Geotechnical Design Report

Benjamin Lincoln Bridge (#6740) over Wilson Stream WIN 026630.08

Dennysville, Maine

Submitted to:
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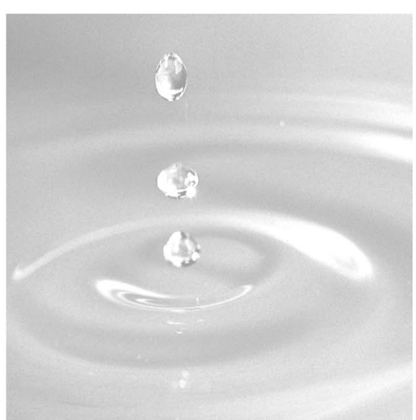

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Executive Summary

This report presents the results of our subsurface explorations and geotechnical recommendations for the replacement of the existing reinforced large culvert (#47382) with Benjamin Lincoln Bridge (#6740), conveying Wilson Stream under Route 1 in Dennysville, Washington County, Maine.

Our recommendations in this report are based on our review of the results of preliminary (Phase 1) and final design (Phase 2) subsurface exploration programs completed by New England Boring Contractors (NEBC) of Hermon, Maine. The Phase 1 subsurface exploration program took place from April 18 to April 23, 2024, during which four borings (BB-DWS-101 through BB-DWS-103A) were advanced. The Phase 2 subsurface exploration program occurred between May 19 and May 20, 2025, and included three additional borings (BB-DWS-201 through BB-DWS-202). Soil sampling was performed at 5-foot intervals using Standard Penetration Testing (SPT). Approximately 11 to 16.5 feet of bedrock was cored in the borings except for BB-DWS-103 and BB-DWS-021. A GEI Consultants, Inc. engineer observed and documented the borings.

The borings encountered between 15.5 and 26.0 feet of fill and glacial till overlying bedrock which consisted of mudstone, breccia, and schist. Bedrock was encountered in the borings from approximately El. 18.7 to El. 5.1 (15.0 to 26.0 feet below ground surface). The borings were terminated between El. 20.1 to El. -8.0 (19.2 to 38.6 feet below ground surface).

Based on our pile design analyses, we recommend that HP14x117 piles approximately 18 feet in length be installed in rock sockets with minimum length of 4.3 feet and 12.3 feet, for Abutments 1 and 2, respectively, and a minimum socket diameter of 30-inches. At Abutment 1, the bottom 3.3 feet of the rock sockets should be tremie filled with 4,000 pounds per square inch (psi) grout, and the remainder backfilled with Granular Borrow, MaineDOT Bridge Design Guide (MaineDOT BDG) Type 4 soil. At Abutment 2, the bottom 7.3 feet of the rock sockets should be tremie filled with 4,000 psi grout, and the remainder backfilled with Granular Borrow, MaineDOT BDG Type 4 soil, 703.19. All piles should be fitted with a steel shoe bearing plate that is welded to the toe of the pile and a minimum of 3-inch grout cover should be provided below the base of the steel shoe bearing plate. We recommend the remainder of drilled hole be backfilled with Granular Borrow, MaineDOT BDG Type 4 soil, 703.19. Piles can be spaced at 6 feet on-center in a single row and oriented with weak axis bending (pile webs perpendicular to centerline of girders).

Our professional services for this project have been performed in accordance with generally accepted engineering practices; no warranty, express or implied, is made.

1. Introduction

1.1. Purpose

This report presents the results of the subsurface explorations, our evaluation of the existing subsurface conditions, and our geotechnical recommendations for design and construction of the proposed replacement of the reinforced large culvert (#47382) with Benjamin Lincoln Bridge (#6740) which carries Route 1 over Wilson Stream in Dennysville, Washington County, Maine as shown in Sheet 1.

1.2. Scope

Our scope of work included:

- Reviewing available published geologic data for the project vicinity and the design drawings of the existing bridge.
- Preparing a Health and Safety Plan prior to conducting field activities.
- Preparing a Traffic Control Plan in accordance with Work Zone Traffic Control Guidebook, MaineDOT, March 2015, and the MUTCD (FHWA).
- Engaging a drilling subcontractor to complete preliminary (Phase 1) and final design (Phase 2) subsurface exploration programs.
- Providing full-time observation during the subsurface exploration programs and classification of the soil samples in general accordance with Maine Department of Transportation (MaineDOT) guidelines.
- Engaging third-party laboratories to perform Atterberg limits, grain size analyses, and water contents of representative soil samples, and elastic moduli of rock in uniaxial compression on representative rock samples.
- Reviewed the results of the subsurface explorations, prepared a subsurface profile, and developed soil properties for geotechnical analyses.
- Developed geotechnical recommendations for the design and construction of a new integral abutment bridge supported on rock socketed H-piles.
- Preparing this geotechnical design report presenting the results of the subsurface explorations and our geotechnical analyses and recommendations.

1.3. Authorization

We performed this work in accordance with our proposal revised January 2, 2025, and the email notice to proceed from Thorton Tomasetti on April 15, 2025.

1.4. Project Personnel

The following personnel at GEI were involved with the field exploration, evaluations, recommendations, and preparation of this report:

Michael Johnescu, P.E.	Project Manager
Laureen Beintum, P.E. (MA)	In-house Consultant
Nicolas Betancur, P.E.	Senior Geotechnical Engineer
Sebastian Carvajal	Staff Engineer
Yonathan Sojo	Drafter

1.5. Elevation Datum

Elevations in this report are in feet and are referenced to the 1988 North American Vertical Datum (NAVD 1988).

2. Site and Project Description

2.1. Site and Project Description

We understand that MaineDOT is considering replacing the reinforced large culvert (#47382) carrying Route 1 over Wilson Stream in Dennysville, Maine. Sheet 1 shows the site location map. The existing culvert is an 8-foot-wide by 8-foot-tall by 74.8-foot-long reinforced concrete box culvert with gabion baskets as wing walls. The culvert was originally constructed in 1938 with concrete wingwalls.

Existing plans from the State Highway Commission include drawings for the culvert dated July 1937 with an unknown reference datum. Based on the drawings, the finished grade at the center of the roadway is at El. 64.9 (datum unknown), with approximately 11.3 feet of fill over the top slab of the culvert. The roof and floor culvert slabs are 1.1 feet thick, with top of roof slab at El. 53.6 and the bottom of the floor slab at El. 43.4. The bottom of the concrete wingwall footings is shown at El. 40. The culvert invert is at El. 44.5.

According to the Culvert Inspection Report prepared by MEDOT, dated February 15, 2023, the ends have been repaired and gabion baskets were installed to replace the original concrete wing walls. The barrel was noted as being in good condition.

The proposed replacement bridge will be an 85-foot-span, 36-foot-wide single span integral abutment bridge, with each abutment supported on six (6) HP 14x117 piles spaced 6’-0” on-center and socketed into bedrock. Grade raises are expected to be minimal, with a finished grade elevations of approximately El. 31 and El. 34.5 at Abutments 1 and 2, respectively. Channel protection consisting of heavy riprap will be placed at an approximate slope of 1.75H:1V in front of each of the proposed abutments.

2.2. Project Design Basis

Our recommendations are based on the Maine Department of Transportation (MaineDOT) Bridge Design Guide (BDG), dated August 2003 and revised June 2018. Our recommendations conform to the AASHTO 2020 LRFD Bridge Design Specifications, 9th Edition.

3. Subsurface Conditions

3.1. Site Geology

The Reconnaissance Surficial Geology of the Eastport Quadrangle, Maine, by Harold W. Borns, Jr. dated 1975, indicates the surficial material in the area of the culvert is Presumpscot Formation, which consists of glaciomarine silt, clay, and sand. In this location, the unit is described as mostly low permeability silt and clay. However, these materials were not encountered in our recent boring explorations, instead artificial fill consisting of mixtures of fine to coarse sand and gravel with boulders and cobbles were encountered. Areas of glacial till are mapped north and east of the bridge, and consist of a heterogeneous mixture of sand, silt, clay, and stones. The glacial till can either be basal till or ablation till. Basal till is described as fine grained and very compact, with low permeability and poor drainage. Ablation till is described as loose, sandy, and stony with moderate permeability and fair to good drainage. The surficial geology map is shown in Fig. A-1 in Appendix A.

The Bedrock Geology of the Eastport Quadrangle, Maine, prepared by Olcott Gates in 1975, indicates bedrock at the site consists of the Edmunds Formation. The site appears to be at the contact of two subunits, Ses and Set, described as:

- Ses: grey mudstone, shale, argillite, chert, and bedded tuff.
- Set: maroon, purple, green lithic crystal lapilli tuff and tuff breccia with local red mudstone beds.

The bedrock geology map is shown in Fig. A-2, Appendix A.

3.2. 2024 Phase 1 Subsurface Exploration Program

New England Boring Contractors (NEBC) of Hermon, Maine drilled four borings (BB-DWS-101 through BB-DWS-103A) between April 18 and April 23, 2024. Boring BB-DWS-103 required an offset boring to be drilled, BB-DWS-103A, due to mangled casing preventing the core barrel to advance. The boring location plan is shown in Sheet 2. The boring locations were chosen in the field based on access and clearance from existing utilities. A GEI field engineer coordinated the drilling and logged the borings. Boring logs are provided in Appendix B.1. The as-drilled boring locations were estimated in the field using tape ties taken by the GEI field engineer at the completion of the drilling program. The as-drilled boring elevations were estimated using MaineDOT topographic survey data in conjunction with the tape ties. The boring locations and elevations are only accurate to the degree implied and are included on the boring logs and summarized in Table 1.

A Mobile B-53 track-mounted drill rig was used to advance the borings. The borings were drilled using a combination of solid stem augers (SSA) for the first 4 feet of fill material, and then 4-inch (HW) and 3-inch-inside-diameter (NW) (ID) steel casing was advanced with drive and wash or spin and wash techniques in all borings. A tri-cone roller bit with water was used to clean the soil cutting from inside the casing. NEBC advanced ahead of the casing with the rotary bit at various depths due to the dense nature of the overburden and the presence of boulders and cobbles. Soil samples were recovered using an oversized 3-inch split spoon sampler when the recovery with the standard split spoon sampler was insufficient. Bedrock was cored using a 2-inch, NQ-sized core barrel in all borings.

Standard Penetration Tests (SPT) were obtained at approximate 5-foot depth intervals in the borings. The split spoons were advanced with an automatic hammer consisting of a hydraulically actuated 140-lb weight falling 30 inches in accordance with ASTM D 1586. At least 10 feet of bedrock was cored in all the borings except BB-DWS-103. New England Boring Contractors provided the Standard Penetration Test Energy Measurement Calibration Report prepared by GZA GeoEnvironmental, Inc. for the Mobile B-53 drill rig used at the site. The calibration results for the automatic hammer (NEBC D-28) indicate an average energy transfer ratio of 76.5%. Therefore, we used a hammer energy ratio correction factor of C_E=1.28 to correct SPT N values for hammer energy.

Recovered split-spoon soil samples were placed in jars, and rock core samples were placed in wooden boxes. The soil and rock samples were sent to our Portland, Maine office for verification of field classification. Individual sample descriptions are provided in the boring logs in Appendix B.1. Rock core photographs are provided in Appendix B.2. Automatic hammer calibration summary tables are provided in Appendix B.3.

Borings BB-DWS-101 through BB-DWS-103A were backfilled with bentonite chips, soil cuttings, and gravel, and patched with asphalt upon completion.

3.3. 2025 Phase 2 Subsurface Exploration Program

GEI engaged NEBC of Hermon, Maine to drill three additional borings (BB-DWS-201 through BB-DWS-202) between May 19 and May 20, 2025. Boring BB-DWS-201 required an offset boring to be drilled, BB-DWS-201A, due to out of plumb casing. Borings BB-DWS-201 and -201A were drilled at proposed Abutment 1 and boring BB-DWS-202 was drilled at proposed Abutment 2 as shown on Sheet 2. A GEI field engineer coordinated the drilling and logged the borings. Boring logs are provided in Appendix B.1. The as-drilled boring locations were estimated in the field using tape ties taken by the GEI field engineer at the completion of the drilling program. The as-drilled boring elevations were estimated using MaineDOT topographic survey data in conjunction with the tape ties. The boring locations and elevations are only accurate to the degree implied and are included on the boring logs and summarized in Table 1.

A Mobile B-53 track-mounted drill rig was used to advance the borings. The borings were drilled using a combination of solid stem augers (SSA) for the first 4 to 9 feet of fill material, and then 4-inch (HW) and 3-inch-inside-diameter (NW) (ID) steel casing was advanced with drive and wash or spin and wash techniques in all borings. A tri-cone roller bit with water was used to clean the soil cutting from inside the casing. NEBC advanced ahead of the casing with the rotary bit at various depths due to the dense nature of the overburden and the presence of boulders and cobbles. A core barrel was required to advance past a boulder/cobble in boring BB-DWS-201A. Bedrock was cored using a 2-inch, NQ-sized core barrel in borings BB-DWS-201A and -202.

Standard Penetration Tests (SPT) were obtained at approximate 5-foot depth intervals in the borings. The split spoons were advanced with an automatic hammer consisting of a hydraulically actuated 140-lb weight falling 30 inches in accordance with ASTM D 1586. At least 10 feet of bedrock was cored in borings BB-DWS-201A and -202. New England Boring Contractors provided the Standard Penetration Test Energy Measurement Calibration Report prepared by GZA GeoEnvironmental, Inc. for the Mobile B-53 drill rig used at the site. The calibration results for the automatic hammer (NEBC D-23) indicate an average energy transfer ratio of 83.4%. Therefore, we used an average hammer energy ratio correction factor of C_E=1.39 to correct SPT N values for hammer energy

Recovered split-spoon soil samples were placed in jars, and rock core samples were placed in wooden boxes. The soil and rock samples were sent to our Portland, Maine office for verification of field classification. Individual sample descriptions are provided in the boring logs in Appendix B.1. Rock core photographs are provided in Appendix B.2. Automatic hammer calibration summary tables are provided in Appendix B.3.

Borings BB-DWS-201 through BB-DWS-202 were backfilled with soil cuttings and gravel, and patched with cold patch asphalt upon completion.

3.4. Sample Review

The soil samples from the borings were examined at the office by Michael Johnescu. The field engineer examined the rock core samples and calculated the Rock Quality Designations (RQDs) of the rock core samples in the field. Based on our review, it is our opinion that the descriptions in the boring logs in Appendix B are a reasonable characterization of the conditions encountered.

3.5. Laboratory Testing

We engaged Soil Metrics LLC. of Cape Elizabeth, Maine to perform grain size analyses (ASTM D 6913) on eleven soil samples, combined sieve and hydrometer analysis (ASTM D 422) on one sample, an Atterberg limits test (ASTM D 4318) on two soil samples, and moisture content tests (ASTM D 2216) on 12 soil samples obtained in the borings to confirm the sample descriptions and to provide data for engineering analyses. GEI also engaged GeoTesting Express, Inc. (GTX) of Acton, Massachusetts to perform Elastic Moduli in Uniaxial Compression in accordance with ASTM D7012D on five rock core samples. The samples were taken from borings BB-DWS-101, -102, -103, -201A, and -202, which are all abutment borings except for BB-DWS-102. There were only a few samples that met the criteria for testing due to the highly fractured nature of the recovered bedrock cores. The gradation results and Atterberg limits results are provided in Tables 2 and 3, respectively, the rock core test results are provided in Table 4, and the compiled soil and rock lab results are provided in Appendix C.

3.6. Subsurface Conditions

The materials encountered in the borings are described below in order of increasing depth. Conditions are only known at the boring locations, and conditions between borings may differ from those indicated below and shown in the interpretative subsurface profile in Sheet 3.

The soil descriptions below refer to N_{60}, which is the measured N-value corrected to an equivalent hammer energy of 60 percent efficiency (i.e., the standard energy assumed in many SPT correlations). Field-measured N-values as well as corrected, N_{60} values are reported on the boring logs in Appendix B.1.

- Existing Fill – Granular fill was encountered in all the borings. The fill ranged in thickness from 11.3 feet at boring BB-DWS-202 to 22.5 feet at boring BB-DWS-102. A 12- to 16-inch-thick layer of asphalt was encountered above the fill in all borings.

  The granular fill observed in the borings was variable from brown, grey and reddish brown, loose to dense, gravel, with trace sand to sandy, and trace silt to some silt, to; brown and grey, medium dense to very dense, fine to coarse sand, with little gravel to gravelly, and trace silt to some silt. This layer contains probable boulders and cobbles based on the drill rig behavior, SPT results, and split-spoon sample recoveries. Grain size analyses performed on seven of the samples indicate the percent fines ranged from 0.5 to 17.0 percent, and moisture contents ranged from 1.3 to 13.1 percent. USCS classifications were SM, SW-SM, GP, and GW, and the AASHTO classifications were A-1-b, and A-1-a.

  Corrected N-values (N_{60}) in the fill ranged from 8 to 90 blows per foot (bpf), with an average of 45 bpf, indicating a mostly dense soil.

- Glacial Till – Glacial till was encountered below the fill in all borings except BB-DWS-102. The thickness of the till ranged from 3.0 feet at boring BB-DWS-202 to 6.0 feet at boring BB-DWS-101. The glacial till was variable from grey and brown, very dense, fine to coarse grained sand, little silt to silty, clayey, little to some gravel, to; light brown, medium stiff, silty clay, some sand, trace gravel. Boulders/cobbles were also encountered in the glacial till in borings BB-DWS-101, -103, and -201A. Grain size analyses performed on five samples indicate percent fines ranging from 14.3 to 70.1 percent, and moisture contents ranged from 9.3 to 21.8 percent. Atterberg limits performed on two samples indicate a plastic index of 9.4 and 11.5 percent, indicating low to medium plasticity fines. USCS classifications were SM and CL, and the AASHTO classifications were A-2(0), A-4, and A-6.

  The N_{60} value ranged from 11 bpf to refusal, with an average of 53 bpf, indicating a mostly very dense soil.

- Bedrock – Bedrock was encountered in all borings except BB-DWS-103 and -201, which required offset borings, between 15.5 and 26.0 feet below ground surface (bgs) (approximately El. 18.7 to El. 5.1). Bedrock was deepest (23.8 to 26.0 feet bgs) in the borings performed at proposed Abutment 1, and shallowest (15.5 to 16.0 feet bgs) in the borings performed at proposed Abutment 2.

  The bedrock in the borings was generally classified as grey, fine grained, hard, mudstone, and ranged from fresh to very slightly weathered. Purplish grey to grey, fine to coarse grained, hard, breccia that was fresh to slightly weathered was encountered at various depths in borings BB-DWS-102, -201A, and -202. Grey and white, fine to coarse grained, hard, schist that ranged from fresh to very slightly weathered was encountered in run one in boring BB-DWS-102. The bedrock had horizontal to vertical dipping joints, as shown in the rock core photos in Appendix B.2. The RQD ranged from 0 to 83 percent, with a weighted average of 52 percent, indicating very poor to good rock quality.

  Elastic Moduli in Uniaxial Compression in accordance with ASTM D7012D were performed on one bedrock sample from each boring where coring was performed. The unconfined compressive strengths ranged from 17,181 psi to 40,859 psi, with an average of 29,282 psi.

3.7. Groundwater and Surface Water Levels

Groundwater levels were measured in all borings except BB-DWS-201 at the beginning of a new shift before any drilling activity or at the end of the borings before backfilling. Groundwater levels ranged from 9.9 to 18.5 feet bgs (approximately El. 23.4 to El. 10.6) in borings BB-DWS-103, -201A, and -202. Groundwater was not encountered in borings BB-DWS-101, -102, and -103A. These measurements may not accurately reflect the true groundwater level. The culvert is constructed on a manmade causeway along the coast, and groundwater levels are likely influenced by tides and precipitation. Significantly different groundwater levels may occur at other times and locations.

According to the tidal hydraulic guidance criteria for the project, Wilson Stream is subject to a Highest Astronomical Tide (HAT) Line at El. 15.3.

4. Design Recommendations

4.1. General

We understand that the preferred configuration of the replacement structure is a simple span concrete superstructure on integral abutments. The new abutments will be approximately 42.5 feet from the existing culvert centerline (i.e., approximately an 85-foot span), and the new bridge is expected to match the approach roadway width. The preferred substructure for the replacement bridge is integral abutments supported on rock socketed H-piles.

The borings encountered bedrock approximately 14 to 15 feet below the proposed bottom of pile cap at abutment 1, and approximately 5 to 6 feet below the proposed bottom of pile cap at abutment 2. At both abutments, bedrock was directly overlain by a very dense glacial till layer.

Significant re-grading of the roadway and embankments surrounding the bridge is not anticipated. The design preference will be to keep final grades as close as possible to existing grades.

Recommendations for foundation design for the replacement abutments are presented below. Calculations supporting these recommendations are presented in Appendix D.

4.2. Soil Properties and Lateral Earth Pressures

Recommended soil properties and earth pressure coefficients for design are presented in Table 5. We selected these values based on published correlations to SPT N-values, our review of the soil descriptions, and our engineering judgment.

For the integral abutments, the lateral earth pressures developed against the abutment by the backfill are a function of the movement of the abutment and can range from at-rest pressure to full passive pressure. The abutment reinforcement should be designed for the passive earth pressure (Pp) that results on the back face of the abutment when the bridge expands. This earth pressure should be calculated using the formula provided in Section 5.4.2.11 of the MaineDOT BDG. The Passive Lateral Earth Pressure Coefficient (Kp) needed for this equation is provided in Table 5 of this report and was evaluated using FHWA NHI-06-089 Figure 10-4. This Kp value was obtained assuming a magnitude of wall rotation equal of 0.02, expressed in terms of the ratio of wall movement to wall height (Y/H). However, the designer should calculate Kp based on estimated superstructure thermal movement using both FHWA NHI-06-089 and MassDOT Bridge Design Manual Figure 3.10.8-1 and use the more stringent value. It should also be noted that the design passive pressure coefficient should be no less than Kp calculated using Rankine, regardless of estimated wall rotation.

4.3. Integral Abutment Pile Design

We understand that the proposed replacement bridge substructure will consist of integral bridge abutments supported on steel H-piles. Based on the results of our subsurface explorations, the depth of overburden below the bottom of the proposed pile caps is limited and it is considered insufficient to provide adequate lateral stability for driven H-piles installed to top of rock. Within the footprint of the proposed abutments, the depth to rock from the bottom of the piles caps varies approximately between 14 and 15 feet at Abutment 1 and between 5 and 6 feet at Abutment 2. Because of the limited embedment depths available at the site, we recommend that the abutments be supported on rock-socketed steel H-piles. Our recommendations are based on design analyses performed using the computer program LPile Version 2022-12.010 by Ensoft Inc., a program for the analysis of individual piles subjected to lateral loading using the p-y method.

We performed LPile analyses for HP 14x89 and HP 14x117 steel piles using loading provided by Thornton Tomasetti. The loading included Strength I Limit State factored axial load of 355 kips and the larger thermal movement between thermal contraction and thermal expansion as estimated by Thornton Tomasetti. The thermal movement was input as unfactored and factored thermal contraction of 0.377 and 0.404 inches, respectively. A load factor γ_{TU} of 1.2 was applied to the thermal movement in accordance with AASHTO LRFD Table 3.4.1-1. It is our understanding that the structural pile design was based on the larger of the bending moment obtained using the factored thermal movement loading and that obtained applying the load factor γ_{TU} of 1.2 to the resulting bending moment using the unfactored thermal movement loading.

The analyses used the intact H-pile section without corrosion loss consideration to maximize the bending moment demand. We assumed a pile spacing of 6 feet and a p-multiplier of 1.0, consistent with a 5B pile spacing (with B equal to a pile depth of 14.2 inches) in accordance with AASHTO LRFD Section 10.7.2.4. A p-multiplier of 1.0 is also conservative as it results in a stiffer soil response and a higher flexural demand on the piles.

Thornton Tomasetti estimated scour depths of approximately 15 and 14 feet for Abutment 1 and 2, respectively. We did not consider scour in our pile design analyses as the scour estimates appear unrealistic. The flood events considered in the scour analyses are tidal in nature and peak velocities occur for discrete amounts of time during the tidal cycle. The peak velocities may not last long enough for scour to reach the estimated depths. Based on our subsurface explorations, we expect the stream bed to be composed of exposed bedrock which we do not expect to be scour-susceptible according to the rock quality encountered. We also considered scour of the estimated magnitude to be unlikely given the proposed heavy riprap protection in front and around the abutments and the significant distance between the proposed abutment piles (approximately 33 to 40 feet) and the toe of the riprap at the Wilson Stream channel.

Based on the results of our laterally loaded pile analyses and coordination with Thornton Tomasetti, we recommend that the pile foundations consist of HP 14x117 steel piles. The recommended pile layout consists of a single row of six (6) HP 14x117 piles oriented with the weak axis bending (pile webs perpendicular to centerline of girders). The piles can be spaced at 6 feet on-center along the bridge transverse direction. The piles should be installed in a minimum 30-inch-diameter rock socket extending a minimum of 4.3 and 12.3 feet into bedrock at abutments 1 and 2, respectively. The rock socket should be tremie filled with grout with a minimum compressive strength of 4,000 psi. The grout column should extend upward a minimum of 3 and 7 feet from the toe of the piles at abutments 1 and 2, respectively. A steel shoe bearing plate should be welded to the toe of the pile and a minimum of 3-inch grout cover should be provided below the base of the steel shoe bearing plate. The rest of the pile length above the grout column should be backfilled with MaineDOT BDG Type 4 Soil, 703.19, (Granular Borrow) to the bottom of the pile cap. The Granular Borrow backfill is recommended to provide a softer soil response and reduce the flexural demand on the piles.

The estimated pile lengths, as measured from the bottom of the proposed pile cap, are approximately 18 feet including a minimum 4.3- and 12.3-foot rock socket length for abutments 1 and 2, respectively. The estimated geotechnical resistance of the piles conservatively ignores the contribution from the Granular Borrow backfill along the piles and relies entirely on the axial resistance of the rock socket. We estimated side and end bearing resistance of the rock socket at each abutment following ASSHTO procedures for drilled shaft design. We adopted side and end bearing resistance factors of 0.55 and 0.5 in accordance with AASHTO LRFD Bridge Design Specifications Table 10.5.5.2.4-1 assuming no load testing is performed. We estimated factored geotechnical resistance in side and end bearing respectively of 194 kips and 2,200 kips for abutment 1 and 430 kips and 2,200 kips for abutment 2. We understand that MaineDOT's preference is for rock socketed H-Piles to rely on end bearing. Assuming intimate contact between the rock surface at the bottom of the excavated rock socket and the grout, a factored axial resistance of 2,200 kips can be used for design. In this case, the structural resistance will control the axial resistance of the pile.

Supporting calculations for these recommendations are provided in Appendix D.

4.4. Seismic Design Parameters

Based on the borings and our seismic design calculations (Appendix D), we conclude that the site should be classified as Site Class C.

Based on the 2020 AASHTO LRFD seismic hazard maps for the 1,000-year return period, we recommend the following parameters for seismic design:

- Horizontal Peak Ground Coefficient (PGA) = 0.080
- Horizontal Response Spectral Coefficient (period = 0.2 sec) (Ss) = 0.160
- Horizontal Response Spectral Coefficient (period = 1.0 sec) (S1) = 0.040

The applicable site coefficients for peak ground acceleration ([F_{PGA}], short-period range [F_A], and long-period range [F_V]) at this site are 1.2, 1.2, and 1.7, respectively. Application of these site coefficients results in the following recommended coefficients for development of design response spectra:

- Response Spectral Acceleration, As = 0.096
- Design Spectral Acceleration Coefficient at 0.2 second period, SDS = 0.192
- Design Spectral Acceleration Coefficient at 1.0 second period, SD1 = 0.068

This site falls into Seismic Zone 1, based on the 1-second-period design spectral acceleration.

4.5. Settlement and Stability

The proposed bridge design calls for minimal grade raises at the approaches, and the existing fill and glacial till encountered in the borings was generally medium dense to very dense sand and gravel, with lesser amounts of silt and clay. The site also has relatively shallow bedrock at the location of the approaches. Based on the material encountered in the borings, MaineDOT slopes of 2H:1V or 1.75H:1V if riprap protected, are expected to be stable. Furthermore, we do not anticipate settlement related issues based on the subsurface conditions encountered.

4.6. Frost Protection

Existing or imported granular backfill and glacial are anticipated to be present at the abutments and are frost susceptible. Based on MaineDOT BDG Section 5.2.1, the Freezing Index for the site is approximately 1200. Tested soils had an average moisture content of 9.3%. For a coarse-grained soil with a water content of 10 percent and a Freeze Index of 1200 the estimated depth of frost penetration is 6.1 feet.

5. Construction Recommendations

5.1. Rock Socketed Pile Installation

The piles will need to be installed by means of temporary casing seated into rock to facilitate excavation of the rock sockets and provide a seal to allow for placement of tremie grout or concrete within the rock socket. A minimum of 3 inches of 4,000 psi grout cover should be provided between the bottom of the rock socket and the tip of the H-Piles. H-Piles should be equipped with a steel bearing shoe plate welded to the toe of the pile. The Contractor should provide means of temporarily supporting the pile between the bottom of the steel plate and the bottom of the rock socket excavation to ensure the minimum grout or concrete cover below the pile toe. This temporary support will also facilitate supporting the pile plumb while the grout attains sufficient strength prior to backfilling around and along the remaining pile length above the grout column.

The Contractor needs to be aware of the strength of the rock encountered at the site when selecting tooling for excavation of the rock sockets. Average measured uniaxial compressive strength of intact specimens is in the order of 29,000 psi. The mudstone encountered on site may be susceptible to softening when exposed to air and water. Rock sockets need to be tremie filled with grout immediately after excavation to minimize the risk of softening due to prolonged exposure to air and water. The Contractor must carefully plan the sequence of pile installation to minimize the amount of time that rock sockets are left open prior to grout placement. Excavated rock sockets should not be allowed to remain open and exposed to air and water overnight. We recommend a maximum waiting period of 4 hours between the end of rock socket excavation and grout placement.

Temporary casing may need to be equipped with carbide teeth to clear obstructions and to be seated into rock. The piles should be backfilled with Granular Borrow prior to removing the temporary casing. The backfill material needs to extend from the top of the rock socket to the bottom of the pile cap.

5.2. Obstructions

The borings indicate the presence of boulders and cobbles in the fill and glacial till. The Contractor needs to consider these obstructions in selecting adequate tooling to advance the temporary casing and excavate the overburden materials.

5.3. Backfilling

MaineDOT granular borrow for underwater backfill should be used behind the abutments in accordance with MaineDOT BDG, Section 5.4.2.13. Drainage behind the integral abutment should be designed in accordance with MaineDOT BDG, Section 5.4.1.9, to minimize hydrostatic pressure and control erosion of the underside of the abutment embankment riprap. It is our understanding that MaineDOT prefers the use of French drains on the uphill side of integral abutments to prevent buildup of hydrostatic pressure. The French drains should be sloped to drain by gravity and should outlet through a series of 4-inch diameter weep holes, spaced at a maximum distance of 10 feet on center.

Fill for the roadway and behind the abutments, backfill of excavations for utilities, and crushed stone for scour protection, if any, should be placed and compacted in accordance with MaineDOT Standard Specifications Section 206 (2020 version). However, we recommend that compaction in areas too small for a smooth wheel vibratory compactor, within 5 feet of walls less than 15 feet high, or within 10 feet of walls greater than 15 feet high, should be performed using a vibratory walk-behind roller or plate compactor (weighing at least 200 pounds imparting an impact load of at least 2.5 tons), with soil placed in maximum 6-inch-loose lifts.

5.4. Re-Use of Existing Materials

Based on the soil descriptions on the boring logs, some of the existing on-site granular soils may meet the requirements for common borrow. Suitability for reuse can be confirmed by testing samples to evaluate if the soil in question meets the MaineDOT requirements for common borrow. The on-site soils may have oversized cobbles and boulders that would need to be removed prior to re-use as common borrow. The Contractor should be aware that materials that are not free draining may be difficult to compact in wet weather.

5.5. Freezing Conditions

If construction is performed during freezing weather, special precautions will be required to prevent the soil subgrades from freezing. Freezing of the soil beneath foundations and pavements during construction may result in heave and subsequent settlement of the structure.

All soil subgrades should be free of frost before foundation construction. Frost-susceptible soils that have frozen should be removed and replaced with compacted gravel borrow. The foundation and the soil adjacent to the foundation should be insulated until they are backfilled.

Soil placed as fill should be free of frost, as should the ground on which it is placed.

6. Limitations

Our recommendations are based on the project information provided to us at the time of this report and may require modification if there are any changes in the nature, design, or location of the proposed construction. We recommend that GEI be engaged to perform a final design geotechnical exploration and prepare final design geotechnical foundation and construction recommendations. We recommend that GEI be engaged to review the final plans and specifications to evaluate whether changes in the project affect the validity of our recommendations and whether our recommendations have been properly implemented in the design.

The recommendations in this report are based in part on the data obtained from the borings. The nature and extent of variations between borings may not become evident until construction. If variations from the anticipated conditions are encountered, it may be necessary to revise the recommendations in this report. Therefore, we recommend that GEI be engaged to make site visits during construction to: a) check that the subsurface conditions exposed during construction are in general conformance with our design assumptions, and b) ascertain that, in general, the geotechnical aspects of the work are being performed in compliance with the contract documents.

Our professional services for this project have been performed in accordance with generally accepted engineering practices; no warranty, express or implied, is made.

Tables

Table 1. Subsurface Explorations
Geotechnical Design Report
Benjamin Lincoln Bridge #6740
WIN 026630.08
Dennysville, Maine

Exploration Number	STA	Offset	Northing (ft)	Easting (ft)	Surface Elevation[1] (ft)	Depth of Exploration (ft)	Depth to Groundwater (ft)	Depth to Fill (Asphalt Thickness) (ft)	Depth to Glacial Till (ft)	Depth to Top of Bedrock (ft)
April 2024 & May 2025 Exploration Programs										
BB-DWS-101	17+19	10.8 LT	401835.3	2464606.7	31.1	37.8	NE	1.3	20.0	26.0
BB-DWS-102	17+42	11.2 LT	401858.0	2464610.7	32.0	38.6	NE	1.0	NE	23.5
BB-DWS-103	17+88	11.3 LT	401904.0	2464620.6	34.4	19.2	12.6	1.0	14.3	NE
BB-DWS-103A	17+91	10.9 LT	401906.7	2464621.7	34.7	27.3	NE	NM	NM	16.0
BB-DWS-201	16+97	8.8 RT	401810.5	2464622.2	29.1	9.0	NM	1.1	NE	NE
BB-DWS-201A	16+99	8.9 RT	401812.7	2464622.8	29.1	37.1	18.5	1.1	15.0	23.8
BB-DWS-202	17+85	6.8 RT	401896.7	2464637.6	33.3	32.5	9.9	1.2	12.5	15.5

1. The boring coordinates and elevations were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
2. Boring BB-DWS-103 was terminated due to pinched casing. Offset boring BB-DWS-103A was drilled approximatly 2.5 feet north of -103.
3. Boring BB-DWS-201 was terminated due to out of plumb casing. Offset boring BB-PSB-201A was drilled approximately 1.5 feet north of -201.
4. NE = Not Encountered
5. NM = Not Measured

Table 2. Grain Size Analysis Results
Geotechnical Design Report
Benjamin Lincoln Bridge #6740
WIN 026630.08
Dennysville, Maine

Exploration Number	Surface Elevation (ft)	Sample Number	Sample Depth (ft)			Sample Elevation (ft)			Material	Description	MC %	% Fines	AASHTO	USCS
BB-DWS-101	31.1	1D	1.5	-	3.5	29.6	-	27.6	Fill	Brown and grey Gravelly fine to coarse SAND, little silt	5.0	16.4	A-1-b	SM
BB-DWS-101	31.1	4D	14.0	-	16.0	17.1	-	15.1	Fill	Brown and grey GRAVEL, trace sand, trace silt	3.7	1.4	A-1-a	GP
BB-DWS-101	31.1	5D	24.0	-	25.9	7.1	-	5.2	Glacial Till	Grey fine to coarse SAND, some silt, some gravel	9.3	32.9	A-2(0)	SM
BB-DWS-102	32.0	3D	9.0	-	11.0	23.0	-	21.0	Fill	Brown and grey Sandy GRAVEL, trace silt	10.8	8.6	A-1-a	GW
BB-DWS-102	32.0	5D	19.0	-	21.0	13.0	-	11.0	Fill	Grey and brown GRAVEL, trace sand, trace silt	1.3	0.5	A-1-a	GP
BB-DWS-103	34.4	2D	4.0	-	6.0	30.4	-	28.4	Fill	Brown and grey Gravelly fine to coarse SAND, little silt	5.2	13.6	A-1-a	SM
BB-DWS-103	34.4	4D(3-6")	14.0	-	14.7	20.4	-	19.7	Glacial Till	Brown and grey Silty SAND, some gravel	12.5	34.6	A-2(0)	SM
BB-DWS-201	29.1	2D	4.0	-	6.0	25.1	-	23.1	Fill	Brown fine to coarse SAND, some gravel, little silt	8.2	11.9	A-1-b	SW-SM
BB-DWS-201A	29.1	3D	15.0	-	17.0	14.1	-	12.1	Glacial Till	Light brown Silty CLAY, some sand, trace gravel	21.8	70.1	A-6	CL
BB-DWS-201A	29.1	4D	19.0	-	21.0	10.1	-	8.1	Glacial Till	Brown fine to coarse SAND, some gravel, little silt	9.4	14.3	A-1-b	SM
BB-DWS-202	33.3	3D	9.0	-	11.0	24.3	-	22.3	Fill	Brown Gravelly fine to coarse SAND, little silt	13.1	17.0	A-1-b	SM
BB-DWS-202	33.3	4D	14.0	-	15.6	19.3	-	17.7	Glacial Till	Light brown SILT & CLAY, some sand, trace gravel	11.2	62.7	A-4	CL

Table 3. Atterberg Limits Test Results
Geotechnical Design Report
Benjamin Lincoln Bridge #6740
WIN 026630.08
Dennysville, Maine

Exploration Number	Surface Elevation (ft)	Sample Number	Sample Depth (ft)			Sample Elevation (ft)			Material	Description	LL	PL	PI	MC (%)	AASHTO	USCS
BB-DWS-201A	29.1	3D	15.0	-	17.0	14.1	-	12.1	Glacial Till	Light brown Silty CLAY, some sand, trace gravel	33.3	21.8	11.5	21.8	A-6	CL
BB-DWS-202	33.3	4D	14.0	-	15.6	19.3	-	17.7	Glacial Till	Light brown SILT & CLAY, some sand, trace gravel	24.5	15.1	9.4	11.2	A-4	CL

Table 4. Rock Core Laboratory Test Results
Geotechnical Design Report
Benjamin Lincoln Bridge #6740
WIN 026630.08
Dennysville, Maine

Exploration Number	Ground Surface El. (ft)	Depth to Bedrock (ft)	Run Number	Run Depth (ft)	Run Depth into Bedrock (ft)	Penetration (in)	Recovery (in)	Recovery (%)	RQD (in)	RQD (%)	Sample Depth (ft)	Sample Depth into Bedrock (ft)	Sample El. (ft)	Unit Weight (lb/ft^3)	Unconfined Compressive Strength (psi)	Young's Modulus (ksi)	Poisson's Ratio	Rock Classification
BB-DWS-101	31.1	26.0	R1	27.0 - 31.3	1.0 - 5.3	52	51	98%	16	31%	30.4 - 30.8	4.4 - 4.8	0.7	176	33,644	8,550	0.22	Mudstone
BB-DWS-101	31.1	26.0	R2	31.3 - 35.8	5.3 - 9.8	54	54	100%	30	56%	-	-						Mudstone
BB-DWS-101	31.1	26.0	R3	35.8 - 37.8	9.8 - 11.8	24	24	100%	5	21%	-	-						Mudstone
BB-DWS-102	32.0	23.5	R1	23.8 - 28.6	0.3 - 5.1	58	40	69%	26	45%	24.0 - 24.3	0.5 - 0.8	8.0	171	31,077	7,230	0.25	Breccia/Mudstone/Schist
BB-DWS-102	32.0	23.5	R2	28.6 - 33.6	5.1 - 10.1	60	60	100%	21	35%	-	-						Mudstone/Breccia
BB-DWS-102	32.0	23.5	R3	33.6 - 38.6	10.1 - 15.1	60	53	88%	46	77%	-	-						Breccia
BB-DWS-103A	34.7	16.0	R1	16.0 - 20.4	0.0 - 4.4	53	52	98%	29	55%	17.2 - 17.6	1.2 - 1.6	17.5	172	23,650	6,030	0.27	Mudstone
BB-DWS-103A	34.7	16.0	R2	20.4 - 24.3	4.4 - 8.3	47	47	100%	33	70%	-	-						Mudstone
BB-DWS-103A	34.7	16.0	R3	24.3 - 27.3	8.3 - 11.3	36	35	97%	30	83%	-	-						Mudstone
BB-DWS-201A	29.1	23.8	R2	24.0 - 26.5	0.2 - 2.7	30	27	90%	9	30%	-	-						Breccia/Mudstone
BB-DWS-201A	29.1	23.8	R3	26.5 - 29.3	2.7 - 5.5	34	33	97%	20	60%	-	-						Mudstone
BB-DWS-201A	29.1	23.8	R4	29.3 - 32.1	5.5 - 8.3	34	30	88%	20	58%	29.5 - 29.9	5.7 - 6.1	-0.4	172	40,859	7,630	0.27	Mudstone
BB-DWS-201A	29.1	23.8	R5	32.1 - 37.1	8.3 - 13.3	60	53	88%	35	58%	-	-						Mudstone
BB-DWS-202	33.3	15.5	R1	16.0 - 19.5	0.5 - 4.0	42	31	74%	5	12%	-	-						Mudstone/Breccia
BB-DWS-202	33.3	15.5	R2	19.5 - 20.5	4.0 - 5.0	12	7	58%	0	0%	-	-						Mudstone
BB-DWS-202	33.3	15.5	R3	20.5 - 23.5	5.0 - 8.0	36	36	100%	24	66%	21.3 - 21.7	5.8 - 6.2	12.0	168	17,181	6,220	0.30	Mudstone
BB-DWS-202	33.3	15.5	R4	23.5 - 28.5	8.0 - 13.0	60	60	100%	49	82%	-	-						Mudstone/Breccia
BB-DWS-202	33.3	15.5	R5	28.5 - 32.5	13.0 - 17.0	48	44	92%	20	42%	-	-						Mudstone

Min	0%
Max	83%
Avg	49%
Weighted Avg.	52%

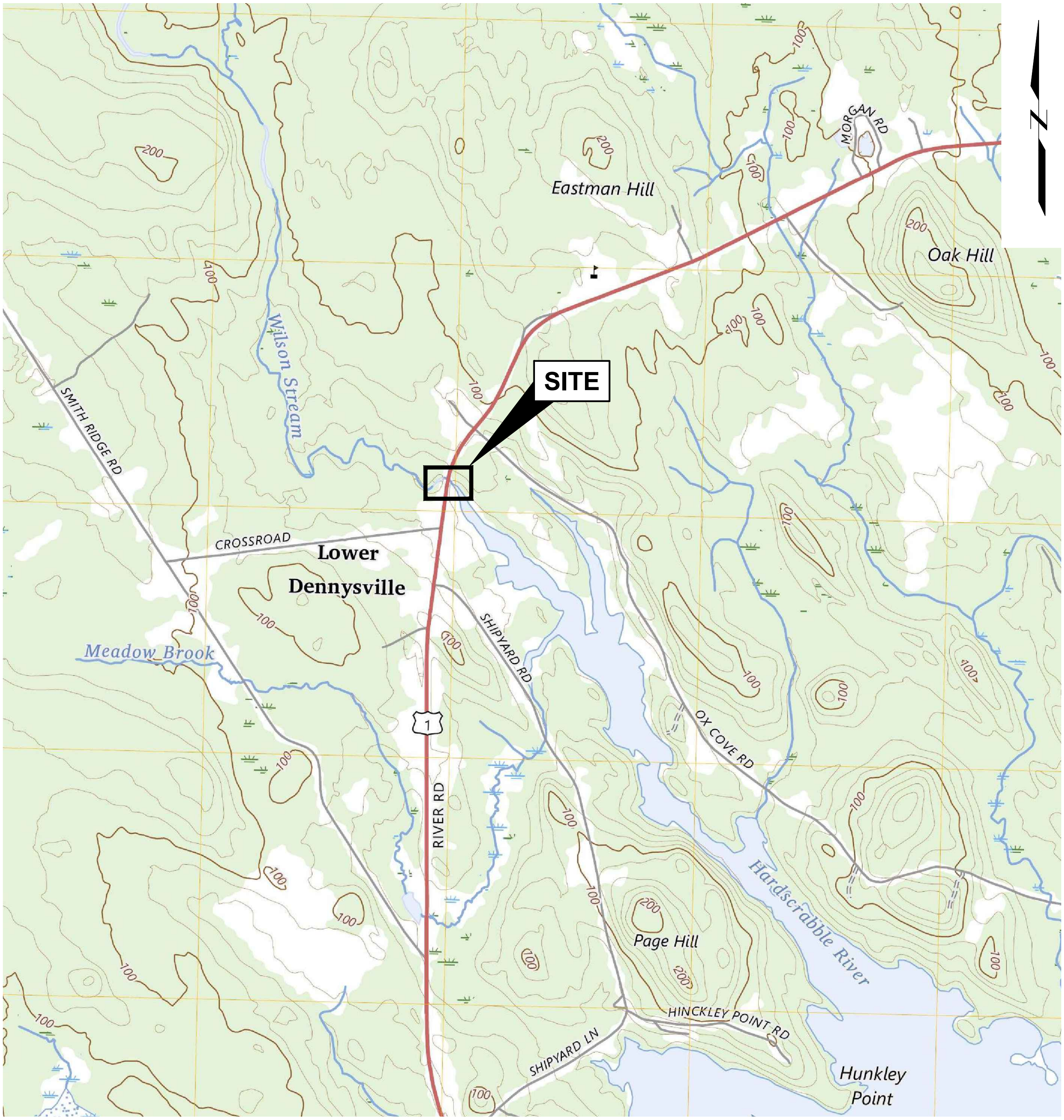
Table 5. Recommended Soil Properties
Geotechnical Design Report
Benjamin Lincoln Bridge #6740
WIN 026630.08
Dennysville, Maine

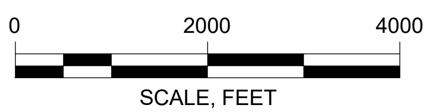
Layer/Soil Type	Unit Weight, γ (pcf)	Friction Angle, ϕ (deg)	Earth Pressure Coefficients[1,2]			
			Active, $K_{a\_Rankine}$[3]	Active, $K_{a\_Coulomb}$[3]	At Rest, K_0	Passive, K_p
Existing Fill	125	34	0.28	0.25	0.44	5.8
Glacial Till	135	38	0.24	0.22	0.38	5.8
Granular Borrow	125	32	0.31	0.27	0.47	5.8
Gravel Borrow	135	36	0.26	0.24	0.41	5.8

Notes:

1. Recommended earth pressure coefficients are associated with vertical wall face and horizontal ground both in front and behind the wall, and are in accordance with the recommendations of Section 3.6 of the MaineDOT BDG, AASHTO LRFD 3.11.5.3 and 3.11.5.4. Supporting calculations are included in Appendix D. For sloping wall face, calculate using log spiral method and actual wall slope angle, with the interface angle assumed to be half the angle of internal friction of the soil.
2. Seismic earth pressure coefficients are not included because the bridge is classified under Seismic Zone 1. Seismic coefficients should be evaluated if necessary during final design based on the final bridge type.
3. Active earth pressure using Coulomb's Theory should be used for gravity and short-heel cantilever walls. Use Rankine's Theory for long-heel cantilever
4. Passive earth pressure for walls should be neglected for cases outlined in MaineDOT BDG 3.6.9. MaineDOT BDG 5.4.2.11 recommends abutment and wingwall reinforcement be sized assuming passive earth pressure on the backface of the wall. Design passive pressure coefficient should be calculated using MassDOT BDM Figure 3.10.8-1 and NHI-06-089 Figure 10-4, and the more stringent value should apply. However, passive earth pressure should be no less than Rankine passive earth pressure, regardless of wall rotation. (FHWA NHI-06-089 Figure 10-4 Assuming a wall rotation of 0.02 for dense granular soil, the bridge designer should use MassDOT BDM Figure 3.10.8-1)

Sheets





SOURCE:

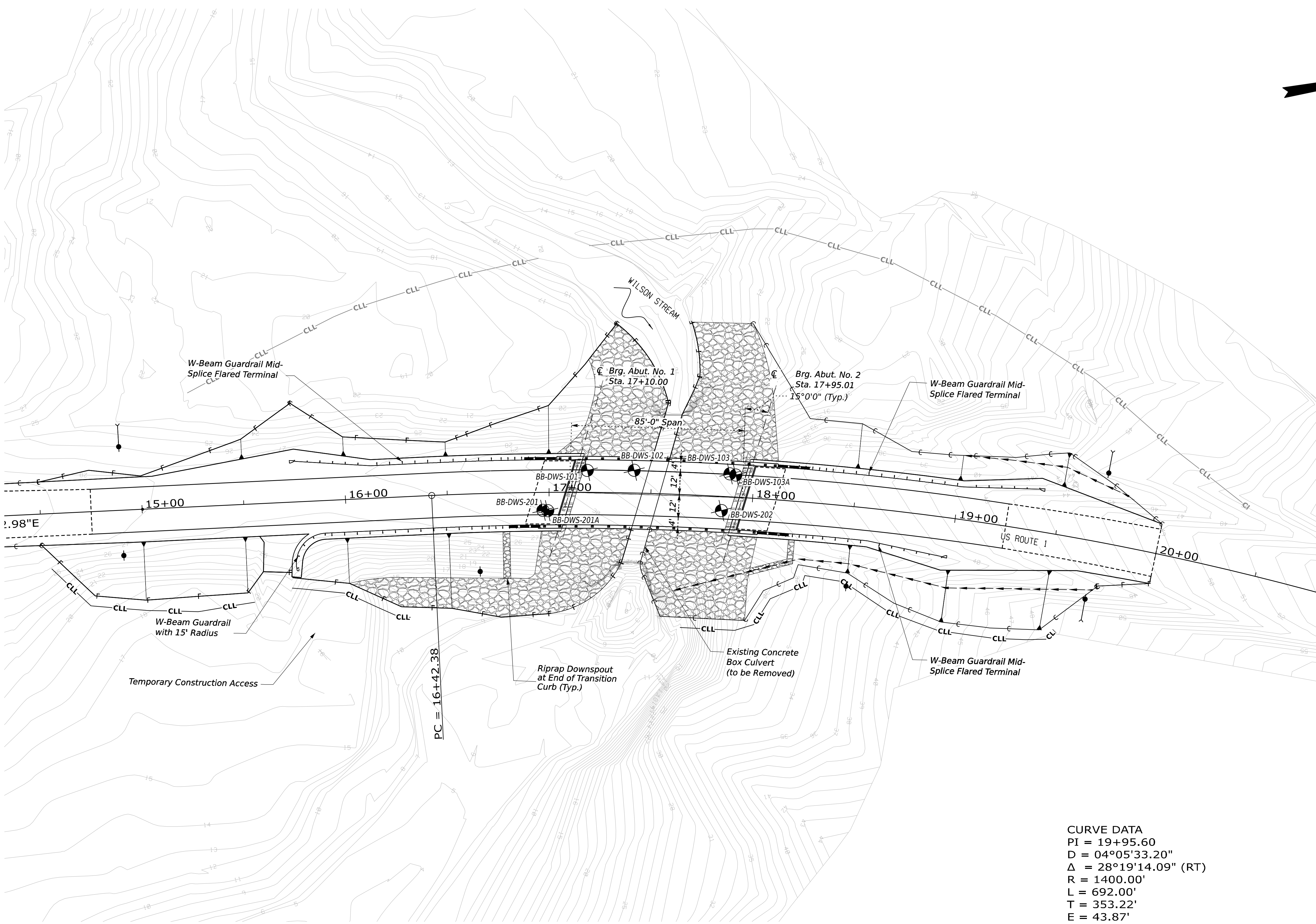
USGS TOPOGRAPHIC QUADRANGLE, 7.5 MINUTE SERIES: PEMBROKE QUADRANGLE, MAINE-WASHINGTON COUNTY, 2024

NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88)

20-FOOT CONTOUR INTERVAL

Benjamin Lincoln Bridge (#6740) over Wilson Stream WIN 026630.08 Dennysville, Maine	GEI Consultants	SITE LOCATION MAP
Thornton Tomasetti Portland, Maine	Project 2502334	August 2025 Sheet 1

CARVAJAL, SEBASTIAN B:\Working\THORNTON TOMASETTI\2502334 MaineDOT Downeast Bridges Phase II\00_CAD\Figures\Sheet 1. Site Location Map\Sheet 1. Site Location Map - Benjamin Lincoln Bridge Ph2 at Dennysville.dwg - 4/30/2025



CURVE DATA
PI = 19+95.60
D = 04°05'33.20"
Δ = 28°19'14.09" (RT)
R = 1400.00'
L = 692.00'
T = 353.22'
E = 43.87'

LEGEND

CASED WASHED BORINGS

SOURCE

Base plan is developed from electronic files (Ground.dgn) provided to GEI by Thornton Tomasetti on April 26, 2024, electronic files (Alignment Route 1.dgn) provided to GEI by Thornton Tomasetti on May 22, 2025 and electronic files (Corridor Route 1 linework.dgn) provided to GEI by Thornton Tomasetti on June 31, 2025

NOTES

1. Borings BB-DWS-101 through BB-DWS-103A were drilled by New England Boring Contractors of Hermon, Maine between April 18 and April 23, 2024 and were observed by GEI personnel.
2. Borings BB-DWS-201 through BB-DWS-202 were drilled by New England Boring Contractors of Hermon, Maine between May 19 and May 20, 2025 and were observed by GEI personnel.
3. As-drilled boring locations were located using tape ties and should be considered accurate to the degree implied.

