ B-004-0-21 | 4.5 | **A-4a ~ SILTY CLAY(CL-ML)** | 25 | 18 | 7 |
| ⊙ B-004-0-21 | 11.0 | **A-4a ~ LEAN CLAY(CL)** | 26 | 18 | 8 |

| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-003-0-21 | 4.0 | 1.617 | 0.088 | 0.013 | 0.006 | 8 | 12 | 33 | 42 | 5 | 0.21 | 23.22 |
| ⊠ B-004-0-21 | 1.5 | 0.97 | 0.206 | 0.12 | 0.028 | 6 | 8 | 65 | 19 | 2 | 2.01 | 8.94 |
| ▲ B-004-0-21 | 4.0 | 30.912 | 0.068 | 0.011 | | 28 | 5 | 16 | 37 | 14 | | |
| ★ B-004-0-21 | 4.5 | 0.051 | 0.005 | | | 2 | 1 | 3 | 44 | 50 | | |
| ⊙ B-004-0-21 | 11.0 | 0.045 | 0.004 | | | 0 | 2 | 4 | 37 | 57 | | |

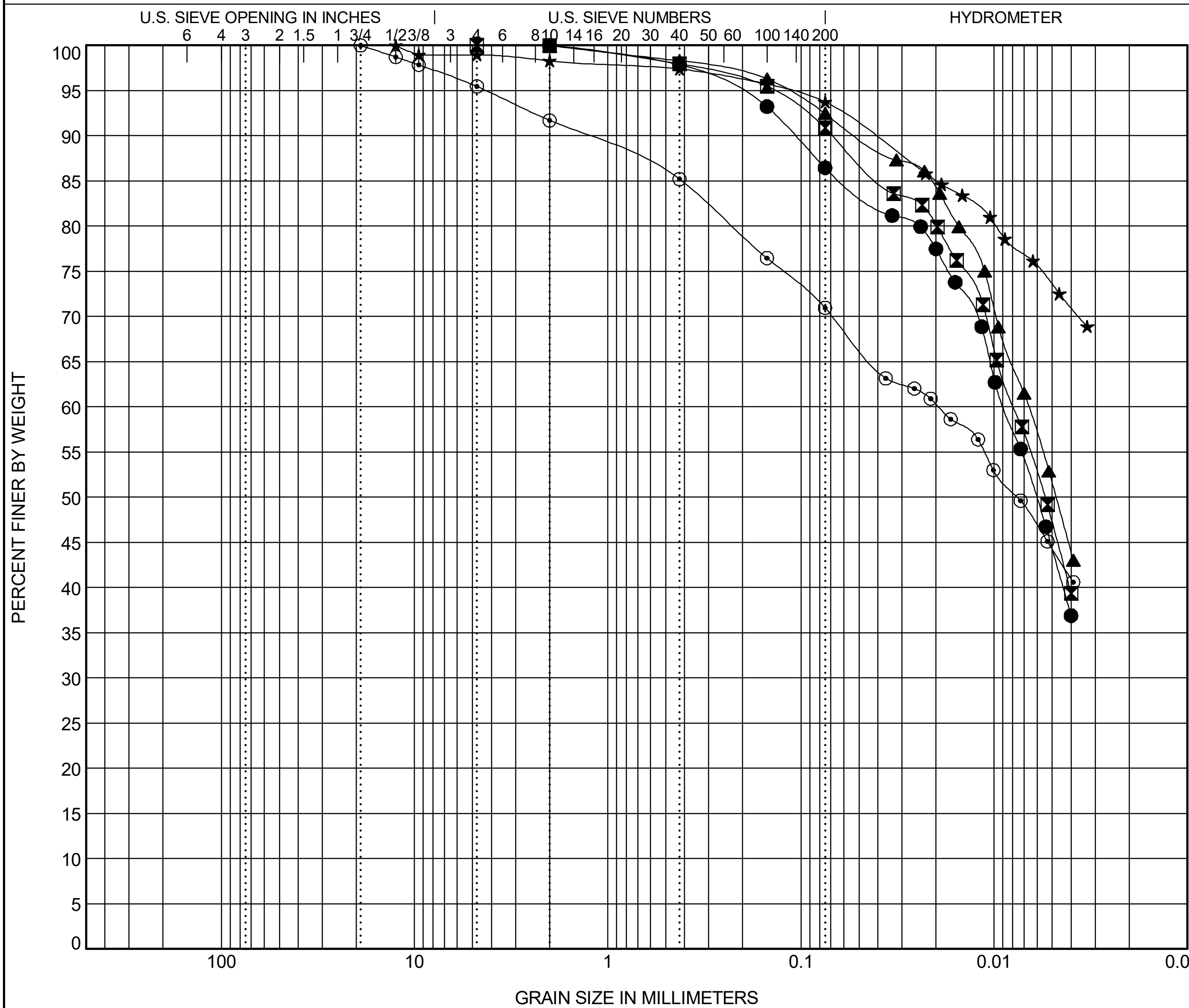
GRAIN SIZE - OH DOT.GDT - 6/16/23 12:42 - S:\PROJECTS\2065201.GPJ

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| COBBLES | GRAVEL | SAND | | SILT | CLAY |
|---|---|---|---|---|---|
| | | coarse | fine | | |

| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-006-0-21 | 3.0 | **A-4a ~ SILTY CLAY(CL-ML)** | 24 | 20 | 4 |
| ⧗ B-006-1-21 | 6.0 | **A-4a ~ SILTY CLAY(CL-ML)** | 25 | 21 | 4 |
| ▲ B-006-1-21 | 13.5 | **A-4a ~ SILT(ML)** | 26 | 23 | 3 |
| ★ B-006-1-21 | 18.5 | **A-7-6 ~ FAT CLAY(CH)** | 51 | 26 | 25 |
| ⊙ B-006-1-21 | 23.0 | **A-6a ~ LEAN CLAY with SAND(CL)** | 25 | 14 | 11 |

| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-006-0-21 | 3.0 | 0.108 | 0.006 | | | 0 | 3 | 11 | 42 | 44 | | |
| ⧗ B-006-1-21 | 6.0 | 0.068 | 0.005 | | | 0 | 2 | 7 | 44 | 47 | | |
| ▲ B-006-1-21 | 13.5 | 0.05 | 0.005 | | | 0 | 2 | 6 | 40 | 52 | | |
| ★ B-006-1-21 | 18.5 | 0.042 | | | | 1 | 1 | 4 | 21 | 73 | | |
| ⊙ B-006-1-21 | 23.0 | 1.331 | 0.008 | | | 9 | 6 | 14 | 27 | 44 | | |

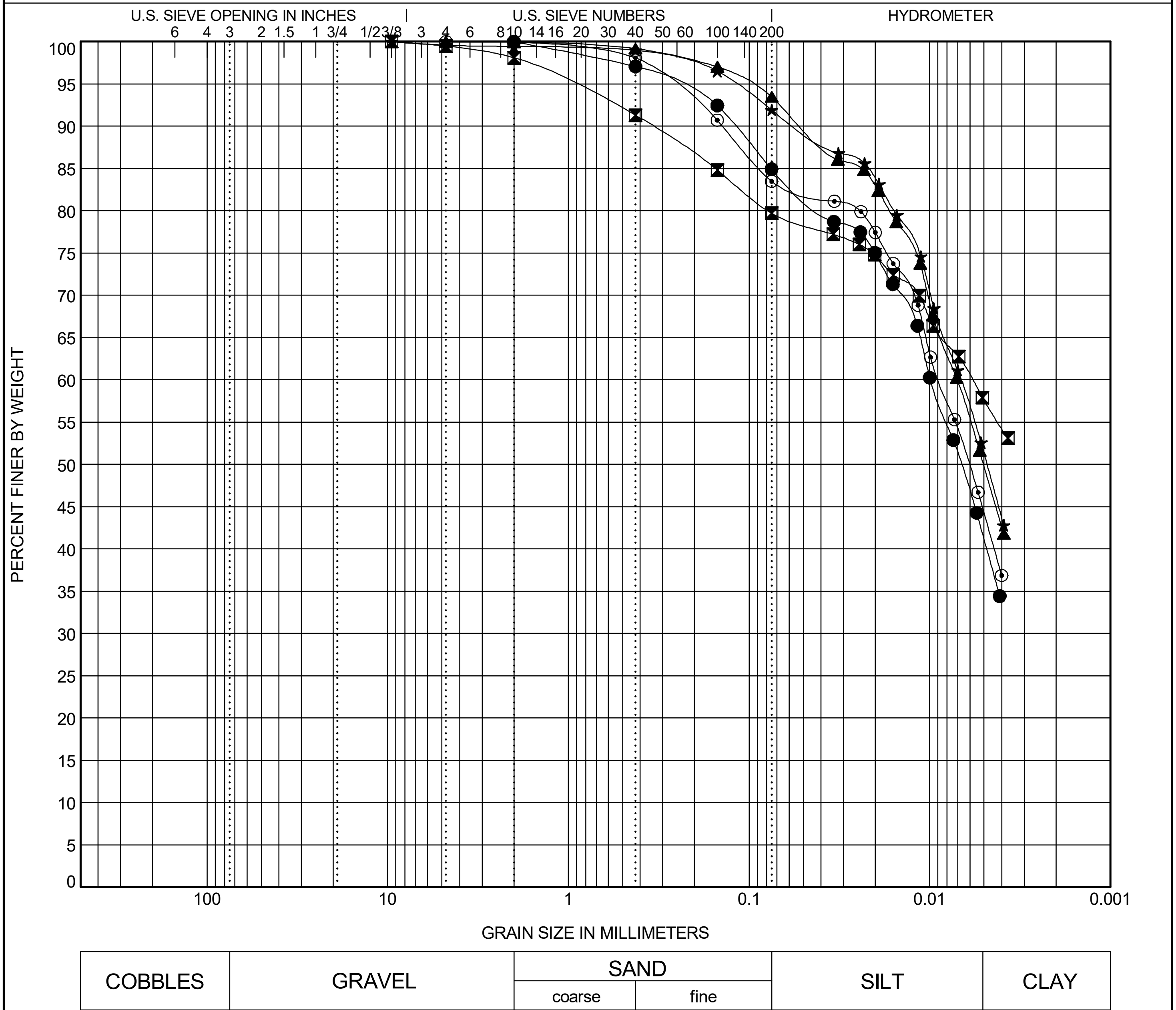
GRAIN SIZE - OH DOT.GDT - 6/16/23 12:42 - S:\PROJECTS\2065201.GPJ

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● **B-008-0-21** | **3.5** | **A-4a ~ SILT with SAND(ML)** | **21** | **18** | **3** |
| ⧗ **B-008-0-21** | **8.5** | **A-6a ~ LEAN CLAY with SAND(CL)** | **26** | **15** | **11** |
| ▲ **B-010-0-21** | **1.5** | **A-4a ~ SILT(ML)** | **23** | **21** | **2** |
| ★ **B-010-0-21** | **4.5** | **A-4a ~ SILT(ML)** | **24** | **21** | **3** |
| ⊙ **B-010-0-21** | **11.0** | **A-4a ~ SILT with SAND(ML)** | **26** | **22** | **4** |

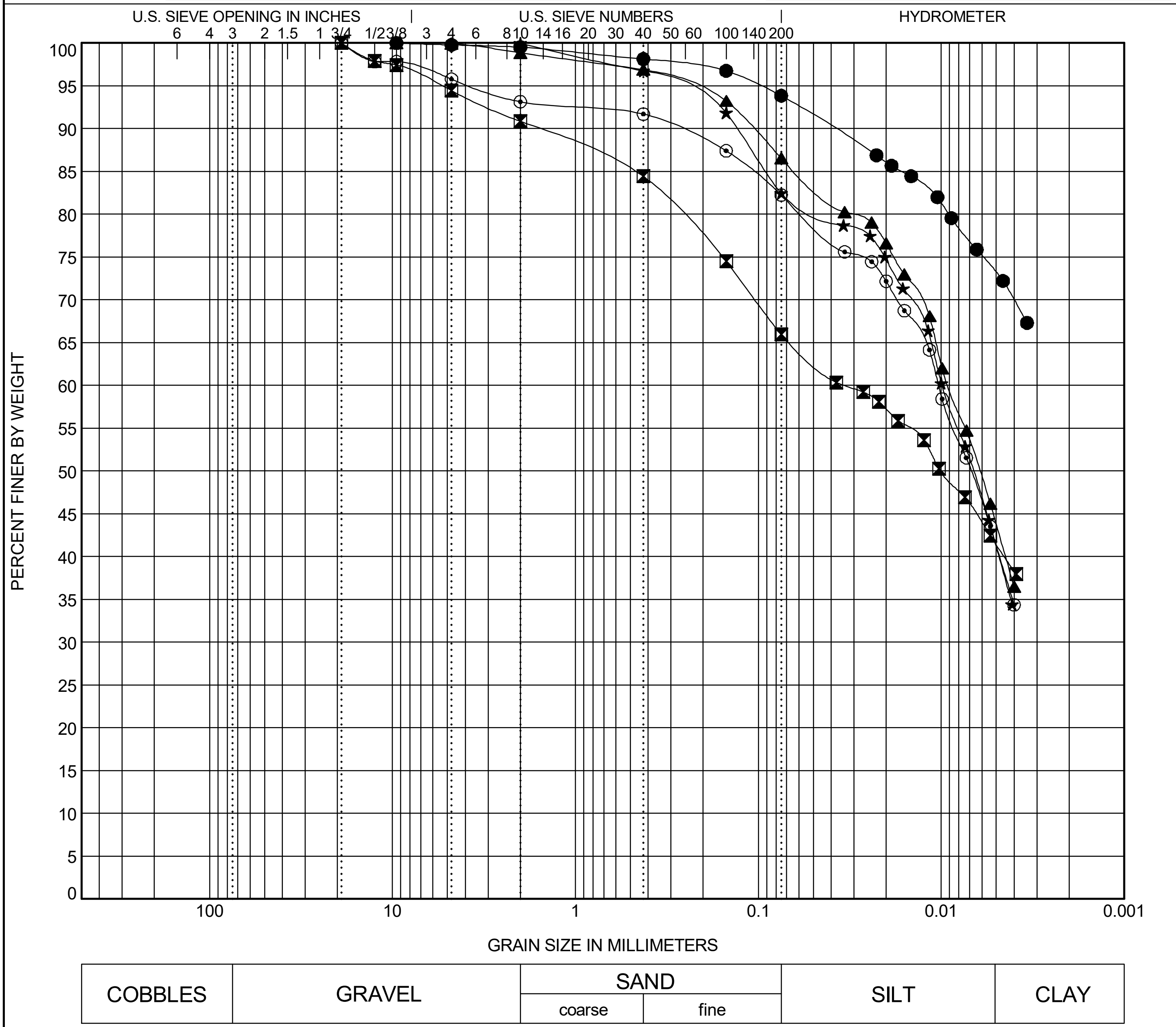
| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● **B-008-0-21** | **3.5** | **0.12** | **0.007** | | | **0** | **3** | **12** | **44** | **41** | | |
| ⧗ **B-008-0-21** | **8.5** | **0.344** | | | | **1** | **7** | **12** | **22** | **58** | | |
| ▲ **B-010-0-21** | **1.5** | **0.051** | **0.005** | | | **0** | **1** | **6** | **43** | **50** | | |
| ★ **B-010-0-21** | **4.5** | **0.054** | **0.005** | | | **1** | **0** | **7** | **41** | **51** | | |
| ⊙ **B-010-0-21** | **11.0** | **0.14** | **0.006** | | | **0** | **2** | **15** | **39** | **44** | | |

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-010-0-21 | 21.0 | **A-7-6 ~ LEAN CLAY(CL)** | 41 | 22 | 19 |
| ⊠ B-010-0-21 | 26.0 | **A-6a ~ SANDY LEAN CLAY(CL)** | 25 | 13 | 12 |
| ▲ B-011-0-21 | 1.5 | **A-4a ~ SILTY CLAY(CL-ML)** | 23 | 19 | 4 |
| ★ B-011-0-21 | 3.0 | **A-4a ~ SILTY CLAY with SAND(CL-ML)** | 23 | 19 | 4 |
| ⊙ B-012-0-21 | 1.0 | **A-4a ~ SILTY CLAY with SAND(CL-ML)** | 23 | 18 | 5 |

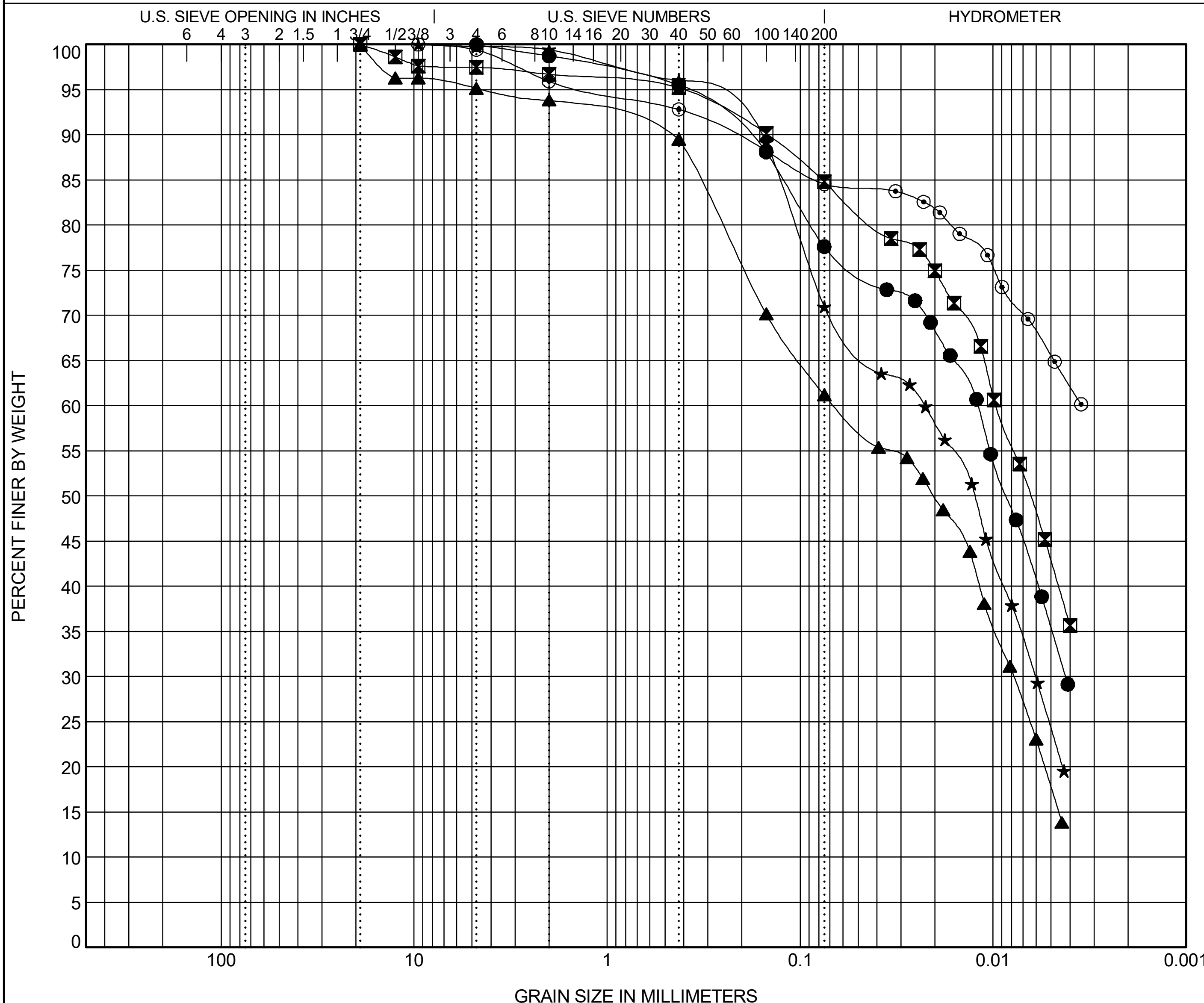
| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-010-0-21 | 21.0 | 0.039 | | | | 1 | 1 | 4 | 21 | 73 | | |
| ⊠ B-010-0-21 | 26.0 | 1.627 | 0.01 | | | 10 | 6 | 18 | 25 | 41 | | |
| ▲ B-011-0-21 | 1.5 | 0.107 | 0.006 | | | 1 | 2 | 10 | 43 | 44 | | |
| ★ B-011-0-21 | 3.0 | 0.131 | 0.007 | | | 0 | 4 | 14 | 41 | 41 | | |
| ⊙ B-012-0-21 | 1.0 | 0.281 | 0.007 | | | 8 | 1 | 9 | 41 | 41 | | |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| COBBLES | GRAVEL | SAND | | SILT | CLAY |
|---|---|---|---|---|---|
| | | coarse | fine | | |

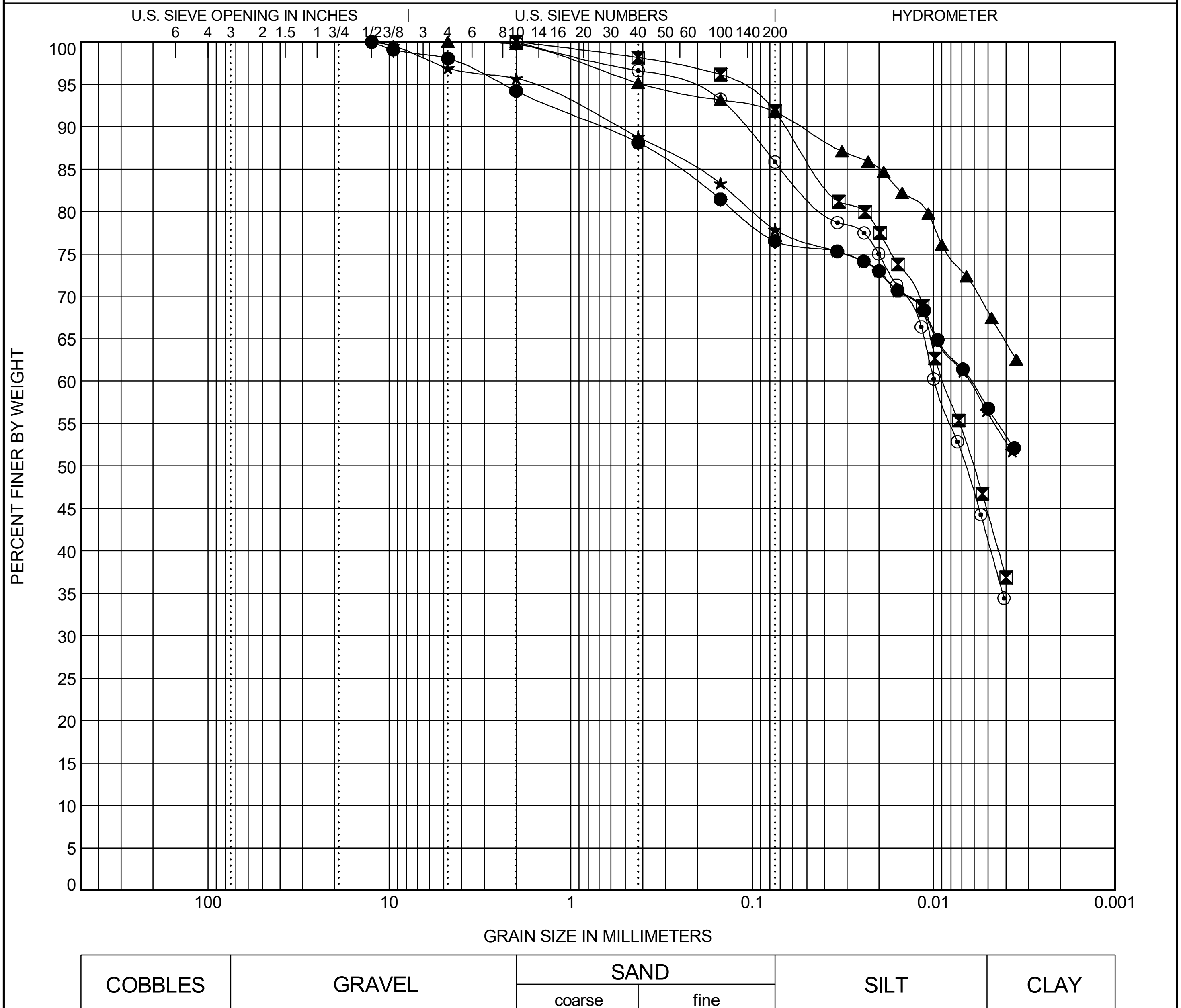
| | Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-012-0-21** | **3.5** | **A-4a ~ SILTY CLAY with SAND(CL-ML)** | **22** | **18** | **4** |
| ⧗ | **B-013-0-21** | **1.5** | **A-4a ~ SILTY CLAY with SAND(CL-ML)** | **23** | **18** | **5** |
| ▲ | **B-013-0-21** | **3.0** | **A-4a ~ SANDY SILT(ML)** | **17** | **15** | **2** |
| ★ | **B-013-0-21** | **8.5** | **A-4a ~ SILT with SAND(ML)** | **20** | **18** | **2** |
| ⊙ | **B-013-0-21** | **16.0** | **A-6a ~ LEAN CLAY with SAND(CL)** | **30** | **16** | **14** |

| | Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-012-0-21** | **3.5** | **0.196** | **0.008** | **0.004** | | **1** | **3** | **18** | **43** | **35** | | |
| ⧗ | **B-013-0-21** | **1.5** | **0.147** | **0.006** | | | **4** | **1** | **10** | **42** | **43** | | |
| ▲ | **B-013-0-21** | **3.0** | **0.506** | **0.02** | **0.008** | | **7** | **4** | **28** | **43** | **18** | | |
| ★ | **B-013-0-21** | **8.5** | **0.17** | **0.012** | **0.006** | | **1** | **3** | **25** | **47** | **24** | | |
| ⊙ | **B-013-0-21** | **16.0** | **0.223** | | | | **4** | **3** | **8** | **20** | **65** | | |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889
**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | B-013-0-21 | 23.5 | A-6a ~ LEAN CLAY with SAND(CL) | 25 | 14 | 11 |
| ⧗ | B-014-0-21 | 1.0 | A-4a ~ SILTY CLAY(CL-ML) | 24 | 19 | 5 |
| ▲ | B-014-0-21 | 6.7 | A-6b ~ LEAN CLAY(CL) | 40 | 19 | 21 |
| ★ | B-014-0-21 | 8.5 | A-6a ~ LEAN CLAY with SAND(CL) | 31 | 16 | 15 |
| ⊙ | B-014-1-21 | 6.0 | A-4a ~ SILT(ML) | 26 | 24 | 2 |

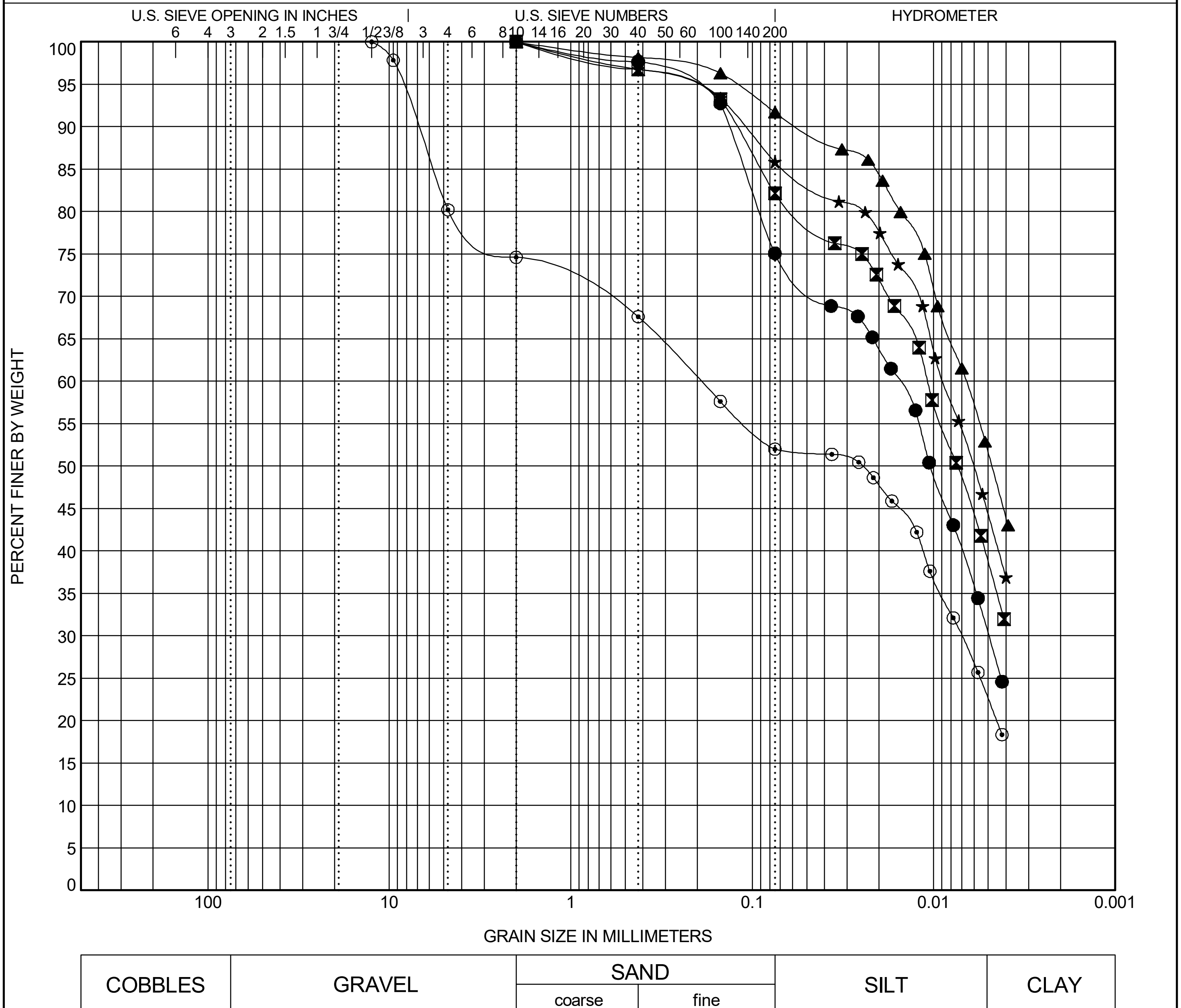
| Specimen Identification | | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-013-0-21 | 23.5 | 0.685 | | | | 5 | 6 | 12 | 20 | 57 | | |
| ⧗ | B-014-0-21 | 1.0 | 0.065 | 0.006 | | | 0 | 2 | 6 | 48 | 44 | | |
| ▲ | B-014-0-21 | 6.7 | 0.054 | | | | 0 | 5 | 3 | 24 | 68 | | |
| ★ | B-014-0-21 | 8.5 | 0.558 | | | | 4 | 7 | 11 | 22 | 56 | | |
| ⊙ | B-014-1-21 | 6.0 | 0.111 | 0.007 | | | 0 | 3 | 11 | 45 | 41 | | |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-015-0-21 | 1.0 | **A-4a ~ SILT with SAND(ML)** | 28 | 25 | 3 |
| ⧗ B-015-0-21 | 2.5 | **A-4a ~ SILT with SAND(ML)** | 21 | 19 | 2 |
| ▲ B-016-0-21 | 2.5 | **A-4a ~ SILT(ML)** | 24 | 21 | 3 |
| ★ B-016-0-21 | 4.0 | **A-4a ~ SILT(ML)** | 26 | 23 | 3 |
| ⊙ B-017-0-21 | 2.2 | **A-4a ~ SANDY SILTY CLAY with GRAVEL(CL-ML)** | 18 | 13 | 5 |

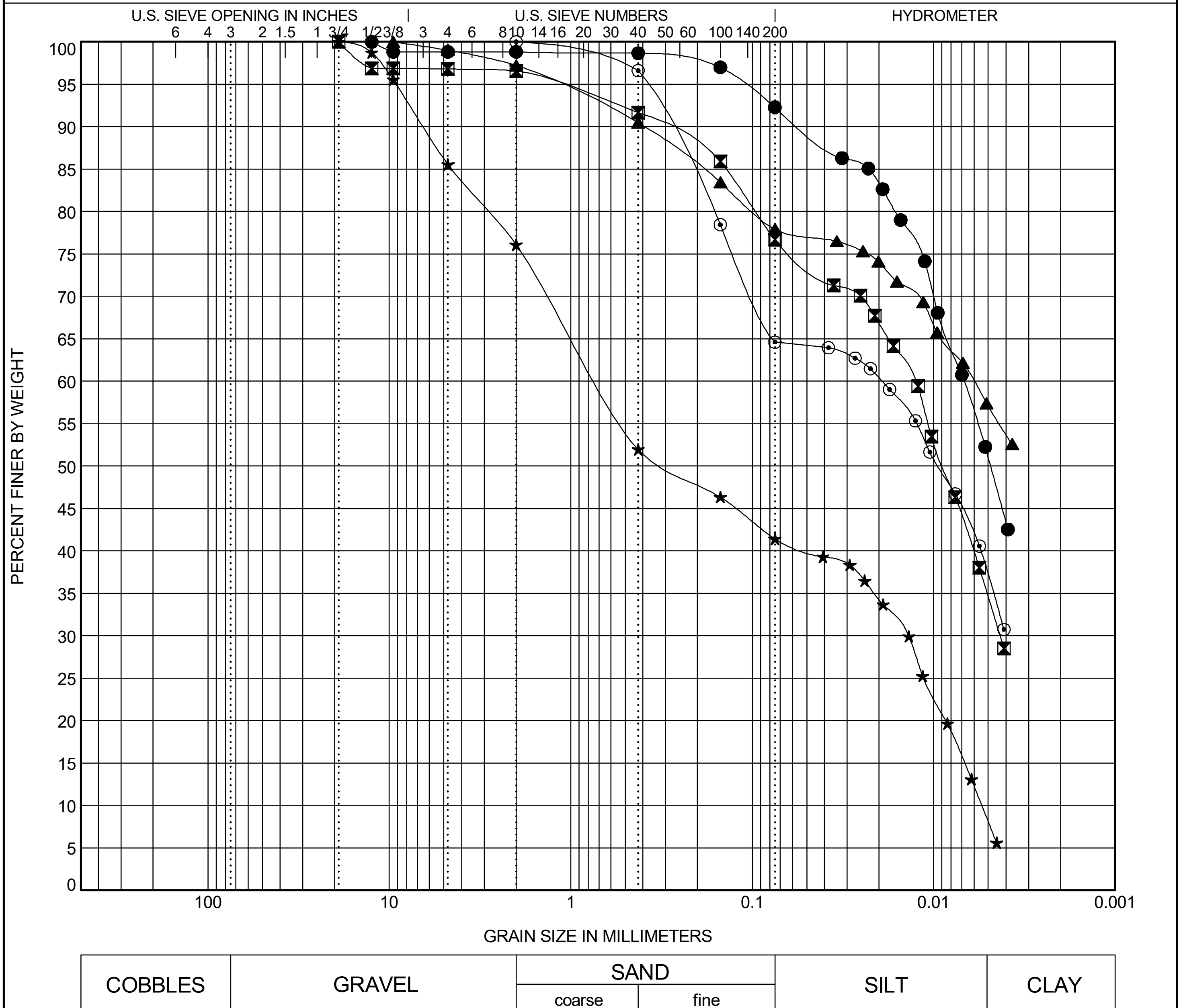
| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-015-0-21 | 1.0 | 0.135 | 0.01 | 0.005 | | 0 | 2 | 23 | 45 | 30 | | |
| ⧗ B-015-0-21 | 2.5 | 0.123 | 0.007 | | | 0 | 3 | 15 | 43 | 39 | | |
| ▲ B-016-0-21 | 2.5 | 0.054 | 0.005 | | | 0 | 2 | 6 | 40 | 52 | | |
| ★ B-016-0-21 | 4.0 | 0.11 | 0.006 | | | 0 | 3 | 11 | 42 | 44 | | |
| ⊙ B-017-0-21 | 2.2 | 6.98 | 0.025 | 0.007 | | 25 | 7 | 16 | 29 | 23 | | |

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-017-0-21** | **6.0** | **A-4a ~ SILTY CLAY(CL-ML)** | **24** | **19** | **5** |
| ⊠ | **B-017-0-21** | **8.5** | **A-4a ~ SILTY CLAY with SAND(CL-ML)** | **25** | **18** | **7** |
| ▲ | **B-017-0-21** | **13.5** | **A-6a ~ LEAN CLAY with SAND(CL)** | **25** | **14** | **11** |
| ★ | **B-017-0-21** | **21.0** | **A-4a ~ SILTY SAND(SM)** | **16** | **14** | **2** |
| ⊙ | **B-021-0-21** | **1.0** | **A-4a ~ SANDY LEAN CLAY(CL)** | **25** | **15** | **10** |

| Specimen Identification | | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-017-0-21** | **6.0** | **0.054** | **0.005** | | | **2** | **0** | **6** | **41** | **51** | | |
| ⊠ | **B-017-0-21** | **8.5** | **0.314** | **0.009** | **0.004** | | **3** | **5** | **15** | **42** | **35** | | |
| ▲ | **B-017-0-21** | **13.5** | **0.396** | | | | **2** | **7** | **13** | **21** | **57** | | |
| ★ | **B-017-0-21** | **21.0** | **6.464** | **0.295** | **0.014** | **0.005** | **24** | **24** | **11** | **33** | **8** | **0.05** | **131.05** |
| ⊙ | **B-021-0-21** | **1.0** | **0.291** | **0.009** | | | **0** | **3** | **32** | **28** | **37** | | |

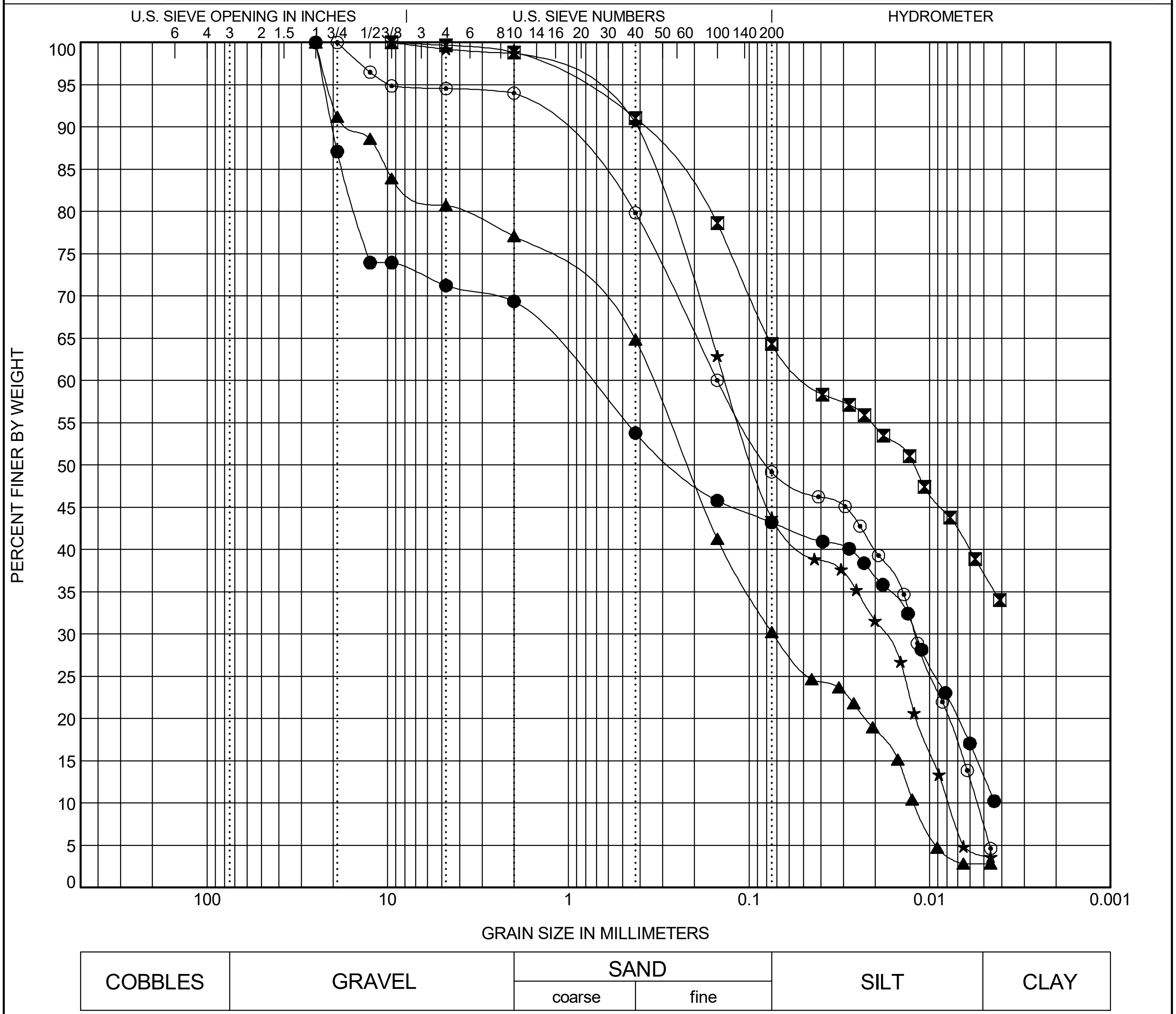
GRAIN SIZE - OH DOT.GDT - 6/16/23 12:43 - S:\PROJECTS\2065201.GPJ

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY



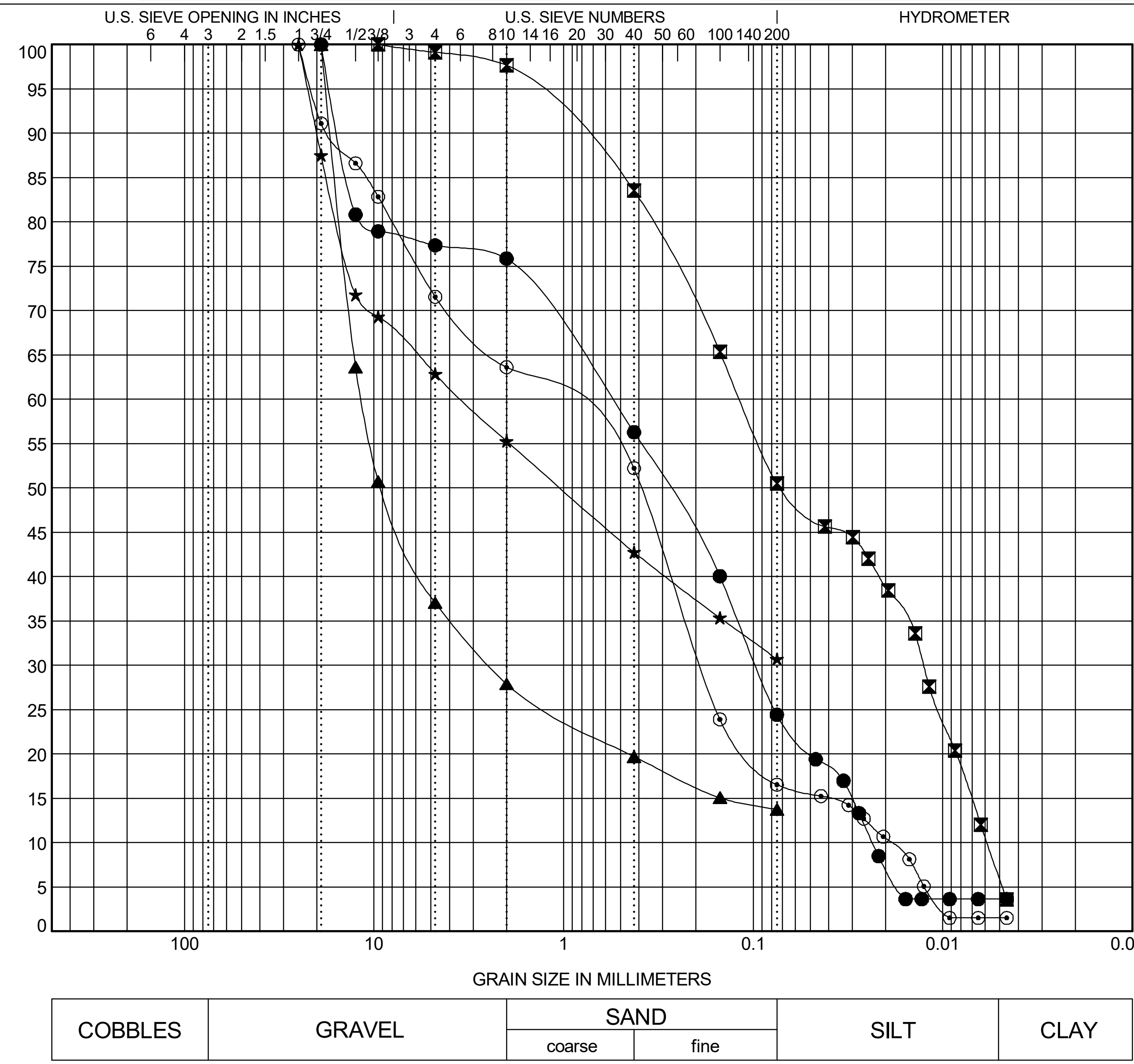

| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-021-0-21 | 3.5 | **A-4a ~ SILTY, CLAYEY GRAVEL with SAND(GC-GM)** | 19 | 14 | 5 |
| ⧗ B-022-0-21 | 1.0 | **A-6a ~ SANDY LEAN CLAY(CL)** | 25 | 14 | 11 |
| ▲ B-022-0-21 | 3.5 | **A-2-4 ~ SILTY, CLAYEY SAND with GRAVEL(SC-SM)** | 17 | 13 | 4 |
| ★ B-022-1-21 | 1.0 | **A-4a ~ CLAYEY SAND(SC)** | 22 | 14 | 8 |
| ⊙ B-022-1-21 | 3.5 | **A-4a ~ CLAYEY SAND(SC)** | 20 | 11 | 9 |

| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-021-0-21 | 3.5 | 20.209 | 0.26 | 0.012 | | 30 | 16 | 11 | 30 | 13 | | |
| ⧗ B-022-0-21 | 1.0 | 0.388 | 0.012 | | | 1 | 8 | 27 | 27 | 37 | | |
| ▲ B-022-0-21 | 3.5 | 15.645 | 0.221 | 0.073 | 0.012 | 23 | 12 | 35 | 27 | 3 | 1.29 | 28.09 |
| ★ B-022-1-21 | 1.0 | 0.416 | 0.094 | 0.018 | 0.008 | 1 | 8 | 47 | 40 | 4 | 0.31 | 17.17 |
| ⊙ B-022-1-21 | 3.5 | 1.29 | 0.079 | 0.012 | 0.005 | 6 | 14 | 31 | 42 | 7 | 0.18 | 27.37 |

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889
**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-022-1-21 | 6.0 | **A-3a ~ SILTY SAND with GRAVEL(SM)** | NP | NP | NP |
| ⊠ B-022-2-21 | 3.5 | **A-4a ~ SANDY LEAN CLAY(CL)** | 24 | 15 | 9 |
| ▲ B-022-2-21 | 6.0 | **A-1-a ~ SILTY GRAVEL with SAND(GM)** | NP | NP | NP |
| ★ B-022-3-21 | 6.0 | **A-2-4 ~ SILTY GRAVEL with SAND(GM)** | NP | NP | NP |
| ⊙ B-023-0-21 | 1.0 | **A-2-4 ~ SILTY SAND with GRAVEL(SM)** | NP | NP | NP |

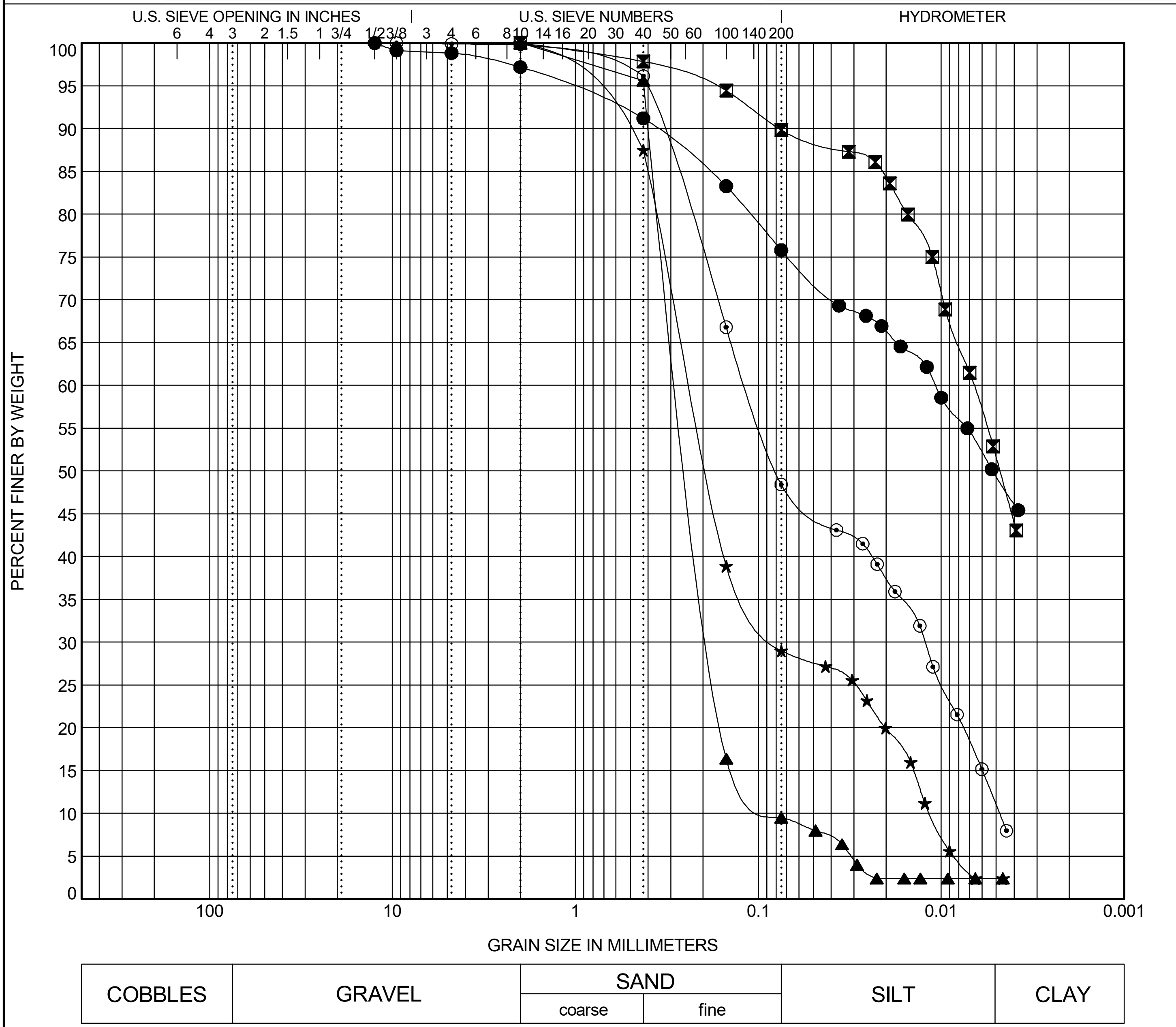
| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-022-1-21 | 6.0 | 15.271 | 0.284 | 0.096 | 0.023 | 24 | 20 | 32 | 20 | 4 | 0.69 | 24.26 |
| ⊠ B-022-2-21 | 3.5 | 0.862 | 0.071 | 0.013 | 0.006 | 3 | 14 | 33 | 44 | 6 | 0.23 | 19.99 |
| ▲ B-022-2-21 | 6.0 | 16.932 | 9.163 | 2.437 | | 72 | 8 | 6 | 14 | | | |
| ★ B-022-3-21 | 6.0 | 20.062 | 1.04 | | | 44 | 13 | 12 | 31 | | | |
| ⊙ B-023-0-21 | 1.0 | 17.129 | 0.391 | 0.188 | 0.019 | 36 | 11 | 36 | 15 | 2 | 1.52 | 64.60 |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-023-0-21** | **10.0** | **A-6b ~ LEAN CLAY with SAND(CL)** | **39** | **19** | **20** |
| ⧗ | **B-023-0-21** | **13.5** | **A-4a ~ LEAN CLAY(CL)** | **25** | **17** | **8** |
| ▲ | **B-024-0-21** | **1.5** | **A-3 ~ POORLY GRADED SAND with SILT(SP-SM)** | **NP** | **NP** | **NP** |
| ★ | **B-024-0-21** | **3.0** | **A-3a ~ SILTY SAND(SM)** | **NP** | **NP** | **NP** |
| ⊙ | **B-026-0-21** | **1.0** | **A-4a ~ SILTY SAND(SM)** | **NP** | **NP** | **NP** |

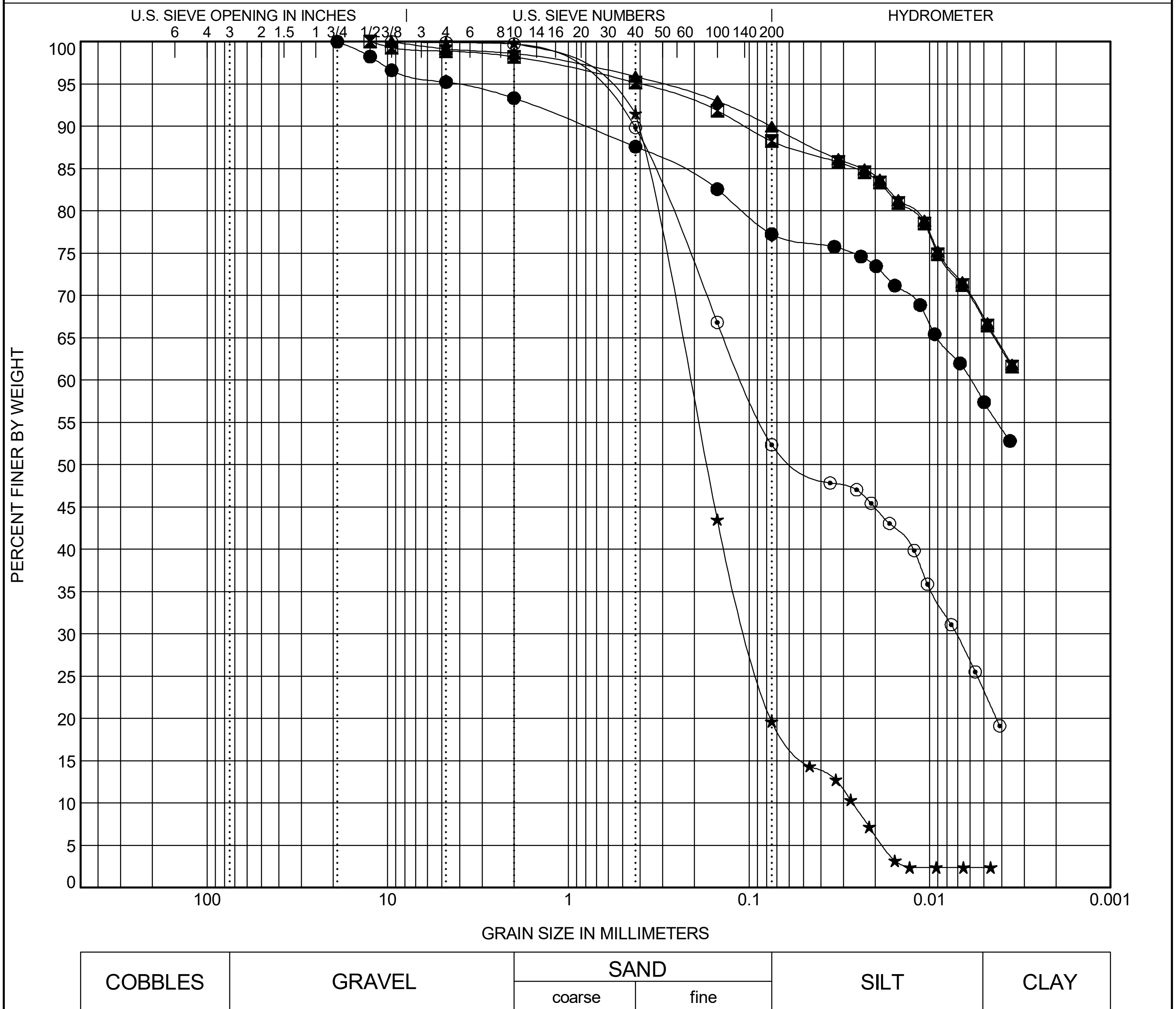
| Specimen Identification | | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-023-0-21** | **10.0** | **0.362** | **0.005** | | | **3** | **6** | **15** | **27** | **49** | | |
| ⧗ | **B-023-0-21** | **13.5** | **0.077** | **0.005** | | | **0** | **2** | **8** | **38** | **52** | | |
| ▲ | **B-024-0-21** | **1.5** | **0.395** | **0.233** | **0.179** | **0.079** | **0** | **4** | **86** | **8** | **2** | **1.53** | **3.37** |
| ★ | **B-024-0-21** | **3.0** | **0.579** | **0.19** | **0.08** | **0.012** | **0** | **12** | **59** | **27** | **2** | **2.38** | **20.49** |
| ⊙ | **B-026-0-21** | **1.0** | **0.342** | **0.08** | **0.012** | **0.005** | **0** | **4** | **48** | **37** | **11** | **0.27** | **24.18** |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-026-0-21 | 4.0 | **A-6a ~ LEAN CLAY with SAND(CL)** | 25 | 14 | 11 |
| ⧗ B-026-0-21 | 6.0 | **A-6a ~ LEAN CLAY(CL)** | 26 | 14 | 12 |
| ▲ B-027-0-21 | 1.0 | **A-6b ~ LEAN CLAY(CL)** | 34 | 16 | 18 |
| ★ B-028-0-21 | 1.0 | **A-3a ~ SILTY SAND(SM)** | NP | NP | NP |
| ⊙ B-028-0-21 | 4.0 | **A-4a ~ SANDY SILTY CLAY(CL-ML)** | 19 | 13 | 6 |

| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-026-0-21 | 4.0 | 0.813 | | | | 7 | 6 | 10 | 20 | 57 | | |
| ⧗ B-026-0-21 | 6.0 | 0.105 | | | | 2 | 3 | 7 | 21 | 67 | | |
| ▲ B-027-0-21 | 1.0 | 0.076 | | | | 1 | 3 | 6 | 23 | 67 | | |
| ★ B-028-0-21 | 1.0 | 0.411 | 0.173 | 0.101 | 0.027 | 0 | 8 | 72 | 18 | 2 | 1.79 | 8.05 |
| ⊙ B-028-0-21 | 4.0 | 0.434 | 0.051 | 0.007 | | 0 | 10 | 38 | 29 | 23 | | |