PLAN

25 0 25 50

Scale of Feet

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

APPROVED | DATE

COMMISSIONER:

CHIEF ENGINEER:

	BY	DATE
PROJ. MANAGER	M. JOHNESCU	
DESIGN-DETAILED	M. JOHNESCU	7/17/2025
CHECKED-REVIEWED	M. JOHNESCU	8/5/2025
DESIGN2-DETAILED2	M. JOHNESCU	
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

U.S. ROUTE 1 BRIDGE NO. 6740
CROSSING WILSON'S STREAM
DENNYSVILLE

BORING LOCATION PLAN

SHEET NUMBER

2

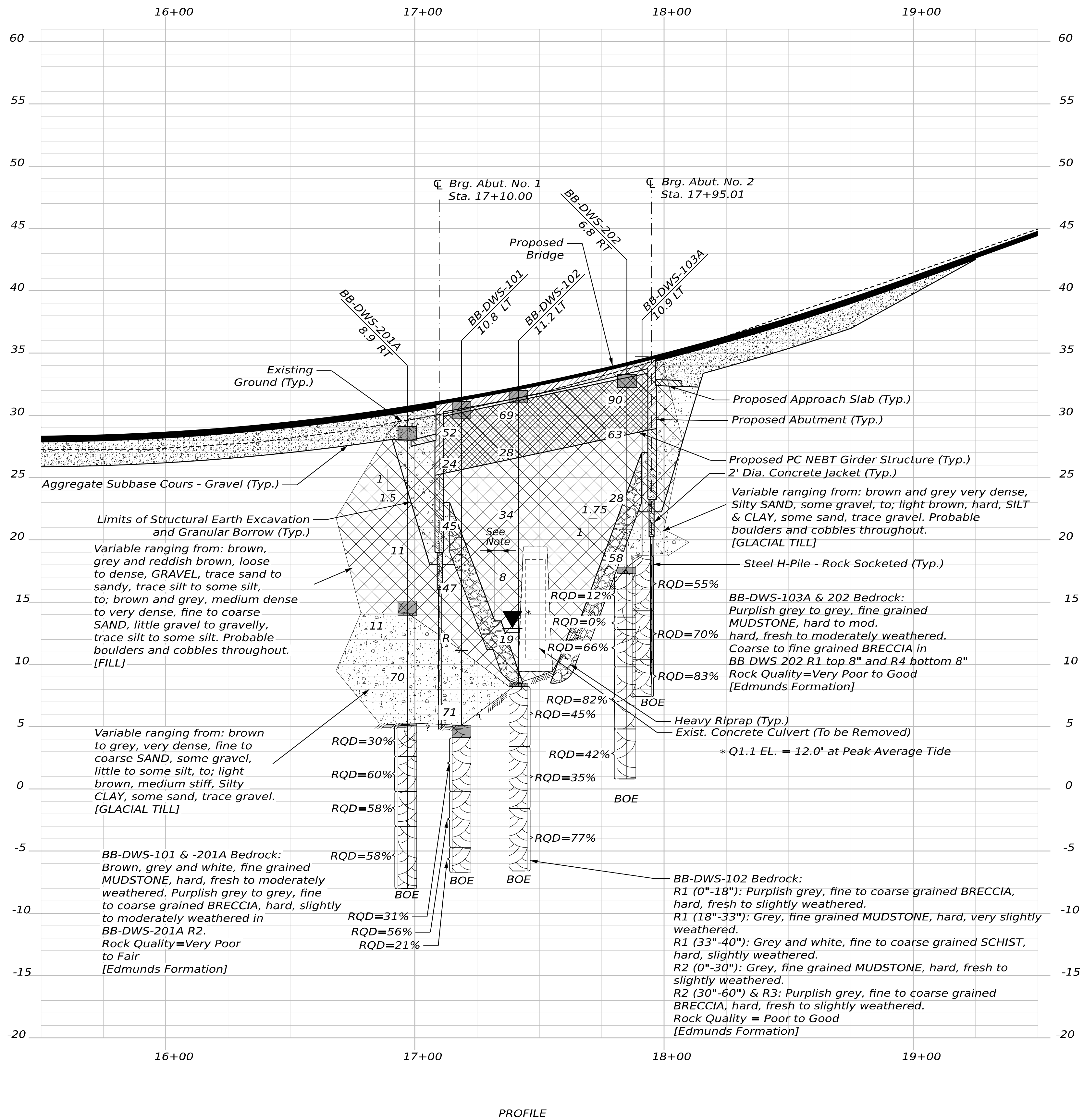
OF 3

USERNAME: SOJO YONATHAN DATE: 8/5/2025

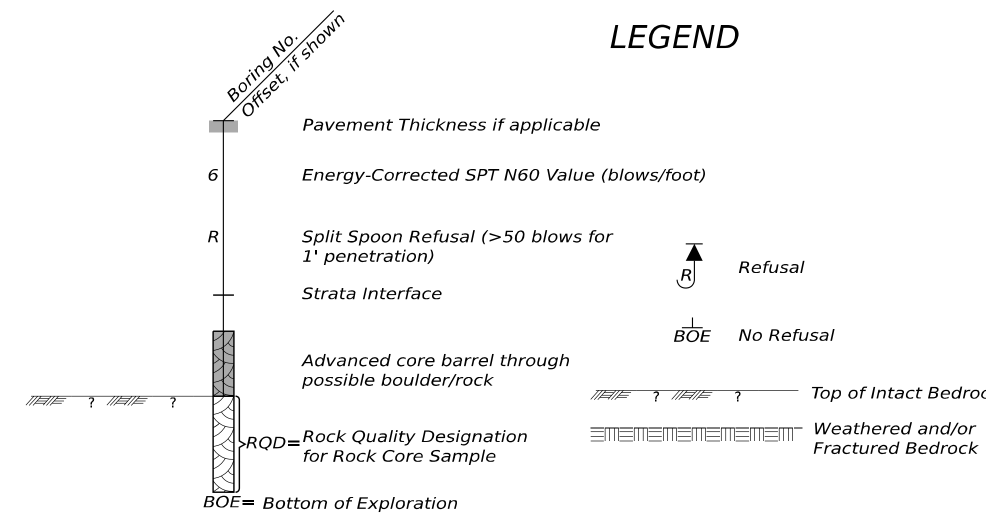
FILENAME: ...\002_GEOPLAN-DENNYSVILLE.DGN DIVISION:

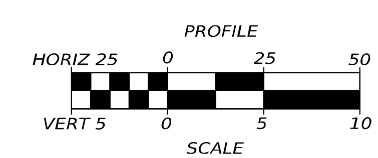
Filename: B:\Working\THORNTON TOMASETTI\2502334 MaineDOT Downeast Bridges Phase II\00__CAD\DGN\01__Dennysville\SHT\002__GeoPlan-Dennysville.dgn

NOTES
1) Profile developed from electronic file (Profile_Route 1.dgn - "Route 1 vert 1- Profile Route 1" model) provided to GEI by Thornton Tomasetti on June 31, 2025.
2) As-drilled boring locations were located using tape ties and should be considered accurate to the degree implied.
3) This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more information refer to the boring logs.
4) Borings BB-DWS-103 and BB-DWS-201 are not shown since offset borings BB-DWS-103A and BB-DWS-201A were drilled. Refer to the boring logs for subsurface conditions and information on borings BB-DWS-103 and BB-DWS-201



LEGEND





STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

APPROVED	DATE
COMMISSIONER:	
CHIEF ENGINEER:	

	BY	DATE	SIGNATURE	P.E. NUMBER	DATE
PROJ. MANAGER	M. JOHNESCU				
DESIGN-DETAILED	M. JOHNESCU	Y.SOJO 7/17/2025			
CHECKED-REVIEWED	M. JOHNESCU	N.BETANCUR 8/5/2025			
DESIGN2-DETAILED2					
DESIGN3-DETAILED3					
REVISIONS 1					
REVISIONS 2					
REVISIONS 3					
REVISIONS 4					
FIELD CHANGES					

U.S. ROUTE 1 BRIDGE NO. 6740
CROSSING WILSON'S STREAM
DENNYSVILLE

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
3
OF 3

FILENAME:...\003_GEOPROFILE-DENNYSVILLE.DGN
DIVISION:
USERNAME:SOJO YONATHAN
DATE:8/5/2025

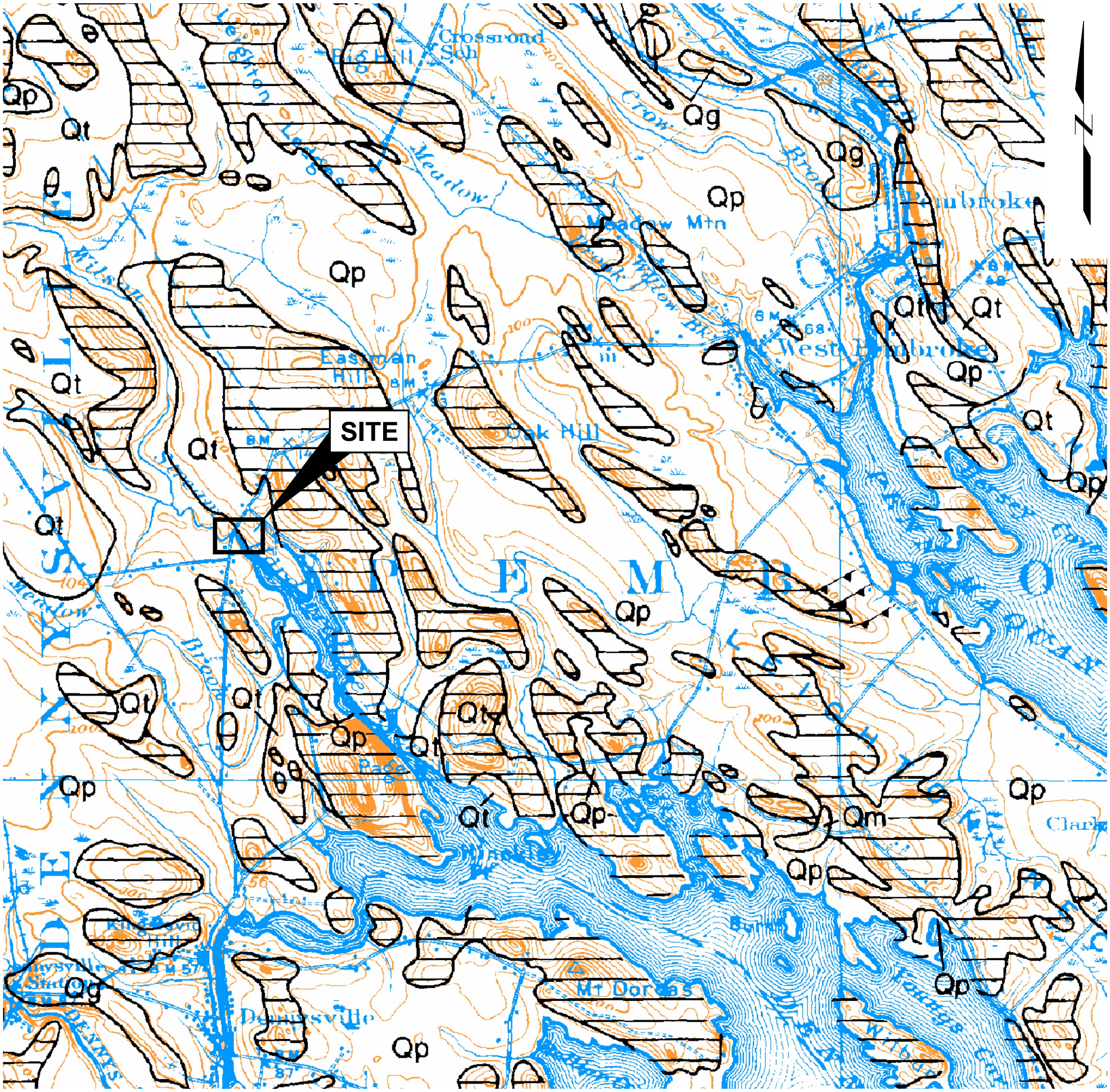
Filename: B:\Working\THORNTON TOMASETTI\2502334 MaineDOT Downeast Bridges Phase II\00__CAD\DGN\01__Dennysville\SHT\003__GeoProfile-Dennysville.dgn

Appendix A Geology

A.1. Surficial Geology Map

A.2. Bedrock Geology

A.1. Surficial Geology Map



0 2,000 4,000 8,000

SCALE, FEET

LEGEND:

Qp - Glacial-marine deposits (Presumpscot Formation): Silt, clay and sand. Commonly a clayey silt, but sand is very abundant at the surface in some places. Low permeability silt and clay.

Qt - Till: Heterogeneous mixture of sand, silt, clay, and stones.

Ruled pattern Indicates areas of many outcrops and/or surficial deposits (generally less than 10 ft. thick).

QUADRANGLE LOCATION

SOURCE:

Map created with Maine Surficial Geology 1:62,500 Maps from Maine Geological Survey. The project site is located on the Eastport Quadrangle, Maine, prepared by Harold W. Borns, Jr in 1975.

Benjamin Lincoln Bridge (#6740) over Wilson Stream
WIN 026630.08
Dennysville, Maine

Thornton Tomasetti
Portland, Maine

GEI Consultants

Project 2502334

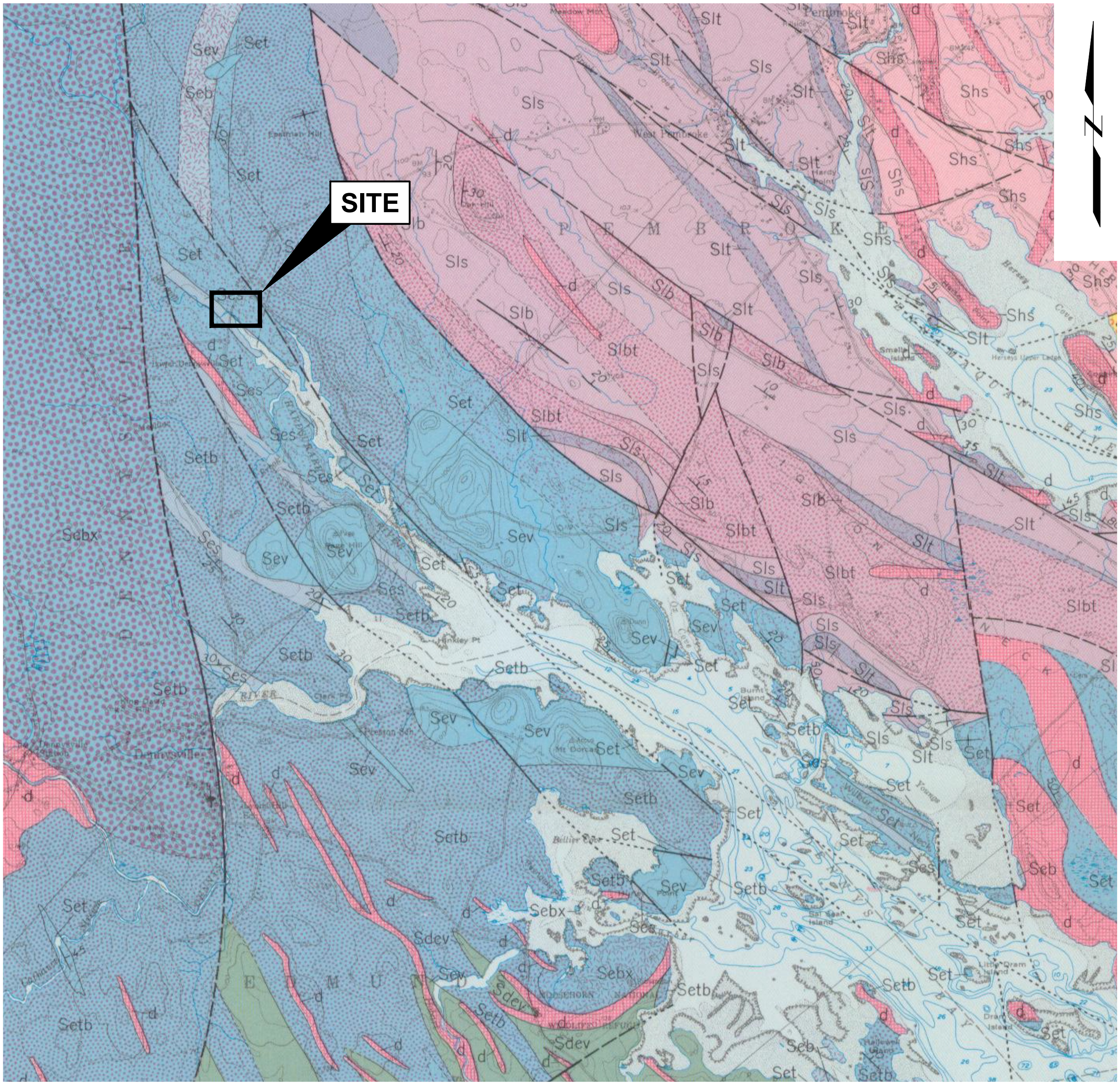
SURFICIAL GEOLOGY MAP

Aug. 2025

Fig. A-1

CARVAJAL, SEBASTIAN B:\Working\THORNTON TOMASETTI\2502334 MaineDOT Downeast Bridges Phase II\00_CAD\Figures\Geology Ph2\Benjamin Lincoln Bridge at Dennysville\A-1 Surficial Geology - Dennysville Ph2.dwg - 5/5/2025

A.2. Bedrock Geology Map



0 2,000 4,000 8,000

SCALE, FEET

LEGEND:

Ses - Edmunds Formation: Grey mudstone, shale, argillite, chert, and bedded tuff.
Set - Edmunds Formation: Maroon, purple, green lithic crystal lapilli tuff and tuff breccia with local red mudstone beds, Rhyolite and dacite.

SOURCE:

Map created with Maine Bedrock Geology 1:48,000 Maps from Maine Geological Survey. The project site is located on Eastport Quadrangle, Maine, prepared by Olcott Gates in 1975.

QUADRANGLE LOCATION

Benjamin Lincoln Bridge (#6740) over Wilson Stream WIN 026630.08 Dennysville, Maine	GEI Consultants	BEDROCK GEOLOGY MAP
Thornton Tomasetti Portland, Maine	Project 2502334	Aug. 2025 Fig. A-2

CARVAJAL, SEBASTIAN B:\Working\THORNTON TOMASETTI\2502334 MaineDOT Downeast Bridges Phase II\00_CAD\Figures\Geology Ph2\Benjamin Lincoln Bridge at Dennysville\A-2 Bedrock Geology - Dennysville Ph2.dwg - 5/5/2025

Appendix B Boring Logs and Core Photographs

B.1. Boring Logs

B.2. Rock Core Photographs

B.3. Automatic Hammer Calibration Report Summary Tables

B.1. Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS (more than half of material is larger than No. 200 sieve size)	GRAVELS (more than half of coarse fraction is larger than No. 4 sieve size)	CLEAN GRAVELS (little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel sand mixtures, little or no fines.
		GRAVEL WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (more than half of coarse fraction is smaller than No. 4 sieve size)	CLEAN SANDS (little or no fines)	SW	Well-graded sands, Gravelly sands, little or no fines
			SP	Poorly-graded sands, Gravelly sand, little or no fines.
		SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (more than half of material is smaller than No. 200 sieve size)	SILTS AND CLAYS (liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, Silty or Clayey fine sands, or Clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, Gravelly clays, Sandy clays, Silty clays, lean clays.
			OL	Organic silts and organic Silty clays of low plasticity.
	SILTS AND CLAYS (liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine Sandy or Silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
	HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.

Desired Soil Observations (in this order, if applicable):
Color (Munsell color chart)
Moisture (dry, damp, moist, wet)
Density/Consistency (from above right hand side)
Texture (fine, medium, coarse, etc.)
Name (Sand, Silty Sand, Clay, etc., including portions - trace, little, etc.)
Gradation (well-graded, poorly-graded, uniform, etc.)
Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic)
Structure (layering, fractures, cracks, etc.)
Bonding (well, moderately, loosely, etc.,)
Cementation (weak, moderate, or strong)
Geologic Origin (till, marine clay, alluvium, etc.)
Groundwater level

MODIFIED BURMISTER SYSTEM

Descriptive Term	Portion of Total (%)
trace	0 - 10
little	11 - 20
some	21 - 35
adjective (e.g. Sandy, Clayey)	36 - 50

TERMS DESCRIBING DENSITY/CONSISTENCY

Coarse-grained soils (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) Silty or Clayey gravels; and (3) Silty, Clayey or Gravelly sands. Density is rated according to standard penetration resistance (N-value).

Density of Cohesionless Soils	Standard Penetration Resistance N_{60}-Value (blows per foot)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

Fine-grained soils (more than half of material is smaller than No. 200 sieve): Includes (1) inorganic and organic silts and clays; (2) Gravelly, Sandy or Silty clays; and (3) Clayey silts. Consistency is rated according to undrained shear strength as indicated.

Consistency of Cohesive soils	SPT N_{60}-Value (blows per foot)	Approximate Undrained Shear Strength (psf)	Field Guidelines
Very Soft	WOH, WOR, WOP, <2	0 - 250	Fist easily penetrates
Soft	2 - 4	250 - 500	Thumb easily penetrates
Medium Stiff	5 - 8	500 - 1000	Thumb penetrates with moderate effort
Stiff	9 - 15	1000 - 2000	Indented by thumb with great effort
Very Stiff	16 - 30	2000 - 4000	Indented by thumbnail
Hard	>30	over 4000	Indented by thumbnail with difficulty

Rock Quality Designation (RQD):

$$RQD\ (\%) = \frac{\text{sum of the lengths of intact pieces of core* > 4 inches}}{\text{length of core advance}}$$

*Minimum NQ rock core (1.88 in. OD of core)

Rock Quality Based on RQD

Rock Quality	RQD (%)
Very Poor	≤25
Poor	26 - 50
Fair	51 - 75
Good	76 - 90
Excellent	91 - 100

Desired Rock Observations (in this order, if applicable):
Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Rock Type (granite, schist, sandstone, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
- -dip (horiz - 0-5 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)
- -spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)
- -tightness (tight, open, or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock quality (very poor, poor, etc.)
ref: ASTM D6032 and FHWA NHI-16-072 GEC 5 - Geotechnical Site Characterization, Table 4-12
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

Maine Department of Transportation
Geotechnical Section
Key to Soil and Rock Descriptions and Terms
Field Identification Information

Sample Container Labeling Requirements:

WIN	Blow Counts
Bridge Name / Town	Sample Recovery
Boring Number	Date
Sample Number	Personnel Initials
Sample Depth	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Benjamin Lincoln Bridge #6740 carrying Route 1 over Wilson Stream Location: Dennysville, Maine	Boring No.: BB-DWS-101 WIN: 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	31.1	**Auger ID/OD:**	5" Solid Stem Auger
Operator:	G. McDougal	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	M. Schoeff	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	4/19/24 - 4/22/24	**Drilling Method:**	Drive & Wash	**Core Barrel:**	NQ-2"
Boring Location:	N 401835.3, E 2464606.7	**Casing ID/OD:**	4.00"/4.50" (HW-4")	**Water Level*:**	Not Encountered
Hammer Efficiency Factor:	0.765	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			16" ASPHALT	
	1D	24/13	1.5 - 3.5	29/23/18/13	41	52		29.8		1.3 Brown and grey, damp, very dense, Gravelly fine to coarse SAND, little silt, (Fill).	A-1-b, SM WC=5.0%
	2D	24/8	4.0 - 6.0	9/11/8/6	19	24	SPIN			Brown, damp, medium dense, fine to coarse SAND, little gravel, trace silt, (Fill). Rock in tip.	
5											
							92			Spin casing 4 to 6 ft to tighten casing.	
							166				
							88			Roll ahead of casing 7.6 to 14.0 ft.	
	3D	24/5	9.0 - 11.0	14/9/26/14	35	45	47			Brown and grey, wet, dense, Gravelly fine to coarse SAND, some silt, (Fill). Hydrocarbon odor.	
10							45				
							87				
							101				
							81				
	4D	24/6	14.0 - 16.0	12/16/21/6	37	47	54			Brown and grey, wet, dense, GRAVEL, trace sand, trace silt, (Fill). Ran a 3-inch spoon at the same interval and recovered 0-inches.	A-1-a, GP WC=3.7%
15							97				
							205				
							198				
							125			Probable boulders/cobbles 16.4 to 20.6 ft bgs.	
	MD	0/0	19.0 - 19.0		--	--	139				
20							126	11.1		20.0	
							168				
							180				
							198				
25	5D	23/11	24.0 - 25.9	20/21/35/50(5")	56	71	149			Grey, wet, very dense, fine to coarse SAND, some silt, some gravel, medium plasticity fines, (Glacial Till).	A-2(0), SM WC=3.7%

Remarks:

1. The boring coordinates and elevations were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
2. Automatic hammer NEBC D-28. Energy Transfer Ratio = 0.765.
3. Borehole backfilled with bentonite chips, soil, and gravel. Patched with cold patch asphalt.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Benjamin Lincoln Bridge #6740 carrying Route 1 over Wilson Stream
Location: Dennysville, Maine

Boring No.: BB-DWS-101
WIN: 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	31.1	**Auger ID/OD:**	5" Solid Stem Auger
Operator:	G. McDougal	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	M. Schoeff	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	4/19/24 - 4/22/24	**Drilling Method:**	Drive & Wash	**Core Barrel:**	NQ-2"
Boring Location:	N 401835.3, E 2464606.7	**Casing ID/OD:**	4.00"/4.50" (HW-4")	**Water Level*:**	Not Encountered
Hammer Efficiency Factor: 0.765		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
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RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25								5.1		26.0 Approximate Top of Bedrock at Elev. 5.1 ft.	
	R1	52/51	27.0 - 31.3	RQD = 31%			NQ			R1: Bedrock: Grey, fine grained MUDSTONE, hard, very slightly to moderately weathered, low angle to vertical, close to very close, tight to open joints with grey fine infilling. intrusion. [Edmunds Formation] Rock Quality: Poor 98% Recovery R1: Core Times (min:sec) 27.0-28.0 ft (1:19) 28.0-29.0 ft (1:37) 29.0-30.0 ft (3:04) 30.0-31.0 ft (2:56) 31.0-31.3 ft (1:19)	q_p = 4845 ksf
30											
	R2	54/54	31.3 - 35.8	RQD = 56%						R2: Bedrock: Grey, fine grained MUDSTONE, hard, slightly weathered, low angle to steep, close to very close, tight to open joints with grey silt infilling. Iron staining at 18"-22". [Edmunds Formation] Rock Quality: Fair 100% Recovery R2: Core Times (min:sec) 31.3-32.3 ft (1:57) 32.3-33.3 ft (1:41) 33.3-34.3 ft (1:39) 34.3-35.3 ft (1:56) 35.3-35.8 ft (1:19)	
35	R3	24/24	35.8 - 37.8	RQD = 21%				-6.7		R3: Bedrock: Grey and white, fine to medium coarse grained MUDSTONE, hard, slightly weathered, low angle to steep, close to very close, tight to open joints with grey silt infilling. [Edmunds Formation] Rock Quality: Very Poor 100% Recovery R3: Core Times (min:sec) 35.8-36.8 ft (1:21) 36.8-37.8 ft (1:52)	
40										37.8 **Bottom of Exploration at 37.8 feet below ground surface.**	
45											
50											

Remarks:

1. The boring coordinates and elevations were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
2. Automatic hammer NEBC D-28. Energy Transfer Ratio = 0.765.
3. Borehole backfilled with bentonite chips, soil, and gravel. Patched with cold patch asphalt.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Benjamin Lincoln Bridge #6740 carrying Route 1 over Wilson Stream **Location:** Dennysville, Maine	**Boring No.:** BB-DWS-102 **WIN:** 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	32.0	**Auger ID/OD:**	5" Solid Stem Auger
Operator:	G. McDougal	**Datum:**	NAVD88	**Sampler:**	Standard 2" and 3" Split Spoon
Logged By:	M. Schoeff	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	4/22/24 - 4/23/24	**Drilling Method:**	Drive & Wash	**Core Barrel:**	NQ-2"
Boring Location:	N 401858.0, E 2464610.7	**Casing ID/OD:**	HW-4" & NW-3"	**Water Level*:**	Not Encountered
Hammer Efficiency Factor: 0.765		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			12" ASPHALT	
	1D	24/15	1.0 - 3.0	26/28/26/30	54	69		31.0		1.0 Brown and grey, dry, very dense, fine to coarse SAND, little gravel, (Fill).	
	2D	24/8	4.0 - 6.0	9/11/11/9	22	28	64			Brown and grey, damp, medium dense, fine to coarse SAND, some gravel, little silt, (Fill).	
5							85				
							89				
							81				
							95				
	3D	24/6	9.0 - 11.0	35/15/12/13	27	34	30			Brown and grey, wet, dense, Sandy GRAVEL, trace silt, (Fill). Ran a 3-inch spoon at the same interval and recovered 6-inches.	A-1-a, GW WC=10.8%
10							38				
							53				
							51				
							46				
	4D	24/4	14.0 - 16.0	13/4/2/5	6	8	27			Grey and reddish brown, wet, loose, GRAVEL, (Fill). Ran a 3-inch spoon at the same interval and recovered 0-inches.	
15							30				
							61				
							46				
							43				
	5D	24/2	19.0 - 21.0	5/6/9/21	15	19	36			Grey and brown, wet, medium dense, GRAVEL, trace sand, trace silt, (Fill). Rock in tip of 2-in spoon. Ran a 3-inch spoon at the same interval and recovered 6-inches.	A-1-a, GP WC=1.3%
20							90				
							117				
							91[1] SPIN			[1]91 blows for 0.5 ft.	
	R1	58/40	23.8 - 28.6	RQD = 45%			NQ	8.5		23.5 Approximate Top of Bedrock at Elev. 8.5 ft. R1(0-18"): Bedrock: Purplish grey, fine to coarse grained BRECCIA, hard, fresh to very slightly weathered, low angle, close, open joints with	q_p = 4475 ksf
25											

Remarks:

1. The boring coordinates and elevations were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
2. Automatic hammer NEBC D-28. Energy Transfer Ratio = 0.765.
3. Borehole backfilled with bentonite chips, soil, and gravel. Patched with cold patch asphalt.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Driller:	New England Boring Contractors	**Elevation (ft.)**	32.0	**Auger ID/OD:**	5" Solid Stem Auger
Operator:	G. McDougal	**Datum:**	NAVD88	**Sampler:**	Standard 2" and 3" Split Spoon
Logged By:	M. Schoeff	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	4/22/24 - 4/23/24	**Drilling Method:**	Drive & Wash	**Core Barrel:**	NQ-2"
Boring Location:	N 401858.0, E 2464610.7	**Casing ID/OD:**	HW-4" & NW-3"	**Water Level*:**	Not Encountered
Hammer Efficiency Factor: 0.765		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										fine grey infilling. R1(18"-33"): Bedrock: Grey, fine grained MUDSTONE, hard, very slight weathered, horizontal to vertical, very close to close, tight to open joints with fine grey infilling. Iron staining at 18"-26". R1(33"-40"): Bedrock: Grey and white, fine to coarse grained SCHIST, hard, slightly weathered with fine grey infilling. [Edmunds Formation] Rock Quality: Poor 69% Recovery R1: Core Times (min:sec) 23.8-24.8 ft (3:03) 24.8-25.8 ft (1:22) 25.8-26.8 ft (1:32) 26.8-27.8 ft (1:27) 27.8-28.6 ft (2:19)	
	R2	60/60	28.6 - 33.6	RQD = 35%						R2(0-30"): Bedrock: Grey, fine grained MUDSTONE, hard, fresh to slightly weathered, low angle to steep, close to very close, tight to open joints with grey fine infilling. R2(30"-60"): Bedrock: Purplish grey, fine to coarse grained BRECCIA, hard, fresh to slightly weathered, low angle to vertical, close to mod. close, tight to open joints with grey fine and coarse infilling. Iron staining at 42"-53". [Edmunds Formation] Rock Quality: Poor 100% Recovery R2: Core Times (min:sec) 28.6-29.6 ft (2:49) 29.6-30.6 ft (2:29) 30.6-31.6 ft (2:32) 31.6-32.6 ft (2:27) 32.6-33.6 ft (2:14)	
30											
	R3	60/53	33.6 - 38.6	RQD = 77%						R3: Bedrock: Purplish grey, fine to coarse grained BRECCIA, hard, fresh to slightly weathered, low angle to steep, mod. close to very close, tight to open joints with grey silt infilling. [Edmunds Formation] Rock Quality: Good 88% Recovery R3: Core Times (min:sec) 33.6-34.6 ft (2:25) 34.6-35.6 ft (2:23) 35.6-36.6 ft (1:44) 36.6-37.6 ft (2:16) 37.6-38.6 ft (2:20)	
35											
								-6.6		38.6	
40										**Bottom of Exploration at 38.6 feet below ground surface.**	
45											
50											

Remarks:

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2. Automatic hammer NEBC D-28. Energy Transfer Ratio = 0.765.
3. Borehole backfilled with bentonite chips, soil, and gravel. Patched with cold patch asphalt.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Benjamin Lincoln Bridge #6740 carrying Route 1 over Wilson Stream
Location: Dennysville, Maine

Boring No.: BB-DWS-103
WIN: 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	34.4	**Auger ID/OD:**	5" Solid Stem Auger
Operator:	G. McDougal	**Datum:**	NAVD88	**Sampler:**	Standard 2" and 3" Split Spoon
Logged By:	M. Schoeff	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	4/18/24 - 4/19/24	**Drilling Method:**	Drive & Wash	**Core Barrel:**	NQ-2"
Boring Location:	N 401904.0, E 246420.6	**Casing ID/OD:**	HW-4" & NW-3"	**Water Level*:**	12.6 ft bgs
Hammer Efficiency Factor: 0.765		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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PL = Plastic Limit
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G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			13" ASPHALT	
								33.4		1.0	
	1D	24/12	1.0 - 3.0	35/35/23/20	58	74				Brown and grey, dry, very dense, fine to coarse SAND, little gravel, trace silt, (Fill).	
	2D	24/8	4.0 - 6.0	10/25/15/15	40	51	109			Brown and grey, damp, very dense, Gravelly fine to coarse SAND, little silt, (Fill).	A-1-a, SM WC=5.2%
5							192				
							260				
							176			Rolling ahead of casing 7.4 ft to 19.2 ft.	
							32			Probable boulders/cobbles at 7.7 ft bgs.	
	3D	23/1	9.0 - 10.9	17/10/21/50(5")	31	40	48			Brown and grey, wet, dense, GRAVEL, little silt, (Fill). Hydrocarbon odor. Poor recovery with 2-inch spoon. Ran a 3-inch spoon at the same interval and recovered 0-inches.	
10							168				
							124				
							80			Probable boulders/cobbles at 11.1 to 13. 7 ft bgs.	
							247				
	4D	8/6	14.0 - 14.7	39/50(2")	--	--	RC	20.1		(0-3"): Brown and grey, wet, Sandy GRAVEL, trace silt, (Fill). 14.3 (3"-6"): Brown and grey, wet, Silty SAND, some gravel, (Glacial Till). Probable boulders/cobbles 14.8 to 15.8 ft.	A-2(0), SM WC=12.5%
15											
										Probable boulders/cobbles 18.2 to 19.2 ft.	
	MD	0/0	19.0 - 19.0	50(0")	--	--		15.2		Attempt to core at 19.2 ft. Barrel pinched in casing on the way down. Abandon Hole. 19.2	
20										**Bottom of Exploration at 19.2 feet below ground surface.**	
25											

Remarks:

1. The boring coordinates and elevations were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
2. Automatic hammer NEBC D-28. Energy Transfer Ratio = 0.765.
3. Core Barrel pinched in casing. Abandoned the borehole and drilled an offset boring 2.5 ft northeast.
4. Water level measured at end of drilling. Borehole backfilled with bentonite chips, soil, and gravel. Patched with cold patch asphalt.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Benjamin Lincoln Bridge #6740 carrying Route 1 over Wilson Stream **Location:** Dennysville, Maine	**Boring No.:** BB-DWS-103A **WIN:** 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	34.7	**Auger ID/OD:**	5" Solid Stem Auger
Operator:	G. McDougal	**Datum:**	NAVD88	**Sampler:**	NA
Logged By:	M. Schoeff	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	NA
Date Start/Finish:	4/23/2024	**Drilling Method:**	Drive & Wash	**Core Barrel:**	NQ-2"
Boring Location:	N 401906.7, E 2464621.7	**Casing ID/OD:**	HW-4" & NW-3"	**Water Level*:**	Not Encountered
Hammer Efficiency Factor:	0.765	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA				
5							DRIVE				
10											
15										Probable boulders/cobbles 14.2 to 16 ft.	
								18.7		16.0	
	R1	53/52	16.0 - 20.4	RQD = 55%			NQ			Approximate Top of Bedrock at Elev. 18.7 ft. R1: Bedrock: Grey, fine grained MUDSTONE, hard, fresh to slightly weathered, mod. weathered at 32"-52", low angle to steep, close to very close, tight to open joints with grey fine infilling. [Edmunds Formation] Rock Quality: Fair 98% Recovery R1: Core Times (min:sec) 16.0-17.0 ft (2:38) 17.0-18.0 ft (2:18) 18.0-19.0 ft (1:52) 19.0-20.0 ft (1:49) 20.0-20.4 ft (1:51)	q_p = 3406 ksf
20	R2	47/47	20.4 - 24.3	RQD = 70%						R2: Bedrock: Grey, fine grained MUDSTONE, hard, fresh to very slightly weathered, mod. dipping to steep, close to mod. close, tight joints with grey fine infilling. [Edmunds Formation] Rock Quality: Fair 100% Recovery	
25	R3	36/35	24.3 - 27.3	RQD = 83%							

Remarks:

1. The boring coordinates and elevations were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
2. Automatic hammer NEBC D-28. Energy Transfer Ratio = 0.765.
3. Borehole backfilled with bentonite chips, soil, and gravel. Patched with cold patch asphalt.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Benjamin Lincoln Bridge #6740 carrying Route 1 over Wilson Stream Location: Dennysville, Maine	Boring No.: BB-DWS-103A WIN: 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	34.7	**Auger ID/OD:**	5" Solid Stem Auger
Operator:	G. McDougal	**Datum:**	NAVD88	**Sampler:**	NA
Logged By:	M. Schoeff	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	NA
Date Start/Finish:	4/23/2024	**Drilling Method:**	Drive & Wash	**Core Barrel:**	NQ-2"
Boring Location:	N 401906.7, E 2464621.7	**Casing ID/OD:**	HW-4" & NW-3"	**Water Level*:**	Not Encountered
Hammer Efficiency Factor:	0.765	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										R2: Core Times (min:sec) 20.4-21.4 ft (2:23) 21.4-22.4 ft (2:14) 22.4-23.4 ft (1:54) 23.4-24.3 ft (3:01)	
								7.4		R3: Bedrock: Grey, fine grained MUDSTONE, hard, fresh, low angle, tight joint with grey-white fine infilling. [Edmunds Formation] Rock Quality: Good 97% Recovery R3: Core Times (min:sec) 24.3-25.3 ft (1:52) 25.3-26.3 ft (1:44) 26.3-27.3 ft (1:52)	
30										27.3	
										Bottom of Exploration at 27.3 feet below ground surface.	
35											
40											
45											
50											

Remarks:
1. The boring coordinates and elevations were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
2. Automatic hammer NEBC D-28. Energy Transfer Ratio = 0.765.
3. Borehole backfilled with bentonite chips, soil, and gravel. Patched with cold patch asphalt.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Benjamin Lincoln Bridge (#6740) carrying Route 1 over Wilson Stream
Location: Dennysville, Maine

Boring No.: BB-DWS-201
WIN: 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	29.1	**Auger ID/OD:**	5.00"
Operator:	B. Enos	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	S. Carvajal	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	5/19/2025 - 5/19/2025	**Drilling Method:**	Solid Steam Auger	**Core Barrel:**	NA
Boring Location:	N:401810.5, E:2464622.2	**Casing ID/OD:**	NA	**Water Level*:**	Not Measured
Hammer Efficiency Factor: 0.834		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			13" ASPHALT	
	1D	24/12	1.1 - 3.1	35/37/22/23	59	82		28.0		1.1 — Dark brown to light brown, dry, very dense, fine to coarse SAND, some gravel, little silt, (Fill).	
	2D	24/9	4.0 - 6.0	14/22/15/7	37	51				Brown, damp, very dense, fine to coarse SAND, some gravel, some silt, (Fill).	A-1-b, SW-SM WC=8.2%
5											
								20.1		9.0 — **Bottom of Exploration at 9.0 feet below ground surface.**	
10											
15											
20											
25											

Remarks:

1. Automatic hammer NEBC D-23. Energy Transfer Ratio = 0.834.
2. Borehole abandoned during HW casing installation due to tilting. Offset borehole was drilled 1.5 ft north.
3. Borehole backfilled with soil cuttings and gravel. Patched with cold patch asphalt.
4. The boring coordinates and elevation were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.

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* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Benjamin Lincoln Bridge (#6740) carrying Route 1 over Wilson Stream Location: Dennysville, Maine	Boring No.: BB-DWS-201A WIN: 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	29.1	**Auger ID/OD:**	5" Solid Steam Auger
Operator:	B. Enos	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	S. Carvajal	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	5/19/2025 - 5/19/2025	**Drilling Method:**	Drive/Spin and Wash	**Core Barrel:**	NQ-2"
Boring Location:	N:401812.7, E:2464622.8	**Casing ID/OD:**	HW-4" & NW-3"	**Water Level*:**	18.5 ft bgs.
Hammer Efficiency Factor:	0.834	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			13" ASPHALT	
								28.0		1.1	
5							120				
							128				
							93				
							94				
	1D	24/4	9.0 - 11.0	7/4/4/2	8	11	50			Brown, wet, medium dense, GRAVEL, some sand, some silt, (Fill).	
10							45				
							57				
							29				
							146				
	2D	0/0	14.0 - 14.0	50 (0")	--	--	CORE			2D: No recovery R1: Boulder.	
15	R1	14/6	14.0 - 15.2					14.1		15.0	
	3D	24/6	15.0 - 17.0	2/4/4/2	8	11	SPIN			3D: Light brown, wet, medium stiff, Silty CLAY, some sand, trace gravel, (Glacial Till).	A-6, CL WC=21.8% LL=33.3 PL=21.8 PI=11.5
	4D	24/8	19.0 - 21.0	12/20/30/53	50	70				Brown, wet, very dense, fine to coarse SAND, some gravel, little silt, (Glacial Till).	A-1-b, SM WC=9.4%
20							53				
							57				
							66				
							37*			*37 blows for 0.5 ft.	
								5.3		23.8	
25	R2	30/27	24.0 - 26.5	RQD = 30%			CORE			Approximate Top of Bedrock at Elev. 5.3 ft. R2: Bedrock: Purplish grey to grey, fine to coarse grained BRECCIA,	

Remarks:

1. Automatic hammer NEBC D-23. Energy Transfer Ratio = 0.834.
2. Borehole was drilled 1.5 ft north of BB-DWS-201.
3. The boring coordinates and elevation were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
4. Water level measured at the end of drilling activities.
5. Borehole backfilled with soil cuttings and gravel. Patched with cold patch asphalt.

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* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Benjamin Lincoln Bridge (#6740) carrying Route 1 over Wilson Stream
Location: Dennysville, Maine

Boring No.: BB-DWS-201A
WIN: 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	29.1	**Auger ID/OD:**	5" Solid Steam Auger
Operator:	B. Enos	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	S. Carvajal	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	5/19/2025 - 5/19/2025	**Drilling Method:**	Drive/Spin and Wash	**Core Barrel:**	NQ-2"
Boring Location:	N:401812.7, E:2464622.8	**Casing ID/OD:**	HW-4" & NW-3"	**Water Level*:**	18.5 ft bgs.
Hammer Efficiency Factor: 0.834		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										hard, slightly to moderately weathered. Joints are low angle to steep, very close to close, tight to open with grey and brown silt infilling. Transition to mudstone in bottom 6 inches. [Edmunds Formation] Rock Quality: Poor 90% Recovery R2: Core Times (min:sec) 24.0 - 25.0 ft (2:57) 25.0 - 26.0 ft (2:16) 26.0 - 26.5 ft (3:40)	
	R3	34/33	26.5 - 29.3	RQD = 60%						R3: Bedrock: Grey to brown, fine grained MUDSTONE, hard, fresh to moderately weathered. Joints are low angle to steep, very close to close, tight to open with grey silt infilling. [Edmunds Formation] Rock Quality: Fair 97% Recovery R3: Core Times (min:sec) 26.5 - 27.5 ft (2:10) 27.5 - 28.5 ft (2:11) 28.5 - 29.3 ft (2:30)	
30	R4	34/30	29.3 - 32.1	RQD = 58%						R4: Bedrock: Grey to bluish grey, fine grained MUDSTONE with calcite intrusions/veins, hard to mod. hard, fresh to moderately weathered. Joints are low angle to mod. dipping, very close to close, tight to open with grey silt infilling and iron staining. [Edmunds Formation] Rock Quality: Fair 88% Recovery R4: Core Times (min:sec) 29.3 - 30.3 ft (2:23) 30.3 - 31.3 ft (2:27) 31.3 - 32.1 ft (2:55)	q_p=5884
35	R5	60/53	32.1 - 37.1	RQD = 58%				-8.0		R5: Bedrock: Grey to bluish grey, fine grained MUDSTONE, hard, fresh to slightly weathered. Joints are horizontal to mod. dipping, very close to mod. close, tight to open with grey silt infilling. [Edmunds Formation] Rock Quality: Fair 88% Recovery R5: Core Times (min:sec) 32.1 - 33.1 ft (1:54) 33.1 - 34.1 ft (2:49) 34.1 - 35.1 ft (2:39) 35.1 - 36.1 ft (1:44) 36.1 - 37.1 ft (2:26)	
40										37.1	
45										**Bottom of Exploration at 37.1 feet below ground surface.**	
50											

Remarks:

1. Automatic hammer NEBC D-23. Energy Transfer Ratio = 0.834.
2. Borehole was drilled 1.5 ft north of BB-DWS-201.
3. The boring coordinates and elevation were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
4. Water level measured at the end of drilling activities.
5. Borehole backfilled with soil cuttings and gravel. Patched with cold patch asphalt.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Benjamin Lincoln Bridge (#6740) carrying Route 1 over Wilson Stream
Location: Dennysville, Maine

Boring No.: BB-DWS-202
WIN: 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	33.3	**Auger ID/OD:**	5" Solid Stem Auger
Operator:	B. Enos	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	S. Carvajal	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	5/20/25-5/20/25	**Drilling Method:**	Drive and Wash	**Core Barrel:**	NQ-2"
Boring Location:	N:401896.7, E:2464637.6	**Casing ID/OD:**	HW-4" & NW-3"	**Water Level*:**	9.9 ft bgs
Hammer Efficiency Factor: 0.834		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
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RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			14" ASPHALT	
	1D	24/12	1.2 - 3.2	47/37/28/31	65	90		32.1		1.2 Dark brown to light brown, dry, very dense, fine to coarse SAND, little gravel, trace silt, (Fill).	
	2D	20/5	4.0 - 5.7	11/12/33/12(2")	45	63				Brown, damp, medium dense, fine to coarse SAND, some gravel, little silt, (Fill).	
5							271				
							127				
							81			Rolled ahead of casing from 7 ft to 9 ft.	
							66				
	3D	24/5	9.0 - 11.0	3/13/7/18	20	28	90			Brown, wet, medium dense, Gravelly fine to coarse SAND, little silt, (Fill).	A-1-b, SM WC=13.1%
10							193				
							80				
							75	20.8		12.5	
							72				
	4D	19/16	14.0 - 15.6	13/17/25/22(1")	42	58	35			Light brown, wet, hard, SILT & CLAY, some sand, trace gravel, (Glacial Till).	A-4, CL WC=11.2% LL=24.5 PL=15.1 PI=9.4
15								17.8		15.5	
	R1	42/32	16.0 - 19.5	RQD = 12%			CORE			Approximate Top of Bedrock at Elev. 17.8 ft. R1: Bedrock: Purplish grey to grey, fine grained MUDSTONE, hard to mod. hard, very slightly to moderately weathered. Joints are low angle to steep, very close to close, tight to open with grey and brown silt infilling and iron staining. Coarse to fine grained BRECCIA in the top 8 inches. [Edmunds Formation] Rock Quality: Very Poor 76% Recovery R1: Core Times (min:sec) 16.0 - 17.0 ft (2:31) 17.0 - 18.0 ft (2:46) 18.0 - 19.0 ft (2:35) 19.0 - 19.5 ft (3:05)	
	R2	12/7	19.5 - 20.5	RQD = 0%						R2: Bedrock: Grey, fine grained MUDSTONE, hard, moderately weathered. Joints are horizontal to low angle, very close, tight to open with grey silt infilling and iron staining. [Edmunds Formation] Rock Quality: Very Poor 58% Recovery R2: Core Times (min:sec)	
20	R3	36/36	20.5 - 23.5	RQD = 66%							q_p=2474
	R4	60/60	23.5 - 28.5	RQD = 82%							
25											

Remarks:

1. Automatic hammer NEBC D-23. Energy Transfer Ratio = 0.834.
2. The boring coordinates and elevation were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
3. Water level measured at the end of drilling activities.
4. Borehole backfilled with soil cuttings and gravel. Patched with cold patch asphalt.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Benjamin Lincoln Bridge (#6740) carrying Route 1 over Wilson Stream **Location:** Dennysville, Maine	**Boring No.:** BB-DWS-202 **WIN:** 026630.08

Driller:	New England Boring Contractors	**Elevation (ft.)**	33.3	**Auger ID/OD:**	5" Solid Stem Auger
Operator:	B. Enos	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	S. Carvajal	**Rig Type:**	Mobile B-53	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	5/20/25-5/20/25	**Drilling Method:**	Drive and Wash	**Core Barrel:**	NQ-2"
Boring Location:	N:401896.7, E:2464637.6	**Casing ID/OD:**	HW-4" & NW-3"	**Water Level*:**	9.9 ft bgs
Hammer Efficiency Factor: 0.834		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_{u/r}$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60}=(Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25										19.5 - 20.5 ft (5:27) R3: Bedrock: Grey, fine grained MUDSTONE, hard, very slightly weathered. Joints are low angle to steep, very close to mod. close, tight with grey and brown silt infilling. [Edmunds Formation] Rock Quality: Fair 100% Recovery R3: Core Times (min:sec) 20.5 - 21.5 ft (3:55) 21.5 - 22.5 ft (1:52) 22.5 - 23.5 ft (2:07) R4: Bedrock: Grey, fine grained MUDSTONE, hard, slightly weathered. Joints are horizontal to steep, very close to mod. close, tight to open with grey and brown silt infilling and iron staining. Coarse to fine grained BRECCIA in the bottom 8 inches. [Edmunds Formation] Rock Quality: Good 100% Recovery R4: Core Times (min:sec) 23.5 - 24.5 ft (2:45) 24.5 - 25.5 ft (2:25) 25.5 - 26.5 ft (2:01) 26.5 - 27.5 ft (2:11) 27.5 - 28.5 ft (2:05) R5: Bedrock: Grey, fine grained MUDSTONE, hard, slightly weathered. Joints are horizontal to steep, very close to mod. close, tight to open with grey silt infilling and iron staining. [Edmunds Formation] Rock Quality: Poor 92% Recovery R5: Core Times (min:sec) 28.5 - 29.5 ft (1:21) 29.5 - 30.5 ft (1:40) 30.5 - 31.5 ft (1:59) 31.5 - 32.5 ft (1:56)	
	R5	48/44	28.5 - 32.5	RQD = 42%							
30											
								0.8		32.5 **Bottom of Exploration at 32.5 feet below ground surface.**	
35											
40											
45											
50											

Remarks:

1. Automatic hammer NEBC D-23. Energy Transfer Ratio = 0.834.
2. The boring coordinates and elevation were estimated using tape ties and a topographic survey provided by MaineDOT, and should be considered accurate to the degree implied.
3. Water level measured at the end of drilling activities.
4. Borehole backfilled with soil cuttings and gravel. Patched with cold patch asphalt.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

B.2. Rock Core Photographs

MaineDOT

MaineDOT

Benjamin Lincoln Bridge #6740 carrying Route 1 over Wilson Stream

Dennysville, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-DWS-101	R1	27.0-31.3	52	51	16	31	Mudstone	1
BB-DWS-101	R2	31.3-35.8	54	54	30	56	Mudstone	2
BB-DWS-101	R3	35.8-37.8	24	24	5	21	Mudstone	3
BB-DWS-102	R1	23.8-28.6	58	40	26	45	Breccia, Mudstone, Schist	4

Notes:

1. "Box Row" indicates the section of the box where core run is contained: 1 = top, 4 = bottom.
2. Top of core at left. Increasing depth left to right.