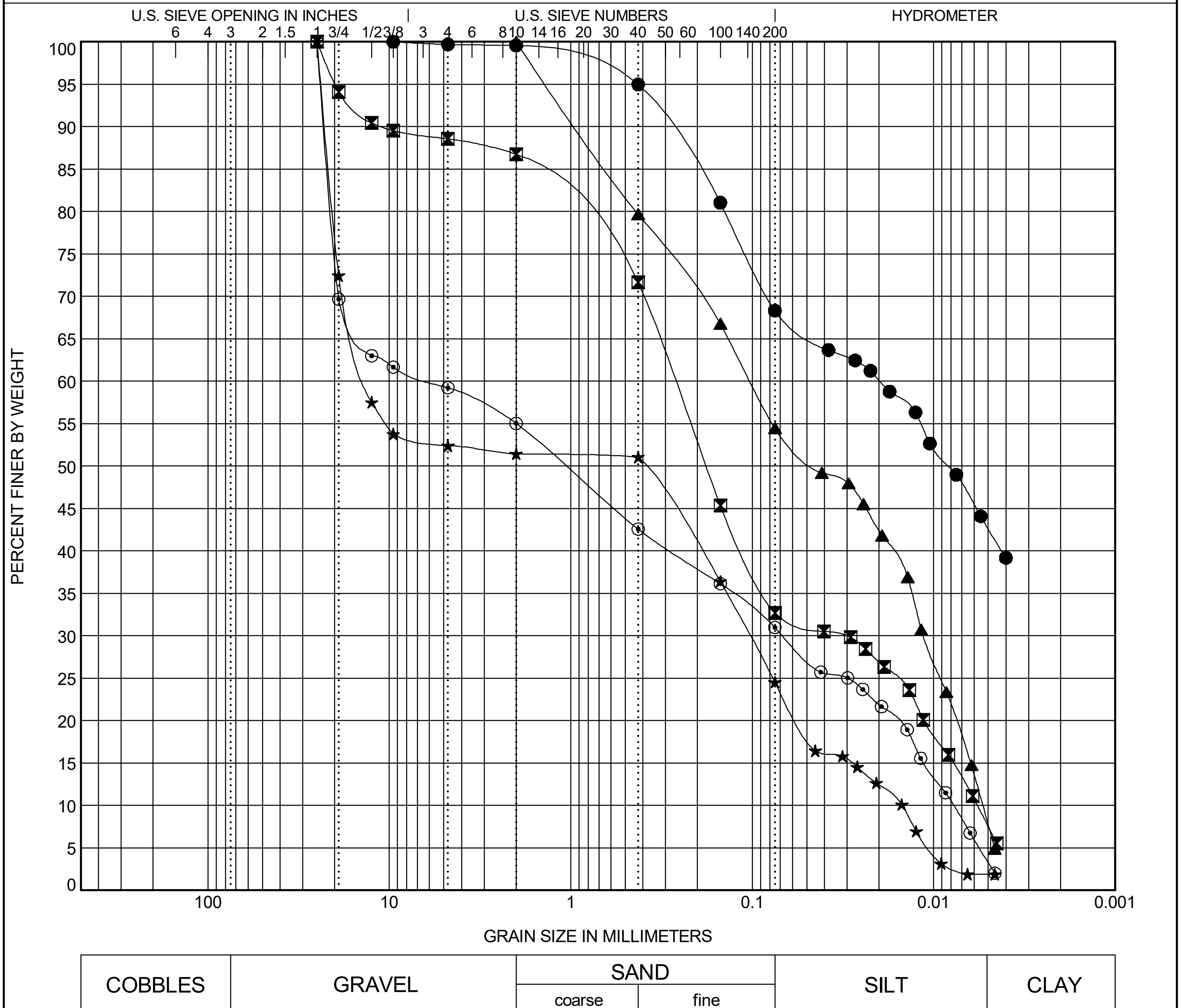
GRAIN SIZE - OH DOT.GDT - 6/16/23 12:45 - S:\PROJECTS\2065201.GPJ

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-028-0-21 | 6.0 | A-6a ~ SANDY LEAN CLAY(CL) | 34 | 21 | 13 |
| ⊠ B-028-0-21 | 8.5 | A-3a ~ SILTY SAND(SM) | NP | NP | NP |
| ▲ B-028-1-21 | 3.5 | A-4a ~ SANDY SILTY CLAY(CL-ML) | 21 | 16 | 5 |
| ★ B-028-1-21 | 6.0 | A-2-4 ~ SILTY, CLAYEY GRAVEL with SAND(GC-GM) | 22 | 16 | 6 |
| ⊙ B-028-1-21 | 8.5 | A-2-4 ~ SILTY, CLAYEY GRAVEL with SAND(GC-GM) | 21 | 17 | 4 |

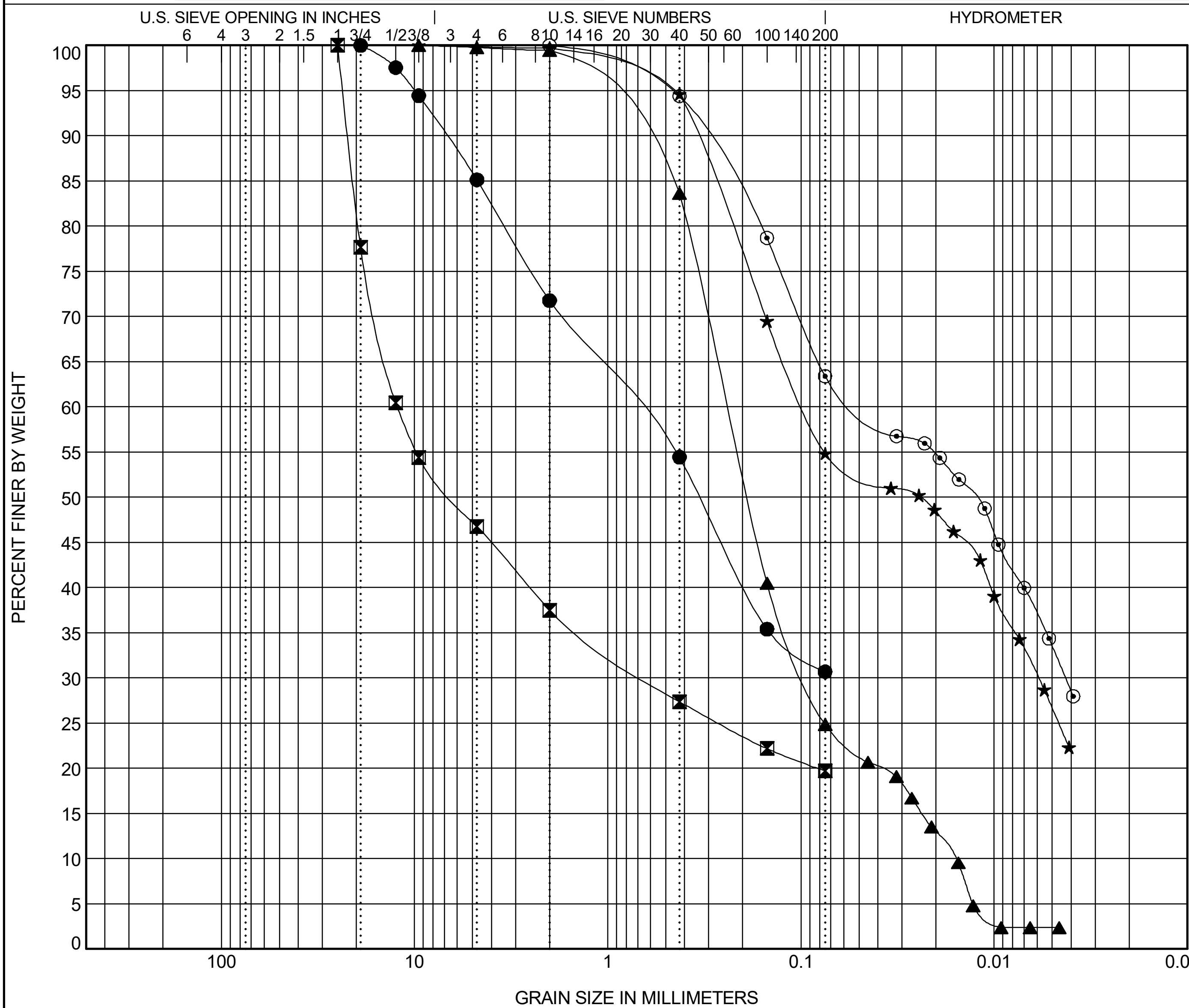
| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-028-0-21 | 6.0 | 0.293 | 0.008 | | | 0 | 5 | 27 | 25 | 43 | | |
| ⊠ B-028-0-21 | 8.5 | 10.945 | 0.18 | 0.031 | 0.006 | 13 | 15 | 39 | 26 | 7 | 0.64 | 46.62 |
| ▲ B-028-1-21 | 3.5 | 0.933 | 0.045 | 0.011 | 0.005 | 0 | 21 | 25 | 46 | 8 | 0.23 | 19.09 |
| ★ B-028-1-21 | 6.0 | 22.629 | 0.394 | 0.103 | 0.015 | 48 | 0 | 27 | 23 | 2 | 0.05 | 899.75 |
| ⊙ B-028-1-21 | 8.5 | 22.837 | 1.069 | 0.067 | 0.008 | 45 | 12 | 12 | 28 | 3 | 0.10 | 757.95 |

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| COBBLES | GRAVEL | SAND | | SILT | CLAY |
|---|---|---|---|---|---|
| | | coarse | fine | | |

| | Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-028-1-21** | **11.0** | **A-2-4 ~ SILTY SAND(SM)** | **NP** | **NP** | **NP** |
| ⧗ | **B-028-2-21** | **0.0** | **A-1-b ~ SILTY GRAVEL with SAND(GM)** | **NP** | **NP** | **NP** |
| ▲ | **B-029-0-21** | **1.0** | **A-3a ~ SILTY SAND(SM)** | **NP** | **NP** | **NP** |
| ★ | **B-029-0-21** | **3.5** | **A-4a ~ SANDY SILT(ML)** | **17** | **14** | **3** |
| ⊙ | **B-029-0-21** | **6.0** | **A-4a ~ SANDY SILTY CLAY(CL-ML)** | **21** | **16** | **5** |

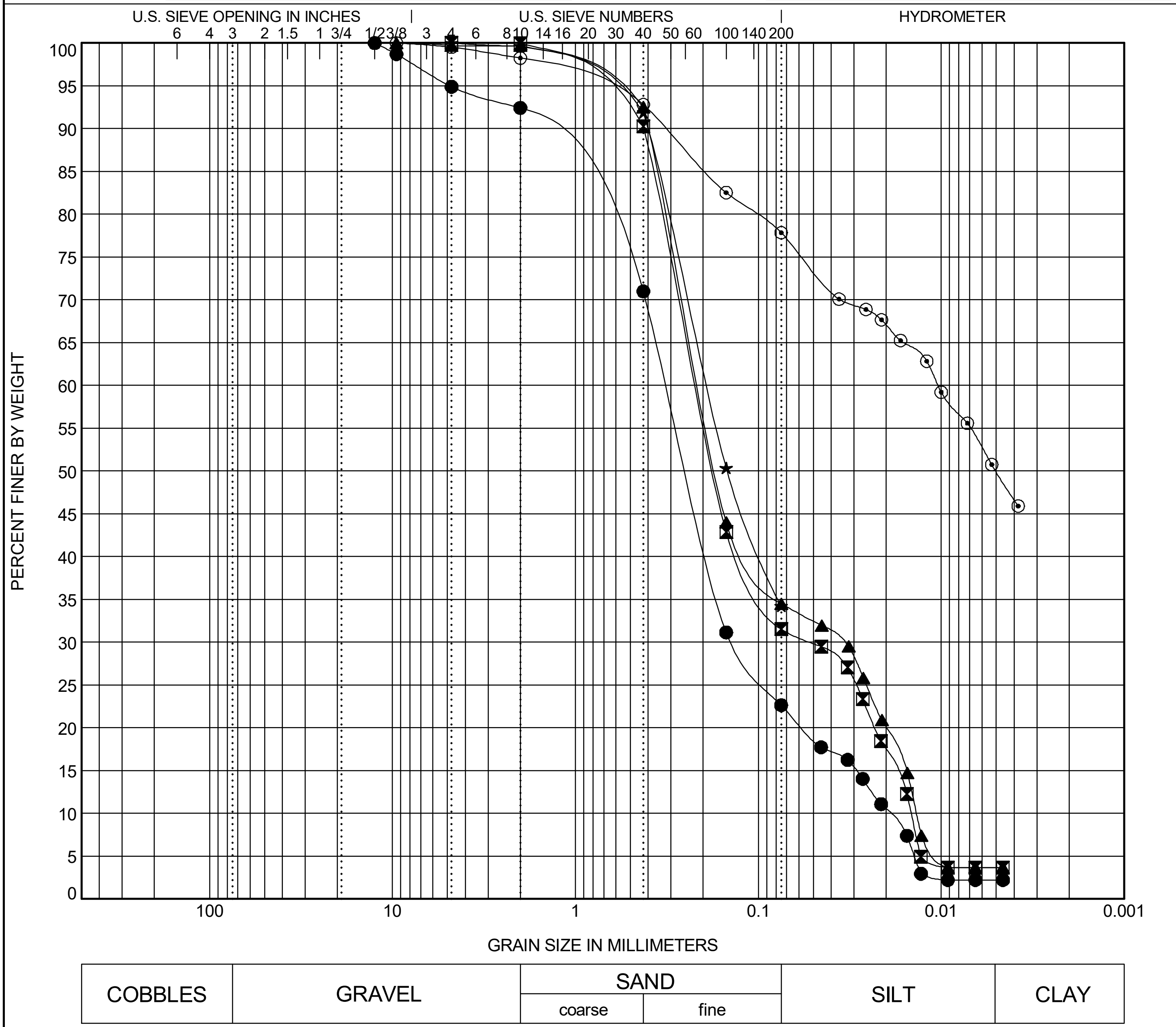
| | Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-028-1-21** | **11.0** | **6.825** | **0.333** | | | **28** | **17** | **24** | **31** | | | |
| ⧗ | **B-028-2-21** | **0.0** | **22.113** | **6.371** | **0.635** | | **62** | **10** | **8** | **20** | | | |
| ▲ | **B-029-0-21** | **1.0** | **0.791** | **0.189** | **0.094** | **0.016** | **0** | **16** | **59** | **23** | **2** | **2.33** | **15.13** |
| ★ | **B-029-0-21** | **3.5** | **0.351** | **0.024** | **0.006** | | **0** | **5** | **40** | **28** | **27** | | |
| ⊙ | **B-029-0-21** | **6.0** | **0.317** | **0.013** | **0.004** | | **0** | **6** | **31** | **29** | **34** | | |

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-029-0-21** | **9.0** | **A-3a ~ SILTY SAND(SM)** | **NP** | **NP** | **NP** |
| ⧗ | **B-029-1-21** | **3.5** | **A-3a ~ SILTY SAND(SM)** | **NP** | **NP** | **NP** |
| ▲ | **B-029-1-21** | **6.0** | **A-3a ~ SILTY SAND(SM)** | **NP** | **NP** | **NP** |
| ★ | **B-029-1-21** | **8.5** | **A-3a ~ SILTY SAND(SM)** | **NP** | **NP** | **NP** |
| ⊙ | **B-029-1-21** | **14.0** | **A-6b ~ LEAN CLAY with SAND(CL)** | **34** | **17** | **17** |

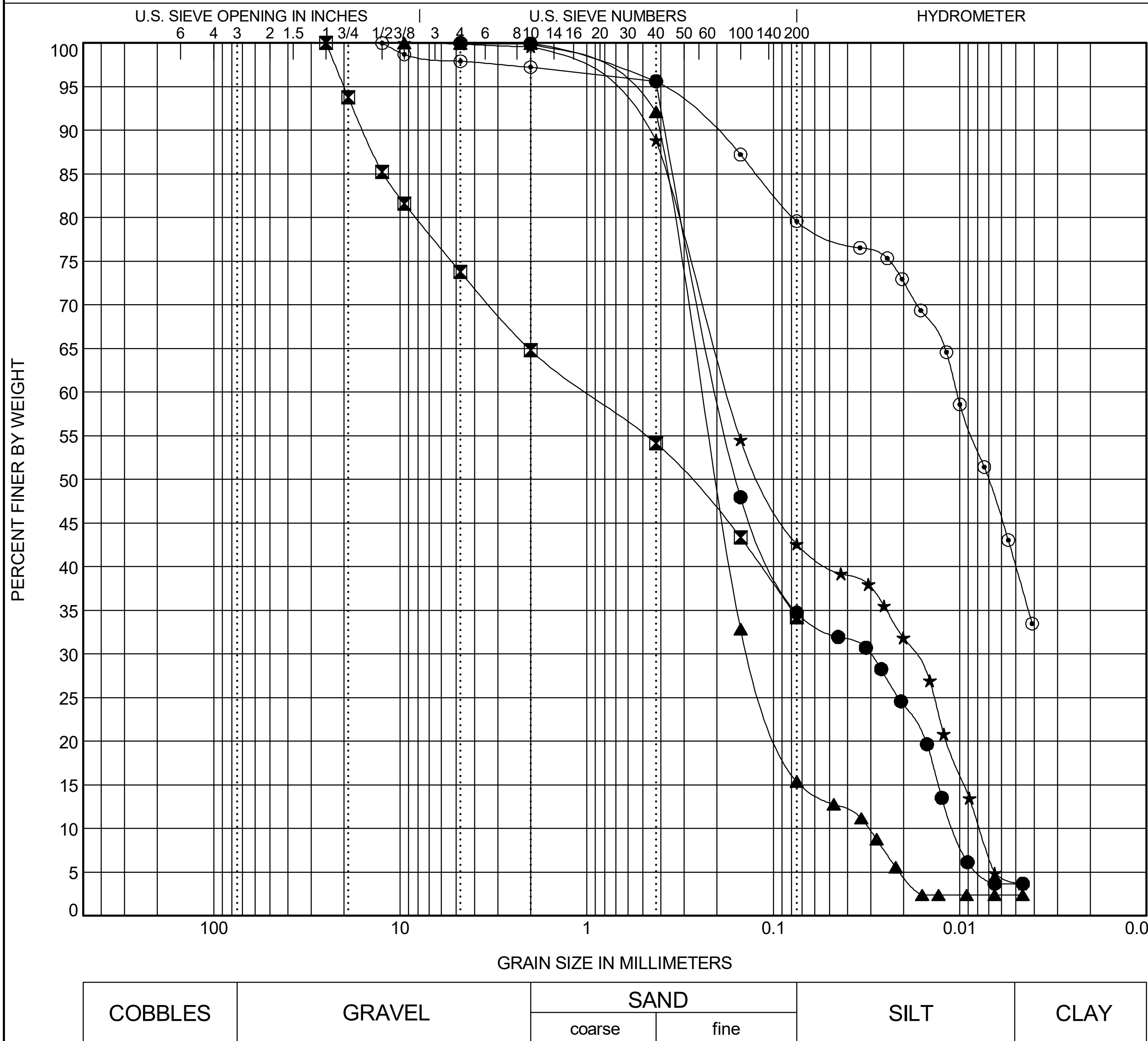
| Specimen Identification | | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-029-0-21** | **9.0** | **1.678** | **0.246** | **0.137** | **0.019** | **8** | **21** | **48** | **21** | **2** | **3.02** | **16.47** |
| ⧗ | **B-029-1-21** | **3.5** | **0.423** | **0.175** | **0.051** | **0.015** | **0** | **9** | **59** | **28** | **4** | **0.83** | **14.99** |
| ▲ | **B-029-1-21** | **6.0** | **0.403** | **0.171** | **0.034** | **0.014** | **0** | **7** | **58** | **31** | **4** | **0.41** | **15.50** |
| ★ | **B-029-1-21** | **8.5** | **0.405** | **0.148** | | | **0** | **8** | **58** | **34** | | | |
| ⊙ | **B-029-1-21** | **14.0** | **0.32** | **0.005** | | | **2** | **5** | **15** | **28** | **50** | | |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-029-1-21 | 16.0 | **A-3a ~ SILTY, CLAYEY SAND(SC-SM)** | 21 | 15 | 6 |
| ⊠ B-029-1-21 | 21.0 | **A-2-4 ~ SILTY SAND with GRAVEL(SM)** | NP | NP | NP |
| ▲ B-030-0-21 | 1.5 | **A-3a ~ SILTY SAND(SM)** | NP | NP | NP |
| ★ B-030-0-21 | 3.4 | **A-4a ~ SILTY SAND(SM)** | NP | NP | NP |
| ⊙ B-031-0-21 | 1.0 | **A-4a ~ SILTY CLAY with SAND(CL-ML)** | 22 | 18 | 4 |

| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-029-1-21 | 16.0 | 0.376 | 0.157 | 0.03 | 0.011 | 0 | 4 | 61 | 31 | 4 | 0.43 | 18.16 |
| ⊠ B-029-1-21 | 21.0 | 15.768 | 0.285 | | | 35 | 11 | 20 | 34 | | | |
| ▲ B-030-0-21 | 1.5 | 0.41 | 0.203 | 0.134 | 0.031 | 0 | 8 | 77 | 13 | 2 | 2.41 | 7.85 |
| ★ B-030-0-21 | 3.4 | 0.5 | 0.115 | 0.018 | 0.008 | 0 | 11 | 46 | 39 | 4 | 0.23 | 22.58 |
| ⊙ B-031-0-21 | 1.0 | 0.212 | 0.007 | | | 2 | 2 | 16 | 40 | 40 | | |

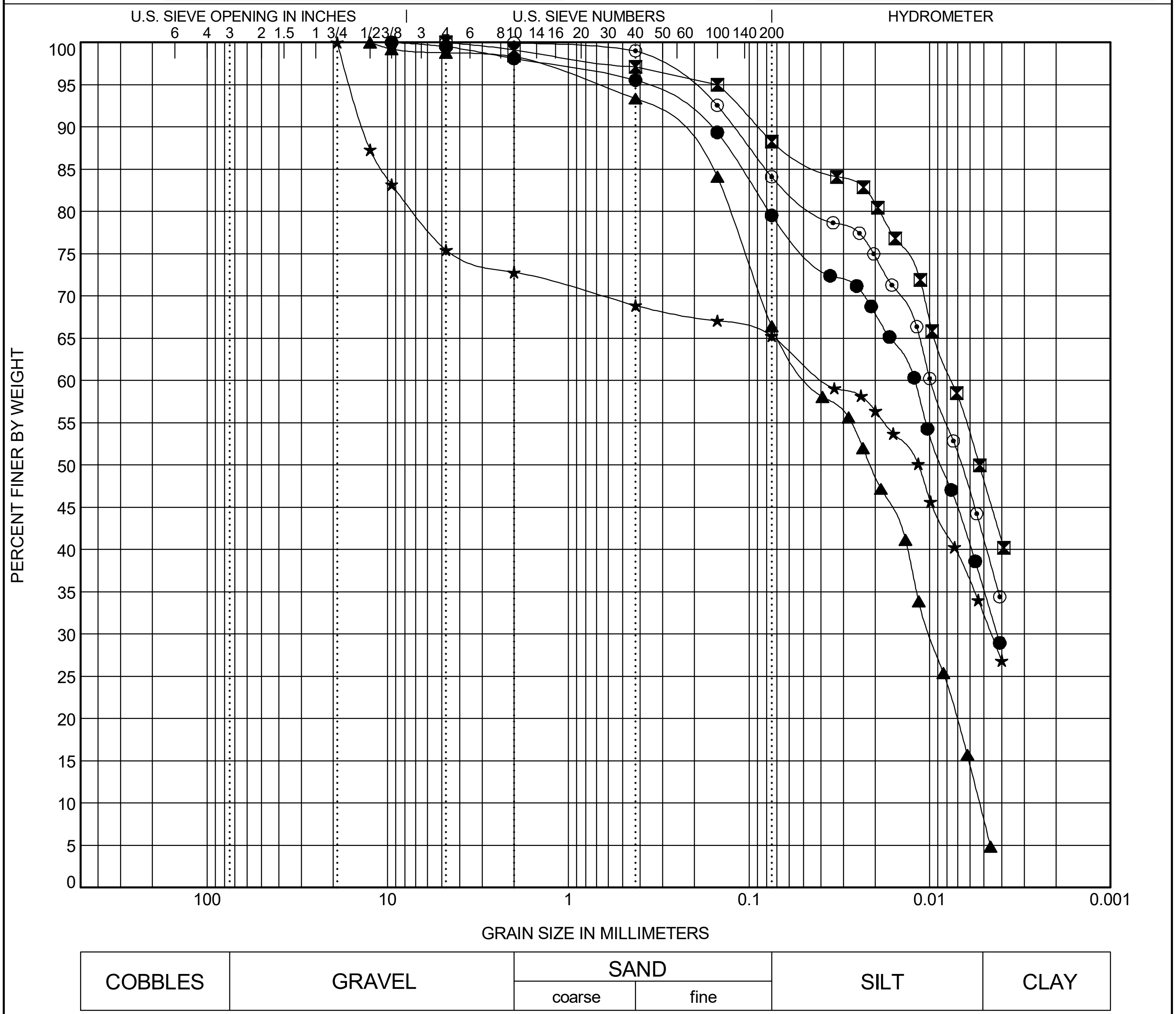
GRAIN SIZE - OH DOT.GDT - 6/16/23 12:48 - S:\PROJECTS\2065201.GPJ

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-031-0-21 | 4.5 | **A-4a ~ SILTY CLAY with SAND(CL-ML)** | 21 | 17 | 4 |
| ⧗ B-031-0-21 | 6.5 | **A-4a ~ SILT(ML)** | 21 | 18 | 3 |
| ▲ B-032-0-21 | 1.0 | **A-4b ~ SANDY SILT(ML)** | 26 | 24 | 2 |
| ★ B-032-0-21 | 5.5 | **A-4a ~ GRAVELLY SILT(ML)** | 25 | 23 | 2 |
| ⊙ B-033-0-21 | 1.0 | **A-4a ~ SILT with SAND(ML)** | 26 | 22 | 4 |

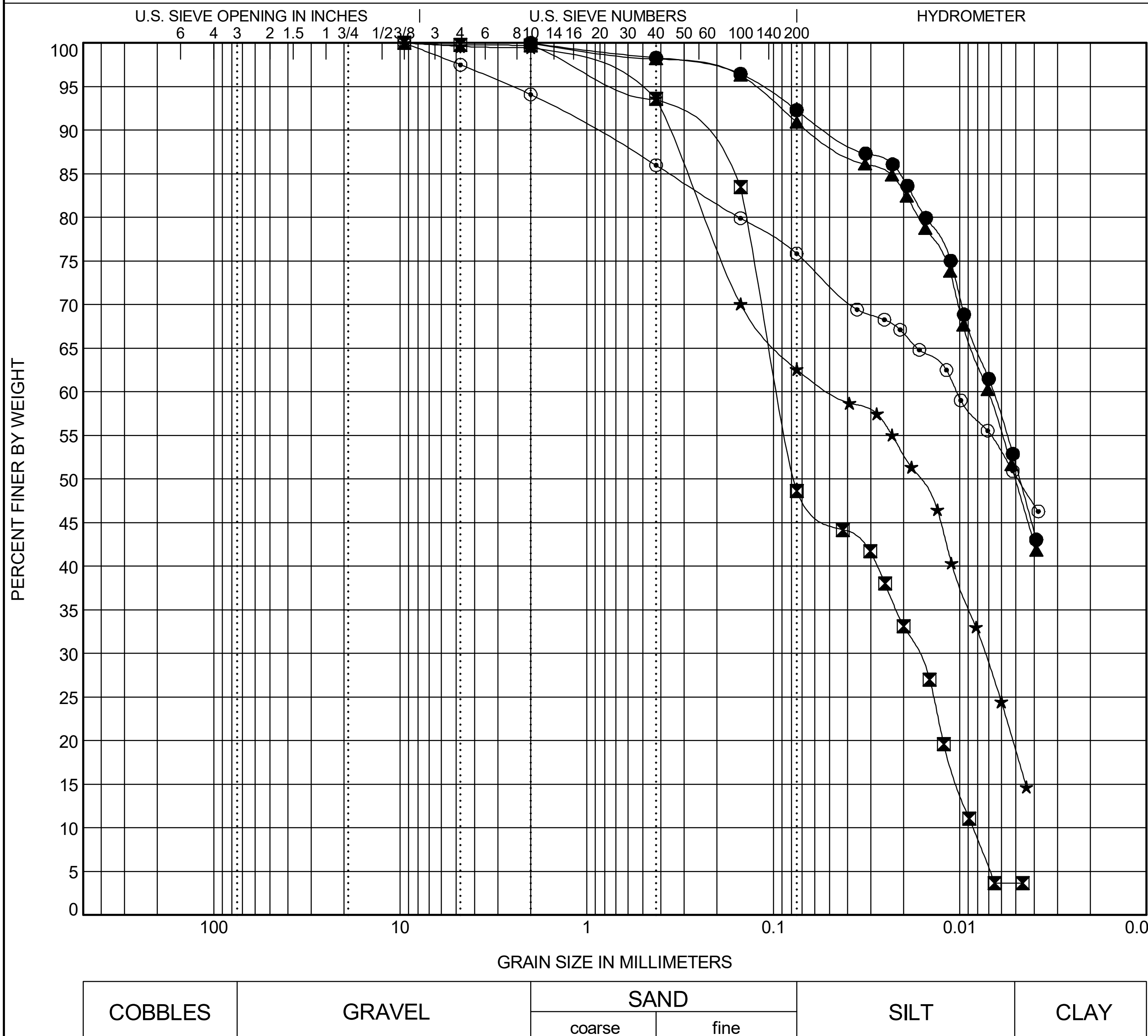
| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-031-0-21 | 4.5 | 0.167 | 0.009 | 0.004 | | 1 | 3 | 16 | 45 | 35 | | |
| ⧗ B-031-0-21 | 6.5 | 0.089 | 0.005 | | | 1 | 2 | 9 | 40 | 48 | | |
| ▲ B-032-0-21 | 1.0 | 0.291 | 0.021 | 0.01 | 0.005 | 2 | 5 | 27 | 58 | 8 | 0.41 | 8.58 |
| ★ B-032-0-21 | 5.5 | 13.663 | 0.012 | 0.005 | | 27 | 4 | 4 | 33 | 32 | | |
| ⊙ B-033-0-21 | 1.0 | 0.122 | 0.007 | | | 0 | 1 | 15 | 43 | 41 | | |

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| | Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-033-0-21** | **2.5** | **A-4a ~ SILT(ML)** | **28** | **25** | **3** |
| ⧗ | **B-034-0-21** | **1.0** | **A-4a ~ SILTY SAND(SM)** | **25** | **23** | **2** |
| ▲ | **B-034-0-21** | **2.5** | **A-4a ~ SILT(ML)** | **24** | **22** | **2** |
| ★ | **B-039-0-21** | **6.0** | **A-4a ~ SANDY SILTY CLAY(CL-ML)** | **20** | **14** | **6** |
| ⊙ | **B-039-0-21** | **11.0** | **A-6a ~ LEAN CLAY with SAND(CL)** | **26** | **15** | **11** |

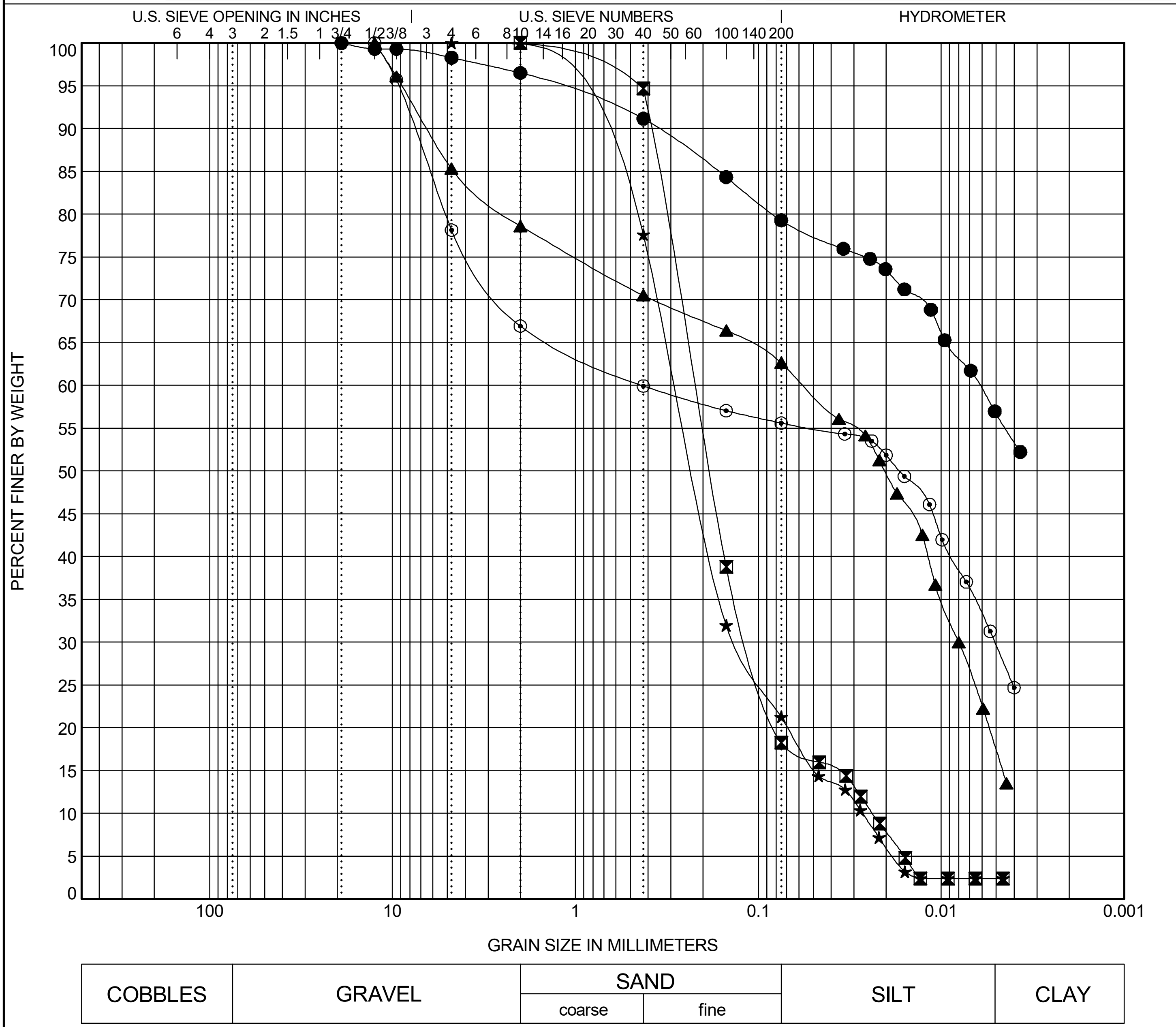
| | Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-033-0-21** | **2.5** | **0.051** | **0.005** | | | **0** | **2** | **6** | **40** | **52** | | |
| ⧗ | **B-034-0-21** | **1.0** | **0.294** | **0.077** | **0.017** | **0.009** | **0** | **6** | **45** | **45** | **4** | **0.36** | **11.04** |
| ▲ | **B-034-0-21** | **2.5** | **0.064** | **0.005** | | | **0** | **2** | **7** | **41** | **50** | | |
| ★ | **B-039-0-21** | **6.0** | **0.362** | **0.017** | **0.007** | | **0** | **6** | **31** | **44** | **19** | | |
| ⊙ | **B-039-0-21** | **11.0** | **0.913** | **0.005** | | | **6** | **8** | **10** | **26** | **50** | | |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-039-1-21 | 9.0 | **A-6a ~ LEAN CLAY with SAND(CL)** | 26 | 14 | 12 |
| ⧗ B-040-0-21 | 1.5 | **A-3a ~ SILTY SAND(SM)** | NP | NP | NP |
| ▲ B-040-0-21 | 4.7 | **A-4a ~ SANDY SILT(ML)** | 21 | 18 | 3 |
| ★ B-041-0-21 | 3.0 | **A-3a ~ SILTY SAND(SM)** | NP | NP | NP |
| ⊙ B-041-0-21 | 4.7 | **A-4a ~ SANDY SILTY CLAY with GRAVEL(CL-ML)** | 23 | 19 | 4 |

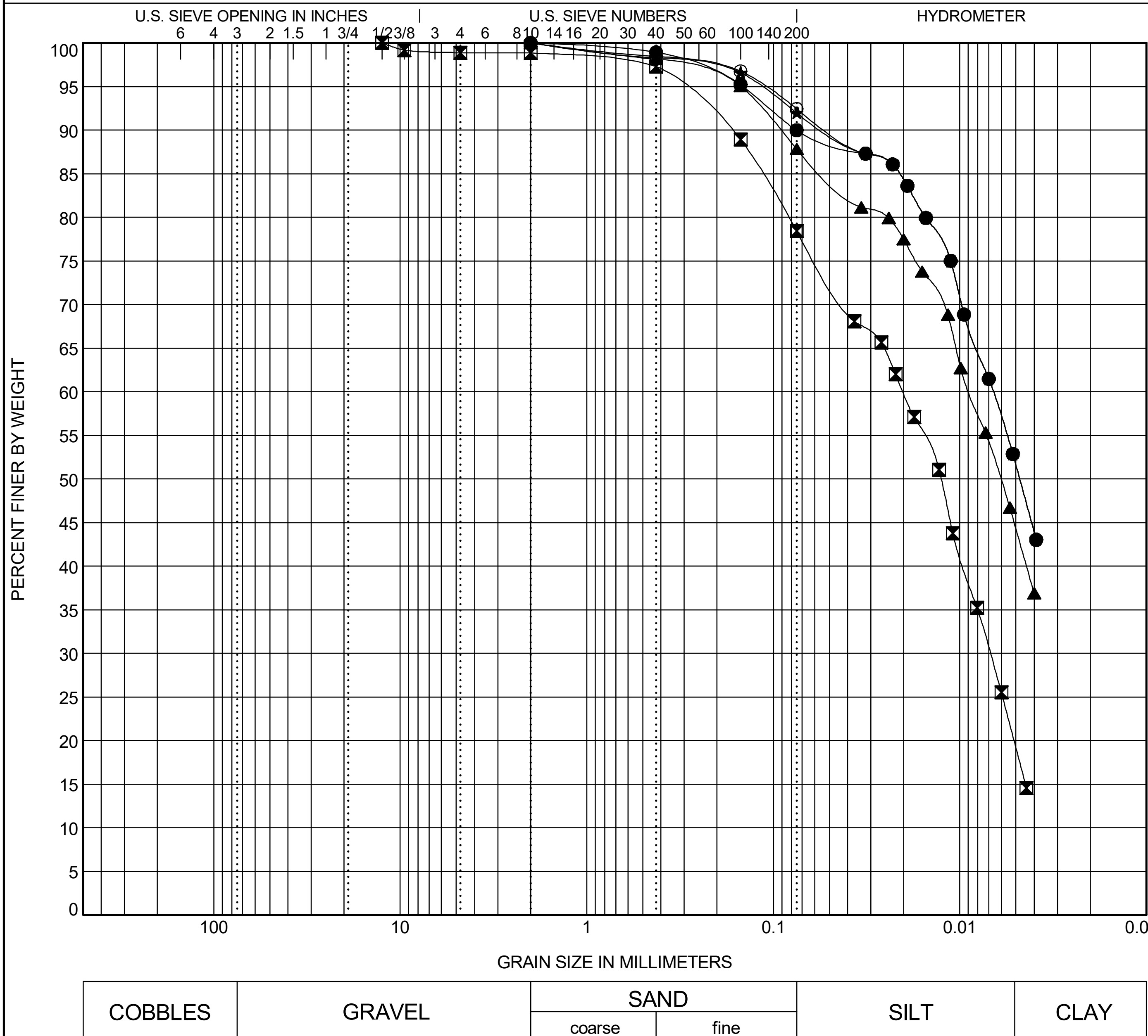
| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-039-1-21 | 9.0 | 0.356 | | | | 4 | 5 | 12 | 22 | 57 | | |
| ⧗ B-040-0-21 | 1.5 | 0.389 | 0.185 | 0.111 | 0.024 | 0 | 6 | 76 | 16 | 2 | 2.35 | 9.38 |
| ▲ B-040-0-21 | 4.7 | 6.422 | 0.02 | 0.008 | | 21 | 8 | 8 | 46 | 17 | | |
| ★ B-041-0-21 | 3.0 | 1.004 | 0.226 | 0.132 | 0.027 | 1 | 22 | 56 | 19 | 2 | 2.28 | 10.56 |
| ⊙ B-041-0-21 | 4.7 | 7.585 | 0.017 | 0.005 | | 33 | 7 | 4 | 26 | 30 | | |

# GRAIN SIZE DISTRIBUTION

**OHIO DEPARTMENT OF TRANSPORTION**
**OFFICE OF GEOTECHNICAL ENGINEERING**

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | **B-043-0-21** | **3.5** | **A-4a ~ SILTY CLAY(CL-ML)** | **22** | **17** | **5** |
| ⊠ | **B-043-0-21** | **6.0** | **A-4b ~ SILT with SAND(ML)** | **21** | **18** | **3** |
| ▲ | **B-043-0-21** | **8.5** | **A-4a ~ LEAN CLAY(CL)** | **29** | **21** | **8** |
| ★ | **B-043-0-21** | **13.5** | **A-4a ~ SILTY CLAY(CL-ML)** | **25** | **19** | **6** |
| ⊙ | **B-043-0-21** | **16.0** | **A-4a ~ SILTY CLAY(CL-ML)** | **24** | **18** | **6** |

| Specimen Identification | | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-043-0-21** | **3.5** | **0.075** | **0.005** | | | **0** | **1** | **9** | **38** | **52** | | |
| ⊠ | **B-043-0-21** | **6.0** | **0.171** | **0.013** | **0.007** | | **1** | **2** | **19** | **59** | **19** | | |
| ▲ | **B-043-0-21** | **8.5** | **0.092** | **0.006** | | | **0** | **2** | **10** | **44** | **44** | | |
| ★ | **B-043-0-21** | **13.5** | **0.052** | **0.005** | | | **0** | **2** | **6** | **40** | **52** | | |
| ⊙ | **B-043-0-21** | **16.0** | **0.05** | **0.005** | | | **0** | **2** | **6** | **40** | **52** | | |

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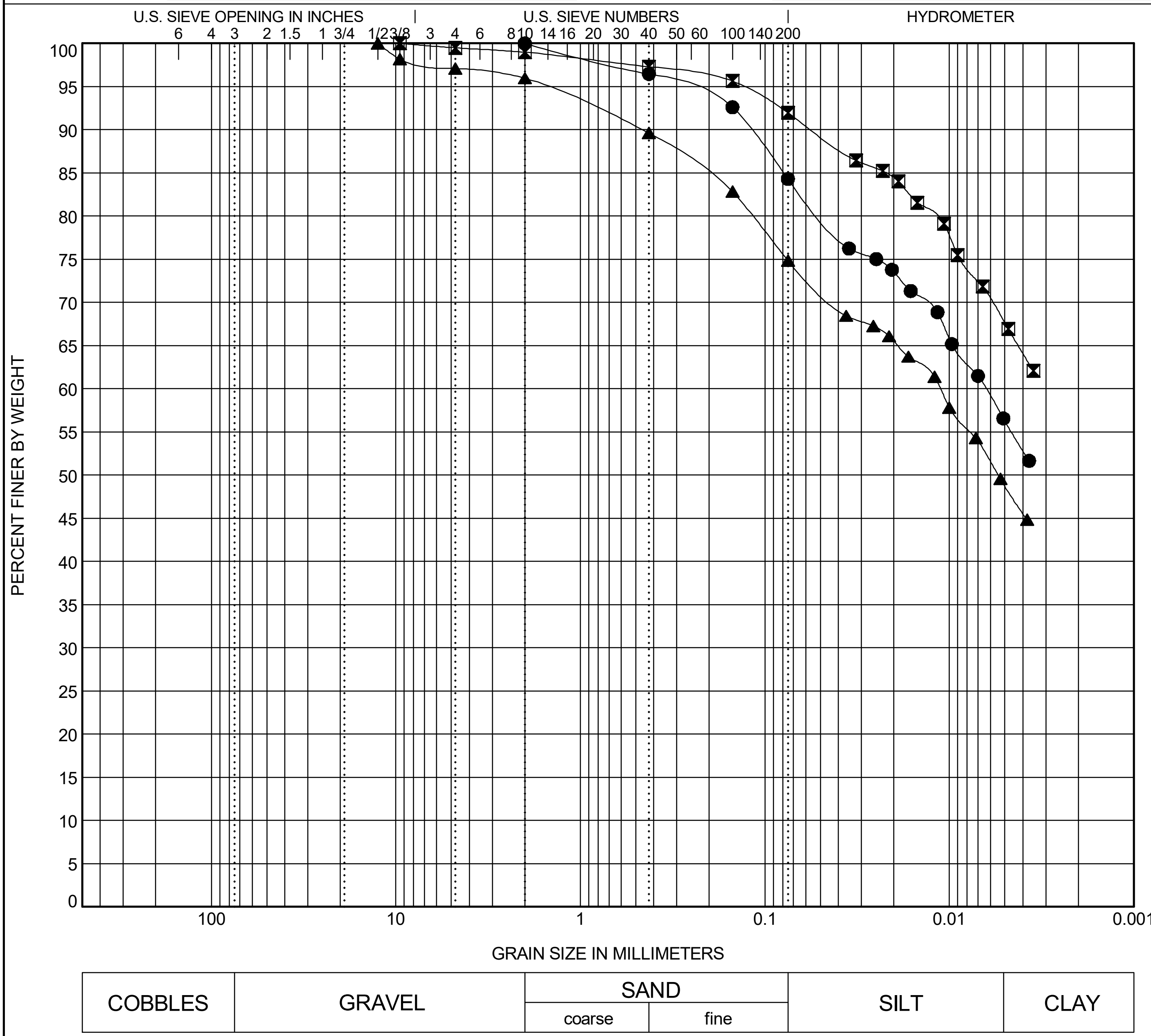
# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** LUC-23-11.75 **PID** 105889

**OGE NUMBER** N/A **PROJECT TYPE** ROADWAY




| Specimen Identification | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|
| ● B-043-0-21 | 18.5 | **A-6a ~ LEAN CLAY with SAND(CL)** | 30 | 19 | 11 |
| ⧗ B-043-0-21 | 21.4 | **A-7-6 ~ LEAN CLAY(CL)** | 42 | 22 | 20 |
| ▲ B-043-0-21 | 23.5 | **A-6a ~ LEAN CLAY with SAND(CL)** | 32 | 19 | 13 |
| | | | | | |
| | | | | | |

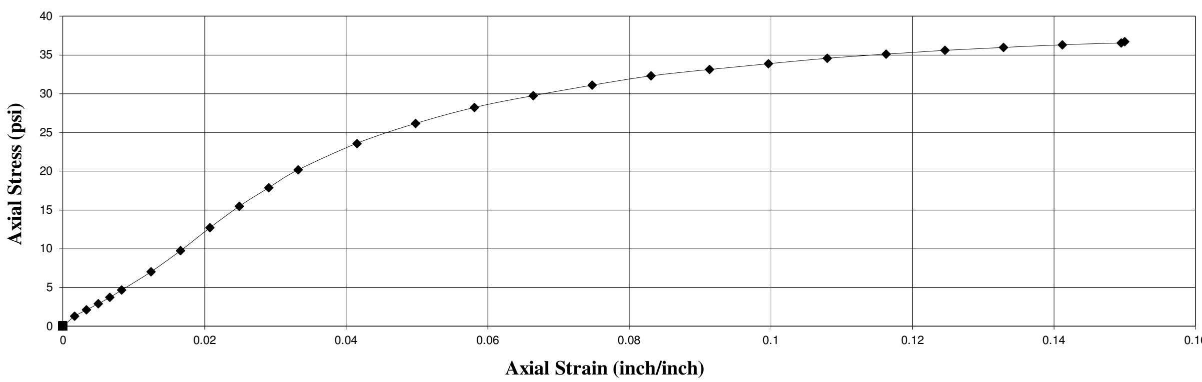
| Specimen Identification | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● B-043-0-21 | 18.5 | 0.121 | | | | 0 | 4 | 12 | 28 | 56 | | |
| ⧗ B-043-0-21 | 21.4 | 0.055 | | | | 1 | 2 | 5 | 24 | 68 | | |
| ▲ B-043-0-21 | 23.5 | 0.466 | 0.005 | | | 4 | 6 | 15 | 26 | 49 | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

## Unconsolidated - Undrained Triaxial Shear Strength Test

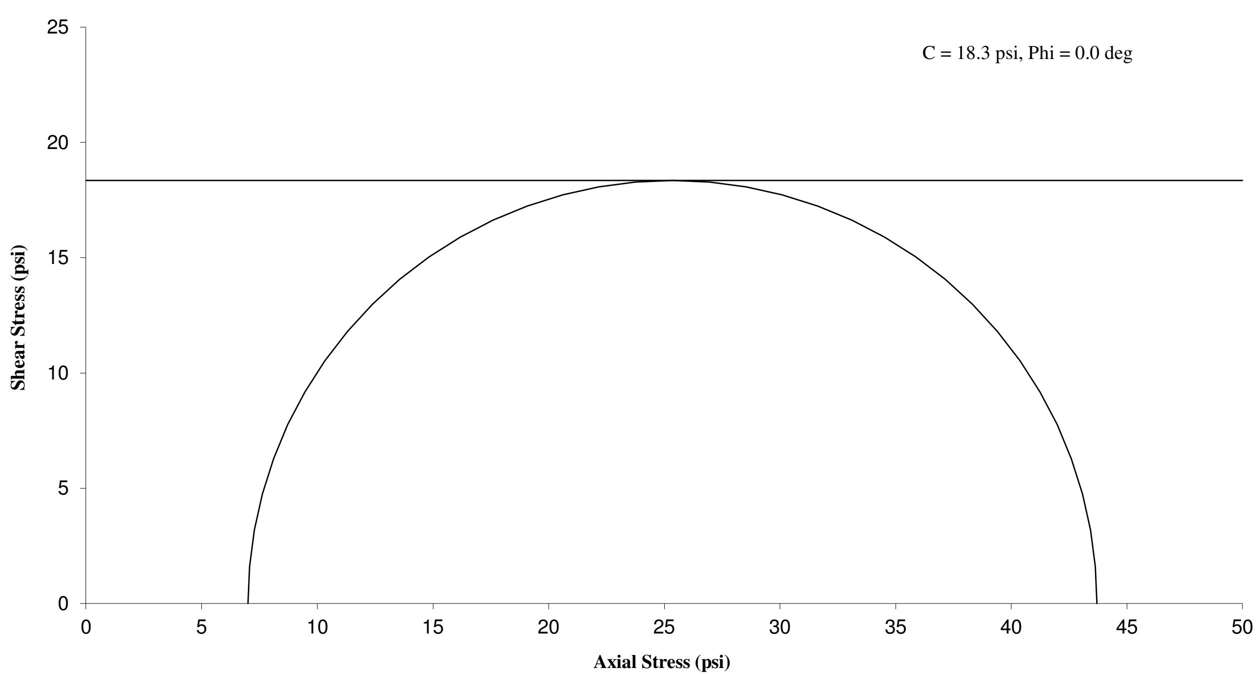
**ASTM D 2850**

| General Sample Data | | Triaxial Specimen Data | | | |
|---|---|---|---|---|---|
| TTL Project No.: | 2065201 | Symbol | ◆ | ■ | ● |
| Project: | LUC-23-11.75 | Init. Specimen Height (in.) | 6.02 | - | - |
| Sample ID: | B-039-1-21 ST-1 | Init. Specimen Diameter (in.) | 2.88 | - | - |
| Sample Interval: | 9.0 - 11.0' | Init. Moisture Content* (%) | 14.1 | - | - |
| Soil Description: | Gray SILT and CLAY, Little Sand, Trace Gravel A-6a (9) | Init. Dry Unit Weight (pcf) | 120.4 | - | - |
| Liquid Limit: | 26 | Init. Void Ratio | 0.42 | - | - |
| Plastic Limit: | 14 | Init. Degree of Saturation (%) | 92 | - | - |
| Plasticity Index: | 12 | Minor Principal Stress (psi) | 7.0 | - | - |
| Specific Gravity: | 2.739 | Deviator Stress at Failure (psi) | 36.7 | - | - |
| Rate of Strain: | 0.03 Inches per Minute | Major Principal Stress (psi) | 43.7 | - | - |
| Failure Criteria: | Peak Deviator Stress or Deviator Stress at 15% Axial Strain | Axial Strain at Failure (%) | 15.0 | - | - |

### Stress/Strain




### Mohr Circle Plot



## UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH
## OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project: LUC-23-11.75 Date: 2/28/2023

Client: ODOT File: 2065201B-039-1-21ST-1

Sample ID: B-039-1-21 ST-1 Depth: 9.0 - 11.0'

TTL Project No.: 2065201 Specimen ID: "C" (10.0 - 10.5 Feet)

### SAMPLE PROPERTIES

Visual Description: Gray SILT and CLAY, Little Sand, Trace Gravel A-6a (9)

Diameter: 2.88 in. Initial Dry Unit Weight of Sample: 120.4 pcf

Area: 6.514 in^2 Initial Moisture Content: 14.1 %

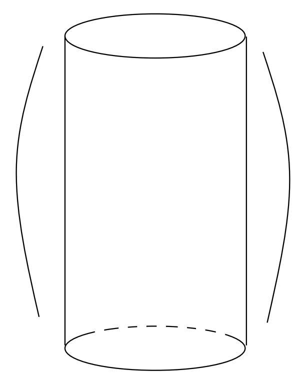
Length: 6.02 in. Specific Gravity: 2.739