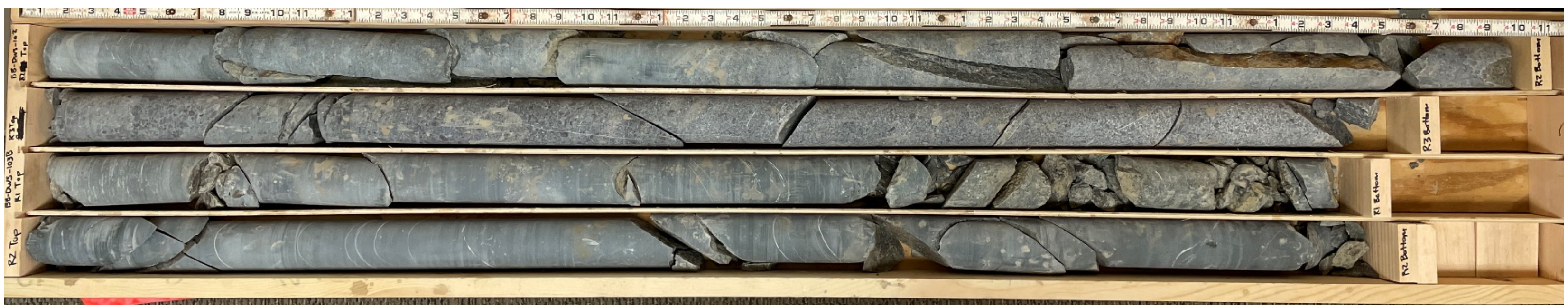
MaineDOT

Benjamin Lincoln Bridge #6740 carrying Route 1 over Wilson Stream

Dennysville, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-DWS-102	R2	28.6-33.6	60	60	21	35	Mudstone, Breccia	1
BB-DWS-102	R3	33.6-38.6	60	53	46	77	Breccia	2
BB-DWS-103A	R1	16.0-20.4	53	52	29	55	Mudstone	3
BB-DWS-103A	R2	20.4-24.3	47	47	33	70	Mudstone	4



Notes:

1. “Box Row” indicates the section of the box where core run is contained: 1 = top, 4 = bottom.
2. Top of core at left. Increasing depth left to right.

Benjamin Lincoln Bridge #6740 carrying Route 1 over Wilson Stream
Dennysville, ME
Rock Core Photographs

MaineDOT

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-DWS-103A	R3	24.3-27.3	36	35	30	83	Mudstone	1

Notes:

1. "Box Row" indicates the section of the box where core run is contained: 1 = top, 4 = bottom.
2. Top of core at left. Increasing depth left to right.

MaineDOT

Benjamin Lincoln Bridge (#6740) carrying Route 1 over Wilson Stream

Dennysville, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-DWS-201A	R2	24.0-26.5	30	27	9	30	Breccia/Mudstone	1
BB-DWS-201A	R3	26.5-29.3	34	33	20	60	Mudstone	1
BB-DWS-201A	R4	29.3-32.1	34	30	19.5	58	Mudstone	2
BB-DWS-201A	R5	32.1-37.1	60	53	35	58	Mudstone	3

Notes:

1. “Box Row” indicates the section of the box where core run is contained: 1 = top, 4 = bottom.
2. Top of core at left. Increasing depth left to right.
3. Top photo is dry, bottom photo is wet

MaineDOT

Benjamin Lincoln Bridge (#6740) carrying Route 1 over Wilson Stream

Dennysville, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-DWS-202	R1	16.0-19.5	42	31	5	12	Breccia/Mudstone	1
BB-DWS-202	R2	19.5-20.5	12	7	0	0	Mudstone	1
BB-DWS-202	R3	20.5-23.5	36	36	24	66	Mudstone	1,2
BB-DWS-202	R4	23.5-28.5	60	60	49	82	Mudstone/Breccia	3
BB-DWS-202	R5	28.5-32.5	48	44	20	42	Mudstone	4

Notes:

4. "Box Row" indicates the section of the box where core run is contained: 1 = top, 4 = bottom.
5. Top of core at left. Increasing depth left to right.
6. Top photo is dry, bottom photo is wet

B.3. Automatic Hammer Calibration Report Summary Tables

TABLE 3 - SUMMARY OF SPT TEST RESULTS
MOBIL B53 - NEBC DRILL RIG #28 (SERIAL NUMBER D28-2/21)

SPT Analyzer Results

PDA-S Ver. 2022.35.2 - Printed: 4/23/2023

Summary of SPT Test Results

Project: Mobil B53 D-28, Test Date: 4/21/2023

BPM: Blows/Minute
FMX: Maximum Force
AMX: Maximum Acceleration
VMX: Maximum Velocity

DMX: Maximum Displacement
DFN: Final Displacement
EMX: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Blows Applied /6"	**N Value**	**N60 Value**	Average BPM bpm	Average FMX kips	Average AMX g's	Average VMX ft/s	Average DMX in	Average DFN in	Average EMX ft-lb	Average ETR %
19.00	**12-19-20-25**	**39**	**49**	50.0	39	3725	14.2	0.42	0.31	252	72.0
24.00	**8-39-26-26**	**65**	**82**	52.7	37	4030	15.1	0.33	0.18	268	76.6
29.00	**5-8-11-13**	**19**	**24**	54.3	40	4426	15.5	0.67	0.63	277	79.2
34.00	**8-7-8-6**	**15**	**19**	54.3	39	3041	14.4	0.83	0.80	270	77.1
39.00	**3-4-6-5**	**10**	**12**	54.2	39	2906	14.4	1.22	1.20	279	79.7
44.00	**11-14-23-15**	**37**	**47**	54.2	40	2694	12.9	0.41	0.32	275	78.7
			Overall Average Values:	52.8	39	3598	14.4	0.49	0.39	268	76.5
			Standard Deviation:	1.6	1	700	1.1	0.26	0.28	11	3.1
			Overall Maximum Value:	55.1	40	5470	17.0	1.50	1.50	288	82.3
			Overall Minimum Value:	49.7	36	2058	12.2	0.25	0.15	240	68.7

Summary of SPT Test Results

Project: Mobil B-53 Drill 23, Test Date: 5/17/2024

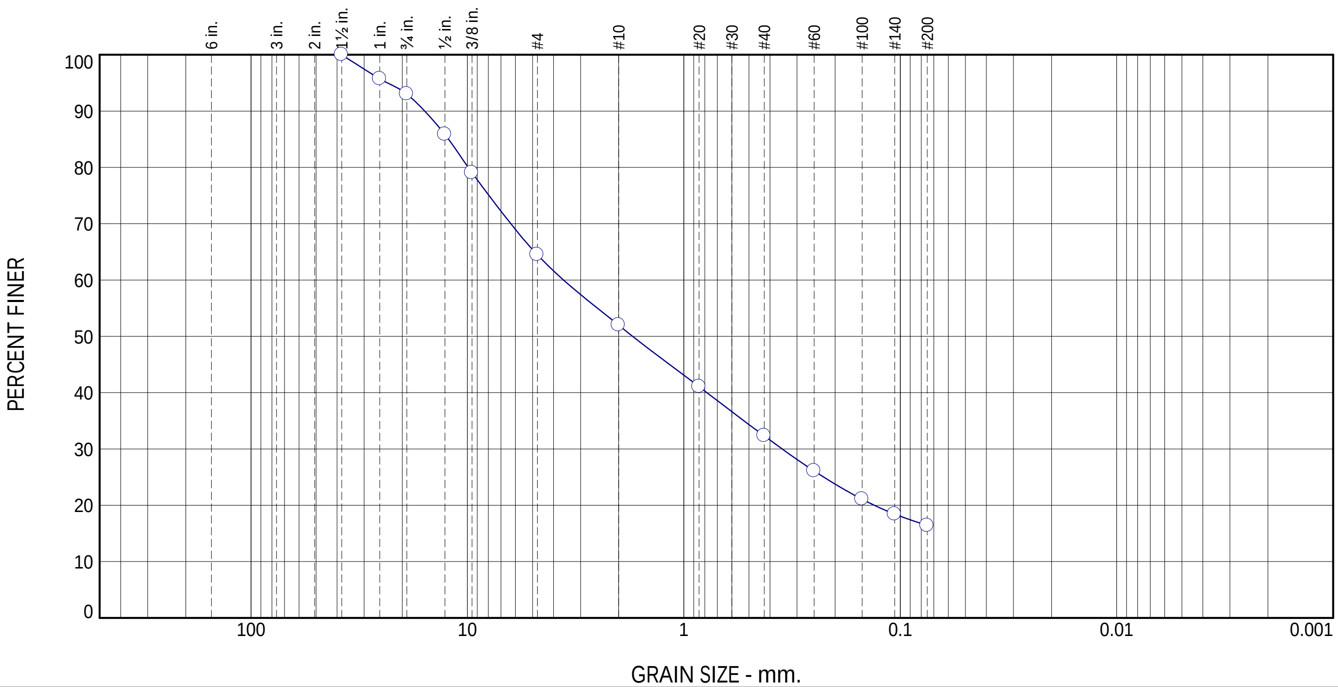
BPM: Blows/Minute
FMX: Maximum Force
AMX: Maximum Acceleration
VMX: Maximum Velocity

DMX: Maximum Displacement
DFN: Final Displacement
EMX: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Blows Applied /6"	**N Value**	**N60 Value**	Average BPM bpm	Average FMX kips	Average AMX g's	Average VMX ft/s	Average DMX in	Average DFN in	Average EMX ft-lb	Average ETR %
19.00	**5-6-5-3**	**11**	**15**	55.6	43	2146	21.3	1.26	1.09	280	80.1
23.00	**7-8-6-7**	**14**	**19**	55.7	42	2272	16.4	0.92	0.86	297	84.8
29.00	**2-6-4-3**	**10**	**13**	55.7	41	2174	17.2	1.37	1.20	288	82.3
31.00	**6-6-5-2**	**11**	**15**	55.7	42	2288	15.0	1.24	1.09	296	84.6
31.00	**3-10-11-9**	**21**	**29**	55.6	42	2130	14.5	0.63	0.57	294	84.1
			Overall Average Values:	55.7	42	2195	16.5	1.01	0.90	292	83.4
			Standard Deviation:	0.1	1	155	2.4	0.34	0.27	8	2.4
			Overall Maximum Value:	56.0	46	2719	21.7	1.77	1.50	313	89.3
			Overall Minimum Value:	55.4	40	1937	14.1	0.60	0.54	275	78.5

Appendix C Laboratory Testing

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	7.0	28.5	12.5	19.7	15.9	16.4	

Test Results (ASTM D6913)			
Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
1.5	100.0		
1	95.7		
.75	93.0		
.5	85.9		
.375	79.0		
#4	64.5		
#10	52.0		
#20	41.1		
#40	32.3		
#60	26.1		
#100	21.1		
#140	18.4		
#200	16.4		

* (no specification provided)

Material Description

Brown gravelly fine to coarse SAND, little silt

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 15.7274 D_{85}= 12.2067
D_{60}= 3.5963 D_{50}= 1.7251
D_{30}= 0.3511 D_{15}=
D_{10}=
C_u= C_c=

Sieve Test (ASTM D6913)

Test Date: 5/1/2024 Technician: sjr

Test Notes

Full sample tested. Moisture Content = 5.0 %

Hydrometer Test

Test Date: ____________ Technician: ____________

Test Notes

USCS (ASTM D2487)

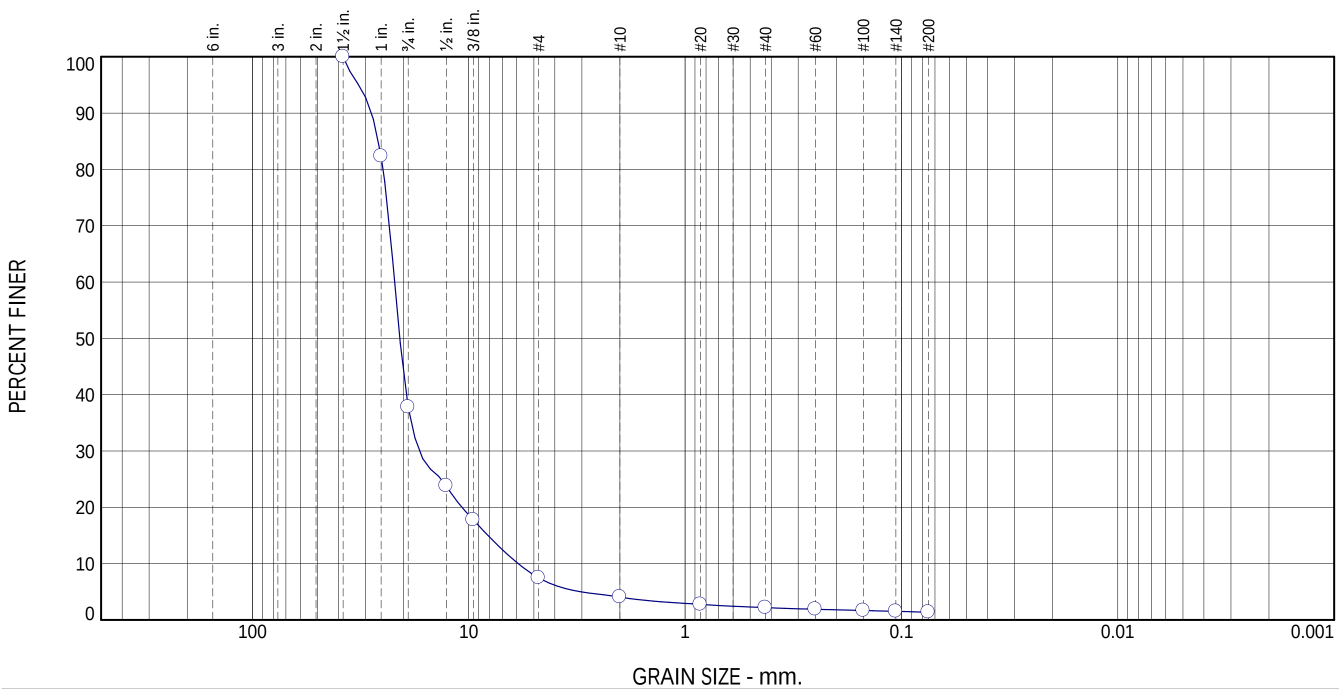
SM

Date Sampled: 4/18-23/2024
Date Received: 4/26/2024
Checked By: sjr
Title: ____________

Source of Sample: BB-DWS-101 Depth: 1.5 - 3.5
Sample Number: 1D

Soil Metrics LLC Cape Elizabeth, Maine	Client: GEI Consultants Project: WIN 026630.08 Large Culvert (#47382) Project No: GEI PN 2400963 - Task 1.1 Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	62.2	30.3	3.4	1.9	0.8	1.4	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
1.5	100.0		
1	82.4		
.75	37.8		
.5	23.8		
.375	17.8		
#4	7.5		
#10	4.1		
#20	2.8		
#40	2.2		
#60	1.9		
#100	1.7		
#140	1.5		
#200	1.4		

* (no specification provided)

Material Description

Brown fine to coarse GRAVEL, trace sand and silt

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 28.1414 D_{85}= 26.1455
D_{60}= 22.0086 D_{50}= 20.8144
D_{30}= 16.9349 D_{15}= 8.1489
D_{10}= 5.9158
C_u= 3.72 C_c= 2.20

Sieve Test (ASTM D6913)

Test Date: 5/1/2024 Technician:

Test Notes

Entire Sample tested. Moisture Content = 3.7 %

Hydrometer Test

Test Date: Technician:

Test Notes

USCS (ASTM D2487)

GP

Date Sampled: 4/18-23/2024
Date Received: 4/26/2024
Checked By: sjr
Title:

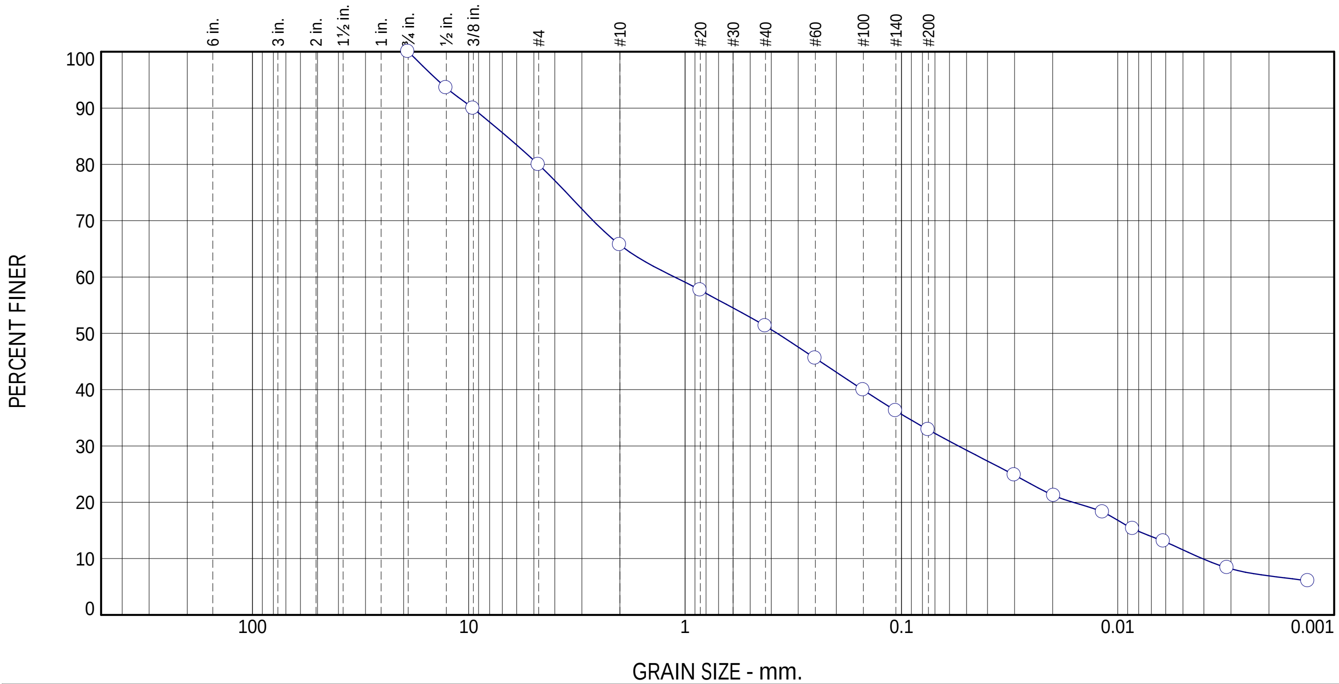
Source of Sample: BB-DWS-101 Depth: 14.0 - 16.0
Sample Number: 4D

Soil Metrics LLC

Cape Elizabeth, Maine

Client: GEI Consultants
Project: WIN 026630.08 Large Culvert (#47382)
Project No: GEI PN 2400963 - Task 1.1 Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	20.1	14.2	14.4	18.4	26.0	6.9

Test Results (ASTM D6913 and D422)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
.75	100.0		
.5	93.6		
.375	89.9		
#4	79.9		
#10	65.7		
#20	57.7		
#40	51.3		
#60	45.6		
#100	39.9		
#140	36.2		
#200	32.9		
0.0300 mm.	24.8		
0.0197 mm.	21.2		
0.0117 mm.	18.2		
0.0085 mm.	15.3		
0.0061 mm.	13.1		
0.0031 mm.	8.4		
0.0013 mm.	6.0		

* (no specification provided)

Material Description

Gravelly, Silty fine to coarse SAND.

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 9.5890 D_{85}= 6.6857
D_{60}= 1.1174 D_{50}= 0.3752
D_{30}= 0.0545 D_{15}= 0.0082
D_{10}= 0.0041
C_u= 274.69 C_c= 0.65

Sieve Test (ASTM D6913)

Test Date: 5/1/2024 Technician: sjr

Test Notes
Entire sample tested. Moisture Content = 9.3 %

Hydrometer Test (ASTM D422)

Test Date: 5/5/2024 Technician: sjr

Test Notes

USCS (ASTM D2487)

SM

Date Sampled: 4/18-23/2024
Date Received: 4/26/2024
Checked By: sjr
Title:

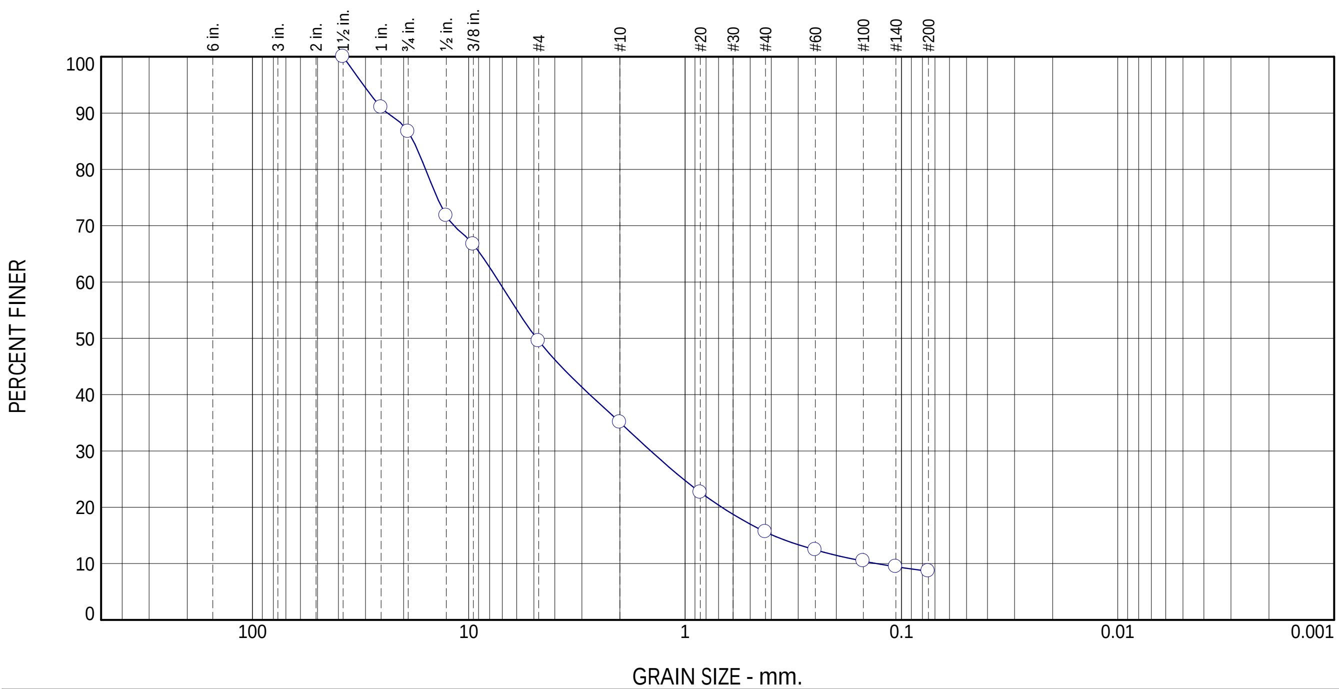
Source of Sample: BB-DWS-101 Depth: 24.0 - 25.9
Sample Number: 5D

Soil Metrics LLC

Cape Elizabeth, Maine

Client: GEI Consultants
Project: WIN 026630.08 Large Culvert (#47382)
Project No: GEI PN 2400963 - Task 1.1 Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	13.3	37.2	14.4	19.5	7.0	8.6	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
1.5	100.0		
1	91.0		
.75	86.7		
.5	71.8		
.375	66.7		
#4	49.5		
#10	35.1		
#20	22.6		
#40	15.6		
#60	12.4		
#100	10.4		
#140	9.4		
#200	8.6		

* (no specification provided)

Material Description

Brown sandy GRAVEL, trace silt.

Sieve Test (ASTM D6913)

Test Date: 5/1/2024 Technician: sjr

Test Notes

Entire sample tested. Moisture Content = 10.8 %

Hydrometer Test

Test Date: ______ Technician: ______

Test Notes

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 23.7899 D_{85}= 18.0007
D_{60}= 7.2327 D_{50}= 4.8538
D_{30}= 1.4406 D_{15}= 0.3925
D_{10}= 0.1304
C_u= 55.47 C_c= 2.20

USCS (ASTM D2487)

GW

Date Sampled: 4/18-23/2024
Date Received: 4/26/24
Checked By: sjr
Title: ______

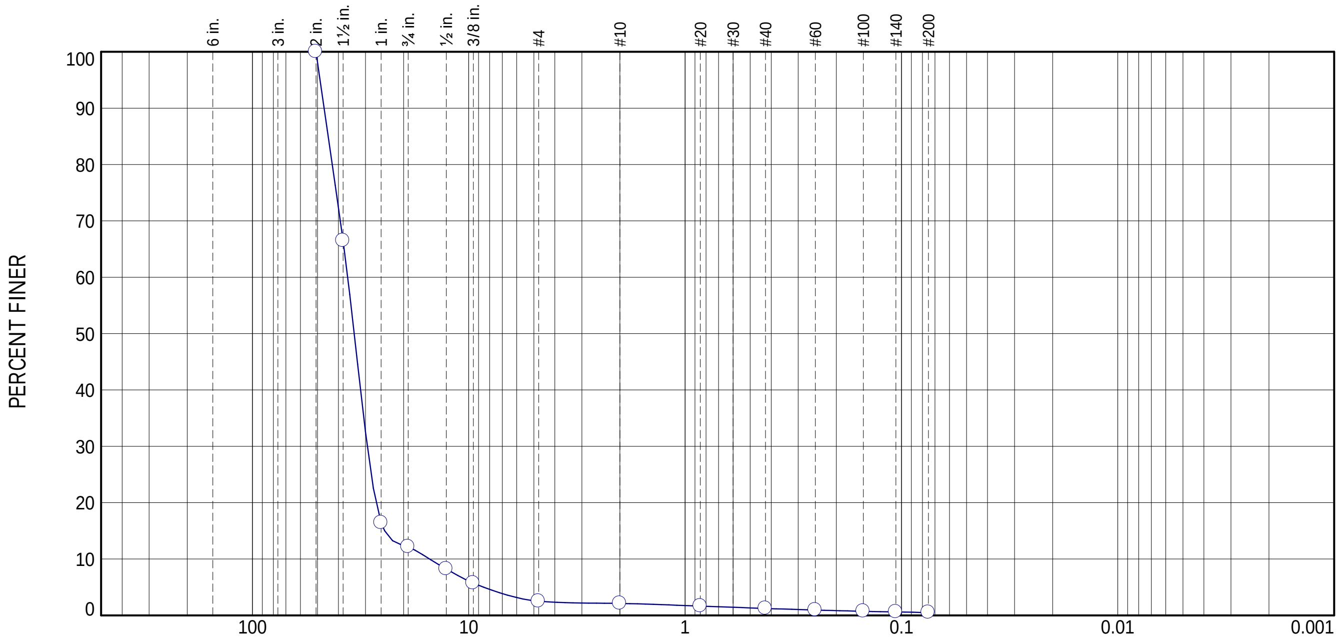
Source of Sample: BB-DWS-102 Depth: 9.0-11.0
Sample Number: 3D

Soil Metrics LLC

Cape Elizabeth, Maine

Client: GEI Consultants
Project: WIN 026630.08 Large Culvert (#47382)
Project No: GEI PN 2400963 - Task 1.1 Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	87.8	9.7	0.4	0.9	0.7	0.5	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
2	100.0		
1.5	66.5		
1	16.4		
.75	12.2		
.5	8.2		
.375	5.7		
#4	2.5		
#10	2.1		
#20	1.6		
#40	1.2		
#60	0.9		
#100	0.7		
#140	0.6		
#200	0.5		

* (no specification provided)

Material Description

Brown/Gray coarse GRAVEL, trace sand and silt.

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 46.5970 D_{85}= 44.6213
D_{60}= 36.2403 D_{50}= 33.8211
D_{30}= 29.4428 D_{15}= 24.4553
D_{10}= 15.1564
C_u= 2.39 C_c= 1.58

Sieve Test (ASTM D6913)

Test Date: 5/1/2024 Technician: sjr

Test Notes

Entire sample tested. Small sample considering size of particles. Moisture Content = 1.3 %

USCS (ASTM D2487)

GP

Hydrometer Test

Test Date: ____________ Technician: ____________

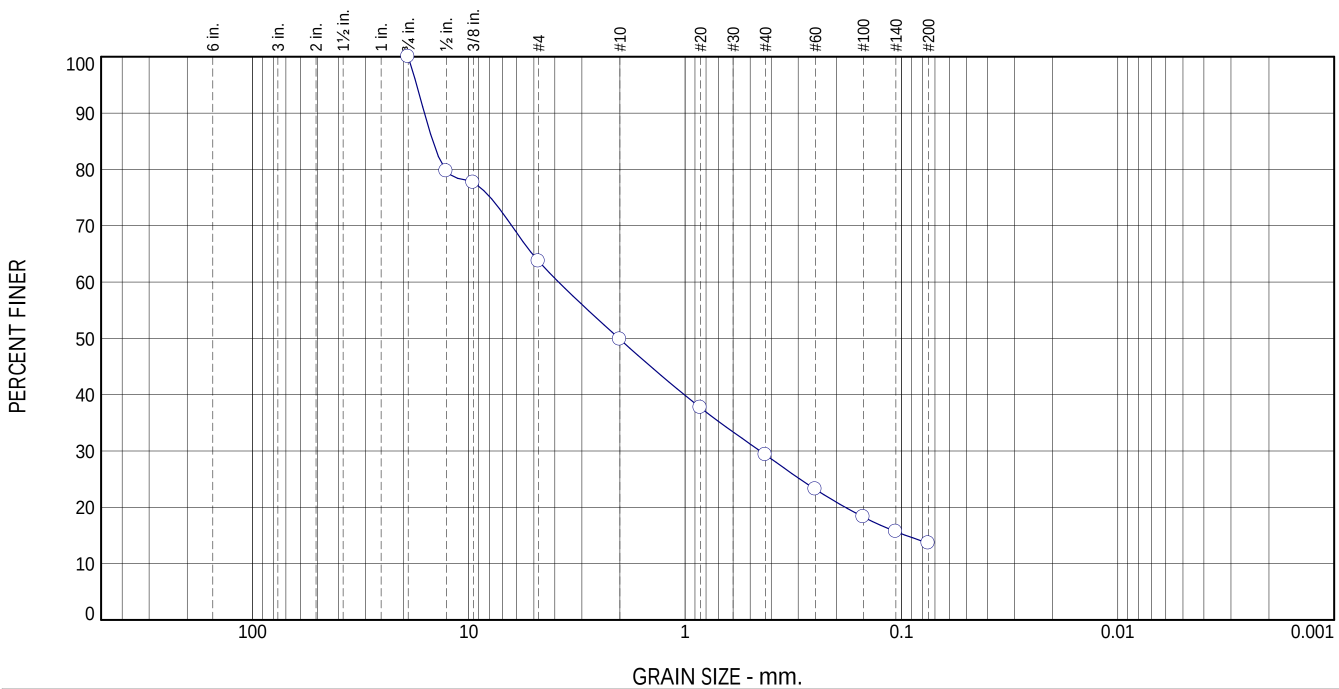
Test Notes

Date Sampled: 4/18-23/2024
Date Received: 4/26/2024
Checked By: sjr
Title: ____________

Source of Sample: BB-DWS-102 Depth: 19.0-21.0
Sample Number: 5D

Soil Metrics LLC Cape Elizabeth, Maine	Client: GEI Consultants Project: WIN 026630.08 Large Culvert (#47382) Project No: GEI PN 2400963 - Task 1.1 Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	36.3	13.9	20.5	15.7	13.6	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
.75	100.0		
.5	79.7		
.375	77.7		
#4	63.7		
#10	49.8		
#20	37.7		
#40	29.3		
#60	23.2		
#100	18.3		
#140	15.7		
#200	13.6		

* (no specification provided)

Material Description

Brown gravelly fine to coarse SAND, little silt.

Sieve Test (ASTM D6913)

Test Date: 5/1/2024 Technician: sjr

Test Notes

Entire Sample tested. Moisture Content = 5.2 %

Hydrometer Test

Test Date: Technician:

Test Notes

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 16.0124 D_{85}= 14.6456

D_{60}= 3.8417 D_{50}= 2.0225

D_{30}= 0.4503 D_{15}= 0.0954

D_{10}=

C_u= C_c=

USCS (ASTM D2487)

SM

Date Sampled: 4/18-23/2024

Date Received: 4/26/2024

Checked By: sjr

Title:

Source of Sample: BB-DWS-103 Depth: 4.0-6.0

Sample Number: 2D

Soil Metrics LLC

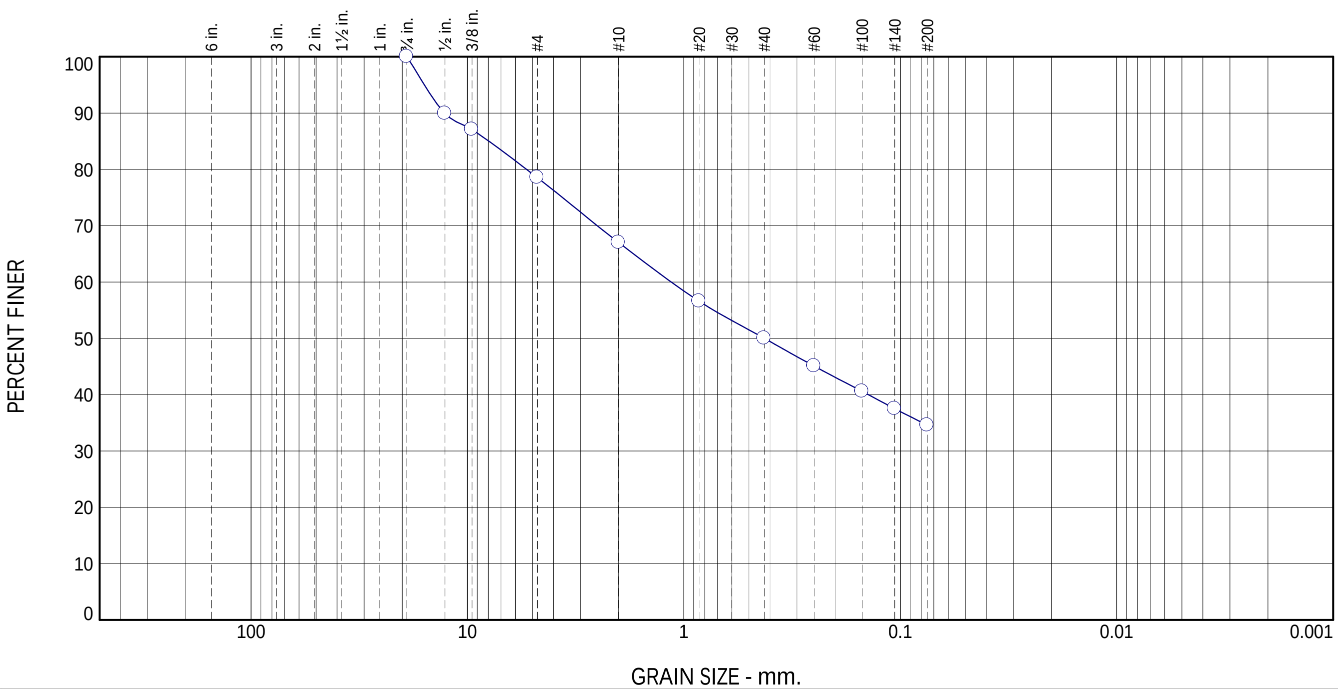
Cape Elizabeth, Maine

Client: GEI Consultants

Project: WIN 026630.08 Large Culvert (#47382)

Project No: GEI PN 2400963 - Task 1.1 Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	21.5	11.5	17.0	15.4	34.6	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
.75	100.0		
.5	89.9		
.375	87.1		
#4	78.5		
#10	67.0		
#20	56.6		
#40	50.0		
#60	45.1		
#100	40.6		
#140	37.5		
#200	34.6		

* (no specification provided)

Material Description

Silty gravelly fine to coarse SAND. Sample from 3" to 6" of recovery

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 12.7600 D_{85}= 7.9485
D_{60}= 1.1438 D_{50}= 0.4244
D_{30}= D_{15}=
D_{10}=
C_u= C_c=

Sieve Test (ASTM D6913)

Test Date: 5/1/2024 Technician: sjr

Test Notes
Entire sample tested. Moisture Content = 12.5 %

Hydrometer Test

Test Date: ______ Technician: ______

Test Notes

USCS (ASTM D2487)

SM

Date Sampled: 4/18-23/2024
Date Received: 4/26/2024
Checked By: sjr
Title: ______

Source of Sample: BB-DWS-103 Depth: 14.0-14.7
Sample Number: 4D

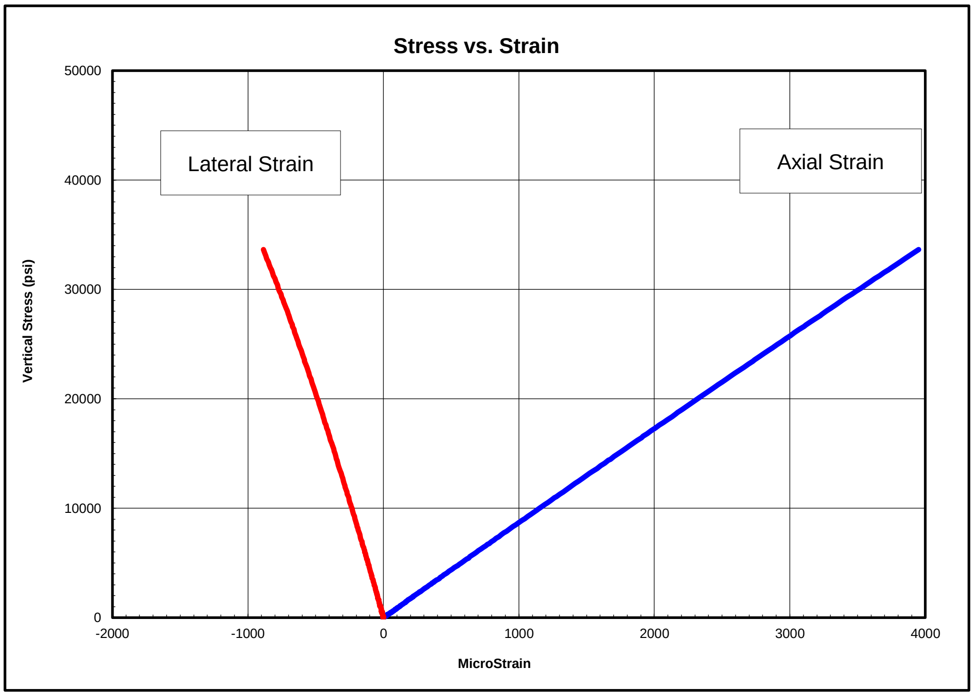
Soil Metrics LLC

Cape Elizabeth, Maine

Client: GEI Consultants
Project: WIN 026630.08 Large Culvert (#47382)
Project No: GEI PN 2400963 - Task 1.1 Figure

Client:	GEI Consultants, Inc.
Project Name:	Large Culvert #47382 Replacement
Project Location:	Dennysville, ME
GTX #:	319168
Test Date:	6/10/2024
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-DWS-101
Sample ID:	R1
Depth, ft:	30.39-30.76
Sample Type:	rock core
Sample Description:	See photographs Intact material failure Best Effort end preparation performed

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 33,644 psi

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
3400-12300	8,630,000	0.21
12300-21300	8,550,000	0.22
21300-30300	8,390,000	0.24

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

Client:	GEI Consultants, Inc.	Test Date:	6/7/2024
Project Name:	Large Culvert #47382 Replacement	Tested By:	gp
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	319168		
Boring ID:	BB-DWS-101		
Sample ID:	R1		
Depth (ft):	30.39-30.76		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average		
Specimen Length, in:	4.35	4.35	4.35		
Specimen Diameter, in:	1.97	1.97	1.97		
Specimen Mass, g:	612.18				
Bulk Density, lb/ft^3	176	**Minimum Diameter Tolerence Met?**		**YES**	
Length to Diameter Ratio:	2.2	**Length to Diameter Ratio Tolerance Met?**		**YES**	

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap $\leq$ 0.02 in.? YES

Maximum difference must be < 0.020 in.

Straightness Tolerance Met? **YES**

END FLATNESS AND PARALLELISM (Procedure FP1)

END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00120	0.00100	0.00090	0.00070	0.00060	0.00030	0.00020	0.00000	0.00000	-0.00020	-0.00050	-0.00070	-0.00090	-0.00110	-0.00150
Diameter 2, in (rotated 90°)	-0.00010	-0.00010	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

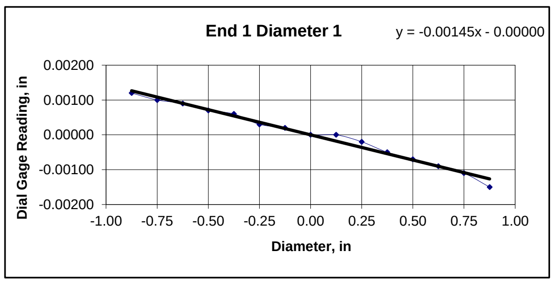
Difference between max and min readings, in:
0° = 0.00270 90° = 0.00010

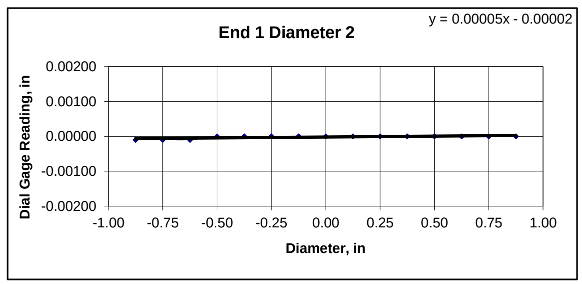
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00120	0.00100	0.00090	0.00070	0.00050	0.00030	0.00010	0.00000	0.00000	-0.00030	-0.00040	-0.00070	-0.00080	-0.00110	-0.00140
Diameter 2, in (rotated 90°)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00010	-0.00020

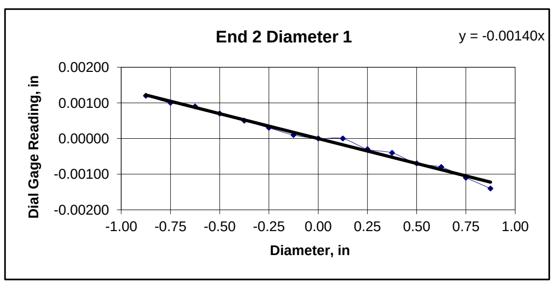
Difference between max and min readings, in:
0° = 0.0026 90° = 0.0002

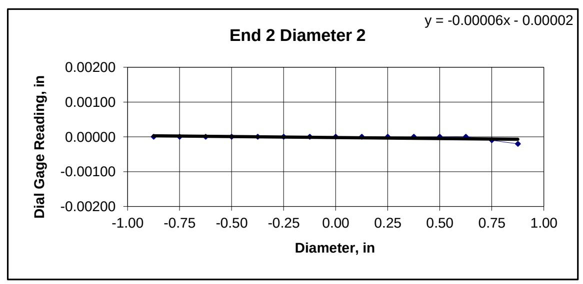
Maximum difference must be < 0.0020 in. Difference = $\pm$ 0.00135

Flatness Tolerance Met? **NO**









DIAMETER 1

End 1:		
	Slope of Best Fit Line	0.00145
	Angle of Best Fit Line:	0.08283
End 2:		
	Slope of Best Fit Line	0.00140
	Angle of Best Fit Line:	0.08005
Maximum Angular Difference:		0.00278

Parallelism Tolerance Met? **YES**
Spherically Seated

DIAMETER 2

End 1:		
	Slope of Best Fit Line	0.00005
	Angle of Best Fit Line:	0.00295
End 2:		
	Slope of Best Fit Line	0.00006
	Angle of Best Fit Line:	0.00327
Maximum Angular Difference:		0.00033

Parallelism Tolerance Met? **YES**
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00270	1.970	0.00137	0.079	YES
Diameter 2, in (rotated 90°)	0.00010	1.970	0.00005	0.003	YES
END 2					
Diameter 1, in	0.00260	1.970	0.00132	0.076	YES
Diameter 2, in (rotated 90°)	0.00020	1.970	0.00010	0.006	YES

Maximum angle of departure must be $\leq$ 0.25°

Perpendicularity Tolerance Met? **YES**

Client:	GEI Consultants, Inc.	Test Date:	6/7/2024
Project Name:	Large Culvert #47382 Replacement	Tested By:	gp
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	319168		
Boring ID:	BB-DWS-101	Reliable dial gauge measurements could not be performed on this rock type. Tolerance measurements were performed using a machinist straightedge and feeler gauges to ASTM specifications.	
Sample ID:	R1		
Depth (ft):	30.39-30.76		
Visual Description:	See photographs		

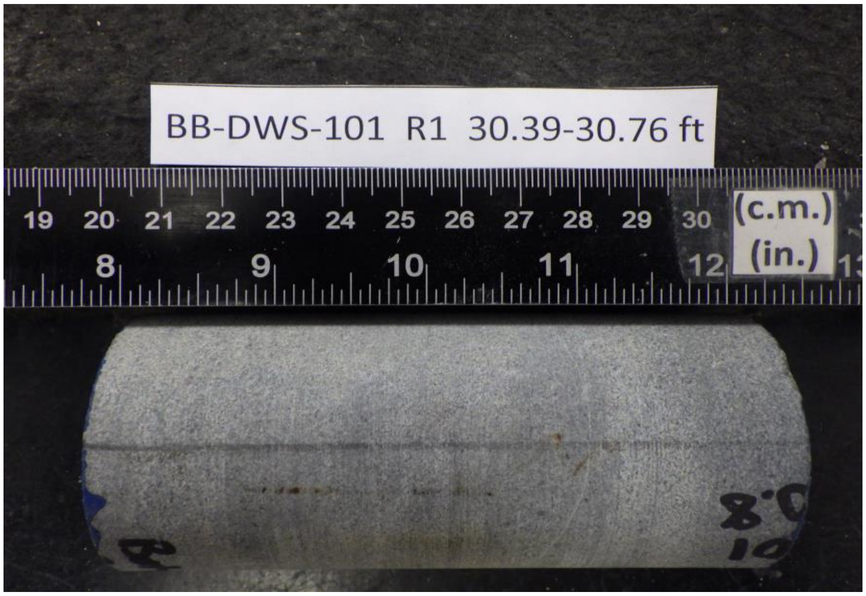
BEST EFFORT END FLATNESS TOLERANCES OF ROCK CORE SPECIMENS TO ASTM D4543

END FLATNESS

END 1		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90^{o})	Is the maximum gap $\leq \pm 0.001$ in.?	YES
END 2		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90^{o})	Is the maximum gap $\leq \pm 0.001$ in.?	YES

End Flatness Tolerance Met? YES

Client:	GEI Consultants, Inc.
Project Name:	Large Culvert #47382 Replacement
Project Location:	Dennysville, ME
GTX #:	319168
Test Date:	6/10/2024
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-DWS-101
Sample ID:	R1
Depth, ft:	30.39-30.76

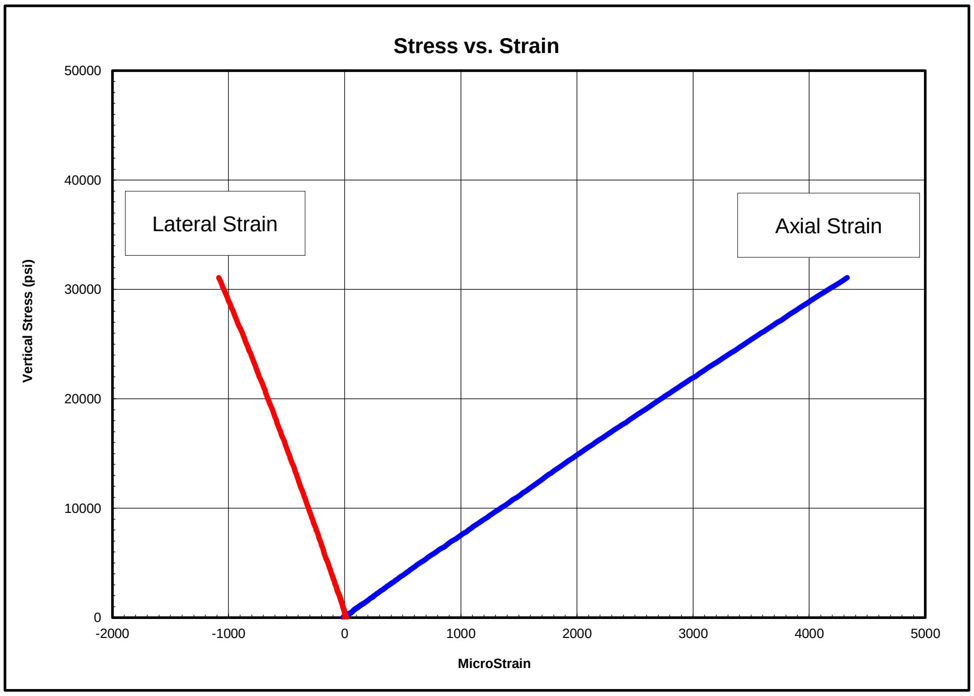


After cutting and grinding

After break

Client:	GEI Consultants, Inc.
Project Name:	Large Culvert #47382 Replacement
Project Location:	Dennysville, ME
GTX #:	319168
Test Date:	6/10/2024
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-DWS-102
Sample ID:	R1
Depth, ft:	23.96-24.34
Sample Type:	rock core
Sample Description:	See photographs Intact material failure Best Effort end preparation performed

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 31,077 psi

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
3100-11400	7,270,000	0.24
11400-19700	7,230,000	0.25
19700-28000	6,960,000	0.26

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

GeoTesting EXPRESS

Client:	GEI Consultants, Inc.	Test Date:	6/7/2024
Project Name:	Large Culvert #47382 Replacement	Tested By:	gp
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	319168		
Boring ID:	BB-DWS-102		
Sample ID:	R1		
Depth (ft):	23.96-24.34		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average	
Specimen Length, in:	4.41	4.41	4.41	
Specimen Diameter, in:	1.97	1.97	1.97	
Specimen Mass, g:	604.46			
Bulk Density, lb/ft^3	171	**Minimum Diameter Tolerence Met?**		**YES**
Length to Diameter Ratio:	2.2	**Length to Diameter Ratio Tolerance Met?**		**YES**

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap $\leq$ 0.02 in.? YES

Maximum difference must be < 0.020 in.
Straightness Tolerance Met? **YES**

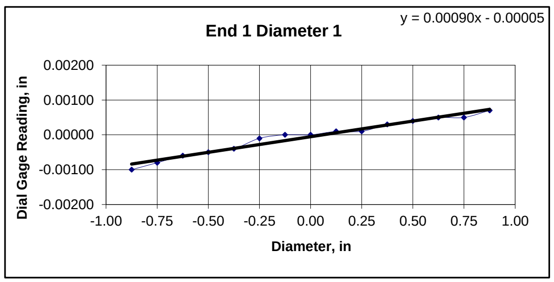
END FLATNESS AND PARALLELISM (Procedure FP1)

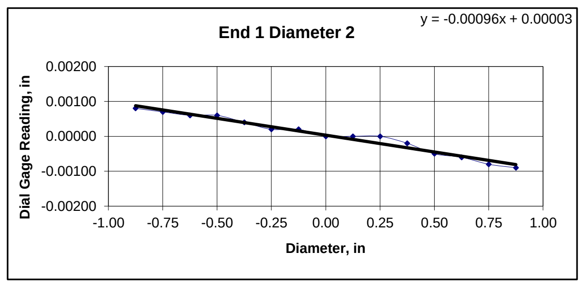
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00100	-0.00080	-0.00060	-0.00050	-0.00040	-0.00010	0.00000	0.00000	0.00010	0.00010	0.00030	0.00040	0.00050	0.00050	0.00070
Diameter 2, in (rotated 90°)	0.00080	0.00070	0.00060	0.00060	0.00040	0.00020	0.00020	0.00000	0.00000	0.00000	-0.00020	-0.00050	-0.00060	-0.00080	-0.00090

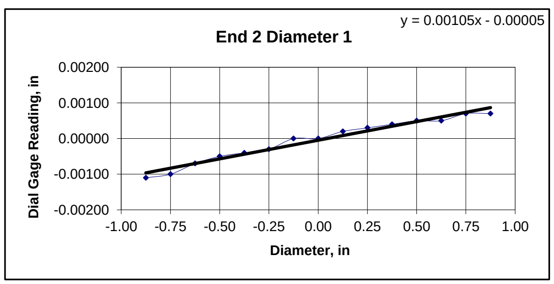
Difference between max and min readings, in:
0° = 0.00170 90° = 0.00170

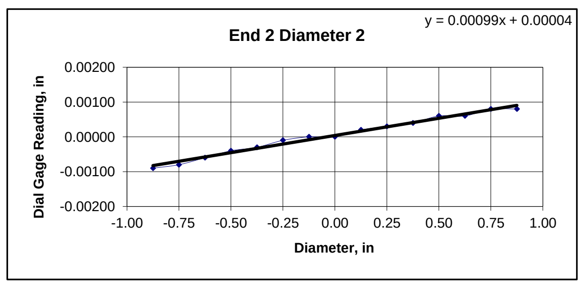
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00110	-0.00100	-0.00070	-0.00050	-0.00040	-0.00030	0.00000	0.00000	0.00020	0.00030	0.00040	0.00050	0.00050	0.00070	0.00070
Diameter 2, in (rotated 90°)	-0.00090	-0.00080	-0.00060	-0.00040	-0.00030	-0.00010	0.00000	0.00000	0.00020	0.00030	0.00040	0.00060	0.00060	0.00080	0.00080

Difference between max and min readings, in:
0° = 0.0018 90° = 0.0017
Maximum difference must be < 0.0020 in. Difference = $\pm$ 0.00090
Flatness Tolerance Met? **YES**









DIAMETER 1

End 1:
Slope of Best Fit Line 0.00090
Angle of Best Fit Line: 0.05140

End 2:
Slope of Best Fit Line 0.00105
Angle of Best Fit Line: 0.05991

Maximum Angular Difference: 0.00851

Parallelism Tolerance Met? **NO**
Spherically Seated

DIAMETER 2

End 1:
Slope of Best Fit Line 0.00096
Angle of Best Fit Line: 0.05517

End 2:
Slope of Best Fit Line 0.00099
Angle of Best Fit Line: 0.05664

Maximum Angular Difference: 0.00147

Parallelism Tolerance Met? **YES**
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00170	1.970	0.00086	0.049	YES
Diameter 2, in (rotated 90°)	0.00170	1.970	0.00086	0.049	YES
END 2					
Diameter 1, in	0.00180	1.970	0.00091	0.052	YES
Diameter 2, in (rotated 90°)	0.00170	1.970	0.00086	0.049	YES

Maximum angle of departure must be $\leq$ 0.25°
Perpendicularity Tolerance Met? **YES**

Client:	GEI Consultants, Inc.	Test Date:	6/7/2024
Project Name:	Large Culvert #47382 Replacement	Tested By:	gp
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	319168		
Boring ID:	BB-DWS-102	Reliable dial gauge measurements could not be performed on this rock type. Tolerance measurements were performed using a machinist straightedge and feeler gauges to ASTM specifications.	
Sample ID:	R1		
Depth (ft):	23.96-24.34		
Visual Description:	See photographs		

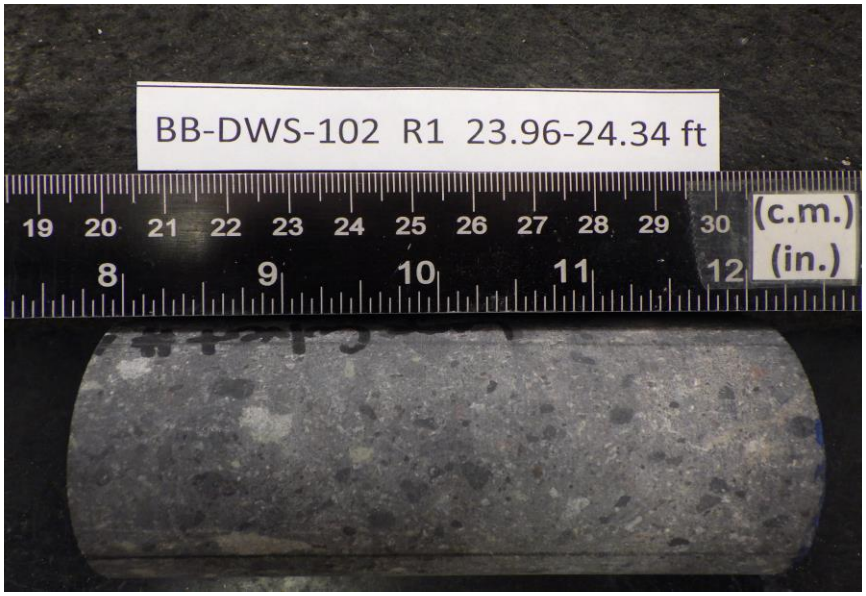
BEST EFFORT END FLATNESS TOLERANCES OF ROCK CORE SPECIMENS TO ASTM D4543

END FLATNESS

END 1		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90^{o})	Is the maximum gap $\leq \pm 0.001$ in.?	YES
END 2		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90^{o})	Is the maximum gap $\leq \pm 0.001$ in.?	YES

End Flatness Tolerance Met? YES

Client:	GEI Consultants, Inc.
Project Name:	Large Culvert #47382 Replacement
Project Location:	Dennysville, ME
GTX #:	319168
Test Date:	6/10/2024
Tested By:	gp
Checked By:	smd
Boring ID:	BB-DWS-102
Sample ID:	R1
Depth, ft:	23.96-24.34



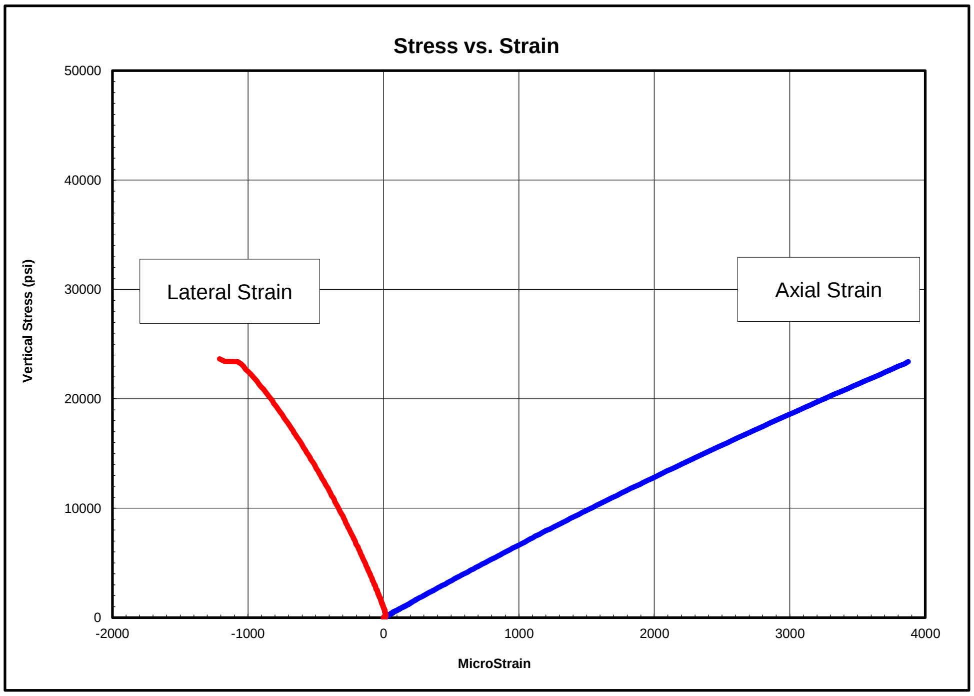
After cutting and grinding

After break

GeoTesting EXPRESS
A SERCEL COMPANY

Client:	GEI Consultants, Inc.
Project Name:	Large Culvert #47382 Replacement
Project Location:	Dennysville, ME
GTX #:	319168
Test Date:	6/10/2024
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-DWS-103A
Sample ID:	R1
Depth, ft:	17.24-17.62
Sample Type:	rock core
Sample Description:	See photographs Intact material failure Best Effort end preparation performed

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 23,650 psi

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
2400-8700	6,540,000	0.24
8700-15000	6,030,000	0.27
15000-21300	5,610,000	0.31

Notes:
Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

Client:	GEI Consultants, Inc.	Test Date:	6/7/2024
Project Name:	Large Culvert #47382 Replacement	Tested By:	gp
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	319168		
Boring ID:	BB-DWS-103A		
Sample ID:	R1		
Depth (ft):	17.24-17.62		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average		
Specimen Length, in:	4.43	4.43	4.43		
Specimen Diameter, in:	1.97	1.97	1.97		
Specimen Mass, g:	611.16				
Bulk Density, lb/ft^3	172			**Minimum Diameter Tolerence Met?**	**YES**
Length to Diameter Ratio:	2.2			**Length to Diameter Ratio Tolerance Met?**	**YES**

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap $\leq$ 0.02 in.? YES

Maximum difference must be < 0.020 in.
Straightness Tolerance Met? **YES**

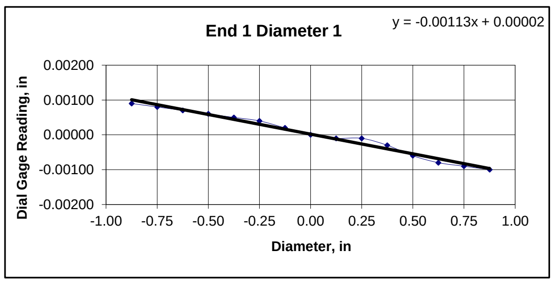
END FLATNESS AND PARALLELISM (Procedure FP1)

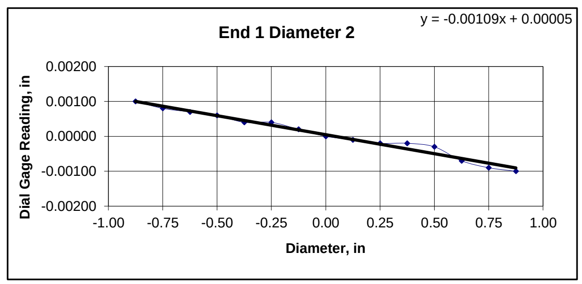
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00090	0.00080	0.00070	0.00060	0.00050	0.00040	0.00020	0.00000	-0.00010	-0.00010	-0.00030	-0.00060	-0.00080	-0.00090	-0.00100
Diameter 2, in (rotated 90°)	0.00100	0.00080	0.00070	0.00060	0.00040	0.00040	0.00020	0.00000	-0.00010	-0.00020	-0.00020	-0.00030	-0.00070	-0.00090	-0.00100

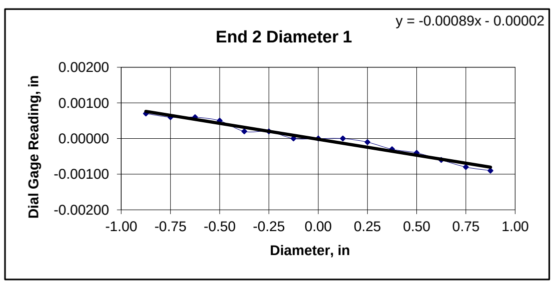
Difference between max and min readings, in:
0° = 0.00190 90° = 0.00200

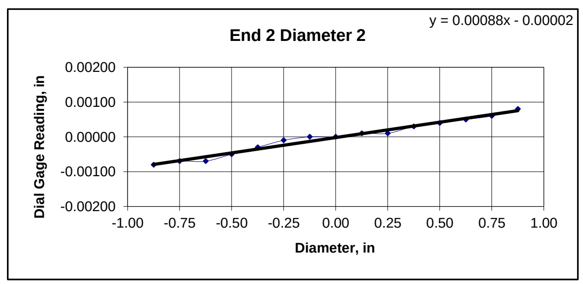
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00070	0.00060	0.00060	0.00050	0.00020	0.00020	0.00000	0.00000	0.00000	-0.00010	-0.00030	-0.00040	-0.00060	-0.00080	-0.00090
Diameter 2, in (rotated 90°)	-0.00080	-0.00070	-0.00070	-0.00050	-0.00030	-0.00010	0.00000	0.00000	0.00010	0.00010	0.00030	0.00040	0.00050	0.00060	0.00080

Difference between max and min readings, in:
0° = 0.0016 90° = 0.0016
Maximum difference must be < 0.0020 in. Difference = $\pm$ 0.00100
Flatness Tolerance Met? **NO**









DIAMETER 1

End 1:		
	Slope of Best Fit Line	0.00113
	Angle of Best Fit Line:	0.06466
End 2:		
	Slope of Best Fit Line	0.00089
	Angle of Best Fit Line:	0.05124
Maximum Angular Difference:		0.01342

Parallelism Tolerance Met? **NO**
Spherically Seated

DIAMETER 2

End 1:		
	Slope of Best Fit Line	0.00109
	Angle of Best Fit Line:	0.06237
End 2:		
	Slope of Best Fit Line	0.00088
	Angle of Best Fit Line:	0.05058
Maximum Angular Difference:		0.01179

Parallelism Tolerance Met? **NO**
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00190	1.970	0.00096	0.055	YES
Diameter 2, in (rotated 90°)	0.00200	1.970	0.00102	0.058	YES
END 2					
Diameter 1, in	0.00160	1.970	0.00081	0.047	YES
Diameter 2, in (rotated 90°)	0.00160	1.970	0.00081	0.047	YES

Maximum angle of departure must be $\leq$ 0.25°
Perpendicularity Tolerance Met? **YES**

Client:	GEI Consultants, Inc.	Test Date:	6/7/2024
Project Name:	Large Culvert #47382 Replacement	Tested By:	gp
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	319168		
Boring ID:	BB-DWS-103A	Reliable dial gauge measurements could not be performed on this rock type. Tolerance measurements were performed using a machinist straightedge and feeler gauges to ASTM specifications.	
Sample ID:	R1		
Depth (ft):	17.24-17.62		
Visual Description:	See photographs		

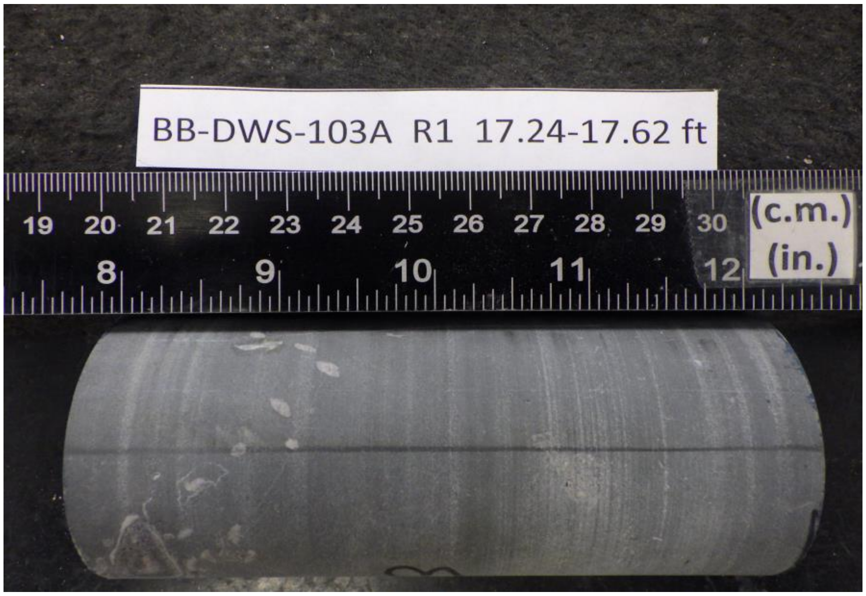
BEST EFFORT END FLATNESS TOLERANCES OF ROCK CORE SPECIMENS TO ASTM D4543

END FLATNESS

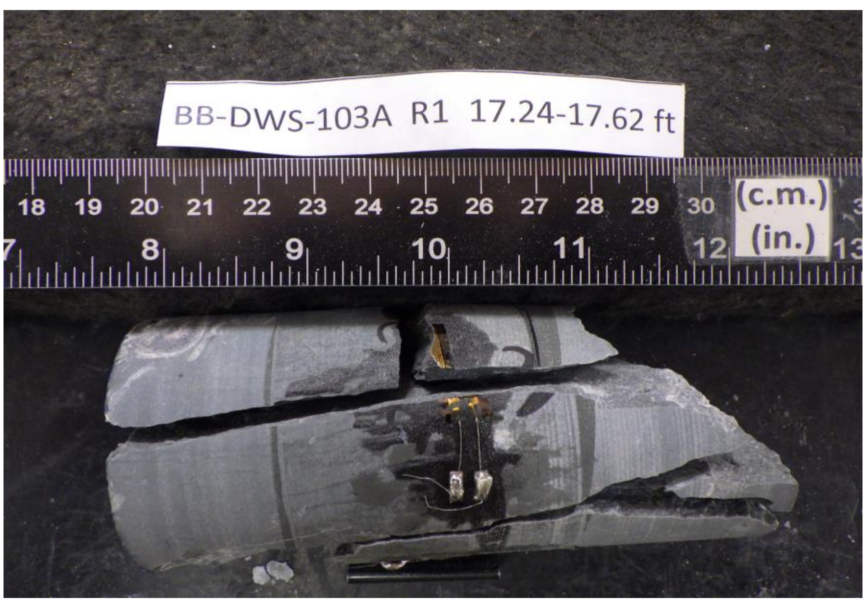
END 1		
Diameter 1	Is the maximum gap $\leq \pm0.001$ in.?	YES
Diameter 2 (rotated 90^{o})	Is the maximum gap $\leq \pm0.001$ in.?	YES
END 2		
Diameter 1	Is the maximum gap $\leq \pm0.001$ in.?	YES
Diameter 2 (rotated 90^{o})	Is the maximum gap $\leq \pm0.001$ in.?	YES

End Flatness Tolerance Met? YES

Client:	GEI Consultants, Inc.
Project Name:	Large Culvert #47382 Replacement
Project Location:	Dennysville, ME
GTX #:	319168
Test Date:	6/10/2024
Tested By:	gp
Checked By:	smd
Boring ID:	BB-DWS-103A
Sample ID:	R1
Depth, ft:	17.24-17.62

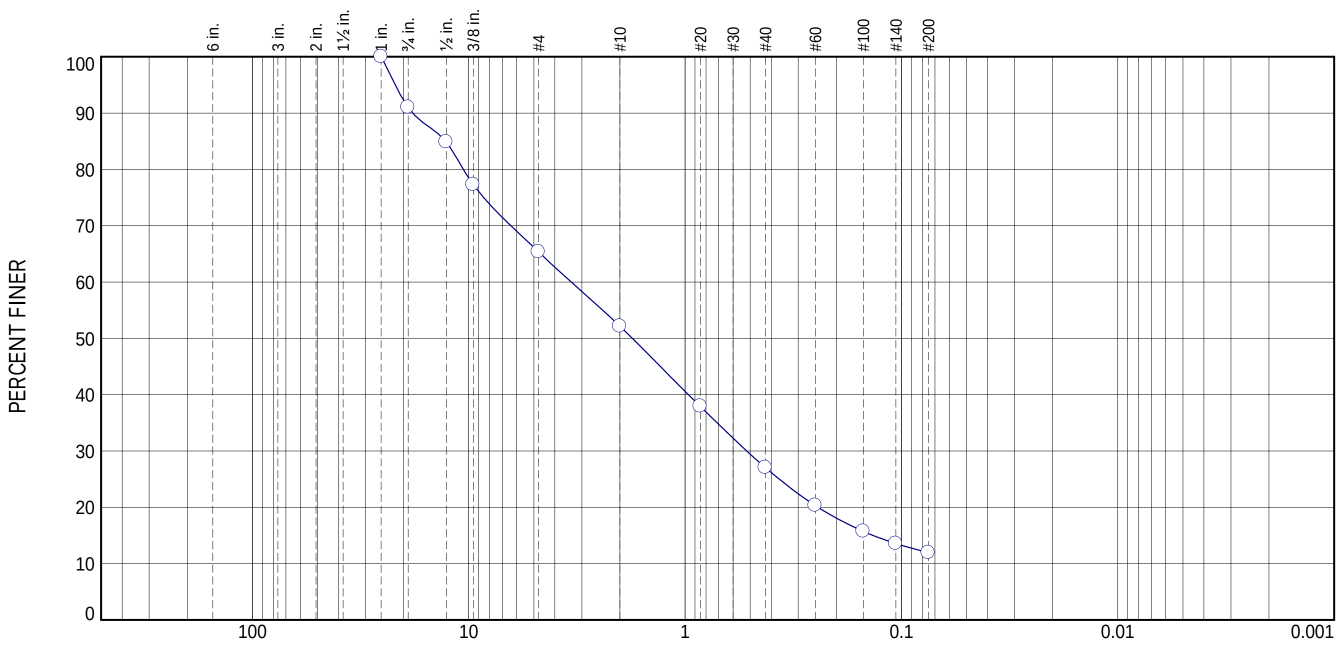


After cutting and grinding



After break

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	9.0	25.7	13.2	25.1	15.1	11.9	

Test Results (ASTM D6913)			
Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
1	100.0		
.75	91.0		
.5	84.8		
.375	77.3		
#4	65.3		
#10	52.1		
#20	37.9		
#40	27.0		
#60	20.3		
#100	15.7		
#140	13.6		
#200	11.9		

* (no specification provided)

Material Description

Gravelly fine to medium SAND with little silt.

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 18.1565 D_{85}= 12.7984
D_{60}= 3.3594 D_{50}= 1.7527
D_{30}= 0.5190 D_{15}= 0.1356
D_{10}=
C_u= C_c=

Sieve Test (ASTM D6913)

Test Date: 5/23/2025 Technician: sjr

Test Notes

Entire sample tested. As-received moisture content = 8.2%

Hydrometer Test

Test Date: ____________ Technician: ____________

Test Notes

USCS (ASTM D2487)

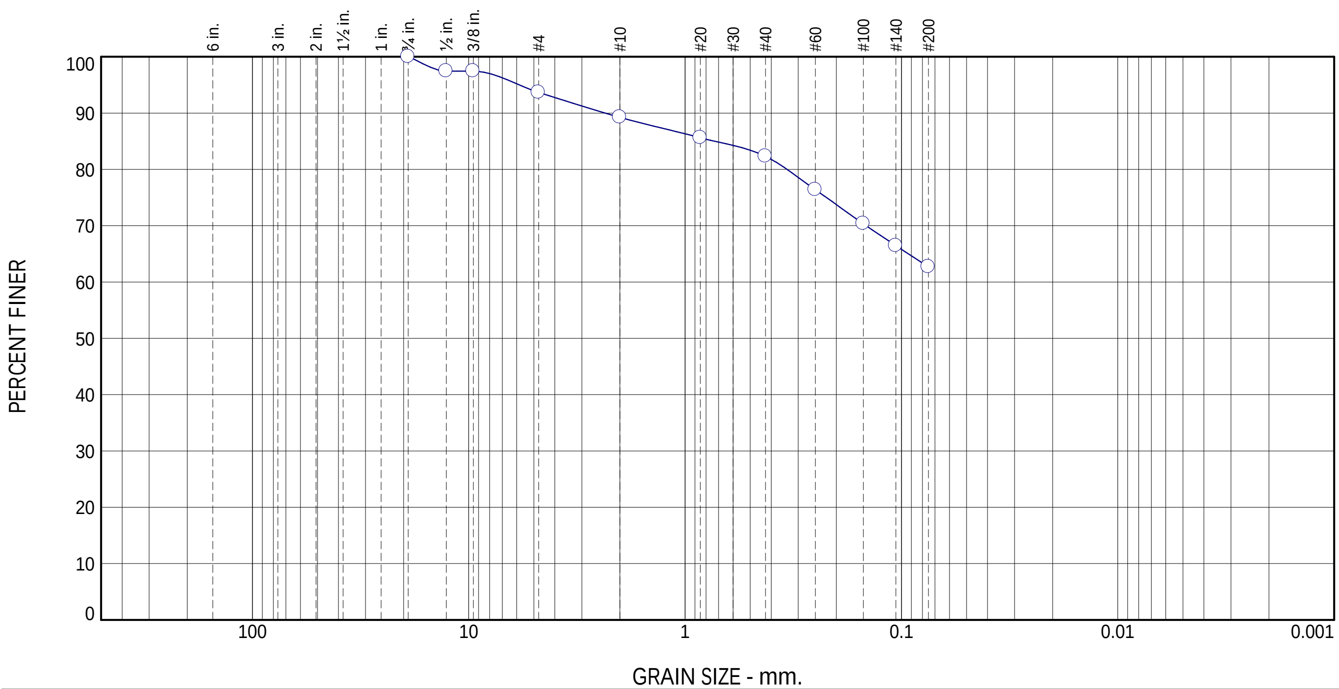
SW-SM

Date Sampled: 5/19-5/20/2025
Date Received: 5/22/2025
Checked By: sjr
Title: ____________

Source of Sample: BB-DWS-201 Depth: 4-6
Sample Number: 2D

Soil Metrics LLC Cape Elizabeth, Maine	Client: GEI Consultants Project: WIN 026630.08 Benjamin Lincoln Bridge # 6740 Dennysville, ME Project No: GEI PN 2502334, Task 1.1 Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	6.3	4.5	6.9	19.6	62.7	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
.75	100.0		
.5	97.4		
.375	97.4		
#4	93.7		
#10	89.2		
#20	85.6		
#40	82.3		
#60	76.4		
#100	70.3		
#140	66.4		
#200	62.7		

* (no specification provided)

Material Description

Sandy CLAY, little fine gravel

Atterberg (ASTM D4318)

PL= 15.1 LL= 24.5 PI= 9.4

Coefficients

D_{90}= 2.3400 D_{85}= 0.7297
D_{60}= D_{50}=
D_{30}= D_{15}=
D_{10}=
C_u= C_c=

Sieve Test (ASTM D6913)

Test Date: 5/23/2025 Technician: sjr

Test Notes

Entire sample tested. Sample was air dried for Atterberg Limits. Air dried as-received moisture content = 11.2%.

Hydrometer Test

Test Date: ____________ Technician: ____________

Test Notes

USCS (ASTM D2487)

CL

Date Sampled: 5/19-5/20/2025
Date Received: 5/22/2025
Checked By: sjr
Title: ____________

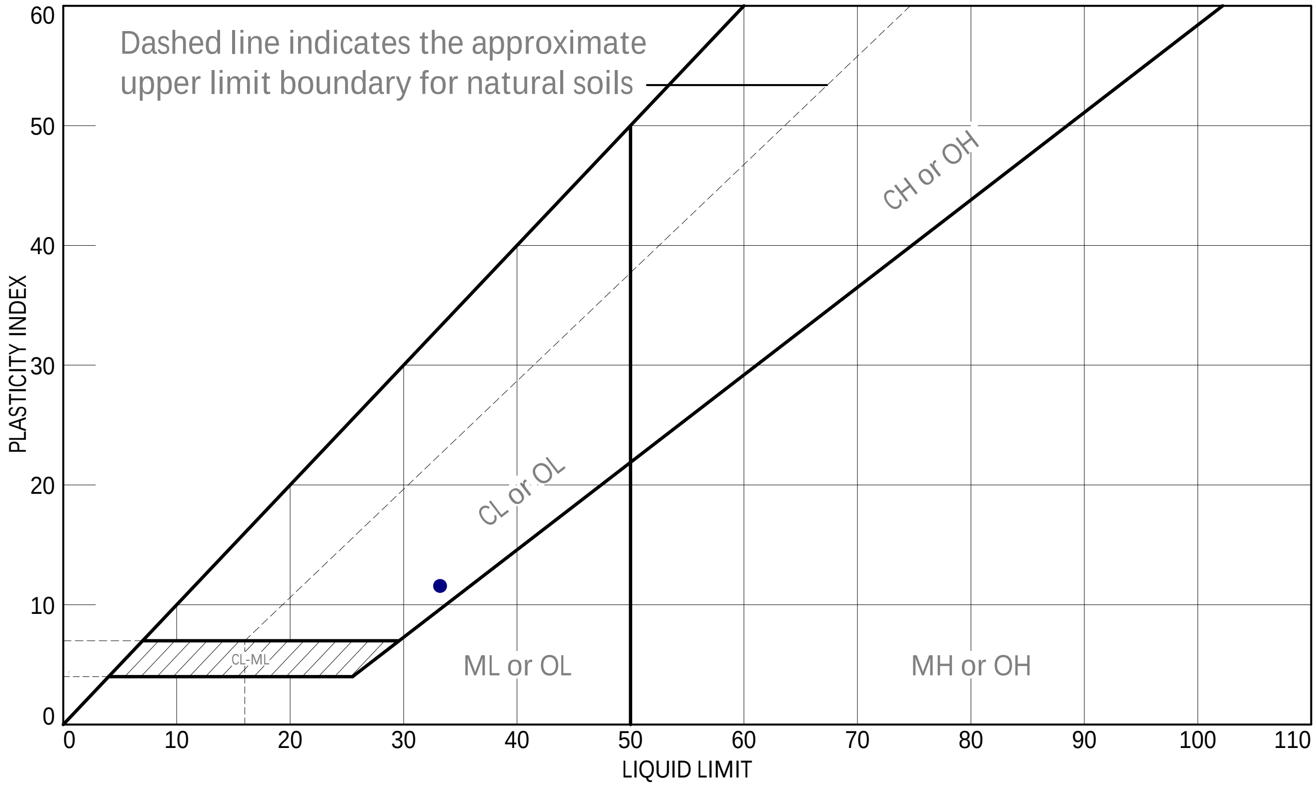
Source of Sample: BB-DWS-202 Depth: 14-15.6
Sample Number: 4D

Soil Metrics LLC

Cape Elizabeth, Maine

Client: GEI Consultants
Project: WIN 026630.08 Benjamin Lincoln Bridge # 6740
Dennysville, ME
Project No: GEI PN 2502334, Task 1.1 Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	SOIL DATA								
	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LIQUIDITY INDEX	USCS
●	BB-DWS-201A	3D	15-17	21.8	21.8	33.3	11.5	0.0	CL

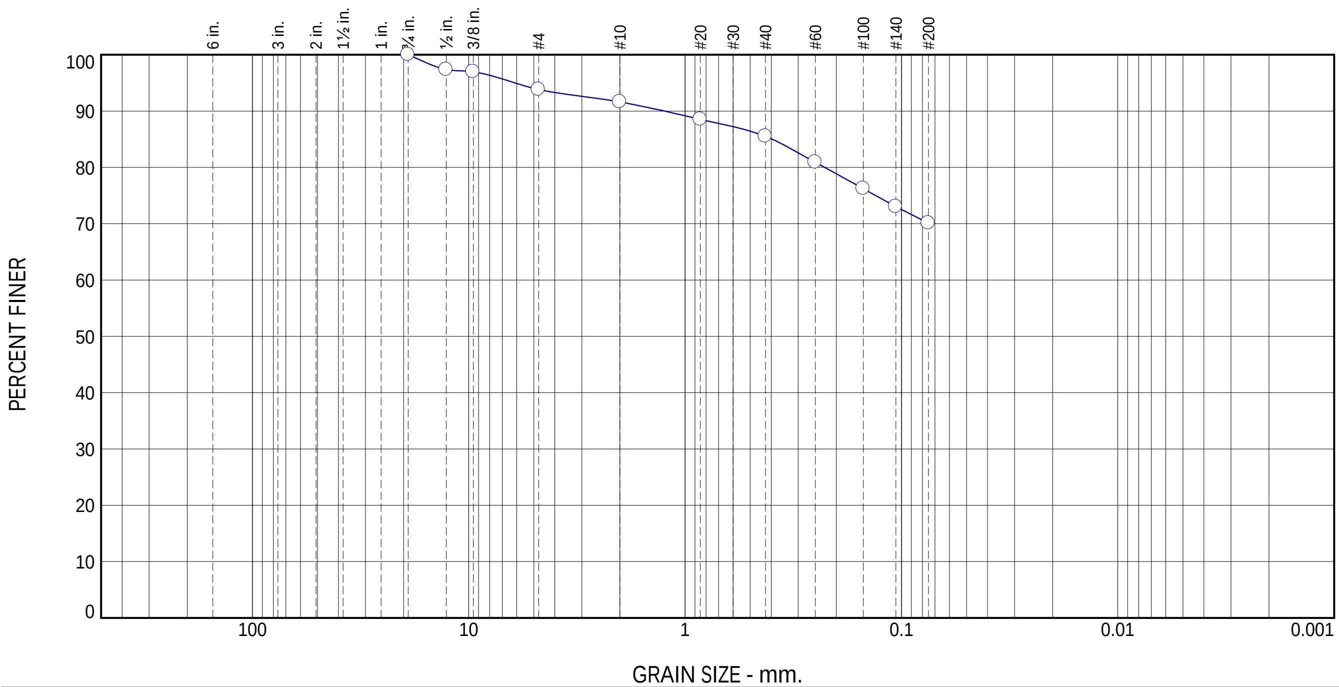
Soil Metrics LLC

Cape Elizabeth, Maine

Client: GEI Consultants
Project: WIN 026630.08 Benjamin Lincoln Bridge # 6740
Dennysville, ME
Project No.: GEI PN 2502334, Task 1.1 Figure

Tested By: sjr Checked By: sjr

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	6.2	2.2	6.1	15.4	70.1	

Test Results (ASTM D6913)			
Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
.75	100.0		
.5	97.4		
.375	97.0		
#4	93.8		
#10	91.6		
#20	88.5		
#40	85.5		
#60	80.9		
#100	76.2		
#140	73.0		
#200	70.1		

* (no specification provided)

Material Description

CLAY with sand and fine gravel.

Sieve Test (ASTM D6913)

Test Date: 5/23/2025 Technician: sjr

Test Notes

Entire sample tested. Sample air dried for Atterberg Limits.
Air dried as-received moisture content = 21.8%.

Hydrometer Test

Test Date: ______ Technician: ______

Test Notes

Atterberg (ASTM D4318)

PL= 21.8 LL= 33.3 PI= 11.5

Coefficients

D_{90}= 1.2453 D_{85}= 0.3948
D_{60}= D_{50}=
D_{30}= D_{15}=
D_{10}=
C_u= C_c=

USCS (ASTM D2487)

CL

Date Sampled: 5/19-5/20//2025
Date Received: 5/22/2025
Checked By: sjr
Title: ______

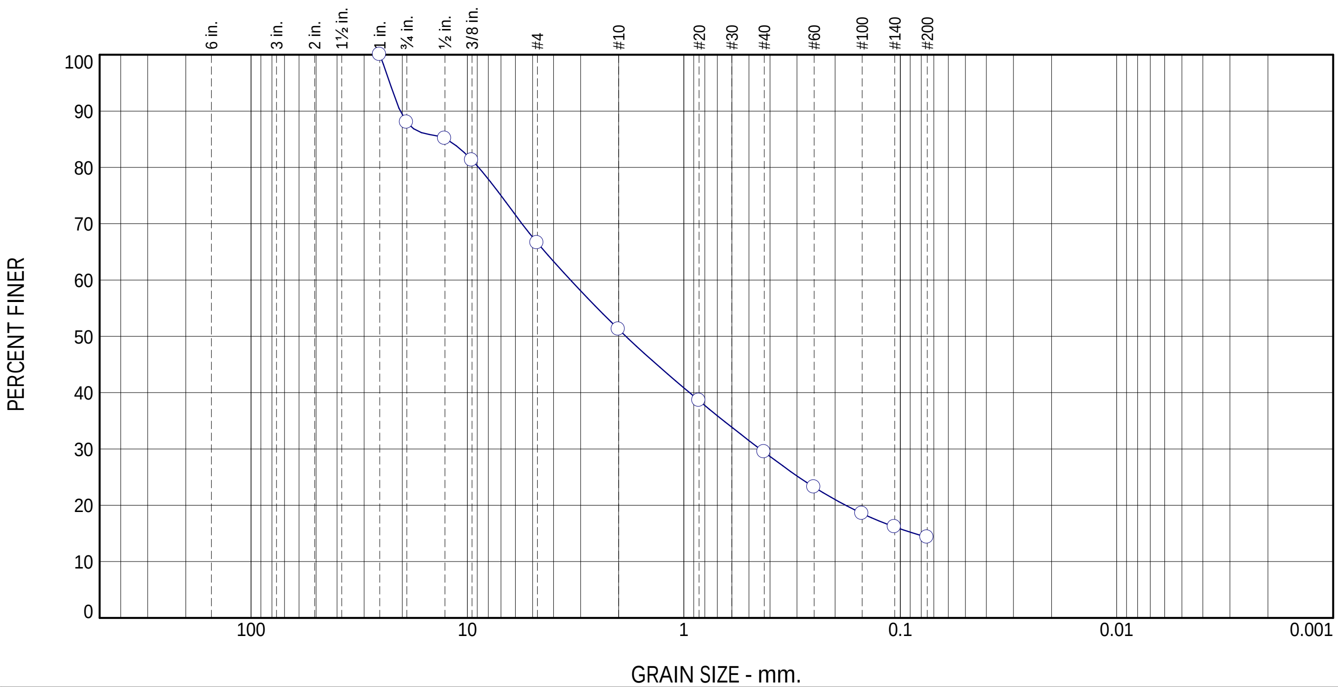
Source of Sample: BB-DWS-201A Depth: 15-17
Sample Number: 3D

Soil Metrics LLC

Cape Elizabeth, Maine

Client: GEI Consultants
Project: WIN 026630.08 Benjamin Lincoln Bridge # 6740
Dennysville, ME
Project No: GEI PN 2502334, Task 1.1 Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	12.0	21.4	15.4	21.8	15.1	14.3	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
1	100.0		
.75	88.0		
.5	85.1		
.375	81.3		
#4	66.6		
#10	51.2		
#20	38.6		
#40	29.4		
#60	23.2		
#100	18.5		
#140	16.1		
#200	14.3		

* (no specification provided)

Material Description

Gravelly fine to coarse SAND, little silt.

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 20.4264 D_{85}= 12.5237
D_{60}= 3.3397 D_{50}= 1.8523
D_{30}= 0.4449 D_{15}= 0.0861
D_{10}=
C_u= C_c=

Sieve Test (ASTM D6913)

Test Date: 5/23/2025 Technician: sjr

Test Notes

Entire sample tested. As-received moisture content = 9.4%

USCS (ASTM D2487)

SM

Hydrometer Test

Test Date: ____ Technician: ____

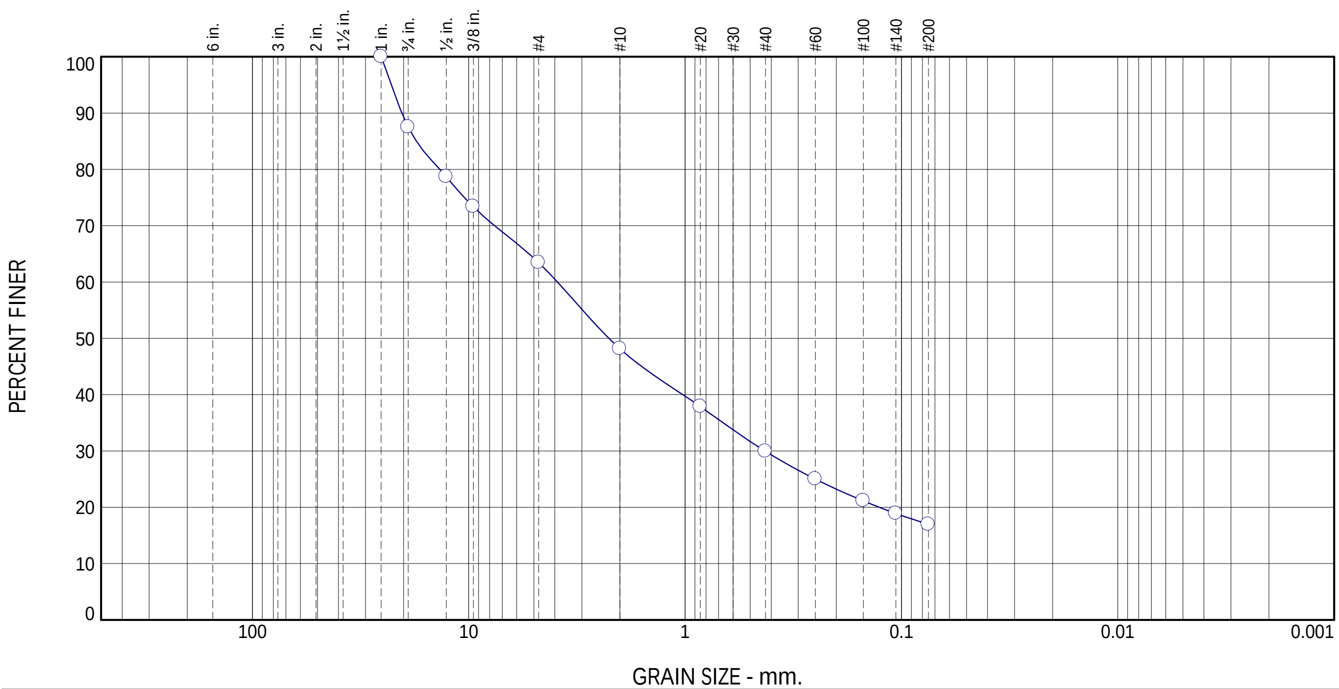
Test Notes

Date Sampled: 5/19-5/20/2025
Date Received: 5/22/2025
Checked By: sjr
Title: ____

Source of Sample: BB-DWS-201A Depth: 19-21
Sample Number: 4D

Soil Metrics LLC Cape Elizabeth, Maine	Client: GEI Consultants Project: WIN 026630.08 Benjamin Lincoln Bridge # 6740 Dennysville, ME Project No: GEI PN 2502334, Task 1.1 Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	12.5	24.1	15.3	18.2	12.9	17.0	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)
1	100.0		
.75	87.5		
.5	78.7		
.375	73.4		
#4	63.4		
#10	48.1		
#20	37.9		
#40	29.9		
#60	25.0		
#100	21.1		
#140	18.9		
#200	17.0		

* (no specification provided)

Material Description

Gravelly fine to coarse SAND, little silt.