Initial Void Ratio: 0.42 Initial Degree of Saturation: 92 %

Chamber Pressure: 7 psi Proving Ring Number: 1155-12-13322

### STRESS-STRAIN DATA

| Speciman Deformation (in) | Vertical Strain | Proving Ring Reading | Piston Load (lbs) | Corrected Area (in^2) | Deviator Stress (psi) |
|---|---|---|---|---|---|
| 0.000 | 0.000 | 0.0 | 0.0 | 6.514 | 0.0 |
| 0.010 | 0.002 | 12.0 | 8.2 | 6.525 | 1.3 |
| 0.020 | 0.003 | 20.0 | 13.7 | 6.536 | 2.1 |
| 0.030 | 0.005 | 27.5 | 18.9 | 6.547 | 2.9 |
| 0.040 | 0.007 | 35.5 | 24.4 | 6.558 | 3.7 |
| 0.050 | 0.008 | 44.5 | 30.5 | 6.569 | 4.6 |
| 0.075 | 0.012 | 67.5 | 46.3 | 6.597 | 7.0 |
| 0.100 | 0.017 | 94.0 | 64.5 | 6.624 | 9.7 |
| 0.125 | 0.021 | 123.0 | 84.4 | 6.653 | 12.7 |
| 0.150 | 0.025 | 150.5 | 103.2 | 6.681 | 15.5 |
| 0.175 | 0.029 | 174.5 | 119.7 | 6.709 | 17.8 |
| 0.200 | 0.033 | 198.0 | 135.8 | 6.738 | 20.2 |
| 0.250 | 0.042 | 233.5 | 160.2 | 6.797 | 23.6 |
| 0.300 | 0.050 | 261.5 | 179.4 | 6.856 | 26.2 |
| 0.350 | 0.058 | 284.5 | 195.2 | 6.917 | 28.2 |
| 0.400 | 0.066 | 302.5 | 207.5 | 6.978 | 29.7 |
| 0.450 | 0.075 | 319.0 | 218.8 | 7.041 | 31.1 |
| 0.500 | 0.083 | 334.5 | 229.5 | 7.104 | 32.3 |
| 0.550 | 0.091 | 346.0 | 237.4 | 7.169 | 33.1 |
| 0.600 | 0.100 | 357.0 | 244.9 | 7.236 | 33.8 |
| 0.650 | 0.108 | 368.0 | 252.4 | 7.303 | 34.6 |
| 0.700 | 0.116 | 377.0 | 258.6 | 7.372 | 35.1 |
| 0.750 | 0.125 | 386.0 | 264.8 | 7.441 | 35.6 |
| 0.800 | 0.133 | 394.0 | 270.3 | 7.513 | 36.0 |
| 0.850 | 0.141 | 401.5 | 275.4 | 7.585 | 36.3 |
| 0.900 | 0.150 | 408.0 | 279.9 | 7.660 | 36.5 |
| 0.903 | 0.150 | 410.0 | 281.3 | 7.664 | 36.7 |
| | | | | | |
| | | | | | |



Sketch of Tested Specimen

### RESULTS

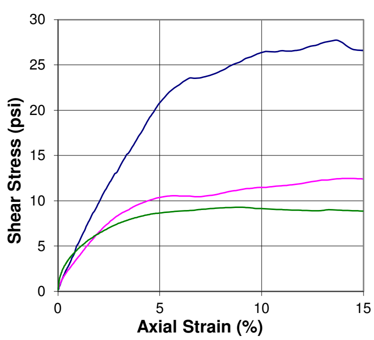
Maximum Deviator Stress 36.7 psi

# Consolidated - Undrained Triaxial Shear Strength Test
**ASTM D 4767**

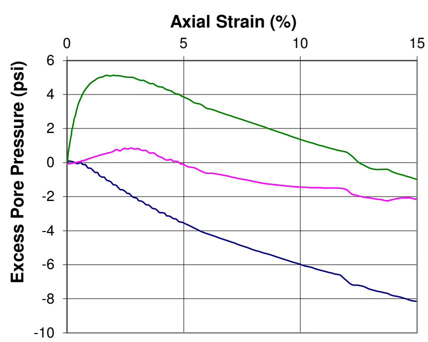
| General Sample Data | | Triaxial Specimen Data | | | |
|---|---|---|---|---|---|
| 6 Project No.: | 2065201 | Plot Color Designation | Blue - B | Purple - C | Green - D |
| Project: | LUC-023-11 75 | Initial Specimen Height (in.) | 5.75 | 5.98 | 5.98 |
| Sample ID: | B-014-1-21 (ST-2) | Initial Specimen Diameter (in.) | 2.88 | 2.88 | 2.88 |
| Sample Interval: | (6.0' - 8.0') | Initial Moisture Content* (%) | 17.7 | 17.7 | 17.7 |
| Soil Description: | Brown Sandy Silt "And" Clay A-4a (8) | Initial Dry Unit Weight (pcf) | 108.0 | 107.2 | 103.1 |
| | | Initial Void Ratio | 0.44 | 0.46 | 0.51 |
| | | Initial Degree of Saturation (%) | 99 | 97 | 86 |
| Liquid Limit: | 26 | | | | |
| Plastic Limit: | 24 | Consolidation Stress | 3 psi | 6 psi | 12 psi |
| Plasticity Index: | 2 | Deviator Stress at Failure (psi) | 55.5 | 25.0 | 18.6 |
| Specific Gravity: | 2.50 (Assumed) | Eff. Minor Principal Stress (psi) | 10.7 | 7.6 | 8.9 |
| Rate of Strain: | 0.00047 Inches per Minute | Eff. Major Principal Stress (psi) | 66.2 | 32.6 | 27.5 |
| Failure Criteria: | Peak Deviator Stress or Deviator Stress at 15% Axial Strain | Axial Strain at Failure (%) | 13.7 | 14.2 | 9.0 |

*Initial Moisture Content from specimen trimings

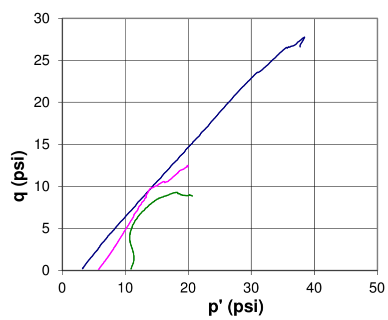
**Stress/Strain**



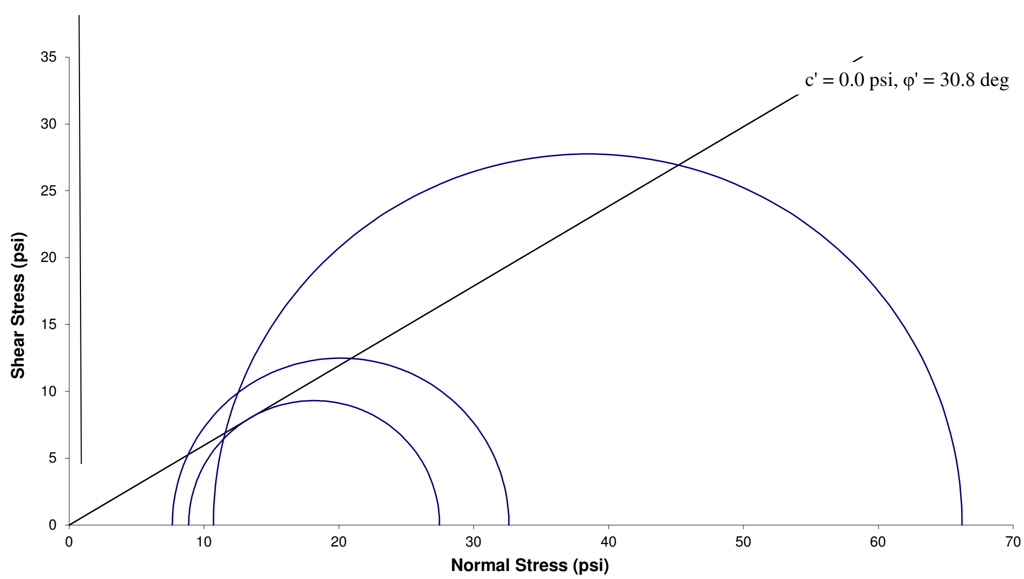

**Pore Pressure/Strain**




**Effective Stress Path**




**Effective Stress Mohr Circle Plot**



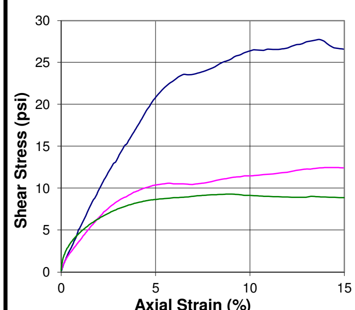
# Consolidated - Undrained Triaxial Shear Strength Test

**ASTM D 4767**

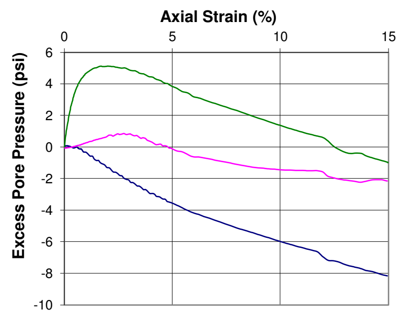
| General Sample Data | | Triaxial Specimen Data | | | |
|---|---|---|---|---|---|
| 6 Project No.: | 2065201 | Plot Color Designation | Blue - B | Purple - C | Green - D |
| Project: | LUC-023-11 75 | Initial Specimen Height (in.) | 5.75 | 5.98 | 5.98 |
| Sample ID: | B-014-1-21 (ST-2) | Initial Specimen Diameter (in.) | 2.88 | 2.88 | 2.88 |
| Sample Interval: | (6.0' - 8.0') | Initial Moisture Content* (%) | 17.7 | 17.7 | 17.7 |
| | | Initial Dry Unit Weight (pcf) | 108.0 | 107.2 | 103.1 |
| Soil Description: | Brown Sandy Silt "And" Clay A-4a (8) | Initial Void Ratio | 0.44 | 0.46 | 0.51 |
| | | Initial Degree of Saturation (%) | 99 | 97 | 86 |
| Liquid Limit: | 26 | | | | |
| Plastic Limit: | 24 | Consolidation Stress | 3 psi | 6 psi | 12 psi |
| Plasticity Index: | 2 | Deviator Stress at Failure (psi) | 55.5 | 25.0 | 18.6 |
| Specific Gravity: | 2.50 (Assumed) | Minor Principal Stress (psi) | 3.0 | 5.6 | 10.7 |
| Rate of Strain: | 0.00047 Inches per Minute | Major Principal Stress (psi) | 58.5 | 30.5 | 29.3 |
| Failure Criteria: | Peak Deviator Stress or Deviator Stress at 15% Axial Strain | Axial Strain at Failure (%) | 13.7 | 14.2 | 9.0 |

*Initial Moisture Content from specimen trimings

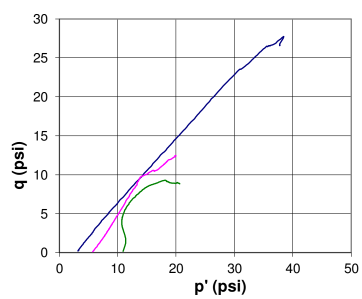
**Stress/Strain**



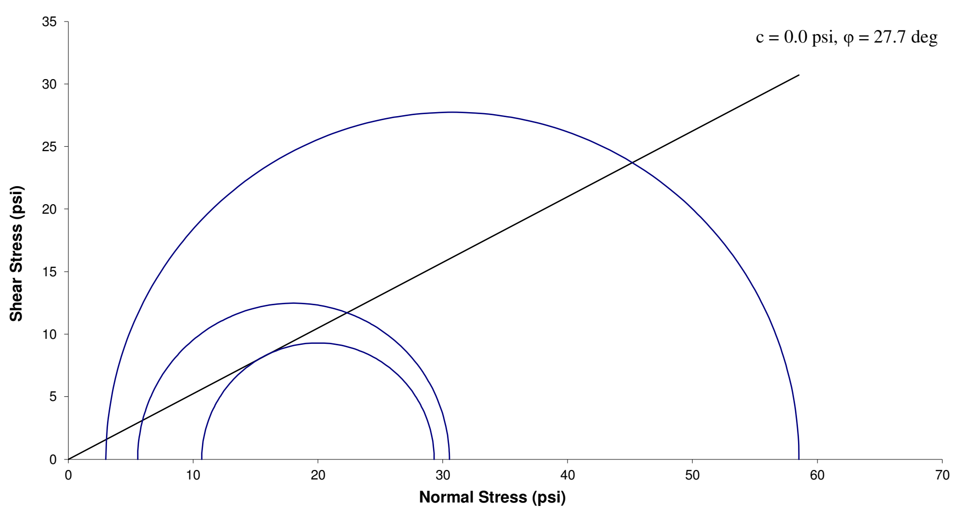

**Pore Pressure/Strain**




**Effective Stress Path**




**Total Stress Mohr Circle Plot**



**CONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH**
**OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 4767)**

Project: LUC-023-11 75
Date: 5/8/2023
Client: Arcadis
File: 2065201_B-014-1_ST-2_CU
Sample ID: B-014-1-21 (ST-2)
Sample Depth: (6.0' - 8.0') (Portion from 6.5' to 7.0')
6 Project No.: 2065201
Specimen ID: B-014-1-21 (ST-2 - B )

**SAMPLE PROPERTIES**

Visual Description: Brown Sandy Silt "And" Clay A-4a (8)

Diameter: 2.88 in.
Initial Dry Unit Weight of Sample: 108.0 pcf
Area: 6.51 $in^2$
Initial Moisture Content: 17.7 %
Length: 5.75 in.
Specific Gravity (Assumed): 2.50
Initial Void Ratio: 0.44
Initial Degree of Saturation: 99 %
Consolidation Stress: 3 psi
External Load Cell: 726856 (200 lbs.)

**STRESS-STRAIN DATA**

| Elapsed Time (min.) | Vertical Load (lbs) | DCDT (inch) | Pore Pressure (psi) | Cell Pressure (psi) | Axial Strain (%) | $\sigma_1'$ (psi) | $\sigma_3'$ (psi) | Obliquity | q (psi) | p' (psi) | Excess Pore Pr. (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 56.52 | 0.0000 | 20.13 | 23.14 | 0.00 | 3.71 | 3.01 | 1.23 | 0.35 | 3.36 | 0.00 |
| 3.0 | 55.05 | 0.0014 | 20.18 | 23.14 | 0.03 | 3.43 | 2.96 | 1.16 | 0.24 | 3.19 | 0.05 |
| 6.0 | 57.56 | 0.0027 | 20.21 | 23.15 | 0.05 | 3.80 | 2.94 | 1.29 | 0.43 | 3.37 | 0.08 |
| 9.0 | 59.73 | 0.0043 | 20.22 | 23.15 | 0.07 | 4.12 | 2.93 | 1.41 | 0.60 | 3.52 | 0.09 |
| 12.0 | 61.85 | 0.0059 | 20.23 | 23.15 | 0.10 | 4.45 | 2.93 | 1.52 | 0.76 | 3.69 | 0.09 |
| 15.0 | 63.83 | 0.0069 | 20.22 | 23.16 | 0.12 | 4.76 | 2.94 | 1.62 | 0.91 | 3.85 | 0.09 |
| 18.0 | 65.72 | 0.0085 | 20.21 | 23.15 | 0.15 | 5.05 | 2.94 | 1.72 | 1.06 | 3.99 | 0.08 |
| 21.0 | 67.64 | 0.0101 | 20.21 | 23.15 | 0.17 | 5.35 | 2.94 | 1.82 | 1.20 | 4.15 | 0.08 |
| 24.0 | 69.50 | 0.0114 | 20.20 | 23.16 | 0.20 | 5.65 | 2.96 | 1.91 | 1.34 | 4.30 | 0.07 |
| 27.0 | 71.25 | 0.0130 | 20.19 | 23.16 | 0.23 | 5.93 | 2.97 | 1.99 | 1.48 | 4.45 | 0.06 |
| 30.0 | 72.89 | 0.0140 | 20.18 | 23.17 | 0.24 | 6.19 | 2.98 | 2.07 | 1.60 | 4.59 | 0.05 |
| 33.0 | 74.59 | 0.0154 | 20.17 | 23.17 | 0.27 | 6.46 | 3.00 | 2.16 | 1.73 | 4.73 | 0.04 |
| 36.0 | 76.32 | 0.0171 | 20.16 | 23.18 | 0.30 | 6.75 | 3.02 | 2.24 | 1.87 | 4.88 | 0.02 |
| 39.0 | 77.97 | 0.0183 | 20.14 | 23.16 | 0.32 | 7.00 | 3.02 | 2.32 | 1.99 | 5.01 | 0.01 |
| 42.0 | 79.77 | 0.0200 | 20.13 | 23.16 | 0.35 | 7.29 | 3.03 | 2.40 | 2.13 | 5.16 | 0.00 |
| 45.0 | 81.40 | 0.0212 | 20.11 | 23.17 | 0.37 | 7.56 | 3.06 | 2.47 | 2.25 | 5.31 | -0.02 |
| 48.1 | 82.73 | 0.0225 | 20.10 | 23.17 | 0.39 | 7.78 | 3.08 | 2.53 | 2.35 | 5.43 | -0.03 |
| 51.1 | 83.63 | 0.0239 | 20.08 | 23.18 | 0.42 | 7.94 | 3.10 | 2.56 | 2.42 | 5.52 | -0.05 |
| 54.1 | 85.12 | 0.0253 | 20.08 | 23.17 | 0.44 | 8.16 | 3.09 | 2.64 | 2.53 | 5.62 | -0.05 |
| 57.1 | 86.81 | 0.0269 | 20.09 | 23.16 | 0.47 | 8.40 | 3.08 | 2.73 | 2.66 | 5.74 | -0.04 |
| 60.1 | 88.56 | 0.0288 | 20.10 | 23.16 | 0.50 | 8.66 | 3.07 | 2.82 | 2.80 | 5.86 | -0.03 |
| 63.1 | 90.20 | 0.0306 | 20.11 | 23.17 | 0.53 | 8.89 | 3.05 | 2.91 | 2.92 | 5.97 | -0.02 |
| 66.1 | 91.83 | 0.0321 | 20.13 | 23.17 | 0.56 | 9.12 | 3.03 | 3.01 | 3.04 | 6.08 | 0.00 |
| 69.1 | 93.41 | 0.0333 | 20.14 | 23.17 | 0.58 | 9.36 | 3.03 | 3.09 | 3.16 | 6.20 | 0.01 |
| 72.1 | 94.77 | 0.0349 | 20.12 | 23.18 | 0.61 | 9.59 | 3.05 | 3.14 | 3.27 | 6.32 | -0.01 |
| 75.1 | 96.48 | 0.0362 | 20.08 | 23.16 | 0.63 | 9.87 | 3.08 | 3.21 | 3.40 | 6.47 | -0.05 |
| 78.1 | 98.13 | 0.0374 | 20.05 | 23.16 | 0.65 | 10.16 | 3.11 | 3.26 | 3.52 | 6.63 | -0.09 |
| 81.1 | 99.80 | 0.0384 | 20.03 | 23.16 | 0.67 | 10.43 | 3.13 | 3.33 | 3.65 | 6.78 | -0.10 |
| 84.1 | 101.44 | 0.0405 | 20.03 | 23.17 | 0.70 | 10.68 | 3.14 | 3.40 | 3.77 | 6.91 | -0.11 |
| 87.1 | 103.06 | 0.0421 | 20.03 | 23.17 | 0.73 | 10.93 | 3.14 | 3.48 | 3.89 | 7.04 | -0.11 |
| 90.1 | 104.74 | 0.0439 | 20.03 | 23.17 | 0.76 | 11.18 | 3.14 | 3.56 | 4.02 | 7.16 | -0.11 |
| 93.1 | 106.13 | 0.0449 | 20.02 | 23.15 | 0.78 | 11.38 | 3.13 | 3.64 | 4.13 | 7.26 | -0.11 |
| 96.1 | 107.73 | 0.0463 | 19.99 | 23.15 | 0.81 | 11.66 | 3.16 | 3.68 | 4.25 | 7.41 | -0.14 |
| 99.1 | 109.79 | 0.0475 | 19.95 | 23.16 | 0.83 | 12.02 | 3.21 | 3.74 | 4.40 | 7.61 | -0.18 |
| 102.1 | 112.03 | 0.0486 | 19.90 | 23.16 | 0.84 | 12.40 | 3.26 | 3.81 | 4.57 | 7.83 | -0.23 |
| 105.1 | 114.50 | 0.0501 | 19.86 | 23.16 | 0.87 | 12.82 | 3.30 | 3.88 | 4.76 | 8.06 | -0.27 |
| 108.1 | 116.67 | 0.0513 | 19.83 | 23.17 | 0.89 | 13.19 | 3.34 | 3.95 | 4.92 | 8.26 | -0.30 |
| 111.1 | 118.45 | 0.0528 | 19.82 | 23.17 | 0.92 | 13.47 | 3.35 | 4.02 | 5.06 | 8.41 | -0.31 |
| 114.1 | 119.67 | 0.0546 | 19.81 | 23.15 | 0.95 | 13.64 | 3.34 | 4.08 | 5.15 | 8.49 | -0.32 |
| 117.1 | 120.70 | 0.0560 | 19.81 | 23.15 | 0.97 | 13.79 | 3.34 | 4.13 | 5.23 | 8.57 | -0.32 |
| 120.1 | 122.31 | 0.0577 | 19.81 | 23.16 | 1.00 | 14.04 | 3.35 | 4.19 | 5.35 | 8.70 | -0.33 |
| 132.1 | 128.32 | 0.0631 | 19.70 | 23.14 | 1.10 | 15.04 | 3.44 | 4.37 | 5.80 | 9.24 | -0.43 |
| 144.1 | 134.58 | 0.0685 | 19.56 | 23.16 | 1.19 | 16.13 | 3.60 | 4.48 | 6.27 | 9.87 | -0.57 |
| 156.1 | 140.60 | 0.0750 | 19.55 | 23.15 | 1.30 | 17.03 | 3.60 | 4.73 | 6.72 | 10.31 | -0.58 |
| 168.1 | 146.73 | 0.0796 | 19.38 | 23.15 | 1.38 | 18.11 | 3.77 | 4.81 | 7.17 | 10.94 | -0.75 |
| 180.1 | 153.35 | 0.0858 | 19.29 | 23.16 | 1.49 | 19.20 | 3.87 | 4.96 | 7.67 | 11.53 | -0.84 |
| 192.1 | 159.52 | 0.0915 | 19.28 | 23.14 | 1.59 | 20.11 | 3.86 | 5.21 | 8.12 | 11.98 | -0.85 |
| 204.1 | 165.79 | 0.0971 | 19.12 | 23.16 | 1.69 | 21.22 | 4.04 | 5.25 | 8.59 | 12.63 | -1.02 |

| Elapsed Time (min.) | Vertical Load (lbs) | DCDT (inch) | Pore Pressure (psi) | Cell Pressure (psi) | Axial Strain (%) | $\sigma_1'$ (psi) | $\sigma_3'$ (psi) | Obliquity | q (psi) | p' (psi) | Excess Pore Pr. (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 216.1 | 169.66 | 0.1029 | 19.06 | 23.15 | 1.79 | 21.83 | 4.09 | 5.34 | 8.87 | 12.96 | -1.07 |
| 228.1 | 175.73 | 0.1085 | 18.98 | 23.13 | 1.89 | 22.80 | 4.16 | 5.49 | 9.32 | 13.48 | -1.15 |
| 240.1 | 181.79 | 0.1140 | 18.84 | 23.15 | 1.98 | 23.84 | 4.31 | 5.54 | 9.77 | 14.08 | -1.29 |
| 252.1 | 187.54 | 0.1199 | 18.82 | 23.14 | 2.09 | 24.71 | 4.33 | 5.71 | 10.19 | 14.52 | -1.32 |
| 264.1 | 193.48 | 0.1254 | 18.68 | 23.13 | 2.18 | 25.70 | 4.45 | 5.78 | 10.63 | 15.08 | -1.45 |
| 276.1 | 198.85 | 0.1308 | 18.55 | 23.15 | 2.27 | 26.63 | 4.60 | 5.79 | 11.02 | 15.62 | -1.58 |
| 288.1 | 204.45 | 0.1370 | 18.54 | 23.14 | 2.38 | 27.45 | 4.60 | 5.97 | 11.43 | 16.02 | -1.59 |
| 300.1 | 209.84 | 0.1422 | 18.46 | 23.14 | 2.47 | 28.32 | 4.68 | 6.05 | 11.82 | 16.50 | -1.68 |
| 312.1 | 215.14 | 0.1482 | 18.33 | 23.14 | 2.58 | 29.21 | 4.81 | 6.08 | 12.20 | 17.01 | -1.80 |
| 324.1 | 220.29 | 0.1538 | 18.31 | 23.13 | 2.68 | 29.97 | 4.82 | 6.22 | 12.58 | 17.40 | -1.82 |
| 336.1 | 225.75 | 0.1592 | 18.16 | 23.14 | 2.77 | 30.93 | 4.98 | 6.20 | 12.97 | 17.95 | -1.97 |
| 348.1 | 228.02 | 0.1653 | 18.08 | 23.14 | 2.88 | 31.30 | 5.05 | 6.19 | 13.13 | 18.18 | -2.05 |
| 360.1 | 233.83 | 0.1715 | 18.05 | 23.12 | 2.98 | 32.16 | 5.07 | 6.34 | 13.54 | 18.61 | -2.08 |
| 372.2 | 239.69 | 0.1765 | 17.90 | 23.14 | 3.07 | 33.17 | 5.23 | 6.34 | 13.97 | 19.20 | -2.23 |
| 384.2 | 244.85 | 0.1823 | 17.88 | 23.13 | 3.17 | 33.92 | 5.25 | 6.46 | 14.34 | 19.58 | -2.25 |
| 396.2 | 250.46 | 0.1880 | 17.80 | 23.13 | 3.27 | 34.80 | 5.32 | 6.54 | 14.74 | 20.06 | -2.33 |
| 408.2 | 255.85 | 0.1937 | 17.68 | 23.14 | 3.37 | 35.71 | 5.46 | 6.54 | 15.12 | 20.58 | -2.46 |
| 420.2 | 258.32 | 0.1994 | 17.66 | 23.12 | 3.47 | 36.05 | 5.47 | 6.59 | 15.29 | 20.76 | -2.48 |
| 432.2 | 264.10 | 0.2056 | 17.56 | 23.14 | 3.58 | 36.98 | 5.57 | 6.63 | 15.70 | 21.27 | -2.57 |
| 444.2 | 268.88 | 0.2108 | 17.45 | 23.13 | 3.67 | 37.77 | 5.69 | 6.64 | 16.04 | 21.73 | -2.69 |
| 456.2 | 273.87 | 0.2165 | 17.43 | 23.12 | 3.77 | 38.47 | 5.68 | 6.77 | 16.39 | 22.08 | -2.70 |
| 468.2 | 279.08 | 0.2219 | 17.34 | 23.13 | 3.86 | 39.31 | 5.79 | 6.79 | 16.76 | 22.55 | -2.80 |
| 480.2 | 284.49 | 0.2276 | 17.20 | 23.13 | 3.96 | 40.21 | 5.93 | 6.78 | 17.14 | 23.07 | -2.93 |
| 492.2 | 289.98 | 0.2340 | 17.19 | 23.12 | 4.07 | 40.98 | 5.93 | 6.92 | 17.53 | 23.45 | -2.94 |
| 504.2 | 295.36 | 0.2400 | 17.16 | 23.12 | 4.17 | 41.77 | 5.97 | 7.00 | 17.90 | 23.87 | -2.98 |
| 516.2 | 300.92 | 0.2453 | 17.01 | 23.12 | 4.27 | 42.69 | 6.10 | 7.00 | 18.29 | 24.40 | -3.12 |
| 528.2 | 306.50 | 0.2510 | 17.00 | 23.13 | 4.37 | 43.50 | 6.13 | 7.09 | 18.68 | 24.82 | -3.14 |
| 540.2 | 311.80 | 0.2564 | 16.94 | 23.12 | 4.46 | 44.29 | 6.18 | 7.17 | 19.06 | 25.24 | -3.19 |
| 552.2 | 316.96 | 0.2621 | 16.84 | 23.11 | 4.56 | 45.09 | 6.27 | 7.19 | 19.41 | 25.68 | -3.29 |
| 564.2 | 322.02 | 0.2687 | 16.82 | 23.12 | 4.67 | 45.82 | 6.30 | 7.28 | 19.76 | 26.06 | -3.31 |
| 576.2 | 326.88 | 0.2740 | 16.69 | 23.12 | 4.76 | 46.62 | 6.43 | 7.26 | 20.10 | 26.52 | -3.44 |
| 588.2 | 331.86 | 0.2794 | 16.65 | 23.11 | 4.86 | 47.34 | 6.46 | 7.33 | 20.44 | 26.90 | -3.49 |
| 600.2 | 336.23 | 0.2850 | 16.61 | 23.12 | 4.96 | 47.98 | 6.50 | 7.38 | 20.74 | 27.24 | -3.52 |
| 630.2 | 346.44 | 0.2999 | 16.45 | 23.11 | 5.22 | 49.50 | 6.65 | 7.44 | 21.42 | 28.08 | -3.68 |
| 660.2 | 355.26 | 0.3143 | 16.29 | 23.11 | 5.47 | 50.84 | 6.83 | 7.45 | 22.01 | 28.83 | -3.85 |
| 690.2 | 362.59 | 0.3286 | 16.11 | 23.11 | 5.71 | 51.96 | 7.00 | 7.43 | 22.48 | 29.48 | -4.02 |
| 720.2 | 368.54 | 0.3426 | 15.97 | 23.10 | 5.96 | 52.83 | 7.13 | 7.41 | 22.85 | 29.98 | -4.16 |
| 750.2 | 375.04 | 0.3569 | 15.87 | 23.09 | 6.21 | 53.74 | 7.23 | 7.44 | 23.26 | 30.48 | -4.27 |
| 780.2 | 380.28 | 0.3718 | 15.74 | 23.08 | 6.47 | 54.48 | 7.34 | 7.42 | 23.57 | 30.91 | -4.39 |
| 810.2 | 380.89 | 0.3858 | 15.62 | 23.08 | 6.71 | 54.57 | 7.46 | 7.32 | 23.55 | 31.01 | -4.51 |
| 840.2 | 382.29 | 0.4001 | 15.51 | 23.08 | 6.96 | 54.75 | 7.57 | 7.23 | 23.59 | 31.16 | -4.63 |
| 870.2 | 385.05 | 0.4147 | 15.39 | 23.09 | 7.21 | 55.15 | 7.70 | 7.16 | 23.72 | 31.43 | -4.75 |
| 900.2 | 388.07 | 0.4289 | 15.27 | 23.08 | 7.46 | 55.56 | 7.81 | 7.11 | 23.87 | 31.69 | -4.86 |
| 930.2 | 391.84 | 0.4436 | 15.14 | 23.08 | 7.72 | 56.09 | 7.94 | 7.07 | 24.07 | 32.01 | -4.99 |
| 960.2 | 396.03 | 0.4577 | 15.03 | 23.09 | 7.96 | 56.67 | 8.06 | 7.03 | 24.31 | 32.37 | -5.11 |
| 990.2 | 400.87 | 0.4720 | 14.92 | 23.08 | 8.21 | 57.33 | 8.16 | 7.02 | 24.58 | 32.75 | -5.22 |
| 1020.2 | 406.81 | 0.4864 | 14.82 | 23.09 | 8.46 | 58.13 | 8.27 | 7.03 | 24.93 | 33.20 | -5.31 |
| 1050.2 | 411.12 | 0.5010 | 14.71 | 23.08 | 8.71 | 58.70 | 8.37 | 7.01 | 25.17 | 33.54 | -5.42 |
| 1080.2 | 415.01 | 0.5153 | 14.60 | 23.09 | 8.96 | 59.22 | 8.48 | 6.98 | 25.37 | 33.85 | -5.53 |
| 1110.2 | 421.20 | 0.5294 | 14.49 | 23.09 | 9.21 | 60.06 | 8.60 | 6.99 | 25.73 | 34.33 | -5.64 |
| 1140.2 | 424.76 | 0.5446 | 14.38 | 23.08 | 9.47 | 60.51 | 8.70 | 6.96 | 25.90 | 34.60 | -5.75 |
| 1170.2 | 429.60 | 0.5585 | 14.27 | 23.09 | 9.71 | 61.16 | 8.82 | 6.94 | 26.17 | 34.99 | -5.86 |
| 1200.2 | 433.43 | 0.5727 | 14.17 | 23.08 | 9.96 | 61.64 | 8.91 | 6.91 | 26.36 | 35.28 | -5.96 |
| 1230.2 | 436.55 | 0.5867 | 14.07 | 23.10 | 10.20 | 62.04 | 9.03 | 6.87 | 26.51 | 35.53 | -6.06 |
| 1260.2 | 437.30 | 0.6017 | 13.98 | 23.09 | 10.47 | 62.08 | 9.11 | 6.81 | 26.48 | 35.60 | -6.16 |
| 1290.2 | 438.01 | 0.6159 | 13.87 | 23.09 | 10.71 | 62.14 | 9.22 | 6.74 | 26.46 | 35.68 | -6.27 |
| 1320.2 | 441.17 | 0.6306 | 13.78 | 23.09 | 10.97 | 62.51 | 9.32 | 6.71 | 26.60 | 35.91 | -6.36 |
| 1350.2 | 441.66 | 0.6450 | 13.69 | 23.09 | 11.22 | 62.52 | 9.40 | 6.65 | 26.56 | 35.96 | -6.45 |
| 1380.3 | 442.84 | 0.6596 | 13.60 | 23.09 | 11.47 | 62.61 | 9.49 | 6.60 | 26.56 | 36.05 | -6.53 |
| 1410.3 | 444.95 | 0.6735 | 13.51 | 23.10 | 11.71 | 62.85 | 9.59 | 6.55 | 26.63 | 36.22 | -6.63 |
| 1440.3 | 447.24 | 0.6870 | 13.22 | 23.11 | 11.95 | 63.32 | 9.89 | 6.40 | 26.71 | 36.60 | -6.91 |
| 1470.3 | 451.70 | 0.7014 | 12.96 | 23.14 | 12.20 | 64.06 | 10.18 | 6.29 | 26.94 | 37.12 | -7.17 |
| 1500.3 | 455.53 | 0.7164 | 12.93 | 23.13 | 12.46 | 64.44 | 10.20 | 6.32 | 27.12 | 37.32 | -7.20 |
| 1530.3 | 457.95 | 0.7308 | 12.86 | 23.12 | 12.71 | 64.67 | 10.27 | 6.30 | 27.20 | 37.47 | -7.28 |
| 1560.3 | 462.66 | 0.7450 | 12.70 | 23.14 | 12.96 | 65.32 | 10.44 | 6.26 | 27.44 | 37.88 | -7.43 |
| 1590.3 | 465.75 | 0.7586 | 12.61 | 23.13 | 13.19 | 65.66 | 10.52 | 6.24 | 27.57 | 38.09 | -7.52 |
| 1620.3 | 468.60 | 0.7738 | 12.53 | 23.12 | 13.46 | 65.94 | 10.59 | 6.23 | 27.68 | 38.27 | -7.60 |
| 1650.3 | 470.98 | 0.7879 | 12.45 | 23.12 | 13.70 | 66.18 | 10.67 | 6.20 | 27.75 | 38.42 | -7.68 |
| 1680.3 | 468.25 | 0.8018 | 12.32 | 23.13 | 13.94 | 65.80 | 10.80 | 6.09 | 27.50 | 38.30 | -7.81 |
| 1710.3 | 462.91 | 0.8168 | 12.26 | 23.12 | 14.21 | 64.98 | 10.86 | 5.99 | 27.06 | 37.92 | -7.87 |
| 1740.3 | 459.60 | 0.8311 | 12.17 | 23.11 | 14.45 | 64.48 | 10.94 | 5.89 | 26.77 | 37.71 | -7.96 |
| 1770.3 | 459.30 | 0.8453 | 12.05 | 23.11 | 14.70 | 64.40 | 11.07 | 5.82 | 26.67 | 37.73 | -8.08 |
| 1800.3 | 459.59 | 0.8595 | 11.98 | 23.10 | 14.95 | 64.34 | 11.12 | 5.79 | 26.61 | 37.73 | -8.15 |
| 1800.3 | 459.48 | 0.8595 | 11.98 | 23.10 | 14.95 | 64.33 | 11.12 | 5.79 | 26.60 | 37.72 | -8.15 |

**CONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 4767)**

Project: LUC-023-11 75 | Date: 5/10/2023
Client: Arcadis | File: 2065201_B-014-1_ST-2_CU
Sample ID: B-014-1-21 (ST-2) | Sample Depth: (6.0' - 8.0') (Portion from 7.0' to 7.5')
6 Project No.: 2065201 | Specimen ID: B-014-1-21 (ST-2 - C )

**SAMPLE PROPERTIES**

Visual Description: Brown Sandy Silt "And" Clay A-4a (8)

Diameter: 2.88 in. | Initial Dry Unit Weight of Sample: 107.2 pcf
Area: 6.51 $in^2$ | Initial Moisture Content: 17.7 %
Length: 5.98 in. | Specific Gravity (Assumed): 2.50
Initial Void Ratio: 0.46 | Initial Degree of Saturation: 97 %
Consolidation Stress: 6 psi | External Load Cell: 726856 (200 lbs.)

**STRESS-STRAIN DATA**

| Elapsed Time (min.) | Vertical Load (lbs) | DCDT (inch) | Pore Pressure (psi) | Cell Pressure (psi) | Axial Strain (%) | $\sigma_1'$ (psi) | $\sigma_3'$ (psi) | Obliquity | q (psi) | p' (psi) | Excess Pore Pr. (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 5.70 | 0.0000 | 20.48 | 26.04 | 0.00 | 5.85 | 5.56 | 1.05 | 0.14 | 5.70 | 0.00 |
| 3.0 | 7.02 | 0.0009 | 20.44 | 26.05 | 0.02 | 6.10 | 5.61 | 1.09 | 0.25 | 5.85 | -0.04 |
| 6.0 | 8.78 | 0.0023 | 20.42 | 26.03 | 0.04 | 6.37 | 5.61 | 1.14 | 0.38 | 5.99 | -0.06 |
| 9.0 | 11.15 | 0.0034 | 20.43 | 26.04 | 0.06 | 6.73 | 5.61 | 1.20 | 0.56 | 6.17 | -0.05 |
| 12.0 | 13.19 | 0.0046 | 20.43 | 26.05 | 0.08 | 7.06 | 5.62 | 1.26 | 0.72 | 6.34 | -0.05 |
| 15.0 | 15.03 | 0.0061 | 20.43 | 26.06 | 0.10 | 7.35 | 5.63 | 1.31 | 0.86 | 6.49 | -0.05 |
| 18.0 | 16.73 | 0.0076 | 20.43 | 26.05 | 0.13 | 7.59 | 5.61 | 1.35 | 0.99 | 6.60 | -0.05 |
| 21.0 | 18.36 | 0.0088 | 20.44 | 26.06 | 0.15 | 7.84 | 5.61 | 1.40 | 1.11 | 6.73 | -0.04 |
| 24.0 | 19.84 | 0.0105 | 20.44 | 26.06 | 0.18 | 8.08 | 5.62 | 1.44 | 1.23 | 6.85 | -0.04 |
| 27.0 | 21.22 | 0.0120 | 20.45 | 26.08 | 0.20 | 8.29 | 5.63 | 1.47 | 1.33 | 6.96 | -0.03 |
| 30.0 | 22.49 | 0.0134 | 20.45 | 26.06 | 0.22 | 8.47 | 5.61 | 1.51 | 1.43 | 7.04 | -0.03 |
| 33.0 | 23.74 | 0.0150 | 20.46 | 26.06 | 0.25 | 8.65 | 5.60 | 1.54 | 1.53 | 7.12 | -0.02 |
| 36.0 | 24.93 | 0.0161 | 20.47 | 26.07 | 0.27 | 8.84 | 5.61 | 1.58 | 1.62 | 7.22 | -0.02 |
| 39.0 | 26.13 | 0.0176 | 20.47 | 26.08 | 0.29 | 9.02 | 5.61 | 1.61 | 1.71 | 7.31 | -0.01 |
| 42.0 | 27.33 | 0.0193 | 20.48 | 26.08 | 0.32 | 9.20 | 5.61 | 1.64 | 1.80 | 7.40 | 0.00 |
| 45.0 | 28.46 | 0.0208 | 20.48 | 26.07 | 0.35 | 9.35 | 5.58 | 1.68 | 1.88 | 7.47 | 0.00 |
| 48.0 | 29.60 | 0.0224 | 20.49 | 26.07 | 0.37 | 9.53 | 5.58 | 1.71 | 1.97 | 7.55 | 0.01 |
| 51.0 | 30.64 | 0.0239 | 20.50 | 26.08 | 0.40 | 9.68 | 5.58 | 1.73 | 2.05 | 7.63 | 0.02 |
| 54.0 | 31.72 | 0.0251 | 20.51 | 26.09 | 0.42 | 9.84 | 5.58 | 1.76 | 2.13 | 7.71 | 0.02 |
| 57.0 | 32.76 | 0.0265 | 20.52 | 26.07 | 0.44 | 9.98 | 5.56 | 1.80 | 2.21 | 7.77 | 0.03 |
| 60.0 | 33.86 | 0.0282 | 20.52 | 26.07 | 0.47 | 10.14 | 5.55 | 1.83 | 2.29 | 7.84 | 0.04 |
| 63.0 | 34.89 | 0.0298 | 20.53 | 26.07 | 0.50 | 10.29 | 5.54 | 1.86 | 2.37 | 7.91 | 0.05 |
| 66.1 | 35.83 | 0.0315 | 20.54 | 26.08 | 0.53 | 10.43 | 5.54 | 1.88 | 2.44 | 7.98 | 0.06 |
| 69.1 | 36.80 | 0.0332 | 20.55 | 26.09 | 0.56 | 10.58 | 5.54 | 1.91 | 2.52 | 8.06 | 0.06 |
| 72.1 | 37.78 | 0.0344 | 20.56 | 26.08 | 0.57 | 10.70 | 5.52 | 1.94 | 2.59 | 8.11 | 0.08 |
| 75.1 | 38.69 | 0.0359 | 20.57 | 26.07 | 0.60 | 10.82 | 5.50 | 1.97 | 2.66 | 8.16 | 0.09 |
| 78.1 | 39.69 | 0.0374 | 20.58 | 26.07 | 0.62 | 10.96 | 5.49 | 2.00 | 2.74 | 8.22 | 0.10 |
| 81.1 | 40.69 | 0.0389 | 20.59 | 26.08 | 0.65 | 11.11 | 5.49 | 2.02 | 2.81 | 8.30 | 0.11 |
| 84.1 | 41.69 | 0.0402 | 20.60 | 26.09 | 0.67 | 11.26 | 5.49 | 2.05 | 2.89 | 8.37 | 0.12 |
| 87.1 | 42.69 | 0.0417 | 20.61 | 26.08 | 0.70 | 11.39 | 5.47 | 2.08 | 2.96 | 8.43 | 0.13 |
| 90.1 | 43.64 | 0.0437 | 20.62 | 26.07 | 0.73 | 11.52 | 5.45 | 2.11 | 3.03 | 8.49 | 0.13 |
| 93.1 | 44.56 | 0.0450 | 20.63 | 26.07 | 0.75 | 11.65 | 5.44 | 2.14 | 3.10 | 8.54 | 0.15 |
| 96.1 | 45.48 | 0.0465 | 20.64 | 26.08 | 0.78 | 11.79 | 5.44 | 2.17 | 3.17 | 8.61 | 0.16 |
| 99.1 | 46.48 | 0.0478 | 20.65 | 26.08 | 0.80 | 11.92 | 5.43 | 2.20 | 3.25 | 8.67 | 0.17 |
| 102.1 | 47.46 | 0.0494 | 20.66 | 26.09 | 0.83 | 12.07 | 5.42 | 2.22 | 3.32 | 8.75 | 0.18 |
| 105.1 | 48.42 | 0.0506 | 20.67 | 26.07 | 0.85 | 12.18 | 5.40 | 2.26 | 3.39 | 8.79 | 0.19 |
| 108.1 | 49.41 | 0.0522 | 20.68 | 26.07 | 0.87 | 12.32 | 5.38 | 2.29 | 3.47 | 8.85 | 0.20 |
| 111.1 | 50.32 | 0.0535 | 20.70 | 26.07 | 0.89 | 12.44 | 5.37 | 2.32 | 3.54 | 8.91 | 0.22 |
| 114.1 | 51.23 | 0.0550 | 20.71 | 26.07 | 0.92 | 12.57 | 5.36 | 2.34 | 3.61 | 8.97 | 0.23 |
| 117.1 | 52.17 | 0.0567 | 20.72 | 26.08 | 0.95 | 12.71 | 5.36 | 2.37 | 3.68 | 9.03 | 0.24 |
| 120.1 | 53.12 | 0.0581 | 20.74 | 26.07 | 0.97 | 12.82 | 5.33 | 2.41 | 3.75 | 9.08 | 0.26 |
| 132.1 | 56.99 | 0.0642 | 20.78 | 26.08 | 1.07 | 13.37 | 5.29 | 2.53 | 4.04 | 9.33 | 0.30 |
| 144.1 | 60.83 | 0.0699 | 20.83 | 26.06 | 1.17 | 13.89 | 5.24 | 2.65 | 4.33 | 9.56 | 0.34 |
| 156.1 | 64.54 | 0.0762 | 20.86 | 26.05 | 1.27 | 14.39 | 5.19 | 2.77 | 4.60 | 9.79 | 0.38 |
| 168.1 | 68.32 | 0.0815 | 20.91 | 26.05 | 1.36 | 14.90 | 5.14 | 2.90 | 4.88 | 10.02 | 0.43 |
| 180.1 | 71.89 | 0.0877 | 20.95 | 26.05 | 1.47 | 15.40 | 5.10 | 3.02 | 5.15 | 10.25 | 0.47 |
| 192.1 | 75.67 | 0.0934 | 20.98 | 26.04 | 1.56 | 15.91 | 5.05 | 3.15 | 5.43 | 10.48 | 0.50 |
| 204.1 | 79.18 | 0.0999 | 21.02 | 26.02 | 1.67 | 16.38 | 5.00 | 3.27 | 5.69 | 10.69 | 0.54 |
| 216.1 | 82.73 | 0.1057 | 21.06 | 26.01 | 1.77 | 16.85 | 4.95 | 3.40 | 5.95 | 10.90 | 0.57 |

| Elapsed Time (min.) | Vertical Load (lbs) | DCDT (inch) | Pore Pressure (psi) | Cell Pressure (psi) | Axial Strain (%) | $\sigma_1'$ (psi) | $\sigma_3'$ (psi) | Obliquity | q (psi) | p' (psi) | Excess Pore Pr. (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 228.1 | 86.31 | 0.1117 | 21.09 | 26.01 | 1.87 | 17.35 | 4.92 | 3.53 | 6.21 | 11.13 | 0.61 |
| 240.1 | 89.54 | 0.1172 | 21.14 | 25.99 | 1.96 | 17.75 | 4.85 | 3.66 | 6.45 | 11.30 | 0.66 |
| 252.1 | 92.82 | 0.1238 | 21.23 | 25.96 | 2.07 | 18.11 | 4.73 | 3.83 | 6.69 | 11.42 | 0.75 |
| 264.1 | 95.87 | 0.1292 | 21.24 | 25.96 | 2.16 | 18.55 | 4.72 | 3.93 | 6.91 | 11.64 | 0.76 |
| 276.1 | 99.16 | 0.1349 | 21.18 | 25.95 | 2.26 | 19.08 | 4.77 | 4.00 | 7.15 | 11.92 | 0.70 |
| 288.1 | 101.91 | 0.1417 | 21.27 | 25.92 | 2.37 | 19.36 | 4.66 | 4.16 | 7.35 | 12.01 | 0.78 |
| 300.1 | 104.61 | 0.1478 | 21.32 | 25.90 | 2.47 | 19.67 | 4.58 | 4.30 | 7.55 | 12.12 | 0.84 |
| 312.1 | 107.33 | 0.1530 | 21.29 | 25.89 | 2.56 | 20.08 | 4.60 | 4.37 | 7.74 | 12.34 | 0.81 |
| 324.1 | 109.83 | 0.1589 | 21.31 | 25.89 | 2.66 | 20.42 | 4.58 | 4.46 | 7.92 | 12.50 | 0.82 |
| 336.1 | 112.25 | 0.1650 | 21.35 | 25.86 | 2.76 | 20.70 | 4.51 | 4.59 | 8.09 | 12.61 | 0.87 |
| 348.1 | 114.57 | 0.1708 | 21.29 | 25.88 | 2.86 | 21.11 | 4.60 | 4.59 | 8.26 | 12.86 | 0.80 |
| 360.1 | 116.92 | 0.1769 | 21.29 | 25.88 | 2.96 | 21.44 | 4.59 | 4.67 | 8.42 | 13.02 | 0.81 |
| 372.1 | 118.78 | 0.1827 | 21.32 | 25.86 | 3.06 | 21.65 | 4.54 | 4.77 | 8.55 | 13.09 | 0.84 |
| 384.1 | 120.66 | 0.1886 | 21.24 | 25.84 | 3.15 | 21.97 | 4.60 | 4.78 | 8.68 | 13.28 | 0.76 |
| 396.1 | 122.44 | 0.1947 | 21.20 | 25.68 | 3.26 | 22.10 | 4.49 | 4.93 | 8.81 | 13.29 | 0.71 |
| 408.1 | 123.88 | 0.2007 | 21.21 | 25.63 | 3.36 | 22.23 | 4.41 | 5.04 | 8.91 | 13.32 | 0.73 |
| 420.1 | 125.38 | 0.2068 | 21.13 | 25.40 | 3.46 | 22.29 | 4.27 | 5.22 | 9.01 | 13.28 | 0.64 |
| 432.1 | 127.31 | 0.2121 | 21.04 | 25.40 | 3.55 | 22.64 | 4.36 | 5.20 | 9.14 | 13.50 | 0.56 |
| 444.1 | 129.29 | 0.2185 | 21.07 | 25.36 | 3.65 | 22.85 | 4.29 | 5.33 | 9.28 | 13.57 | 0.59 |
| 456.1 | 131.01 | 0.2241 | 21.03 | 25.29 | 3.75 | 23.05 | 4.25 | 5.42 | 9.40 | 13.65 | 0.55 |
| 468.1 | 132.77 | 0.2300 | 20.92 | 25.15 | 3.85 | 23.27 | 4.24 | 5.49 | 9.52 | 13.75 | 0.43 |
| 480.2 | 134.21 | 0.2365 | 20.85 | 25.04 | 3.96 | 23.42 | 4.20 | 5.58 | 9.61 | 13.81 | 0.36 |
| 492.2 | 135.60 | 0.2431 | 20.79 | 24.97 | 4.07 | 23.59 | 4.18 | 5.64 | 9.70 | 13.89 | 0.30 |
| 504.2 | 136.96 | 0.2484 | 20.71 | 24.99 | 4.15 | 23.87 | 4.28 | 5.58 | 9.79 | 14.08 | 0.23 |
| 516.2 | 138.23 | 0.2542 | 20.63 | 25.11 | 4.25 | 24.24 | 4.48 | 5.41 | 9.88 | 14.36 | 0.15 |
| 528.2 | 139.70 | 0.2605 | 20.66 | 25.27 | 4.36 | 24.56 | 4.61 | 5.32 | 9.97 | 14.59 | 0.17 |
| 540.2 | 140.89 | 0.2671 | 20.66 | 25.47 | 4.47 | 24.91 | 4.81 | 5.18 | 10.05 | 14.86 | 0.18 |
| 552.2 | 141.94 | 0.2722 | 20.57 | 25.57 | 4.55 | 25.24 | 5.01 | 5.04 | 10.12 | 15.13 | 0.08 |
| 564.2 | 142.96 | 0.2784 | 20.57 | 25.55 | 4.65 | 25.34 | 4.98 | 5.09 | 10.18 | 15.16 | 0.09 |
| 576.2 | 144.06 | 0.2845 | 20.53 | 25.55 | 4.76 | 25.52 | 5.01 | 5.09 | 10.25 | 15.26 | 0.05 |
| 588.2 | 145.14 | 0.2897 | 20.43 | 25.56 | 4.85 | 25.77 | 5.12 | 5.03 | 10.32 | 15.45 | -0.05 |
| 600.2 | 145.84 | 0.2961 | 20.41 | 25.55 | 4.95 | 25.87 | 5.14 | 5.03 | 10.36 | 15.51 | -0.08 |
| 630.2 | 147.66 | 0.3109 | 20.25 | 25.56 | 5.20 | 26.25 | 5.31 | 4.94 | 10.47 | 15.78 | -0.24 |
| 660.2 | 149.11 | 0.3262 | 20.19 | 25.55 | 5.45 | 26.45 | 5.36 | 4.93 | 10.54 | 15.91 | -0.30 |
| 690.2 | 150.06 | 0.3411 | 20.02 | 25.55 | 5.70 | 26.70 | 5.53 | 4.83 | 10.58 | 16.11 | -0.46 |
| 720.2 | 149.87 | 0.3556 | 19.87 | 25.55 | 5.95 | 26.76 | 5.67 | 4.72 | 10.54 | 16.22 | -0.61 |
| 750.2 | 150.09 | 0.3716 | 19.85 | 25.53 | 6.21 | 26.74 | 5.68 | 4.71 | 10.53 | 16.21 | -0.63 |
| 780.2 | 150.32 | 0.3865 | 19.80 | 25.52 | 6.46 | 26.75 | 5.72 | 4.68 | 10.52 | 16.24 | -0.68 |
| 810.2 | 150.08 | 0.4013 | 19.75 | 25.51 | 6.71 | 26.71 | 5.76 | 4.63 | 10.47 | 16.24 | -0.74 |
| 840.2 | 150.36 | 0.4164 | 19.67 | 25.49 | 6.96 | 26.75 | 5.82 | 4.59 | 10.46 | 16.29 | -0.82 |
| 870.2 | 151.78 | 0.4312 | 19.59 | 25.52 | 7.21 | 27.00 | 5.93 | 4.56 | 10.54 | 16.47 | -0.89 |
| 900.2 | 153.02 | 0.4463 | 19.53 | 25.67 | 7.46 | 27.34 | 6.14 | 4.45 | 10.60 | 16.74 | -0.95 |
| 930.2 | 154.64 | 0.4611 | 19.46 | 25.67 | 7.71 | 27.57 | 6.20 | 4.44 | 10.68 | 16.89 | -1.02 |
| 960.2 | 156.76 | 0.4764 | 19.39 | 25.66 | 7.97 | 27.88 | 6.27 | 4.44 | 10.80 | 17.08 | -1.09 |
| 990.2 | 159.06 | 0.4911 | 19.32 | 25.66 | 8.21 | 28.21 | 6.34 | 4.45 | 10.94 | 17.27 | -1.16 |
| 1020.2 | 161.07 | 0.5063 | 19.27 | 25.67 | 8.47 | 28.49 | 6.40 | 4.45 | 11.05 | 17.44 | -1.21 |
| 1050.2 | 162.99 | 0.5214 | 19.21 | 25.66 | 8.72 | 28.75 | 6.45 | 4.46 | 11.15 | 17.60 | -1.27 |
| 1080.2 | 164.74 | 0.5361 | 19.18 | 25.68 | 8.97 | 28.99 | 6.50 | 4.46 | 11.24 | 17.75 | -1.31 |
| 1110.2 | 166.64 | 0.5513 | 19.14 | 25.68 | 9.22 | 29.23 | 6.54 | 4.47 | 11.34 | 17.89 | -1.34 |
| 1140.2 | 167.43 | 0.5662 | 19.11 | 25.69 | 9.47 | 29.32 | 6.58 | 4.45 | 11.37 | 17.95 | -1.38 |
| 1170.2 | 169.32 | 0.5809 | 19.08 | 25.70 | 9.71 | 29.56 | 6.62 | 4.47 | 11.47 | 18.09 | -1.40 |
| 1200.2 | 169.90 | 0.5960 | 19.05 | 25.67 | 9.97 | 29.57 | 6.61 | 4.47 | 11.48 | 18.09 | -1.43 |
| 1230.2 | 170.73 | 0.6112 | 19.03 | 25.70 | 10.22 | 29.67 | 6.67 | 4.45 | 11.50 | 18.17 | -1.45 |
| 1260.2 | 172.21 | 0.6257 | 19.02 | 25.69 | 10.46 | 29.82 | 6.67 | 4.47 | 11.57 | 18.25 | -1.46 |
| 1290.2 | 173.47 | 0.6409 | 19.01 | 25.72 | 10.72 | 29.96 | 6.71 | 4.47 | 11.63 | 18.33 | -1.47 |
| 1320.2 | 174.61 | 0.6564 | 19.00 | 25.71 | 10.98 | 30.05 | 6.71 | 4.48 | 11.67 | 18.38 | -1.48 |
| 1350.3 | 175.70 | 0.6709 | 19.00 | 25.70 | 11.22 | 30.13 | 6.71 | 4.49 | 11.71 | 18.42 | -1.49 |
| 1380.3 | 177.24 | 0.6857 | 18.99 | 25.72 | 11.47 | 30.29 | 6.72 | 4.51 | 11.78 | 18.51 | -1.49 |
| 1410.3 | 178.60 | 0.7004 | 18.99 | 25.71 | 11.71 | 30.41 | 6.73 | 4.52 | 11.84 | 18.57 | -1.50 |
| 1440.3 | 180.20 | 0.7154 | 18.91 | 25.71 | 11.96 | 30.63 | 6.80 | 4.51 | 11.92 | 18.71 | -1.57 |
| 1470.3 | 182.03 | 0.7295 | 18.64 | 25.75 | 12.20 | 31.13 | 7.11 | 4.38 | 12.01 | 19.12 | -1.84 |
| 1500.3 | 184.40 | 0.7444 | 18.55 | 25.78 | 12.45 | 31.51 | 7.24 | 4.35 | 12.14 | 19.37 | -1.94 |
| 1530.3 | 185.88 | 0.7594 | 18.46 | 25.78 | 12.70 | 31.71 | 7.31 | 4.34 | 12.20 | 19.51 | -2.02 |
| 1560.3 | 187.86 | 0.7746 | 18.41 | 25.77 | 12.95 | 31.95 | 7.36 | 4.34 | 12.30 | 19.66 | -2.08 |
| 1590.3 | 188.45 | 0.7894 | 18.35 | 25.77 | 13.20 | 32.02 | 7.42 | 4.32 | 12.30 | 19.72 | -2.13 |
| 1620.3 | 190.06 | 0.8039 | 18.31 | 25.77 | 13.44 | 32.21 | 7.46 | 4.32 | 12.37 | 19.83 | -2.17 |
| 1650.3 | 191.49 | 0.8191 | 18.25 | 25.78 | 13.70 | 32.39 | 7.53 | 4.30 | 12.43 | 19.96 | -2.23 |
| 1680.3 | 192.50 | 0.8342 | 18.32 | 25.76 | 13.95 | 32.37 | 7.44 | 4.35 | 12.46 | 19.91 | -2.17 |
| 1710.3 | 193.35 | 0.8497 | 18.40 | 25.76 | 14.21 | 32.32 | 7.36 | 4.39 | 12.48 | 19.84 | -2.08 |
| 1740.3 | 193.72 | 0.8648 | 18.42 | 25.75 | 14.46 | 32.26 | 7.33 | 4.40 | 12.47 | 19.80 | -2.06 |
| 1770.3 | 194.07 | 0.8791 | 18.41 | 25.76 | 14.70 | 32.26 | 7.35 | 4.39 | 12.46 | 19.80 | -2.07 |
| 1800.3 | 194.14 | 0.8935 | 18.33 | 25.74 | 14.94 | 32.26 | 7.41 | 4.35 | 12.43 | 19.84 | -2.15 |
| 1800.7 | 194.11 | 0.8936 | 18.33 | 25.74 | 14.94 | 32.26 | 7.41 | 4.35 | 12.42 | 19.84 | -2.15 |

**CONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH**
**OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 4767)**

| | | | |
|---|---|---|---|
| Project: | LUC-023-11 75 | Date: | 5/12/2023 |
| Client: | Arcadis | File: | 2065201_B-014-1_ST-2_CU |
| Sample ID: | B-014-1-21 (ST-2) | Sample Depth: | (6.0' - 8.0') (Portion from 7.5' to 8.0') |
| 6 Project No.: | 2065201 | Specimen ID: | B-014-1-21 (ST-2 - D ) |

## SAMPLE PROPERTIES

Visual Description: Brown Sandy Silt "And" Clay A-4a (8)

| | | | |
|---|---|---|---|
| Diameter: | 2.88 in. | Initial Dry Unit Weight of Sample: | 103.1 pcf |
| Area: | 6.51 $in^2$ | Initial Moisture Content: | 17.7 % |
| Length: | 5.98 in. | Specific Gravity (Assumed): | 2.50 |
| Initial Void Ratio: | 0.51 | Initial Degree of Saturation: | 86 % |
| Consolidation Stress: | 12 psi | External Load Cell: | 726856 (200 lbs.) |

## STRESS-STRAIN DATA

| Elapsed Time (min.) | Vertical Load (lbs) | DCDT (inch) | Pore Pressure (psi) | Cell Pressure (psi) | Axial Strain (%) | $\sigma_1'$ (psi) | $\sigma_3'$ (psi) | Obliquity | q (psi) | p' (psi) | Excess Pore Pr. (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 9.8 | 0.0 | 21.26 | 31.95 | 0.00 | 11.08 | 10.69 | 1.04 | 0.19 | 10.89 | 0.00 |
| 3.0 | 14.5 | 0.0 | 21.43 | 31.94 | 0.02 | 11.63 | 10.51 | 1.11 | 0.56 | 11.07 | 0.17 |
| 6.0 | 19.3 | 0.0 | 21.63 | 31.95 | 0.03 | 12.16 | 10.32 | 1.18 | 0.92 | 11.24 | 0.37 |
| 9.0 | 23.2 | 0.0 | 21.85 | 31.96 | 0.05 | 12.56 | 10.11 | 1.24 | 1.22 | 11.34 | 0.60 |
| 12.0 | 26.5 | 0.0 | 22.08 | 31.97 | 0.08 | 12.83 | 9.88 | 1.30 | 1.48 | 11.36 | 0.83 |
| 15.0 | 29.3 | 0.0 | 22.31 | 31.97 | 0.10 | 13.04 | 9.66 | 1.35 | 1.69 | 11.35 | 1.05 |
| 18.0 | 31.7 | 0.0 | 22.52 | 31.97 | 0.13 | 13.20 | 9.45 | 1.40 | 1.87 | 11.32 | 1.27 |
| 21.0 | 33.8 | 0.0 | 22.74 | 31.98 | 0.16 | 13.31 | 9.24 | 1.44 | 2.04 | 11.28 | 1.48 |
| 24.0 | 35.8 | 0.0 | 22.93 | 31.98 | 0.18 | 13.42 | 9.05 | 1.48 | 2.18 | 11.23 | 1.67 |
| 27.0 | 37.6 | 0.0 | 23.13 | 31.98 | 0.20 | 13.50 | 8.85 | 1.53 | 2.33 | 11.18 | 1.87 |
| 30.0 | 39.4 | 0.0 | 23.31 | 31.99 | 0.23 | 13.60 | 8.68 | 1.57 | 2.46 | 11.14 | 2.05 |
| 33.0 | 41.0 | 0.0 | 23.49 | 31.99 | 0.26 | 13.67 | 8.51 | 1.61 | 2.58 | 11.09 | 2.23 |
| 36.0 | 42.5 | 0.0 | 23.66 | 31.99 | 0.28 | 13.72 | 8.33 | 1.65 | 2.69 | 11.03 | 2.40 |
| 39.0 | 43.9 | 0.0 | 23.81 | 31.99 | 0.30 | 13.78 | 8.18 | 1.68 | 2.80 | 10.98 | 2.56 |
| 42.1 | 45.3 | 0.0 | 23.96 | 31.99 | 0.34 | 13.85 | 8.03 | 1.72 | 2.91 | 10.94 | 2.70 |
| 45.1 | 46.5 | 0.0 | 24.10 | 31.99 | 0.36 | 13.89 | 7.90 | 1.76 | 3.00 | 10.89 | 2.84 |
| 48.1 | 47.8 | 0.0 | 24.23 | 32.00 | 0.39 | 13.96 | 7.77 | 1.80 | 3.10 | 10.87 | 2.98 |
| 51.1 | 48.9 | 0.0 | 24.36 | 32.00 | 0.41 | 14.01 | 7.64 | 1.83 | 3.18 | 10.82 | 3.10 |
| 54.1 | 50.1 | 0.0 | 24.48 | 32.00 | 0.44 | 14.06 | 7.52 | 1.87 | 3.27 | 10.79 | 3.22 |
| 57.1 | 51.1 | 0.0 | 24.59 | 32.00 | 0.45 | 14.11 | 7.42 | 1.90 | 3.35 | 10.77 | 3.33 |
| 60.1 | 52.1 | 0.0 | 24.69 | 32.00 | 0.48 | 14.17 | 7.32 | 1.94 | 3.43 | 10.74 | 3.43 |
| 63.1 | 53.2 | 0.0 | 24.78 | 32.00 | 0.50 | 14.23 | 7.22 | 1.97 | 3.51 | 10.72 | 3.53 |
| 66.1 | 54.2 | 0.0 | 24.87 | 32.00 | 0.53 | 14.29 | 7.13 | 2.00 | 3.58 | 10.71 | 3.62 |
| 69.1 | 55.2 | 0.0 | 24.96 | 32.00 | 0.56 | 14.36 | 7.04 | 2.04 | 3.66 | 10.70 | 3.71 |
| 72.1 | 56.2 | 0.0 | 25.05 | 32.01 | 0.58 | 14.42 | 6.96 | 2.07 | 3.73 | 10.69 | 3.79 |
| 75.1 | 57.1 | 0.0 | 25.12 | 32.01 | 0.61 | 14.49 | 6.89 | 2.10 | 3.80 | 10.69 | 3.87 |
| 78.1 | 58.0 | 0.0 | 25.19 | 32.00 | 0.63 | 14.55 | 6.81 | 2.14 | 3.87 | 10.68 | 3.94 |
| 81.1 | 58.9 | 0.0 | 25.26 | 32.00 | 0.65 | 14.61 | 6.74 | 2.17 | 3.93 | 10.68 | 4.00 |
| 84.1 | 59.7 | 0.0 | 25.33 | 32.01 | 0.68 | 14.68 | 6.68 | 2.20 | 4.00 | 10.68 | 4.07 |
| 87.1 | 60.6 | 0.0 | 25.38 | 32.01 | 0.71 | 14.75 | 6.62 | 2.23 | 4.06 | 10.69 | 4.13 |
| 90.1 | 61.5 | 0.0 | 25.45 | 32.01 | 0.73 | 14.82 | 6.56 | 2.26 | 4.13 | 10.69 | 4.19 |
| 93.1 | 62.3 | 0.0 | 25.50 | 32.02 | 0.76 | 14.90 | 6.51 | 2.29 | 4.19 | 10.71 | 4.25 |
| 96.1 | 63.1 | 0.0 | 25.56 | 32.02 | 0.78 | 14.97 | 6.46 | 2.32 | 4.25 | 10.71 | 4.30 |
| 99.1 | 63.9 | 0.0 | 25.61 | 32.02 | 0.81 | 15.03 | 6.41 | 2.34 | 4.31 | 10.72 | 4.35 |
| 102.1 | 64.7 | 0.0 | 25.65 | 32.01 | 0.83 | 15.10 | 6.37 | 2.37 | 4.37 | 10.73 | 4.39 |
| 105.1 | 65.4 | 0.1 | 25.69 | 32.01 | 0.87 | 15.16 | 6.32 | 2.40 | 4.42 | 10.74 | 4.43 |
| 108.1 | 66.1 | 0.1 | 25.73 | 32.01 | 0.89 | 15.23 | 6.28 | 2.43 | 4.48 | 10.76 | 4.48 |
| 111.1 | 66.9 | 0.1 | 25.77 | 32.01 | 0.91 | 15.31 | 6.24 | 2.45 | 4.54 | 10.78 | 4.52 |
| 114.1 | 67.7 | 0.1 | 25.82 | 32.02 | 0.94 | 15.39 | 6.21 | 2.48 | 4.59 | 10.80 | 4.56 |
| 117.1 | 68.4 | 0.1 | 25.85 | 32.02 | 0.96 | 15.46 | 6.17 | 2.51 | 4.65 | 10.81 | 4.60 |
| 120.1 | 69.1 | 0.1 | 25.88 | 32.02 | 0.97 | 15.53 | 6.14 | 2.53 | 4.70 | 10.83 | 4.63 |
| 132.1 | 71.9 | 0.1 | 26.00 | 32.03 | 1.08 | 15.84 | 6.03 | 2.63 | 4.91 | 10.93 | 4.75 |
| 144.1 | 74.5 | 0.1 | 26.09 | 32.02 | 1.18 | 16.13 | 5.94 | 2.72 | 5.10 | 11.03 | 4.83 |
| 156.1 | 77.2 | 0.1 | 26.20 | 32.02 | 1.29 | 16.41 | 5.82 | 2.82 | 5.29 | 11.11 | 4.94 |
| 168.1 | 79.5 | 0.1 | 26.26 | 32.00 | 1.38 | 16.67 | 5.75 | 2.90 | 5.46 | 11.21 | 5.00 |
| 180.1 | 81.9 | 0.1 | 26.28 | 32.01 | 1.48 | 17.01 | 5.73 | 2.97 | 5.64 | 11.37 | 5.03 |
| 192.1 | 84.1 | 0.1 | 26.33 | 32.00 | 1.58 | 17.27 | 5.67 | 3.05 | 5.80 | 11.47 | 5.08 |
| 204.1 | 86.1 | 0.1 | 26.39 | 31.99 | 1.68 | 17.51 | 5.61 | 3.12 | 5.95 | 11.56 | 5.13 |
| 216.1 | 88.2 | 0.1 | 26.36 | 31.99 | 1.77 | 17.84 | 5.63 | 3.17 | 6.10 | 11.73 | 5.11 |
| 228.1 | 90.1 | 0.1 | 26.36 | 32.00 | 1.87 | 18.12 | 5.64 | 3.21 | 6.24 | 11.88 | 5.10 |

| Elapsed Time (min.) | Vertical Load (lbs) | DCDT (inch) | Pore Pressure (psi) | Cell Pressure (psi) | Axial Strain (%) | $\sigma_1'$ (psi) | $\sigma_3'$ (psi) | Obliquity | q (psi) | p' (psi) | Excess Pore Pr. (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 240.1 | 92.1 | 0.1 | 26.39 | 31.98 | 1.99 | 18.35 | 5.60 | 3.28 | 6.38 | 11.97 | 5.13 |
| 252.1 | 93.8 | 0.1 | 26.38 | 31.99 | 2.07 | 18.62 | 5.61 | 3.32 | 6.51 | 12.12 | 5.12 |
| 264.1 | 95.5 | 0.1 | 26.37 | 31.98 | 2.18 | 18.86 | 5.61 | 3.36 | 6.63 | 12.24 | 5.11 |
| 276.1 | 97.3 | 0.1 | 26.36 | 31.98 | 2.27 | 19.13 | 5.62 | 3.40 | 6.75 | 12.38 | 5.10 |
| 288.1 | 99.0 | 0.1 | 26.33 | 31.97 | 2.37 | 19.39 | 5.64 | 3.44 | 6.87 | 12.51 | 5.07 |
| 300.2 | 100.7 | 0.1 | 26.30 | 31.97 | 2.48 | 19.66 | 5.67 | 3.47 | 6.99 | 12.66 | 5.05 |
| 312.2 | 102.3 | 0.2 | 26.28 | 32.08 | 2.57 | 20.01 | 5.80 | 3.45 | 7.10 | 12.90 | 5.02 |
| 324.2 | 104.0 | 0.2 | 26.27 | 32.07 | 2.66 | 20.26 | 5.81 | 3.49 | 7.22 | 13.03 | 5.01 |
| 336.2 | 105.3 | 0.2 | 26.28 | 32.07 | 2.78 | 20.42 | 5.79 | 3.53 | 7.31 | 13.11 | 5.02 |
| 348.2 | 106.7 | 0.2 | 26.24 | 32.06 | 2.88 | 20.65 | 5.82 | 3.55 | 7.41 | 13.24 | 4.98 |
| 360.2 | 108.1 | 0.2 | 26.17 | 32.07 | 2.97 | 20.92 | 5.90 | 3.55 | 7.51 | 13.41 | 4.92 |
| 372.2 | 109.4 | 0.2 | 26.12 | 32.07 | 3.07 | 21.14 | 5.95 | 3.55 | 7.60 | 13.54 | 4.87 |
| 384.2 | 110.6 | 0.2 | 26.09 | 32.07 | 3.17 | 21.34 | 5.98 | 3.57 | 7.68 | 13.66 | 4.84 |
| 396.2 | 111.8 | 0.2 | 26.09 | 32.07 | 3.27 | 21.50 | 5.98 | 3.59 | 7.76 | 13.74 | 4.83 |
| 408.2 | 112.9 | 0.2 | 26.04 | 32.05 | 3.36 | 21.68 | 6.02 | 3.60 | 7.83 | 13.85 | 4.78 |
| 420.2 | 114.0 | 0.2 | 25.96 | 32.06 | 3.46 | 21.92 | 6.10 | 3.59 | 7.91 | 14.01 | 4.71 |
| 432.2 | 115.3 | 0.2 | 25.91 | 32.05 | 3.57 | 22.13 | 6.15 | 3.60 | 7.99 | 14.14 | 4.65 |
| 444.2 | 116.3 | 0.2 | 25.89 | 32.05 | 3.68 | 22.28 | 6.16 | 3.62 | 8.06 | 14.22 | 4.64 |
| 456.2 | 117.2 | 0.2 | 25.83 | 32.03 | 3.77 | 22.43 | 6.20 | 3.62 | 8.12 | 14.32 | 4.57 |
| 468.2 | 118.2 | 0.2 | 25.75 | 32.05 | 3.87 | 22.66 | 6.29 | 3.60 | 8.18 | 14.47 | 4.50 |
| 480.2 | 119.1 | 0.2 | 25.71 | 32.04 | 3.97 | 22.81 | 6.33 | 3.60 | 8.24 | 14.57 | 4.45 |
| 492.2 | 120.0 | 0.2 | 25.70 | 32.03 | 4.08 | 22.93 | 6.34 | 3.62 | 8.30 | 14.63 | 4.44 |
| 504.2 | 120.8 | 0.2 | 25.62 | 32.02 | 4.17 | 23.10 | 6.40 | 3.61 | 8.35 | 14.75 | 4.37 |
| 516.2 | 121.6 | 0.3 | 25.55 | 32.04 | 4.27 | 23.29 | 6.49 | 3.59 | 8.40 | 14.89 | 4.29 |
| 528.2 | 122.4 | 0.3 | 25.51 | 32.02 | 4.37 | 23.42 | 6.52 | 3.59 | 8.45 | 14.97 | 4.25 |
| 540.2 | 123.1 | 0.3 | 25.46 | 32.02 | 4.47 | 23.55 | 6.56 | 3.59 | 8.49 | 15.05 | 4.20 |
| 552.2 | 123.9 | 0.3 | 25.36 | 32.01 | 4.57 | 23.72 | 6.65 | 3.57 | 8.54 | 15.19 | 4.11 |
| 564.2 | 124.6 | 0.3 | 25.30 | 32.03 | 4.67 | 23.89 | 6.73 | 3.55 | 8.58 | 15.31 | 4.04 |
| 576.2 | 125.1 | 0.3 | 25.27 | 32.01 | 4.78 | 23.96 | 6.73 | 3.56 | 8.61 | 15.34 | 4.02 |
| 588.2 | 125.5 | 0.3 | 25.20 | 32.01 | 4.87 | 24.08 | 6.81 | 3.54 | 8.63 | 15.44 | 3.94 |
| 600.2 | 125.9 | 0.3 | 25.12 | 32.01 | 4.97 | 24.19 | 6.89 | 3.51 | 8.65 | 15.54 | 3.87 |
| 630.2 | 127.1 | 0.3 | 24.98 | 32.01 | 5.22 | 24.46 | 7.03 | 3.48 | 8.72 | 15.75 | 3.72 |
| 660.2 | 128.1 | 0.3 | 24.78 | 32.01 | 5.45 | 24.77 | 7.23 | 3.43 | 8.77 | 16.00 | 3.52 |
| 690.2 | 129.2 | 0.3 | 24.67 | 31.99 | 5.73 | 24.97 | 7.32 | 3.41 | 8.82 | 16.14 | 3.42 |
| 720.2 | 130.3 | 0.4 | 24.45 | 32.01 | 5.97 | 25.31 | 7.55 | 3.35 | 8.88 | 16.43 | 3.20 |
| 750.2 | 131.0 | 0.4 | 24.38 | 31.97 | 6.22 | 25.40 | 7.60 | 3.34 | 8.90 | 16.50 | 3.12 |
| 780.2 | 131.7 | 0.4 | 24.25 | 31.95 | 6.48 | 25.56 | 7.69 | 3.32 | 8.93 | 16.63 | 3.00 |
| 810.2 | 132.7 | 0.4 | 24.13 | 31.95 | 6.73 | 25.78 | 7.82 | 3.30 | 8.98 | 16.80 | 2.87 |
| 840.2 | 134.1 | 0.4 | 24.02 | 31.94 | 6.98 | 26.04 | 7.93 | 3.28 | 9.05 | 16.98 | 2.76 |
| 870.2 | 135.1 | 0.4 | 23.90 | 31.94 | 7.23 | 26.23 | 8.03 | 3.26 | 9.10 | 17.13 | 2.65 |
| 900.2 | 136.0 | 0.4 | 23.79 | 31.96 | 7.48 | 26.45 | 8.17 | 3.24 | 9.14 | 17.31 | 2.54 |
| 930.2 | 137.0 | 0.5 | 23.68 | 31.95 | 7.72 | 26.63 | 8.26 | 3.22 | 9.18 | 17.45 | 2.43 |
| 960.2 | 137.9 | 0.5 | 23.57 | 31.94 | 7.98 | 26.82 | 8.37 | 3.20 | 9.23 | 17.60 | 2.32 |
| 990.2 | 138.6 | 0.5 | 23.45 | 31.94 | 8.23 | 26.99 | 8.49 | 3.18 | 9.25 | 17.74 | 2.20 |
| 1020.2 | 139.1 | 0.5 | 23.33 | 31.95 | 8.48 | 27.13 | 8.61 | 3.15 | 9.26 | 17.87 | 2.08 |
| 1050.2 | 139.9 | 0.5 | 23.21 | 31.94 | 8.73 | 27.30 | 8.72 | 3.13 | 9.29 | 18.01 | 1.96 |
| 1080.2 | 140.4 | 0.5 | 23.10 | 31.93 | 8.98 | 27.44 | 8.84 | 3.11 | 9.30 | 18.14 | 1.84 |
| 1110.2 | 140.4 | 0.6 | 22.98 | 31.95 | 9.23 | 27.52 | 8.97 | 3.07 | 9.28 | 18.24 | 1.73 |
| 1140.2 | 140.1 | 0.6 | 22.86 | 31.96 | 9.47 | 27.55 | 9.09 | 3.03 | 9.23 | 18.32 | 1.61 |
| 1170.2 | 139.4 | 0.6 | 22.74 | 31.96 | 9.73 | 27.53 | 9.22 | 2.99 | 9.16 | 18.37 | 1.49 |
| 1200.2 | 139.8 | 0.6 | 22.63 | 31.98 | 9.98 | 27.66 | 9.35 | 2.96 | 9.16 | 18.51 | 1.38 |
| 1230.2 | 139.6 | 0.6 | 22.52 | 31.98 | 10.23 | 27.70 | 9.46 | 2.93 | 9.12 | 18.58 | 1.26 |
| 1260.2 | 139.6 | 0.6 | 22.41 | 31.98 | 10.49 | 27.74 | 9.57 | 2.90 | 9.09 | 18.65 | 1.16 |
| 1290.2 | 139.3 | 0.6 | 22.31 | 32.00 | 10.74 | 27.78 | 9.69 | 2.87 | 9.05 | 18.74 | 1.06 |
| 1320.2 | 139.5 | 0.7 | 22.21 | 31.99 | 10.99 | 27.85 | 9.78 | 2.85 | 9.04 | 18.82 | 0.96 |
| 1350.2 | 139.4 | 0.7 | 22.12 | 31.99 | 11.23 | 27.88 | 9.87 | 2.82 | 9.01 | 18.88 | 0.86 |
| 1380.2 | 139.6 | 0.7 | 22.03 | 32.00 | 11.49 | 27.95 | 9.97 | 2.80 | 8.99 | 18.96 | 0.77 |
| 1410.3 | 139.7 | 0.7 | 21.94 | 32.01 | 11.73 | 28.01 | 10.06 | 2.78 | 8.97 | 19.04 | 0.69 |
| 1440.3 | 139.9 | 0.7 | 21.85 | 32.02 | 11.99 | 28.08 | 10.16 | 2.76 | 8.96 | 19.12 | 0.60 |
| 1470.3 | 139.9 | 0.7 | 21.62 | 32.02 | 12.22 | 28.26 | 10.39 | 2.72 | 8.93 | 19.33 | 0.37 |
| 1500.3 | 140.1 | 0.7 | 21.29 | 32.04 | 12.47 | 28.59 | 10.74 | 2.66 | 8.92 | 19.67 | 0.04 |
| 1530.3 | 140.3 | 0.8 | 21.10 | 32.06 | 12.72 | 28.79 | 10.96 | 2.63 | 8.91 | 19.87 | -0.15 |
| 1560.3 | 141.0 | 0.8 | 20.93 | 32.07 | 12.97 | 29.00 | 11.13 | 2.60 | 8.93 | 20.07 | -0.32 |
| 1590.3 | 142.7 | 0.8 | 20.85 | 32.06 | 13.22 | 29.24 | 11.20 | 2.61 | 9.02 | 20.22 | -0.40 |
| 1620.3 | 143.0 | 0.8 | 20.87 | 32.03 | 13.49 | 29.18 | 11.16 | 2.62 | 9.01 | 20.17 | -0.39 |
| 1650.3 | 142.8 | 0.8 | 20.86 | 32.01 | 13.74 | 29.10 | 11.15 | 2.61 | 8.98 | 20.13 | -0.40 |
| 1680.3 | 142.9 | 0.8 | 20.69 | 32.02 | 13.98 | 29.23 | 11.33 | 2.58 | 8.95 | 20.28 | -0.56 |
| 1710.3 | 143.0 | 0.9 | 20.59 | 32.03 | 14.23 | 29.32 | 11.44 | 2.56 | 8.94 | 20.38 | -0.67 |
| 1740.3 | 143.1 | 0.9 | 20.49 | 32.03 | 14.47 | 29.37 | 11.54 | 2.54 | 8.91 | 20.46 | -0.77 |
| 1770.3 | 143.2 | 0.9 | 20.40 | 32.03 | 14.73 | 29.42 | 11.63 | 2.53 | 8.89 | 20.53 | -0.86 |
| 1800.3 | 143.2 | 0.9 | 20.28 | 32.04 | 14.98 | 29.50 | 11.76 | 2.51 | 8.87 | 20.63 | -0.98 |
| 1800.6 | 143.2 | 0.9 | 20.28 | 32.04 | 14.98 | 29.50 | 11.76 | 2.51 | 8.87 | 20.63 | -0.98 |

**Consolidation Laboratory Calculations**

| | | | |
|---|---|---|---|
| Consolidometer: | **1** | | |
| Method: | ASTM D 2435 Method B | | |
| Project No. : | 2065201 | | |
| Client: | Arcadis | | |
| Project: | LUC-23-11.75 | | |
| Location: | Sylvania, OH | | |
| Boring No. : | B-028-0-21 | Visual Description: | Gray SILT and CLAY, Some Sand A-6a (8) |
| Sample No.: | ST-3 | Liquid Limit: | 34 % |
| Depth: | 6.0 - 8.0' | Plastic Limit: | 21 % |
| Date of Test: | 4/13/2023 | Plasticity Index: | 13 % |

| ***Initial Sample Data*** | | | ***Final Sample Data*** | | |
|---|---|---|---|---|---|
| Initial Height | 1.000 in. | | Final Height | 0.892 in. | |
| Ring Dia. | 2.493 in. | | Ring Dia. | 2.493 in. | |
| Area of Ring | 4.8813 $in^2$ | | Area of Ring | 4.8813 $in^2$ | |
| Initial Volume | 4.8813 $in^3$ | 0.00282 $ft^3$ | Final Volume | 4.3539 $in^3$ | 0.00252 $ft^3$ |
| Specific Gravity | 2.743 | | | | |
| | | | Final wet mass soil, pan & ring | 345.7 g | |
| | | | Wt of Pan | 52.2 g | |
| Initial wet mass soil & ring | 295.3 g | | Final wet mass soil & ring | 293.5 | |
| Mass of ring | 146.3 g | | Mass of ring | 146.3 g | |
| | | | Final dry mass of soil, pan & ring | 317.1 g | |
| Initial wet mass soil | 149 g | 0.32849 lb | Final wet mass soil | 147.2 g | 0.32452 lb |
| | | | Weight of water | 28.6 g | 0.06305 lb |

***Initial Water Content***

| | |
|---|---|
| Mass can & wet soil | 242.9 g |
| Mass can & dry soil | 191.8 g |
| Mass of can | 50.9 g |
| Mass of water | 51.1 g |
| Mass of soil | 140.9 g |
| Initial water content | 36.27 % (trimmings) |

| | | | | | |
|---|---|---|---|---|---|
| Initial water content | 25.63 % (based on final dry weight) | | Final water content | 24.11 % (based on final dry weight) | |
| | | | Final weight of solids (Md) | 118.6 g | 0.26147 lb |
| Initial dry density | 92.6 pcf | | Final dry density | 103.8 pcf | |
| | | | Final volume of solids (Vs) | 2.6384 $in^3$ | 0.00153 $ft^3$ |
| | | | Final height of solids (Hs) | 0.5405 in. | |
| Initial void ratio (eo) | 0.850 | | Final void ratio (ef) | 0.650 | |
| Initial volume of voids (Vvo) | 2.2429 $in^3$ | 0.00130 $ft^3$ | Final volume of voids (Vvf) | 1.7154 $in^3$ | 0.00099 $ft^3$ |
| Initial volume of water (Vwo) | 1.8551 $in^3$ | 0.00107 $ft^3$ | Final volume of water (Vwf) | 1.7452 $in^3$ | 0.00101 $ft^3$ |
| Initial degree of saturation (So) | 82.71 % | | Final degree of saturation (Sf) | 101.74 % | |

Checks:
Final DD >= Initial DD TRUE

Project No.: 2065201
Date: 4/13/2023
Client: Arcadis
Project: LUC-23-11.75
Sylvania, OH
Boring No.: B-028-0-21
Sample No.: ST-3
Depth: 6.0 - 8.0'

Initial H= 1 inches

| Pressure tsf | Final Height (in) | Initial Height (in) | DH | Average H (in) | e | t50 (min) | Ave P (tsf) | Cv (in2/s) | Cv (ft2/d) |
|---|---|---|---|---|---|---|---|---|---|
| 0.125 | 1.00000 | 1.00000 | 0.00000 | 1.0000 | 0.850 | | | | |
| 0.25 | 0.99215 | 1.00000 | 0.00785 | 0.9961 | 0.836 | 0.9 | 0.125 | 0.000892 | 0.535 |
| 0.5 | 0.98755 | 0.99215 | 0.01245 | 0.9899 | 0.827 | 1.7 | 0.375 | 0.000463 | 0.278 |
| 1 | 0.97385 | 0.98755 | 0.02615 | 0.9807 | 0.802 | 0.8 | 0.75 | 0.000998 | 0.599 |
| 2 | 0.95955 | 0.97385 | 0.04045 | 0.9667 | 0.775 | 1.8 | 1.5 | 0.000416 | 0.249 |
| 4 | 0.93375 | 0.95955 | 0.06625 | 0.9467 | 0.728 | 0.8 | 3 | 0.000949 | 0.569 |
| 8 | 0.89625 | 0.93375 | 0.10375 | 0.9150 | 0.658 | 1.3 | 6 | 0.000527 | 0.316 |
| 16 | 0.85905 | 0.89625 | 0.14095 | 0.8777 | 0.589 | 1.7 | 12 | 0.000380 | 0.228 |
| 4 | 0.86405 | 0.85905 | 0.13595 | 0.8616 | 0.599 | | 10 | | |
| 1 | 0.87505 | 0.86405 | 0.12495 | 0.8696 | 0.619 | | 2.5 | | |
| 0.25 | 0.89195 | 0.87505 | 0.10805 | 0.8835 | 0.650 | | 0.625 | | |

Estimated Cc: 0.229
Estimated Cr: 0.034

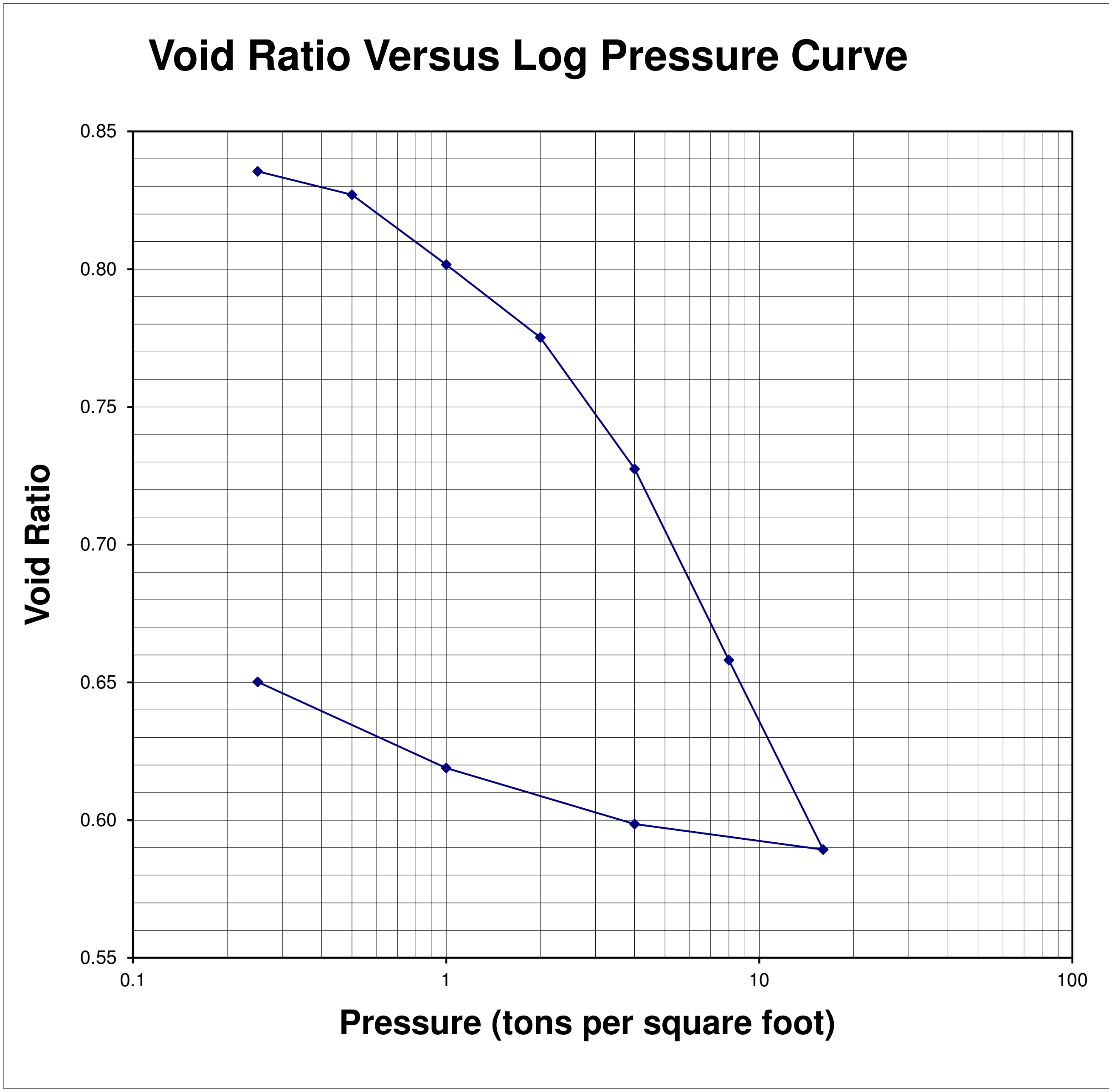
Soil Description: Gray SILT and CLAY, Some Sand A-6a (8)
Specific Gravity: 2.743
Liquid Limit: 34
Plastic Limit: 21
Plasticity Index: 13

| | | | |
|---|---|---|---|
| Initial Water Content: | 25.6 % | Final Water Content: | 24.1 % |
| Inital Dry Density: | 92.6 pcf | Final Dry Density: | 103.8 pcf |
| Initial Void Ratio: | 0.850 | Final Void Ratio: | 0.650 |
| Initial Degree of Saturation: | 82.7 % | Final Degree of Saturation | 101.7 % |

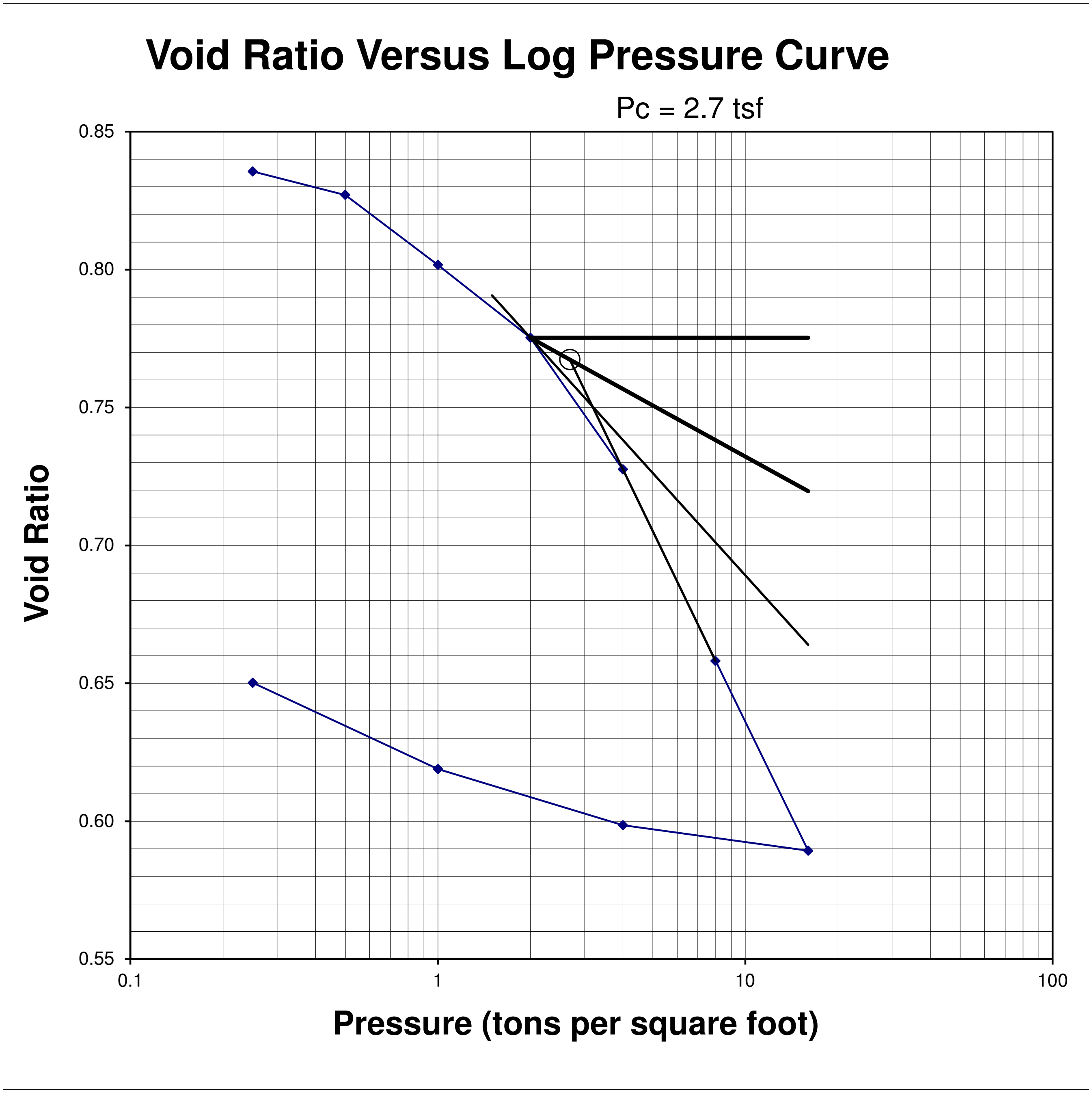
Estimated Preconsolidation Pressure: 2.7 tsf

The sample for the test was trimmed from a Shelby tube sample using a cutting shoe. Test Method B was used with the specimen inundated during testing. Coefficients of consolidation were computed by log of time method.

Project No.: 2065201
Date: 4/13/2023
Client: Arcadis
Project: LUC-23-11.75
Sylvania, OH
Boring No.: B-028-0-21
Sample No.: ST-3
Depth: 6.0 - 8.0'



Project No.: 2065201
Date: 4/13/2023
Client: Arcadis
Project: LUC-23-11.75
Sylvania, OH
Boring No.: B-028-0-21
Sample No.: ST-3
Depth: 6.0 - 8.0'



Project No. : 2065201 Sample No.: ST-3
Boring No. : B-028-0-21 Depth: 6.0 - 8.0'

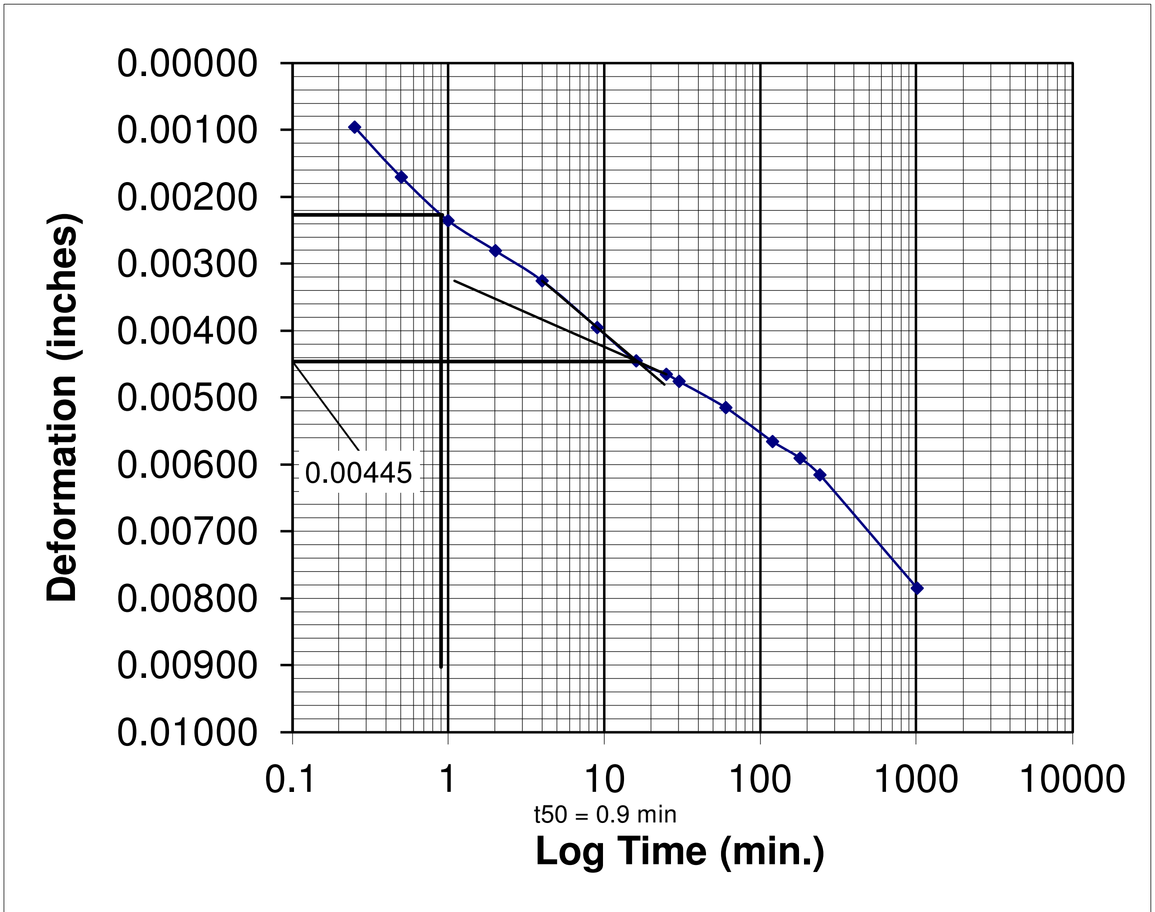
0.25 tsf Load

initial height= 1 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: -0.00045
2) 0.5 to 2.0: 0.00060
3) 1.0 to 4.0: 0.00145
Do Avg 1&2: 0.00007
Do Avg 1-3: 0.00053
**Use Do=** 0.00007
**D100=** 0.00445
**D50= D100+0.5(Do-D100)**
**D50=** 0.00226

**t50 =** 0.9 min.

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.39485 | | | | |
| 0.25 | 0.38960 | 0.00525 | 0.00430 | 0.00095 | 0.99905 |
| 0.5 | 0.38885 | 0.00600 | 0.00430 | 0.00170 | 0.99830 |
| 1 | 0.38820 | 0.00665 | 0.00430 | 0.00235 | 0.99765 |
| 2 | 0.38775 | 0.00710 | 0.00430 | 0.00280 | 0.99720 |
| 4 | 0.38730 | 0.00755 | 0.00430 | 0.00325 | 0.99675 |
| 9 | 0.38660 | 0.00825 | 0.00430 | 0.00395 | 0.99605 |
| 16 | 0.38610 | 0.00875 | 0.00430 | 0.00445 | 0.99555 |
| 25 | 0.38590 | 0.00895 | 0.00430 | 0.00465 | 0.99535 |
| 30 | 0.38580 | 0.00905 | 0.00430 | 0.00475 | 0.99525 |
| 60 | 0.38540 | 0.00945 | 0.00430 | 0.00515 | 0.99485 |
| 120 | 0.38490 | 0.00995 | 0.00430 | 0.00565 | 0.99435 |
| 180 | 0.38465 | 0.01020 | 0.00430 | 0.00590 | 0.99410 |
| 240 | 0.38440 | 0.01045 | 0.00430 | 0.00615 | 0.99385 |
| 1015 | 0.38270 | 0.01215 | 0.00430 | 0.00785 | 0.99215 |



Project No. : 2065201 Sample No.: ST-3
Boring No. : B-028-0-21 Depth: 6.0 - 8.0'

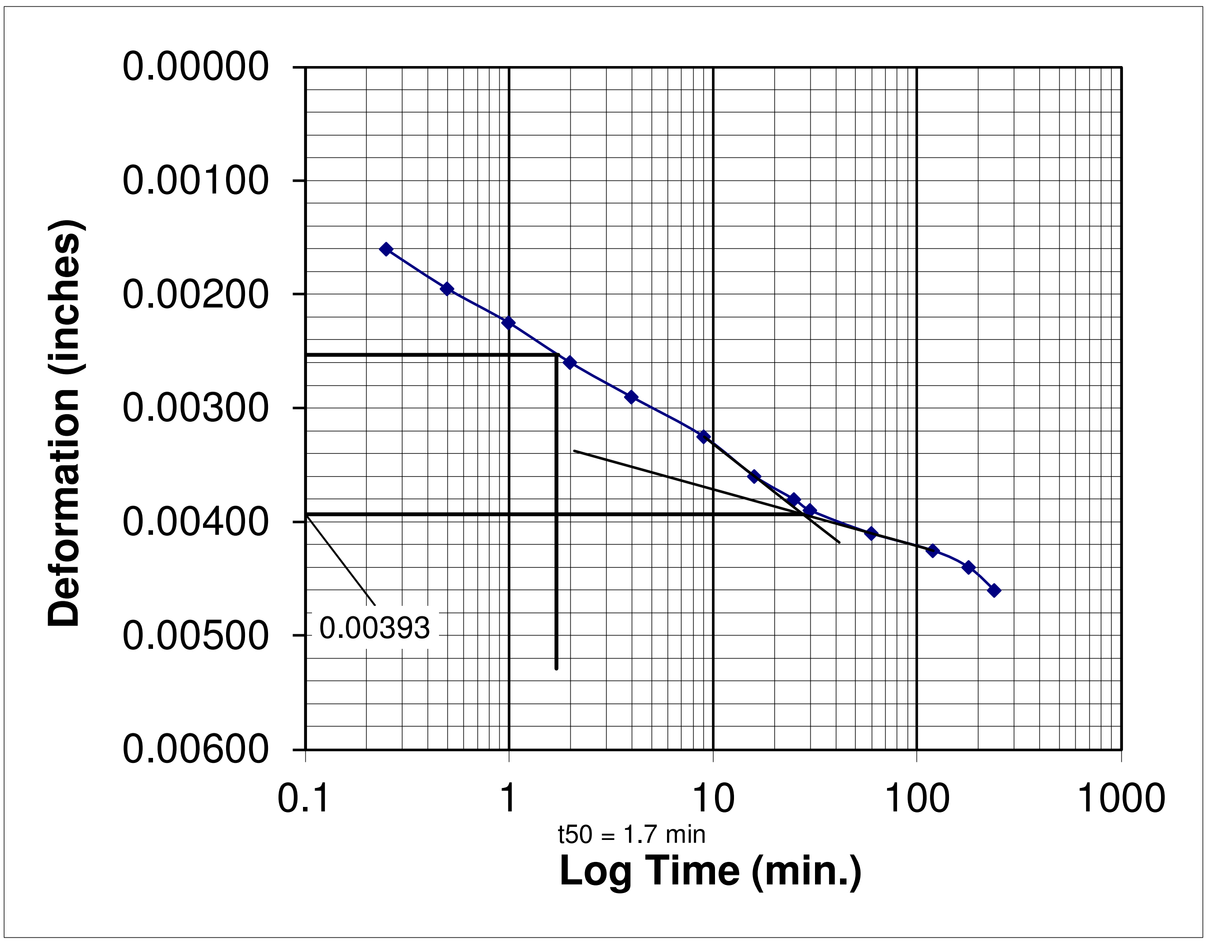
0.5 tsf Load

initial height= 0.99215 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00095
2) 0.5 to 2.0: 0.00130
3) 1.0 to 4.0: 0.00160
Do Avg 1&2: 0.00113
Do Avg 1-3: 0.00128
**Use Do=** 0.00113
**D100=** 0.00393
**D50= D100+0.5(Do-D100)**
**D50=** 0.00253

**t50 =** 1.7 min.

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.38270 | | | | |
| 0.25 | 0.38110 | 0.00160 | 0.00000 | 0.00160 | 0.99055 |
| 0.5 | 0.38075 | 0.00195 | 0.00000 | 0.00195 | 0.99020 |
| 1 | 0.38045 | 0.00225 | 0.00000 | 0.00225 | 0.98990 |
| 2 | 0.38010 | 0.00260 | 0.00000 | 0.00260 | 0.98955 |
| 4 | 0.37980 | 0.00290 | 0.00000 | 0.00290 | 0.98925 |
| 9 | 0.37945 | 0.00325 | 0.00000 | 0.00325 | 0.98890 |
| 16 | 0.37910 | 0.00360 | 0.00000 | 0.00360 | 0.98855 |
| 25 | 0.37890 | 0.00380 | 0.00000 | 0.00380 | 0.98835 |
| 30 | 0.37880 | 0.00390 | 0.00000 | 0.00390 | 0.98825 |
| 60 | 0.37860 | 0.00410 | 0.00000 | 0.00410 | 0.98805 |
| 120 | 0.37845 | 0.00425 | 0.00000 | 0.00425 | 0.98790 |
| 180 | 0.37830 | 0.00440 | 0.00000 | 0.00440 | 0.98775 |
| 240 | 0.37810 | 0.00460 | 0.00000 | 0.00460 | 0.98755 |



Project No. : 2065201 Sample No.: ST-3
Boring No. : B-028-0-21 Depth: 6.0 - 8.0'

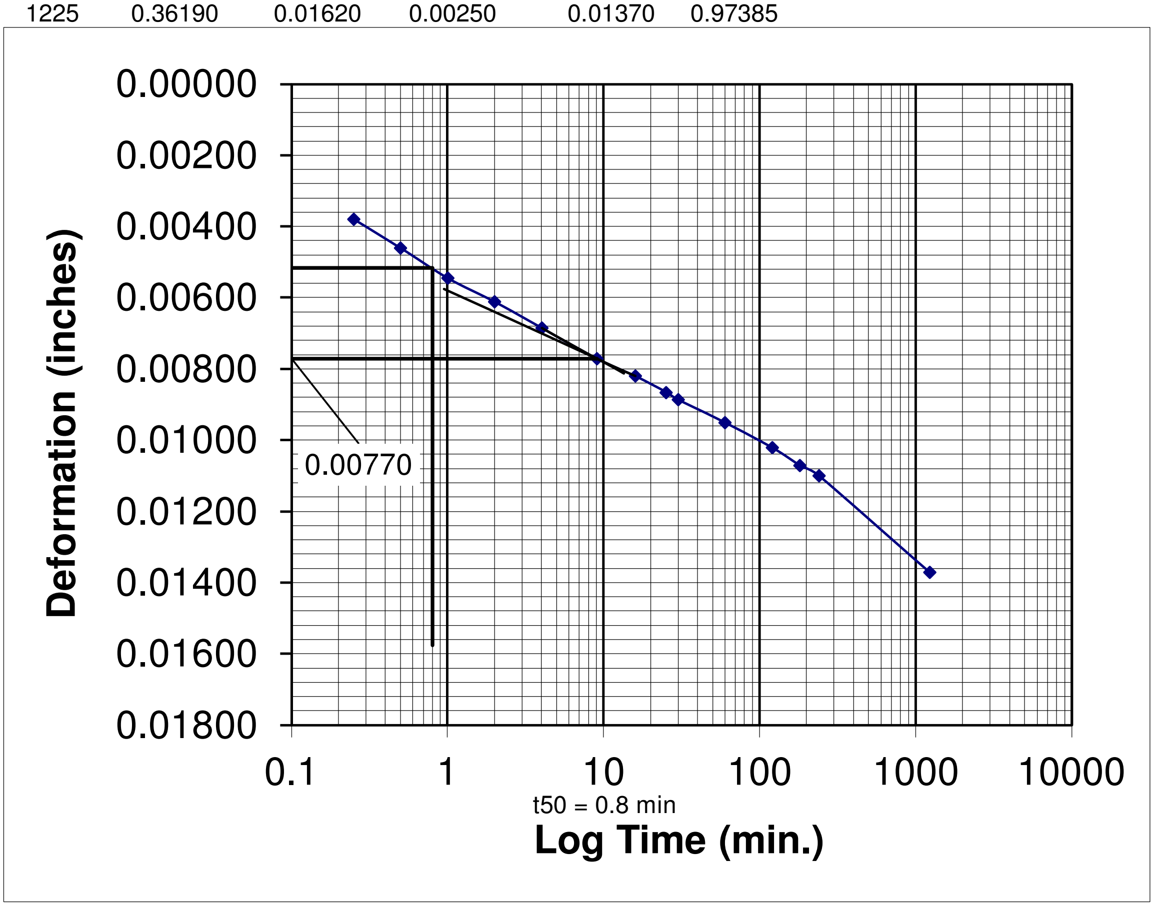
1.0 tsf Load

initial height= 0.98755 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00215
2) 0.5 to 2.0: 0.00310
3) 1.0 to 4.0: 0.00405
Do Avg 1&2: 0.00262
Do Avg 1-3: 0.00310
**Use Do=** 0.00262
**D100=** 0.00770
**D50= D100+0.5(Do-D100)**
**D50=** 0.00516