Atterberg (ASTM D4318)

PL= LL= PI=

Coefficients

D_{90}= 20.3687 D_{85}= 17.4458
D_{60}= 3.8885 D_{50}= 2.2508
D_{30}= 0.4280 D_{15}=
D_{10}=
C_u= C_c=

Sieve Test (ASTM D6913)

Test Date: 5/23/2025 Technician: sjr

Test Notes

Entire sample tested As-received moisture content = 13.1%

Hydrometer Test

Test Date: ______ Technician: ______

Test Notes

USCS (ASTM D2487)

SM

Date Sampled: 5/19-5/20/2025
Date Received: 5/22/2025
Checked By: sjr
Title: ______

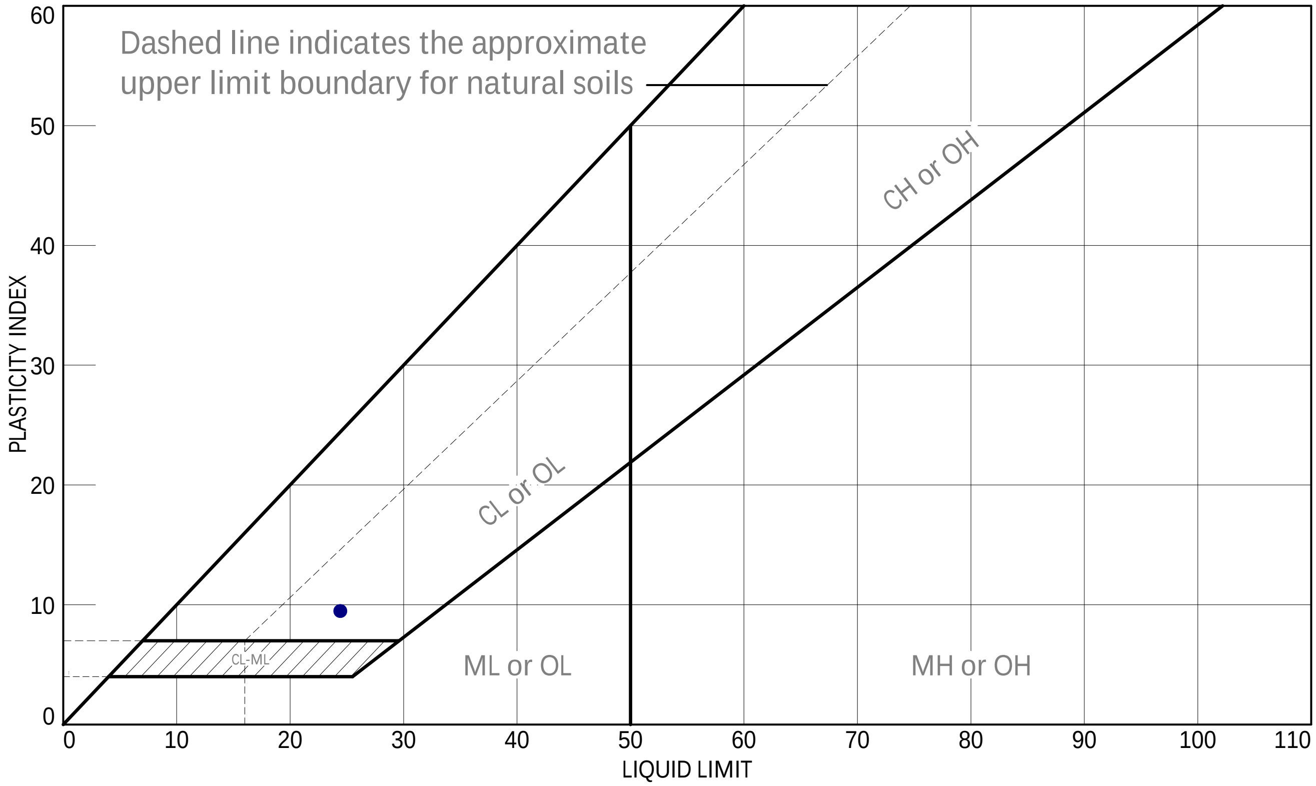
Source of Sample: BB-DWS-202 Depth: 9-11
Sample Number: 3D

Soil Metrics LLC

Cape Elizabeth, Maine

Client: GEI Consultants
Project: WIN 026630.08 Benjamin Lincoln Bridge # 6740
Dennysville, ME
Project No: GEI PN 2502334, Task 1.1 Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

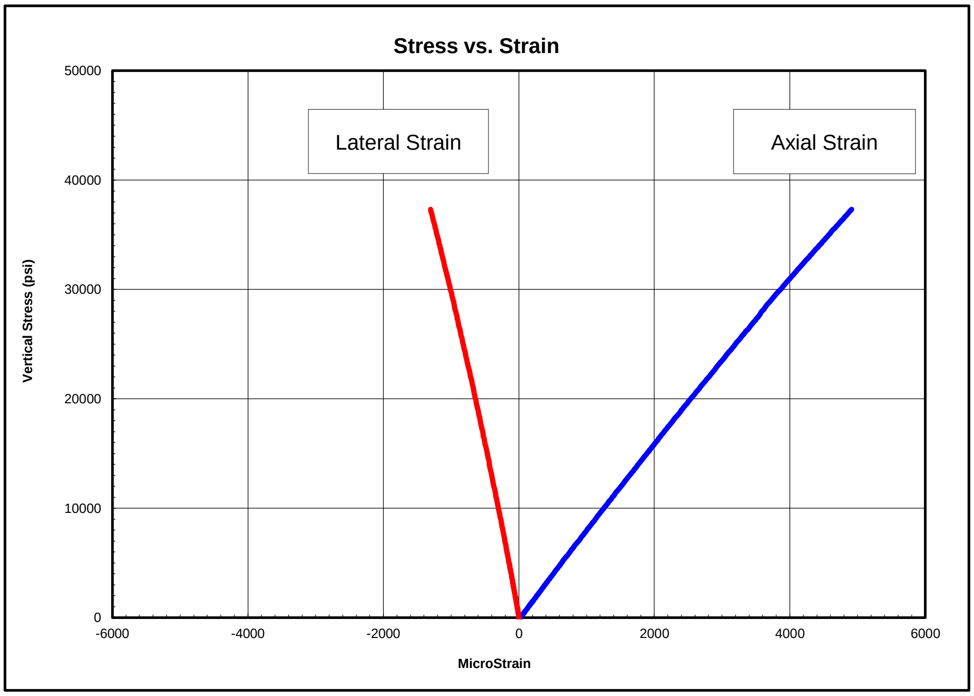
	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LIQUIDITY INDEX	USCS
●	BB-DWS-202	4D	14-15.6	11.2	15.1	24.5	9.4	-0.4	CL

Soil Metrics LLC Cape Elizabeth, Maine	Client: GEI Consultants Project: WIN 026630.08 Benjamin Lincoln Bridge # 6740 Dennysville, ME Project No.: GEI PN 2502334, Task 1.1 Figure

Tested By: sjr Checked By: sjr

Client:	GEI Consultants, Inc.
Project Name:	WIN 26630.08 Benjamin Lincoln Br. Rep.
Project Location:	Dennysville, ME
GTX #:	321116
Test Date:	6/5/2025
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-DWS-201A
Sample ID:	R4
Depth, ft:	29.52-29.90
Sample Type:	rock core
Sample Description:	See photographs Intact material failure Best Effort end preparation performed

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 40,859 psi

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
4100-15000	7,950,000	0.26
15000-25900	7,630,000	0.27
25900-36800	7,140,000	0.28

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

Client:	GEI Consultants, Inc.	Test Date:	6/4/2025
Project Name:	WIN 26630.08 Benjamin Lincoln Br. Rep.	Tested By:	jss
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	321116		
Boring ID:	BB-DWS-201A		
Sample ID:	R4		
Depth (ft):	29.52-29.90		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average	
Specimen Length, in:	4.35	4.35	4.35	
Specimen Diameter, in:	1.99	1.99	1.99	
Specimen Mass, g:	610.62			
Bulk Density, lb/ft^3	172	**Minimum Diameter Tolerence Met?**		**YES**
Length to Diameter Ratio:	2.2	**Length to Diameter Ratio Tolerance Met?**		**YES**

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap $\leq$ 0.02 in.? YES

Maximum difference must be < 0.020 in.
Straightness Tolerance Met? **YES**

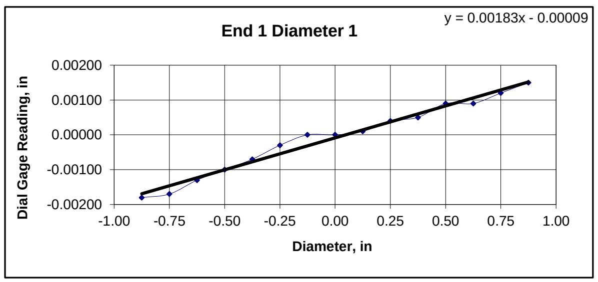
END FLATNESS AND PARALLELISM (Procedure FP1)

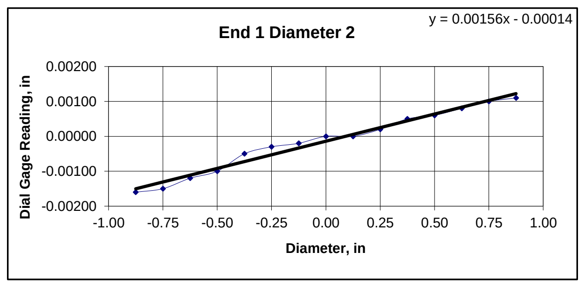
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00180	-0.00170	-0.00130	-0.00100	-0.00070	-0.00030	0.00000	0.00000	0.00010	0.00040	0.00050	0.00090	0.00090	0.00120	0.00150
Diameter 2, in (rotated 90°)	-0.00160	-0.00150	-0.00120	-0.00100	-0.00050	-0.00030	-0.00020	0.00000	0.00000	0.00020	0.00050	0.00060	0.00080	0.00100	0.00110

Difference between max and min readings, in:
0° = 0.00330 90° = 0.00270

END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00180	-0.00150	-0.00100	-0.00090	-0.00070	-0.00030	0.00000	0.00000	0.00010	0.00040	0.00090	0.00090	0.00100	0.00120	0.00150
Diameter 2, in (rotated 90°)	0.00120	0.00120	0.00090	0.00070	0.00070	0.00030	0.00000	0.00000	-0.00010	-0.00030	-0.00050	-0.00080	-0.00100	-0.00140	-0.00150

Difference between max and min readings, in:
0° = 0.0033 90° = 0.0027
Maximum difference must be < 0.0020 in. Difference = $\pm$ 0.00165
Flatness Tolerance Met? **NO**





DIAMETER 1

End 1:

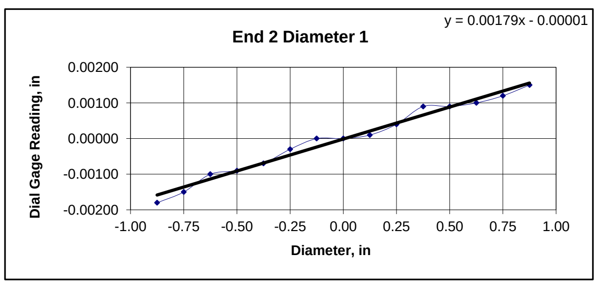
Slope of Best Fit Line	0.00183
Angle of Best Fit Line:	0.10510

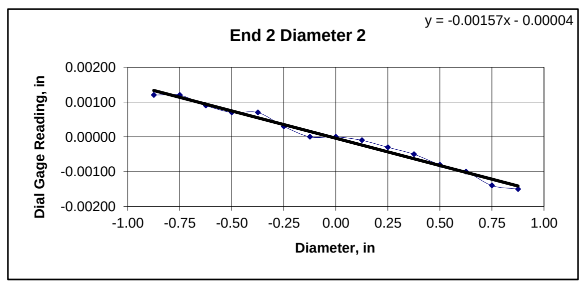
End 2:

Slope of Best Fit Line	0.00179
Angle of Best Fit Line:	0.10280

Maximum Angular Difference: 0.00229

Parallelism Tolerance Met? **YES**
Spherically Seated





DIAMETER 2

End 1:

Slope of Best Fit Line	0.00156
Angle of Best Fit Line:	0.08922

End 2:

Slope of Best Fit Line	0.00157
Angle of Best Fit Line:	0.08987

Maximum Angular Difference: 0.00065

Parallelism Tolerance Met? **YES**
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

Maximum angle of departure must be $\leq$ 0.25°

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00330	1.988	0.00166	0.095	YES
Diameter 2, in (rotated 90°)	0.00270	1.988	0.00136	0.078	YES
END 2					
Diameter 1, in	0.00330	1.988	0.00166	0.095	YES
Diameter 2, in (rotated 90°)	0.00270	1.988	0.00136	0.078	YES

Perpendicularity Tolerance Met? **YES**

Client:	GEI Consultants, Inc.	Test Date:	6/4/2025
Project Name:	WIN 26630.08 Benjamin Lincoln Br. Rep.	Tested By:	jss
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	321116		
Boring ID:	BB-DWS-201A	Reliable dial gauge measurements could not be performed on this rock type. Tolerance measurements were performed using a machinist straightedge and feeler gauges to ASTM specifications.	
Sample ID:	R4		
Depth (ft):	29.52-29.90		
Visual Description:	See photographs		

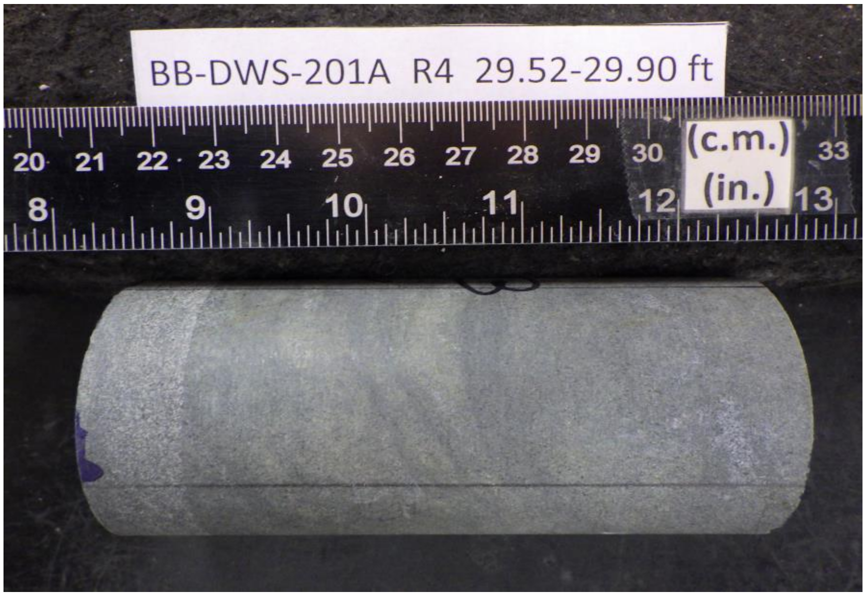
BEST EFFORT END FLATNESS TOLERANCES OF ROCK CORE SPECIMENS TO ASTM D4543

END FLATNESS

END 1		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90^{o})	Is the maximum gap $\leq \pm 0.001$ in.?	YES
END 2		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90^{o})	Is the maximum gap $\leq \pm 0.001$ in.?	YES

End Flatness Tolerance Met? YES

Client:	GEI Consultants, Inc.
Project Name:	WIN 26630.08 Benjamin Lincoln Br. Rep.
Project Location:	Dennysville, ME
GTX #:	321116
Test Date:	6/5/2025
Tested By:	gp
Checked By:	smd
Boring ID:	BB-DWS-201A
Sample ID:	R4
Depth, ft:	29.52-29.90

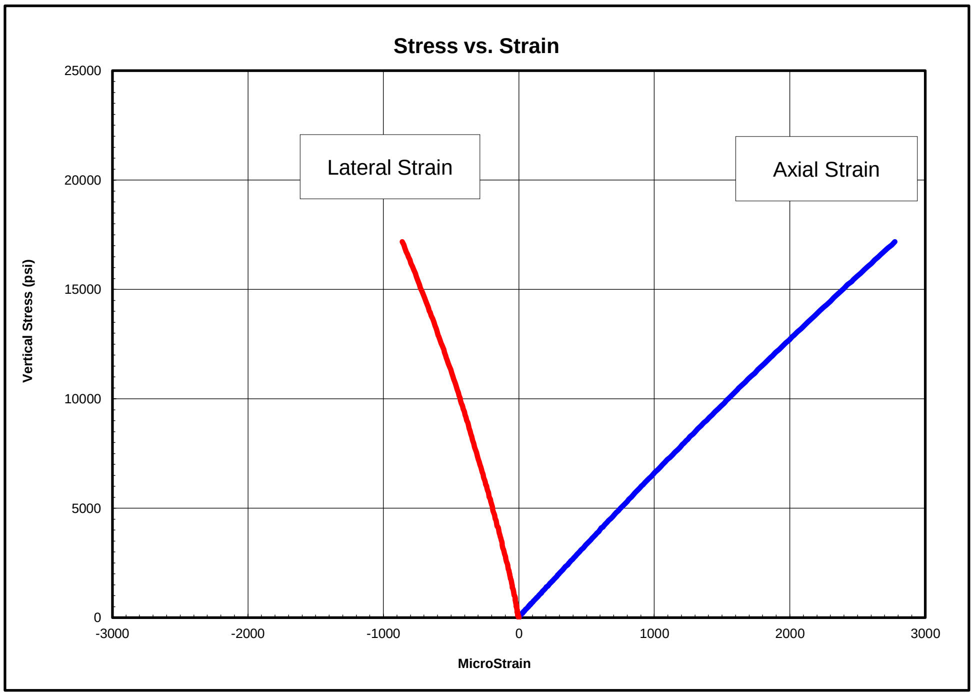


After cutting and grinding

After break

Client:	GEI Consultants, Inc.
Project Name:	WIN 26630.08 Benjamin Lincoln Br. Rep.
Project Location:	Dennysville, ME
GTX #:	321116
Test Date:	6/5/2025
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-DWS-202
Sample ID:	R3
Depth, ft:	21.29-21.67
Sample Type:	rock core
Sample Description:	See photographs Intact material failure Best Effort end preparation performed

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 17,181 psi

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
1700-6300	6,580,000	0.28
6300-10900	6,220,000	0.30
10900-15500	5,850,000	0.34

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

Client:	GEI Consultants, Inc.	Test Date:	6/4/2025
Project Name:	WIN 26630.08 Benjamin Lincoln Br. Rep.	Tested By:	jss
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	321116		
Boring ID:	BB-DWS-202		
Sample ID:	R3		
Depth (ft):	21.29-21.67		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average		
Specimen Length, in:	4.43	4.44	4.43		
Specimen Diameter, in:	1.99	1.98	1.99		
Specimen Mass, g:	608.74				
Bulk Density, lb/ft^3	168			**Minimum Diameter Tolerence Met?**	YES
Length to Diameter Ratio:	2.2			**Length to Diameter Ratio Tolerance Met?**	YES

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap ≤ 0.02 in.? YES

Maximum difference must be < 0.020 in.
Straightness Tolerance Met? YES

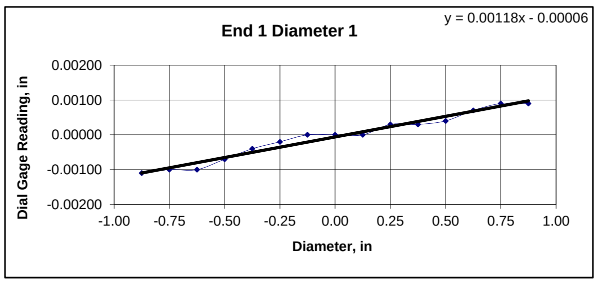
END FLATNESS AND PARALLELISM (Procedure FP1)

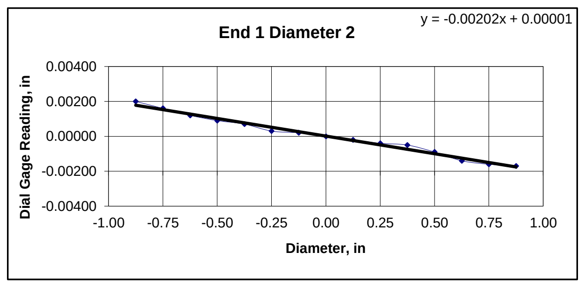
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00110	-0.00100	-0.00100	-0.00070	-0.00040	-0.00020	0.00000	0.00000	0.00000	0.00030	0.00030	0.00040	0.00070	0.00090	0.00090
Diameter 2, in (rotated 90°)	0.00200	0.00160	0.00120	0.00090	0.00070	0.00030	0.00020	0.00000	-0.00020	-0.00040	-0.00050	-0.00090	-0.00140	-0.00160	-0.00170

Difference between max and min readings, in:
0° = 0.00200 90° = 0.00370

END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00090	-0.00080	-0.00080	-0.00060	-0.00030	-0.00010	0.00000	0.00000	0.00000	0.00040	0.00070	0.00080	0.00080	0.00080	0.00090
Diameter 2, in (rotated 90°)	-0.00220	-0.00180	-0.00160	-0.00120	-0.00080	-0.00030	-0.00010	0.00000	0.00000	0.00020	0.00060	0.00080	0.00110	0.00140	0.00160

Difference between max and min readings, in:
0° = 0.0018 90° = 0.0038
Maximum difference must be < 0.0020 in. Difference = ± 0.00190
Flatness Tolerance Met? NO





DIAMETER 1

End 1:

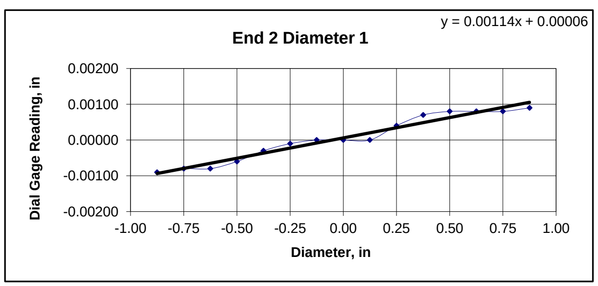
Slope of Best Fit Line	0.00118
Angle of Best Fit Line:	0.06777

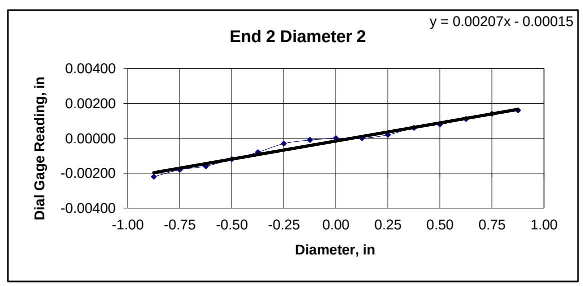
End 2:

Slope of Best Fit Line	0.00114
Angle of Best Fit Line:	0.06515

Maximum Angular Difference: 0.00262

Parallelism Tolerance Met? YES
Spherically Seated





DIAMETER 2

End 1:

Slope of Best Fit Line	0.00202
Angle of Best Fit Line:	0.11574

End 2:

Slope of Best Fit Line	0.00207
Angle of Best Fit Line:	0.11885

Maximum Angular Difference: 0.00311

Parallelism Tolerance Met? YES
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00200	1.987	0.00101	0.058	YES
Diameter 2, in (rotated 90°)	0.00370	1.987	0.00186	0.107	YES
END 2					
Diameter 1, in	0.00180	1.987	0.00091	0.052	YES
Diameter 2, in (rotated 90°)	0.00380	1.987	0.00191	0.110	YES

Maximum angle of departure must be ≤ 0.25°
Perpendicularity Tolerance Met? YES

Client:	GEI Consultants, Inc.	Test Date:	6/4/2025
Project Name:	WIN 26630.08 Benjamin Lincoln Br. Rep.	Tested By:	jss
Project Location:	Dennysville, ME	Checked By:	smd
GTX #:	321116		
Boring ID:	BB-DWS-202	Reliable dial gauge measurements could not be performed on this rock type. Tolerance measurements were performed using a machinist straightedge and feeler gauges to ASTM specifications.	
Sample ID:	R3		
Depth (ft):	21.29-21.67		
Visual Description:	See photographs		

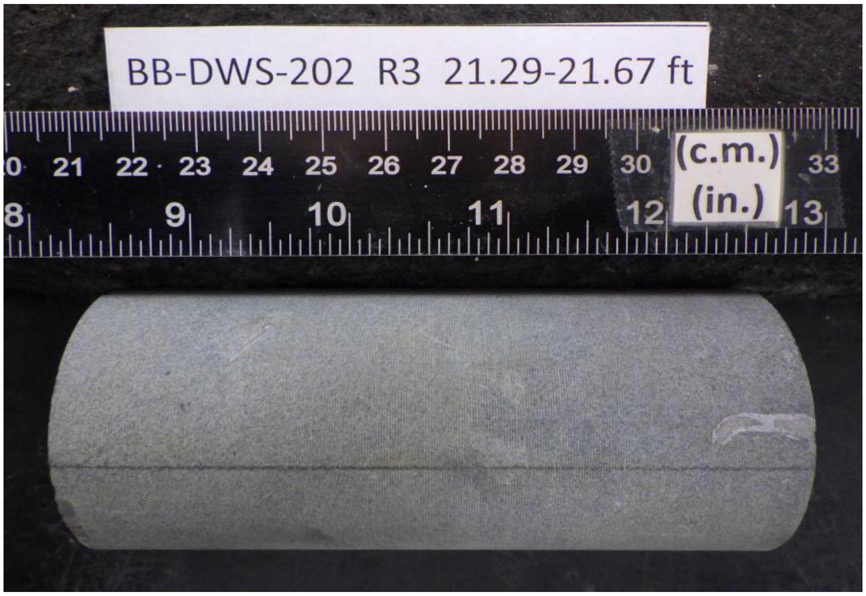
BEST EFFORT END FLATNESS TOLERANCES OF ROCK CORE SPECIMENS TO ASTM D4543

END FLATNESS

END 1		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90°)	Is the maximum gap $\leq \pm 0.001$ in.?	YES
END 2		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90°)	Is the maximum gap $\leq \pm 0.001$ in.?	YES

End Flatness Tolerance Met? YES

Client:	GEI Consultants, Inc.
Project Name:	WIN 26630.08 Benjamin Lincoln Br. Rep.
Project Location:	Dennysville, ME
GTX #:	321116
Test Date:	6/5/2025
Tested By:	gp
Checked By:	smd
Boring ID:	BB-DWS-202
Sample ID:	R3
Depth, ft:	21.29-21.67



After cutting and grinding

After break

Appendix D Geotechnical Calculations

D.1 Recommended Soil Properties

D.2 Earth Pressure Coefficients

D.3 Site Class Evaluation

D.4 Frost Depth Calculation

D.5 LPile Analyses

D.6 End Bearing Calculation for Rock Socketed Piles

D.1. Recommended Soil Properties

Soil Properties Selection

Purpose:
The purpose of this evaluation is to select representative soil properties for the design of the proposed bridge replacement project. The soil properties will be used in our engineering analyses.

Approach:
We selected values for the engineering properties of soils. Values were selected for the general soil layers observed in the borings.

Unit Weight
We selected a saturated (total) unit weight in pounds per cubic foot (pcf). The buoyant unit weight can then be determined by subtracting the unit weight of fresh water (approximately 62.4 pcf).

Angle of Internal Friction
We selected an angle of internal friction (ϕ) in degrees. We used Mohr-Coulomb drained properties for each soil.

Subsurface Investigation and SPT Correlations for Observed Soil Layers:
We reviewed Standard Penetration Test (SPT) N-Values collected during our subsurface investigation. We estimated angles of internal friction for the soils below based on N-Values corrected for overburden and hammer efficiency ($N1_{60}$). SPTs for borings BB-DSW-101 through BB-DSW-103 were performed with an automatic hammer with a measured efficiency of 76.5 percent. SPTs for borings BB-DSW-201 and BB-DSW-202 were performed with an automatic hammer with a measured efficiency of 83.4 percent

A summary of corrected N-Values based on general soil type is shown below. We did not include refusals due to cobbles or boulders, and we limited the uncorrected (field) N-value to a maximum of 100 blows per foot.

Results:
We selected the following soil properties for each layer/soil type based on the references provided in the following pages and our engineering judgment:

Soil Type	Average $N1_{60}$ (Blows/ft)	Bulk Unit Weight (γ) (pcf)	Cohesion (c') (lb/ft^2)	Friction Angle (ϕ') (deg)
Fill	66	125	0	34
Glacial Till	52	135	0	38

References:

1. AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
2. Terzaghi, K., Peck, R.B., 1968. Soil Mechanics in Engineering Practice, 2nd Edition, John Wiley & Sons, New York.
3. Caltrans Geotechnical Manual, March 2014.
4. NAVFAC Design Manual 7.01 Soil Mechanics, Naval Facilities Engineering Command, September 1986.
5. MaineDOT Bridge Design Guide, August 2003, Updated 2018.

AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020

Table 10.4.6.2.4-1 recommends using the following correlation to select friction angles of granular soils:

Table 10.4.6.2.4-1—Correlation of *SPT* $N1_{60}$ Values to Drained Friction Angle of Granular Soils (modified after Bowles, 1977)

$N1_{60}$	ϕ_f
<4	25–30
4	27–32
10	30–35
30	35–40
50	38–43

Soil Mechanics in Engineering Practice

Karl Terzaghi and Ralph Peck compiled various parameters of soils into the tables below:

Table 6.3
Porosity, Void Ratio, and Unit Weight of Typical Soils in Natural State

Description	Porosity, n (%)	Void ratio, e	Water content, w (%)	Unit weight grams/cm³ γ_d	grams/cm³ γ	lb/ft³ γ_d	lb/ft³ γ
1. Uniform sand, loose	46	0.85	32	1.43	1.89	90	118
2. Uniform sand, dense	34	0.51	19	1.75	2.09	109	130
3. Mixed-grained sand, loose	40	0.67	25	1.59	1.99	99	$\boxed{124}$
4. Mixed-grained sand, dense	30	0.43	16	1.86	2.16	116	$\boxed{135}$
5. Glacial till, very mixed-grained	20	0.25	9	2.12	2.32	132	$\boxed{145}$
6. Soft glacial clay	55	1.2	45	–	1.77	–	110
7. Stiff glacial clay	37	0.6	22	–	2.07	–	129
8. Soft slightly organic clay	66	1.9	70	–	1.58	–	98
9. Soft very organic clay	75	3.0	110	–	1.43	–	89
10. Soft bentonite	84	5.2	194	–	1.27	–	80

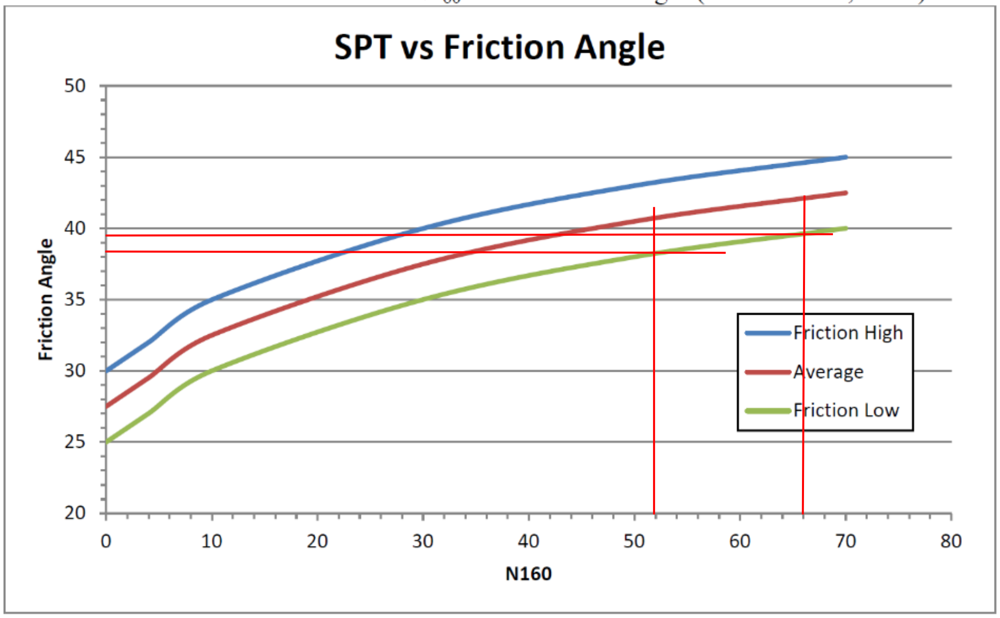
w = water content when saturated, in per cent of dry weight.
γ^d = unit weight in dry state.
γ = unit weight in saturated state.

Table 17.1
Representative Values of ϕ for Sands and Silts

Material	*Degrees* *Loose*	*Dense*
Sand, round grains, uniform	27.5	34
Sand, angular grains, well graded	33	45
Sandy gravels	35	50
Silty sand	27–33	30–34
Inorganic silt	27–30	30–35

Caltrans Geotechnical Manual (March 2014)

Chart 1: Correlation of SPT $N1_{60}$ with Friction Angle (after Bowles, 1977)



Choose the friction angle (expressed to the nearest degree) based upon the soil type, particle size(s), and rounding or angularity. Experience should be used to select specific values within the ranges. In general, finer materials or materials with significant (about 30+ %) silt-sized material will fall in the lower portion of the range. Coarser materials with less than 5% fines will fall in the upper portion of the range. The extreme range of phi angles for any $N1_{60}$ is five degrees, so the adjustment factors for particle size and roundness should be only a degree or two. The following bullets provide help in determining which value to select for a given $N1_{60}$ and soil type:

- Use the maximum value for GW
- Use the average for GM and SP
- Use the minimum for SC
- Use the minimum + 0.5 for ML
- Use the average +1 for SW
- Use the average -1 for GC
- Use the Maximum -1 for GP

Values may also be increased with increasing grain size and/or particle angularity, and decreased with decreasing grain size and/or increasing roundness. For example, an SP with $N1_{60}$ = 30 could be assigned phi angles of 37, 38 or 39 degrees for fine, medium and coarse grain sizes respectively.

NAVFAC Design Manual 7.01 Soil Mechanics

TABLE 6
Typical Values of Soil Index Properties

	Particle Size and Gradation				Voids[1]					Unit Weight[2] (lb./cu.ft.)						
	Approximate Size Range (mm)		Approx. D_{10} (mm)	Approx. Range Uniform Coefficient C_u	Void Ratio			Porosity (%)		Dry Weight			Wet Weight		Submerged Weight	
	D_{max}	D_{min}			e_{max} loose	e_{cr}	e_{min} dense	n_{max} loose	n_{min} dense	Min loose	100% Mod. AASHO	Max dense	Min loose	Max dense	Min loose	Max dense
GRANULAR MATERIALS																
Uniform Materials																
a. Equal spheres (theoretical values)	-	-	-	1.0	0.92	-	0.35	47.6	26	-	-	-	-	-	-	-
b. Standard Ottawa SAND	0.84	0.59	0.67	1.1	0.80	0.75	0.50	44	33	92	-	110	93	131	57	69
c. Clean, uniform SAND (fine or medium)	-	-	-	1.2 to 2.0	1.0	0.80	0.40	50	29	83	115	118	84	136	52	73
d. Uniform, inorganic SILT	0.05	0.005	0.012	1.2 to 2.0	1.1	-	0.40	52	29	80	-	118	81	136	51	73
Well-graded Materials																
a. Silty SAND	2.0	0.005	0.02	5 to 10	0.90	-	0.30	47	23	87	122	127	88	142	54	79
b. Clean, fine to coarse SAND	2.0	0.05	0.09	4 to 6	0.95	0.70	0.20	49	17	85	132	138	86	148	53	86
c. Micaceous SAND	-	-	-	-	1.2	-	0.40	55	29	76	-	120	77	139	48	76
d. Silty SAND & GRAVEL	100	0.005	0.02	15 to 300	0.85	-	0.14	46	12	89	-	146[3]	90	155[3]	56	92
MIXED SOILS																
Sandy or Silty CLAY	2.0	0.001	0.003	10 to 30	1.8	-	0.25	64	20	60	130	135	100	147	38	85
Skip-graded Silty CLAY with stones or rk fgmts	250	0.001	-	-	1.0	-	0.20	50	17	84	-	140	115	151	53	89
Well-graded GRAVEL, SAND, SILT & CLAY mixture	250	0.001	0.002	25 to 1000	0.70	-	0.13	41	11	100	140	148[4]	125	156[4]	62	94
CLAY SOILS																
CLAY (30%-50% clay sizes)	0.05	0.5µ	0.001	-	2.4	-	0.50	71	33	50	105	112	94	133	31	71
Colloidal CLAY (-0.002 mm: 50%)	0.01	10Å	-	-	12	-	0.60	92	37	13	90	106	71	128	8	66
ORGANIC SOILS																
Organic SILT	-	-	-	-	3.0	-	0.55	75	35	40	-	110	87	131	25	69
Organic CLAY (30% - 50% clay sizes)	-	-	-	-	4.4	-	0.70	81	41	30		100	81	125	18	62

N Value (blows/ft or 305 mm)	Relative Density	Approximate $\bar{\phi}_{tc}$ (degrees) (a)	Approximate $\bar{\phi}_{tc}$ (degrees) (b)
0 to 4	very loose	< 28	< 30
4 to 10	loose	28 to 30	30 to 35
10 to 30	medium	30 to 36	35 to 40
30 to 50	dense	36 to 41	40 to 45
> 50	very dense	> 41	> 45

a - Source: Peck, Hanson, and Thornburn (12), p. 310.
b - Source: Meyerhof (13), p. 17.

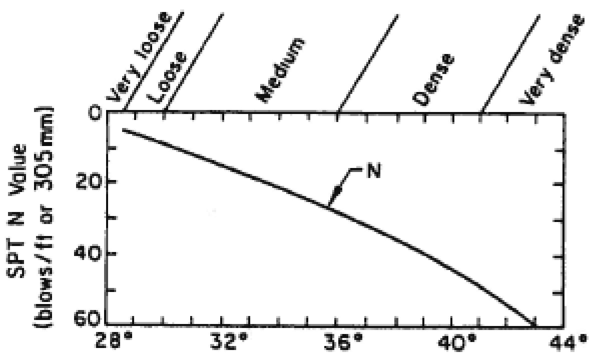


Figure 4-12. N versus $\bar{\phi}_{tc}$

Source: Peck, Hanson, and Thornburn (12), p. 310.

MaineDOT Bridge Design Guide:

Table 3-3 Material Classification

Soil Type	Soil Description	Internal Angle of Friction of Soil, ϕ	Soil Total Unit Weight (pcf)	Coeff. of Friction, tan δ, Concrete to Soil	Interface Friction, Angle, Concrete to Soil δ
1	Very loose to loose silty sand and gravel Very loose to loose sand Very loose to medium density sandy silt Stiff to very stiff clay or clayey silt	29° *	100	0.35	19°
2	Medium density silty sand and gravel Medium density to dense sand Dense to very dense sandy silt	33°	120	0.40	22°
3	Dense to very dense silty sand and gravel Very dense sand	36°	130	0.45	24°
4	Granular underwater backfill Granular borrow	32°	125	0.45	24°
5	Gravel Borrow	36°	135	0.50	27°

* The value given for the internal angle of friction (ϕ) for stiff to very stiff silty clay or clayey silt should be used with caution due to the large possible variation with different moisture contents.

GEI Consultants

Client:	Thornton Tomasetti
Project:	WIN 026630.08 Benjamin Lincoln Bridge #6740
Project No.:	2502334
Subject:	Corrected Blow Counts
Prepared By:	M. Johnescu
Date:	7/22/2025
Checked By:	A. Espinosa
Date:	08/02//2025

Summary of Corrected Blow Counts by Layer

Fill

Boring	No. Values	N_{60} Avg.	N_{60} Max.	N_{60} Min.	$N1_{60}$ Avg.	$N1_{60}$ Max.	$N1_{60}$ Min.
BB-DWS-101	4	42	52	24	55	85	34
BB-DWS-102	5	32	69	8	45	117	8
BB-DWS-103	3	55	74	40	81	126	46
BB-DWS-201 & 201A	3	48	82	11	75	139	13
BB-DWS-202	3	60	90	28	91	153	32
	Average N_{60}:	**45**		**Average $N1_{60}$:**	**66**		

Glacial Till

Boring	No. Values	N_{60} Avg.	N_{60} Max.	N_{60} Min.	$N1_{60}$ Avg.	$N1_{60}$ Max.	$N1_{60}$ Min.
BB-DWS-101	1	71	71	71	68	68	68
BB-DWS-201 & 201A	2	41	70	11	38	65	11
BB-DWS-202	1	58	58	58	64	64	64
	Average N_{60}:	**53**		**Average $N1_{60}$:**	**52**		

Client: Thornton Tomasetti	**Prepared By:** M. Johnescu
Project: WIN 026630.08 Benjamin Lincoln Bridge #6740	**Date:** 7/22/2025
Project No.: 2502334	**Checked By:** A. Espinosa
Subject: Corrected Blow Counts	**Date:** 08/02//2025

References: 1) American Association of State Highway and Transportation Officials (AASHTO) "LRFD Bridge Design Specifications, 9th Edition, 2020"

Equations:

Ref. 1 Eqn. No.	Equation		
10.4.6.2.4-2	$N_{60} = (ER / 60\%) * N$	where: N_{60} =	SPT blow count corrected for hammer efficiency (blows/ft)
		ER =	hammer efficiency expressed as percent of theoretical free fall energy
		N =	Uncorrected SPT blow count (blows/ft)
10.4.6.2.4-3	$N1_{60} = C_N * N_{60}$	where: $N1_{60}$ =	SPT blow count corrected for overburden and hammer efficiency (blows/ft)
		C_N =	$0.77 * \log_{10}(40/\sigma'_v)$ $[C_N < 2.0]$
		σ'_v =	vertical effective stress (ksf)

Assumptions:

Ground Surface El.:	31.1	ft	
Groundwater El.:	18.5	ft	
Depth to Groundwater:	12.6	ft	(from BB-DWS-103)
Average Total Unit Weight of Soil:	125	pcf	

Hammer Type	ER (%)	C_E = ER / 60%
Donut	45	0.75
Safety	60	1.00
Automatic	76.5	1.28

Boring:	***BB-DWS-101***			**Corrected Blow Counts**				**Overburden Correction**					**Hammer Efficiency Correction**		
Depth (ft)	**El. (ft)**	**Layer Name**	**N**	**N_{60}**	**$N1_{60}$**	**Avg. N_{60}**	**Avg. $N1_{60}$**	**σ_v (psf)**	**u (psf)**	**σ'_v (psf)**	**σ'_v (ksf)**	**C_N**	**Hammer Type**	**ER (%)**	**C_E**
2.5	28.6	Fill	41	52	85	42	55	313	0	313	0.3	1.62	Automatic	76.5	1.28
5	26.1	Fill	19	24	34			625	0	625	0.6	1.39	Automatic	76.5	1.28
10	21.1	Fill	35	45	52			1,250	0	1,250	1.3	1.16	Automatic	76.5	1.28
15	16.1	Fill	37	47	50			1,875	150	1,725	1.7	1.05	Automatic	76.5	1.28
25	6.1	Glacial Till	56	71	68	71	68	3,125	774	2,351	2.4	0.95	Automatic	76.5	1.28

GEI Consultants

Client:	Thornton Tomasetti	**Prepared By:**	M. Johnescu
Project:	WIN 026630.08 Benjamin Lincoln Bridge #6740	**Date:**	7/22/2025
Project No.:	2502334	**Checked By:**	A. Espinosa
Subject:	Corrected Blow Counts	**Date:**	08/02//2025

References: 1) American Association of State Highway and Transportation Officials (AASHTO) "LRFD Bridge Design Specifications, 9th Edition, 2020"

Equations:

Ref. 1 Eqn. No.	Equation		
10.4.6.2.4-2	N_{60} = (ER / 60%) * N	where: N_{60} =	SPT blow count corrected for hammer efficiency (blows/ft)
		ER =	hammer efficiency expressed as percent of theoretical free fall energy
		N =	Uncorrected SPT blow count (blows/ft)
10.4.6.2.4-3	$N1_{60} = C_N * N_{60}$	where: $N1_{60}$ =	SPT blow count corrected for overburden and hammer efficiency (blows/ft)
		C_N =	$0.77 * \log_{10}(40/\sigma'_v)$ [$C_N < 2.0$]
		σ'_v =	vertical effective stress (ksf)

Assumptions:

Ground Surface El.:	32.0	ft	
Groundwater El.:	19.4	ft	
Depth to Groundwater:	12.6	ft	(from BB-DWS-103)
Average Total Unit Weight of Soil:	125	pcf	

Hammer Type	ER (%)	C_E = ER / 60%
Donut	45	0.75
Safety	60	1.00
Automatic	76.5	1.28

Boring:	***BB-DWS-102***			**Corrected Blow Counts**				**Overburden Correction**					**Hammer Efficiency Correction**		
Depth (ft)	**El. (ft)**	**Layer Name**	**N**	**N_{60}**	**$N1_{60}$**	**Avg. N_{60}**	**Avg. $N1_{60}$**	**σ_v (psf)**	**u (psf)**	**σ'_v (psf)**	**σ'_v (ksf)**	**C_N**	**Hammer Type**	**ER (%)**	**C_E**
2	30.0	Fill	54	69	117			250	0	250	0.3	1.70	Automatic	76.5	1.28
5	27.0	Fill	22	28	39			625	0	625	0.6	1.39	Automatic	76.5	1.28
10	22.0	Fill	27	34	40	32	45	1,250	0	1,250	1.3	1.16	Automatic	76.5	1.28
15	17.0	Fill	6	8	8			1,875	150	1,725	1.7	1.05	Automatic	76.5	1.28
20	12.0	Fill	15	19	19			2,500	462	2,038	2.0	1.00	Automatic	76.5	1.28

GEI Consultants	**Client:** Thornton Tomasetti **Project:** WIN 026630.08 Benjamin Lincoln Bridge #6740 **Project No.:** 2502334 **Subject:** Corrected Blow Counts	**Prepared By:** M. Johnescu **Date:** 7/22/2025 **Checked By:** A. Espinosa **Date:** 08/02//2025

References: 1) American Association of State Highway and Transportation Officials (AASHTO) "LRFD Bridge Design Specifications, 9th Edition, 2020"

Equations:

Ref. 1 Eqn. No.	Equation			
10.4.6.2.4-2	$N_{60} = (ER / 60\%) * N$	where:	N_{60} =	SPT blow count corrected for hammer efficiency (blows/ft)
			ER =	hammer efficiency expressed as percent of theoretical free fall energy
			N =	Uncorrected SPT blow count (blows/ft)
10.4.6.2.4-3	$N1_{60} = C_N * N_{60}$	where:	$N1_{60}$ =	SPT blow count corrected for overburden and hammer efficiency (blows/ft)
			C_N =	$0.77 * \log_{10}(40/\sigma'_v)$ $[C_N < 2.0]$
			σ'_v =	vertical effective stress (ksf)

Assumptions:

Ground Surface El.:	34.4	ft
Groundwater El.:	21.8	ft
Depth to Groundwater:	12.6	ft
Average Total Unit Weight of Soil:	125	pcf

Hammer Type	ER (%)	C_E = ER / 60%
Donut	45	0.75
Safety	60	1.00
Automatic	76.5	1.28

Boring:	***BB-DWS-103***			**Corrected Blow Counts**				**Overburden Correction**					**Hammer Efficiency Correction**		
Depth (ft)	**El. (ft)**	**Layer Name**	**N**	N_{60}	$N1_{60}$	**Avg.** N_{60}	**Avg.** $N1_{60}$	σ_v **(psf)**	**u (psf)**	σ'_v **(psf)**	σ'_v **(ksf)**	C_N	**Hammer Type**	**ER (%)**	C_E
2	32.4	Fill	58	74	126			250	0	250	0.3	1.70	Automatic	76.5	1.28
5	29.4	Fill	40	51	71	55	81	625	0	625	0.6	1.39	Automatic	76.5	1.28
10	24.4	Fill	31	40	46			1,250	0	1,250	1.3	1.16	Automatic	76.5	1.28

GEI Consultants	**Client:** Thornton Tomasetti **Project:** WIN 026630.08 Benjamin Lincoln Bridge #6740 **Project No.:** 2502334 **Subject:** Corrected Blow Counts	**Prepared By:** M. Johnescu **Date:** 7/22/2025 **Checked By:** A. Espinosa **Date:** 08/02//2025

References: 1) American Association of State Highway and Transportation Officials (AASHTO) "LRFD Bridge Design Specifications, 9th Edition, 2020"

Equations:

Ref. 1 Eqn. No.	Equation		
10.4.6.2.4-2	$N_{60} = (ER / 60\%) * N$	where:	N_{60} = SPT blow count corrected for hammer efficiency (blows/ft) ER = hammer efficiency expressed as percent of theoretical free fall energy N = Uncorrected SPT blow count (blows/ft)
10.4.6.2.4-3	$N1_{60} = C_N * N_{60}$	where:	$N1_{60}$ = SPT blow count corrected for overburden and hammer efficiency (blows/ft) $C_N = 0.77 * \log_{10}(40/\sigma'_v)$ $[C_N < 2.0]$ σ'_v = vertical effective stress (ksf)

Assumptions:

Ground Surface El.:	29.1	ft
Groundwater El.:	10.6	ft
Depth to Groundwater:	18.5	ft
Average Total Unit Weight of Soil:	125	pcf

Hammer Type	ER (%)	C_E = ER / 60%
Donut	45	0.75
Safety	60	1.00
Automatic	83.4	1.39

Boring: BB-DWS-201 & 201A

				Corrected Blow Counts				**Overburden Correction**					**Hammer Efficiency Correction**		
Depth (ft)	**El. (ft)**	**Layer Name**	**N**	**N_{60}**	**$N1_{60}$**	**Avg. N_{60}**	**Avg. $N1_{60}$**	**σ_v (psf)**	**u (psf)**	**σ'_v (psf)**	**σ'_v (ksf)**	**C_N**	**Hammer Type**	**ER (%)**	**C_E**
2	27.1	Fill	59	82	139			250	0	250	0.3	1.70	Automatic	83.4	1.39
5	24.1	Fill	37	51	72	48	75	625	0	625	0.6	1.39	Automatic	83.4	1.39
10	19.1	Fill	8	11	13			1,250	0	1,250	1.3	1.16	Automatic	83.4	1.39
16	13.1	Glacial Till	8	11	11	41	38	2,000	0	2,000	2.0	1.00	Automatic	83.4	1.39
20	9.1	Glacial Till	50	70	65			2,500	94	2,406	2.4	0.94	Automatic	83.4	1.39

GEI Consultants	**Client:** Thornton Tomasetti **Project:** WIN 026630.08 Benjamin Lincoln Bridge #6740 **Project No.:** 2502334 **Subject:** Corrected Blow Counts	**Prepared By:** M. Johnescu **Date:** 7/22/2025 **Checked By:** A. Espinosa **Date:** 08/02//2025

References: 1) American Association of State Highway and Transportation Officials (AASHTO) "LRFD Bridge Design Specifications, 9th Edition, 2020"

Equations:

Ref. 1 Eqn. No.	Equation		
10.4.6.2.4-2	$N_{60} = (ER / 60\%) * N$	where: N_{60} =	SPT blow count corrected for hammer efficiency (blows/ft)
		ER =	hammer efficiency expressed as percent of theoretical free fall energy
		N =	Uncorrected SPT blow count (blows/ft)
10.4.6.2.4-3	$N1_{60} = C_N * N_{60}$	where: $N1_{60}$ =	SPT blow count corrected for overburden and hammer efficiency (blows/ft)
		C_N =	$0.77 * \log_{10}(40/\sigma'_v)$ [$C_N < 2.0$]
		σ'_v =	vertical effective stress (ksf)

Assumptions:

Ground Surface El.:	33.3	ft
Groundwater El.:	23.4	ft
Depth to Groundwater:	9.9	ft
Average Total Unit Weight of Soil:	125	pcf

Hammer Type	ER (%)	C_E = ER / 60%
Donut	45	0.75
Safety	60	1.00
Automatic	83.4	1.39

Boring:		***BB-DWS-202***		**Corrected Blow Counts**				**Overburden Correction**					**Hammer Efficiency Correction**		
Depth (ft)	**El. (ft)**	**Layer Name**	**N**	**N_{60}**	**$N1_{60}$**	**Avg. N_{60}**	**Avg. $N1_{60}$**	**σ_v (psf)**	**u (psf)**	**σ'_v (psf)**	**σ'_v (ksf)**	**C_N**	**Hammer Type**	**ER (%)**	**C_E**
2	31.3	Fill	65	90	153			250	0	250	0.3	1.70	Automatic	83.4	1.39
5	28.3	Fill	45	63	87	60	91	625	0	625	0.6	1.39	Automatic	83.4	1.39
10	23.3	Fill	20	28	32			1,250	6	1,244	1.2	1.16	Automatic	83.4	1.39
14.8	18.5	Glacial Till	42	58	64	58	64	1,850	306	1,544	1.5	1.09	Automatic	83.4	1.39

D.2. Earth Pressure Coefficients

CALCULATE EARTH PRESSURE COEFFICIENTS

Calculations of earth pressure coefficients assigned to soils listed in Soil Properties table of the report are provided in this packet. Active, at-rest, and passive pressures were determined for different soils.

Equations/references utilized for these calculations are provided at the back of this calculation.

	Existing Fill	Glacial Till	Granular Borrow	Gravel Borrow
Friction angle, ϕ (deg)	34	38	32	36
Angle of friction between soil and wall, δ (deg)	23	25	24	27
Slope of backfill behind wall, β (deg)	0	0	0	0
Slope of backfill in front of wall, α (deg) (for passive - enter as neg)	0	0	0	0
Angle of back face of wall to horz, θ (deg)	90	90	90	90
δ/ϕ	0.7	0.7	0.8	0.8
β/ϕ	0.0	0.0	0.0	0.0
Γ	2.93	3.17	2.87	3.12
Active earth pressure coefficient (Rankine method, MaineDOT BDG 3.6.5.2 and AASHTO C3.11.5.3-1), Ka[1]	0.28	0.24	0.31	0.26
Active earth pressure coefficient (Coloumb method, AASHTO LRFD 3.11.5.3-1), Ka[1]	0.25	0.22	0.27	0.24
At-rest earth pressure coefficient (AASHTO LRFD 3.11.5.2-1), Ko	0.44	0.38	0.47	0.41
Passive earth pressure coefficient[2] (FHWA NHI-06-089 Figure 10-4 Assuming a wall rotation of 0.02 for dense granular soil. The bridge designer should use MassDOT BDM Figure 3.10.8-1)	5.8	5.8	5.8	5.8

1. For long-heel cantilever walls, use Rankine active earth pressure in accordance with MaineDOT BDG 3.6.5.2 and AASHTO LRFD Figure C3.11.5.3-1.
2. Passive earth pressure for walls should be neglected for cases outlined in MaineDOT BDG 3.6.9. MaineDOT BDG 5.4.2.11 recommends abutment and wingwall reinforcement be sized assuming passive earth pressure on the backface of the wall. Design passive earth pressure coefficient should be calculated using MassDOT BDM Figure 3.10.8-1 and NHI-06-089 Figure 10-4, and the more stringent value should apply. However, passive earth pressure should be no less than Rankine passive earth pressure, regardless of wall rotation.

From AASHTO LRFD 2021:

3.11.5.2—At-Rest Lateral Earth Pressure Coefficient, k_o

For normally consolidated soils, vertical wall, and level ground, the coefficient of at-rest lateral earth pressure may be taken as:

$$k_o = 1 - \sin \phi'_f \qquad (3.11.5.2\text{-}1)$$

where:

ϕ'_f = effective friction angle of soil
k_o = coefficient of at-rest lateral earth pressure

3.11.5.3—Active Lateral Earth Pressure Coefficient, k_a

Values for the coefficient of active lateral earth pressure may be taken as:

$$k_a = \frac{\sin^2(\theta + \phi'_f)}{\Gamma\,[\sin^2\theta \sin(\theta - \delta)]} \qquad (3.11.5.3\text{-}1)$$

in which:

$$\Gamma = \left[1 + \sqrt{\frac{\sin(\phi'_f + \delta)\sin(\phi'_f - \beta)}{\sin(\theta - \delta)\sin(\theta + \beta)}}\right]^2 \qquad (3.11.5.3\text{-}2)$$

where:

δ = friction angle between fill and wall (degrees)
β = angle of fill to the horizontal as shown in Figure 3.11.5.3-1 (degrees)
θ = angle of back face of wall to the horizontal as shown in Figure 3.11.5.3-1 (degrees)
ϕ'_f = effective angle of internal friction (degrees)

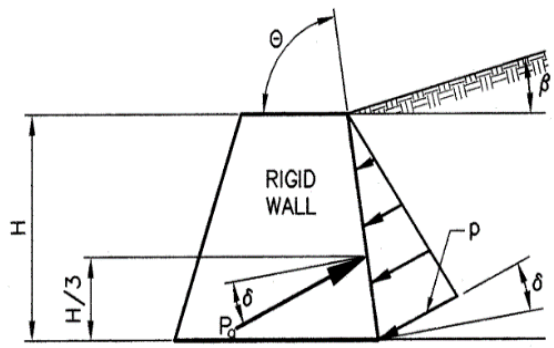


Figure 3.11.5.3-1—Notation for Coulomb Active Earth Pressure

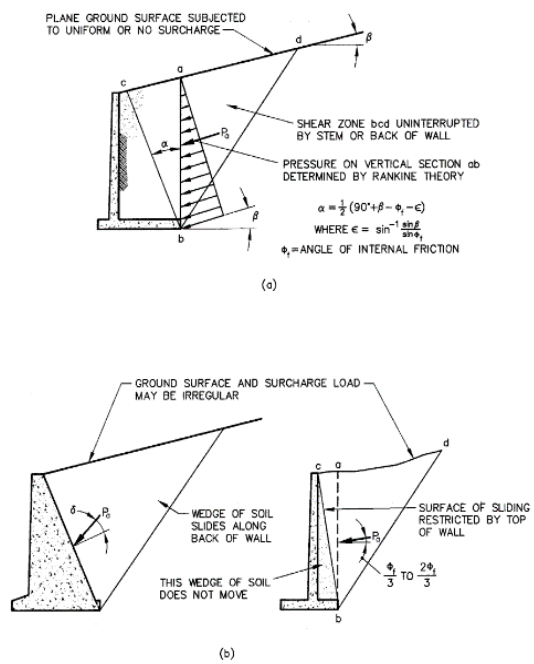
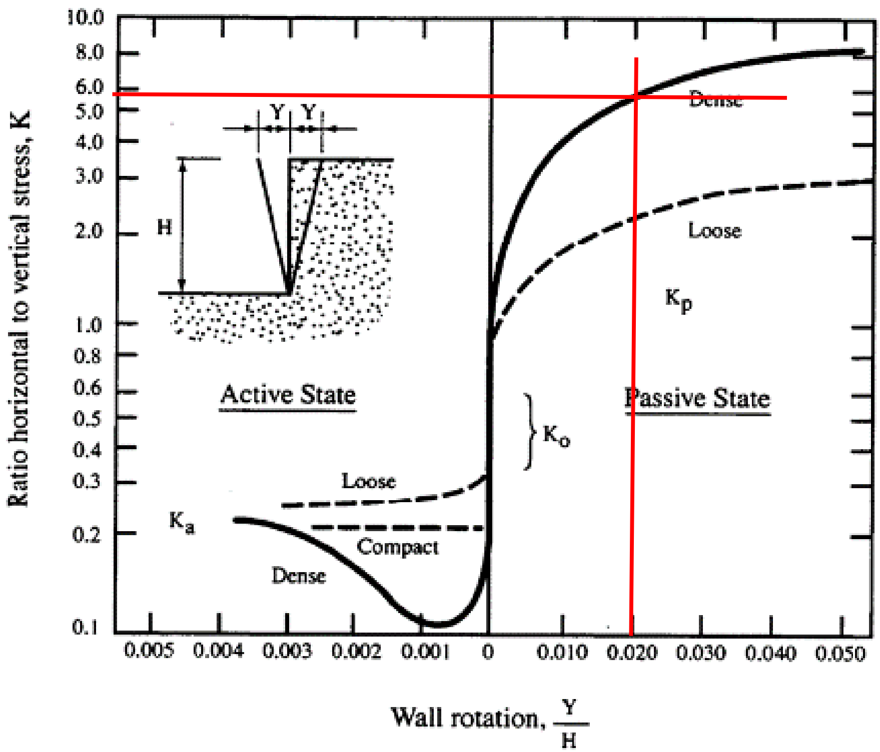


Figure C3.11.5.3-1—Application of (a) Rankine and (b) Coulomb Earth Pressure Theories in Retaining Wall Design

From FHWA NHI-06-089:



Magnitude of Wall Rotation to Reach Failure

Soil type and condition	Rotation, Y/H	
	Active	Passive
Dense cohesionless	0.001	0.02
Loose cohesionless	0.004	0.06
Stiff cohesive	0.010	0.02
Soft cohesive	0.020	0.04

Figure 10-4. Effect of wall movement on wall pressures (after Canadian Geotechnical Society, 1992).

From MaineDOT BDG 2003:

Table 3-3 Material Classification

Soil Type	Soil Description	Internal Angle of Friction of Soil, ϕ	Soil Total Unit Weight (pcf)	Coeff. of Friction, tan δ, Concrete to Soil	Interface Friction, Angle, Concrete to Soil δ
1	Very loose to loose silty sand and gravel Very loose to loose sand Very loose to medium density sandy silt Stiff to very stiff clay or clayey silt	29° *	100	0.35	19°
2	Medium density silty sand and gravel Medium density to dense sand Dense to very dense sandy silt	33°	120	0.40	22°
3	Dense to very dense silty sand and gravel Very dense sand	36°	130	0.45	24°
4	Granular underwater backfill Granular borrow	32°	125	0.45	24°
5	Gravel Borrow	36°	135	0.50	27°

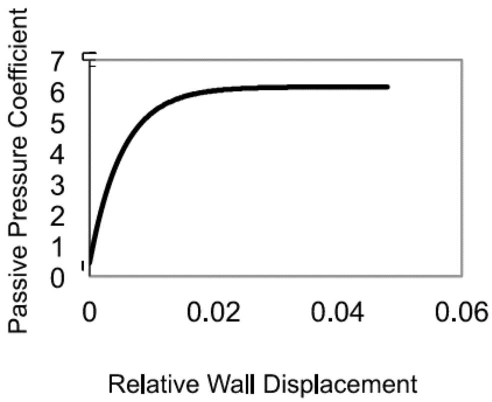
* The value given for the internal angle of friction (ϕ) for stiff to very stiff silty clay or clayey silt should be used with caution due to the large possible variation with different moisture contents.

For a sloped backfill surface where $\beta > 0°$, the coefficient of active earth pressure (Rankine), K_a, may be taken as:

$$K_a = \cos\beta \cdot \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}$$

From MassDOT BDM:

$$K = 0.43 + 5.7[1 - e^{-190(\delta_T/H)}]$$



δ_T/H = 0.02

Kp= 6.0

Figure 3.10.8-1: Plot of Passive Pressure Coefficient, K, vs. Relative Wall Displacement, δ_T/H.

D.3. Site Class Evaluation

Project: Benjamin Lincoln Bridge (#6740) Replacement Project
WIN 026630.08
GEI Project No.: 2502334

By: M. Johnescu
Date: 7/25/2025
Checked By: A. Espinosa
Date: 8/2/2025

Site Class Evaluation - Benjamin Lincoln Bridge #6740 over Wilson Stream

Purpose: Evaluate seismic design criteria in accordance with 2020 AASHTO LRFD Seismic Bridge Design. Evaluate borings based on N_{60} values.

Point	BB-DWS-101		
	N_i	Layer (d_i)	d_i/N_i
1	52	4	0.08
2	24	5	0.21
3	45	5	0.11
4	47	10	0.21
5	71	2	0.03
6	100	74	0.74
	Σ =	100	1.4
		$\bar{N}$	**73**

Point	BB-DWS-102		
	N_i	Layer (d_i)	d_i/N_i
1	69	4	0.06
2	28	5	0.18
3	34	5	0.15
4	8	5	0.63
5	19	5	0.24
6	100	77	0.77
	Σ =	100	2.0
		$\bar{N}$	**50**

Point	BB-DWS-202		
	N_i	Layer (d_i)	d_i/N_i
1	90	4	0.04
2	63	5	0.08
3	28	5	0.18
4	58	2	0.03
5	100	85	0.85
	Σ =	100	1.2
		$\bar{N}$	**85**

Point	BB-DWS-103/103A		
	N_i	Layer (d_i)	d_i/N_i
1	74	4	0.05
2	51	5	0.10
3	40	6	0.15
4	100	85	0.85
	Σ =	100	1.2
		$\bar{N}$	**87**

Point	BB-DWS-201/201A		
	N_i	Layer (d_i)	d_i/N_i
1	82	4	0.05
2	51	5	0.10
3	11	6	0.55
4	11	4	0.36
5	70	5	0.07
6	100	76	0.76
	Σ =	100	1.9
		$\bar{N}$	**53**

$$\bar{N} = \frac{\sum d_i}{\sum d_i / N_i}$$

From AASHTO

N-values are N60 values (i.e., corrected for hammer energy)

Avg. $\bar{N}$ 69

From AASHTO Table 3.10.3.1-1 N > 50
Use Site Class C

Site Seismic Coefficients

Horizontal Peak Ground Acceleration,	$PGA =$	0.080	USGS Seismic Design Maps (AASHTO Figs. 3.10.2.1-1,-2, and -3)
Horizontal Response Spectral Acceleration (0.2 sec),	$S_s =$	0.160	
Horizontal Response Spectral Acceleration (1 sec),	$S_1 =$	0.040	
	$F_{PGA} =$	1.2	AASHTO Table 3.10.3.2-1
	$F_A =$	1.2	AASHTO Table 3.10.3.2-2
	$F_V =$	1.7	AASHTO Table 3.10.3.2-3

Design Response Spectra

Acceleration Coefficient,	$A_S = PGA \times F_{PGA}$	$A_S =$	0.096	AASHTO Eq. 3.10.4.2-2
Design Spectral Acceleration (0.2 sec),	$S_{DS} = S_S \times F_A$	$S_{DS} =$	0.192	AASHTO Eq. 3.10.4.2-3
Design Spectral Acceleration (1 sec),	$S_{D1} = S_1 \times F_V$	$S_{D1} =$	0.068	AASHTO Eq. 3.10.4.2-6

From AASHTO Table 3.10.6-1
Seismic Zone 1

AASHTO Tables:

Table 3.4.2.3-1—Values of F_{pga} and F_a as a Function of Site Class and Mapped Peak Ground Acceleration or Short-Period Spectral Acceleration Coefficient

Site Class	Mapped Peak Ground Acceleration or Spectral Response Acceleration Coefficient at Short Periods				
	$PGA \leq 0.10$ $S_s \leq 0.25$	$PGA = 0.20$ $S_s = 0.50$	$PGA = 0.30$ $S_s = 0.75$	$PGA = 0.40$ $S_s = 1.00$	$PGA \geq 0.50$ $S_s \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	[a]	[a]	[a]	[a]	[a]

Note: Use straight line interpolation for intermediate values of PGA and S_s, where PGA is the peak ground acceleration and S_s is the spectral acceleration coefficient at 0.2 sec obtained from the ground motion maps.

[a] Site-specific response geotechnical investigation and dynamic site response analyses should be considered (Article 3.4.3).

Table 3.4.2.3-2—Values of F_v as a Function of Site Class and Mapped 1-sec Period Spectral Acceleration Coefficient

Site Class	Mapped Spectral Response Acceleration Coefficient at 1-sec Periods				
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \geq 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	[a]	[a]	[a]	[a]	[a]

Note: Use straight line interpolation for intermediate values of S_1, where S_1 is the spectral acceleration coefficient at 1.0 sec obtained from the ground motion maps.

[a] Site-specific response geotechnical investigation and dynamic site response analyses should be considered (Article 3.4.3).

Table 3.10.6-1—Seismic Zones

Acceleration Coefficient, S_{D1}	Seismic Zone
$S_{D1} \leq 0.15$	1
$0.15 < S_{D1} \leq 0.30$	2
$0.30 < S_{D1} \leq 0.50$	3
$0.50 < S_{D1}$	4

D.4. Frost Depth Calculation

5.2 General

5.2.1 Frost

Any foundation placed on seasonally frozen soils must be embedded below the depth of frost penetration to provide adequate frost protection and to minimize the potential for freeze/thaw movements. Fine-grained soils with low cohesion tend to be most frost susceptible. Soils containing a high percentage of particles smaller than the No. 200 sieve also tend to promote frost penetration.

In order to estimate the depth of frost penetration at a site, Table 5-1 has been developed using the Modified Berggren equation and Figure 5-1 Maine Design Freezing Index Map. The use of Table 5-1 assumes site specific, uniform soil conditions where the Geotechnical Designer has evaluated subsurface conditions. Coarse-grained soils are defined as soils with sand as the major constituent. Fine-grained soils are those having silt and/or clay as the major constituent. If the make-up of the soil is not easily discerned, consult the Geotechnical Designer for assistance. In the event that specific site soil conditions vary, the depth of frost penetration should be calculated by the Geotechnical Designer.

Table 5-1 Depth of Frost Penetration

Design Freezing Index	Frost Penetration (in)					
	Coarse Grained			Fine Grained		
	w=10%	w=20%	w=30%	w=10%	w=20%	w=30%
1000	66.3	55.0	47.5	47.1	40.7	36.9
1100	69.8	57.8	49.8	49.6	42.7	38.7
1200	73.1	60.4	52.0	51.9	44.7	40.5
1300	76.3	63.0	54.3	54.2	46.6	42.2
1400	79.2	65.5	56.4	56.3	48.5	43.9
1500	82.1	67.9	58.4	58.3	50.2	45.4
1600	84.8	70.2	60.3	60.2	51.9	46.9
1700	87.5	72.4	62.2	62.2	53.5	48.4
1800	90.1	74.5	64.0	64.0	55.1	49.8
1900	92.6	76.6	65.7	65.8	56.7	51.1
2000	95.1	78.7	67.5	67.6	58.2	52.5
2100	97.6	80.7	69.2	69.3	59.7	53.8
2200	100.0	82.6	70.8	71.0	61.1	55.1
2300	102.3	84.5	72.4	72.7	62.5	56.4
2400	104.6	86.4	74.0	74.3	63.9	57.6
2500	106.9	88.2	75.6	75.9	65.2	58.8
2600	109.1	89.9	77.1	77.5	66.5	60.0

Design Freezing Index based on Figure 5-1: 1200
Material Based on Laboratory Testing: Granular
Avg. Moisture Content based on Laboratory Testing: 9.3%

Notes: 1. w = water content
2. Where the Freezing Index and/or water content is between the presented values, linear interpretation may be used to determine the frost penetration.

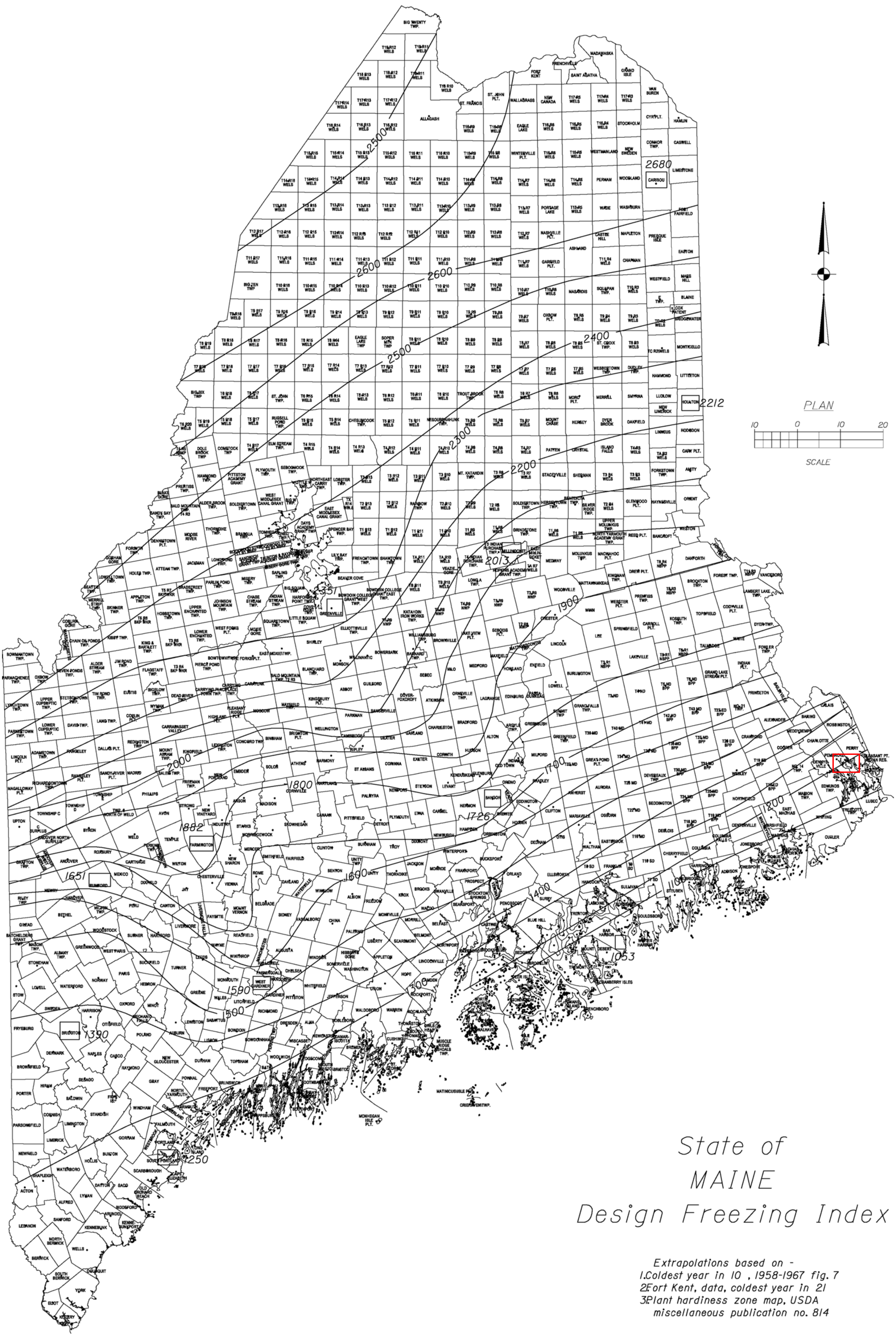


Figure 5-1 Maine Design Freezing Index Map

Example 5-1 illustrates how to use Table 5-1 and Figure 5-1 to determine the depth of frost penetration:

Example 5-1 Depth of Frost Penetration

Given: Site location is Freeport, Maine
Soil conditions: Silty fine to coarse Sand

Step 1. From Figure 5-1 Design Freezing Index = 1300 degree-days
Step 2. From laboratory results: soil water content = 28% and major constituent Sand
Step 3. From Table 5-1: Depth of frost penetration = 56 inches = 4.7 feet

Spread footings founded on bedrock require no minimum embedment depth. Pile supported footings will be embedded for frost protection. The minimum depth of embedment will be calculated using the techniques discussed in Example 5-1. Pile supported integral abutments will be embedded no less than 4.0 feet for frost protection.

Riprap is not to be considered as contributing to the overall thickness of soils required for frost protection.

The final depth of footing embedment may be controlled by the calculated scour depth and be deeper than the depth required for frost protection. Refer to Section 2.3.11 Scour for information regarding scour depth.

5.2.2 Seal Cofferdams

Seal cofferdams are used when a substructure unit must be constructed with its foundation more than 4 feet below the water table, to counteract the buoyant forces produced during pumping of the cofferdam. Once the cofferdam is constructed, the seal is placed under water and water is then pumped out of the cofferdam. This provides a dry platform for construction of the spread footing, or in the case of a pile foundation, the distribution slab. When a seal is needed, the top of footing or distribution slab is located approximately at streambed, and the depth of seal is calculated based upon the buoyancy of the concrete under the expected water surface during construction. The following formula can be used:

$$145 \cdot y = 62.4 \cdot z$$

where:

145 lb/ft^3 =	unit weight of concrete
62.4 lb/ft^3 =	unit weight of water
y =	the depth of seal from top of seal to bottom of seal
z =	the depth of water from water surface to bottom of seal

D.5. LPile Analyses

LPile Soil Input Parameters
Geotechnical Design Report
Benjamin Lincoln Bridge #6740
WIN 026630.08
Dennysville, Maine

Abutment 1						
Stratum	**Soil Model**	**Top of Layer Elevation (NAVD88 ft)**	**Effective Unit Weight (pcf)**	**Friction Angle (deg)**	**k (pci)**	**Length Along Pile (ft)**
Existing Fill Above GWT	Sand (Reese)	19	125	34	122	0
Glacial Till Above GWT	Sand (Reese)	12.6	135	38	209	6.4
Glacial Till Below GWT	Sand (Reese)	10.6	72.6	38	120	8.4
Granular Borrow	Sand (Reese)	5.2	62.6	32	55	13.8
Bedrock	Massive Rock	4.2	109.4	--	--	14.8

Notes:
1) pcf = lbs per cubic foot, deg = degrees, pci = lbs per cubic inch
2) Top of pile elevation is approx. El. 19.0 for proposed Abutment 1 based on Sheet 3, "Interpretive Subsurface Profile," dated June, 2025.
3) Groundwater at El. 10.6 based on the average of borings BB-DWS-201A.
4) Top of layer elevations based on borings BB-DWS-101 and -201A.
5) Correlations between the horizontal modulus of subgrade reaction (k) and the soil internal friction angle of a given stratum are based on Figure 3.34 presented in the 2022 LPile Technical Manual.
6) Massive Rock Input Parameters: Unconfined Compressive Strength = 29,282 psi, mi=4, υ=0.25, GSI=45, Rock mass modulus=739,400 psi.
7) Model assumes that the top 1 ft of the rock socket is backfilled with Granular Borrow MaineDOT Soil Type 4 (703.19) and grout below that.
8) Model uses a 30-inch rock socket.

Abutment 2						
Stratum	**Soil Model**	**Top of Layer Elevation (NAVD88 ft)**	**Effective Unit Weight (pcf)**	**Friction Angle (deg)**	**k (pci)**	**Length Along Pile (ft)**
Existing Fill Above GWT	Sand (Reese)	23.3	125	34	122	0
Existing Fill Below GWT	Sand (Reese)	22.6	62.6	34	75	0.7
Glacial Till	Sand (Reese)	20.5	72.6	38	120	2.8
Granular Borrow	Sand (Reese)	18.3	62.6	32	55	5
Bedrock	Massive Rock	13.3	109.4	--	--	10

Notes:
1) pcf = lbs per cubic foot, deg = degrees, pci = lbs per cubic inch
2) Top of pile elevation is approx. El. 23.3 for proposed Abutment 2 based on Sheet 3, "Interpretive Subsurface Profile," dated June, 2025.
3) Groundwater at El. 22.6 based on boring BB-DWS-103 and -202.
4) Top of layer elevations based on borings BB-DWS-103, -103A and -202.
5) Correlations between the horizontal modulus of subgrade reaction (k) and the soil internal friction angle of a given stratum are based on Figure 3.34 presented in the 2022 LPile Technical Manual.
6) Massive Rock Input Parameters: Unconfined Compressive Strength = 29,282 psi, mi=4, υ=0.25, GSI=45, Rock mass modulus=739,400 psi.
7) Model assumes that the top 5 ft of the rock socket is backfilled with Granular Borrow MaineDOT Soil Type 4 (703.19) and grout below that.
8) Model uses a 30-inch rock socket.

LPile Output Summary
Geotechnical Design Report
Benjamin Lincoln Bridge #6740
WIN 026630.08
Dennysville, Maine

Abutment 1 (4.3' Rock Socket)								
H-Pile Size	**Lpile Case #**	**Lateral Deflection (in)**	**Maximum Factored Axial Load (kips)**	**Max. Shear Force (kips)**	**Max. Moment (in-kips)**	**Max Total Stress (ksi)**	**Max Bending Stress (ksi)**	**Max Axial Stress (ksi)**
HP 14x117	1	0.337	355	37.7	1848	41.4	31.1	10.3
HP 14x117	2	0.4044	355	43.0	2150	46.5	36.1	10.3

Notes:

1) Lateral deflection and maximum factored axial load were provided to GEI by Thornton Tomasetti on May 22, 2025.

2) Load Case #1 uses the unfactored thermal contraction movement, Load Case #2 uses the thermal contraction movement with a 1.2 factor.

Abutment 2 (12.3' Rock Socket)								
H-Pile Size	**Lpile Case #**	**Lateral Deflection (in)**	**Maximum Factored Axial Load (kips)**	**Max. Shear Force (kips)**	**Max. Moment (in-kips)**	**Max Total Stress (ksi)**	**Max Bending Stress (ksi)**	**Max Axial Stress (ksi)**
HP 14x117	1	0.337	355	39.2	2008	44.1	33.8	10.3
HP 14x117	2	0.4044	355	45.6	2377	50.3	40.0	10.3

Notes:

1) Lateral deflection and maximum factored axial load were provided to GEI by Thornton Tomasetti on May 22, 2025.

2) Load Case #1 uses the unfactored thermal contraction movement, Load Case #2 uses the thermal contraction movement with a 1.2 factor.

3) Grouted socket length needs to be at least 7.3' long for the tip movement to stabilize and move towards fixity.

Thornton Tomasetti

Project:	Dennysville	W.O.:	P24772.00	Sheet:	
Subject:	Pile Loads	Calc By:	MJM	Date:	5/22/2025
		Check By:		Date:	

Summary of Unfactored Pile Loads:

DC	207	k/pile
DW	10	k/pile
LL+I, STR I	46	k/pile
LL+ I, others	39	k/pile

Notes: Loads do not include weigh of steel H-Pile

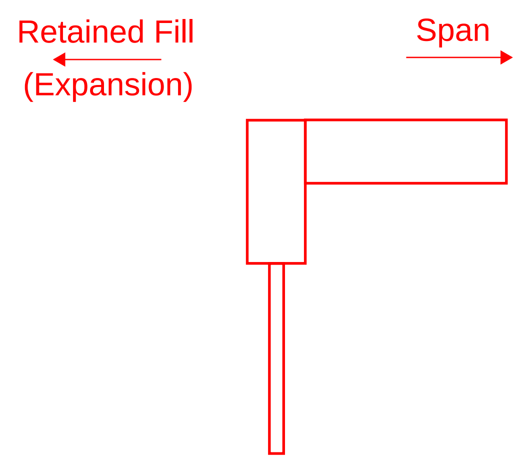
Summary of Factored Pile Loads:

STRENGTH I = 355 k/pile

SERVICE I = 342 k/pile

Thermal Contraction - Temperature Fall (toward span)

Δ fall =	0.337	in



Thermal Expansion - Temperature Rise (into backfill)

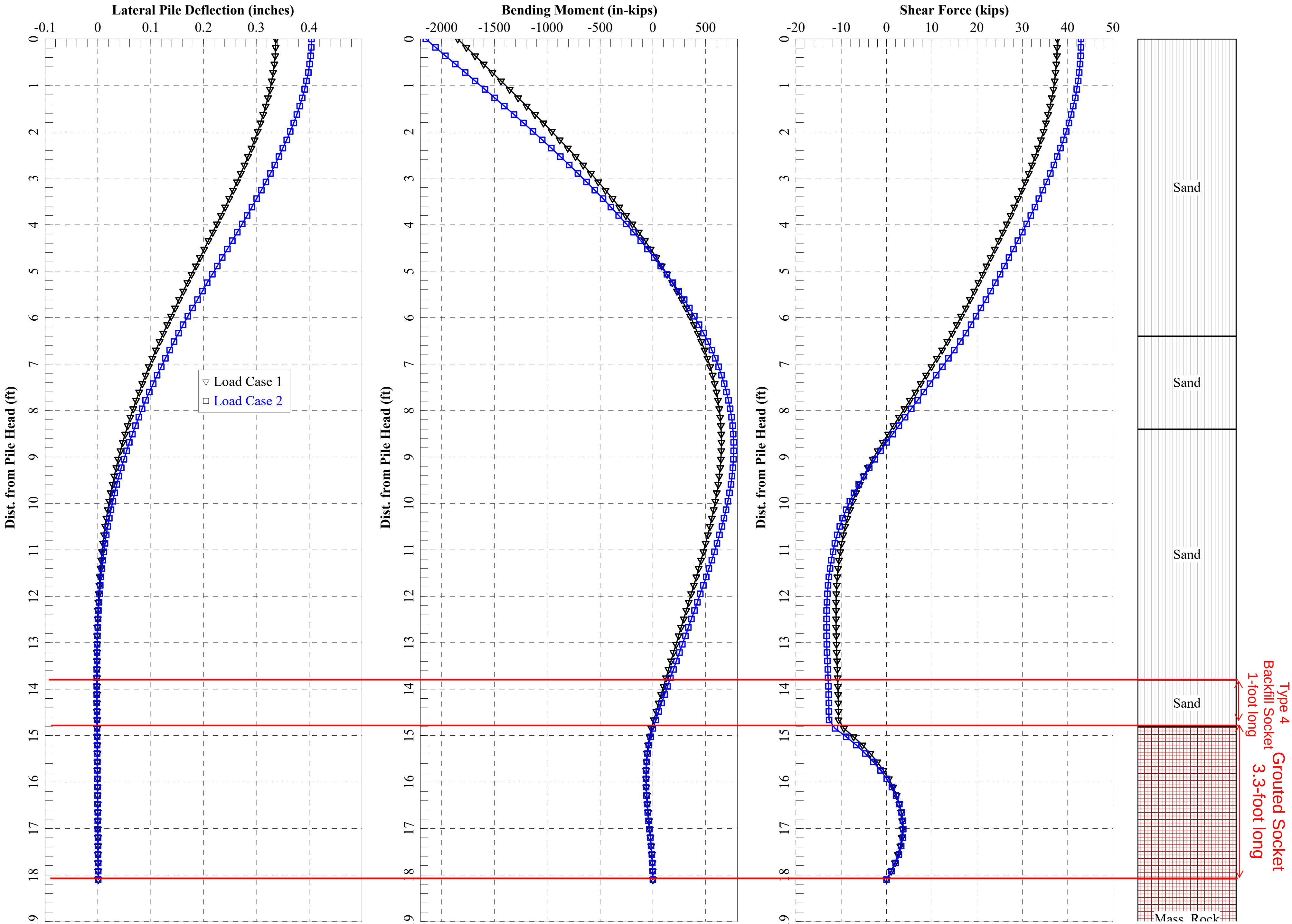
Δ rise =	0.281	in

Total Thermal Movement Range at Each Abutment

Δ range =	0.4208	in

Note: Thermal movement does NOT include load factors

Benjamin Lincoln Bridge
Abutment 1 14x117 Piles, No Scour, No Corrosion



```
===============================================================================

                    LPile for Windows, Version 2022-12.010

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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===============================================================================

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Michael Johnescu
GEI Portland, Maine


Serial Number of Security Device: 264780746

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-------------------------------------------------------------------------------
                             Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\Working\THORNTON TOMASETTI\2502334 MaineDOT Downeast Bridges Phase II\09_Engineering\01_Dennysville\07_Lpile\Pile Runs\No Scour No
Corrosion\

Name of input data file:
Dennysville Abutment 1 HP14x117 2025-07-08.lp12d

Name of output report file:
Dennysville Abutment 1 HP14x117 2025-07-08.lp12o

Name of plot output file:
Dennysville Abutment 1 HP14x117 2025-07-08.lp12p

Name of runtime message file:
Dennysville Abutment 1 HP14x117 2025-07-08.lp12r

-------------------------------------------------------------------------------
                            Date and Time of Analysis
-------------------------------------------------------------------------------

               Date:  July 8, 2025               Time:  18:31:16


-------------------------------------------------------------------------------
                                  Problem Title
-------------------------------------------------------------------------------

Project Name: Benjamin Lincoln Bridge #6740

Job Number: 2502334

Client: Thornton Tomasetti

Engineer: M. Johnescu

Description: Lateral Pile Analysis Abutment 1 HP14x117



-------------------------------------------------------------------------------
                           Program Options and Settings
-------------------------------------------------------------------------------

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
```

```
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                       =           3
Total length of pile                                  =       18.100 ft
Depth of ground surface below top of pile             =       0.0000 ft

Pile diameters used for p-y curve computations are defined using 6 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000          14.9000
  2           14.800          14.9000
  3           14.800          30.0000
  4           17.800          30.0000
  5           17.800          30.0000
  6           18.100          30.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H weak axis steel pile
   Length of section                                  =    14.800000 ft
   Pile width                                         =    14.200000 in
```

```
Pile Section No. 2:

   Section 2 is a drilled shaft with casing and H section core/insert
   Length of section                                  =     3.000000 ft
   Section Diameter                                   =    30.000000 in

Pile Section No. 3:

   Section 3 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                  =     0.300000 ft
   Shaft Diameter                                     =    30.000000 in



--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =       0.0000 ft
   Distance from top of pile to bottom of layer       =     6.400000 ft
   Effective unit weight at top of layer              =   125.000000 pcf
   Effective unit weight at bottom of layer           =   125.000000 pcf
   Friction angle at top of layer                     =    34.000000 deg.
   Friction angle at bottom of layer                  =    34.000000 deg.
   Subgrade k at top of layer                         =   122.000000 pci
   Subgrade k at bottom of layer                      =   122.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =     6.400000 ft
   Distance from top of pile to bottom of layer       =     8.400000 ft
   Effective unit weight at top of layer              =   135.000000 pcf
   Effective unit weight at bottom of layer           =   135.000000 pcf
   Friction angle at top of layer                     =    38.000000 deg.
   Friction angle at bottom of layer                  =    38.000000 deg.
   Subgrade k at top of layer                         =   209.000000 pci
   Subgrade k at bottom of layer                      =   209.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =     8.400000 ft
   Distance from top of pile to bottom of layer       =    13.800000 ft
   Effective unit weight at top of layer              =    72.600000 pcf
```

Effective unit weight at bottom of layer = 72.600000 pcf
Friction angle at top of layer = 38.000000 deg.
Friction angle at bottom of layer = 38.000000 deg.
Subgrade k at top of layer = 120.000000 pci
Subgrade k at bottom of layer = 120.000000 pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 13.800000 ft
Distance from top of pile to bottom of layer = 14.800000 ft
Effective unit weight at top of layer = 62.600000 pcf
Effective unit weight at bottom of layer = 62.600000 pcf
Friction angle at top of layer = 32.000000 deg.
Friction angle at bottom of layer = 32.000000 deg.
Subgrade k at top of layer = 55.000000 pci
Subgrade k at bottom of layer = 55.000000 pci

Layer 5 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 14.800000 ft
Distance from top of pile to bottom of layer = 50.000000 ft
Effective unit weight at top of layer = 109.400000 pcf
Effective unit weight at bottom of layer = 109.400000 pcf
Uniaxial compressive strength at top of layer = 29282. psi
Uniaxial compressive strength at bottom of layer = 29282. psi
Poisson's ratio at top of layer = 0.250000
Poisson's ratio at bottom of layer = 0.250000
Option 1: Intact rock modulus at top of layer = 0.0000 psi
Intact rock modulus at bottom of layer = 0.0000 psi
Option 1: Geologic Strength Index for layer = 45.000000
Option 2: Rock mass modulus at top of layer = 739400. psi
Rock mass modulus at bottom of layer = 739400. psi
Option 2 will use the input value of rock mass modulus to compute the p-y curve in massive rock.
The rock type is (sedimentary) claystones, Hoek-Brown Material Constant mi = 4

(Depth of the lowest soil layer extends 31.900 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	kpy pci	Rock Mass Modulus psi	Geologic Strength Index	Int. Rock Modulus psi	Hoek-Brown Material Index, mi	Poisson's Ratio
1	Sand	0.00	125.0000	34.0000	--	122.0000	--	--	0.00	0.00	0.00
	(Reese, et al.)	6.4000	125.0000	34.0000	--	122.0000	--	--	0.00	0.00	0.00
2	Sand	6.4000	135.0000	38.0000	--	209.0000	--	--	0.00	0.00	0.00
	(Reese, et al.)	8.4000	135.0000	38.0000	--	209.0000	--	--	0.00	0.00	0.00
3	Sand	8.4000	72.6000	38.0000	--	120.0000	--	--	0.00	0.00	0.00
	(Reese, et al.)	13.8000	72.6000	38.0000	--	120.0000	--	--	0.00	0.00	0.00
4	Sand	13.8000	62.6000	32.0000	--	55.0000	--	--	0.00	0.00	0.00
	(Reese, et al.)	14.8000	62.6000	32.0000	--	55.0000	--	--	0.00	0.00	0.00
5	Massive	14.8000	109.4000	--	29282.	--	739400.	45.0000	0.00	4.0000	0.2500
	Rock	50.0000	109.4000	--	29282.	--		45.0000	0.00	4.0000	0.2500

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	5	y = 0.337000 in	S = 0.0000 in/in	355000.	N.A.	Yes
2	5	y = 0.404400 in	S = 0.0000 in/in	355000.	N.A.	Yes

V = shear force applied normal to pile axis

M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 3

Pile Section No. 1:

Dimensions and Properties of Steel H Weak Axis:

Length of Section	=	14.800000 ft
Flange Width	=	14.900000 in
Section Depth	=	14.200000 in
Flange Thickness	=	0.805000 in
Web Thickness	=	0.805000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	34.123950 sq. in.
Moment of Inertia	=	444.363799 in^4
Elastic Bending Stiffness	=	12886550. kip-in^2
Plastic Modulus, Z	=	91.398684in^3
Plastic Moment Capacity = Fy Z	=	4570.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	1706.197 kips
Nominal Axial Tensile Capacity	=	-1706.197 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	355.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 355.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000453	58.3569131	12886018.	86.6631881	11.3718919	
0.00000906	116.7138261	12886018.	47.0565936	12.3405333	
0.00001359	175.0707392	12886018.	33.8543957	13.3091748	
0.00001811	233.4276522	12886018.	27.2532968	14.2778163	
0.00002264	291.7845653	12886018.	23.2926374	15.2464576	
0.00002717	350.1414784	12886018.	20.6521979	16.2150990	
0.00003170	408.4983914	12886018.	18.7661696	17.1837405	
0.00003623	466.8553045	12886018.	17.3516484	18.1523819	
0.00004076	525.2122175	12886018.	16.2514652	19.1210233	
0.00004529	583.5691306	12886018.	15.3713187	20.0896648	
0.00004982	641.9260437	12886018.	14.6511988	21.0583063	
0.00005434	700.2829567	12886018.	14.0510989	22.0269477	
0.00005887	758.6398698	12886018.	13.5433221	22.9955891	
0.00006340	816.9967828	12886018.	13.1080848	23.9642305	
0.00006793	875.3536959	12886018.	12.7308791	24.9328720	
0.00007246	933.7106090	12886018.	12.4008242	25.9015134	
0.00007699	992.0675220	12886018.	12.1095992	26.8701548	
0.00008152	1050.	12886018.	11.8507326	27.8387963	
0.00008605	1109.	12886018.	11.6191151	28.8074377	
0.00009057	1167.	12886018.	11.4106594	29.7760791	
0.00009510	1225.	12886018.	11.2220565	30.7447206	
0.00009963	1284.	12886018.	11.0505994	31.7133620	
0.0001042	1342.	12886018.	10.8940516	32.6820034	
0.0001087	1401.	12886018.	10.7505495	33.6506449	
0.0001132	1459.	12886018.	10.6185275	34.6192863	
0.0001177	1517.	12886018.	10.4966610	35.5879277	
0.0001223	1576.	12886018.	10.3838217	36.5565691	
0.0001268	1634.	12886018.	10.2790424	37.5252106	
0.0001313	1692.	12886018.	10.1814892	38.4938520	
0.0001359	1751.	12886018.	10.0904396	39.4624934	
0.0001404	1809.	12886018.	10.0052641	40.4311349	
0.0001449	1867.	12886018.	9.9254121	41.3997763	
0.0001494	1926.	12886018.	9.8503996	42.3684177	
0.0001540	1984.	12886018.	9.7797996	43.3370592	

0.0001585	2042.	12886018.	9.7132339	44.3057006	
0.0001630	2101.	12886018.	9.6503663	45.2743420	
0.0001676	2159.	12886018.	9.5908970	46.2429835	
0.0001721	2218.	12886018.	9.5345576	47.2116249	
0.0001766	2276.	12886018.	9.4811074	48.1802663	
0.0001857	2392.	12884890.	9.3821835	50.0000000	Y
0.0001947	2503.	12852606.	9.2967962	50.0000000	Y
0.0002038	2606.	12788156.	9.2240451	50.0000000	Y
0.0002128	2703.	12699436.	9.1619690	50.0000000	Y
0.0002219	2794.	12592889.	9.1089066	50.0000000	Y
0.0002310	2881.	12473784.	9.0634366	50.0000000	Y
0.0002400	2963.	12345513.	9.0244954	50.0000000	Y
0.0002491	3041.	12210540.	8.9912347	50.0000000	Y
0.0002581	3116.	12072289.	8.9626558	50.0000000	Y
0.0002672	3188.	11931549.	8.9382789	50.0000000	Y
0.0002763	3257.	11789671.	8.9175502	50.0000000	Y
0.0002853	3323.	11648357.	8.8998643	50.0000000	Y
0.0002944	3386.	11504391.	8.8841802	50.0000000	Y
0.0003034	3444.	11351939.	8.8689565	50.0000000	Y
0.0003125	3498.	11192946.	8.8540712	50.0000000	Y
0.0003215	3546.	11029038.	8.8393987	50.0000000	Y
0.0003306	3591.	10862815.	8.8250832	50.0000000	Y
0.0003397	3633.	10695613.	8.8110726	50.0000000	Y
0.0003487	3671.	10528567.	8.7973181	50.0000000	Y
0.0003578	3707.	10362631.	8.7837746	50.0000000	Y
0.0003668	3741.	10197826.	8.7706581	50.0000000	Y
0.0003759	3772.	10034726.	8.7577999	50.0000000	Y
0.0003849	3801.	9874068.	8.7449095	50.0000000	Y
0.0003940	3828.	9715795.	8.7324683	50.0000000	Y
0.0004031	3854.	9560818.	8.7203088	50.0000000	Y
0.0004121	3878.	9409376.	8.7083761	50.0000000	Y
0.0004212	3900.	9259753.	8.6965548	50.0000000	Y
0.0004302	3921.	9114342.	8.6849071	50.0000000	Y
0.0004393	3941.	8972043.	8.6738100	50.0000000	Y
0.0004483	3960.	8832578.	8.6624580	50.0000000	Y
0.0004574	3978.	8696873.	8.6516774	50.0000000	Y
0.0004665	3995.	8563946.	8.6408891	50.0000000	Y
0.0004755	4011.	8434742.	8.6302572	50.0000000	Y
0.0004846	4026.	8308140.	8.6200465	50.0000000	Y
0.0004936	4040.	8185027.	8.6097567	50.0000000	Y
0.0005027	4054.	8064804.	8.5997936	50.0000000	Y
0.0005117	4067.	7947410.	8.5900403	50.0000000	Y
0.0005208	4080.	7833163.	8.5802373	50.0000000	Y
0.0005299	4091.	7721750.	8.5708463	50.0000000	Y
0.0005389	4103.	7612553.	8.5614821	50.0000000	Y
0.0005751	4143.	7203530.	8.5257123	50.0000000	Y
0.0006114	4177.	6832177.	8.4920010	50.0000000	Y
0.0006476	4206.	6494981.	8.4605282	50.0000000	Y
0.0006838	4231.	6187725.	8.4308240	50.0000000	Y
0.0007201	4253.	5906468.	8.4027819	50.0000000	Y
0.0007563	4272.	5648574.	8.3764352	50.0000000	Y
0.0007925	4289.	5411491.	8.3510890	50.0000000	Y
0.0008288	4303.	5192561.	8.3274676	50.0000000	Y
0.0008650	4317.	4990490.	8.3048229	50.0000000	Y
0.0009012	4329.	4803256.	8.2837138	50.0000000	Y
0.0009374	4339.	4628861.	8.2632671	50.0000000	Y
0.0009737	4349.	4466755.	8.2437020	50.0000000	Y
0.0010099	4358.	4315284.	8.2254651	50.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	355.0000000000	4358.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and H Weak Axis Core/Insert:

Length of Section	=	3.000000 ft
Outside Diameter of Casing	=	30.000000 in
Casing Wall Thickness	=	0.0000 in
Moment of Inertia of Steel Casing	=	0.0000 in^4
Width Flange of Core/Insert	=	14.900000 in
Depth of Core/Insert	=	14.200000 in
Flange Thickness of Core/Insert	=	0.805000 in
Web Thickness of Core/Insert	=	0.805000 in

```
Moment of Inertia of Steel Core/Insert               =   444.363799 in^4
Yield Stress of Casing                               =       50000. psi
Elastic Modulus of Casing                            =    29000000. psi
Yield Stress of Core/Insert                          =       50000. psi
Elastic Modulus of Core/Insert                       =    29000000. psi
Number of Reinforcing Bars                           =            0 bars
Gross Area of Pile                                   =   706.858347 sq. in.
Area of Concrete                                     =   672.734397 sq. in.
Cross-sectional Area of Steel Casing                 =       0.0000 sq. in.
Cross-sectional Area of Steel Core/Insert            =    34.123950 sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)    =    34.123950 sq. in.
Area Ratio of All Steel to Gross Area                =         4.83 percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =     3993.494 kips
Tensile Load for Cracking of Concrete                  =     -393.967 kips
Nominal Axial Tensile Capacity                         =    -1706.197 kips



Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                    kips
   ------     ------------------
      1             355.000

Definition of Run Messages:

   Y = part of pipe section has yielded.


Axial Thrust Force =    355.000 kips
```

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Max Core Stress ksi	Run Msg
0.00000453	775.8459704	171317583.	35.8381574	0.0001623	0.00002644	0.6560962	0.00000	0.00000	3.7020157	
0.00000906	1550.	171167197.	25.4946077	0.0002309	-0.00004081	0.9144774	0.00000	0.00000	4.6881730	
0.00001359	2314.	170318804.	22.0718814	0.0002999	-0.000108	1.1634387	0.00000	0.00000	5.6821894	
0.00001811	2314.	127739103.	19.2152857	0.0003481	-0.000195	1.3306548	0.00000	0.00000	6.0755826	C
0.00002264	2576.	113769057.	17.8136957	0.0004034	-0.000276	1.5164863	0.00000	0.00000	6.6741080	C
0.00002717	2846.	104729232.	16.8341102	0.0004574	-0.000358	1.6916599	0.00000	0.00000	7.2370286	C
0.00003170	3101.	97813818.	16.1111890	0.0005107	-0.000440	1.8581427	0.00000	0.00000	7.7785930	C
0.00003623	3346.	92354106.	15.5557983	0.0005636	-0.000523	2.0169679	0.00000	0.00000	8.3062938	C
0.00004076	3584.	87944554.	15.1182451	0.0006162	-0.000607	2.1690226	0.00000	0.00000	8.8273967	C
0.00004529	3818.	84313055.	14.7672932	0.0006688	-0.000690	2.3148996	0.00000	0.00000	-9.958543	C
0.00004982	4048.	81261683.	14.4807840	0.0007214	-0.000773	2.4548048	0.00000	0.00000	-11.368305	C
0.00005434	4274.	78646966.	14.2426848	0.0007740	-0.000856	2.5887380	0.00000	0.00000	-12.777029	C
0.00005887	4496.	76365084.	14.0410177	0.0008266	-0.000940	2.7165725	0.00000	0.00000	-14.186093	C
0.00006340	4714.	74354950.	13.8697255	0.0008794	-0.001023	2.8385663	0.00000	0.00000	-15.592274	C
0.00006793	4929.	72561564.	13.7227033	0.0009322	-0.001106	2.9546797	0.00000	0.00000	-16.995638	C
0.00007246	5141.	70946098.	13.5957768	0.0009851	-0.001189	3.0649347	0.00000	0.00000	-18.395392	C
0.00007699	5349.	69475913.	13.4852106	0.0010382	-0.001271	3.1692591	0.00000	0.00000	-19.791957	C
0.00008152	5554.	68130498.	13.3894213	0.0010915	-0.001354	3.2677832	0.00000	0.00000	-21.182632	C
0.00008605	5755.	66887081.	13.3052904	0.0011449	-0.001437	3.3603203	0.00000	0.00000	-22.569377	C
0.00009057	5953.	65730404.	13.2312558	0.0011984	-0.001519	3.4468491	0.00000	0.00000	-23.951699	C
0.00009510	6148.	64649400.	13.1665548	0.0012522	-0.001601	3.5274091	0.00000	0.00000	-25.327727	C
0.00009963	6340.	63633149.	13.1099594	0.0013062	-0.001683	3.6019288	0.00000	0.00000	-26.697331	C
0.0001042	6528.	62672610.	13.0604568	0.0013604	-0.001764	3.6703340	0.00000	0.00000	-28.060377	C
0.0001087	6713.	61759028.	13.0165514	0.0014148	-0.001846	3.7324706	0.00000	0.00000	-29.418783	C
0.0001132	6893.	60887190.	12.9780805	0.0014693	-0.001927	3.7883368	0.00000	0.00000	-30.770880	C
0.0001177	7071.	60052046.	12.9446460	0.0015242	-0.002008	3.8378765	0.00000	0.00000		