**t50 =** 0.8 min.

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.37810 | | | | |
| 0.25 | 0.37180 | 0.00630 | 0.00250 | 0.00380 | 0.98375 |
| 0.5 | 0.37100 | 0.00710 | 0.00250 | 0.00460 | 0.98295 |
| 1 | 0.37015 | 0.00795 | 0.00250 | 0.00545 | 0.98210 |
| 2 | 0.36950 | 0.00860 | 0.00250 | 0.00610 | 0.98145 |
| 4 | 0.36875 | 0.00935 | 0.00250 | 0.00685 | 0.98070 |
| 9 | 0.36790 | 0.01020 | 0.00250 | 0.00770 | 0.97985 |
| 16 | 0.36740 | 0.01070 | 0.00250 | 0.00820 | 0.97935 |
| 25 | 0.36695 | 0.01115 | 0.00250 | 0.00865 | 0.97890 |
| 30 | 0.36675 | 0.01135 | 0.00250 | 0.00885 | 0.97870 |
| 60 | 0.36610 | 0.01200 | 0.00250 | 0.00950 | 0.97805 |
| 120 | 0.36540 | 0.01270 | 0.00250 | 0.01020 | 0.97735 |
| 180 | 0.36490 | 0.01320 | 0.00250 | 0.01070 | 0.97685 |
| 240 | 0.36460 | 0.01350 | 0.00250 | 0.01100 | 0.97655 |
| 1225 | 0.36190 | 0.01620 | 0.00250 | 0.01370 | 0.97385 |



Project No. : 2065201 Sample No.: ST-3
Boring No. : B-028-0-21 Depth: 6.0 - 8.0'

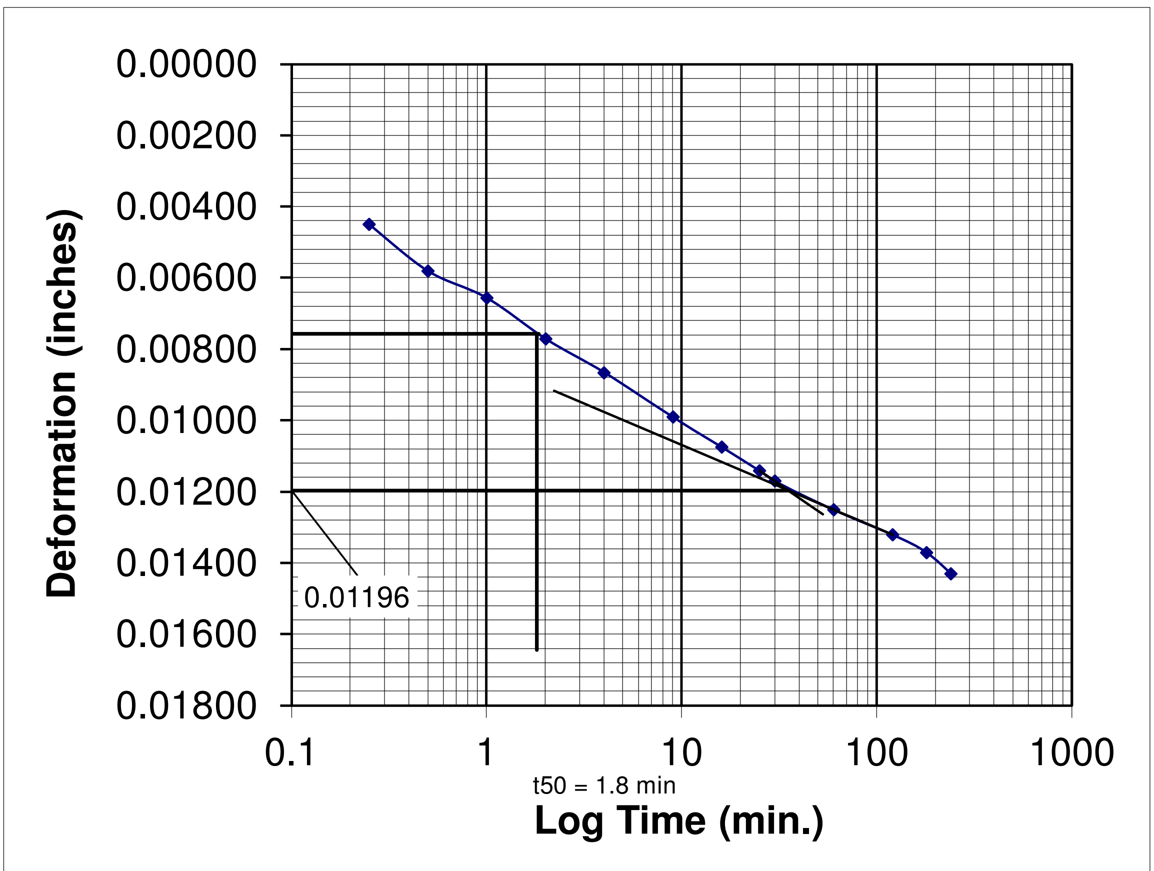
2.0 tsf Load

initial height= 0.97385 inches

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.36190 | | | | |
| 0.25 | 0.35450 | 0.00740 | 0.00290 | 0.00450 | 0.96935 |
| 0.5 | 0.35320 | 0.00870 | 0.00290 | 0.00580 | 0.96805 |
| 1 | 0.35245 | 0.00945 | 0.00290 | 0.00655 | 0.96730 |
| 2 | 0.35130 | 0.01060 | 0.00290 | 0.00770 | 0.96615 |
| 4 | 0.35035 | 0.01155 | 0.00290 | 0.00865 | 0.96520 |
| 9 | 0.34910 | 0.01280 | 0.00290 | 0.00990 | 0.96395 |
| 16 | 0.34825 | 0.01365 | 0.00290 | 0.01075 | 0.96310 |
| 25 | 0.34760 | 0.01430 | 0.00290 | 0.01140 | 0.96245 |
| 30 | 0.34730 | 0.01460 | 0.00290 | 0.01170 | 0.96215 |
| 60 | 0.34650 | 0.01540 | 0.00290 | 0.01250 | 0.96135 |
| 120 | 0.34580 | 0.01610 | 0.00290 | 0.01320 | 0.96065 |
| 180 | 0.34530 | 0.01660 | 0.00290 | 0.01370 | 0.96015 |
| 240 | 0.34470 | 0.01720 | 0.00290 | 0.01430 | 0.95955 |

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00245
2) 0.5 to 2.0: 0.00390
3) 1.0 to 4.0: 0.00445
Do Avg 1&2: 0.00318
Do Avg 1-3: 0.00360
**Use Do=** 0.00318
**D100=** 0.01196
**D50= D100+0.5(Do-D100)**
**D50=** 0.00757

**t50 =** 1.8 min.



Project No. : 2065201 Sample No.: ST-3
Boring No. : B-028-0-21 Depth: 6.0 - 8.0'

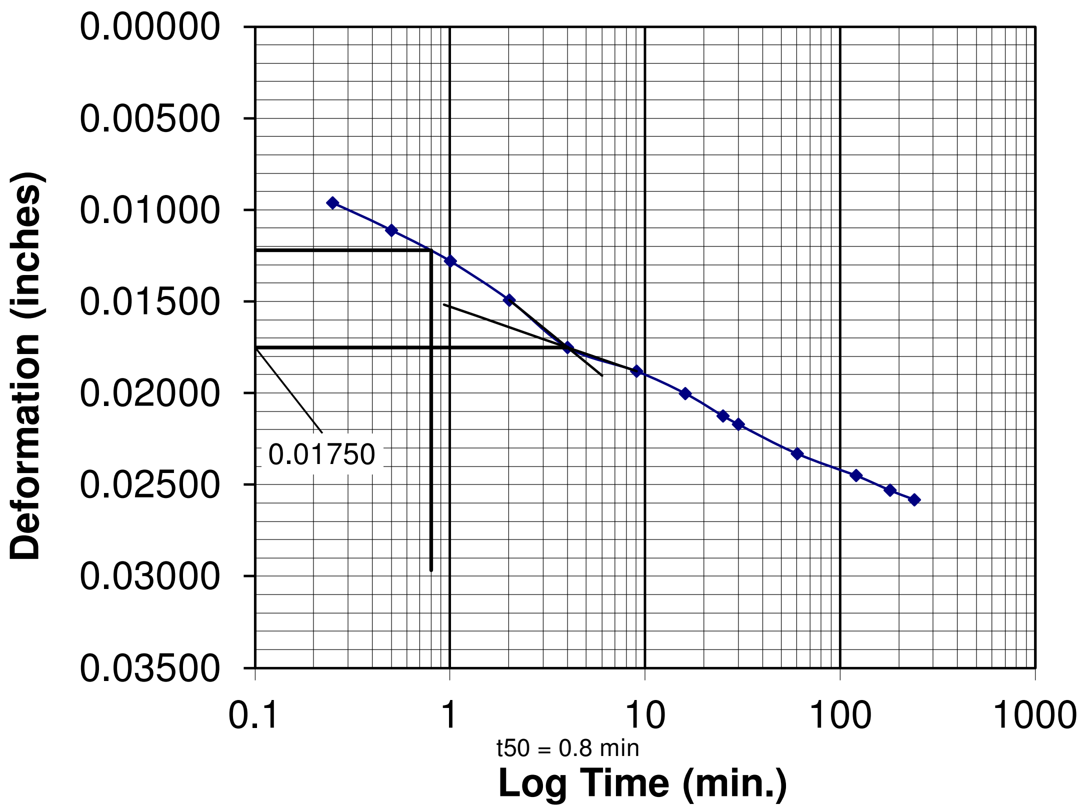
4.0 tsf Load

initial height= 0.95955 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00640
2) 0.5 to 2.0: 0.00730
3) 1.0 to 4.0: 0.00810
Do Avg 1&2: 0.00685
Do Avg 1-3: 0.00727
**Use Do=** 0.00685
**D100=** 0.01750
**D50= D100+0.5(Do-D100)**
**D50=** 0.01218

**t50 =** 0.8 min.

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.34470 | | | | |
| 0.25 | 0.33250 | 0.01220 | 0.00260 | 0.00960 | 0.94995 |
| 0.5 | 0.33100 | 0.01370 | 0.00260 | 0.01110 | 0.94845 |
| 1 | 0.32930 | 0.01540 | 0.00260 | 0.01280 | 0.94675 |
| 2 | 0.32720 | 0.01750 | 0.00260 | 0.01490 | 0.94465 |
| 4 | 0.32460 | 0.02010 | 0.00260 | 0.01750 | 0.94205 |
| 9 | 0.32330 | 0.02140 | 0.00260 | 0.01880 | 0.94075 |
| 16 | 0.32210 | 0.02260 | 0.00260 | 0.02000 | 0.93955 |
| 25 | 0.32085 | 0.02385 | 0.00260 | 0.02125 | 0.93830 |
| 30 | 0.32040 | 0.02430 | 0.00260 | 0.02170 | 0.93785 |
| 60 | 0.31880 | 0.02590 | 0.00260 | 0.02330 | 0.93625 |
| 120 | 0.31760 | 0.02710 | 0.00260 | 0.02450 | 0.93505 |
| 180 | 0.31680 | 0.02790 | 0.00260 | 0.02530 | 0.93425 |
| 240 | 0.31630 | 0.02840 | 0.00260 | 0.02580 | 0.93375 |



Project No. : 2065201 Sample No.: ST-3
Boring No. : B-028-0-21 Depth: 6.0 - 8.0'

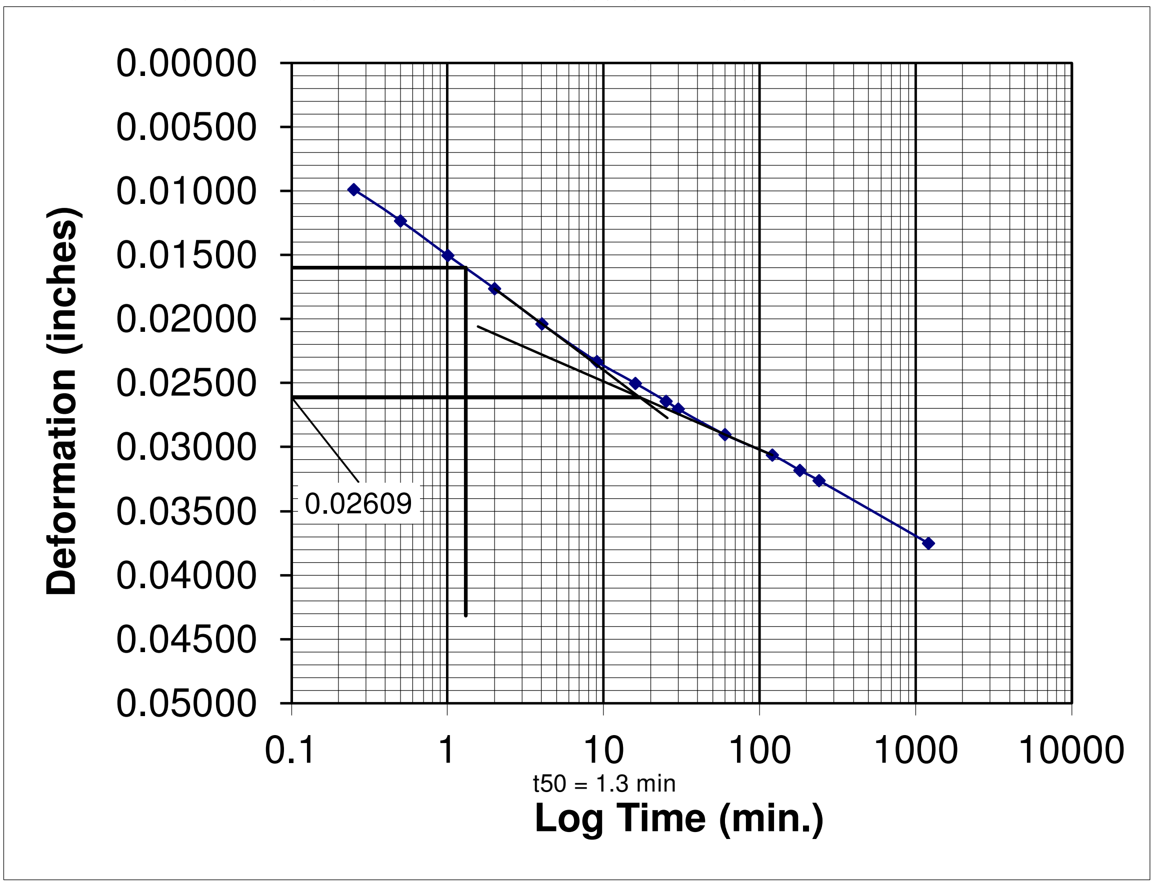
8.0 tsf Load

initial height= 0.93375 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00480
2) 0.5 to 2.0: 0.00700
3) 1.0 to 4.0: 0.00965
Do Avg 1&2: 0.00590
Do Avg 1-3: 0.00715
**Use Do=** 0.00590
**D100=** 0.02609
**D50= D100+0.5(Do-D100)**
**D50=** 0.01599

**t50 =** 1.3 min.

| **Interval Minutes** | **Dial Reading** | **ΔH** | **Deformation Constant** | **TRUE ΔH** | **Height of Sample** |
|---|---|---|---|---|---|
| 0 | 0.31630 | | | | |
| 0.25 | 0.30420 | 0.01210 | 0.00220 | 0.00990 | 0.92385 |
| 0.5 | 0.30180 | 0.01450 | 0.00220 | 0.01230 | 0.92145 |
| 1 | 0.29910 | 0.01720 | 0.00220 | 0.01500 | 0.91875 |
| 2 | 0.29650 | 0.01980 | 0.00220 | 0.01760 | 0.91615 |
| 4 | 0.29375 | 0.02255 | 0.00220 | 0.02035 | 0.91340 |
| 9 | 0.29080 | 0.02550 | 0.00220 | 0.02330 | 0.91045 |
| 16 | 0.28910 | 0.02720 | 0.00220 | 0.02500 | 0.90875 |
| 25 | 0.28770 | 0.02860 | 0.00220 | 0.02640 | 0.90735 |
| 30 | 0.28710 | 0.02920 | 0.00220 | 0.02700 | 0.90675 |
| 60 | 0.28510 | 0.03120 | 0.00220 | 0.02900 | 0.90475 |
| 120 | 0.28350 | 0.03280 | 0.00220 | 0.03060 | 0.90315 |
| 180 | 0.28230 | 0.03400 | 0.00220 | 0.03180 | 0.90195 |
| 240 | 0.28150 | 0.03480 | 0.00220 | 0.03260 | 0.90115 |
| 1205 | 0.27660 | 0.03970 | 0.00220 | 0.03750 | 0.89625 |



Project No. : 2065201　　Sample No.: ST-3
Boring No. : B-028-0-21　　Depth: 6.0 - 8.0'

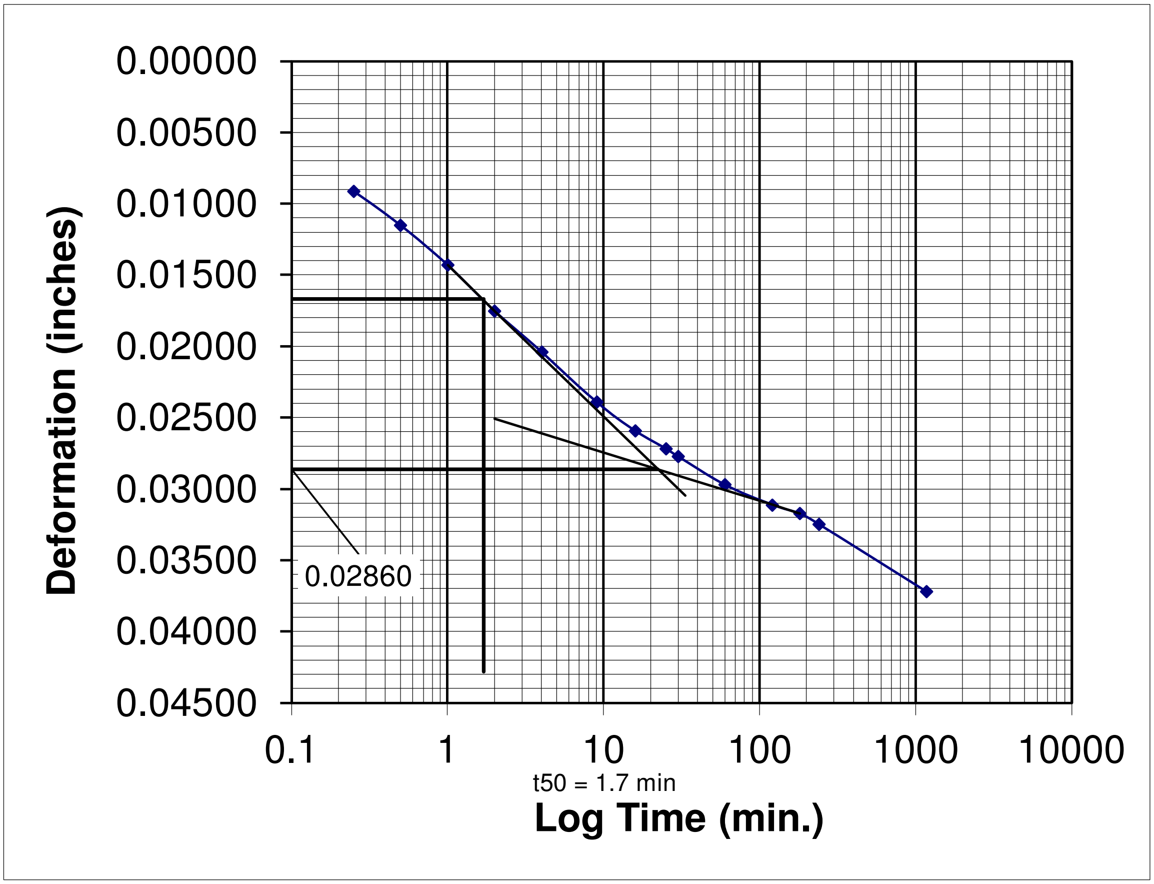
16 tsf Load

initial height= 0.89625 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00390
2) 0.5 to 2.0: 0.00550
3) 1.0 to 4.0: 0.00820
Do Avg 1&2: 0.00470
Do Avg 1-3: 0.00587
**Use Do=** 0.00470
**D100=** 0.02860
**D50= D100+0.5(Do-D100)**
**D50=** 0.01665

**t50 =** 1.7 min.

| **Interval Minutes** | **Dial Reading** | **ΔH** | **Deformation Constant** | **TRUE ΔH** | **Height of Sample** |
|---|---|---|---|---|---|
| 0 | 0.27660 | | | | |
| 0.25 | 0.26560 | 0.01100 | 0.00190 | 0.00910 | 0.88715 |
| 0.5 | 0.26320 | 0.01340 | 0.00190 | 0.01150 | 0.88475 |
| 1 | 0.26040 | 0.01620 | 0.00190 | 0.01430 | 0.88195 |
| 2 | 0.25720 | 0.01940 | 0.00190 | 0.01750 | 0.87875 |
| 4 | 0.25430 | 0.02230 | 0.00190 | 0.02040 | 0.87585 |
| 9 | 0.25080 | 0.02580 | 0.00190 | 0.02390 | 0.87235 |
| 16 | 0.24880 | 0.02780 | 0.00190 | 0.02590 | 0.87035 |
| 25 | 0.24755 | 0.02905 | 0.00190 | 0.02715 | 0.86910 |
| 30 | 0.24700 | 0.02960 | 0.00190 | 0.02770 | 0.86855 |
| 60 | 0.24500 | 0.03160 | 0.00190 | 0.02970 | 0.86655 |
| 120 | 0.24360 | 0.03300 | 0.00190 | 0.03110 | 0.86515 |
| 180 | 0.24300 | 0.03360 | 0.00190 | 0.03170 | 0.86455 |
| 240 | 0.24225 | 0.03435 | 0.00190 | 0.03245 | 0.86380 |
| 1170 | 0.23750 | 0.03910 | 0.00190 | 0.03720 | 0.85905 |

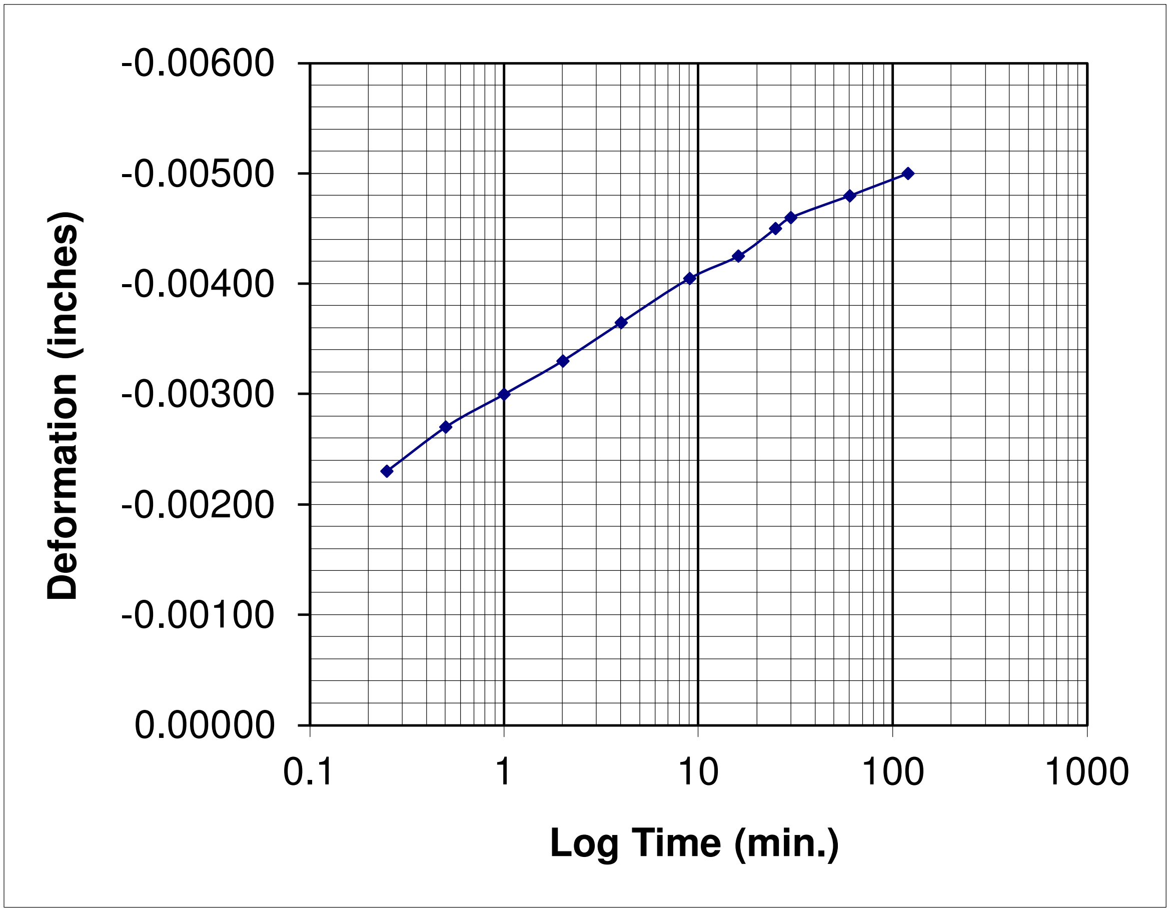


Project No. : 2065201 Sample No.: ST-3
Boring No. : B-028-0-21 Depth: 6.0 - 8.0'

4.0 tsf Unload

initial height= 0.85905 inches

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.23750 | | | | |
| 0.25 | 0.24110 | -0.00360 | -0.00130 | -0.00230 | 0.86135 |
| 0.5 | 0.24150 | -0.00400 | -0.00130 | -0.00270 | 0.86175 |
| 1 | 0.24180 | -0.00430 | -0.00130 | -0.00300 | 0.86205 |
| 2 | 0.24210 | -0.00460 | -0.00130 | -0.00330 | 0.86235 |
| 4 | 0.24245 | -0.00495 | -0.00130 | -0.00365 | 0.86270 |
| 9 | 0.24285 | -0.00535 | -0.00130 | -0.00405 | 0.86310 |
| 16 | 0.24305 | -0.00555 | -0.00130 | -0.00425 | 0.86330 |
| 25 | 0.24330 | -0.00580 | -0.00130 | -0.00450 | 0.86355 |
| 30 | 0.24340 | -0.00590 | -0.00130 | -0.00460 | 0.86365 |
| 60 | 0.24360 | -0.00610 | -0.00130 | -0.00480 | 0.86385 |
| 120 | 0.24380 | -0.00630 | -0.00130 | -0.00500 | 0.86405 |



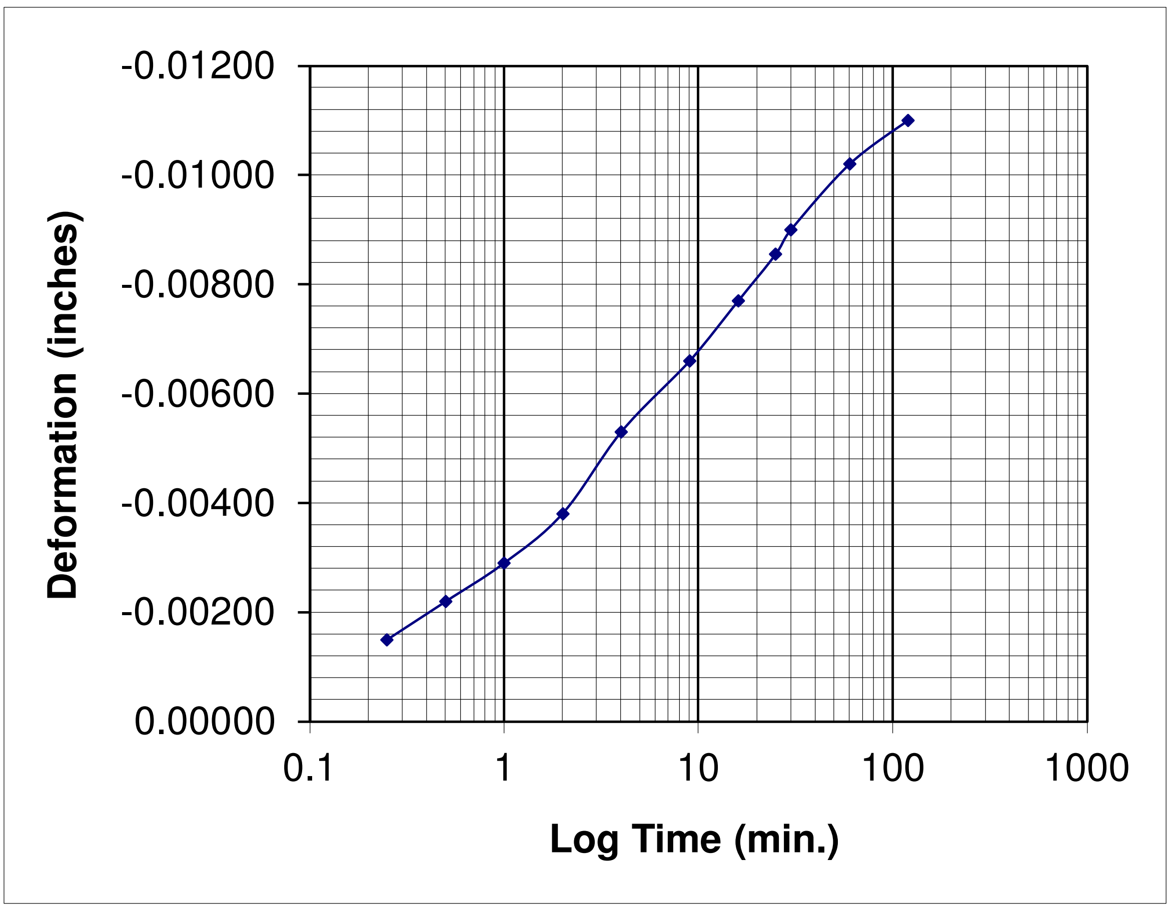
Project No. : 2065201
Boring No. : B-028-0-21

Sample No.: ST-3
Depth: 6.0 - 8.0'

1.0 tsf Unload

initial height= 0.86405 inches

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.24380 | | | | |
| 0.25 | 0.24720 | -0.00340 | -0.00190 | -0.00150 | 0.86555 |
| 0.5 | 0.24790 | -0.00410 | -0.00190 | -0.00220 | 0.86625 |
| 1 | 0.24860 | -0.00480 | -0.00190 | -0.00290 | 0.86695 |
| 2 | 0.24950 | -0.00570 | -0.00190 | -0.00380 | 0.86785 |
| 4 | 0.25100 | -0.00720 | -0.00190 | -0.00530 | 0.86935 |
| 9 | 0.25230 | -0.00850 | -0.00190 | -0.00660 | 0.87065 |
| 16 | 0.25340 | -0.00960 | -0.00190 | -0.00770 | 0.87175 |
| 25 | 0.25425 | -0.01045 | -0.00190 | -0.00855 | 0.87260 |
| 30 | 0.25470 | -0.01090 | -0.00190 | -0.00900 | 0.87305 |
| 60 | 0.25590 | -0.01210 | -0.00190 | -0.01020 | 0.87425 |
| 120 | 0.25670 | -0.01290 | -0.00190 | -0.01100 | 0.87505 |

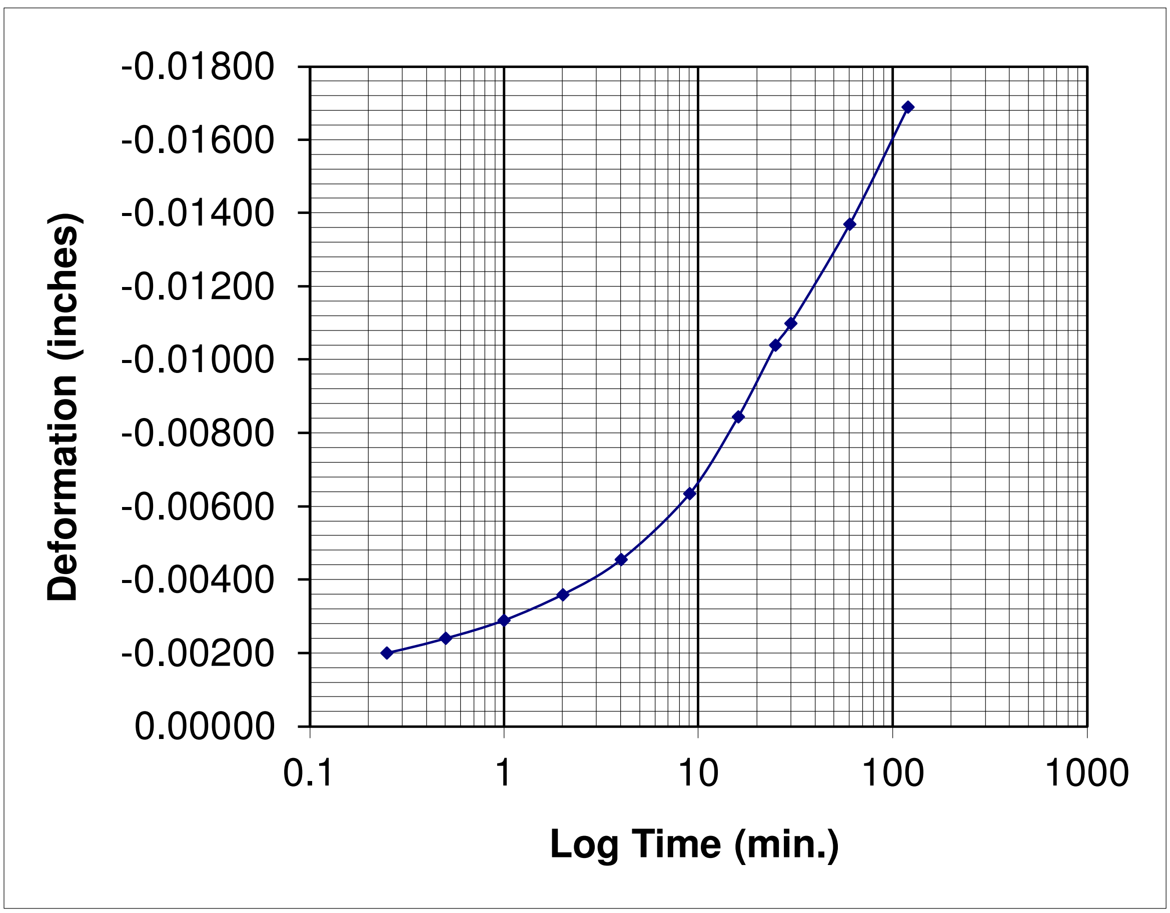


Project No. : 2065201 Sample No.: ST-3
Boring No. : B-028-0-21 Depth: 6.0 - 8.0'

0.25 tsf Unload

initial height= 0.87505 inches

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.25670 | | | | |
| 0.25 | 0.25870 | -0.00200 | 0.00000 | -0.00200 | 0.87705 |
| 0.5 | 0.25910 | -0.00240 | 0.00000 | -0.00240 | 0.87745 |
| 1 | 0.25960 | -0.00290 | 0.00000 | -0.00290 | 0.87795 |
| 2 | 0.26030 | -0.00360 | 0.00000 | -0.00360 | 0.87865 |
| 4 | 0.26125 | -0.00455 | 0.00000 | -0.00455 | 0.87960 |
| 9 | 0.26305 | -0.00635 | 0.00000 | -0.00635 | 0.88140 |
| 16 | 0.26515 | -0.00845 | 0.00000 | -0.00845 | 0.88350 |
| 25 | 0.26710 | -0.01040 | 0.00000 | -0.01040 | 0.88545 |
| 30 | 0.26770 | -0.01100 | 0.00000 | -0.01100 | 0.88605 |
| 60 | 0.27040 | -0.01370 | 0.00000 | -0.01370 | 0.88875 |
| 120 | 0.27360 | -0.01690 | 0.00000 | -0.01690 | 0.89195 |



**Consolidation Laboratory Calculations**

| | | | | | | |
|---|---|---|---|---|---|---|
| Consolidometer: | **2** | | | | | |
| Method: | ASTM D 2435 Method B | | | | | |
| Project No. : | 2065201 | | | | | |
| Client: | ARCADIS | | | | | |
| Project: | LUC-23-11.75 | | | | | |
| Location: | Sylvania, OH | | | | | |
| Boring No. : | B-039-1-21 | | | Visual Description: | Brown/Gray SILT and CLAY,Little Sand, Trace Gravel A-6a (9) | |
| Sample No.: | ST-1 | | | Liquid Limit: | 26 % | |
| Depth: | 9.0 - 11.0' | | | Plastic Limit: | 14 % | |
| Date of Test: | 2/27/2023 | | | Plasticity Index: | 12 % | |
| ***Initial Sample Data*** | | | | ***Final Sample Data*** | | |
| Initial Height | 1.000 in. | | | Final Height | 0.939 in. | |
| Ring Dia. | 2.493 in. | | | Ring Dia. | 2.493 in. | |
| Area of Ring | 4.8813 $in^2$ | | | Area of Ring | 4.8813 $in^2$ | |
| Initial Volume | 4.8813 $in^3$ | 0.00282 $ft^3$ | | Final Volume | 4.5855 $in^3$ | 0.00265 $ft^3$ |
| Specific Gravity | 2.739 | | | | | |
| | | | | Final wet mass soil, pan & ring | 370.3 g | |
| | | | | Wt of Pan | 50.8 g | |
| Initial wet mass soil & ring | 320.4 g | | | Final wet mass soil & ring | 319.5 | |
| Mass of ring | 146.3 g | | | Mass of ring | 146.3 g | |
| | | | | Final dry mass of soil, pan & ring | 349.0 g | |
| Initial wet mass soil | 174.1 g | 0.38383 lb | | Final wet mass soil | 173.2 g | 0.38184 lb |
| | | | | Weight of water | 21.3 g | 0.04696 lb |
| ***Initial Water Content*** | | | | | | |
| Mass can & wet soil | 543.6 g | | | | | |
| Mass can & dry soil | 480.5 g | | | | | |
| Mass of can | 52.7 g | | | | | |
| Mass of water | 63.1 g | | | | | |
| Mass of soil | 427.8 g | | | | | |
| Initial water content | 14.75 % (trimmings) | | | | | |
| Initial water content | 14.61 % (based on final dry weight) | | | Final water content | 14.02 % (based on final dry weight) | |
| | | | | Final weight of solids (Md) | 151.9 g | 0.33488 lb |
| Initial dry density | 118.6 pcf | | | Final dry density | 126.2 pcf | |
| | | | | Final volume of solids (Vs) | 3.3842 $in^3$ | 0.00196 $ft^3$ |
| | | | | Final height of solids (Hs) | 0.6933 in. | |
| Initial void ratio (eo) | 0.442 | | | Final void ratio (ef) | 0.355 | |
| Initial volume of voids (Vvo) | 1.4971 $in^3$ | 0.00087 $ft^3$ | | Final volume of voids (Vvf) | 1.2013 $in^3$ | 0.00070 $ft^3$ |
| Initial volume of water (Vwo) | 1.3547 $in^3$ | 0.00078 $ft^3$ | | Final volume of water (Vwf) | 1.2998 $in^3$ | 0.00075 $ft^3$ |
| Initial degree of saturation (So) | 90.49 % | | | Final degree of saturation (Sf) | 108.20 % | |

Checks:

Final DD >= Initial DD TRUE

Project No.: 2065201
Date: 2/27/2023
Client: ARCADIS
Project: LUC-23-11.75
Sylvania, OH
Boring No.: B-039-1-21
Sample No.: ST-1
Depth: 9.0 - 11.0'

Initial H= 1 inches

| Pressure tsf | Final Height (in) | Initial Height (in) | DH | Average H (in) | e | t50 (min) | Ave P (tsf) | Cv (in2/s) | Cv (ft2/d) |
|---|---|---|---|---|---|---|---|---|---|
| 0.25 | 0.98760 | 1.00000 | 0.01240 | 0.9938 | 0.425 | 7.8 | 0.125 | 0.000104 | 0.062 |
| 0.5 | 0.98140 | 0.98760 | 0.01860 | 0.9845 | 0.416 | 1.6 | 0.375 | 0.000489 | 0.293 |
| 1 | 0.97195 | 0.98140 | 0.02805 | 0.9767 | 0.402 | 1.8 | 0.75 | 0.000439 | 0.264 |
| 2 | 0.96045 | 0.97195 | 0.03955 | 0.9662 | 0.385 | 1.7 | 1.5 | 0.000449 | 0.269 |
| 4 | 0.95025 | 0.96045 | 0.04975 | 0.9554 | 0.371 | 2.8 | 3 | 0.000268 | 0.161 |
| 8 | 0.93610 | 0.95025 | 0.06390 | 0.9432 | 0.350 | 1.8 | 6 | 0.000409 | 0.245 |
| 16 | 0.91700 | 0.93610 | 0.08300 | 0.9266 | 0.323 | 1.6 | 12 | 0.000428 | 0.257 |
| 4 | 0.92070 | 0.91700 | 0.07930 | 0.9189 | 0.328 | | 10 | | |
| 1 | 0.92880 | 0.92070 | 0.07120 | 0.9248 | 0.340 | | 2.5 | | |
| 0.25 | 0.93940 | 0.92880 | 0.06060 | 0.9341 | 0.355 | | 0.625 | | |

Estimated Cc: 0.092
Estimated Cr: 0.018

Soil Description: Brown/Gray SILT and CLAY,Little Sand, Trace Gravel A-6a (9)
Specific Gravity: 2.739
Liquid Limit: 26
Plastic Limit: 14
Plasticity Index: 12

| | | | |
|---|---|---|---|
| Initial Water Content: | 14.6 % | Final Water Content: | 14.0 % |
| Inital Dry Density: | 118.6 pcf | Final Dry Density: | 126.2 pcf |
| Initial Void Ratio: | 0.442 | Final Void Ratio: | 0.355 |
| Initial Degree of Saturation: | 90.5 % | Final Degree of Saturation | 108.2 % |

Estimated Preconsolidation Pressure: 2.9 tsf

The sample for the test was trimmed from a Shelby tube sample using a cutting shoe. Test Method B was used with the specimen inundated during testing. Coefficients of consolidation were computed by log of time method.

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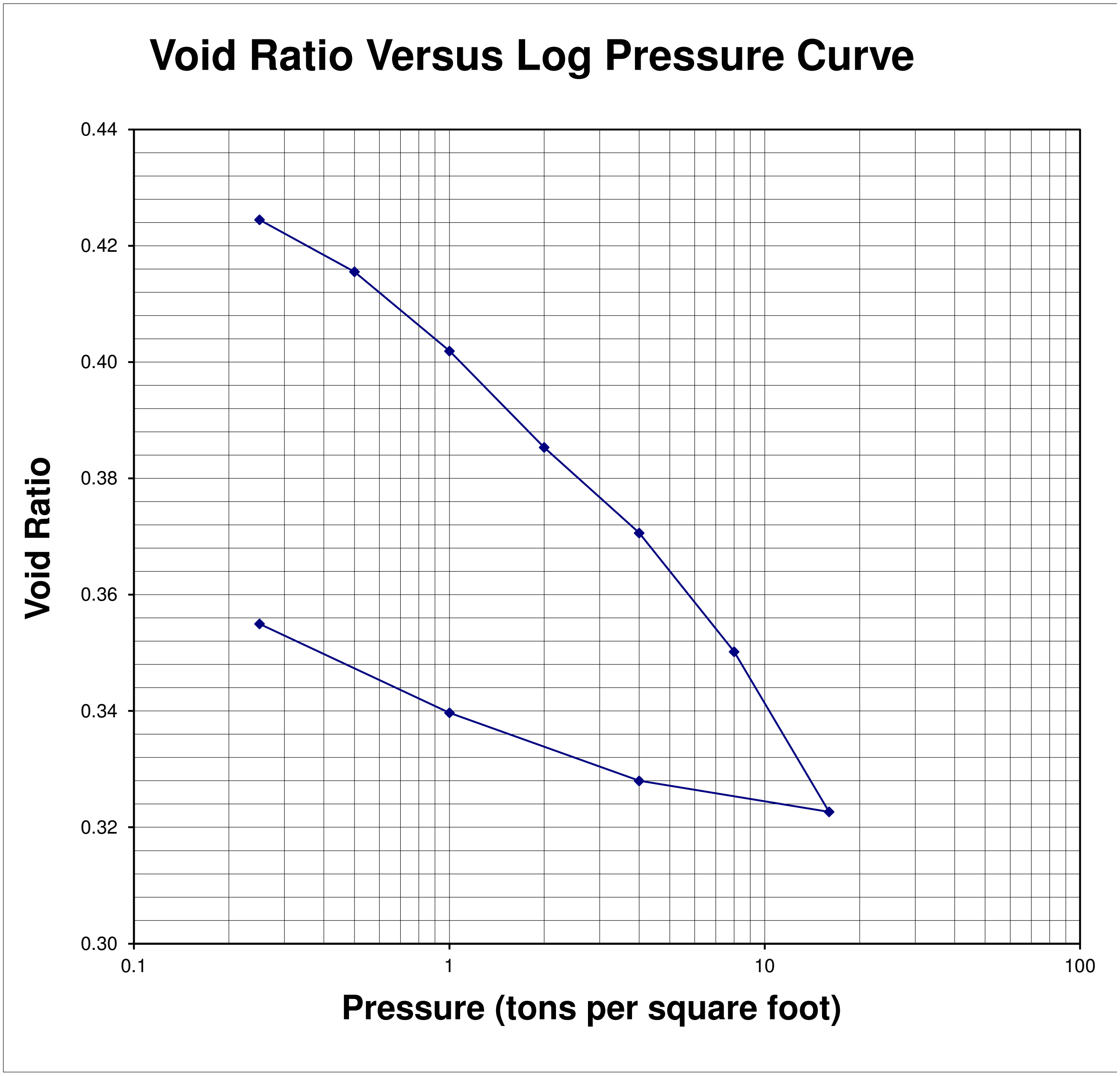
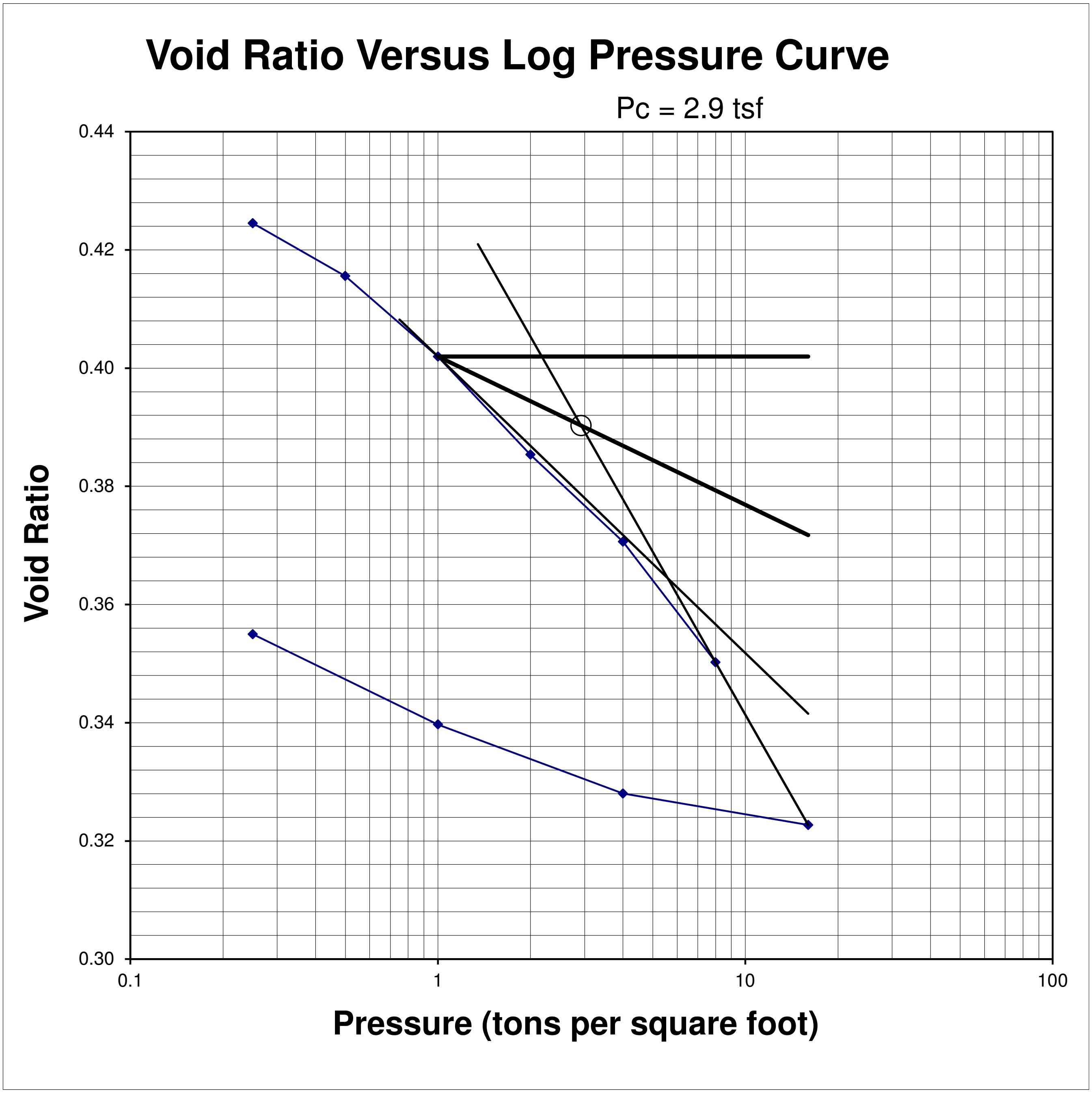
Environmental, Geotechnical Engineering & Testing

Project No.: 2065201
Date: 2/27/2023
Client: ARCADIS
Project: LUC-23-11.75
Sylvania, OH
Boring No.: B-039-1-21
Sample No.: ST-1
Depth: 9.0 - 11.0'



Project No.: 2065201
Date: 2/27/2023
Client: ARCADIS
Project: LUC-23-11.75
Sylvania, OH
Boring No.: B-039-1-21
Sample No.: ST-1
Depth: 9.0 - 11.0'



Project No. : 2065201 Sample No.: ST-1
Boring No. : B-039-1-21 Depth: 9.0 - 11.0'

0.25 tsf Load

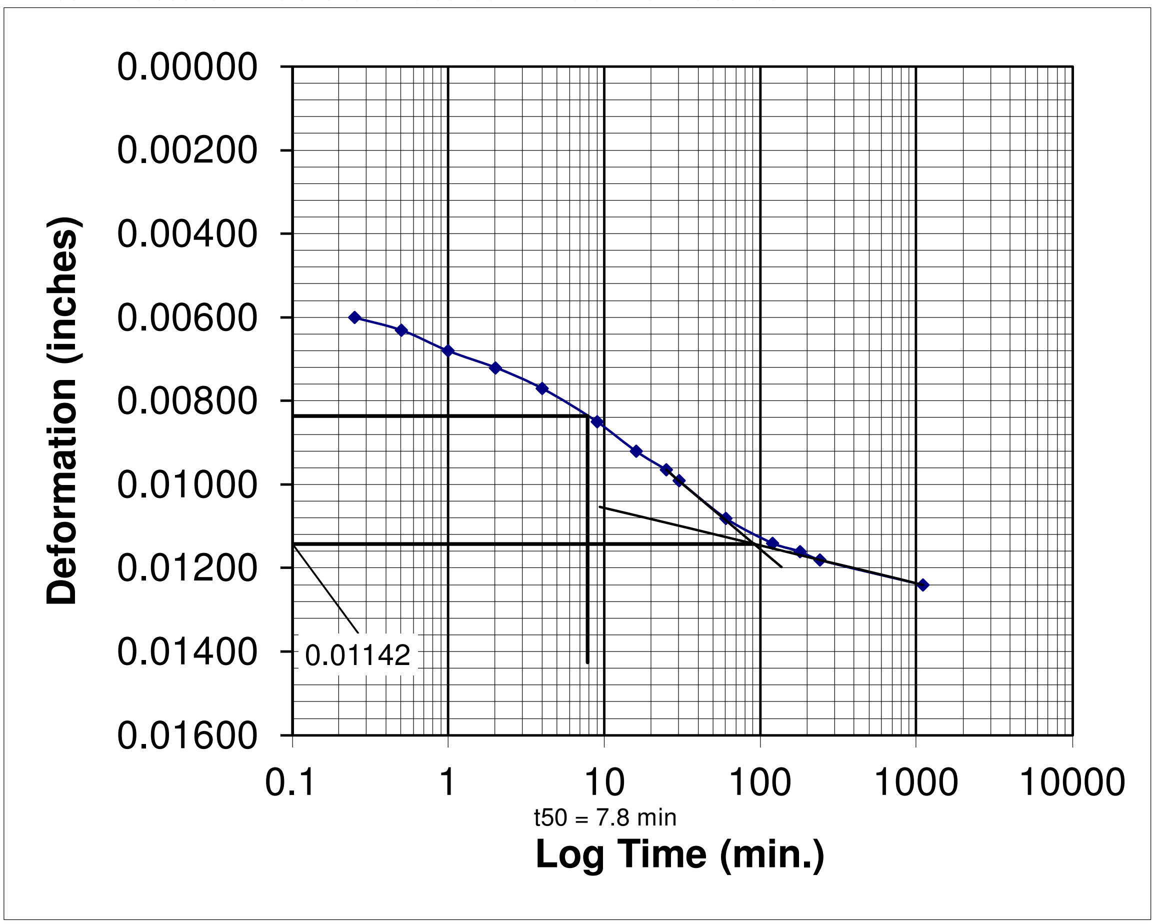
initial height= 1 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00520
2) 0.5 to 2.0: 0.00540
3) 1.0 to 4.0: 0.00590
Do Avg 1&2: 0.00530
Do Avg 1-3: 0.00550

**Use Do=** 0.00530
**D100=** 0.01142
**D50= D100+0.5(Do-D100)**
**D50=** 0.00836

**t50 =** 7.8 min.

| **Interval Minutes** | **Dial Reading** | **ΔH** | **Deformation Constant** | **TRUE ΔH** | **Height of Sample** |
|---|---|---|---|---|---|
| 0 | 0.39680 | | | | |
| 0.25 | 0.38980 | 0.00700 | 0.00100 | 0.00600 | 0.99400 |
| 0.5 | 0.38950 | 0.00730 | 0.00100 | 0.00630 | 0.99370 |
| 1 | 0.38900 | 0.00780 | 0.00100 | 0.00680 | 0.99320 |
| 2 | 0.38860 | 0.00820 | 0.00100 | 0.00720 | 0.99280 |
| 4 | 0.38810 | 0.00870 | 0.00100 | 0.00770 | 0.99230 |
| 9 | 0.38730 | 0.00950 | 0.00100 | 0.00850 | 0.99150 |
| 16 | 0.38660 | 0.01020 | 0.00100 | 0.00920 | 0.99080 |
| 25 | 0.38615 | 0.01065 | 0.00100 | 0.00965 | 0.99035 |
| 30 | 0.38590 | 0.01090 | 0.00100 | 0.00990 | 0.99010 |
| 60 | 0.38500 | 0.01180 | 0.00100 | 0.01080 | 0.98920 |
| 120 | 0.38440 | 0.01240 | 0.00100 | 0.01140 | 0.98860 |
| 180 | 0.38420 | 0.01260 | 0.00100 | 0.01160 | 0.98840 |
| 240 | 0.38400 | 0.01280 | 0.00100 | 0.01180 | 0.98820 |
| 1105 | 0.38340 | 0.01340 | 0.00100 | 0.01240 | 0.98760 |



Project No. : 2065201 Sample No.: ST-1
Boring No. : B-039-1-21 Depth: 9.0 - 11.0'

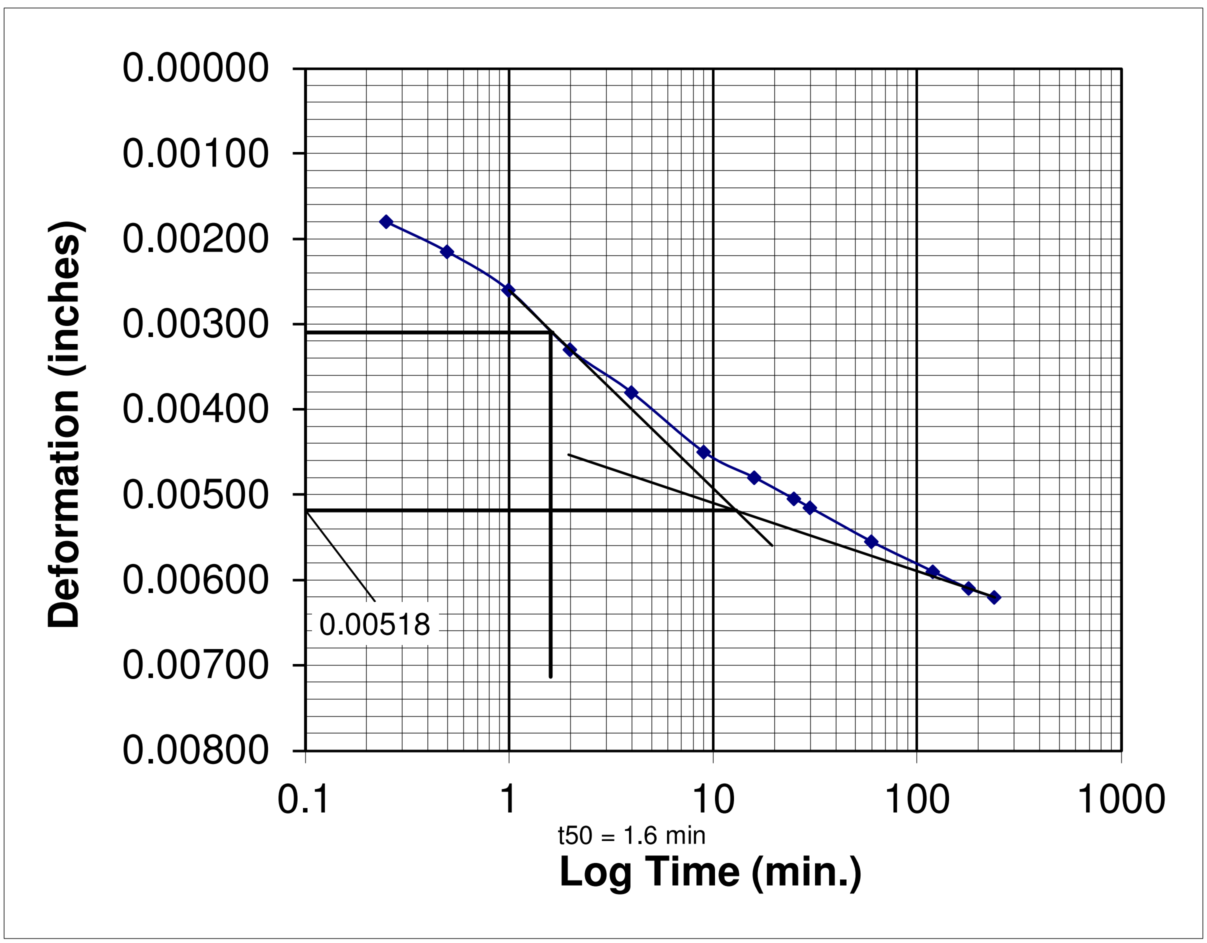
0.5 tsf Load

initial height= 0.9876 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00100
2) 0.5 to 2.0: 0.00100
3) 1.0 to 4.0: 0.00140
Do Avg 1&2: 0.00100
Do Avg 1-3: 0.00113
**Use Do=** 0.00100
**D100=** 0.00518
**D50= D100+0.5(Do-D100)**
**D50=** 0.00309

**t50 =** 1.6 min.

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.38340 | | | | |
| 0.25 | 0.38020 | 0.00320 | 0.00140 | 0.00180 | 0.98580 |
| 0.5 | 0.37985 | 0.00355 | 0.00140 | 0.00215 | 0.98545 |
| 1 | 0.37940 | 0.00400 | 0.00140 | 0.00260 | 0.98500 |
| 2 | 0.37870 | 0.00470 | 0.00140 | 0.00330 | 0.98430 |
| 4 | 0.37820 | 0.00520 | 0.00140 | 0.00380 | 0.98380 |
| 9 | 0.37750 | 0.00590 | 0.00140 | 0.00450 | 0.98310 |
| 16 | 0.37720 | 0.00620 | 0.00140 | 0.00480 | 0.98280 |
| 25 | 0.37695 | 0.00645 | 0.00140 | 0.00505 | 0.98255 |
| 30 | 0.37685 | 0.00655 | 0.00140 | 0.00515 | 0.98245 |
| 60 | 0.37645 | 0.00695 | 0.00140 | 0.00555 | 0.98205 |
| 120 | 0.37610 | 0.00730 | 0.00140 | 0.00590 | 0.98170 |
| 180 | 0.37590 | 0.00750 | 0.00140 | 0.00610 | 0.98150 |
| 240 | 0.37580 | 0.00760 | 0.00140 | 0.00620 | 0.98140 |

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Project No. : 2065201 Sample No.: ST-1
Boring No. : B-039-1-21 Depth: 9.0 - 11.0'

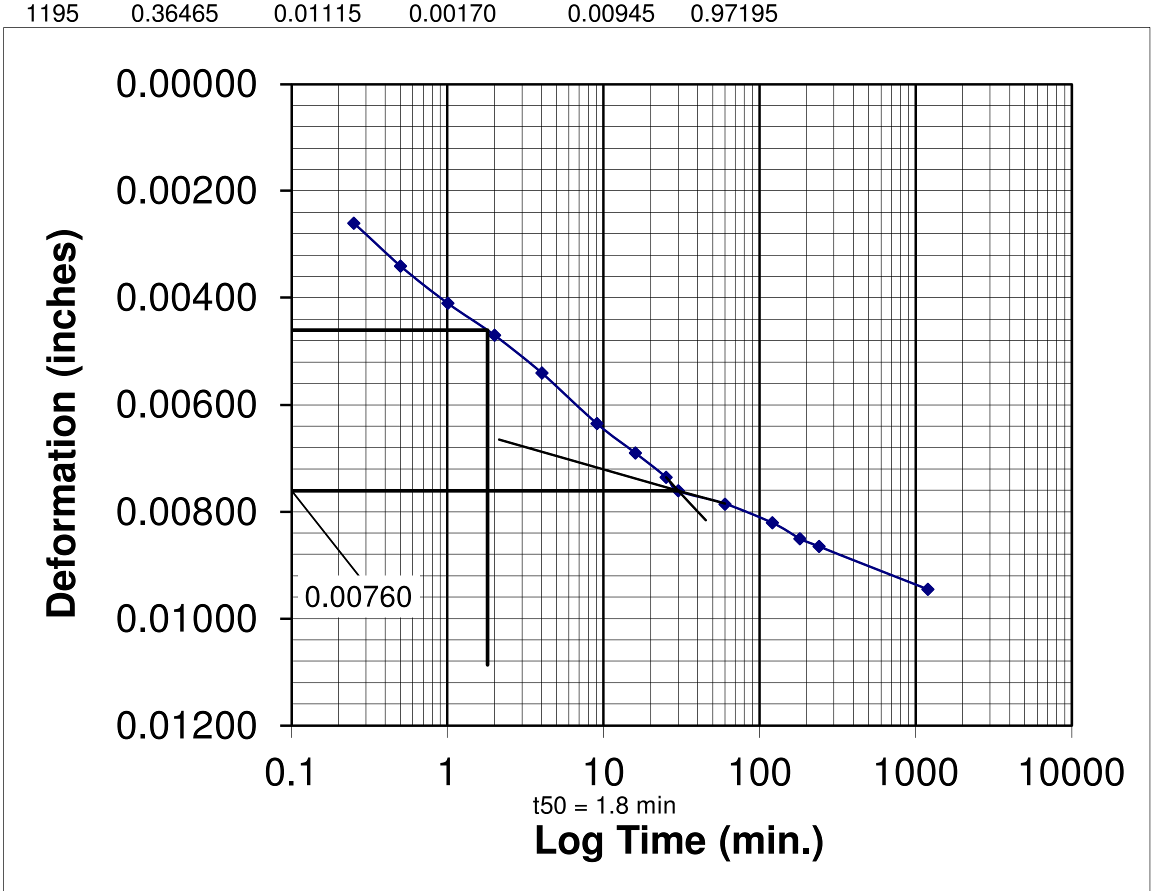
1.0 tsf Load

initial height= 0.9814 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00110
2) 0.5 to 2.0: 0.00210
3) 1.0 to 4.0: 0.00280
Do Avg 1&2: 0.00160
Do Avg 1-3: 0.00200
**Use Do=** 0.00160
**D100=** 0.00760
**D50= D100+0.5(Do-D100)**
**D50=** 0.00460

**t50 =** 1.8 min.

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.37580 | | | | |
| 0.25 | 0.37150 | 0.00430 | 0.00170 | 0.00260 | 0.97880 |
| 0.5 | 0.37070 | 0.00510 | 0.00170 | 0.00340 | 0.97800 |
| 1 | 0.37000 | 0.00580 | 0.00170 | 0.00410 | 0.97730 |
| 2 | 0.36940 | 0.00640 | 0.00170 | 0.00470 | 0.97670 |
| 4 | 0.36870 | 0.00710 | 0.00170 | 0.00540 | 0.97600 |
| 9 | 0.36775 | 0.00805 | 0.00170 | 0.00635 | 0.97505 |
| 16 | 0.36720 | 0.00860 | 0.00170 | 0.00690 | 0.97450 |
| 25 | 0.36675 | 0.00905 | 0.00170 | 0.00735 | 0.97405 |
| 30 | 0.36650 | 0.00930 | 0.00170 | 0.00760 | 0.97380 |
| 60 | 0.36625 | 0.00955 | 0.00170 | 0.00785 | 0.97355 |
| 120 | 0.36590 | 0.00990 | 0.00170 | 0.00820 | 0.97320 |
| 180 | 0.36560 | 0.01020 | 0.00170 | 0.00850 | 0.97290 |
| 240 | 0.36545 | 0.01035 | 0.00170 | 0.00865 | 0.97275 |
| 1195 | 0.36465 | 0.01115 | 0.00170 | 0.00945 | 0.97195 |



Project No. : 2065201    Sample No.: ST-1
Boring No. : B-039-1-21    Depth: 9.0 - 11.0'

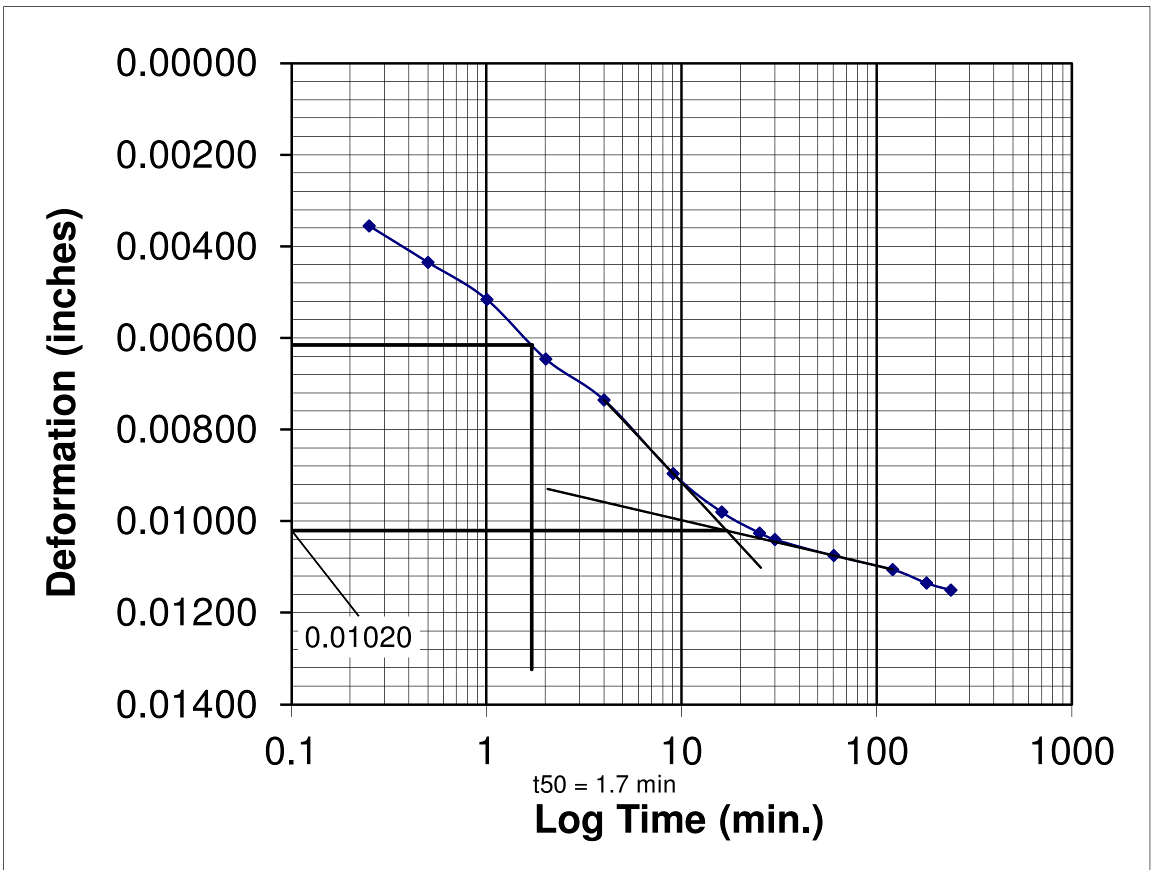
2.0 tsf Load

initial height= 0.97195 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00195
2) 0.5 to 2.0: 0.00225
3) 1.0 to 4.0: 0.00295
Do Avg 1&2: 0.00210
Do Avg 1-3: 0.00238
**Use Do=** 0.00210
**D100=** 0.01020
**D50= D100+0.5(Do-D100)**
**D50=** 0.00615

**t50 =** 1.7 min.

| **Interval Minutes** | **Dial Reading** | **ΔH** | **Deformation Constant** | **TRUE ΔH** | **Height of Sample** |
|---|---|---|---|---|---|
| 0 | 0.36465 | | | | |
| 0.25 | 0.35840 | 0.00625 | 0.00270 | 0.00355 | 0.96840 |
| 0.5 | 0.35760 | 0.00705 | 0.00270 | 0.00435 | 0.96760 |
| 1 | 0.35680 | 0.00785 | 0.00270 | 0.00515 | 0.96680 |
| 2 | 0.35550 | 0.00915 | 0.00270 | 0.00645 | 0.96550 |
| 4 | 0.35460 | 0.01005 | 0.00270 | 0.00735 | 0.96460 |
| 9 | 0.35300 | 0.01165 | 0.00270 | 0.00895 | 0.96300 |
| 16 | 0.35215 | 0.01250 | 0.00270 | 0.00980 | 0.96215 |
| 25 | 0.35170 | 0.01295 | 0.00270 | 0.01025 | 0.96170 |
| 30 | 0.35155 | 0.01310 | 0.00270 | 0.01040 | 0.96155 |
| 60 | 0.35120 | 0.01345 | 0.00270 | 0.01075 | 0.96120 |
| 120 | 0.35090 | 0.01375 | 0.00270 | 0.01105 | 0.96090 |
| 180 | 0.35060 | 0.01405 | 0.00270 | 0.01135 | 0.96060 |
| 240 | 0.35045 | 0.01420 | 0.00270 | 0.01150 | 0.96045 |



Project No. : 2065201 Sample No.: ST-1
Boring No. : B-039-1-21 Depth: 9.0 - 11.0'

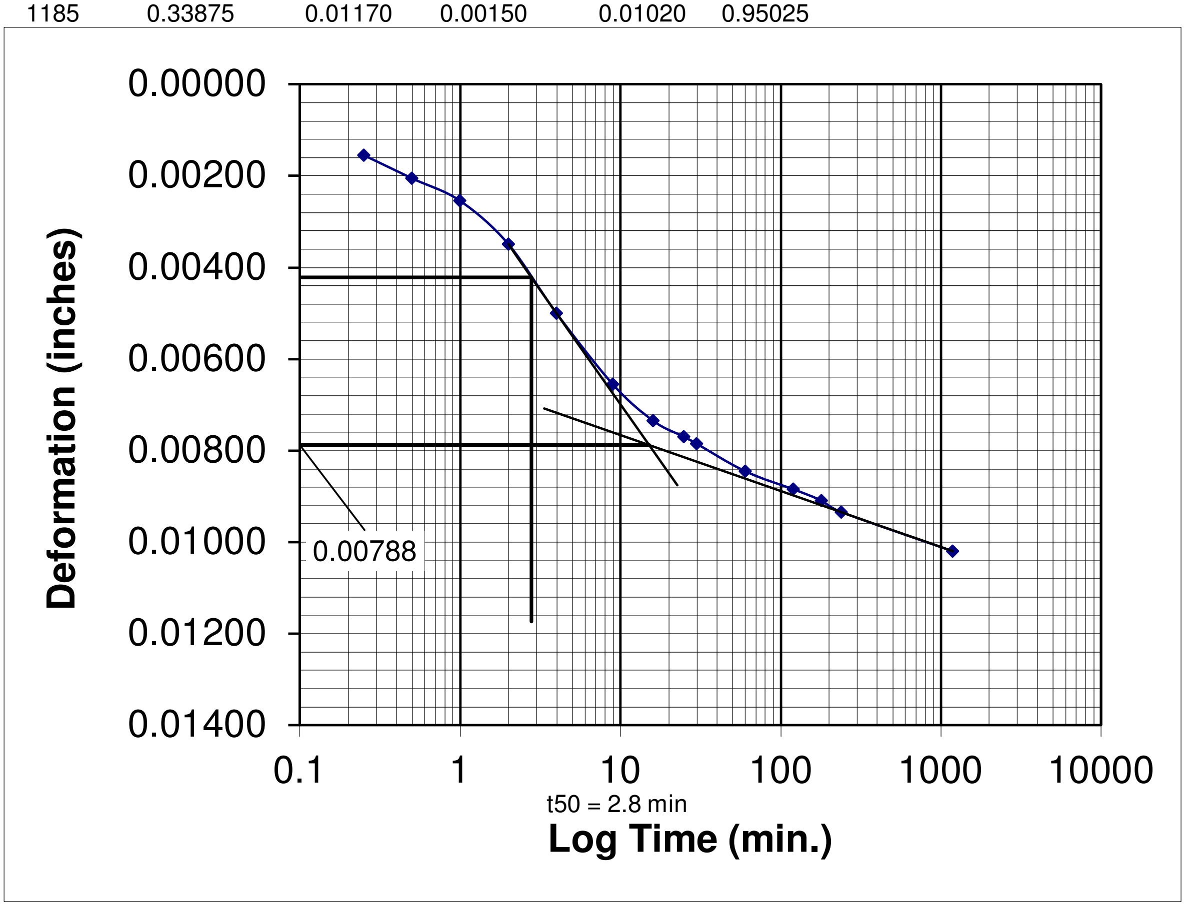
4.0 tsf Load

initial height= 0.96045 inches

Do= D1-(D2-D1)
1) 0.25 to 1.0: 0.00055
2) 0.5 to 2.0: 0.00060
3) 1.0 to 4.0: 0.00010
Do Avg 1&2: 0.00057
Do Avg 1-3: 0.00042
**Use Do=** 0.00057
**D100=** 0.00788
**D50= D100+0.5(Do-D100)**
**D50=** 0.00423

**t50 =** 2.8 min.

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.35045 | | | | |
| 0.25 | 0.34740 | 0.00305 | 0.00150 | 0.00155 | 0.95890 |
| 0.5 | 0.34690 | 0.00355 | 0.00150 | 0.00205 | 0.95840 |
| 1 | 0.34640 | 0.00405 | 0.00150 | 0.00255 | 0.95790 |
| 2 | 0.34545 | 0.00500 | 0.00150 | 0.00350 | 0.95695 |
| 4 | 0.34395 | 0.00650 | 0.00150 | 0.00500 | 0.95545 |
| 9 | 0.34240 | 0.00805 | 0.00150 | 0.00655 | 0.95390 |
| 16 | 0.34160 | 0.00885 | 0.00150 | 0.00735 | 0.95310 |
| 25 | 0.34125 | 0.00920 | 0.00150 | 0.00770 | 0.95275 |
| 30 | 0.34110 | 0.00935 | 0.00150 | 0.00785 | 0.95260 |
| 60 | 0.34050 | 0.00995 | 0.00150 | 0.00845 | 0.95200 |
| 120 | 0.34010 | 0.01035 | 0.00150 | 0.00885 | 0.95160 |
| 180 | 0.33985 | 0.01060 | 0.00150 | 0.00910 | 0.95135 |
| 240 | 0.33960 | 0.01085 | 0.00150 | 0.00935 | 0.95110 |
| 1185 | 0.33875 | 0.01170 | 0.00150 | 0.01020 | 0.95025 |



Project No. : 2065201 Sample No.: ST-1
Boring No. : B-039-1-21 Depth: 9.0 - 11.0'

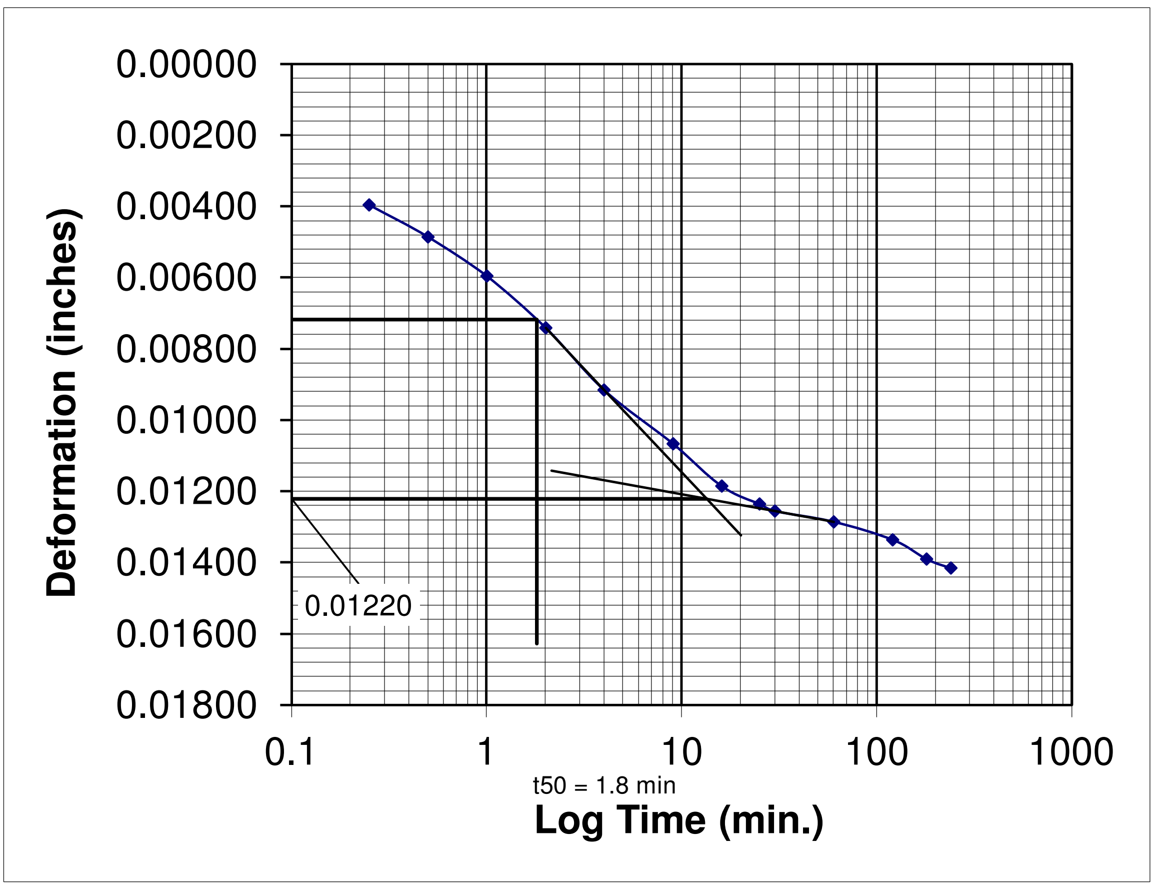
8.0 tsf Load

initial height= 0.95025 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00195
2) 0.5 to 2.0: 0.00230
3) 1.0 to 4.0: 0.00275
Do Avg 1&2: 0.00212
Do Avg 1-3: 0.00233
**Use Do=** 0.00212
**D100=** 0.01220
**D50= D100+0.5(Do-D100)**
**D50=** 0.00716

**t50 =** 1.8 min.

| **Interval Minutes** | **Dial Reading** | **ΔH** | **Deformation Constant** | **TRUE ΔH** | **Height of Sample** |
|---|---|---|---|---|---|
| 0 | 0.33875 | | | | |
| 0.25 | 0.33300 | 0.00575 | 0.00180 | 0.00395 | 0.94630 |
| 0.5 | 0.33210 | 0.00665 | 0.00180 | 0.00485 | 0.94540 |
| 1 | 0.33100 | 0.00775 | 0.00180 | 0.00595 | 0.94430 |
| 2 | 0.32955 | 0.00920 | 0.00180 | 0.00740 | 0.94285 |
| 4 | 0.32780 | 0.01095 | 0.00180 | 0.00915 | 0.94110 |
| 9 | 0.32630 | 0.01245 | 0.00180 | 0.01065 | 0.93960 |
| 16 | 0.32510 | 0.01365 | 0.00180 | 0.01185 | 0.93840 |
| 25 | 0.32460 | 0.01415 | 0.00180 | 0.01235 | 0.93790 |
| 30 | 0.32440 | 0.01435 | 0.00180 | 0.01255 | 0.93770 |
| 60 | 0.32410 | 0.01465 | 0.00180 | 0.01285 | 0.93740 |
| 120 | 0.32360 | 0.01515 | 0.00180 | 0.01335 | 0.93690 |
| 180 | 0.32305 | 0.01570 | 0.00180 | 0.01390 | 0.93635 |
| 240 | 0.32280 | 0.01595 | 0.00180 | 0.01415 | 0.93610 |



Project No. : 2065201
Boring No. : B-039-1-21

Sample No.: ST-1
Depth: 9.0 - 11.0'

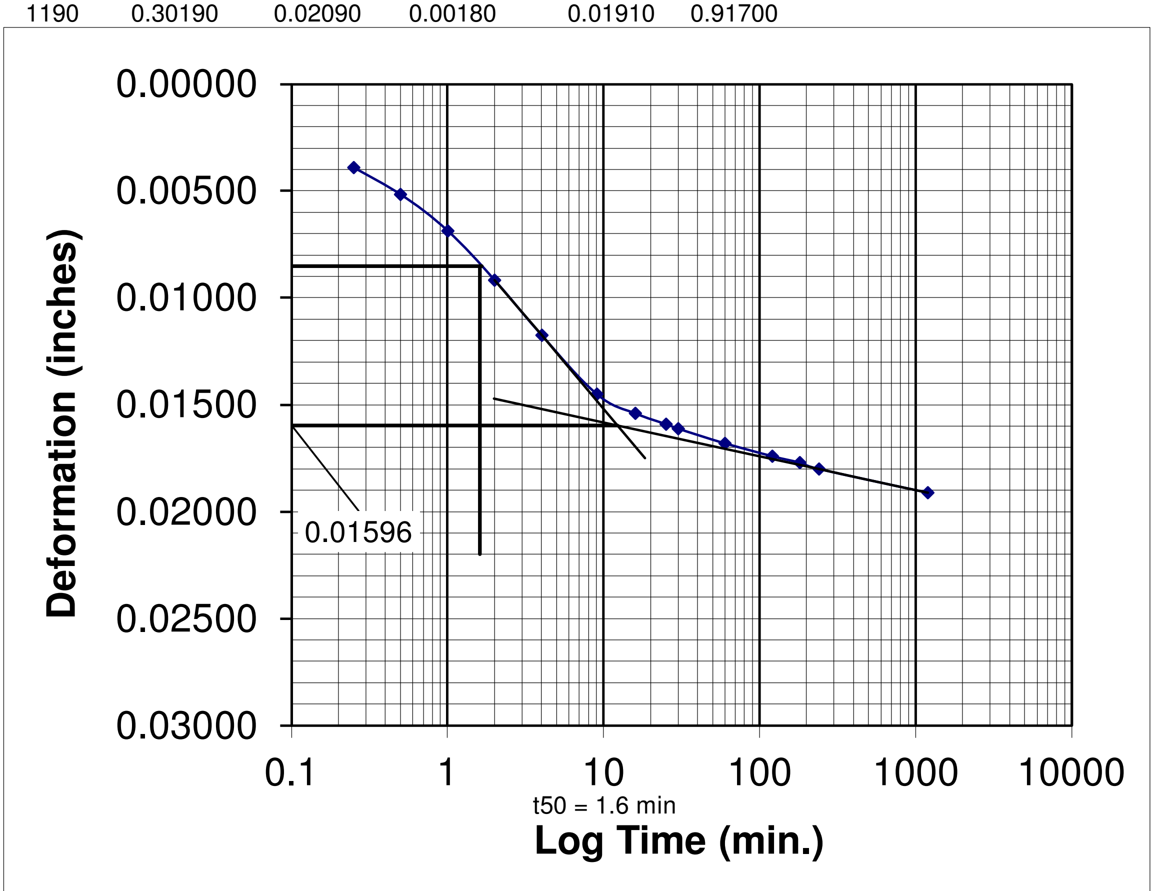
16 tsf Load

initial height= 0.9361 inches

**Do= D1-(D2-D1)**
1) 0.25 to 1.0: 0.00095
2) 0.5 to 2.0: 0.00115
3) 1.0 to 4.0: 0.00195
Do Avg 1&2: 0.00105
Do Avg 1-3: 0.00135
**Use Do=** 0.00105
**D100=** 0.01596
**D50= D100+0.5(Do-D100)**
**D50=** 0.00850

**t50 =** 1.6 min.

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.32280 | | | | |
| 0.25 | 0.31710 | 0.00570 | 0.00180 | 0.00390 | 0.93220 |
| 0.5 | 0.31585 | 0.00695 | 0.00180 | 0.00515 | 0.93095 |
| 1 | 0.31415 | 0.00865 | 0.00180 | 0.00685 | 0.92925 |
| 2 | 0.31185 | 0.01095 | 0.00180 | 0.00915 | 0.92695 |
| 4 | 0.30925 | 0.01355 | 0.00180 | 0.01175 | 0.92435 |
| 9 | 0.30650 | 0.01630 | 0.00180 | 0.01450 | 0.92160 |
| 16 | 0.30560 | 0.01720 | 0.00180 | 0.01540 | 0.92070 |
| 25 | 0.30510 | 0.01770 | 0.00180 | 0.01590 | 0.92020 |
| 30 | 0.30490 | 0.01790 | 0.00180 | 0.01610 | 0.92000 |
| 60 | 0.30420 | 0.01860 | 0.00180 | 0.01680 | 0.91930 |
| 120 | 0.30360 | 0.01920 | 0.00180 | 0.01740 | 0.91870 |
| 180 | 0.30330 | 0.01950 | 0.00180 | 0.01770 | 0.91840 |
| 240 | 0.30300 | 0.01980 | 0.00180 | 0.01800 | 0.91810 |
| 1190 | 0.30190 | 0.02090 | 0.00180 | 0.01910 | 0.91700 |

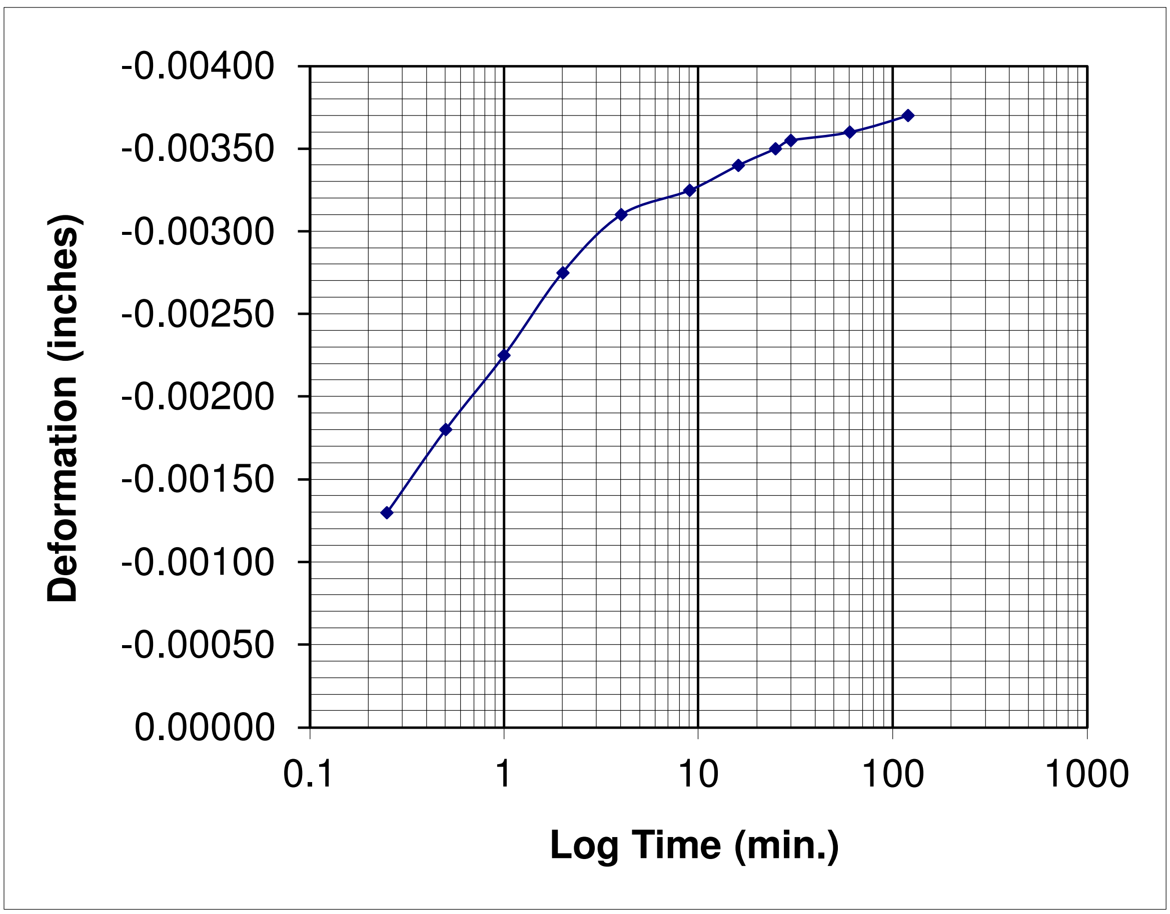


Project No. : 2065201 Sample No.: ST-1
Boring No. : B-039-1-21 Depth: 9.0 - 11.0'

4.0 tsf Unload

initial height= 0.917 inches

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.30190 | | | | |
| 0.25 | 0.30430 | -0.00240 | -0.00110 | -0.00130 | 0.91830 |
| 0.5 | 0.30480 | -0.00290 | -0.00110 | -0.00180 | 0.91880 |
| 1 | 0.30525 | -0.00335 | -0.00110 | -0.00225 | 0.91925 |
| 2 | 0.30575 | -0.00385 | -0.00110 | -0.00275 | 0.91975 |
| 4 | 0.30610 | -0.00420 | -0.00110 | -0.00310 | 0.92010 |
| 9 | 0.30625 | -0.00435 | -0.00110 | -0.00325 | 0.92025 |
| 16 | 0.30640 | -0.00450 | -0.00110 | -0.00340 | 0.92040 |
| 25 | 0.30650 | -0.00460 | -0.00110 | -0.00350 | 0.92050 |
| 30 | 0.30655 | -0.00465 | -0.00110 | -0.00355 | 0.92055 |
| 60 | 0.30660 | -0.00470 | -0.00110 | -0.00360 | 0.92060 |
| 120 | 0.30670 | -0.00480 | -0.00110 | -0.00370 | 0.92070 |

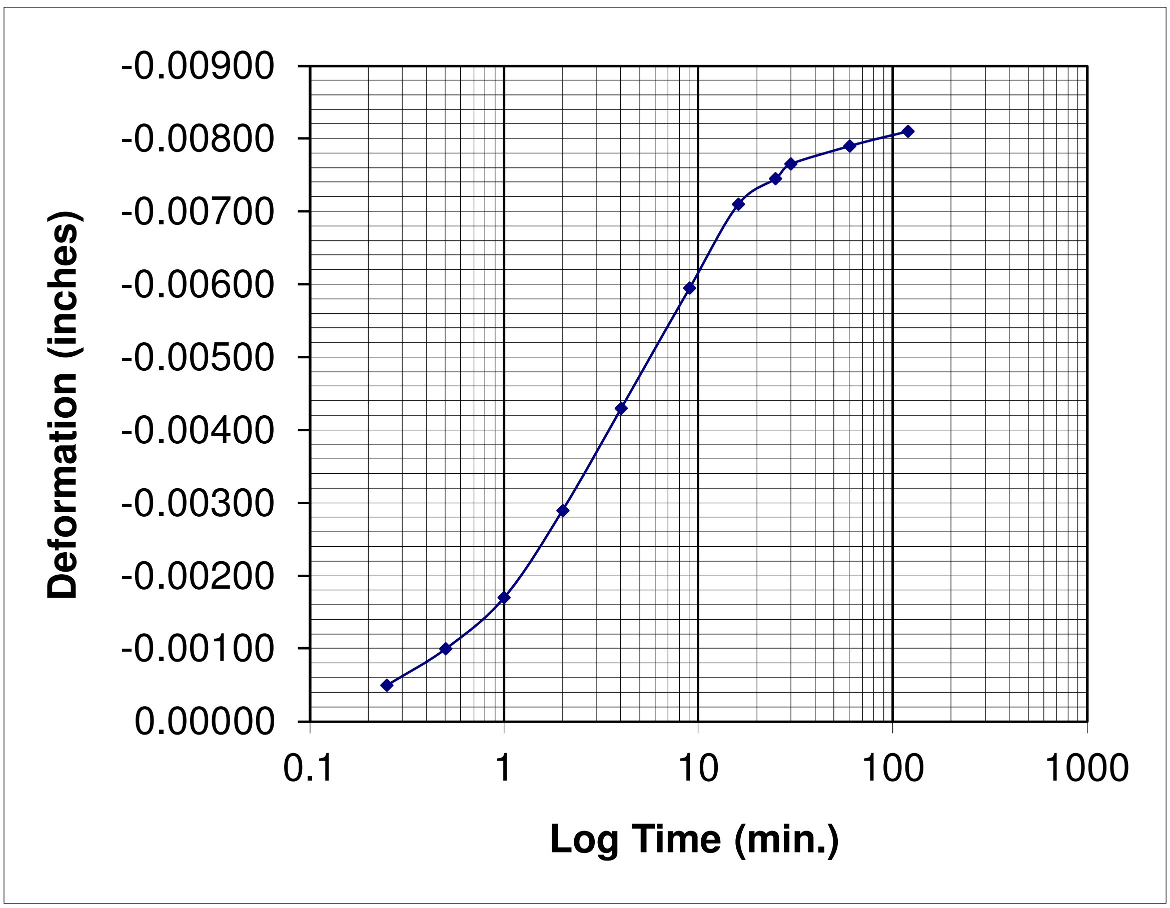


Project No. : 2065201 Sample No.: ST-1
Boring No. : B-039-1-21 Depth: 9.0 - 11.0'

1.0 tsf Unload

initial height= 0.9207 inches

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.30670 | | | | |
| 0.25 | 0.30880 | -0.00210 | -0.00160 | -0.00050 | 0.92120 |
| 0.5 | 0.30930 | -0.00260 | -0.00160 | -0.00100 | 0.92170 |
| 1 | 0.31000 | -0.00330 | -0.00160 | -0.00170 | 0.92240 |
| 2 | 0.31120 | -0.00450 | -0.00160 | -0.00290 | 0.92360 |
| 4 | 0.31260 | -0.00590 | -0.00160 | -0.00430 | 0.92500 |
| 9 | 0.31425 | -0.00755 | -0.00160 | -0.00595 | 0.92665 |
| 16 | 0.31540 | -0.00870 | -0.00160 | -0.00710 | 0.92780 |
| 25 | 0.31575 | -0.00905 | -0.00160 | -0.00745 | 0.92815 |
| 30 | 0.31595 | -0.00925 | -0.00160 | -0.00765 | 0.92835 |
| 60 | 0.31620 | -0.00950 | -0.00160 | -0.00790 | 0.92860 |
| 120 | 0.31640 | -0.00970 | -0.00160 | -0.00810 | 0.92880 |

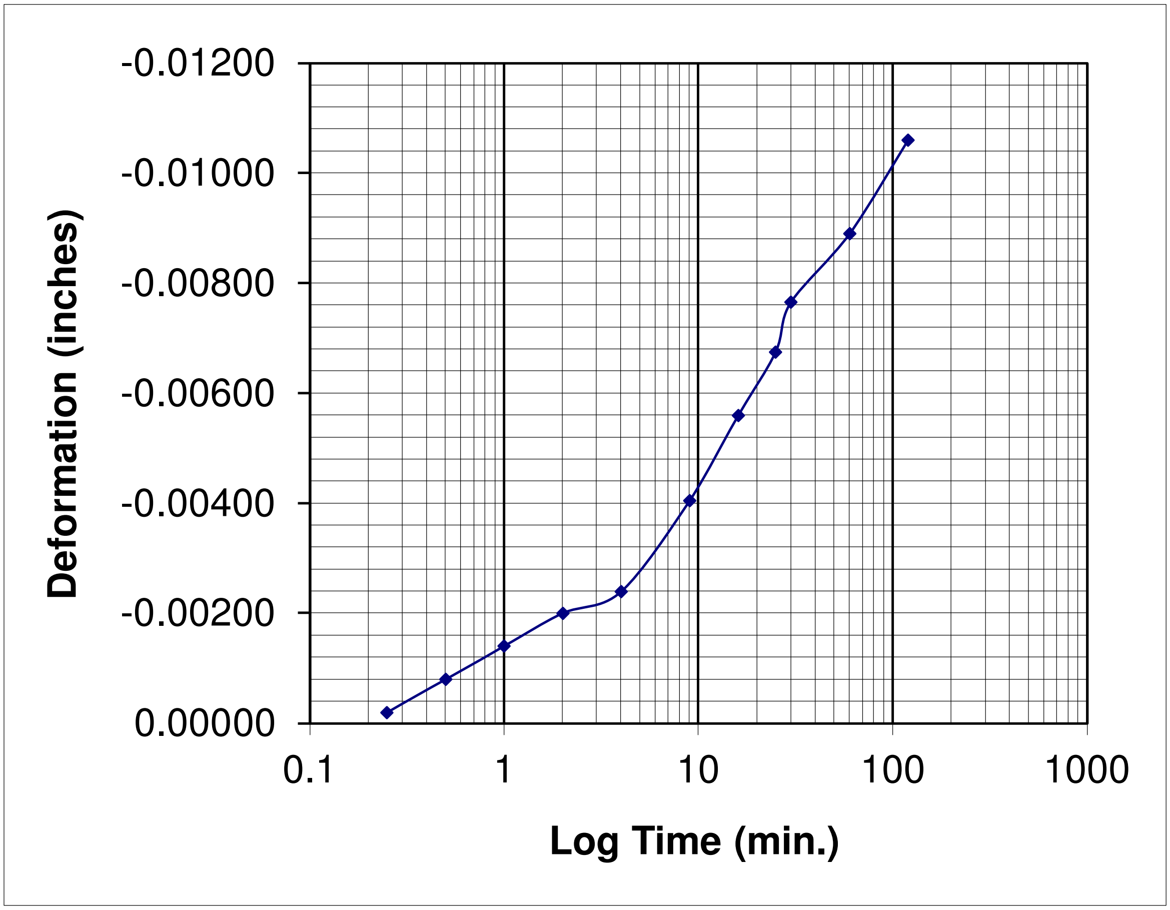


Project No. : 2065201 Sample No.: ST-1
Boring No. : B-039-1-21 Depth: 9.0 - 11.0'

0.25 tsf Unload

initial height= 0.9288 inches

| Interval Minutes | Dial Reading | ΔH | Deformation Constant | TRUE ΔH | Height of Sample |
|---|---|---|---|---|---|
| 0 | 0.31640 | | | | |
| 0.25 | 0.31800 | -0.00160 | -0.00140 | -0.00020 | 0.92900 |
| 0.5 | 0.31860 | -0.00220 | -0.00140 | -0.00080 | 0.92960 |
| 1 | 0.31920 | -0.00280 | -0.00140 | -0.00140 | 0.93020 |
| 2 | 0.31980 | -0.00340 | -0.00140 | -0.00200 | 0.93080 |
| 4 | 0.32020 | -0.00380 | -0.00140 | -0.00240 | 0.93120 |
| 9 | 0.32185 | -0.00545 | -0.00140 | -0.00405 | 0.93285 |
| 16 | 0.32340 | -0.00700 | -0.00140 | -0.00560 | 0.93440 |
| 25 | 0.32455 | -0.00815 | -0.00140 | -0.00675 | 0.93555 |
| 30 | 0.32545 | -0.00905 | -0.00140 | -0.00765 | 0.93645 |
| 60 | 0.32670 | -0.01030 | -0.00140 | -0.00890 | 0.93770 |
| 120 | 0.32840 | -0.01200 | -0.00140 | -0.01060 | 0.93940 |

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# APPENDIX H

# Pavement Core Photographic Logs

# Core Log For B-001-0-21

Project : LUC-023-11.75, PID 105889 Interchange Improvements

Project Location : Sylvania, Lucas County, Ohio

TTL Project No. 2065201

Core Date: November 1, 2021


| | | |
|---|---|---|
| ASPHALT THICKNESS (in.) | = | 3.75 |
| CONCRETE THICKNES (in.) | = | 9.75 |
| AGGREGATE BASE THICKNESS (in.) | = | 5.5 |
| CORE BARREL DIAMETER (in.) | = | 4 |

**VISUAL DESCRIPTION:**

Pavement core appeared in good condition.
Apparent asphalt coarse or overlay change at approximately 1.25 inches below top of pavement.

# Core Log For B-002-0-21

Project : LUC-023-11.75, PID 105889 Interchange Improvements

Project Location : Sylvania, Lucas County, Ohio

TTL Project No. 2065201

Core Date: November 1, 2021


| | | |
|---|---|---|
| ASPHALT THICKNESS (in.) | = | 7.75 |
| AGGREGATE BASE THICKNESS (in.) | = | 8.25 |
| CORE BARREL DIAMETER (in.) | = | 4 |

**VISUAL DESCRIPTION:**

Pavement core appeared in good condition.

# Core Log For B-010-0-21

Project : LUC-023-11.75, PID 105889 Interchange Improvements

Project Location : Sylvania, Lucas County, Ohio

TTL Project No. 2065201

Core Date: November 11, 2021


| | | |
|---|---|---|
| ASPHALT THICKNESS (in.) | = | 2.5 |
| CONCRETE THICKNESS (in.) | = | 9 |
| AGGREGATE BASE THICKNESS (in.) | = | 9 |
| CORE BARREL DIAMETER (in.) | = | 4 |

**VISUAL DESCRIPTION:**

Pavement core appeared in good condition.

Rebar present at 5 inches below top of concrete

# Core Log For B-015-0-21

Project : LUC-023-11.75, PID 105889 Interchange Improvements

Project Location : Sylvania, Lucas County, Ohio

TTL Project No. 2065201

Core Date: November 1, 2021


| | | |
|---|---|---|
| ASPHALT THICKNESS (in.) | = | 3.5 |
| CONCRETE THICKNESS (in.) | = | 9 |
| AGGREGATE BASE THICKNESS (in.) | = | 5.5 |
| CORE BARREL DIAMETER (in.) | = | 4 |

**VISUAL DESCRIPTION:**

Pavement core appeared in good condition.

# Core Log For B-016-0-21

Project : LUC-023-11.75, PID 105889 Interchange Improvements

Project Location : Sylvania, Lucas County, Ohio

TTL Project No. 2065201

Core Date: November 1, 2021


| | | |
|---|---|---|
| ASPHALT THICKNESS (in.) | = | 4.5 |
| CORE BARRELL DIAMETER (in.) | = | 4 |

**VISUAL DESCRIPTION:**

Pavement core appeared in good condition.

No encountered aggregate base.

# Core Log For B-032-0-21

Project : LUC-023-11.75, PID 105889 Interchange Improvements

Project Location : Sylvania, Lucas County, Ohio

TTL Project No. 2065201

Core Date: November 1, 2021


| | | |
|---|---|---|
| ASPHALT THICKNESS (in.) | = | 10.75 |
| AGGREGATE BASE THICKNESS (in.) | = | 9.25 |
| CORE BARRELL DIAMETER (in.) | = | 4 |

**VISUAL DESCRIPTION:**

Pavement core appeared in good condition.

# Core Log For B-033-0-21

Project : LUC-023-11.75, PID 105889 Interchange Improvements

Project Location : Sylvania, Lucas County, Ohio

TTL Project No. 2065201

Core Date: November 1, 2021


| | | |
|---|---|---|
| ASPHALT THICKNESS (in.) | = | 2.5 |
| CONCRETE THICKNESS (in.) | = | 9 |
| CORE BARRELL DIAMETER (in.) | = | 4 |

**VISUAL DESCRIPTION:**

Pavement core appeared in good condition.

No encountered aggregate base.

# Core Log For B-034-0-21

Project : LUC-023-11.75, PID 105889 Interchange Improvements

Project Location : Sylvania, Lucas County, Ohio

TTL Project No. 2065201

Core Date: November 1, 2021


| | | |
|---|---|---|
| ASPHALT THICKNESS (in.) | = | 9.5 |
| AGGREGATE BASE THICKNESS (in.) | = | 6.5 |
| CORE BARRELL DIAMETER (in.) | = | 4 |

**VISUAL DESCRIPTION:**

Pavement core appeared in good condition.