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-32.115884 C
   0.0001223      7245.    59248929.   12.9157343    0.0015793    -0.002089    3.8810044     0.00000     0.00000
-33.453633 C
   0.0001268      7415.    58473816.   12.8909073    0.0016346    -0.002169    3.9176324     0.00000     0.00000
-34.783957 C
   0.0001313      7581.    57723219.   12.8697892    0.0016902    -0.002250    3.9476689     0.00000     0.00000
-36.106676 C
   0.0001359      7743.    56994086.   12.8520561    0.0017461    -0.002330    3.9710193     0.00000     0.00000
-37.421607 C
   0.0001404      7902.    56283744.   12.8374276    0.0018022    -0.002409    3.9875850     0.00000     0.00000
-38.728550 C
   0.0001449      8056.    55589819.   12.8238738    0.0018584    -0.002489    3.9972638     0.00000     0.00000
-40.027306 C
   0.0001494      8206.    54910000.   12.8136249    0.0019150    -0.002568    3.9983659     0.00000     0.00000
-41.317619 C
   0.0001540      8352.    54240682.   12.8100159    0.0019724    -0.002647    3.9990335     0.00000     0.00000
-42.598877 C
   0.0001585      8493.    53580224.   12.8058778    0.0020298    -0.002725    3.9994099     0.00000     0.00000
-43.870808 C
   0.0001630      8629.    52928190.   12.8039539    0.0020875    -0.002804    3.9995986     0.00000     0.00000
-45.133352 C
   0.0001676      8761.    52284591.   12.8040531    0.0021455    -0.002881    3.9996644     0.00000     0.00000
-46.386575 C
   0.0001721      8888.    51649670.   12.8059913    0.0022038    -0.002959    3.9996335     0.00000     0.00000
-47.630593 C
   0.0001766      9012.    51023761.   12.8095944    0.0022624    -0.003036    3.9994927     0.00000     0.00000
-48.865574 C
   0.0001857      9242.    49774039.   12.8193126    0.0023802    -0.003190    3.9986069     0.00000     0.00000
-50.000000 CY
   0.0001947      9443.    48492921.   12.8284532    0.0024981    -0.003344    3.9999973     0.00000     0.00000
-50.000000 CY
   0.0002038      9619.    47201665.   12.8356447    0.0026158    -0.003498    3.9986700     0.00000     0.00000
-50.000000 CY
   0.0002128      9775.    45923819.   12.8455591    0.0027342    -0.003651    3.9997751     0.00000     0.00000
-50.000000 CY
   0.0002219      9912.    44669566.   12.8538009    0.0028523    -0.003805    3.9997557     0.00000     0.00000
-50.000000 CY
   0.0002310     10034.    43445826.   12.8619148    0.0029706    -0.003958    3.9967415     0.00000     0.00000
-50.000000 CY
   0.0002400     10143.    42259056.   12.8699464    0.0030891    -0.004112    3.9963065     0.00000     0.00000
-50.000000 CY
   0.0002491     10240.    41112894.   12.8779387    0.0032076    -0.004265    3.9958115     0.00000     0.00000
-50.000000 CY
   0.0002581     10328.    40009710.   12.8853712    0.0033262    -0.004418    3.9976760     0.00000     0.00000
-50.000000 CY
   0.0002672     10407.    38950633.   12.8941530    0.0034452    -0.004571    3.9999812     0.00000     0.00000
-50.000000 CY
   0.0002763     10478.    37927969.   12.9016654    0.0035641    -0.004723    3.9995020     0.00000     0.00000
-50.000000 CY
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   0.0002853     10542.    36949386.   12.9098739    0.0036833    -0.004876    3.9979003     0.00000     0.00000
-50.000000 CY
   0.0002944     10601.    36012929.   12.9180151    0.0038026    -0.005028    3.9944534     0.00000     0.00000
-50.000000 CY
   0.0003034     10601.    34938096.   12.9373521    0.0039255    -0.005177    3.9999113     0.00000     0.00000
-50.000000 CY
   0.0003125     10601.    33925398.   12.9927426    0.0040600    -0.005314    3.9990591     0.00000     0.00000
-50.000000 CY
   0.0003215     10601.    32969753.   13.0326138    0.0041905    -0.005456    3.9960738     0.00000     0.00000
50.0000000 CY
   0.0003306     10601.    32066472.   13.0749929    0.0043225    -0.005595    3.9979934     0.00000     0.00000
50.0000000 CY
   0.0003397     10601.    31211366.   13.1625967    0.0044707    -0.005719    3.9997838     0.00000     0.00000
50.0000000 CY
   0.0003487     10601.    30400681.   13.2142541    0.0046079    -0.005853    3.9971271     0.00000     0.00000
50.0000000 CY
   0.0003578     10601.    29631044.   13.2685276    0.0047470    -0.005986    3.9948124     0.00000     0.00000
50.0000000 CY
   0.0003668     10601.    28899413.   13.3250442    0.0048880    -0.006117    3.9993186     0.00000     0.00000
50.0000000 CY
   0.0003759     10601.    28203042.   13.3826203    0.0050303    -0.006246    3.9945312     0.00000     0.00000
50.0000000 CY
   0.0003849     10601.    27539441.   13.4415618    0.0051742    -0.006374    3.9999880     0.00000     0.00000
50.0000000 CY
   0.0003940     10601.    26906350.   13.5018501    0.0053197    -0.006500    3.9968010     0.00000     0.00000
50.0000000 CY
   0.0004031     10601.    26301713.   13.5647913    0.0054673    -0.006624    3.9955923     0.00000     0.00000
50.0000000 CY
   0.0004121     10601.    25723653.   13.6268988    0.0056158    -0.006748    3.9981222     0.00000     0.00000
50.0000000 CY
   0.0004212     10601.    25170457.   13.6918992    0.0057666    -0.006868    3.9916488     0.00000     0.00000
50.0000000 CY
   0.0004302     10601.    24640552.   13.6962906    0.0058925    -0.007014    3.9960682     0.00000     0.00000
50.0000000 CY
   0.0004393     10601.    24132500.   13.7605164    0.0060448    -0.007134    3.9977028     0.00000     0.00000
50.0000000 CY
   0.0004483     10601.    23644974.   13.8254872    0.0061985    -0.007252    3.9960865     0.00000     0.00000
50.0000000 CY
   0.0004574     10601.    23176757.   13.8917122    0.0063541    -0.007368    3.9974470     0.00000     0.00000
50.0000000 CY
   0.0004665     10601.    22726723.   13.8968482    0.0064823    -0.007511    3.9905084     0.00000     0.00000
50.0000000 CY
   0.0004755     10601.    22293833.   13.9614347    0.0066389    -0.007627    3.9992541     0.00000     0.00000
50.0000000 CY
   0.0004846     10601.    21877126.   14.0283015    0.0067977    -0.007739    3.9878701     0.00000     0.00000
50.0000000 CY
   0.0004936     10601.    21475711.   14.0322193    0.0069267    -0.007882    3.9947059     0.00000     0.00000
50.0000000 CY
   0.0005027     10601.    21088761.   14.0973225    0.0070865    -0.007994    3.9999927     0.00000     0.00000
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50.0000000 CY								
0.0005117	10601.	20715508.	14.1009077	0.0072160	-0.008136	3.9895551	0.00000	0.00000
50.0000000 CY								
0.0005208	10601.	20355239.	14.1673233	0.0073783	-0.008246	3.9966673	0.00000	0.00000
50.0000000 CY								
0.0005299	10601.	20007286.	14.2341090	0.0075421	-0.008354	3.9959876	0.00000	0.00000
50.0000000 CY								

Summary of Results for Nominal Moment Capacity for Section 2

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	355.0000000000	10601.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Pile Section No. 3:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	0.300000 ft
Shaft Diameter	=	30.000000 in
Number of Reinforcing Bars	=	0 bars
Yield Stress of Reinforcing Bars	=	0.0000 psi
Modulus of Elasticity of Reinforcing Bars	=	0.0000 psi
Gross Area of Shaft	=	706.858347 sq. in.
Total Area of Reinforcing Steel	=	0.0000 sq. in.
Area Ratio of Steel Reinforcement	=	0.00 percent
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	2403.318 kips
Tensile Load for Cracking of Concrete	=	-293.989 kips
Nominal Axial Tensile Capacity	=	0.000 kips

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.34165 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	355.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 355.000 kips

Bending Curvature	Bending Moment	Bending Stiffness	Depth to N Axis	Max Comp Strain	Max Tens Strain	Max Conc Stress	Max Steel Stress	Run Msg

rad/in.	in-kip	kip-in2	in	in/in	in/in	ksi	ksi
0.00000125	197.1345174	157707614.	112.9289563	0.0001412	0.0001037	0.5755514	0.00000
0.00000250	394.2523254	157700930.	63.9943795	0.0001600	0.00008499	0.6482973	0.00000
0.00000375	591.3367123	157689790.	47.6961453	0.0001789	0.00006636	0.7204535	0.00000
0.00000500	788.3709617	157674192.	39.5569988	0.0001978	0.00004778	0.7920140	0.00000
0.00000625	985.3383501	157654136.	34.6814898	0.0002168	0.00002926	0.8629723	0.00000
0.00000750	1182.	157629619.	31.4378021	0.0002358	0.00001078	0.9333224	0.00000
0.00000875	1379.	157600339.	29.1265788	0.0002549	-0.00000764	1.0030576	0.00000
0.00001000	1576.	157552613.	27.3977915	0.0002740	-0.00002602	1.0721589	0.00000
0.00001125	1771.	157462095.	26.0564862	0.0002931	-0.00004436	1.1405876	0.00000
0.00001250	1967.	157320087.	24.9857772	0.0003123	-0.00006268	1.2083105	0.00000
0.00001375	2161.	157127778.	24.1114394	0.0003315	-0.00008097	1.2753035	0.00000
0.00001500	2353.	156890088.	23.3789460	0.0003507	-0.00009932	1.3415491	0.00000
0.00001625	2353.	144821619.	22.0318216	0.0003580	-0.000129	1.3659313	0.00000 C
0.00001750	2353.	134477218.	21.3410964	0.0003735	-0.000152	1.4182052	0.00000 C
0.00001875	2353.	125512070.	20.7223044	0.0003885	-0.000174	1.4686796	0.00000 C
0.00002000	2405.	120253509.	20.1634244	0.0004033	-0.000197	1.5174907	0.00000 C
0.00002125	2470.	116251063.	19.6555498	0.0004177	-0.000220	1.5647898	0.00000 C
0.00002250	2530.	112448518.	19.1897109	0.0004318	-0.000243	1.6105724	0.00000 C
0.00002375	2586.	108876243.	18.7622838	0.0004456	-0.000267	1.6551215	0.00000 C
0.00002500	2637.	105488526.	18.3667604	0.0004592	-0.000291	1.6983397	0.00000 C
0.00002625	2685.	102294458.	17.9998590	0.0004725	-0.000315	1.7404188	0.00000 C
0.00002750	2730.	99280203.	17.6583282	0.0004856	-0.000339	1.7814228	0.00000 C
0.00002875	2772.	96431139.	17.3391927	0.0004985	-0.000364	1.8213979	0.00000 C
0.00003000	2812.	93734902.	17.0401949	0.0005112	-0.000389	1.8603925	0.00000 C
0.00003125	2849.	91180920.	16.7590906	0.0005237	-0.000414	1.8984580	0.00000 C
0.00003250	2885.	88760056.	16.4942123	0.0005361	-0.000439	1.9356488	0.00000 C
0.00003375	2918.	86464334.	16.2441864	0.0005482	-0.000464	1.9720228	0.00000 C
0.00003500	2950.	84286718.	16.0078863	0.0005603	-0.000490	2.0076410	0.00000 C
0.00003625	2980.	82212765.	15.7834625	0.0005722	-0.000515	2.0424688	0.00000 C
0.00003750	3009.	80232800.	15.5695491	0.0005839	-0.000541	2.0764989	0.00000 C
0.00003875	3036.	78352317.	15.3666595	0.0005955	-0.000567	2.1099170	0.00000 C
0.00004000	3062.	76561449.	15.1736339	0.0006069	-0.000593	2.1427168	0.00000 C
0.00004125	3087.	74841236.	14.9880291	0.0006183	-0.000619	2.1747241	0.00000 C
0.00004250	3111.	73207586.	14.8119191	0.0006295	-0.000645	2.2062811	0.00000 C
0.00004375	3134.	71636668.	14.6422487	0.0006406	-0.000672	2.2371167	0.00000 C
0.00004500	3156.	70137069.	14.4802018	0.0006516	-0.000698	2.2674587	0.00000 C
0.00004625	3177.	68698287.	14.3244807	0.0006625	-0.000725	2.2972260	0.00000 C
0.00004750	3198.	67318644.	14.1748902	0.0006733	-0.000752	2.3264663	0.00000 C
0.00004875	3217.	65993695.	14.0309595	0.0006840	-0.000778	2.3551870	0.00000 C
0.00005125	3254.	63496506.	13.7587348	0.0007051	-0.000832	2.4111404	0.00000 C
0.00005375	3289.	61184927.	13.5054943	0.0007259	-0.000887	2.4652326	0.00000 C
0.00005625	3321.	59040736.	13.2695313	0.0007464	-0.000941	2.5176167	0.00000 C
0.00005875	3352.	57048526.	13.0491777	0.0007666	-0.000996	2.5684537	0.00000 C
0.00006125	3380.	55178100.	12.8401583	0.0007865	-0.001051	2.6173830	0.00000 C
0.00006375	3406.	53433631.	12.6447106	0.0008061	-0.001106	2.6649666	0.00000 C
0.00006625	3432.	51803612.	12.4607573	0.0008255	-0.001162	2.7113144	0.00000 C
0.00006875	3456.	50261873.	12.2854667	0.0008446	-0.001218	2.7559200	0.00000 C
0.00007125	3478.	48820242.	12.1207721	0.0008636	-0.001274	2.7995817	0.00000 C
0.00007375	3500.	47452952.	11.9631365	0.0008823	-0.001330	2.8416800	0.00000 C
0.00007625	3520.	46168445.	11.8140539	0.0009008	-0.001387	2.8828716	0.00000 C
0.00007875	3540.	44946476.	11.6715673	0.0009191	-0.001443	2.9226157	0.00000 C
0.00008125	3558.	43796727.	11.5372268	0.0009374	-0.001500	2.9616313	0.00000 C
0.00008375	3576.	42696015.	11.4062473	0.0009553	-0.001557	2.9990991	0.00000 C
0.00008625	3593.	41658260.	11.2833123	0.0009732	-0.001614	3.0359600	0.00000 C
0.00008875	3609.	40665166.	11.1638680	0.0009908	-0.001672	3.0715068	0.00000 C
0.00009125	3625.	39720781.	11.0499087	0.0010083	-0.001729	3.1061908	0.00000 C
0.00009375	3640.	38824883.	10.9420531	0.0010258	-0.001787	3.1402203	0.00000 C
0.00009625	3654.	37960537.	10.8355348	0.0010429	-0.001845	3.1727981	0.00000 C
0.00009875	3668.	37139315.	10.7347737	0.0010601	-0.001902	3.2048152	0.00000 C
0.0001013	3681.	36356471.	10.6388153	0.0010772	-0.001960	3.2361650	0.00000 C
0.0001038	3693.	35599093.	10.5436619	0.0010939	-0.002019	3.2661669	0.00000 C
0.0001063	3706.	34876806.	10.4533119	0.0011107	-0.002077	3.2956299	0.00000 C
0.0001088	3718.	34187180.	10.3674523	0.0011275	-0.002135	3.3245502	0.00000 C
0.0001113	3729.	33519114.	10.2822714	0.0011439	-0.002194	3.3522626	0.00000 C
0.0001138	3740.	32877628.	10.2002255	0.0011603	-0.002252	3.3792793	0.00000 C
0.0001163	3751.	32263264.	10.1219959	0.0011767	-0.002311	3.4057755	0.00000 C
0.0001188	3761.	31673951.	10.0472126	0.0011931	-0.002369	3.4317194	0.00000 C
0.0001213	3771.	31099408.	9.9718454	0.0012091	-0.002428	3.4563915	0.00000 C
0.0001238	3780.	30547675.	9.8997832	0.0012251	-0.002487	3.4805658	0.00000 C
0.0001263	3790.	30017392.	9.8308303	0.0012411	-0.002546	3.5042388	0.00000 C
0.0001288	3799.	29507303.	9.7648061	0.0012572	-0.002605	3.5274074	0.00000 C
0.0001313	3808.	29010174.	9.6986505	0.0012729	-0.002665	3.5495217	0.00000 C
0.0001338	3816.	28529503.	9.6343202	0.0012886	-0.002724	3.5709904	0.00000 C
0.0001363	3824.	28066125.	9.5725793	0.0013043	-0.002783	3.5919775	0.00000 C
0.0001388	3832.	27619104.	9.5132881	0.0013200	-0.002843	3.6124800	0.00000 C
0.0001413	3840.	27187566.	9.4563180	0.0013357	-0.002902	3.6324948	0.00000 C
0.0001438	3847.	26764958.	9.3984826	0.0013510	-0.002961	3.6514601	0.00000 C
0.0001463	3855.	26355779.	9.3424114	0.0013663	-0.003021	3.6698903	0.00000 C
0.0001488	3862.	25960063.	9.2884275	0.0013817	-0.003081	3.6878561	0.00000 C
0.0001588	3888.	24492493.	9.0874589	0.0014426	-0.003320	3.7543481	0.00000 C
0.0001688	3912.	23181358.	8.9041464	0.0015026	-0.003560	3.8120452	0.00000 C
0.0001788	3933.	22002264.	8.7377027	0.0015619	-0.003801	3.8613238	0.00000 C
0.0001888	3952.	20939733.	8.5871822	0.0016208	-0.004042	3.9029901	0.00000 C
0.0001988	3969.	19971656.	8.4465310	0.0016787	-0.004284	3.9366768	0.00000 C
0.0002088	3985.	19090302.	8.3189824	0.0017366	-0.004526	3.9631711	0.00000 C
0.0002188	3999.	18282798.	8.2013572	0.0017940	-0.004768	3.9824247	0.00000 C
0.0002288	4012.	17537882.	8.0906994	0.0018507	-0.005012	3.9945171	0.00000 C
0.0002388	4024.	16853011.	7.9912981	0.0019079	-0.005255	3.9997746	0.00000 C
0.0002488	4034.	16216692.	7.8973810	0.0019645	-0.005498	3.9987206	0.00000 C
0.0002588	4043.	15624256.	7.8090717	0.0020206	-0.005742	3.9959883	0.00000 C
0.0002688	4051.	15073765.	7.7292571	0.0020772	-0.005985	3.9998738	0.00000 C
0.0002788	4059.	14560580.	7.6570893	0.0021344	-0.006228	3.9977700	0.00000 C
0.0002888	4065.	14077285.	7.5850669	0.0021902	-0.006472	3.9997701	0.00000 C
0.0002988	4070.	13624090.	7.5188246	0.0022462	-0.006716	3.9978933	0.00000 C
0.0003088	4075.	13199255.	7.4583849	0.0023028	-0.006960	3.9999999	0.00000 C
0.0003188	4080.	12799486.	7.4024891	0.0023595	-0.007203	3.9969130	0.00000 C

0.0003288	4084.	12423216.	7.3524423	0.0024171	-0.007445	3.9998508	0.00000 C
0.0003388	4087.	12065407.	7.3007603	0.0024731	-0.007689	3.9938934	0.00000 C
0.0003488	4090.	11727264.	7.2525600	0.0025293	-0.007933	3.9984609	0.00000 C
0.0003588	4092.	11407430.	7.2079401	0.0025858	-0.008177	3.9999947	0.00000 C
0.0003688	4095.	11103938.	7.1665943	0.0026427	-0.008420	3.9939957	0.00000 C
0.0003788	4097.	10816049.	7.1292056	0.0027002	-0.008662	3.9983533	0.00000 C
0.0003888	4098.	10542542.	7.0939489	0.0027578	-0.008905	3.9999887	0.00000 C
0.0003988	4100.	10281942.	7.0617265	0.0028159	-0.009147	3.9914477	0.00000 C
0.0004088	4101.	10032895.	7.0287996	0.0028730	-0.009389	3.9965294	0.00000 C
0.0004188	4102.	9794966.	6.9961537	0.0029296	-0.009633	3.9993313	0.00000 C
0.0004288	4102.	9567790.	6.9660210	0.0029867	-0.009876	3.9977746	0.00000 C
0.0004388	4103.	9350474.	6.9378366	0.0030440	-0.010119	3.9903568	0.00000 C
0.0004488	4103.	9142645.	6.9119203	0.0031017	-0.010361	3.9954692	0.00000 C
0.0004588	4103.	8943677.	6.8873761	0.0031596	-0.010603	3.9986909	0.00000 C
0.0004688	4103.	8752996.	6.8642849	0.0032176	-0.010845	3.9999769	0.00000 C
0.0004788	4103.	8570166.	6.8432603	0.0032762	-0.011086	3.9920043	0.00000 C
0.0004888	4103.	8394817.	6.8234479	0.0033350	-0.011328	3.9907207	0.00000 C
0.0004988	4103.	8226500.	6.8047943	0.0033939	-0.011569	3.9954840	0.00000 C
0.0005088	4103.	8064800.	6.7872065	0.0034530	-0.011810	3.9985670	0.00000 C
0.0005188	4103.	7909334.	6.7706551	0.0035123	-0.012050	3.9999314	0.00000 C
0.0005288	4103.	7759748.	6.7560860	0.0035723	-0.012290	3.9935796	0.00000 C
0.0005388	4103.	7615716.	6.7404632	0.0036314	-0.012531	3.9855089	0.00000 C
0.0005488	4103.	7476933.	6.7243842	0.0036900	-0.012772	3.9910045	0.00000 C
0.0006088	4103.	6739987.	6.7848538	0.0041303	-0.014132	3.9983072	0.00000 C

Summary of Results for Nominal Moment Capacity for Section 3

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	355.000	4102.267	0.00300000	-0.00993224

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	355.000000	4102.	230.750000	2666.	103542120.
1	0.75	355.000000	4102.	266.250000	3077.	75571288.
1	0.90	355.000000	4102.	319.500000	3692.	35683097.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	40961.
2	6.4000	5.5991	Yes	No	40961.	44998.
3	8.4000	7.5598	Yes	No	85958.	251164.
4	13.8000	15.9816	Yes	No	337122.	60131.
5	14.8000	14.8000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals
for Layer n. Layering correction equivalent depths are computed only
for soil types with both shallow-depth and deep-depth expressions for
peak lateral load transfer. These soil types are soft and stiff clays,
non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)

Displacement of pile head = 0.337000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 355000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3370	-1847665.	37718.	0.00	41380.	1.29E+10	0.00	0.00	0.00
0.1810	0.3367	-1765671.	37674.	-3.05E-04	40006.	1.29E+10	-19.168	123.6649	0.00
0.3620	0.3357	-1683538.	37609.	-5.95E-04	38629.	1.29E+10	-40.685	263.2494	0.00
0.5430	0.3341	-1601378.	37496.	-8.72E-04	37251.	1.29E+10	-63.977	415.9482	0.00
0.7240	0.3319	-1519312.	37330.	-0.00114	35875.	1.29E+10	-88.536	579.4108	0.00
0.9050	0.3291	-1437466.	37110.	-0.00138	34503.	1.29E+10	-113.836	751.1931	0.00
1.0860	0.3259	-1355970.	36835.	-0.00162	33137.	1.29E+10	-139.284	928.3426	0.00
1.2670	0.3221	-1274955.	36506.	-0.00184	31779.	1.29E+10	-164.406	1109.	0.00
1.4480	0.3179	-1194550.	36122.	-0.00205	30431.	1.29E+10	-189.215	1293.	0.00
1.6290	0.3132	-1114883.	35685.	-0.00224	29095.	1.29E+10	-212.808	1476.	0.00
1.8100	0.3081	-1036074.	35199.	-0.00243	27774.	1.29E+10	-234.693	1654.	0.00
1.9910	0.3027	-958238.	34665.	-0.00259	26469.	1.29E+10	-256.560	1841.	0.00
2.1720	0.2969	-881488.	34086.	-0.00275	25182.	1.29E+10	-277.391	2030.	0.00
2.3530	0.2907	-805932.	33463.	-0.00289	23915.	1.29E+10	-296.025	2212.	0.00
2.5340	0.2843	-731667.	32802.	-0.00302	22670.	1.29E+10	-312.794	2390.	0.00
2.7150	0.2776	-658783.	32105.	-0.00314	21448.	1.29E+10	-328.832	2573.	0.00
2.8960	0.2707	-587365.	31376.	-0.00324	20251.	1.29E+10	-342.224	2746.	0.00
3.0770	0.2635	-517485.	30621.	-0.00334	19079.	1.29E+10	-352.682	2907.	0.00
3.2580	0.2562	-449202.	29843.	-0.00342	17934.	1.29E+10	-364.383	3089.	0.00
3.4390	0.2487	-382579.	29041.	-0.00349	16817.	1.29E+10	-374.079	3267.	0.00
3.6200	0.2410	-317671.	28221.	-0.00355	15729.	1.29E+10	-380.736	3431.	0.00
3.8010	0.2333	-254518.	27386.	-0.00359	14670.	1.29E+10	-388.118	3614.	0.00
3.9820	0.2254	-193163.	26532.	-0.00363	13642.	1.29E+10	-398.463	3839.	0.00
4.1630	0.2175	-133662.	25658.	-0.00366	12644.	1.29E+10	-406.277	4057.	0.00
4.3440	0.2095	-76061.	24770.	-0.00368	11678.	1.29E+10	-411.327	4264.	0.00
4.5250	0.2015	-20391.	23874.	-0.00369	10745.	1.29E+10	-413.386	4455.	0.00
4.7060	0.1935	33332.	22978.	-0.00368	10962.	1.29E+10	-412.246	4627.	0.00
4.8870	0.1855	85106.	22087.	-0.00367	11830.	1.29E+10	-407.716	4773.	0.00
5.0680	0.1776	134946.	21198.	-0.00366	12666.	1.29E+10	-411.143	5030.	0.00
5.2490	0.1696	182828.	20293.	-0.00363	13468.	1.29E+10	-421.856	5401.	0.00
5.4300	0.1618	228696.	19367.	-0.00359	14237.	1.29E+10	-431.258	5790.	0.00
5.6110	0.1540	272500.	18421.	-0.00355	14972.	1.29E+10	-439.264	6194.	0.00
5.7920	0.1464	314197.	17460.	-0.00350	15671.	1.29E+10	-445.794	6616.	0.00
5.9730	0.1388	353749.	16487.	-0.00345	16334.	1.29E+10	-450.781	7054.	0.00
6.1540	0.1314	391129.	15504.	-0.00338	16961.	1.29E+10	-454.163	7508.	0.00
6.3350	0.1241	426316.	14511.	-0.00331	17551.	1.29E+10	-460.417	8058.	0.00
6.5160	0.1170	459275.	13435.	-0.00324	18103.	1.29E+10	-530.316	9846.	0.00
6.6970	0.1100	489673.	12278.	-0.00316	18613.	1.29E+10	-534.731	10556.	0.00
6.8780	0.1033	517484.	11114.	-0.00308	19079.	1.29E+10	-536.950	11295.	0.00
7.0590	0.09667	542695.	9945.	-0.00299	19502.	1.29E+10	-539.291	12117.	0.00
7.2400	0.09029	565291.	8767.	-0.00289	19881.	1.29E+10	-546.080	13137.	0.00
7.4210	0.08411	585238.	7575.	-0.00280	20215.	1.29E+10	-551.306	14237.	0.00
7.6020	0.07814	602508.	6373.	-0.00270	20505.	1.29E+10	-554.927	15425.	0.00
7.7830	0.07240	617081.	5166.	-0.00259	20749.	1.29E+10	-556.905	16708.	0.00
7.9640	0.06688	628947.	3956.	-0.00249	20948.	1.29E+10	-557.212	18097.	0.00
8.1450	0.06159	638103.	2747.	-0.00238	21101.	1.29E+10	-555.824	19601.	0.00
8.3260	0.05654	644553.	1543.	-0.00227	21210.	1.29E+10	-552.728	21235.	0.00
8.5070	0.05172	648313.	357.4188	-0.00216	21273.	1.29E+10	-539.392	22653.	0.00
8.6880	0.04714	649443.	-801.422	-0.00205	21292.	1.29E+10	-527.681	24316.	0.00
8.8690	0.04279	648000.	-1933.	-0.00195	21267.	1.29E+10	-514.667	26123.	0.00
9.0500	0.03869	644044.	-3036.	-0.00184	21201.	1.29E+10	-500.386	28094.	0.00
9.2310	0.03481	637644.	-4082.	-0.00173	21094.	1.29E+10	-462.779	28872.	0.00
9.4120	0.03118	628978.	-5043.	-0.00162	20948.	1.29E+10	-422.559	29438.	0.00
9.5930	0.02777	618237.	-5919.	-0.00152	20768.	1.29E+10	-383.623	30004.	0.00
9.7740	0.02459	605606.	-6711.	-0.00141	20557.	1.29E+10	-346.097	30570.	0.00
9.9550	0.02163	591263.	-7424.	-0.00131	20316.	1.29E+10	-310.091	31136.	0.00
10.1360	0.01889	575380.	-8060.	-0.00121	20050.	1.29E+10	-275.702	31702.	0.00
10.3170	0.01636	558122.	-8623.	-0.00112	19760.	1.29E+10	-243.013	32268.	0.00
10.4980	0.01403	539645.	-9118.	-0.00103	19451.	1.29E+10	-212.094	32834.	0.00
10.6790	0.01190	520098.	-9547.	-9.37E-04	19123.	1.29E+10	-182.999	33400.	0.00
10.8600	0.00996	499619.	-9915.	-8.51E-04	18780.	1.29E+10	-155.772	33967.	0.00
11.0410	0.00820	478341.	-10225.	-7.68E-04	18423.	1.29E+10	-130.442	34533.	0.00
11.2220	0.00662	456385.	-10483.	-6.90E-04	18055.	1.29E+10	-107.026	35099.	0.00
11.4030	0.00521	433865.	-10692.	-6.15E-04	17677.	1.29E+10	-85.529	35665.	0.00
11.5840	0.00395	410885.	-10857.	-5.43E-04	17292.	1.29E+10	-65.945	36231.	0.00
11.7650	0.00285	387541.	-10981.	-4.76E-04	16901.	1.29E+10	-48.255	36797.	0.00
11.9460	0.00189	363918.	-11069.	-4.13E-04	16505.	1.29E+10	-32.429	37363.	0.00
12.1270	0.00106	340096.	-11124.	-3.53E-04	16105.	1.29E+10	-18.428	37929.	0.00
12.3080	3.50E-04	316142.	-11151.	-2.98E-04	15704.	1.29E+10	-6.201	38495.	0.00
12.4890	-2.40E-04	292117.	-11153.	-2.47E-04	15301.	1.29E+10	4.3121	39062.	0.00
12.6700	-7.22E-04	268076.	-11134.	-2.00E-04	14898.	1.29E+10	13.1814	39628.	0.00
12.8510	-0.00111	244061.	-11097.	-1.56E-04	14495.	1.29E+10	20.4862	40194.	0.00
13.0320	-0.00140	220111.	-11046.	-1.17E-04	14094.	1.29E+10	26.3147	40760.	0.00
13.2130	-0.00162	196257.	-10984.	-8.23E-05	13694.	1.29E+10	30.7639	41326.	0.00
13.3940	-0.00176	172523.	-10914.	-5.12E-05	13296.	1.29E+10	33.9392	41892.	0.00
13.5750	-0.00184	148926.	-10838.	-2.41E-05	12900.	1.29E+10	35.9542	42458.	0.00
13.7560	-0.00186	125480.	-10759.	-9.79E-07	12507.	1.29E+10	36.9307	43024.	0.00
13.9370	-0.00184	102191.	-10700.	1.82E-05	12117.	1.29E+10	16.9576	19979.	0.00
14.1180	-0.00179	78969.	-10664.	3.35E-05	11727.	1.29E+10	16.6350	20238.	0.00
14.2990	-0.00170	55816.	-10628.	4.48E-05	11339.	1.29E+10	16.0256	20498.	0.00
14.4800	-0.00159	32731.	-10594.	5.23E-05	10952.	1.29E+10	15.2002	20757.	0.00
14.6610	-0.00147	9713.	-10563.	5.59E-05	10566.	1.29E+10	14.2331	21017.	0.00
14.8420	-0.00135	-13239.	-9423.	5.66E-05	0.00	1.71E+11	1035.	1668731.	0.00
15.0230	-0.00123	-31306.	-7271.	5.63E-05	0.00	1.71E+11	945.3464	1676137.	0.00
15.2040	-0.00110	-44913.	-5319.	5.58E-05	0.00	1.71E+11	852.7930	1679141.	0.00
15.3850	-9.82E-04	-54496.	-3566.	5.52E-05	0.00	1.71E+11	760.8501	1682124.	0.00
15.5660	-8.63E-04	-60489.	-2013.	5.45E-05	0.00	1.71E+11	669.7286	1685078.	0.00
15.7470	-7.46E-04	-63322.	-655.780	5.37E-05	0.00	1.71E+11	579.5659	1687998.	0.00
15.9280	-6.30E-04	-63421.	506.2400	5.29E-05	0.00	1.71E+11	490.4344	1690883.	0.00
16.1090	-5.16E-04	-61205.	1476.	5.21E-05	0.00	1.71E+11	402.3488	1693731.	0.00
16.2900	-4.04E-04	-57090.	2255.	5.14E-05	0.00	1.71E+11	315.2741	1696545.	0.00
16.4710	-2.93E-04	-51488.	2846.	5.07E-05	0.00	1.71E+11	229.1339	1699326.	0.00
16.6520	-1.84E-04	-44804.	3251.	5.01E-05	0.00	1.71E+11	143.8188	1702078.	0.00

16.8330	-7.54E-05	-37441.	3472.	4.95E-05	0.00	1.71E+11	59.1941	1704806.	0.00
17.0140	3.17E-05	-29798.	3509.	4.91E-05	0.00	1.71E+11	-24.868	1705911.	0.00
17.1950	1.38E-04	-22273.	3365.	4.88E-05	0.00	1.71E+11	-108.154	1703231.	0.00
17.3760	2.44E-04	-15257.	3040.	4.85E-05	0.00	1.71E+11	-190.700	1700577.	0.00
17.5570	3.49E-04	-9141.	2537.	4.84E-05	0.00	1.71E+11	-272.663	1697943.	0.00
17.7380	4.54E-04	-4311.	1856.	4.83E-05	0.00	1.71E+11	-354.178	1695326.	0.00
17.9190	5.59E-04	-1152.	1010.	4.83E-05	0.00	1.58E+11	-425.316	1653708.	0.00
18.1000	6.63E-04	0.00	0.00	4.83E-05	0.00	1.58E+11	-504.367	825617.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection            =     0.33700000 inches
Computed slope at pile head     =       0.000000 radians
Maximum bending moment          =      -1847665. inch-lbs
Maximum shear force             =         37718. lbs
Depth of maximum bending moment =       0.000000 feet below pile head
Depth of maximum shear force    =       0.000000 feet below pile head
Number of iterations            =              7
Number of zero deflection points =             2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

```
Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head                        =     0.404400 inches
Rotation of pile head                            =    0.000E+00 radians
Axial load on pile head                          =     355000.0 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.4044	-2150240.	42953.	0.00	46453.	1.29E+10	0.00	0.00	0.00
0.1810	0.4040	-2056859.	42906.	-3.55E-04	44888.	1.29E+10	-20.426	109.8133	0.00
0.3620	0.4029	-1963308.	42837.	-6.93E-04	43319.	1.29E+10	-43.419	234.0911	0.00
0.5430	0.4010	-1869706.	42716.	-0.00102	41750.	1.29E+10	-68.384	370.4064	0.00
0.7240	0.3984	-1776184.	42538.	-0.00132	40182.	1.29E+10	-94.724	516.3591	0.00
0.9050	0.3952	-1682878.	42303.	-0.00162	38618.	1.29E+10	-121.843	669.5672	0.00
1.0860	0.3914	-1589928.	42009.	-0.00189	37059.	1.29E+10	-149.144	827.5884	0.00
1.2670	0.3870	-1497475.	41656.	-0.00215	35509.	1.29E+10	-176.119	988.3749	0.00
1.4480	0.3821	-1405658.	41244.	-0.00240	33970.	1.29E+10	-202.744	1153.	0.00
1.6290	0.3766	-1314615.	40776.	-0.00263	32443.	1.29E+10	-228.083	1315.	0.00
1.8100	0.3707	-1224477.	40255.	-0.00284	30932.	1.29E+10	-251.613	1474.	0.00
1.9910	0.3643	-1135367.	39683.	-0.00304	29438.	1.29E+10	-275.155	1641.	0.00
2.1720	0.3575	-1047408.	39061.	-0.00322	27964.	1.29E+10	-297.617	1808.	0.00
2.3530	0.3503	-960716.	38393.	-0.00339	26510.	1.29E+10	-317.760	1970.	0.00
2.5340	0.3428	-875399.	37683.	-0.00355	25080.	1.29E+10	-335.896	2129.	0.00
2.7150	0.3349	-791552.	36935.	-0.00369	23674.	1.29E+10	-353.138	2290.	0.00
2.8960	0.3267	-709269.	36152.	-0.00381	22295.	1.29E+10	-367.557	2443.	0.00
3.0770	0.3183	-628627.	35342.	-0.00393	20943.	1.29E+10	-378.852	2585.	0.00
3.2580	0.3097	-549691.	34505.	-0.00402	19619.	1.29E+10	-391.935	2749.	0.00
3.4390	0.3008	-472533.	33641.	-0.00411	18326.	1.29E+10	-403.045	2910.	0.00
3.6200	0.2918	-397214.	32757.	-0.00418	17063.	1.29E+10	-411.057	3059.	0.00
3.8010	0.2827	-323783.	31854.	-0.00425	15832.	1.29E+10	-420.119	3228.	0.00
3.9820	0.2734	-252292.	30928.	-0.00429	14633.	1.29E+10	-432.673	3438.	0.00
4.1630	0.2640	-182809.	29977.	-0.00433	13468.	1.29E+10	-442.805	3643.	0.00
4.3440	0.2546	-115392.	29008.	-0.00436	12338.	1.29E+10	-450.286	3842.	0.00
4.5250	0.2451	-50083.	28025.	-0.00437	11243.	1.29E+10	-454.882	4031.	0.00
4.7060	0.2356	13085.	27035.	-0.00437	10623.	1.29E+10	-456.244	4206.	0.00
4.8870	0.2261	74100.	26046.	-0.00437	11646.	1.29E+10	-454.101	4362.	0.00
5.0680	0.2166	132963.	25054.	-0.00435	12632.	1.29E+10	-459.804	4610.	0.00
5.2490	0.2072	189640.	24041.	-0.00432	13583.	1.29E+10	-472.747	4955.	0.00
5.4300	0.1979	244061.	23002.	-0.00428	14495.	1.29E+10	-484.300	5316.	0.00
5.6110	0.1886	296166.	21939.	-0.00424	15369.	1.29E+10	-494.364	5693.	0.00
5.7920	0.1794	345901.	20856.	-0.00418	16202.	1.29E+10	-502.843	6086.	0.00
5.9730	0.1704	393218.	19756.	-0.00412	16996.	1.29E+10	-509.653	6495.	0.00
6.1540	0.1615	438080.	18644.	-0.00405	17748.	1.29E+10	-514.717	6921.	0.00
6.3350	0.1528	480456.	17518.	-0.00397	18458.	1.29E+10	-522.525	7427.	0.00
6.5160	0.1443	520305.	16299.	-0.00389	19126.	1.29E+10	-599.857	9031.	0.00
6.6970	0.1359	557257.	14989.	-0.00380	19746.	1.29E+10	-606.372	9690.	0.00
6.8780	0.1278	591276.	13667.	-0.00370	20316.	1.29E+10	-610.480	10378.	0.00
7.0590	0.1198	622338.	12337.	-0.00360	20837.	1.29E+10	-614.530	11138.	0.00
7.2400	0.1121	650419.	10993.	-0.00349	21308.	1.29E+10	-622.976	12067.	0.00
7.4210	0.1047	675478.	9633.	-0.00338	21728.	1.29E+10	-629.693	13068.	0.00
7.6020	0.09744	697478.	8259.	-0.00327	22097.	1.29E+10	-634.629	14146.	0.00
7.7830	0.09048	716393.	6878.	-0.00315	22414.	1.29E+10	-637.740	15310.	0.00
7.9640	0.08377	732207.	5491.	-0.00302	22679.	1.29E+10	-638.988	16567.	0.00
8.1450	0.07734	744911.	4104.	-0.00290	22892.	1.29E+10	-638.346	17928.	0.00
8.3260	0.07117	754506.	2720.	-0.00277	23053.	1.29E+10	-635.793	19402.	0.00
8.5070	0.06529	761005.	1355.	-0.00265	23162.	1.29E+10	-621.497	20676.	0.00
8.6880	0.05968	764472.	18.4123	-0.00252	23220.	1.29E+10	-609.096	22167.	0.00
8.8690	0.05435	764967.	-1289.	-0.00239	23228.	1.29E+10	-595.220	23786.	0.00
9.0500	0.04931	762554.	-2566.	-0.00226	23188.	1.29E+10	-579.907	25546.	0.00
9.2310	0.04454	757306.	-3807.	-0.00213	23100.	1.29E+10	-563.199	27466.	0.00
9.4120	0.04005	749303.	-5008.	-0.00200	22966.	1.29E+10	-542.749	29438.	0.00
9.5930	0.03583	738642.	-6135.	-0.00188	22787.	1.29E+10	-494.934	30004.	0.00

9.7740	0.03188	725551.	-7160.	-0.00176	22567.	1.29E+10	-448.727	30570.	0.00
9.9550	0.02820	710248.	-8086.	-0.00163	22311.	1.29E+10	-404.270	31136.	0.00
10.1360	0.02478	692945.	-8918.	-0.00152	22021.	1.29E+10	-361.690	31702.	0.00
10.3170	0.02161	673846.	-9660.	-0.00140	21701.	1.29E+10	-321.096	32268.	0.00
10.4980	0.01869	653145.	-10315.	-0.00129	21354.	1.29E+10	-282.580	32834.	0.00
10.6790	0.01601	631026.	-10889.	-0.00118	20983.	1.29E+10	-246.218	33400.	0.00
10.8600	0.01356	607663.	-11387.	-0.00108	20591.	1.29E+10	-212.072	33967.	0.00
11.0410	0.01133	583221.	-11813.	-9.77E-04	20181.	1.29E+10	-180.185	34533.	0.00
11.2220	0.00932	557853.	-12172.	-8.80E-04	19756.	1.29E+10	-150.588	35099.	0.00
11.4030	0.00751	531702.	-12470.	-7.89E-04	19318.	1.29E+10	-123.294	35665.	0.00
11.5840	0.00589	504900.	-12710.	-7.01E-04	18868.	1.29E+10	-98.303	36231.	0.00
11.7650	0.00446	477569.	-12899.	-6.18E-04	18410.	1.29E+10	-75.602	36797.	0.00
11.9460	0.00321	449819.	-13041.	-5.40E-04	17945.	1.29E+10	-55.162	37363.	0.00
12.1270	0.00212	421751.	-13141.	-4.67E-04	17474.	1.29E+10	-36.944	37929.	0.00
12.3080	0.00118	393453.	-13204.	-3.98E-04	17000.	1.29E+10	-20.894	38495.	0.00
12.4890	3.86E-04	365006.	-13234.	-3.34E-04	16523.	1.29E+10	-6.945	39062.	0.00
12.6700	-2.73E-04	336478.	-13237.	-2.75E-04	16044.	1.29E+10	4.9780	39628.	0.00
12.8510	-8.09E-04	307931.	-13215.	-2.21E-04	15566.	1.29E+10	14.9654	40194.	0.00
13.0320	-0.00123	279414.	-13174.	-1.71E-04	15088.	1.29E+10	23.1165	40760.	0.00
13.2130	-0.00155	250969.	-13116.	-1.27E-04	14611.	1.29E+10	29.5419	41326.	0.00
13.3940	-0.00178	222631.	-13047.	-8.66E-05	14136.	1.29E+10	34.3623	41892.	0.00
13.5750	-0.00193	194427.	-12969.	-5.15E-05	13663.	1.29E+10	37.7089	42458.	0.00
13.7560	-0.00201	166375.	-12885.	-2.11E-05	13193.	1.29E+10	39.7223	43024.	0.00
13.9370	-0.00202	138489.	-12821.	4.60E-06	12725.	1.29E+10	18.5868	19979.	0.00
14.1180	-0.00199	110673.	-12781.	2.56E-05	12259.	1.29E+10	18.4988	20238.	0.00
14.2990	-0.00191	82929.	-12741.	4.19E-05	11794.	1.29E+10	18.0200	20498.	0.00
14.4800	-0.00180	55260.	-12703.	5.36E-05	11330.	1.29E+10	17.2330	20757.	0.00
14.6610	-0.00168	27665.	-12667.	6.06E-05	10867.	1.29E+10	16.2247	21017.	0.00
14.8420	-0.00154	142.2964	-11368.	6.29E-05	0.00	1.71E+11	1180.	1663446.	0.00
15.0230	-0.00140	-21815.	-8914.	6.27E-05	0.00	1.71E+11	1080.	1671770.	0.00
15.2040	-0.00127	-38676.	-6679.	6.24E-05	0.00	1.71E+11	977.6028	1675106.	0.00
15.3850	-0.00113	-50925.	-4667.	6.18E-05	0.00	1.71E+11	875.2775	1678426.	0.00
15.5660	-9.99E-04	-59044.	-2876.	6.11E-05	0.00	1.71E+11	773.6144	1681722.	0.00
15.7470	-8.67E-04	-63512.	-1305.	6.03E-05	0.00	1.71E+11	672.7955	1684987.	0.00
15.9280	-7.37E-04	-64806.	47.6591	5.95E-05	0.00	1.71E+11	572.9280	1688220.	0.00
16.1090	-6.09E-04	-63397.	1185.	5.87E-05	0.00	1.71E+11	474.0532	1691418.	0.00
16.2900	-4.82E-04	-59751.	2108.	5.79E-05	0.00	1.71E+11	376.1549	1694581.	0.00
16.4710	-3.57E-04	-54329.	2820.	5.72E-05	0.00	1.71E+11	279.1686	1697713.	0.00
16.6520	-2.34E-04	-47590.	3322.	5.65E-05	0.00	1.71E+11	182.9904	1700816.	0.00
16.8330	-1.12E-04	-39987.	3615.	5.60E-05	0.00	1.71E+11	87.4862	1703895.	0.00
17.0140	9.54E-06	-31971.	3702.	5.55E-05	0.00	1.71E+11	-7.497	1706470.	0.00
17.1950	1.30E-04	-23991.	3584.	5.52E-05	0.00	1.71E+11	-101.739	1703437.	0.00
17.3760	2.49E-04	-16490.	3261.	5.49E-05	0.00	1.71E+11	-195.132	1700434.	0.00
17.5570	3.68E-04	-9909.	2737.	5.48E-05	0.00	1.71E+11	-287.843	1697455.	0.00
17.7380	4.87E-04	-4686.	2011.	5.47E-05	0.00	1.71E+11	-380.020	1694495.	0.00
17.9190	6.06E-04	-1256.	1098.	5.46E-05	0.00	1.58E+11	-460.910	1652591.	0.00
18.1000	7.24E-04	0.00	0.00	5.46E-05	0.00	1.58E+11	-550.237	824897.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection = 0.40440000 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -2150240. inch-lbs
Maximum shear force = 42953. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 7
Number of zero deflection points = 2

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

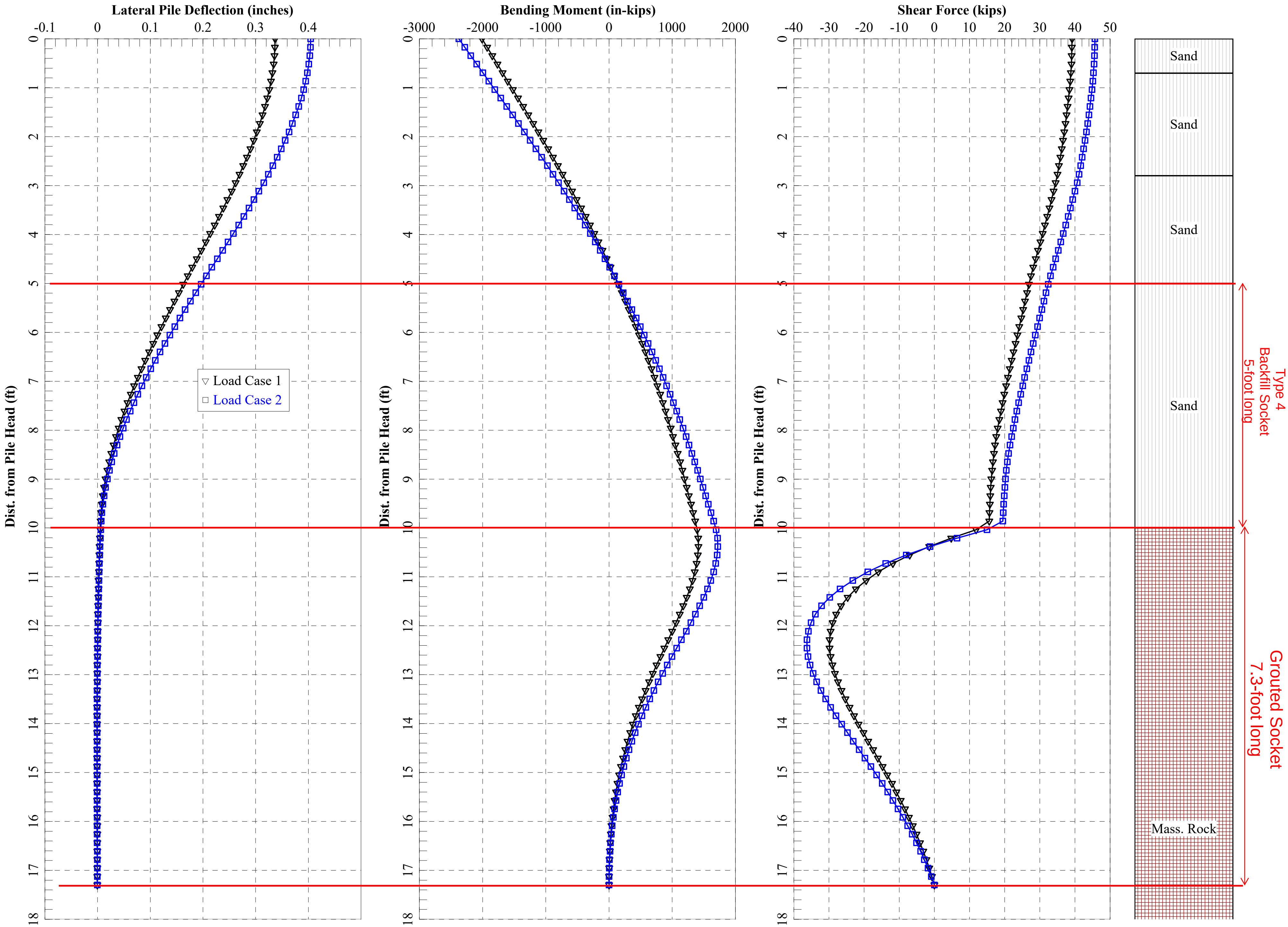
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.3370	S, rad	0.00	355000.	0.3370	0.00	37718.	-1847665.
2	y, in	0.4044	S, rad	0.00	355000.	0.4044	0.00	42953.	-2150240.

Maximum pile-head deflection = 0.4044000000 inches
Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

The analysis ended normally.

Benjamin Lincoln Bridge
Abutment 2 14x117 Piles, No Scour, No Corrosion



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                    LPile for Windows, Version 2022-12.010

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
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                             Files Used for Analysis
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Path to file locations:
\Working\THORNTON TOMASETTI\2502334 MaineDOT Downeast Bridges Phase II\09_Engineering\01_Dennysville\07_Lpile\Pile Runs\No Scour No
Corrosion\

Name of input data file:
Dennysville Abutment 2 HP14x117 2025-07-08.lp12d

Name of output report file:
Dennysville Abutment 2 HP14x117 2025-07-08.lp12o

Name of plot output file:
Dennysville Abutment 2 HP14x117 2025-07-08.lp12p

Name of runtime message file:
Dennysville Abutment 2 HP14x117 2025-07-08.lp12r

--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  July 8, 2025               Time:  18:57:16


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Benjamin Lincoln Bridge #6740

Job Number: 2502334

Client: Thornton Tomasetti

Engineer: M. Johnescu

Description: Lateral Pile Analysis Abutment 2 HP14x117



--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
```

- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

```
Number of pile sections defined                        =           3
Total length of pile                                   =      17.300 ft
Depth of ground surface below top of pile              =      0.0000 ft
```

Pile diameters used for p-y curve computations are defined using 6 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.9000
2	10.000	14.9000
3	10.000	30.0000
4	17.000	30.0000
5	17.000	30.0000
6	17.300	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a H weak axis steel pile
   Length of section                                   =    10.000000 ft
   Pile width                                          =    14.200000 in
```

Pile Section No. 2:

```
   Section 2 is a drilled shaft with casing and H section core/insert
   Length of section                                   =     7.000000 ft
   Section Diameter                                    =    30.000000 in
```

Pile Section No. 3:

```
   Section 3 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                   =     0.300000 ft
   Shaft Diameter                                      =    30.000000 in
```

Soil and Rock Layering Information

The soil profile is modelled using 5 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer           =      0.0000 ft
   Distance from top of pile to bottom of layer        =    0.700000 ft
   Effective unit weight at top of layer               =  125.000000 pcf
   Effective unit weight at bottom of layer            =  125.000000 pcf
   Friction angle at top of layer                      =   34.000000 deg.
   Friction angle at bottom of layer                   =   34.000000 deg.
   Subgrade k at top of layer                          =  122.000000 pci
   Subgrade k at bottom of layer                       =  122.000000 pci
```

Layer 2 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer           =    0.700000 ft
   Distance from top of pile to bottom of layer        =    2.800000 ft
   Effective unit weight at top of layer               =   62.600000 pcf
   Effective unit weight at bottom of layer            =   62.600000 pcf
   Friction angle at top of layer                      =   34.000000 deg.
   Friction angle at bottom of layer                   =   34.000000 deg.
   Subgrade k at top of layer                          =   75.000000 pci
   Subgrade k at bottom of layer                       =   75.000000 pci
```

Layer 3 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer           =    2.800000 ft
   Distance from top of pile to bottom of layer        =    5.000000 ft
   Effective unit weight at top of layer               =   72.600000 pcf
```

```
   Effective unit weight at bottom of layer          =    72.600000 pcf
   Friction angle at top of layer                    =    38.000000 deg.
   Friction angle at bottom of layer                 =    38.000000 deg.
   Subgrade k at top of layer                        =   120.000000 pci
   Subgrade k at bottom of layer                     =   120.000000 pci
```

Layer 4 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer         =     5.000000 ft
   Distance from top of pile to bottom of layer      =    10.000000 ft
   Effective unit weight at top of layer             =    62.600000 pcf
   Effective unit weight at bottom of layer          =    62.600000 pcf
   Friction angle at top of layer                    =    32.000000 deg.
   Friction angle at bottom of layer                 =    32.000000 deg.
   Subgrade k at top of layer                        =    55.000000 pci
   Subgrade k at bottom of layer                     =    55.000000 pci
```

Layer 5 is massive rock, p-y criteria by Liang et al., 2009

```
   Distance from top of pile to top of layer         =    10.000000 ft
   Distance from top of pile to bottom of layer      =    50.000000 ft
   Effective unit weight at top of layer             =   109.400000 pcf
   Effective unit weight at bottom of layer          =   109.400000 pcf
   Uniaxial compressive strength at top of layer     =       29282. psi
   Uniaxial compressive strength at bottom of layer  =       29282. psi
   Poisson's ratio at top of layer                   =     0.250000
   Poisson's ratio at bottom of layer                =     0.250000
   Option 1: Intact rock modulus at top of layer     =       0.0000 psi
             Intact rock modulus at bottom of layer  =       0.0000 psi
   Option 1: Geologic Strength Index for layer       =    45.000000
   Option 2: Rock mass modulus at top of layer       =      739400. psi
             Rock mass modulus at bottom of layer    =      739400. psi
   Option 2 will use the input value of rock mass modulus to compute the p-y curve
            in massive rock.
   The rock type is (sedimentary) claystones, Hoek-Brown Material Constant mi = 4
```

(Depth of the lowest soil layer extends 32.700 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	kpy pci	Rock Mass Modulus psi	Geologic Strength Index	Int. Rock Modulus psi	Hoek-Brown Material Index, mi	Poisson's Ratio
1	Sand	0.00	125.0000	34.0000	--	122.0000	--	--	0.00	0.00	0.00
	(Reese, et al.)	0.7000	125.0000	34.0000	--	122.0000	--	--	0.00	0.00	0.00
2	Sand	0.7000	62.6000	34.0000	--	75.0000	--	--	0.00	0.00	0.00
	(Reese, et al.)	2.8000	62.6000	34.0000	--	75.0000	--	--	0.00	0.00	0.00
3	Sand	2.8000	72.6000	38.0000	--	120.0000	--	--	0.00	0.00	0.00
	(Reese, et al.)	5.0000	72.6000	38.0000	--	120.0000	--	--	0.00	0.00	0.00
4	Sand	5.0000	62.6000	32.0000	--	55.0000	--	--	0.00	0.00	0.00
	(Reese, et al.)	10.0000	62.6000	32.0000	--	55.0000	--	--	0.00	0.00	0.00
5	Massive	10.0000	109.4000	--	29282.	--	739400.	45.0000	0.00	4.0000	0.2500
	Rock	50.0000	109.4000	--	29282.	--		45.0000	0.00	4.0000	0.2500

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	5	y = 0.337000 in	S = 0.0000 in/in	355000.	N.A.	Yes
2	5	y = 0.404400 in	S = 0.0000 in/in	355000.	N.A.	Yes

V = shear force applied normal to pile axis

```
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.