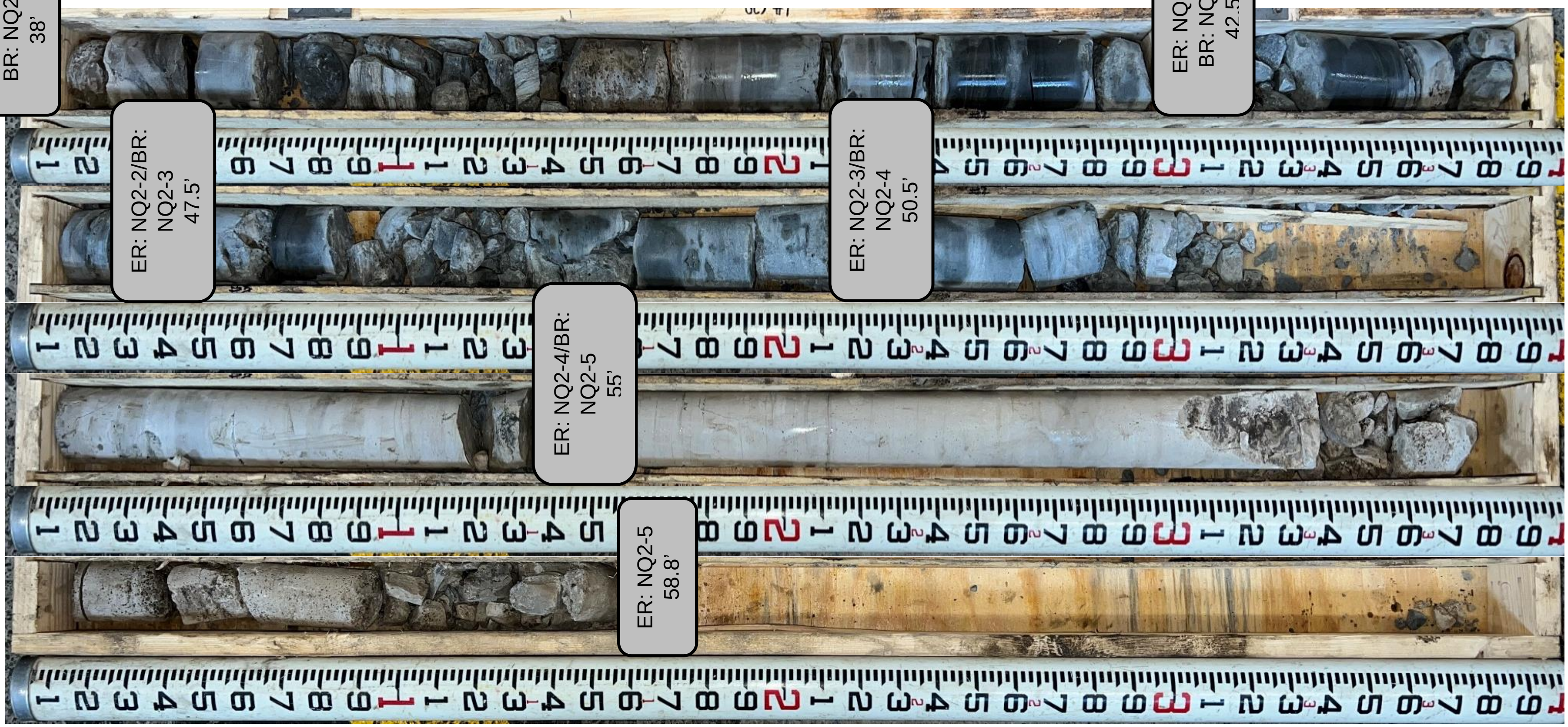
# APPENDIX I

## Rock Core Photographic Logs

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office o… echnical Engineering

# B-006-1-21




| Core Date: | November 10, 2021 | | | | Ground Surface Elevation: 652' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 38' | 42.5' | 614' | 609.5' | 35/54 | 65% | 5/54 | 9% |
| NQ2-2 | 42.5' | 47.5' | 609.5' | 604.5' | 12/60 | 20% | 0/60 | 0% |
| NQ2-3 | 47.5' | 50.5' | 604.5' | 601.5' | 22/36 | 61% | 0/36 | 0% |
| NQ2-4 | 50.5' | 55 | 601.5' | 597' | 26/54 | 48% | 18/54 | 33% |
| NQ2-5 | 55' | 58.8' | 597' | 593.2' | 45/45 | 100% | 28/45 | 62% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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TTL Project No.: 2065201

# B-008-0-21


| Core Date: April 12, 2023 | | | | | Ground Surface Elevation: 630.8' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 14' | 18' | 616.8' | 612.8' | 48/48 | 100 | 0/48 | 0% |
| NQ2-2 | 18' | 23' | 612.8' | 607.8' | 48/60 | 80% | 11/60 | 18% |
| NQ2-3 | 23' | 25.8' | 607.8' | 605' | 17/33 | 52% | 5/60 | 8% |
| NQ2-4 | 25.8' | 30.8' | 605' | 600' | 54/60 | 90% | 12/60 | 20% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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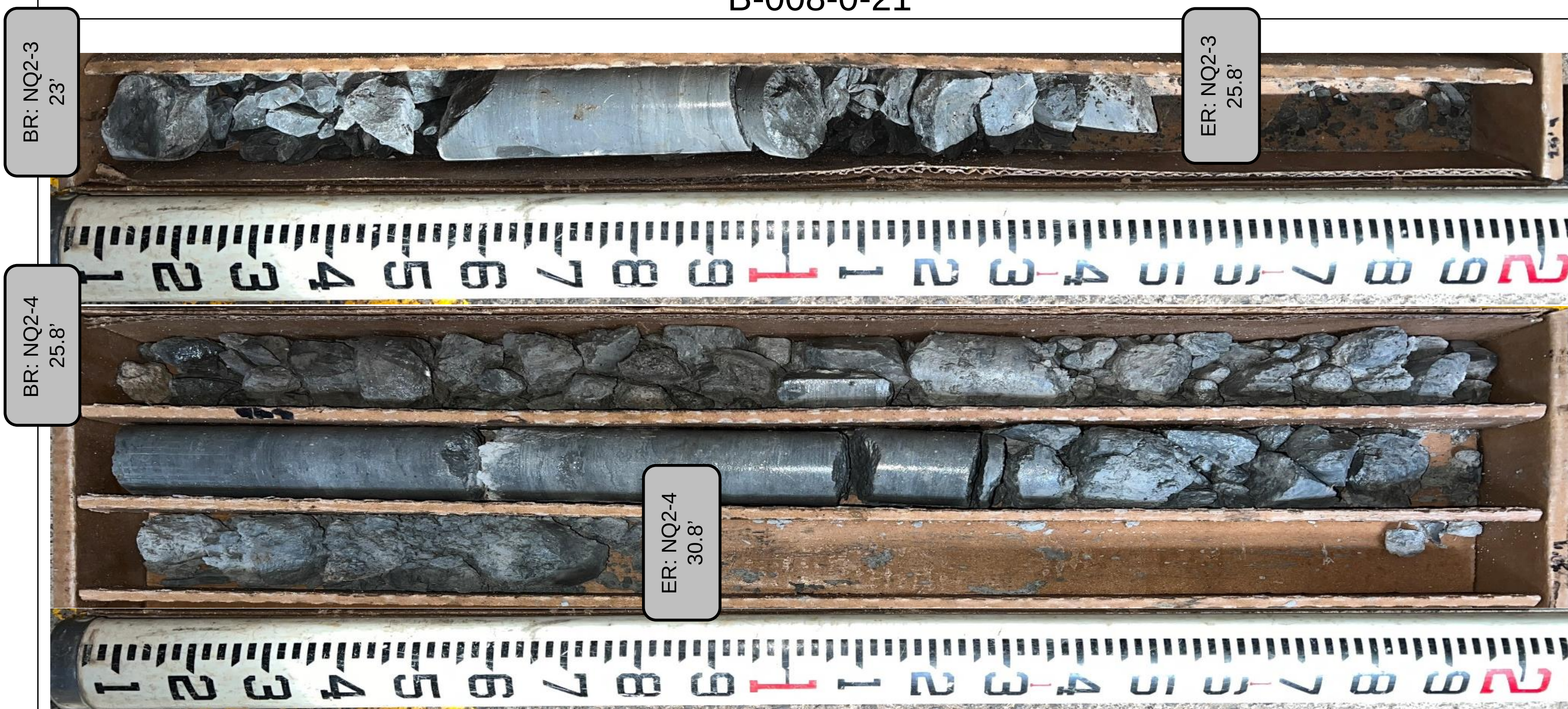
Ohio Department of Transportation
Division of Engineering

Office of Geotechnical Engineering

# B-008-0-21




| Core Date: April 12, 2023 | | | | | Ground Surface Elevation: 630.8' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 14' | 18' | 616.8' | 612.8' | 48/48 | 100 | 0/48 | 0% |
| NQ2-2 | 18' | 23' | 612.8' | 607.8' | 48/60 | 80% | 11/60 | 18% |
| NQ2-3 | 23' | 25.8' | 607.8' | 605' | 17/33 | 52% | 5/60 | 8% |
| NQ2-4 | 25.8' | 30.8' | 605' | 600' | 54/60 | 90% | 12/60 | 20% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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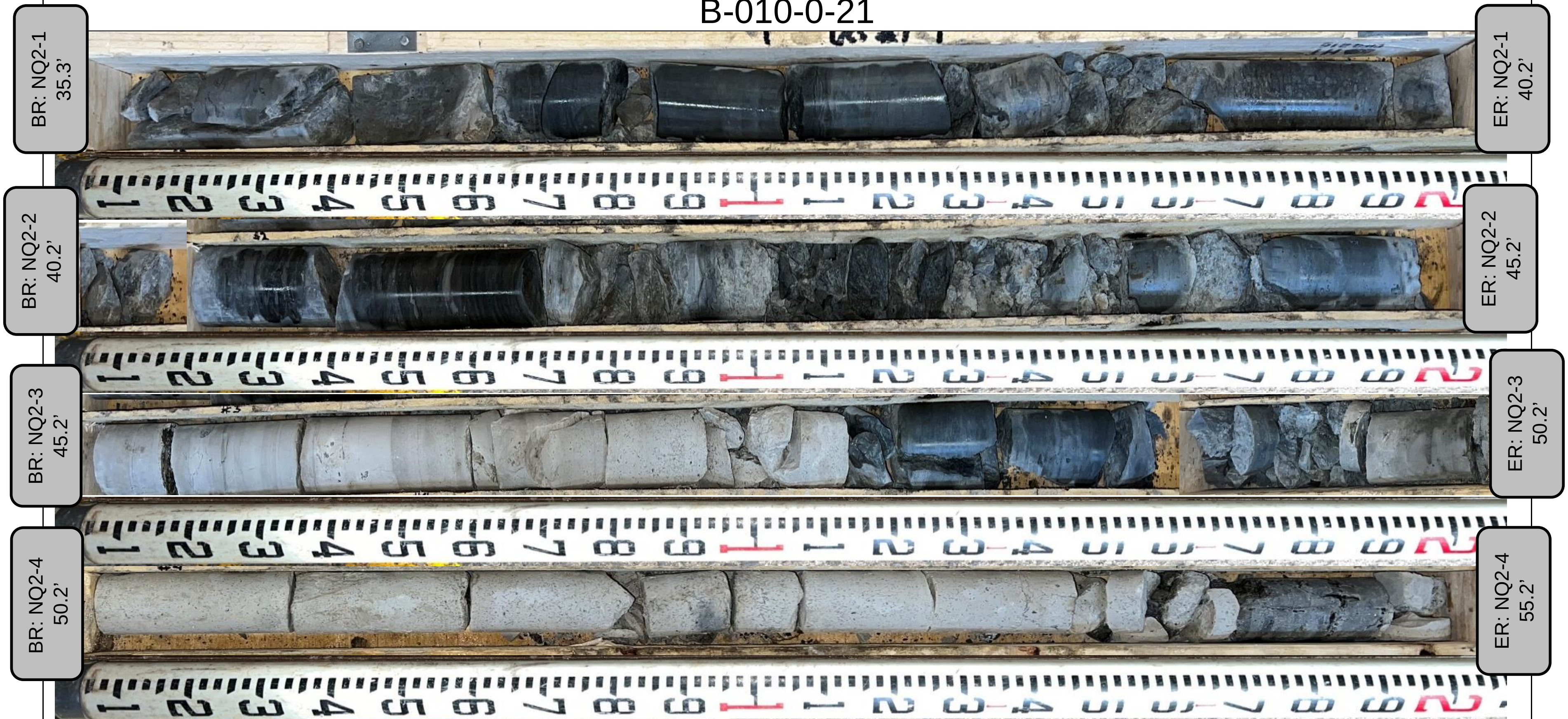
# B-010-0-21




| Core Date: November 11, 2021 | | | | | Ground Surface Elevation: 650.98' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 35.3' | 40.2' | 615.7' | 610.9' | 40/58 | 69% | 21/40 | 53% |
| NQ2-2 | 40.2' | 45.2' | 610.9' | 605.9' | 49/60 | 82% | 22/49 | 45% |
| NQ2-3 | 45.2' | 50.2' | 605.9' | 600.9' | 54/60 | 90% | 29/54 | 54% |
| NQ2-4 | 50.2' | 55.2' | 600.9' | 595.9' | 52/60 | 87% | 29/52 | 56% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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# B-022-0-21

BR: NQ2-1 8'

ER: NQ2-1 13'

BR: NQ2-2 13'

ER: NQ2-2 18'

| Core Date: | March 22, 2023 | | | | Ground Surface Elevation: | 615.11' | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 8' | 13' | 607.1' | 602.1' | 44/60 | 73% | 17/44 | 39% |
| NQ2-2 | 13' | 18' | 602.1' | 597.1' | 55/60 | 92% | 27/55 | 49% |
| NQ2-3 | 18' | 23' | 597.1' | 592.1' | 40/60 | 67% | 7/40 | 18% |
| NQ2-4 | 23' | 28' | 592.1' | 587.1' | 57/60 | 95% | 19/57 | 33% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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Office of Geotechnical Engineering

# B-022-0-21


| Core Date: March 22, 2023 | | | | | Ground Surface Elevation: 615.11' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 8' | 13' | 607.1' | 602.1' | 44/60 | 73% | 17/44 | 39% |
| NQ2-2 | 13' | 18' | 602.1' | 597.1' | 55/60 | 92% | 27/55 | 49% |
| NQ2-3 | 18' | 23' | 597.1' | 592.1' | 40/60 | 67% | 7/40 | 18% |
| NQ2-4 | 23' | 28' | 592.1' | 587.1' | 57/60 | 95% | 19/57 | 33% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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# B-022-1-21


| Core Date: | March 21, 2023 | | | | Ground Surface Elevation: 616.10’ | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 8.6’ | 13.6’ | 607.5’ | 602.5’ | 51/60 | 85% | 13/51 | 26% |
| NQ2-2 | 13.6’ | 18.6’ | 602.5’ | 597.5’ | 43/60 | 72% | 8/43 | 19% |
| NQ2-3 | 18.6’ | 23.6’ | 597.5’ | 592.5’ | 48/60 | 80% | 7/48 | 15% |
| NQ2-4 | 23.6’ | 28.6’ | 592.5’ | 587.5’ | 60/60 | 100% | 13/60 | 22% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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Division of Engineering

Office of Geotechnical Engineering

# B-022-1-21


| Core Date: | March 21, 2023 | | | | Ground Surface Elevation: 616.10' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 8.6' | 13.6' | 607.5' | 602.5' | 51/60 | 85% | 13/51 | 26% |
| NQ2-2 | 13.6' | 18.6' | 602.5' | 597.5' | 43/60 | 72% | 8/43 | 19% |
| NQ2-3 | 18.6' | 23.6' | 597.5' | 592.5' | 48/60 | 80% | 7/48 | 15% |
| NQ2-4 | 23.6' | 28.6' | 592.5' | 587.5' | 60/60 | 100% | 13/60 | 22% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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Office of Geotechnical Engineering

# B-022-3-21


| Core Date: | March 20, 2023 | | | | Ground Surface Elevation: 616.03' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 9.3' | 14.3' | 606.7' | 601.7' | 60/60 | 100% | 27/60 | 45% |
| NQ2-2 | 14.3' | 19.3' | 601.7' | 596.7' | 20/60 | 33% | 0/20 | 0% |
| NQ2-3 | 19.3' | 24.3' | 596.7' | 591.7' | 52/60 | 87% | 30/52 | 58% |
| NQ2-4 | 24.3' | 29.3' | 591.7' | 586.7' | 48/60 | 80% | 20/48 | 42% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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# B-022-3-21


| Core Date: March 20, 2023 | | | | | Ground Surface Elevation: 616.03' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 9.3' | 14.3' | 606.7' | 601.7' | 60/60 | 100% | 27/60 | 45% |
| NQ2-2 | 14.3' | 19.3' | 601.7' | 596.7' | 20/60 | 33% | 0/20 | 0% |
| NQ2-3 | 19.3' | 24.3' | 596.7' | 591.7' | 52/60 | 87% | 30/52 | 58% |
| NQ2-4 | 24.3' | 29.3' | 591.7' | 586.7' | 48/60 | 80% | 20/48 | 42% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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# B-023-0-21


| Core Date: April 04, 2023 | | | | | Ground Surface Elevation: 624.15’ | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 16.5’ | 21.5’ | 607.7 | 602.7’ | 55/60 | 92% | 39/55 | 71% |
| NQ2-2 | 21.5’ | 26.5’ | 602.7’ | 597.7’ | 54/60 | 90% | 32/54 | 59% |
| NQ2-3 | 26.5’ | 31.5’ | 597.7’ | 592.7’ | 50/60 | 83% | 5/50 | 10% |
| NQ2-4 | 31.5’ | 36.5’ | 592.7’ | 587.7’ | 59/60 | 98% | 13/59 | 22% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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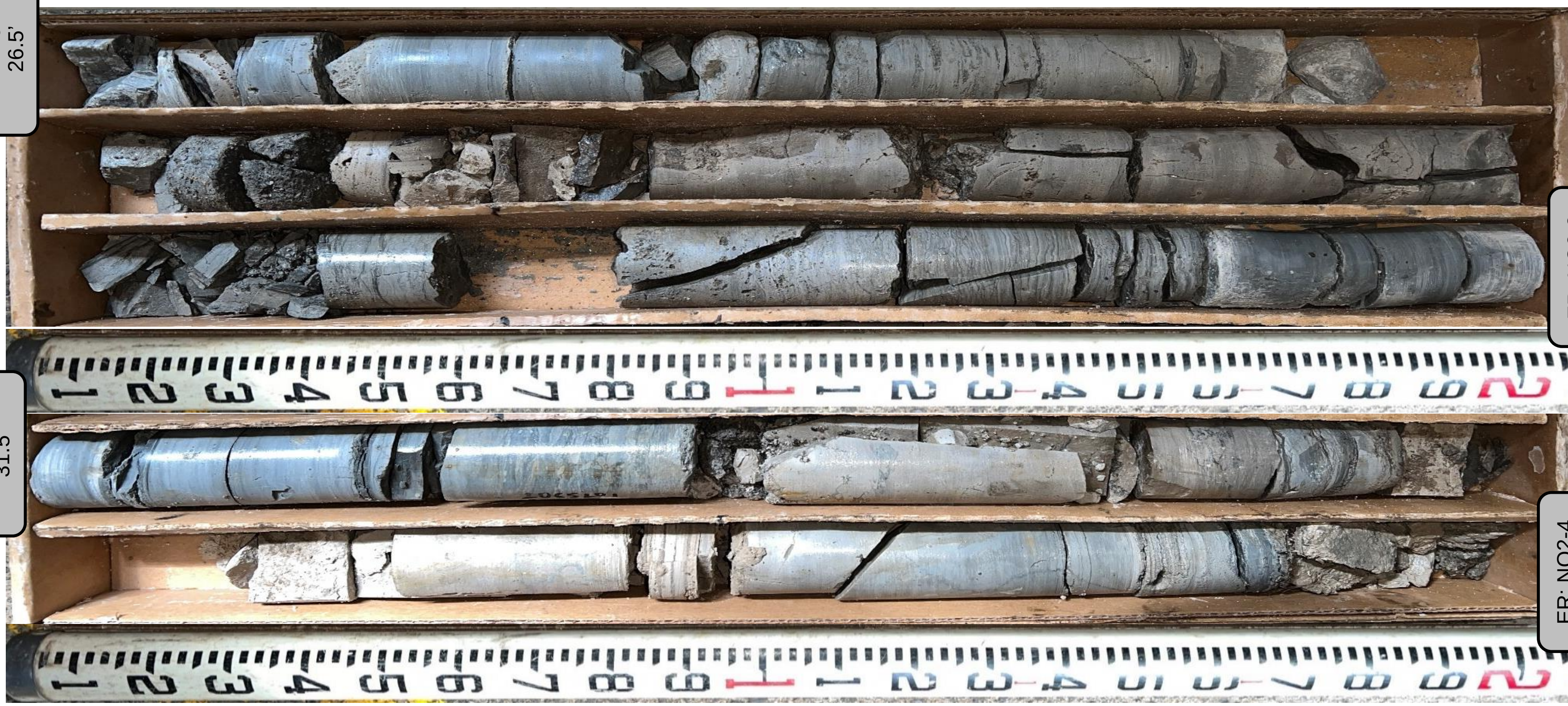
# B-023-0-21




| Core Date: April 04, 2023 | | | | | Ground Surface Elevation: 624.15' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 16.5' | 21.5' | 607.7 | 602.7' | 55/60 | 92% | 39/55 | 71% |
| NQ2-2 | 21.5' | 26.5' | 602.7' | 597.7' | 54/60 | 90% | 32/54 | 59% |
| NQ2-3 | 26.5' | 31.5' | 597.7' | 592.7' | 50/60 | 83% | 5/50 | 10% |
| NQ2-4 | 31.5' | 36.5' | 592.7' | 587.7' | 59/60 | 98% | 13/59 | 22% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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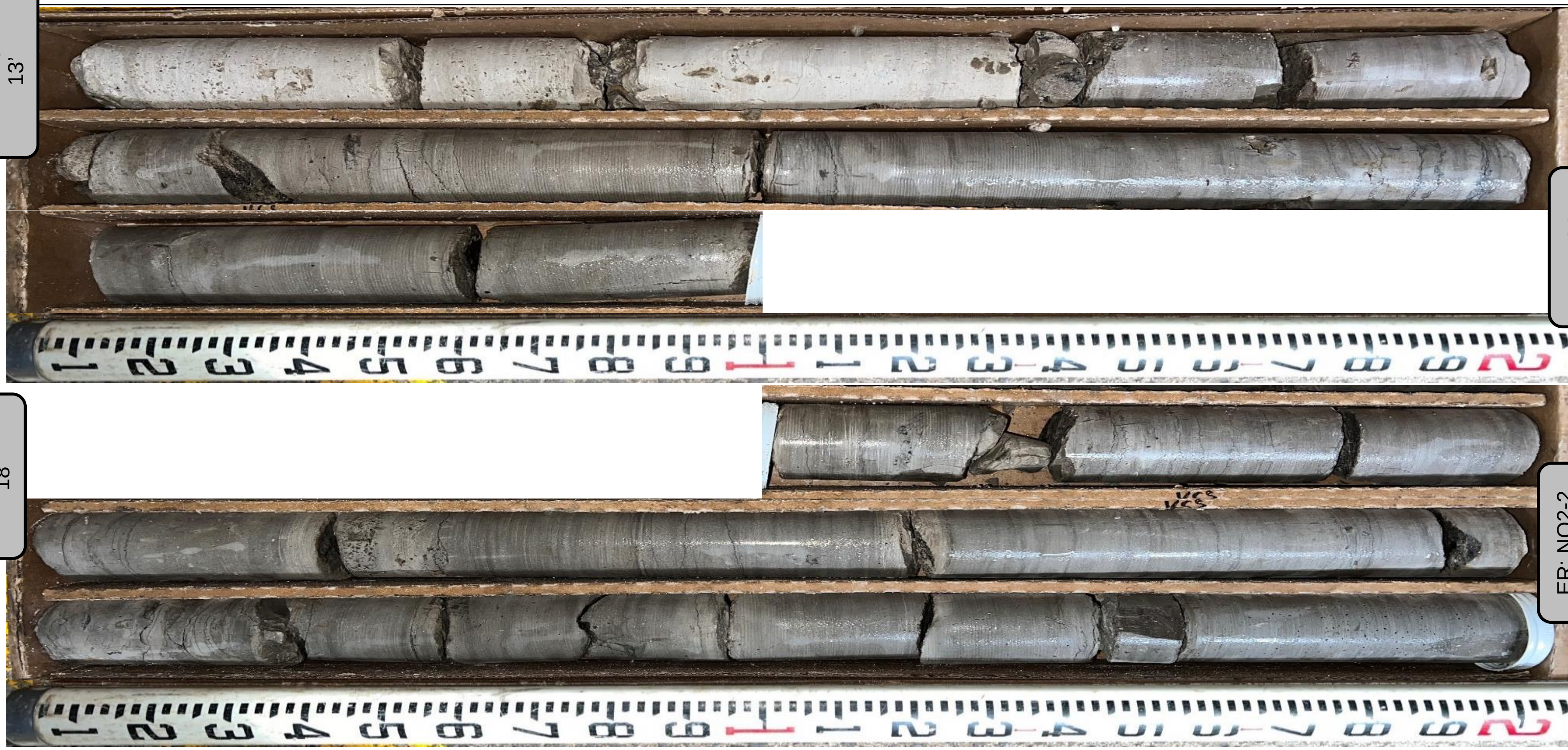
# B-028-0-21




| Core Date: | April 10, 2023 | | | | Ground Surface Elevation: 620.28' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 13' | 18' | 607.3' | 602.3' | 57/60 | 92% | 41/57 | 72% |
| NQ2-2 | 18' | 23' | 602.3' | 597.3' | 60/60 | 90% | 32/60 | 53% |
| NQ2-3 | 23' | 28' | 597.3' | 592.3' | 58/60 | 83% | 27/58 | 47% |
| NQ2-4 | 28' | 33' | 592.3' | 587.3' | 59/60 | 98% | 10/59 | 17% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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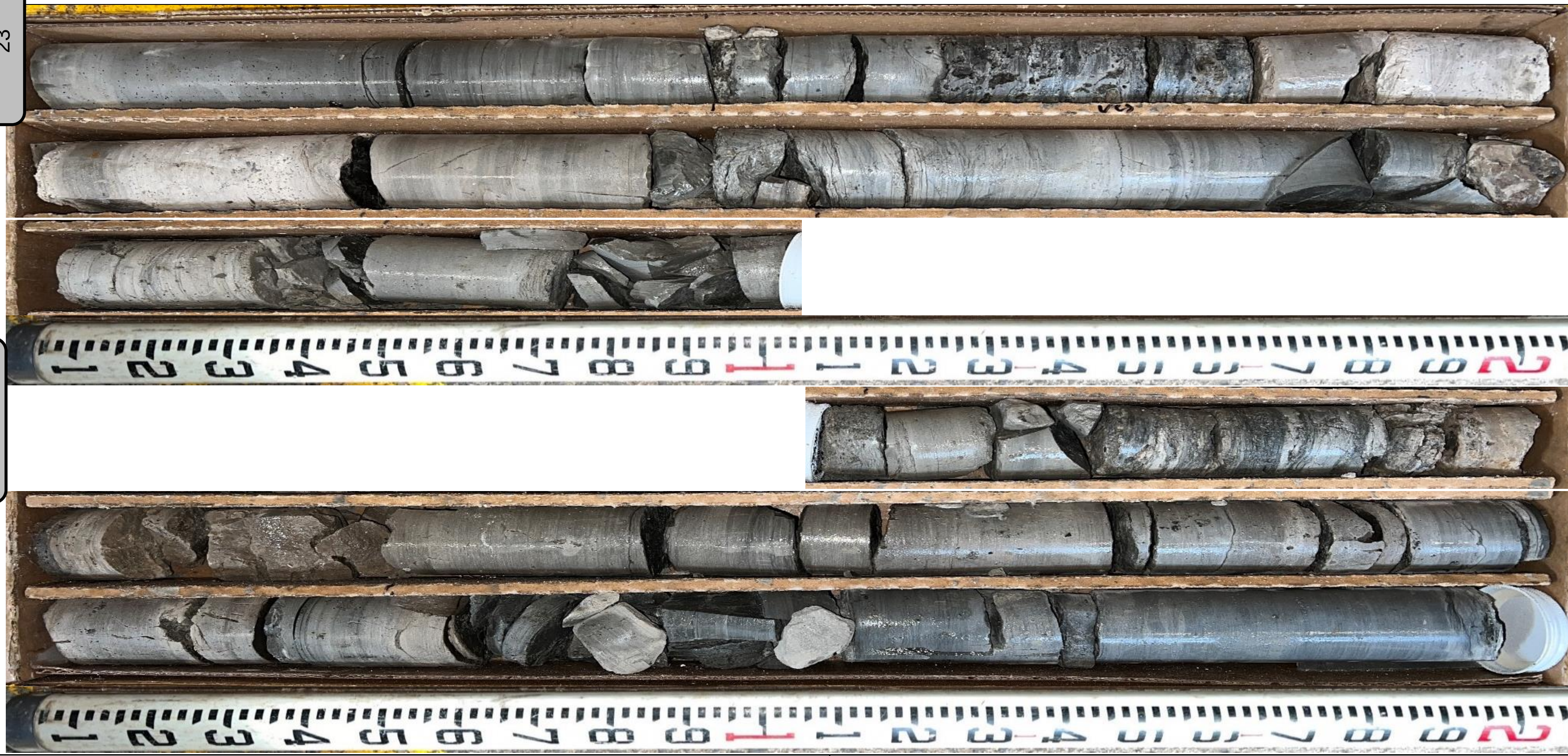
# B-028-0-21




| Core Date: April 10, 2023 | | | | | Ground Surface Elevation: 620.28' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 13' | 18' | 607.3' | 602.3' | 57/60 | 92% | 41/57 | 72% |
| NQ2-2 | 18' | 23' | 602.3' | 597.3' | 60/60 | 90% | 32/60 | 53% |
| NQ2-3 | 23' | 28' | 597.3' | 592.3' | 58/60 | 83% | 27/58 | 47% |
| NQ2-4 | 28' | 33' | 592.3' | 587.3' | 59/60 | 98% | 10/59 | 17% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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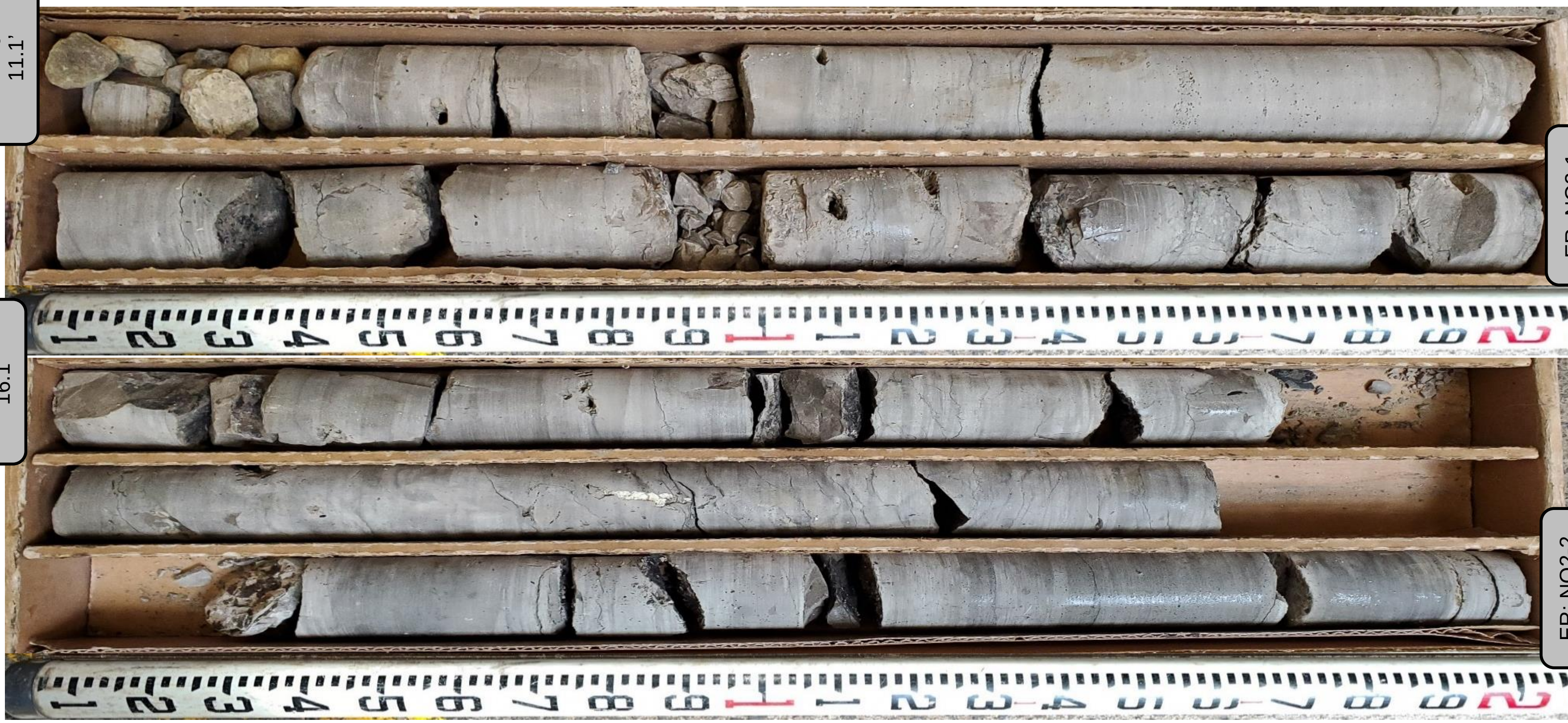
# B-028-1-21




| Core Date: March 21, 2023 | | | | | Ground Surface Elevation: 616.63’ | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 11.1’ | 16.1’ | 605.5’ | 600.5’ | 48/60 | 80% | 46/48 | 96% |
| NQ2-2 | 16.1’ | 21.1’ | 600.5’ | 595.5’ | 59/60 | 98% | 34/59 | 58% |
| NQ2-3 | 21.1’ | 26.1’ | 595.5’ | 590.5’ | 43/60 | 72% | 4/43 | 9% |
| NQ2-4 | 26.1’ | 31.1’ | 590.5’ | 585.5’ | 57/60 | 95% | 21/57 | 37% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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# B-028-1-21


| Core Date: March 21, 2023 | | | | | Ground Surface Elevation: 616.63' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 11.1' | 16.1' | 605.5' | 600.5' | 48/60 | 80% | 46/48 | 96% |
| NQ2-2 | 16.1' | 21.1' | 600.5' | 595.5' | 59/60 | 98% | 34/59 | 58% |
| NQ2-3 | 21.1' | 26.1' | 595.5' | 590.5' | 43/60 | 72% | 4/43 | 9% |
| NQ2-4 | 26.1' | 31.1' | 590.5' | 585.5' | 57/60 | 95% | 21/57 | 37% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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Office of Geotechnical Engineering

# B-029-0-21


| Core Date: April 07, 2023 | | | | | Ground Surface Elevation: 620.5' | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 16' | 21' | 604.5' | 599.5' | 59/60 | 98% | 42/59 | 71% |
| NQ2-2 | 21' | 26' | 599.5' | 594.5' | 59/60 | 98% | 30/59 | 51% |
| NQ2-3 | 26' | 31' | 594.5' | 589.5' | 57/60 | 95% | 11/57 | 19% |
| NQ2-4 | 31' | 36' | 589.5' | 584.5' | 60/60 | 100% | 17/60 | 28% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

Prepared by TTL associates inc Environmental, Geotechnical Engineering & Testing

TTL Project No.: 2065201

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

# B-029-0-21


| Core Date: | April 07, 2023 | | | | Ground Surface Elevation: | 620.5' | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 16' | 21' | 604.5' | 599.5' | 59/60 | 98% | 42/59 | 71% |
| NQ2-2 | 21' | 26' | 599.5' | 594.5' | 59/60 | 98% | 30/59 | 51% |
| NQ2-3 | 26' | 31' | 594.5' | 589.5' | 57/60 | 95% | 11/57 | 19% |
| NQ2-4 | 31' | 36' | 589.5' | 584.5' | 60/60 | 100% | 17/60 | 28% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

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TTL associates inc
Environmental, Geotechnical Engineering & Testing

TTL Project No.: 2065201

Ohio Department of Transportation
Division of Engineering

Office of Geotechnical Engineering

# B-039-0-21


| Core Date: | February 24, 2023 | | | | Ground Surface Elevation: | 636.2’ | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 15’ | 20’ | 621.2’ | 616.2’ | 60/60 | 100% | 29/60 | 48% |
| NQ2-2 | 20’ | 25’ | 616.2’ | 611.2’ | 56/60 | 93% | 28/56 | 50% |
| NQ2-3 | 25’ | 30’ | 611.2’ | 606.2’ | 60/60 | 100% | 35/60 | 58% |
| NQ2-4 | 30’ | 35’ | 606.2’ | 601.2’ | 53/60 | 88% | 35/53 | 66% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

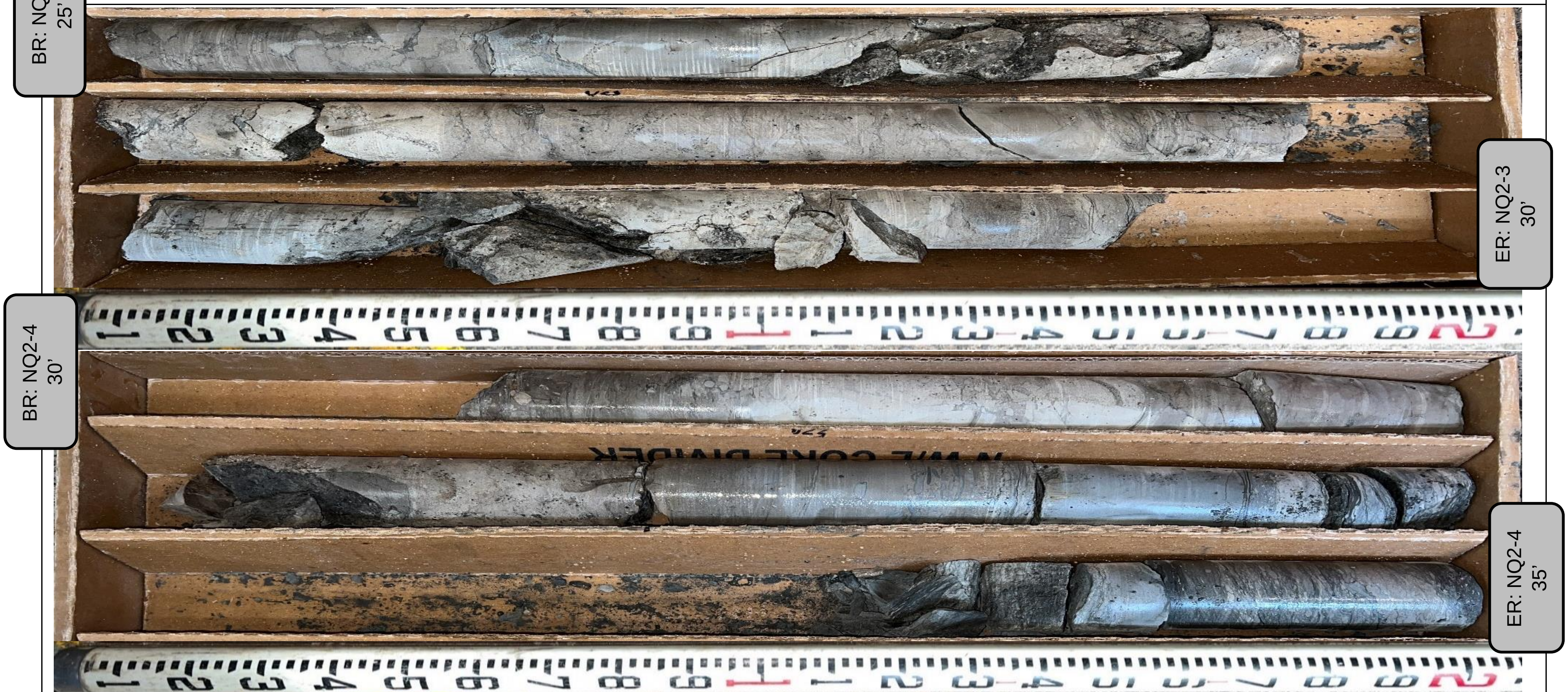
Prepared by TTL associates inc
Environmental, Geotechnical Engineering & Testing

TTL Project No.: 2065201

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

# B-039-0-21




| Core Date: February 24, 2023 | | | | | Ground Surface Elevation: 636.2’ | | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 15’ | 20’ | 621.2’ | 616.2’ | 60/60 | 100% | 29/60 | 48% |
| NQ2-2 | 20’ | 25’ | 616.2’ | 611.2’ | 56/60 | 93% | 28/56 | 50% |
| NQ2-3 | 25’ | 30’ | 611.2’ | 606.2’ | 60/60 | 100% | 35/60 | 58% |
| NQ2-4 | 30’ | 35’ | 606.2’ | 601.2’ | 53/60 | 88% | 35/53 | 66% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

Prepared by TTL associates inc. Environmental, Geotechnical Engineering & Testing

TTL Project No.: 2065201

# B-043-0-21


| Core Date: | March 09, 2023 | | | | Ground Surface Elevation: | 647.6' | | |
|---|---|---|---|---|---|---|---|---|
| Run #: | Depth | | Elevation | | Recovery | | RQD | |
| NQ2-1 | 27.7' | 32.7' | 619.9' | 614.9' | 48/60 | 80% | 18/48 | 38% |
| NQ2-2 | 32.7' | 37.7' | 614.9' | 609.9' | 34/60 | 57% | 17/34 | 50% |
| LUC-023-11.75, PID 105889 | | | | | | | | |

Prepared by

TTL Project No.: 2065201

# APPENDIX J

# Rock Core Laboratory Test Data

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-006-1-21 | SAMPLE NUMBER | NQ2-1 |
| SAMPLE DEPTH (FEET) | 38–42.5 (NQ2-1) | SPECIMEN DEPTH (FEET) | 39.7-40.1 |

| | |
|---|---|
| ROCK DESCRIPTION | (Natural Vertical Seam) |

| | |
|---|---|
| LENGTH (INCHES) | 4.1 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.06 |
| CORRECTION FACTOR | 1.0 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 549.7 |
| UNIT WEIGHT (LBS/CU. FT.) | 164 |
| | |
| MAXIMUM LOAD (LBS) | 37,070 |
| COMPRESSIVE STRENGTH (PSI) | 11,920 |


TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-006-1-21 | SAMPLE NUMBER | NQ2-4 |
| SAMPLE DEPTH (FEET) | 50.5–55 (NQ2-4) | SPECIMEN DEPTH (FEET) | 50.5-50.9 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.05 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.04 |
| CORRECTION FACTOR | 1.0 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 532.8 |
| UNIT WEIGHT (LBS/CU. FT.) | 161 |
| | |
| MAXIMUM LOAD (LBS) | 44,400 |
| COMPRESSIVE STRENGTH (PSI) | 14,280 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

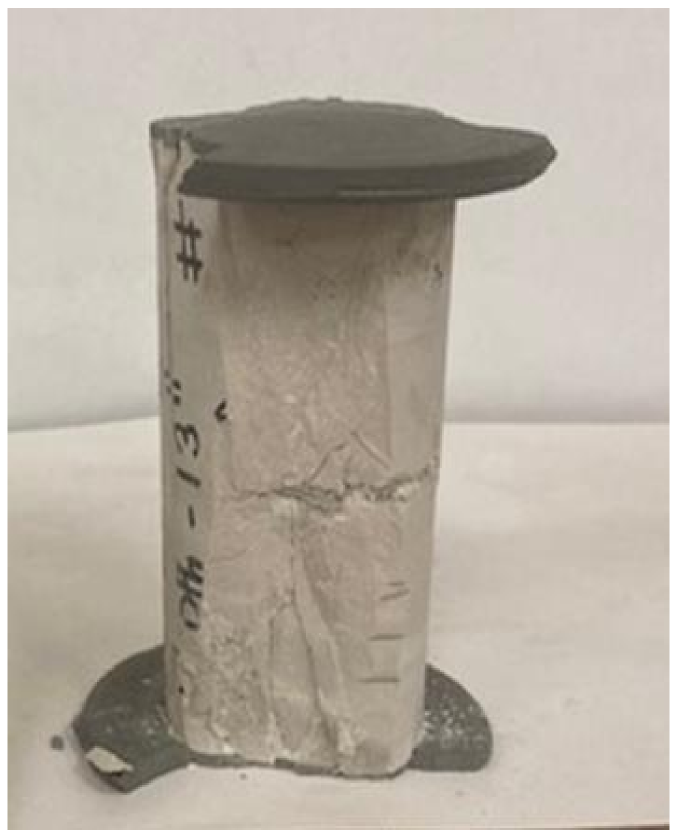
| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-006-1-21 | SAMPLE NUMBER | NQ2-4 |
| SAMPLE DEPTH (FEET) | 50.5–55 (NQ2-4) | SPECIMEN DEPTH (FEET) | 51.5-52.6 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.1 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.06 |
| CORRECTION FACTOR | 1.0 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 530.5 |
| UNIT WEIGHT (LBS/CU. FT.) | 158 |
| | |
| MAXIMUM LOAD (LBS) | 34,540 |
| COMPRESSIVE STRENGTH (PSI) | 11,110 |


TEST SPECIMEN PHOTO



TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-008-0-21 | SAMPLE NUMBER | NQ2-1 |
| SAMPLE DEPTH (FEET) | 14–18 (NQ2-1) | SPECIMEN DEPTH (FEET) | 16.8-17 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 2.24 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 1.13 |
| CORRECTION FACTOR | 0.9 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 300.6 |
| UNIT WEIGHT (LBS/CU. FT.) | 164 |
| | |
| MAXIMUM LOAD (LBS) | 64,900 |
| COMPRESSIVE STRENGTH (PSI) | 18,780 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
## ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-008-0-21 | Sample Number | NQ2-2 |
| Sample Depth (feet) | 18-23 (NQ2-2) | Specimen Depth (feet) | 18.9-19.4 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.88 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 1.95 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 508.1 |
| Unit Weight (lbs/cu. ft.) | 160 |
| | |
| Maximum Load (lbs) | 62,150 |
| Compressive Strength (psi) | 19,980 |


Test Specimen Photo


Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-008-0-21 | SAMPLE NUMBER | NQ2-4 |
| SAMPLE DEPTH (FEET) | 25.8-30.8 (NQ2-4) | SPECIMEN DEPTH (FEET) | 28-28.5 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.01 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.02 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 526.3 |
| UNIT WEIGHT (LBS/CU. FT.) | 161 |
| | |
| MAXIMUM LOAD (LBS) | 55,100 |
| COMPRESSIVE STRENGTH (PSI) | 17,720 |


TEST SPECIMEN PHOTO


TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-010-0-21 | SAMPLE NUMBER | NQ2-1 |
| SAMPLE DEPTH (FEET) | 35.3-40.2 (NQ2-1) | SPECIMEN DEPTH (FEET) | 37.1-37.5 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 3.43 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 1.72 |
| CORRECTION FACTOR | 0.98 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 459.7 |
| UNIT WEIGHT (LBS/CU. FT.) | 164 |
| | |
| MAXIMUM LOAD (LBS) | 57,190 |
| COMPRESSIVE STRENGTH (PSI) | 18,020 |


TEST SPECIMEN PHOTO


TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-010-0-21 | Sample Number | NQ2-2 |
| Sample Depth (feet) | 40.2-45.2 (NQ2-2) | Specimen Depth (feet) | 40.4-40.8 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 4.12 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 2.07 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 545.1 |
| Unit Weight (lbs/cu. ft.) | 162 |
| | |
| Maximum Load (lbs) | 59,690 |
| Compressive Strength (psi) | 19,190 |

Test Specimen Photo

Test Specimen Photo

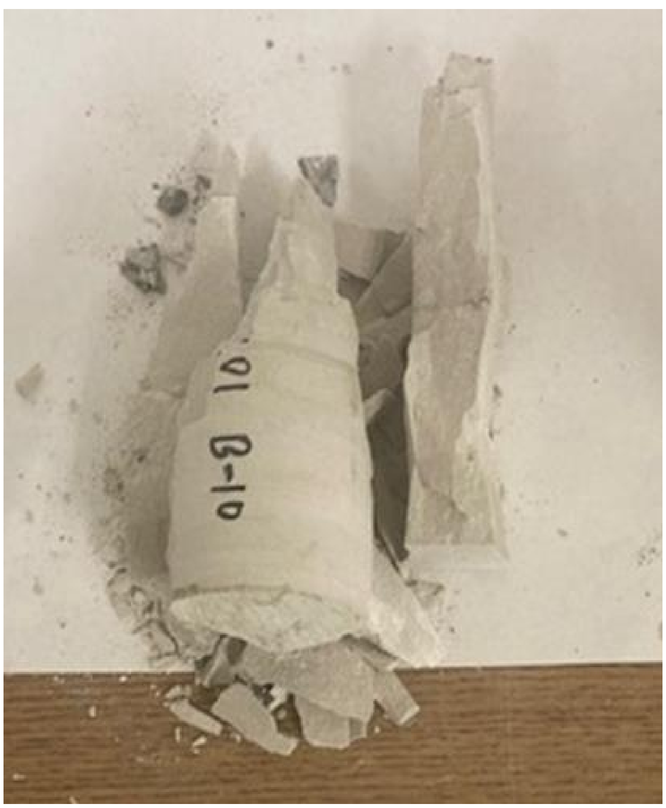
# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-010-0-21 | Sample Number | NQ2-3 |
| Sample Depth (feet) | 45.2-50.2 (NQ2-3) | Specimen Depth (feet) | 45.5-45.9 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 4.16 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 2.09 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 546.9 |
| Unit Weight (lbs/cu. ft.) | 161 |
| | |
| Maximum Load (lbs) | 53,200 |
| Compressive Strength (psi) | 17,110 |



Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-010-0-21 | SAMPLE NUMBER | NQ2-4 |
| SAMPLE DEPTH (FEET) | 50.2-55.2 (NQ2-4) | SPECIMEN DEPTH (FEET) | 50.2-50.6 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.05 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.04 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 513.1 |
| UNIT WEIGHT (LBS/CU. FT.) | 155 |
| | |
| MAXIMUM LOAD (LBS) | 38,150 |
| COMPRESSIVE STRENGTH (PSI) | 12,270 |


TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-022-0-21 | Sample Number | NQ2-1 |
| Sample Depth (feet) | 8-13 (NQ2-1) | Specimen Depth (feet) | 12.3-13 |

| | |
|---|---|
| Rock Description | (Natural Vertical Seam) |

| | |
|---|---|
| Length (inches) | 3.95 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 1.98 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 511.9 |
| Unit Weight (lbs/cu. ft.) | 159 |
| | |
| Maximum Load (lbs) | 19,450 |
| Compressive Strength (psi) | 6,250 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-022-0-21 | SAMPLE NUMBER | NQ2-2 |
| SAMPLE DEPTH (FEET) | 13-18 (NQ2-2) | SPECIMEN DEPTH (FEET) | 14.6-15 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.02 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.02 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 521.5 |
| UNIT WEIGHT (LBS/CU. FT.) | 159 |
| | |
| MAXIMUM LOAD (LBS) | 42,880 |
| COMPRESSIVE STRENGTH (PSI) | 13,790 |


TEST SPECIMEN PHOTO


TEST SPECIMEN PHOTO

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# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-022-0-21 | Sample Number | NQ2-3 |
| Sample Depth (feet) | 18-23 (NQ2-3) | Specimen Depth (feet) | 21-21.6 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.99 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 2.01 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 533.9 |
| Unit Weight (lbs/cu. ft.) | 164 |
| | |
| Maximum Load (lbs) | 46,740 |
| Compressive Strength (psi) | 15,030 |


Test Specimen Photo


Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-022-1-21 | Sample Number | NQ2-1 |
| Sample Depth (feet) | 8.6-13.6 (NQ2-1) | Specimen Depth (feet) | 11.8-12.3 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 4.04 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 2.03 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 538.1 |
| Unit Weight (lbs/cu. ft.) | 163 |
| | |
| Maximum Load (lbs) | 48,610 |
| Compressive Strength (psi) | 15,630 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-022-1-21 | Sample Number | NQ2-2 |
| Sample Depth (feet) | 13.6-18.6 (NQ2-2) | Specimen Depth (feet) | 13.8-14.2 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.37 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 1.69 |
| Correction Factor | 0.98 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 444.3 |
| Unit Weight (lbs/cu. ft.) | 161 |
| | |
| Maximum Load (lbs) | 72,750 |
| Compressive Strength (psi) | 22,920 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-022-1-21 | Sample Number | NQ2-3 |
| Sample Depth (feet) | 18.6-23.6 (NQ2-3) | Specimen Depth (feet) | 18.6-19.2 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.68 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 1.85 |
| Correction Factor | 0.99 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 482.5 |
| Unit Weight (lbs/cu. ft.) | 161 |
| | |
| Maximum Load (lbs) | 23,080 |
| Compressive Strength (psi) | 7,350 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-022-1-21 | Sample Number | NQ2-4 |
| Sample Depth (feet) | 23.6-28.6 (NQ2-4) | Specimen Depth (feet) | 23.6-24.3 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.96 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 1.99 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 538 |
| Unit Weight (lbs/cu. ft.) | 166 |
| | |
| Maximum Load (lbs) | 51,210 |
| Compressive Strength (psi) | 16,470 |


Test Specimen Photo


Test Specimen Photo

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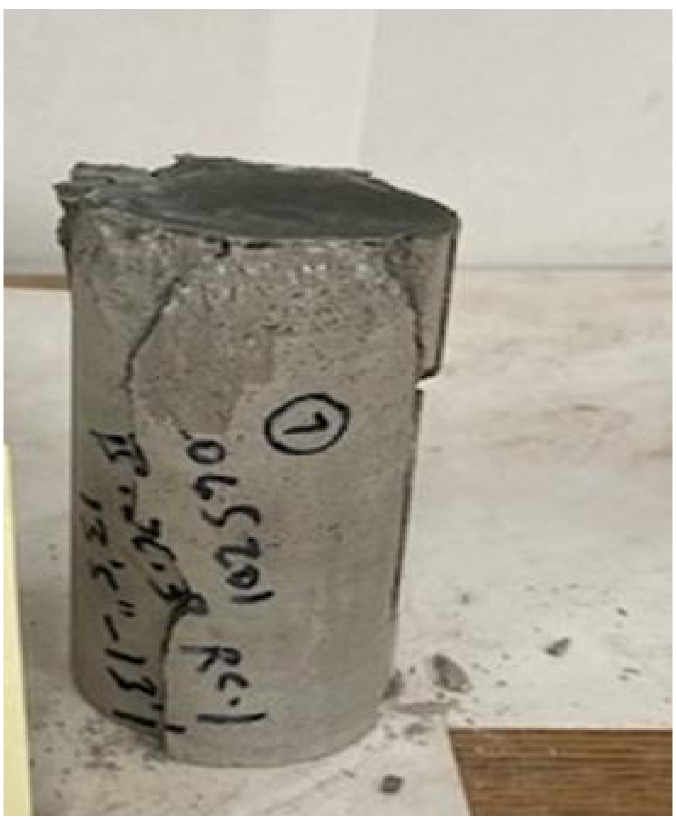
# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-022-3-21 | SAMPLE NUMBER | NQ2-1 |
| SAMPLE DEPTH (FEET) | 9.3-14.3 (NQ2-1) | SPECIMEN DEPTH (FEET) | 13.4-13.9 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 3.97 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 1.99 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 515.9 |
| UNIT WEIGHT (LBS/CU. FT.) | 159 |
| | |
| MAXIMUM LOAD (LBS) | 55,490 |
| COMPRESSIVE STRENGTH (PSI) | 17,840 |



TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-022-3-21 | Sample Number | NQ2-3 |
| Sample Depth (feet) | 19.3-24.3 (NQ2-3) | Specimen Depth (feet) | 19.3-19.7 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.75 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 1.88 |
| Correction Factor | 0.99 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 500.9 |
| Unit Weight (lbs/cu. ft.) | 164 |
| | |
| Maximum Load (lbs) | 74,820 |
| Compressive Strength (psi) | 23,820 |

Test Specimen Photo

Test Specimen Photo

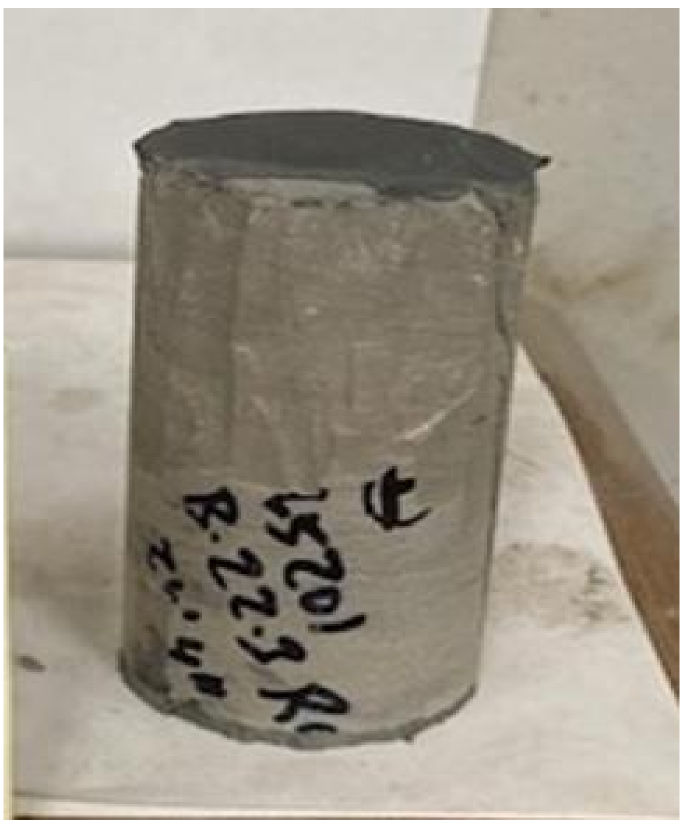
# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-022-3-21 | SAMPLE NUMBER | NQ2-4 |
| SAMPLE DEPTH (FEET) | 24.3-29.3 (NQ2-4) | SPECIMEN DEPTH (FEET) | 24.3-24.9 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 3.48 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 1.75 |
| CORRECTION FACTOR | 0.98 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 469.7 |
| UNIT WEIGHT (LBS/CU. FT.) | 165 |
| | |
| MAXIMUM LOAD (LBS) | 75,940 |
| COMPRESSIVE STRENGTH (PSI) | 23,930 |



TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-023-0-21 | SAMPLE NUMBER | NQ2-1 |
| SAMPLE DEPTH (FEET) | 16.5-21.5 (NQ2-1) | SPECIMEN DEPTH (FEET) | 18.3-18.7 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.05 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.04 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 536 |
| UNIT WEIGHT (LBS/CU. FT.) | 162 |
| | |
| MAXIMUM LOAD (LBS) | 64,840 |
| COMPRESSIVE STRENGTH (PSI) | 20,850 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-023-0-21 | Sample Number | NQ2-2 |
| Sample Depth (feet) | 21.5-26.5 (NQ2-2) | Specimen Depth (feet) | 23.2-23.8 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 4.0 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 2.01 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 516.4 |
| Unit Weight (lbs/cu. ft.) | 158 |
| | |
| Maximum Load (lbs) | 37,730 |
| Compressive Strength (psi) | 12,130 |


Test Specimen Photo


Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-023-0-21 | SAMPLE NUMBER | NQ2-4 |
| SAMPLE DEPTH (FEET) | 31.5-36.5 (NQ2-4) | SPECIMEN DEPTH (FEET) | 33.3-33.6 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 2.79 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 1.40 |
| CORRECTION FACTOR | 0.95 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 374.5 |
| UNIT WEIGHT (LBS/CU. FT.) | 164 |
| | |
| MAXIMUM LOAD (LBS) | 49,630 |
| COMPRESSIVE STRENGTH (PSI) | 15,160 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

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Environmental, Geotechnical Engineering & Testing

# Compressive Strength of Rock
# ASTM D 7012, Method C

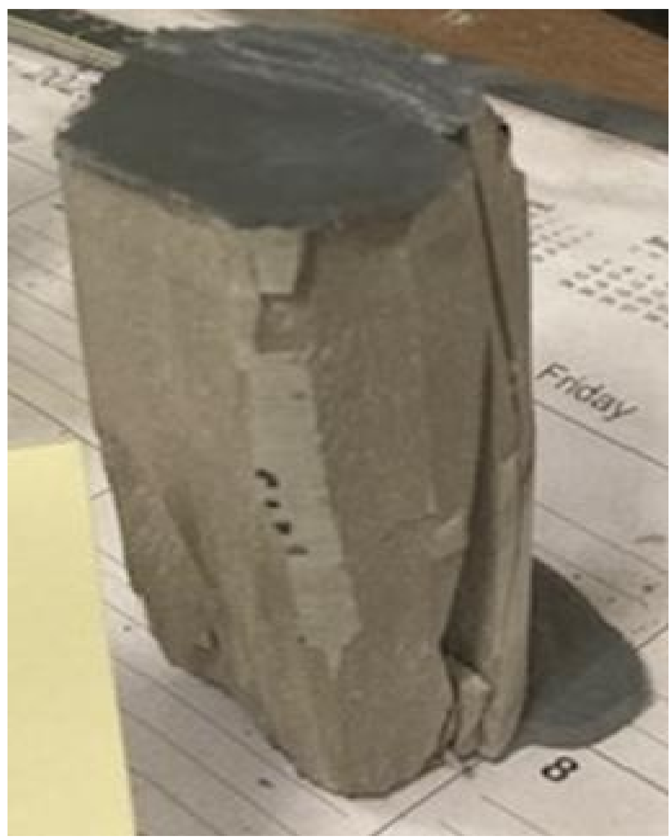
| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-028-0-21 | Sample Number | NQ2-1 |
| Sample Depth (feet) | 13-18 (NQ2-1) | Specimen Depth (feet) | 17-17.5 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 4.06 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 2.04 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 543.6 |
| Unit Weight (lbs/cu. ft.) | 164 |
| | |
| Maximum Load (lbs) | 68,410 |
| Compressive Strength (psi) | 22,000 |


Test Specimen Photo




Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-028-0-21 | SAMPLE NUMBER | NQ2-2 |
| SAMPLE DEPTH (FEET) | 18-23 (NQ2-2) | SPECIMEN DEPTH (FEET) | 20.2-20.9 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.01 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.02 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 528.4 |
| UNIT WEIGHT (LBS/CU. FT.) | 161 |
| | |
| MAXIMUM LOAD (LBS) | 62,880 |
| COMPRESSIVE STRENGTH (PSI) | 20,200 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-028-0-21 | SAMPLE NUMBER | NQ2-3 |
| SAMPLE DEPTH (FEET) | 23-28 (NQ2-3) | SPECIMEN DEPTH (FEET) | 26.1-26.7 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.0 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.01 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 524.8 |
| UNIT WEIGHT (LBS/CU. FT.) | 161 |
| | |
| MAXIMUM LOAD (LBS) | 53,160 |
| COMPRESSIVE STRENGTH (PSI) | 17,090 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

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Environmental, Geotechnical Engineering & Testing

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-028-1-21 | SAMPLE NUMBER | NQ2-1 |
| SAMPLE DEPTH (FEET) | 11.1-16.1 (NQ2-1) | SPECIMEN DEPTH (FEET) | 12.4-13.1 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.04 |
| DIAMETER (INCHES) | 1.98 |
| LENGTH / DIAMETER | 2.04 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.08 |

| | |
|---|---|
| MASS (GRAMS) | 522.7 |
| UNIT WEIGHT (LBS/CU. FT.) | 160 |
| | |
| MAXIMUM LOAD (LBS) | 66,250 |
| COMPRESSIVE STRENGTH (PSI) | 21,510 |


TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-028-1-21 | SAMPLE NUMBER | NQ2-2 |
| SAMPLE DEPTH (FEET) | 16.1-21.1 (NQ2-2) | SPECIMEN DEPTH (FEET) | 17.2-17.5 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 3.25 |
| DIAMETER (INCHES) | 1.98 |
| LENGTH / DIAMETER | 1.64 |
| CORRECTION FACTOR | 0.97 |
| AREA (SQ. IN.) | 3.08 |

| | |
|---|---|
| MASS (GRAMS) | 430 |
| UNIT WEIGHT (LBS/CU. FT.) | 164 |
| | |
| MAXIMUM LOAD (LBS) | 41,750 |
| COMPRESSIVE STRENGTH (PSI) | 13,150 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

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Environmental, Geotechnical Engineering & Testing

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-028-1-21 | Sample Number | NQ2-4 |
| Sample Depth (feet) | 26.1-31.1 (NQ2-4) | Specimen Depth (feet) | 27.0-27.3 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.67 |
| Diameter (inches) | 1.98 |
| Length / Diameter | 1.85 |
| Correction Factor | 0.99 |
| Area (sq. in.) | 3.08 |

| | |
|---|---|
| Mass (grams) | 485.2 |
| Unit Weight (lbs/cu. ft.) | 164 |
| | |
| Maximum Load (lbs) | 60,490 |
| Compressive Strength (psi) | 19,440 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-028-2-21 | Sample Number | NQ2-1 |
| Sample Depth (feet) | 1.5-5 (NQ2-1) | Specimen Depth (feet) | 2.2-2.7 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.99 |
| Diameter (inches) | 1.98 |
| Length / Diameter | 2.02 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.08 |

| | |
|---|---|
| Mass (grams) | 530.8 |
| Unit Weight (lbs/cu. ft.) | 165 |
| | |
| Maximum Load (lbs) | 33,120 |
| Compressive Strength (psi) | 10,750 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-028-2-21 | Sample Number | NQ2-2 |
| Sample Depth (feet) | 5-10 (NQ2-2) | Specimen Depth (feet) | 6.1-7 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 4.01 |
| Diameter (inches) | 1.98 |
| Length / Diameter | 2.03 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.08 |

| | |
|---|---|
| Mass (grams) | 532.6 |
| Unit Weight (lbs/cu. ft.) | 164 |
| | |
| Maximum Load (lbs) | 59,220 |
| Compressive Strength (psi) | 19,230 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-028-2-21 | Sample Number | NQ2-4 |
| Sample Depth (feet) | 15-20 (NQ2-4) | Specimen Depth (feet) | 16.8-17.1 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.09 |
| Diameter (inches) | 1.98 |
| Length / Diameter | 1.56 |
| Correction Factor | 0.97 |
| Area (sq. in.) | 3.08 |

| | |
|---|---|
| Mass (grams) | 414.2 |
| Unit Weight (lbs/cu. ft.) | 166 |
| | |
| Maximum Load (lbs) | 55,910 |
| Compressive Strength (psi) | 17,610 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-029-0-21 | Sample Number | NQ2-1 |
| Sample Depth (feet) | 16-21 (NQ2-1) | Specimen Depth (feet) | 16.9-17.3 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.99 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 2.01 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 528.1 |
| Unit Weight (lbs/cu. ft.) | 162 |
| | |
| Maximum Load (lbs) | 55,110 |
| Compressive Strength (psi) | 17,720 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-029-0-21 | Sample Number | NQ2-2 |
| Sample Depth (feet) | 21-26 (NQ2-2) | Specimen Depth (feet) | 24-24.5 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 4.04 |
| Diameter (inches) | 1.99 |
| Length / Diameter | 2.03 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.11 |

| | |
|---|---|
| Mass (grams) | 523.1 |
| Unit Weight (lbs/cu. ft.) | 159 |
| | |
| Maximum Load (lbs) | 39,540 |
| Compressive Strength (psi) | 12,710 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-029-0-21 | SAMPLE NUMBER | NQ2-4 |
| SAMPLE DEPTH (FEET) | 31-36 (NQ2-4) | SPECIMEN DEPTH (FEET) | 32.3-32.6 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.0 |
| DIAMETER (INCHES) | 1.99 |
| LENGTH / DIAMETER | 2.01 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.11 |

| | |
|---|---|
| MASS (GRAMS) | 524.7 |
| UNIT WEIGHT (LBS/CU. FT.) | 161 |
| | |
| MAXIMUM LOAD (LBS) | 46,580 |
| COMPRESSIVE STRENGTH (PSI) | 14,980 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

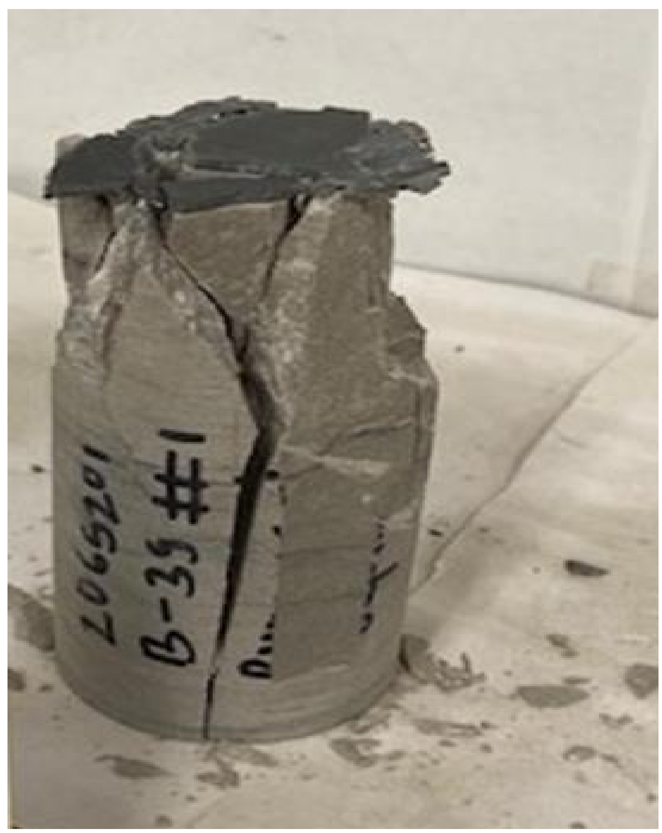
| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-039-0-21 | Sample Number | NQ2-1 |
| Sample Depth (feet) | 15-20 (NQ2-1) | Specimen Depth (feet) | 16.7-17.6 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 4.01 |
| Diameter (inches) | 1.98 |
| Length / Diameter | 2.03 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.08 |

| | |
|---|---|
| Mass (grams) | 532.5 |
| Unit Weight (lbs/cu. ft.) | 164 |
| | |
| Maximum Load (lbs) | 51,520 |
| Compressive Strength (psi) | 16,730 |

Test Specimen Photo



Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-039-0-21 | Sample Number | NQ2-2 |
| Sample Depth (feet) | 20-25 (NQ2-2) | Specimen Depth (feet) | 20.0-20.7 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.97 |
| Diameter (inches) | 1.98 |
| Length / Diameter | 2.01 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.08 |

| | |
|---|---|
| Mass (grams) | 521.2 |
| Unit Weight (lbs/cu. ft.) | 162 |
| | |
| Maximum Load (lbs) | 48,250 |
| Compressive Strength (psi) | 15,670 |

Test Specimen Photo

Test Specimen Photo

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-039-0-21 | SAMPLE NUMBER | NQ2-3 |
| SAMPLE DEPTH (FEET) | 25-30 (NQ2-3) | SPECIMEN DEPTH (FEET) | 27.0-27.9 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4.01 |
| DIAMETER (INCHES) | 1.98 |
| LENGTH / DIAMETER | 2.03 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.08 |

| | |
|---|---|
| MASS (GRAMS) | 531.9 |
| UNIT WEIGHT (LBS/CU. FT.) | 164 |
| | |
| MAXIMUM LOAD (LBS) | 61,020 |
| COMPRESSIVE STRENGTH (PSI) | 19,820 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| Project | LUC-023-11.75, PID 105889 | TTL Project Number | 2065201 |
| Location | Sylvania, Lucas County, Ohio | | |
| Client | ARCADIS U.S., Inc. | | |
| Boring Number | B-039-0-21 | Sample Number | NQ2-4 |
| Sample Depth (feet) | 30-35 (NQ2-4) | Specimen Depth (feet) | 32.2-32.7 |

| | |
|---|---|
| Rock Description | |

| | |
|---|---|
| Length (inches) | 3.96 |
| Diameter (inches) | 1.98 |
| Length / Diameter | 2.00 |
| Correction Factor | 1 |
| Area (sq. in.) | 3.08 |

| | |
|---|---|
| Mass (grams) | 535.4 |
| Unit Weight (lbs/cu. ft.) | 167 |
| | |
| Maximum Load (lbs) | 55,140 |
| Compressive Strength (psi) | 17,910 |

Test Specimen Photo

Test Specimen Photo

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Environmental, Geotechnical Engineering & Testing

# Compressive Strength of Rock
# ASTM D 7012, Method C

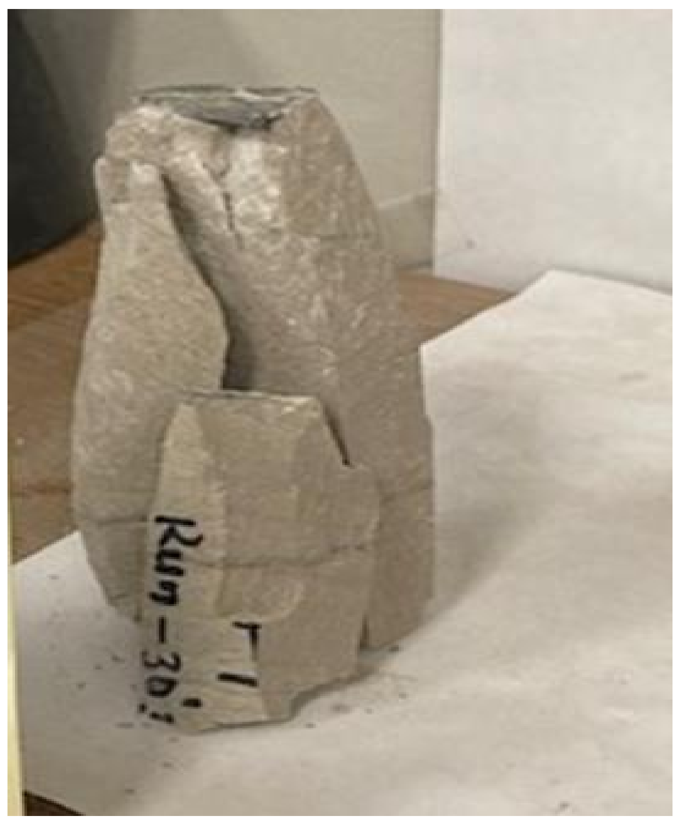
| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-043-0-21 | SAMPLE NUMBER | NQ2-1 |
| SAMPLE DEPTH (FEET) | 27.7-32.7 (NQ2-1) | SPECIMEN DEPTH (FEET) | 30.3-30.7 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 3.99 |
| DIAMETER (INCHES) | 1.98 |
| LENGTH / DIAMETER | 2.02 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.08 |

| | |
|---|---|
| MASS (GRAMS) | 514.3 |
| UNIT WEIGHT (LBS/CU. FT.) | 159 |
| | |
| MAXIMUM LOAD (LBS) | 65,730 |
| COMPRESSIVE STRENGTH (PSI) | 21,350 |


TEST SPECIMEN PHOTO




TEST SPECIMEN PHOTO

# Compressive Strength of Rock
# ASTM D 7012, Method C

| | | | |
|---|---|---|---|
| PROJECT | LUC-023-11.75, PID 105889 | TTL PROJECT NUMBER | 2065201 |
| LOCATION | Sylvania, Lucas County, Ohio | | |
| CLIENT | ARCADIS U.S., Inc. | | |
| BORING NUMBER | B-043-0-21 | SAMPLE NUMBER | NQ2-2 |
| SAMPLE DEPTH (FEET) | 32.7-37.7 (NQ2-2) | SPECIMEN DEPTH (FEET) | 32.7-33.1 |

| | |
|---|---|
| ROCK DESCRIPTION | |

| | |
|---|---|
| LENGTH (INCHES) | 4 |
| DIAMETER (INCHES) | 1.98 |
| LENGTH / DIAMETER | 2.02 |
| CORRECTION FACTOR | 1 |
| AREA (SQ. IN.) | 3.08 |

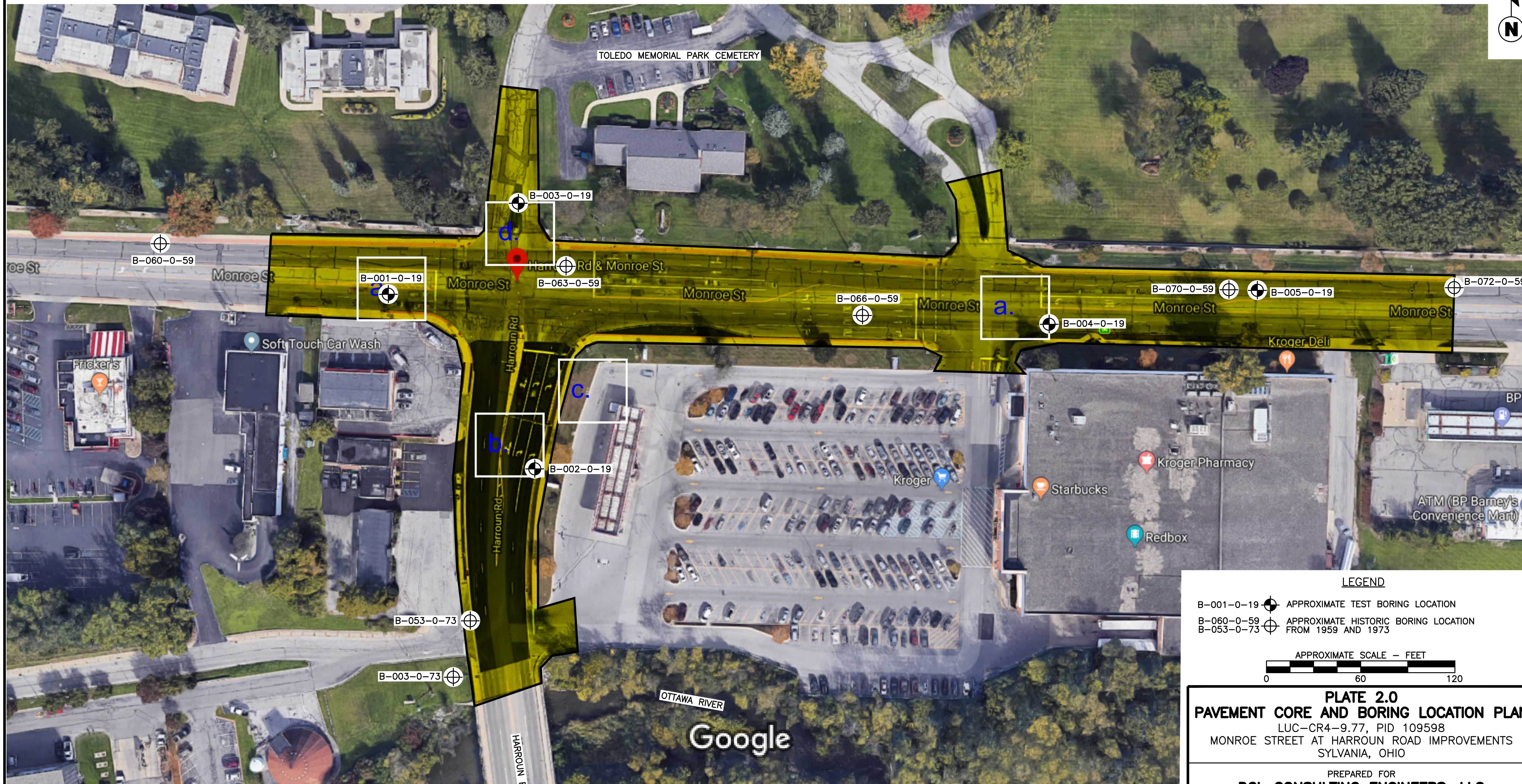
| | |
|---|---|
| MASS (GRAMS) | 524.9 |
| UNIT WEIGHT (LBS/CU. FT.) | 162 |
| | |
| MAXIMUM LOAD (LBS) | 68,770 |
| COMPRESSIVE STRENGTH (PSI) | 22,330 |

TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

# APPENDIX K

# Historic Borings




LEGEND

B-001-0-19 — APPROXIMATE TEST BORING LOCATION

B-060-0-59
B-053-0-73 — APPROXIMATE HISTORIC BORING LOCATION FROM 1959 AND 1973

APPROXIMATE SCALE – FEET

0 60 120

**PLATE 2.0**

**PAVEMENT CORE AND BORING LOCATION PLAN**

LUC-CR4-9.77, PID 109598

MONROE STREET AT HARROUN ROAD IMPROVEMENTS

SYLVANIA, OHIO

PREPARED FOR

**DGL CONSULTING ENGINEERS, LLC**

**MAUMEE, OHIO**

| | | | |
|---|---|---|---|
| DRAWN | TRR/10-29-19 | CHECKED | CPI/10-30-19 |
| REVISED | | APPROVED | |
| JOB NO. | 1837201 | | |
| DRAWING NUMBER | **1837201-02G** | | |

TTL associates inc
Environmental, Geotechnical Engineering & Testing

BASE PLAN PROVIDED BY DGL CONSULTING ENGINEERS, LLC ON JUNE 19, 2019.

| PROJECT: LUC-CR4-09.77 | DRILLING FIRM / OPERATOR: TTL / IC | DRILL RIG: CME 75 TRUCK 844 | STATION / OFFSET: 63+50, 63' LT. | EXPLORATION ID B-003-0-19 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TTL / KKC | HAMMER: CME AUTOMATIC | ALIGNMENT: MONROE | |
| PID: 109598 SFN: N/A | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 1/10/17 | ELEVATION: 644.5 (NAVD88) EOB: 18.8 ft. | PAGE 1 OF 1 |
| START: 9/27/19 END: 9/27/19 | SAMPLING METHOD: SPT / ST | ENERGY RATIO (%): 70.4 | LAT / LONG: 41.715589, -83.694811 | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 644.5 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL - 6 INCHES | 644.0 | | | | | | | | | | | | | | | | | |
| MEDIUM STIFF, BROWN, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, ORGANICS, DAMP TO MOIST | 641.5 | 1 – 2 | 2 3 3 | 7 | 33 | SS-1 | 2.00 | 1 | 5 | 14 | 43 | 37 | 27 | 20 | 7 | 20 | A-4a (8) | |
| STIFF TO VERY STIFF, BROWN, **SANDY SILT**, "AND" CLAY, DAMP | 638.5 | 3 – 5 | 4 4 6 | 12 | 78 | SS-2 | 2.50 | 0 | 3 | 7 | 40 | 50 | 25 | 23 | 2 | 20 | A-4a (8) | |
| STIFF TO VERY STIFF, BROWN, **SILT AND CLAY**, LITTLE SAND, MOIST | 636.5 | 6 – 7 | 4 5 6 | 13 | 100 | SS-3 | 2.25 | - | - | - | - | - | - | - | - | 25 | A-6a (V) | |
| STIFF TO VERY STIFF, BROWN/GRAY, **SILTY CLAY**, LITTLE SAND AND TRACE GRAVEL, MOIST | | 8 – 10 | 4 5 5 | 12 | 100 | SS-4 | 3.25 | - | - | - | - | - | - | - | - | 21 | A-6b (V) | |
| @12': VERY STIFF, GRAY, DAMP | | 11 – 13 | | | 100 | ST-5 | 2.71* | - | - | - | - | - | - | - | - | 14 | A-6b (V) | |
| | 629.0 | 14 – 15 TR | 5 10 10 | 23 | 100 | SS-6 | >4.5 | - | - | - | - | - | - | - | - | 12 | A-6b (V) | |
| GRAY, **WEATHERED ROCK WITH SAND** | 625.7 | 16 – 18 EOB | 50/3" | - | 67 | SS-7 | NP | - | - | - | - | - | - | - | - | 5 | Rock (V) | |

NOTES: "*" - UNCONFINED STRENGTH DETERMINED BY ASTM D 2166. "NP" - NON PLASTIC

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

| | | | | |
|---|---|---|---|---|
| PROJECT: LUC-CR4-09.77<br>TYPE: ROADWAY<br>PID: 109598 SFN: N/A<br>START: 9/27/19 END: 9/27/19 | DRILLING FIRM / OPERATOR: TTL / IC<br>SAMPLING FIRM / LOGGER: TTL / KKC<br>DRILLING METHOD: SSA<br>SAMPLING METHOD: SPT | DRILL RIG: CME 75 TRUCK 844<br>HAMMER: CME AUTOMATIC<br>CALIBRATION DATE: 1/10/17<br>ENERGY RATIO (%): 70.4 | STATION / OFFSET: 70+54, 19' LT.<br>ALIGNMENT: MONROE<br>ELEVATION: 642.7 (NAVD88) EOB: 10.0 ft.<br>LAT / LONG: 41.715344, -83.692242 | EXPLORATION ID<br>B-005-0-19<br>PAGE<br>1 OF 1 |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 642.7 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT - 4.5 INCHES | 642.3 | | | | | | | | | | | | | | | | | |
| CONCRETE - 6.5 INCHES | 641.8 | 1 | | | | | | | | | | | | | | | | |
| MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, CRUSHED STONE, TRACE CLAY, AND ORGANICS, MOIST **FILL** | 640.4 | 2 | 5 6 5 | 13 | 78 | SS-1 | NP | 10 | 10 | 63 | 15 | 2 | NP | NP | NP | 6 | A-3a (0) | |
| CRUSHED STONE **FILL** | 639.9 | | | | | | | | | | | | | | | | | |
| MEDIUM STIFF, BROWN, **SANDY SILT**, SOME CLAY AND TRACE GRAVEL, MOIST | | 3 | 2 2 2 | 5 | 100 | SS-2 | 0.75 | 1 | 5 | 30 | 31 | 33 | 25 | 20 | 5 | 22 | A-4a (6) | |
| @4': VERY SOFT, BROWN/DARK BROWN | | 4<br>5 | 1 1 1 | 2 | 67 | SS-3 | 0.25 | - | - | - | - | - | - | - | - | 22 | A-4a (V) | |
| @6': BROWN, WET | 635.5 | 6<br>7 | 1 1 1 | 2 | 100 | SS-4 | 0.15* | - | - | - | - | - | - | - | - | 27 | A-4a (V) | |
| VERY STIFF, GRAY/BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, AND CALCITE STAIN SEAM, MOIST | | 634.2<br>8 | 4 6 10 | 19 | 100 | SS-5 | 3.00 | - | - | - | - | - | - | - | - | 27 | A-6b (V) | |
| @8.5': BROWN, WET SAND SEAMS | 632.7 | 9<br>EOB 10 | 5 6 8 | 16 | 100 | SS-6 | 3.50 | - | - | - | - | - | - | - | - | 23 | A-6b (V) | |

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 12/10/20 12:09 - S:\PROJECTS\1837201.GPJ

NOTES: "*" - UNCONFINED STRENGTH DETERMINED BY ASTM D 2166. "NP" - NON PLASTIC

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.25 BAG ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 0.5 BAG BENTONITE CHIPS

# APPENDIX L

# ODOT Design Checklists

## I. Geotechnical Design Checklists

| | | | |
|---|---|---|---|
| **Project:** | **LUC-023-11.75** | **PDP Path:** | |
| **PID:** | **105889** | **Review Stage:** | |

| **Checklist** | **Included in This Submission** |
|---|---|
| II. Reconnaissance and Planning | ✓ |
| III. A. Centerline Cuts | |
| III. B. Embankments | ✓ |
| III. C. Subgrade | ✓ |
| IV. A. Foundations of Structures | ✓ |
| IV. B. Retaining Wall | ✓ |
| V. A. Landslide Remediation | |
| V. B. Rockfall Remediation | |
| V. C. Wetland or Peat Remediation | |
| V. D. Underground Mine Remediation | |
| V. E. Surface Mine Remediation | |
| V. F. Karst Remediation | |
| VI. A. Geotechnical Profile | |
| VI. D. Geotechnical Reports | ✓ |

## II. Reconnaissance and Planning Checklist

| C-R-S: LUC-023-11.75 | PID: 105889 | Reviewer: CPI | Date: 7/1/2023 |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Reconnaissance** | | (Y/N/X) | Notes: |
| 1 | Based on Section 302.1 in the SGE, have the necessary plans been developed in the following areas prior to the commencement of the subsurface exploration reconnaissance: | Y | |
| | Roadway plans | ✓ | |
| | Structures plans | ✓ | |
| | Geohazards plans | | |
| 2 | Have the resources listed in Section 302.2.1 of the SGE been reviewed as part of the office reconnaissance? | Y | |
| 3 | Have all the features listed in Section 302.3 of the SGE been observed and evaluated during the field reconnaissance? | Y | |
| 4 | If notable features were discovered in the field reconnaissance, were the GPS coordinates of these features recorded? | X | |
| **Planning - General** | | (Y/N/X) | Notes: |
| 5 | In planning the geotechnical exploration program for the project, have the specific geologic conditions, the proposed work, and historic subsurface exploration work been considered? | Y | |
| 6 | Has the ODOT Transportation Information Mapping System (TIMS) been accessed to find all available historic boring information and inventoried geohazards? | Y | |
| 7 | Have the borings been located to develop the maximum subsurface information while using a minimum number of borings, utilizing historic geotechnical explorations to the fullest extent possible? | Y | |
| 8 | Have the topography, geologic origin of materials, surface manifestation of soil conditions, and any other special design considerations been utilized in determining the spacing and depth of borings? | Y | |
| 9 | Have the borings been located so as to provide adequate overhead clearance for the equipment, clearance of underground utilities, minimize damage to private property, and minimize disruption of traffic, without compromising the quality of the exploration? | Y | |

## II. Reconnaissance and Planning Checklist

| **Planning - General** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 10 | Have the scaled boring plans, showing all project and historic borings, and a schedule of borings in tabular format, been submitted to the District Geotechnical Engineer? | Y | Scaled plan is provided with project borings and appropriate historic borings that were included in the report. |
| | The schedule of borings should present the following information for each boring: | | |
| a. | exploration identification number | Y | |
| b. | location by station and offset | N | Station and offset not available at time of DRAFT report submittal. |
| c. | estimated amount of rock and soil, including the total for each for the entire program. | Y | |
| | | | |
| **Planning – Exploration Number** | | (Y/N/X) | Notes: |
| 11 | Have the coordinates, stations and offsets of all explorations (borings, soundings, test pits, etc.) been identified? | N | Station and offset not available at time of DRAFT report submittal. |
| 12 | Has each exploration been assigned a unique identification number, in the following format X-ZZZ-W-YY, as per Section 303.2 of the SGE? | Y | |
| 13 | When referring to historic explorations that did not use the identification scheme in 12 above, have the historic explorations been assigned identification numbers according to Section 303.2 of the SGE? | Y | |

## II. Reconnaissance and Planning Checklist

| **Planning – Boring Types** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 14 | Based on Sections 303.3 to 303.7.6 of the SGE, have the location, depth, and sampling requirements for the following boring types been determined for the project? | Y | |
| | Check all boring types utilized for this project: | | |
| | Existing Subgrades (Type A) | ✓ | |
| | Roadway Borings (Type B) | ✓ | |
| | Embankment Foundations (Type B1) | ✓ | |
| | Cut Sections (Type B2) | | |
| | Sidehill Cut Sections (Type B3) | | |
| | Sidehill Cut-Fill Sections (Type B4) | | |
| | Sidehill Fill Sections on Unstable Slopes (Type B5) | | |
| | Geohazard Borings (Type C) | | |
| | Lakes, Ponds, and Low-Lying Areas (Type C1) | | |
| | Peat Deposits, Compressible Soils, and Low Strength Soils (Type C2) | | |
| | Uncontrolled Fills, Waste Pits, and Reclaimed Surface Mines (Type C3) | | |
| | Underground Mines (C4) | | |
| | Landslides (Type C5) | | |
| | Rock Slope (Type C6) | | |
| | Karst (Type C7) | | |
| | Proposed Underground Utilities (Type D) | | |
| | Structure Borings (Type E) | ✓ | |
| | Bridges (Type E1) | ✓ | |
| | Culverts (Type E2 a,b,c) | | |
| | Retaining Walls (Type E3 a and b) | ✓ | |
| | Noise Barrier (Type E4) | | |
| | CCTV & High Mast Lighting Towers (Type E5) | | |
| | Buildings and Salt Domes (Type E6) | | |

## III.B. Embankments Checklist

| C-R-S: | LUC-023-11.75 | PID: | 105889 | Reviewer: | CPI | Date: | 7/1/2023 |
|---|---|---|---|---|---|---|---|

***Use this checklist in conjunction with the Embankment Design Guidance in GDM Section 500***
***If you do not have an embankment on the project, you do not have to fill out this checklist.***

| **Settlement** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 1 | If soil conditions and project requirements warrant, have settlement issues been addressed? If not applicable (X), go to Question 14 | Y | |
| 2 | Have consolidation properties of the foundation soils been determined? | Y | C' method for granular soils using N60 values. |
| | Check methods used: | | |
| | laboratory consolidation tests | | |
| | empirical correlations with moisture content and Atterberg values | ✓ | |
| | other (describe other methods) | ✓ | |
| 3 | Have calculations been performed to estimate the total expected embankment settlement and the time of consolidation? Indicate method used. | Y | Consolidation and correlation with LL. |
| 4 | If differing foundation soil and/or loading conditions occur throughout the embankment area, have sufficient analyses been completed to evaluate consolidation at locations representative of the most critical conditions? | Y | |
| 5 | Have the total settlement and the time of consolidation analyses indicated acceptable values at all locations for the scope of the embankment work? | Y | |
| 6 | If total settlement or time of consolidation is unacceptable, have the stations and lateral extent of the problem areas been defined? | Y | |
| 7 | Has a method been chosen as a solution to the settlement issues? | Y | Downdrag considerations addressed for embankment fill at rear and forward abutments for Ramp A and Ramp B over Ottawa River. |
| | Check the method(s) used: | | |
| | waiting periods with monitoring | ✓ | |
| | drainage blanket and wick drains | | |
| | surcharge (preloading) | | |
| | removal and replacement of weak soil | | |
| | lowering proposed grade / change alignment | | |
| | lightweight fill | | |
| | other (describe other methods) | ✓ | |

## III.B. Embankments Checklist

| **Settlement** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 8 | Based on accepted design practices, and where applicable, adhering to published guidelines and design recommendations from FHWA, have calculations been performed to evaluate the effectiveness of the chosen solution(s)? | Y | |
| 9 | Has an economic analysis been performed to evaluate the cost benefits of the recommended solution compared to others? | X | |
| 10 | Have all necessary notes, specifications, and details for the chosen solution been determined? | X | Plans to be prepared by others. |
| 11 | Have the need, locations, type, plan notes, and reading schedule for settlement platforms or cells been determined? | X | Plans to be prepared by others. |
| 12 | Have the effects of the predicted settlement and the chosen solution been determined and accounted for on the construction schedule? | X | To be evaluated by others. |
| 13 | Has the effect of any foundation soil consolidation (including differential settlement) been evaluated with regard to adjacent structures (e.g., bridges, buildings, culverts, utilities) which will also undergo settlement and be subject to stresses induced by the consolidation of the surrounding soil? | X | |

| **Stability** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 14 | If soil conditions and project requirements warrant, have stability issues been addressed?<br>If not applicable (X), go to Question 29 | X | |
| 15 | Has the total (short term) and effective (long term) shear strength of the foundation soils been determined? | | |
| | Check method used: | | |
| | laboratory shear tests | | |
| | estimation from SPT or field tests | | |
| 16 | Have the values of shear strength for proposed embankment fill material, as determined from GDM Section 500, been used in the stability analyses? | | |

## III.B. Embankments Checklist

| Stability | | (Y/N/X) | Notes: |
|---|---|---|---|
| 17 | Have calculations been performed to determine the F.S. for stability? Indicate which program and which analysis method (Spencer, Bishop, etc) was used. | X | |
| 18 | Have the following F.S. been met or exceeded, as determined by the calculations, for the given stability conditions: | | |
| a. | 1.30 for short term (undrained) condition | | |
| b. | 1.30 for long term (drained) condition | | |
| c. | 1.10 for rapid drawdown, flood condition | | |
| d. | 1.50 for embankment containing or supporting a structural element | | |
| 19 | When differing soil or loading conditions occur throughout the embankment area, have sufficient analyses been completed to evaluate the stability at locations representative of the most critical conditions? | | |
| 20 | If the F.S. was not met or exceeded, have the stations and lateral extent of the problem areas been defined? | | |
| 21 | Has a method been chosen as a solution to the stability issues? | | |
| | Check the method(s) used: | | |
| | flattening slopes | | |
| | counterberm | | |
| | lightweight embankment | | |
| | reinforced soil slope | | |
| | soil nailing | | |
| | drainage blanket and wick drains | | |
| | removal of soft soil, adding shear key | | |
| | reduced grade / change alignment | | |
| | staged construction | | |
| | controlled rate of fill placement | | |
| | drilled shaft slope stabilization | | |
| | other (describe other methods) | | |
| 22 | Based on accepted design practices, and where applicable, adhering to published guidelines and design recommendations from FHWA, have calculations been performed to evaluate the effectiveness of the chosen solution(s)? | | |
| 23 | Has an economic analysis been performed to evaluate the cost benefits of the recommended solution compared to others? | | |

## III.B. Embankments Checklist

| **Stability** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 24 | Have all necessary notes, specifications, and details for the chosen solution been determined? | X | |
| 25 | Have the need, location, type, plan notes, and reading schedule for piezometers and inclinometers been determined? | X | |
| 26 | If piezometers will be used, has the critical pressure value been determined and the appropriate information included in the plans? | X | |
| 27 | Have the effects of the stability solution been determined and accounted for on the construction schedule? | X | |
| 28 | Has the effect of the stability solution been evaluated with regard to structures (e.g., bridges, buildings, culverts, utilities) which may be subject to unusual stresses or require special construction considerations? | X | |

| **Sidehill Fills** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 29 | If soil conditions and project requirements warrant, have sidehill fill issues been addressed? If not applicable (X), go to Question 34 | Y | |
| 30 | In accordance with GDM Section 800, have sidehill fills been evaluated to determine if special benching or shear keys are needed? | Y | |
| 31 | In accordance with GDM Section 800, if special benching or shear keys are required, | X | |
| a. | has Plan Note G109 from L&D3 been included in the General Notes? | | |
| b. | have quantities for both excavation and embankment been calculated for the benched areas and added to the plan General Quantities? | | |
| c. | have the special benching or shear keys been indicated on the appropriate cross sections? | | |
| 32 | Have water bearing zones been identified and their impact addressed? | X | |
| 33 | Have subsurface drainage controls been adequately addressed? | X | |

## III.B. Embankments Checklist

| **Special** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 34 | Have all of the environmental factors, including wetlands, stream mitigation, and landfills, been considered and incorporated prior to design and analysis of embankment settlement and stability, including EPA or other government agencies' involvement, mitigation, or special design or construction considerations? | X | To be evaluated by others. |
| 35 | If an embankment is to be placed through standing water or over weak, wet soils (with or without a fabric separator), the fill should be placed by the method of end dumping to a given height above the standing water or until compaction is achievable over the soft soil. If end dumping is to be specified, | X | |
| a. | has the material type for the fill to be end dumped been specified? | X | |
| b. | has the need for a fabric separator or filter layer been determined? | X | |
| c. | has the height of fill to be end dumped been determined? | X | |
| d. | have all notes and specifications for end dumping been developed? | X | |

## IV.B. Retaining Wall Checklist

| C-R-S: LUC-023-11.75 | PID: 105889 | Reviewer: | Date: |
|---|---|---|---|

***If you do not have a retaining wall on the project, you do not have to fill out this checklist.***

| **Soil Data and Preliminary Calculations** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 1 | Has a justification study been performed to determine the necessity of a wall as opposed to ROW purchase or other project alternatives? | X | Evaluation by others. In existing ROW. |
| 2 | Have the necessary soil strength parameters and unit weights been determined? | Y | |
| | Check method used: | | |
| | laboratory shear tests | ✓ | |
| | estimation from SPT or field tests | ✓ | |
| 3 | Has the groundwater elevation been determined? | Y | |
| 4 | Have the proper loading conditions been determined? | Y | |
| a. | If yes, check which loading conditions apply: | | |
| | Backfill (Active Earth Pressure Loading): | ✓ | |
| | Backfill (Apparent Earth Pressure (AEP) Loading for Ground Anchors): | | |
| | Backfill (At-Rest Earth Pressure Loading): | | |
| | Backfill (Flat, No Slope): | | |
| | Backfill (Infinite Slope): | | |
| | Backfill (Broken Back Slope): | ✓ | |
| | Earth Surcharge: | ✓ | |
| | Live Load Surcharge: | ✓ | |
| | Other (describe): | | |
| 5 | Have the correct Load Factors, Load Combinations, and Limit States been considered, per AASHTO LRFD 9th Ed. Articles 3.4.1, 10.5, and 11.5? | X | Load factors by others. |
| 6 | Are earth pressure loads inclined at the soil-structure interaction friction angle, δ and has δ been determined per BDM 307.1.1? | X | By others. |
| 7 | Have the correct Resistance Factors been considered, per AASHTO LRFD 9th Ed. Articles 10.5 and 11.5? | X | Soil properties provided for soil nail wall. |
| 8 | If applicable, has the influence of groundwater been taken into account with regards to soil unit weights and active pressures? | Y | |
| 9 | Has the Coulomb method been utilized to determine the lateral earth pressure? | Y | |

## IV.B. Retaining Wall Checklist

| Design | | (Y/N/X) | Notes: |
|---|---|---|---|
| 10 | For preliminary wall design, have the design criteria and wall type selection process been followed as instructed in BDM 201.1.2.5? | X | Design by others. |
| 11 | Was an economic analysis performed to evaluate the cost benefits of the chosen wall type compared to others? | X | By others |
| 12 | Were representative sections analyzed for the entire length of the retaining wall for the following: | X | Soil nail wall design properties provided |
| a. | bearing resistance? | | |
| b. | sliding resistance? | | |
| c. | limiting eccentricity and overturning resistance? Analyze moment equilibrium about toe for non-gravity cantilever walls. | | |
| d. | total and differential settlement? | | |
| e. | overall (global) stability? | | |
| 13 | If poor foundation soils are present, has a solution been determined with respect to the following: | X | |
| a. | excessive settlement? | | |
| b. | inadequate bearing resistance? | | |
| c. | inadequate sliding resistance? | | |
| d. | overall (global) instability? | | |
| 14 | For non-proprietary walls, each wall type has design recommendations which need to be determined. For the wall type being evaluated, have the following design recommendations been determined by accepted design methods or, where applicable, FHWA design guidelines: | X | By others |
| a. | Rigid Gravity and Semigravity -- footing width and elevation, maximum factored Service and Strength Limit State bearing pressures, factored bearing resistance (BDM 307.1.5 & 307.2 ) | | |
| b. | Drilled Shafts - diameter, spacing, embedment, arrangement and percent reinforcement, maximum moment and lateral shear, maximum deflection (see BDM 307.6) | | |
| c. | Soldier Pile -pile size and type, drilled hole diameter, embedment, spacing, lagging design, facing, maximum moment and lateral shear, section modulus, maximum deflection | | |

## IV.B. Retaining Wall Checklist

| Design | | (Y/N/X) | Notes: |
|---|---|---|---|
| d. | Sheet Pile - pile size, embedment, maximum moment and lateral shear, section modulus, maximum deflection (BDM 307.7.1) | | |
| e. | Cellular - type, maximum factored Service and Strength Limit State bearing pressures, factored bearing resistance, fill material (BDM 307.7.2) | | |
| f. | Soil Anchor - load per anchor, number of rows, wale design, anchor inclination and minimum length, type of anchor, pile size, type, spacing, and embedment, maximum moment and lateral shear, section modulus, lagging design, facing (BDM 307.8) | | |
| g. | Soil Nail - nail size, spacing, inclination, and length, loading per nail, facing (BDM 307.9) | X | Design by others. |
| 15 | Has the need for load testing of the retaining wall elements been evaluated? | X | Design by others. |
| a. | If needed, have details and plan notes for load testing been included in the plans? | | |
| 16 | Proprietary wall designs require a special process for detail design, as outlined in BDM 307.3 and 307.4. Has this procedure been followed for this project? | X | Design by others. |
| 17 | Temporary walls - have the same design requirements as permanent walls of the same type been followed, except the design service life is no more than three years (BDM 307.10)? | X | |
| 18 | The presence and quality of water behind the wall structure and in the backfill can be a major source of overloading and failure. | X | Design by others. |
| a. | Has the quality / chemistry of the groundwater been accounted for in the drainage system? | | |
| b. | Has an adequate drainage system been included in the detail wall design? | | |
| c. | If there is a water source behind the wall, has additional drainage been added to control the effect of this water source on the wall? | | |
| 19 | Have the effects of the wall design and construction procedure been determined and accounted for on the construction schedule? | | |

## IV.B. Retaining Wall Checklist

| **Design** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 20 | Has the effect of the wall design and construction been evaluated with regard to structures (e.g., bridges, culverts, buildings, utilities), which may be subject to unusual stresses or require special design or construction considerations? | X | Design by others |
| **Plans and Contract Documents** | | (Y/N/X) | Notes: |
| 21 | Have all the necessary notes, specifications, special provisions, and details for the construction of the wall system been included in the plans? | X | Plans by others |
| 22 | Have the need, location, type, plan notes, and reading schedule for any instrumentation been determined and included in the plans? | X | |
| | Check the types of instrumentation specified: | | |
| | settlement cells | | |
| | settlement platforms | | |
| | inclinometers | | |
| | monitoring wells / piezometers | | |
| | load cells | | |
| | strain gages | | |
| | other (describe other types) | | |

## III.C. Subgrade Checklist

| C-R-S: LUC-023-11.75 | PID: 105889 | Reviewer: CPI | Date: 7/1/2023 |
|---|---|---|---|

***Use this Checklist in conjunction with the Subgrade design guidance in GDM Section 600***
***If you do not have any subgrade work on the project, you do not have to fill out this checklist.***

| Subgrade | | (Y/N/X) | Notes: |
|---|---|---|---|
| 1 | Has the subsurface exploration adequately characterized the soil or rock according to GDM Section 600? | Y | |
| a. | Has each sample been visually classified and inspected for the presence of gypsum? Has a moisture content been performed on each sample? | Y | |
| b. | Has mechanical classification (Plastic Limit (PL), Liquid Limit (LL), and gradation testing) been done on at least two samples from each boring within six feet of the proposed subgrade? | Y | |
| c. | Has the sulfate content of at least one sample from each boring within 3 feet of the proposed subgrade been determined, per Supplement 1122, Determining Sulfate Content in Soils? | Y | |
| d. | Has the sulfate content of all samples that exhibit gypsum crystals been determined? | X | |
| e. | Have A-2-5, A-4b, A-5, A-7-5, A-8a, or A-8b soils within the top 3 feet of the proposed subgrade been mechanically classified? | Y | |
| 2 | If soils classified as A-2-5, A-4b, A-5, A-7-5, A-8a, or A-8b, or having a LL>65, are present at the proposed subgrade (geotechnical profile), do the plans specify that these materials need to be removed and replaced or chemically stabilized? | X | Plans to be prepared by others. Noted in the geotechnical report. |
| a. | If these materials are to be removed and replaced, have the station limits, depth, and lateral limits for the planned removal been provided? | X | Stationing not available at time of DRAFT report. Approximate limits and length of roadway/ramp provided. |
| 3 | If there is any rock, shale, or coal present at the proposed subgrade (C&MS 204.05), do the plans specify the removal of the material? | X | |
| a. | If removal of any rock, shale, or coal is required, have the station limits, depth, and lateral limits for the planned removal of the material at proposed subgrade been provided? | X | |

## III.C. Subgrade Checklist

| **Subgrade** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 4 | In accordance with GDM Section 600, do the SPT ($N_{60}$)/HP values and existing moisture contents for the proposed subgrade soils indicate the need for subgrade stabilization? | Y | |
| a. | If removal and replacement is applicable, has the detail of subgrade removal been shown on the plans, including depth of removal, station limits, lateral extent, replacement material, and plan notes (Item 204 - Subgrade Compaction and Proof Rolling)? | X | Plans to be prepared by others. Noted in the geotechnical report. |
| b. | If chemical stabilization is applicable, has the detail of this treatment been shown on the plans, including depth, percentage of chemical, station limits, lateral extent, and plan notes? | X | Plans to be prepared by others. Noted in the geotechnical report. |
| | Indicate type of chemcial stabilization specified: | | |
| | cement stabilization | ✓ | |
| | lime stabilization | | |
| 5 | If removal and replacement has been specified, do the plans include Plan Note G121 from L&D3? | X | Plans to be prepared by others. Noted in the geotechnical report. |
| 6 | If drainage or groundwater is an issue with the proposed subgrade, has an appropriate drainage system (e.g., pipe, underdrains) been provided? | X | |
| 7 | Has an appropriate quantity of Proof Rolling (C&MS 204.06) and has Plan Note G111 from L&D3 been included in the plans? | X | Plans to be prepared by others. Noted in the geotechnical report. |
| 8 | Has a design CBR value been provided? | Y | |

## IV.A Foundations of Structures Checklist

| C-R-S: LUC-023-11.75 | PID: 105889 | Reviewer: CPI | Date: 7/1/2023 |
|---|---|---|---|

***Use this Checklist in conjunction with the bridge foundation design guidance in GDM Section 1300***
***If you do not have such a foundation or structure on the project, you do not have to fill out this checklist.***

| **Soil and Bedrock Strength Data** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 1 | Has the shear strength of the foundation soils been determined? | Y | |
| | Check method used: | | |
| | laboratory shear tests | ✓ | |
| | estimation from SPT or field tests | ✓ | |
| 2 | Have sufficient soil shear strength, consolidation, and other parameters been determined so that the required allowable loads for the foundation/structure can be designed? | Y | |
| 3 | Has the shear strength of the foundation bedrock been determined? | Y | |
| | Check method used: | | |
| | laboratory shear tests | ✓ | |
| | other (describe other methods) | | |
| **Spread Footings** | | (Y/N/X) | Notes: |
| 4 | Are there spread footings on the project? If no, go to Question 11 | Y | |
| 5 | Have the recommended bottom of footing elevation and reason for this recommendation been provided? | Y | |
| a. | Has the recommended bottom of footing elevation taken scour from streams or other water flow into account? | X | |
| 6 | Were representative sections analyzed for the entire length of the structure for the following: | Y | |
| a. | factored bearing resistance? | Y | |
| b. | factored sliding resistance? | X | Recommendations provided for evaluation by others |
| c. | eccentric load limitations (overturning)? | X | |
| d. | predicted settlement? | Y | |
| e. | overall (global) stability? | X | |
| 7 | Has the need for a shear key been evaluated? | X | |
| a. | If needed, have the details been included in the plans? | | |
| 8 | If special conditions exist (e.g. geometry, sloping rock, varying soil conditions), was the bottom of footing “stepped” to accommodate them? | X | |
| 9 | Have the Service I and Maximum Strength Limit States for bearing pressure on soil or rock been provided? | Y | |

# IV.A Foundations of Structures Checklist

| Spread Footings | | (Y/N/X) | Notes: |
|---|---|---|---|
| 10 | If weak soil is present at the proposed foundation level, has the removal / treatment of this soil been developed and included in the plans? | X | Bearing on rock. |
| a. | Have the procedure and quantities related to this removal / treatment been included in the plans? | | |
| **Pile Structures** | | (Y/N/X) | Notes: |
| 11 | Are there piles on the project?<br>If no, go to Question 17 | Y | |
| 12 | Has an appropriate pile type been selected? | | |
| | Check the type selected: | | |
| | H-pile (driven) | ✓ | |
| | H-pile (prebored) | | |
| | Cast In-place Reinforced Concrete Pipe | | |
| | Micropile | | |
| | Continuous Flight Auger (CFA) | | |
| | other (describe other types) | | |
| 13 | Have the estimated pile length or tip elevation and section (diameter) based on either the Ultimate Bearing Value (UBV) or the depth to top of bedrock been specified? Indicate method used. | Y | Top of rock for end-bearing piles |
| 14 | If scour is predicted, has pile resistance in the scour zone been neglected? | | Not near waterway |
| 15 | Has a wave equation drivability analysis been performed as per BDM 305.3.1.2 to determine whether the pile can be driven to either the UBV, the pile tip elevation, or refusal on bedrock without overstressing the pile? | X | Not at this time |
| 16 | If required for design, have sufficient soil parameters been provided and calculations performed to evaluate the: | | Rock-bearing piles. |
| a. | Nominal unit tip resistance and maximum settlement of the piles? | | |
| b. | Nominal unit side resistance for each contributing soil layer and maximum deflection of the piles? | | |
| c. | Downdrag load on piles driven through new embankment or compressible soil layers, as per BDM 305.3.2.2? | X | Prescribed waiting period. |
| d. | Potential for and impact of lateral squeeze from soft foundation soils? | | |

## IV.A Foundations of Structures Checklist

| Pile Structures | | (Y/N/X) | Notes: |
|---|---|---|---|
| 17 | If piles are to be driven to strong bedrock ($Q_u$ >7.5 ksi) or through very dense granular soils or overburden containing boulders, have “pile points” been recommended in order to protect the tips of the steel piling, as per BDM 305.3.5.6? | Y | |
| 18 | If subsurface obstacles exist, has preboring been recommended to avoid these obstructions? | X | |
| 19 | If piles will be driven through 15 feet or more of new embankment, has preboring been specified as per BDM 305.3.5.7? | Y | |

# IV.A Foundations of Structures Checklist

| Drilled Shafts | | (Y/N/X) | Notes: |
|---|---|---|---|
| 20 | Are there drilled shafts on the project?<br>If no, go to the next checklist. | Y | |
| 21 | Have the drilled shaft diameter and embedment length been specified? | Y | |
| 22 | Have the recommended drilled shaft diameter and embedment been developed based on the nominal unit side resistance and nominal unit tip resistance for vertical loading situations? | Y | |
| 23 | For shafts undergoing lateral loading, have the following been determined: | Y | Lateral load-deflection parameters provided to structural engineer. |
| a. | total factored lateral shear? | | |
| b. | total factored bending moment? | | |
| c. | maximum deflection? | | |
| d. | reinforcement design? | | |
| 24 | If a bedrock socket is required, has a minimum rock socket length equal to 1.5 times the rock socket diameter been used, as per BDM 305.4.2? | Y | Yes, then deeper embedment required for scour considerations. |
| 25 | Generally, bedrock sockets are 6" smaller in diameter than the soil embedment section of the drilled shaft. Has this factor been accounted for in the drilled shaft design? | Y | Initially considered, but now structural engineer is prescribing straight shafts through soil and rock. |
| 26 | If scour is predicted, has shaft resistance in the scour zone been neglected? | ✓ | |
| 27 | Has the site been assessed for groundwater influence? | Y | |
| a. | If yes, and if artesian flow is a potential concern, does the design address control of groundwater flow during construction? | X | |
| 28 | Have all the proper items been included in the plans for integrity testing? | X | Plans to be prepared by others. |
| 29 | If special construction features (e.g., slurry, casing, load tests) are required, have all the proper items been included in the plans? | X | Plans to be prepared by others. Provided recommendations in geotechnical report. |
| 30 | If necessary, have wet construction methods been specified? | Y | |
| **General** | | (Y/N/X) | Notes: |
| 31 | Has the need for load testing of the foundations been evaluated? | X | |
| a. | If needed, have details and plan notes for load testing been included in the plans? | | |

## VI.B. Geotechnical Reports

| C-R-S: LUC-023-11.75 | PID: 105889 | Reviewer: CPI | Date: 7/1/2023 |
|---|---|---|---|

| General | | (Y/N/X) | Notes: |
|---|---|---|---|
| 1 | Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)? | Y | This report is being provided electronically. |
| 2 | Has the first complete version of a geotechnical report being submitted been labeled as 'Draft'? | Y | This is the DRAFT report submission |
| 3 | Subsequent to ODOT's review and approval, has the complete version of the revised geotechnical report being submitted been labeled 'Final'? | X | This is the DRAFT report submission |
| 4 | Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files meet this demand? | X | The gINT Project file will be provided with the final report. |
| 5 | Does the report cover format follow ODOT's Brand and Identity Guidelines Report Standards found at http://www.dot.state.oh.us/brand/Pages/default.aspx ? | Y | |
| 6 | Have all geotechnical reports being submitted been titled correctly as prescribed in Section 706.1 of the SGE? | Y | |
| **Report Body** | | (Y/N/X) | Notes: |
| 7 | Do all geotechnical reports being submitted contain the following: | Y | |
| a. | an Executive Summary as described in Section 706.2 of the SGE? | Y | |
| b. | an Introduction as described in Section 706.3 of the SGE? | Y | |
| c. | a section titled "Geology and Observations of the Project," as described in Section 706.4 of the SGE? | Y | |
| d. | a section titled "Exploration," as described in Section 706.5 of the SGE? | Y | |
| e. | a section titled "Findings," as described in Section 706.6 of the SGE? | Y | |
| f. | a section titled "Analyses and Recommendations," as described in Section 706.7 of the SGE? | Y | |
| **Appendices** | | (Y/N/X) | Notes: |
| 8 | Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 706.8 of the SGE? | Y | |
| 9 | Do the Appendices present a site Boring Plan showing all boring locations as described in Section 706.8.1 of the SGE? | Y | |

## VI.B. Geotechnical Reports

| **Appendices** | | (Y/N/X) | Notes: |
|---|---|---|---|
| 10 | Do the Appendices include boring logs and color pictures of rock, if applicable, as described in Section 706.8.2 of the SGE? | Y | |
| 11 | Do the Appendices include reports of undisturbed test data as described in Section 706.8.3 of the SGE? | Y | |
| 12 | Do the Appendices include calculations in a logical format to support recommendations as described in Section 706.8.4 of the SGE? | Y | |