--------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 3

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel H Weak Axis:
---------------------------------------------

Length of Section                                    =    10.000000 ft
Flange Width                                         =    14.900000 in
Section Depth                                        =    14.200000 in
Flange Thickness                                     =     0.805000 in
Web Thickness                                        =     0.805000 in
Yield Stress of Pipe                                 =    50.000000 ksi
Elastic Modulus                                      =       29000. ksi
Cross-sectional Area                                 =    34.123950 sq. in.
Moment of Inertia                                    =   444.363799 in^4
Elastic Bending Stiffness                            =    12886550. kip-in^2
Plastic Modulus, Z                                   =    91.398684in^3
Plastic Moment Capacity = Fy Z                       =        4570.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As               =     1706.197 kips
Nominal Axial Tensile Capacity                       =    -1706.197 kips



Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
```

```
                   kips
   ------     ------------------
      1             355.000

Definition of Run Messages:

   Y = part of pipe section has yielded.


Axial Thrust Force =    355.000 kips
```

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000453	58.3569131	12886018.	86.6631881	11.3718919	
0.00000906	116.7138261	12886018.	47.0565936	12.3405333	
0.00001359	175.0707392	12886018.	33.8543957	13.3091748	
0.00001811	233.4276522	12886018.	27.2532968	14.2778163	
0.00002264	291.7845653	12886018.	23.2926374	15.2464576	
0.00002717	350.1414784	12886018.	20.6521979	16.2150990	
0.00003170	408.4983914	12886018.	18.7661696	17.1837405	
0.00003623	466.8553045	12886018.	17.3516484	18.1523819	
0.00004076	525.2122175	12886018.	16.2514652	19.1210233	
0.00004529	583.5691306	12886018.	15.3713187	20.0896648	
0.00004982	641.9260437	12886018.	14.6511988	21.0583063	
0.00005434	700.2829567	12886018.	14.0510989	22.0269477	
0.00005887	758.6398698	12886018.	13.5433221	22.9955891	
0.00006340	816.9967828	12886018.	13.1080848	23.9642305	
0.00006793	875.3536959	12886018.	12.7308791	24.9328720	
0.00007246	933.7106090	12886018.	12.4008242	25.9015134	
0.00007699	992.0675220	12886018.	12.1095992	26.8701548	
0.00008152	1050.	12886018.	11.8507326	27.8387963	
0.00008605	1109.	12886018.	11.6191151	28.8074377	
0.00009057	1167.	12886018.	11.4106594	29.7760791	
0.00009510	1225.	12886018.	11.2220565	30.7447206	
0.00009963	1284.	12886018.	11.0505994	31.7133620	
0.0001042	1342.	12886018.	10.8940516	32.6820034	
0.0001087	1401.	12886018.	10.7505495	33.6506449	
0.0001132	1459.	12886018.	10.6185275	34.6192863	
0.0001177	1517.	12886018.	10.4966610	35.5879277	
0.0001223	1576.	12886018.	10.3838217	36.5565691	
0.0001268	1634.	12886018.	10.2790424	37.5252106	
0.0001313	1692.	12886018.	10.1814892	38.4938520	
0.0001359	1751.	12886018.	10.0904396	39.4624934	
0.0001404	1809.	12886018.	10.0052641	40.4311349	
0.0001449	1867.	12886018.	9.9254121	41.3997763	
0.0001494	1926.	12886018.	9.8503996	42.3684177	
0.0001540	1984.	12886018.	9.7797996	43.3370592	

0.0001585	2042.	12886018.	9.7132339	44.3057006	
0.0001630	2101.	12886018.	9.6503663	45.2743420	
0.0001676	2159.	12886018.	9.5908970	46.2429835	
0.0001721	2218.	12886018.	9.5345576	47.2116249	
0.0001766	2276.	12886018.	9.4811074	48.1802663	
0.0001857	2392.	12884890.	9.3821835	50.0000000	Y
0.0001947	2503.	12852606.	9.2967962	50.0000000	Y
0.0002038	2606.	12788156.	9.2240451	50.0000000	Y
0.0002128	2703.	12699436.	9.1619690	50.0000000	Y
0.0002219	2794.	12592889.	9.1089066	50.0000000	Y
0.0002310	2881.	12473784.	9.0634366	50.0000000	Y
0.0002400	2963.	12345513.	9.0244954	50.0000000	Y
0.0002491	3041.	12210540.	8.9912347	50.0000000	Y
0.0002581	3116.	12072289.	8.9626558	50.0000000	Y
0.0002672	3188.	11931549.	8.9382789	50.0000000	Y
0.0002763	3257.	11789671.	8.9175502	50.0000000	Y
0.0002853	3323.	11648357.	8.8998643	50.0000000	Y
0.0002944	3386.	11504391.	8.8841802	50.0000000	Y
0.0003034	3444.	11351939.	8.8689565	50.0000000	Y
0.0003125	3498.	11192946.	8.8540712	50.0000000	Y
0.0003215	3546.	11029038.	8.8393987	50.0000000	Y
0.0003306	3591.	10862815.	8.8250832	50.0000000	Y
0.0003397	3633.	10695613.	8.8110726	50.0000000	Y
0.0003487	3671.	10528567.	8.7973181	50.0000000	Y
0.0003578	3707.	10362631.	8.7837746	50.0000000	Y
0.0003668	3741.	10197826.	8.7706581	50.0000000	Y
0.0003759	3772.	10034726.	8.7577999	50.0000000	Y
0.0003849	3801.	9874068.	8.7449095	50.0000000	Y
0.0003940	3828.	9715795.	8.7324683	50.0000000	Y
0.0004031	3854.	9560818.	8.7203088	50.0000000	Y
0.0004121	3878.	9409376.	8.7083761	50.0000000	Y
0.0004212	3900.	9259753.	8.6965548	50.0000000	Y
0.0004302	3921.	9114342.	8.6849071	50.0000000	Y
0.0004393	3941.	8972043.	8.6738100	50.0000000	Y
0.0004483	3960.	8832578.	8.6624580	50.0000000	Y
0.0004574	3978.	8696873.	8.6516774	50.0000000	Y
0.0004665	3995.	8563946.	8.6408891	50.0000000	Y
0.0004755	4011.	8434742.	8.6302572	50.0000000	Y
0.0004846	4026.	8308140.	8.6200465	50.0000000	Y
0.0004936	4040.	8185027.	8.6097567	50.0000000	Y
0.0005027	4054.	8064804.	8.5997936	50.0000000	Y
0.0005117	4067.	7947410.	8.5900403	50.0000000	Y
0.0005208	4080.	7833163.	8.5802373	50.0000000	Y
0.0005299	4091.	7721750.	8.5708463	50.0000000	Y
0.0005389	4103.	7612553.	8.5614821	50.0000000	Y
0.0005751	4143.	7203530.	8.5257123	50.0000000	Y
0.0006114	4177.	6832177.	8.4920010	50.0000000	Y
0.0006476	4206.	6494981.	8.4605282	50.0000000	Y
0.0006838	4231.	6187725.	8.4308240	50.0000000	Y
0.0007201	4253.	5906468.	8.4027819	50.0000000	Y
0.0007563	4272.	5648574.	8.3764352	50.0000000	Y
0.0007925	4289.	5411491.	8.3510890	50.0000000	Y
0.0008288	4303.	5192561.	8.3274676	50.0000000	Y
0.0008650	4317.	4990490.	8.3048229	50.0000000	Y
0.0009012	4329.	4803256.	8.2837138	50.0000000	Y
0.0009374	4339.	4628861.	8.2632671	50.0000000	Y
0.0009737	4349.	4466755.	8.2437020	50.0000000	Y
0.0010099	4358.	4315284.	8.2254651	50.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	355.0000000000	4358.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and H Weak Axis Core/Insert:

Length of Section	=	7.000000 ft
Outside Diameter of Casing	=	30.000000 in
Casing Wall Thickness	=	0.0000 in
Moment of Inertia of Steel Casing	=	0.0000 in^4
Width Flange of Core/Insert	=	14.900000 in
Depth of Core/Insert	=	14.200000 in
Flange Thickness of Core/Insert	=	0.805000 in
Web Thickness of Core/Insert	=	0.805000 in

Moment of Inertia of Steel Core/Insert	=	444.363799 in^4
Yield Stress of Casing	=	50000. psi
Elastic Modulus of Casing	=	29000000. psi
Yield Stress of Core/Insert	=	50000. psi
Elastic Modulus of Core/Insert	=	29000000. psi
Number of Reinforcing Bars	=	0 bars
Gross Area of Pile	=	706.858347 sq. in.
Area of Concrete	=	672.734397 sq. in.
Cross-sectional Area of Steel Casing	=	0.0000 sq. in.
Cross-sectional Area of Steel Core/Insert	=	34.123950 sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	34.123950 sq. in.
Area Ratio of All Steel to Gross Area	=	4.83 percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	3993.494 kips
Tensile Load for Cracking of Concrete	=	-393.967 kips
Nominal Axial Tensile Capacity	=	-1706.197 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	355.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 355.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Max Core Stress ksi	Run Msg
0.00000453	775.8459704	171317583.	35.8381574	0.0001623	0.00002644	0.6560962	0.00000	0.00000	3.7020157	
0.00000906	1550.	171167197.	25.4946077	0.0002309	-0.00004081	0.9144774	0.00000	0.00000	4.6881730	
0.00001359	2314.	170318804.	22.0718814	0.0002999	-0.000108	1.1634387	0.00000	0.00000	5.6821894	
0.00001811	2314.	127739103.	19.2152857	0.0003481	-0.000195	1.3306548	0.00000	0.00000	6.0755826	C
0.00002264	2576.	113769057.	17.8136957	0.0004034	-0.000276	1.5164863	0.00000	0.00000	6.6741080	C
0.00002717	2846.	104729232.	16.8341102	0.0004574	-0.000358	1.6916599	0.00000	0.00000	7.2370286	C
0.00003170	3101.	97813818.	16.1111890	0.0005107	-0.000440	1.8581427	0.00000	0.00000	7.7785930	C
0.00003623	3346.	92354106.	15.5557983	0.0005636	-0.000523	2.0169679	0.00000	0.00000	8.3062938	C
0.00004076	3584.	87944554.	15.1182451	0.0006162	-0.000607	2.1690226	0.00000	0.00000	8.8273967	C
0.00004529	3818.	84313055.	14.7672932	0.0006688	-0.000690	2.3148996	0.00000	0.00000	-9.958543	C
0.00004982	4048.	81261683.	14.4807840	0.0007214	-0.000773	2.4548048	0.00000	0.00000	-11.368305	C
0.00005434	4274.	78646966.	14.2426848	0.0007740	-0.000856	2.5887380	0.00000	0.00000	-12.777029	C
0.00005887	4496.	76365084.	14.0410177	0.0008266	-0.000940	2.7165725	0.00000	0.00000	-14.186093	C
0.00006340	4714.	74354950.	13.8697255	0.0008794	-0.001023	2.8385663	0.00000	0.00000	-15.592274	C
0.00006793	4929.	72561564.	13.7227033	0.0009322	-0.001106	2.9546797	0.00000	0.00000	-16.995638	C
0.00007246	5141.	70946098.	13.5957768	0.0009851	-0.001189	3.0649347	0.00000	0.00000	-18.395392	C
0.00007699	5349.	69475913.	13.4852106	0.0010382	-0.001271	3.1692591	0.00000	0.00000	-19.791957	C
0.00008152	5554.	68130498.	13.3894213	0.0010915	-0.001354	3.2677832	0.00000	0.00000	-21.182632	C
0.00008605	5755.	66887081.	13.3052904	0.0011449	-0.001437	3.3603203	0.00000	0.00000	-22.569377	C
0.00009057	5953.	65730404.	13.2312558	0.0011984	-0.001519	3.4468491	0.00000	0.00000	-23.951699	C
0.00009510	6148.	64649400.	13.1665548	0.0012522	-0.001601	3.5274091	0.00000	0.00000	-25.327727	C
0.00009963	6340.	63633149.	13.1099594	0.0013062	-0.001683	3.6019288	0.00000	0.00000	-26.697331	C
0.0001042	6528.	62672610.	13.0604568	0.0013604	-0.001764	3.6703340	0.00000	0.00000	-28.060377	C
0.0001087	6713.	61759028.	13.0165514	0.0014148	-0.001846	3.7324706	0.00000	0.00000	-29.418783	C
0.0001132	6893.	60887190.	12.9780805	0.0014693	-0.001927	3.7883368	0.00000	0.00000	-30.770880	C
0.0001177	7071.	60052046.	12.9446460	0.0015242	-0.002008	3.8378765	0.00000	0.00000		

```
-32.115884 C
    0.0001223         7245.     59248929.    12.9157343     0.0015793     -0.002089     3.8810044       0.00000       0.00000
-33.453633 C
    0.0001268         7415.     58473816.    12.8909073     0.0016346     -0.002169     3.9176324       0.00000       0.00000
-34.783957 C
    0.0001313         7581.     57723219.    12.8697892     0.0016902     -0.002250     3.9476689       0.00000       0.00000
-36.106676 C
    0.0001359         7743.     56994086.    12.8520561     0.0017461     -0.002330     3.9710193       0.00000       0.00000
-37.421607 C
    0.0001404         7902.     56283744.    12.8374276     0.0018022     -0.002409     3.9875850       0.00000       0.00000
-38.728550 C
    0.0001449         8056.     55589819.    12.8238738     0.0018584     -0.002489     3.9972638       0.00000       0.00000
-40.027306 C
    0.0001494         8206.     54910000.    12.8136249     0.0019150     -0.002568     3.9983659       0.00000       0.00000
-41.317619 C
    0.0001540         8352.     54240682.    12.8100159     0.0019724     -0.002647     3.9990335       0.00000       0.00000
-42.598877 C
    0.0001585         8493.     53580224.    12.8058778     0.0020298     -0.002725     3.9994099       0.00000       0.00000
-43.870808 C
    0.0001630         8629.     52928190.    12.8039539     0.0020875     -0.002804     3.9995986       0.00000       0.00000
-45.133352 C
    0.0001676         8761.     52284591.    12.8040531     0.0021455     -0.002881     3.9996644       0.00000       0.00000
-46.386575 C
    0.0001721         8888.     51649670.    12.8059913     0.0022038     -0.002959     3.9996335       0.00000       0.00000
-47.630593 C
    0.0001766         9012.     51023761.    12.8095944     0.0022624     -0.003036     3.9994927       0.00000       0.00000
-48.865574 C
    0.0001857         9242.     49774039.    12.8193126     0.0023802     -0.003190     3.9986069       0.00000       0.00000
-50.000000 CY
    0.0001947         9443.     48492921.    12.8284532     0.0024981     -0.003344     3.9999973       0.00000       0.00000
-50.000000 CY
    0.0002038         9619.     47201665.    12.8356447     0.0026158     -0.003498     3.9986700       0.00000       0.00000
-50.000000 CY
    0.0002128         9775.     45923819.    12.8455591     0.0027342     -0.003651     3.9997751       0.00000       0.00000
-50.000000 CY
    0.0002219         9912.     44669566.    12.8538009     0.0028523     -0.003805     3.9997557       0.00000       0.00000
-50.000000 CY
    0.0002310        10034.     43445826.    12.8619148     0.0029706     -0.003958     3.9967415       0.00000       0.00000
-50.000000 CY
    0.0002400        10143.     42259056.    12.8699464     0.0030891     -0.004112     3.9963065       0.00000       0.00000
-50.000000 CY
    0.0002491        10240.     41112894.    12.8779387     0.0032076     -0.004265     3.9958115       0.00000       0.00000
-50.000000 CY
    0.0002581        10328.     40009710.    12.8853712     0.0033262     -0.004418     3.9976760       0.00000       0.00000
-50.000000 CY
    0.0002672        10407.     38950633.    12.8941530     0.0034452     -0.004571     3.9999812       0.00000       0.00000
-50.000000 CY
    0.0002763        10478.     37927969.    12.9016654     0.0035641     -0.004723     3.9995020       0.00000       0.00000
-50.000000 CY

    0.0002853        10542.     36949386.    12.9098739     0.0036833     -0.004876     3.9979003       0.00000       0.00000
-50.000000 CY
    0.0002944        10601.     36012929.    12.9180151     0.0038026     -0.005028     3.9944534       0.00000       0.00000
-50.000000 CY
    0.0003034        10601.     34938096.    12.9373521     0.0039255     -0.005177     3.9999113       0.00000       0.00000
-50.000000 CY
    0.0003125        10601.     33925398.    12.9927426     0.0040600     -0.005314     3.9990591       0.00000       0.00000
-50.000000 CY
    0.0003215        10601.     32969753.    13.0326138     0.0041905     -0.005456     3.9960738       0.00000       0.00000
50.0000000 CY
    0.0003306        10601.     32066472.    13.0749929     0.0043225     -0.005595     3.9979934       0.00000       0.00000
50.0000000 CY
    0.0003397        10601.     31211366.    13.1625967     0.0044707     -0.005719     3.9997838       0.00000       0.00000
50.0000000 CY
    0.0003487        10601.     30400681.    13.2142541     0.0046079     -0.005853     3.9971271       0.00000       0.00000
50.0000000 CY
    0.0003578        10601.     29631044.    13.2685276     0.0047470     -0.005986     3.9948124       0.00000       0.00000
50.0000000 CY
    0.0003668        10601.     28899413.    13.3250442     0.0048880     -0.006117     3.9993186       0.00000       0.00000
50.0000000 CY
    0.0003759        10601.     28203042.    13.3826203     0.0050303     -0.006246     3.9945312       0.00000       0.00000
50.0000000 CY
    0.0003849        10601.     27539441.    13.4415618     0.0051742     -0.006374     3.9999880       0.00000       0.00000
50.0000000 CY
    0.0003940        10601.     26906350.    13.5018501     0.0053197     -0.006500     3.9968010       0.00000       0.00000
50.0000000 CY
    0.0004031        10601.     26301713.    13.5647913     0.0054673     -0.006624     3.9955923       0.00000       0.00000
50.0000000 CY
    0.0004121        10601.     25723653.    13.6268988     0.0056158     -0.006748     3.9981222       0.00000       0.00000
50.0000000 CY
    0.0004212        10601.     25170457.    13.6918992     0.0057666     -0.006868     3.9916488       0.00000       0.00000
50.0000000 CY
    0.0004302        10601.     24640552.    13.6962906     0.0058925     -0.007014     3.9960682       0.00000       0.00000
50.0000000 CY
    0.0004393        10601.     24132500.    13.7605164     0.0060448     -0.007134     3.9977028       0.00000       0.00000
50.0000000 CY
    0.0004483        10601.     23644974.    13.8254872     0.0061985     -0.007252     3.9960865       0.00000       0.00000
50.0000000 CY
    0.0004574        10601.     23176757.    13.8917122     0.0063541     -0.007368     3.9974470       0.00000       0.00000
50.0000000 CY
    0.0004665        10601.     22726723.    13.8968482     0.0064823     -0.007511     3.9905084       0.00000       0.00000
50.0000000 CY
    0.0004755        10601.     22293833.    13.9614347     0.0066389     -0.007627     3.9992541       0.00000       0.00000
50.0000000 CY
    0.0004846        10601.     21877126.    14.0283015     0.0067977     -0.007739     3.9878701       0.00000       0.00000
50.0000000 CY
    0.0004936        10601.     21475711.    14.0322193     0.0069267     -0.007882     3.9947059       0.00000       0.00000
50.0000000 CY
    0.0005027        10601.     21088761.    14.0973225     0.0070865     -0.007994     3.9999927       0.00000       0.00000
```

50.0000000 CY								
0.0005117	10601.	20715508.	14.1009077	0.0072160	-0.008136	3.9895551	0.00000	0.00000
50.0000000 CY								
0.0005208	10601.	20355239.	14.1673233	0.0073783	-0.008246	3.9966673	0.00000	0.00000
50.0000000 CY								
0.0005299	10601.	20007286.	14.2341090	0.0075421	-0.008354	3.9959876	0.00000	0.00000
50.0000000 CY								

Summary of Results for Nominal Moment Capacity for Section 2

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	355.0000000000	10601.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Pile Section No. 3:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	0.300000 ft
Shaft Diameter	=	30.000000 in
Number of Reinforcing Bars	=	0 bars
Yield Stress of Reinforcing Bars	=	0.0000 psi
Modulus of Elasticity of Reinforcing Bars	=	0.0000 psi
Gross Area of Shaft	=	706.858347 sq. in.
Total Area of Reinforcing Steel	=	0.0000 sq. in.
Area Ratio of Steel Reinforcement	=	0.00 percent
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	2403.318 kips
Tensile Load for Cracking of Concrete	=	-293.989 kips
Nominal Axial Tensile Capacity	=	0.000 kips

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.34165 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	355.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 355.000 kips

Bending Curvature	Bending Moment	Bending Stiffness	Depth to N Axis	Max Comp Strain	Max Tens Strain	Max Conc Stress	Max Steel Stress	Run Msg

rad/in.	in-kip	kip-in2	in	in/in	in/in	ksi	ksi	
0.00000125	197.1345174	157707614.	112.9289563	0.0001412	0.0001037	0.5755514	0.00000	
0.00000250	394.2523254	157700930.	63.9943795	0.0001600	0.00008499	0.6482973	0.00000	
0.00000375	591.3367123	157689790.	47.6961453	0.0001789	0.00006636	0.7204535	0.00000	
0.00000500	788.3709617	157674192.	39.5569988	0.0001978	0.00004778	0.7920140	0.00000	
0.00000625	985.3383501	157654136.	34.6814898	0.0002168	0.00002926	0.8629723	0.00000	
0.00000750	1182.	157629619.	31.4378021	0.0002358	0.00001078	0.9333224	0.00000	
0.00000875	1379.	157600339.	29.1265788	0.0002549	-0.00000764	1.0030576	0.00000	
0.00001000	1576.	157552613.	27.3977915	0.0002740	-0.00002602	1.0721589	0.00000	
0.00001125	1771.	157462095.	26.0564862	0.0002931	-0.00004436	1.1405876	0.00000	
0.00001250	1967.	157320087.	24.9857772	0.0003123	-0.00006268	1.2083105	0.00000	
0.00001375	2161.	157127778.	24.1114394	0.0003315	-0.00008097	1.2753035	0.00000	
0.00001500	2353.	156890088.	23.3789460	0.0003507	-0.00009932	1.3415491	0.00000	
0.00001625	2353.	144821619.	22.0318216	0.0003580	-0.000129	1.3659313	0.00000	C
0.00001750	2353.	134477218.	21.3410964	0.0003735	-0.000152	1.4182052	0.00000	C
0.00001875	2353.	125512070.	20.7223044	0.0003885	-0.000174	1.4686796	0.00000	C
0.00002000	2405.	120253509.	20.1634244	0.0004033	-0.000197	1.5174907	0.00000	C
0.00002125	2470.	116251063.	19.6555498	0.0004177	-0.000220	1.5647898	0.00000	C
0.00002250	2530.	112448518.	19.1897109	0.0004318	-0.000243	1.6105724	0.00000	C
0.00002375	2586.	108876243.	18.7622838	0.0004456	-0.000267	1.6551215	0.00000	C
0.00002500	2637.	105488526.	18.3667604	0.0004592	-0.000291	1.6983397	0.00000	C
0.00002625	2685.	102294458.	17.9998590	0.0004725	-0.000315	1.7404188	0.00000	C
0.00002750	2730.	99280203.	17.6583282	0.0004856	-0.000339	1.7814228	0.00000	C
0.00002875	2772.	96431139.	17.3391927	0.0004985	-0.000364	1.8213979	0.00000	C
0.00003000	2812.	93734902.	17.0401949	0.0005112	-0.000389	1.8603925	0.00000	C
0.00003125	2849.	91180920.	16.7590906	0.0005237	-0.000414	1.8984580	0.00000	C
0.00003250	2885.	88760056.	16.4942123	0.0005361	-0.000439	1.9356488	0.00000	C
0.00003375	2918.	86464334.	16.2441864	0.0005482	-0.000464	1.9720228	0.00000	C
0.00003500	2950.	84286718.	16.0078863	0.0005603	-0.000490	2.0076410	0.00000	C
0.00003625	2980.	82212765.	15.7834625	0.0005722	-0.000515	2.0424688	0.00000	C
0.00003750	3009.	80232800.	15.5695491	0.0005839	-0.000541	2.0764989	0.00000	C
0.00003875	3036.	78352317.	15.3666595	0.0005955	-0.000567	2.1099170	0.00000	C
0.00004000	3062.	76561449.	15.1736339	0.0006069	-0.000593	2.1427168	0.00000	C
0.00004125	3087.	74841236.	14.9880291	0.0006183	-0.000619	2.1747241	0.00000	C
0.00004250	3111.	73207586.	14.8119191	0.0006295	-0.000645	2.2062811	0.00000	C
0.00004375	3134.	71636668.	14.6422487	0.0006406	-0.000672	2.2371167	0.00000	C
0.00004500	3156.	70137069.	14.4802018	0.0006516	-0.000698	2.2674587	0.00000	C
0.00004625	3177.	68698287.	14.3244807	0.0006625	-0.000725	2.2972260	0.00000	C
0.00004750	3198.	67318644.	14.1748902	0.0006733	-0.000752	2.3264663	0.00000	C
0.00004875	3217.	65993695.	14.0309595	0.0006840	-0.000778	2.3551870	0.00000	C
0.00005125	3254.	63496506.	13.7587348	0.0007051	-0.000832	2.4111404	0.00000	C
0.00005375	3289.	61184927.	13.5054943	0.0007259	-0.000887	2.4652326	0.00000	C
0.00005625	3321.	59040736.	13.2695313	0.0007464	-0.000941	2.5176167	0.00000	C
0.00005875	3352.	57048526.	13.0491777	0.0007666	-0.000996	2.5684537	0.00000	C
0.00006125	3380.	55178100.	12.8401583	0.0007865	-0.001051	2.6173830	0.00000	C
0.00006375	3406.	53433631.	12.6447106	0.0008061	-0.001106	2.6649666	0.00000	C
0.00006625	3432.	51803612.	12.4607573	0.0008255	-0.001162	2.7113144	0.00000	C
0.00006875	3456.	50261873.	12.2854667	0.0008446	-0.001218	2.7559200	0.00000	C
0.00007125	3478.	48820242.	12.1207721	0.0008636	-0.001274	2.7995817	0.00000	C
0.00007375	3500.	47452952.	11.9631365	0.0008823	-0.001330	2.8416800	0.00000	C
0.00007625	3520.	46168445.	11.8140539	0.0009008	-0.001387	2.8828716	0.00000	C
0.00007875	3540.	44946476.	11.6715673	0.0009191	-0.001443	2.9226157	0.00000	C
0.00008125	3558.	43796727.	11.5372268	0.0009374	-0.001500	2.9616313	0.00000	C
0.00008375	3576.	42696015.	11.4062473	0.0009553	-0.001557	2.9990991	0.00000	C
0.00008625	3593.	41658260.	11.2833123	0.0009732	-0.001614	3.0359600	0.00000	C
0.00008875	3609.	40665166.	11.1638680	0.0009908	-0.001672	3.0715068	0.00000	C
0.00009125	3625.	39720781.	11.0499087	0.0010083	-0.001729	3.1061908	0.00000	C
0.00009375	3640.	38824883.	10.9420531	0.0010258	-0.001787	3.1402203	0.00000	C
0.00009625	3654.	37960537.	10.8355348	0.0010429	-0.001845	3.1727981	0.00000	C
0.00009875	3668.	37139315.	10.7347737	0.0010601	-0.001902	3.2048152	0.00000	C
0.0001013	3681.	36356471.	10.6388153	0.0010772	-0.001960	3.2361650	0.00000	C
0.0001038	3693.	35599093.	10.5436619	0.0010939	-0.002019	3.2661669	0.00000	C
0.0001063	3706.	34876806.	10.4533119	0.0011107	-0.002077	3.2956299	0.00000	C
0.0001088	3718.	34187180.	10.3674523	0.0011275	-0.002135	3.3245502	0.00000	C
0.0001113	3729.	33519114.	10.2822714	0.0011439	-0.002194	3.3522626	0.00000	C
0.0001138	3740.	32877628.	10.2002255	0.0011603	-0.002252	3.3792793	0.00000	C
0.0001163	3751.	32263264.	10.1219959	0.0011767	-0.002311	3.4057755	0.00000	C
0.0001188	3761.	31673951.	10.0472126	0.0011931	-0.002369	3.4317194	0.00000	C
0.0001213	3771.	31099408.	9.9718454	0.0012091	-0.002428	3.4563915	0.00000	C
0.0001238	3780.	30547675.	9.8997832	0.0012251	-0.002487	3.4805658	0.00000	C
0.0001263	3790.	30017392.	9.8308303	0.0012411	-0.002546	3.5042388	0.00000	C
0.0001288	3799.	29507303.	9.7648061	0.0012572	-0.002605	3.5274074	0.00000	C
0.0001313	3808.	29010174.	9.6986505	0.0012729	-0.002665	3.5495217	0.00000	C
0.0001338	3816.	28529503.	9.6343202	0.0012886	-0.002724	3.5709904	0.00000	C
0.0001363	3824.	28066125.	9.5725793	0.0013043	-0.002783	3.5919775	0.00000	C
0.0001388	3832.	27619104.	9.5132881	0.0013200	-0.002843	3.6124800	0.00000	C
0.0001413	3840.	27187566.	9.4563180	0.0013357	-0.002902	3.6324948	0.00000	C
0.0001438	3847.	26764958.	9.3984826	0.0013510	-0.002961	3.6514601	0.00000	C
0.0001463	3855.	26355779.	9.3424114	0.0013663	-0.003021	3.6698903	0.00000	C
0.0001488	3862.	25960063.	9.2884275	0.0013817	-0.003081	3.6878561	0.00000	C
0.0001588	3888.	24492493.	9.0874589	0.0014426	-0.003320	3.7543481	0.00000	C
0.0001688	3912.	23181358.	8.9041464	0.0015026	-0.003560	3.8120452	0.00000	C
0.0001788	3933.	22002264.	8.7377027	0.0015619	-0.003801	3.8613238	0.00000	C
0.0001888	3952.	20939733.	8.5871822	0.0016208	-0.004042	3.9029901	0.00000	C
0.0001988	3969.	19971656.	8.4465310	0.0016787	-0.004284	3.9366768	0.00000	C
0.0002088	3985.	19090302.	8.3189824	0.0017366	-0.004526	3.9631711	0.00000	C
0.0002188	3999.	18282798.	8.2013572	0.0017940	-0.004768	3.9824247	0.00000	C
0.0002288	4012.	17537882.	8.0906994	0.0018507	-0.005012	3.9945171	0.00000	C
0.0002388	4024.	16853011.	7.9912981	0.0019079	-0.005255	3.9997746	0.00000	C
0.0002488	4034.	16216692.	7.8973810	0.0019645	-0.005498	3.9987206	0.00000	C
0.0002588	4043.	15624256.	7.8090717	0.0020206	-0.005742	3.9959883	0.00000	C
0.0002688	4051.	15073765.	7.7292571	0.0020772	-0.005985	3.9998738	0.00000	C
0.0002788	4059.	14560580.	7.6570893	0.0021344	-0.006228	3.9977700	0.00000	C
0.0002888	4065.	14077285.	7.5850669	0.0021902	-0.006472	3.9997701	0.00000	C
0.0002988	4070.	13624090.	7.5188246	0.0022462	-0.006716	3.9978933	0.00000	C
0.0003088	4075.	13199255.	7.4583849	0.0023028	-0.006960	3.9999999	0.00000	C
0.0003188	4080.	12799486.	7.4024891	0.0023595	-0.007203	3.9969130	0.00000	C

0.0003288	4084.	12423216.	7.3524423	0.0024171	-0.007445	3.9998508	0.00000 C
0.0003388	4087.	12065407.	7.3007603	0.0024731	-0.007689	3.9938934	0.00000 C
0.0003488	4090.	11727264.	7.2525600	0.0025293	-0.007933	3.9984609	0.00000 C
0.0003588	4092.	11407430.	7.2079401	0.0025858	-0.008177	3.9999947	0.00000 C
0.0003688	4095.	11103938.	7.1665943	0.0026427	-0.008420	3.9939957	0.00000 C
0.0003788	4097.	10816049.	7.1292056	0.0027002	-0.008662	3.9983533	0.00000 C
0.0003888	4098.	10542542.	7.0939489	0.0027578	-0.008905	3.9999887	0.00000 C
0.0003988	4100.	10281942.	7.0617265	0.0028159	-0.009147	3.9914477	0.00000 C
0.0004088	4101.	10032895.	7.0287996	0.0028730	-0.009389	3.9965294	0.00000 C
0.0004188	4102.	9794966.	6.9961537	0.0029296	-0.009633	3.9993313	0.00000 C
0.0004288	4102.	9567790.	6.9660210	0.0029867	-0.009876	3.9977746	0.00000 C
0.0004388	4103.	9350474.	6.9378366	0.0030440	-0.010119	3.9903568	0.00000 C
0.0004488	4103.	9142645.	6.9119203	0.0031017	-0.010361	3.9954692	0.00000 C
0.0004588	4103.	8943677.	6.8873761	0.0031596	-0.010603	3.9986909	0.00000 C
0.0004688	4103.	8752996.	6.8642849	0.0032176	-0.010845	3.9999769	0.00000 C
0.0004788	4103.	8570166.	6.8432603	0.0032762	-0.011086	3.9920043	0.00000 C
0.0004888	4103.	8394817.	6.8234479	0.0033350	-0.011328	3.9907207	0.00000 C
0.0004988	4103.	8226500.	6.8047943	0.0033939	-0.011569	3.9954840	0.00000 C
0.0005088	4103.	8064800.	6.7872065	0.0034530	-0.011810	3.9985670	0.00000 C
0.0005188	4103.	7909334.	6.7706551	0.0035123	-0.012050	3.9999314	0.00000 C
0.0005288	4103.	7759748.	6.7560860	0.0035723	-0.012290	3.9935796	0.00000 C
0.0005388	4103.	7615716.	6.7404632	0.0036314	-0.012531	3.9855089	0.00000 C
0.0005488	4103.	7476933.	6.7243842	0.0036900	-0.012772	3.9910045	0.00000 C
0.0006088	4103.	6739987.	6.7848538	0.0041303	-0.014132	3.9983072	0.00000 C

Summary of Results for Nominal Moment Capacity for Section 3

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	355.000	4102.267	0.00300000	-0.00993224

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	355.000000	4102.	230.750000	2666.	103542120.
1	0.75	355.000000	4102.	266.250000	3077.	75571288.
1	0.90	355.000000	4102.	319.500000	3692.	35683097.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	413.0999
2	0.7000	0.6998	Yes	No	413.0999	5026.
3	2.8000	2.6033	Yes	No	5439.	12797.
4	5.0000	5.9899	Yes	No	18236.	62732.
5	10.0000	10.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.337000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 355000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3370	-2008193.	39188.	0.00	44072.	1.29E+10	0.00	0.00	0.00
0.1730	0.3367	-1926764.	39148.	-3.17E-04	42706.	1.29E+10	-18.267	112.6395	0.00
0.3460	0.3357	-1845185.	39088.	-6.21E-04	41339.	1.29E+10	-38.698	239.3264	0.00
0.5190	0.3341	-1763554.	38985.	-9.12E-04	39970.	1.29E+10	-60.792	377.7617	0.00
0.6920	0.3319	-1681975.	38835.	-0.00119	38602.	1.29E+10	-84.084	525.9354	0.00
0.8650	0.3291	-1600559.	38646.	-0.00145	37237.	1.29E+10	-97.811	616.9079	0.00
1.0380	0.3259	-1519374.	38429.	-0.00170	35876.	1.29E+10	-110.867	706.3022	0.00
1.2110	0.3221	-1438487.	38186.	-0.00194	34520.	1.29E+10	-123.460	795.7965	0.00
1.3840	0.3178	-1357961.	37917.	-0.00217	33170.	1.29E+10	-135.740	886.7164	0.00
1.5570	0.3131	-1277859.	37623.	-0.00238	31827.	1.29E+10	-147.295	976.7302	0.00
1.7300	0.3079	-1198240.	37307.	-0.00258	30492.	1.29E+10	-157.836	1064.	0.00
1.9030	0.3024	-1119159.	36969.	-0.00277	29167.	1.29E+10	-167.590	1151.	0.00
2.0760	0.2964	-1040668.	36611.	-0.00294	27851.	1.29E+10	-177.608	1244.	0.00
2.2490	0.2901	-962818.	36233.	-0.00310	26545.	1.29E+10	-186.448	1334.	0.00
2.4220	0.2835	-885657.	35838.	-0.00325	25252.	1.29E+10	-193.943	1420.	0.00
2.5950	0.2766	-809228.	35428.	-0.00339	23970.	1.29E+10	-200.965	1508.	0.00
2.7680	0.2695	-733568.	35004.	-0.00351	22702.	1.29E+10	-207.156	1596.	0.00
2.9410	0.2621	-658714.	34505.	-0.00362	21447.	1.29E+10	-273.744	2169.	0.00
3.1140	0.2544	-584961.	33927.	-0.00372	20210.	1.29E+10	-283.031	2309.	0.00
3.2870	0.2466	-512359.	33332.	-0.00381	18993.	1.29E+10	-290.055	2442.	0.00
3.4600	0.2386	-440946.	32722.	-0.00389	17796.	1.29E+10	-298.235	2595.	0.00
3.6330	0.2305	-370766.	32096.	-0.00395	16619.	1.29E+10	-304.482	2743.	0.00
3.8060	0.2222	-301854.	31460.	-0.00401	15464.	1.29E+10	-308.290	2881.	0.00
3.9790	0.2138	-234236.	30816.	-0.00405	14330.	1.29E+10	-311.918	3029.	0.00
4.1520	0.2054	-167933.	30162.	-0.00408	13219.	1.29E+10	-318.301	3218.	0.00
4.3250	0.1969	-102983.	29497.	-0.00411	12130.	1.29E+10	-322.591	3402.	0.00
4.4980	0.1883	-39410.	28825.	-0.00412	11064.	1.29E+10	-324.613	3579.	0.00
4.6710	0.1798	22768.	28151.	-0.00412	10785.	1.29E+10	-324.201	3744.	0.00
4.8440	0.1712	83546.	27482.	-0.00411	11804.	1.29E+10	-321.207	3895.	0.00
5.0170	0.1627	142930.	26881.	-0.00409	12800.	1.29E+10	-257.750	3289.	0.00
5.1900	0.1542	201186.	26345.	-0.00406	13776.	1.29E+10	-258.076	3474.	0.00
5.3630	0.1458	258306.	25807.	-0.00403	14734.	1.29E+10	-260.184	3704.	0.00
5.5360	0.1375	314274.	25265.	-0.00398	15672.	1.29E+10	-262.152	3958.	0.00
5.7090	0.1293	369075.	24719.	-0.00393	16591.	1.29E+10	-263.448	4230.	0.00
5.8820	0.1212	422697.	24172.	-0.00386	17490.	1.29E+10	-264.043	4523.	0.00
6.0550	0.1132	475131.	23624.	-0.00379	18369.	1.29E+10	-263.909	4838.	0.00
6.2280	0.1055	526370.	23077.	-0.00371	19228.	1.29E+10	-263.020	5178.	0.00
6.4010	0.09784	576414.	22533.	-0.00362	20067.	1.29E+10	-261.353	5545.	0.00
6.5740	0.09042	625263.	21993.	-0.00352	20886.	1.29E+10	-258.887	5944.	0.00
6.7470	0.08321	672922.	21459.	-0.00342	21685.	1.29E+10	-255.605	6377.	0.00
6.9200	0.07622	719399.	20932.	-0.00331	22464.	1.29E+10	-251.492	6850.	0.00
7.0930	0.06948	764707.	20415.	-0.00319	23224.	1.29E+10	-246.537	7367.	0.00
7.2660	0.06299	808862.	19909.	-0.00306	23964.	1.29E+10	-240.734	7934.	0.00
7.4390	0.05677	851883.	19417.	-0.00293	24686.	1.29E+10	-234.083	8560.	0.00
7.6120	0.05083	893794.	18938.	-0.00279	25388.	1.29E+10	-226.591	9254.	0.00
7.7850	0.04520	934623.	18477.	-0.00264	26073.	1.29E+10	-218.269	10025.	0.00
7.9580	0.03988	974400.	18033.	-0.00249	26740.	1.29E+10	-209.142	10888.	0.00
8.1310	0.03488	1013160.	17622.	-0.00233	27389.	1.29E+10	-187.172	11141.	0.00
8.3040	0.03022	1050992.	17255.	-0.00216	28024.	1.29E+10	-165.625	11378.	0.00
8.4770	0.02591	1087987.	16933.	-0.00199	28644.	1.29E+10	-144.981	11615.	0.00
8.6500	0.02197	1124227.	16652.	-0.00181	29252.	1.29E+10	-125.430	11852.	0.00
8.8230	0.01840	1159793.	16411.	-0.00162	29848.	1.29E+10	-107.169	12089.	0.00
8.9960	0.01523	1194760.	16206.	-0.00143	30434.	1.29E+10	-90.396	12326.	0.00
9.1690	0.01245	1229195.	16034.	-0.00124	31011.	1.29E+10	-75.316	12563.	0.00
9.3420	0.01008	1263160.	15891.	-0.00104	31581.	1.29E+10	-62.136	12800.	0.00
9.5150	0.00813	1296707.	15774.	-8.33E-04	32143.	1.29E+10	-51.068	13037.	0.00
9.6880	0.00662	1329879.	15677.	-6.21E-04	32699.	1.29E+10	-42.328	13274.	0.00
9.8610	0.00555	1362712.	15595.	-4.04E-04	33250.	1.29E+10	-36.139	13511.	0.00
10.0340	0.00494	1395227.	11849.	-2.86E-04	0.00	1.71E+11	-3573.	1501095.	0.00
10.2070	0.00436	1412331.	4801.	-2.69E-04	0.00	1.71E+11	-3217.	1530058.	0.00
10.3800	0.00382	1415558.	-1487.	-2.52E-04	0.00	1.71E+11	-2840.	1541945.	0.00
10.5530	0.00332	1406530.	-7013.	-2.35E-04	0.00	1.71E+11	-2483.	1553210.	0.00
10.7260	0.00285	1386788.	-11818.	-2.18E-04	0.00	1.71E+11	-2146.	1563827.	0.00
10.8990	0.00241	1357783.	-15946.	-2.01E-04	0.00	1.71E+11	-1830.	1573780.	0.00
11.0720	0.00201	1320877.	-19440.	-1.85E-04	0.00	1.71E+11	-1536.	1583056.	0.00
11.2450	0.00165	1277340.	-22345.	-1.69E-04	0.00	1.71E+11	-1262.	1591654.	0.00
11.4180	0.00131	1228351.	-24704.	-1.54E-04	0.00	1.71E+11	-1010.	1599576.	0.00
11.5910	0.00101	1174997.	-26562.	-1.39E-04	0.00	1.71E+11	-779.495	1606832.	0.00
11.7640	7.32E-04	1118272.	-27962.	-1.26E-04	0.00	1.71E+11	-569.199	1613434.	0.00
11.9370	4.86E-04	1059085.	-28946.	-1.12E-04	0.00	1.71E+11	-378.972	1619402.	0.00
12.1100	2.66E-04	998255.	-29555.	-9.99E-05	0.00	1.71E+11	-208.119	1624759.	0.00
12.2830	7.11E-05	936518.	-29829.	-8.82E-05	0.00	1.71E+11	-55.838	1629529.	0.00
12.4560	-1.00E-04	874533.	-29806.	-7.72E-05	0.00	1.71E+11	78.5215	1628820.	0.00
12.6290	-2.49E-04	812879.	-29522.	-6.69E-05	0.00	1.71E+11	195.1539	1625172.	0.00
12.8020	-3.78E-04	752058.	-29012.	-5.75E-05	0.00	1.71E+11	295.3821	1622040.	0.00
12.9750	-4.88E-04	692504.	-28311.	-4.87E-05	0.00	1.71E+11	380.5792	1619380.	0.00
13.1480	-5.80E-04	634583.	-27447.	-4.07E-05	0.00	1.71E+11	452.0484	1617152.	0.00
13.3210	-6.57E-04	578605.	-26447.	-3.33E-05	0.00	1.71E+11	511.0248	1615316.	0.00
13.4940	-7.19E-04	524825.	-25337.	-2.66E-05	0.00	1.71E+11	558.6761	1613834.	0.00
13.6670	-7.67E-04	473447.	-24138.	-2.06E-05	0.00	1.71E+11	596.1032	1612673.	0.00
13.8400	-8.04E-04	424635.	-22871.	-1.51E-05	0.00	1.71E+11	624.3417	1611800.	0.00
14.0130	-8.30E-04	378509.	-21554.	-1.03E-05	0.00	1.71E+11	644.3628	1611183.	0.00
14.1860	-8.47E-04	335157.	-20203.	-5.96E-06	0.00	1.71E+11	657.0743	1610795.	0.00
14.3590	-8.55E-04	294634.	-18833.	-2.14E-06	0.00	1.71E+11	663.3222	1610608.	0.00
14.5320	-8.56E-04	256967.	-17455.	1.20E-06	0.00	1.71E+11	663.8919	1610599.	0.00
14.7050	-8.50E-04	222159.	-16081.	4.10E-06	0.00	1.71E+11	659.5095	1610744.	0.00
14.8780	-8.39E-04	190191.	-14721.	6.60E-06	0.00	1.71E+11	650.8435	1611021.	0.00
15.0510	-8.23E-04	161026.	-13383.	8.73E-06	0.00	1.71E+11	638.5060	1611413.	0.00
15.2240	-8.02E-04	134612.	-12073.	1.05E-05	0.00	1.71E+11	623.0547	1611902.	0.00
15.3970	-7.79E-04	110882.	-10799.	1.20E-05	0.00	1.71E+11	604.9941	1612471.	0.00
15.5700	-7.53E-04	89759.	-9564.	1.32E-05	0.00	1.71E+11	584.7773	1613107.	0.00
15.7430	-7.24E-04	71154.	-8372.	1.42E-05	0.00	1.71E+11	562.8079	1613796.	0.00
15.9160	-6.94E-04	54975.	-7228.	1.50E-05	0.00	1.71E+11	539.4418	1614529.	0.00

16.0890	-6.62E-04	41120.	-6134.	1.55E-05	0.00	1.71E+11	514.9888	1615294.	0.00
16.2620	-6.29E-04	29484.	-5091.	1.60E-05	0.00	1.71E+11	489.7146	1616085.	0.00
16.4350	-5.96E-04	19959.	-4101.	1.63E-05	0.00	1.71E+11	463.8429	1616893.	0.00
16.6080	-5.62E-04	12432.	-3166.	1.65E-05	0.00	1.71E+11	437.5572	1617713.	0.00
16.7810	-5.27E-04	6791.	-2285.	1.66E-05	0.00	1.71E+11	411.0026	1618542.	0.00
16.9540	-4.93E-04	2922.	-1459.	1.66E-05	0.00	1.71E+11	384.2884	1619374.	0.00
17.1270	-4.58E-04	708.3430	-697.797	1.67E-05	0.00	1.58E+11	349.2386	1582814.	0.00
17.3000	-4.23E-04	0.00	0.00	1.67E-05	0.00	1.58E+11	323.0127	791805.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection            =     0.33700000 inches
Computed slope at pile head     =       0.000000 radians
Maximum bending moment          =      -2008193. inch-lbs
Maximum shear force             =         39188. lbs
Depth of maximum bending moment =       0.000000 feet below pile head
Depth of maximum shear force    =       0.000000 feet below pile head
Number of iterations            =              6
Number of zero deflection points =             1
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

```
Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head                          =     0.404400 inches
Rotation of pile head                              =    0.000E+00 radians
Axial load on pile head                            =     355000.0 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.4044	-2377062.	45645.	0.00	50256.	1.29E+10	0.00	0.00	0.00
0.1730	0.4040	-2282210.	45602.	-3.75E-04	48666.	1.29E+10	-19.464	100.0173	0.00
0.3460	0.4028	-2187171.	45539.	-7.35E-04	47072.	1.29E+10	-41.292	212.7959	0.00
0.5190	0.4009	-2092049.	45428.	-0.00108	45478.	1.29E+10	-64.961	336.3515	0.00
0.6920	0.3984	-1996960.	45268.	-0.00141	43883.	1.29E+10	-89.942	468.7223	0.00
0.8650	0.3951	-1902021.	45066.	-0.00172	42292.	1.29E+10	-104.658	549.9171	0.00
1.0380	0.3912	-1807307.	44834.	-0.00202	40704.	1.29E+10	-118.665	629.7246	0.00
1.2110	0.3867	-1712890.	44573.	-0.00231	39121.	1.29E+10	-132.186	709.6415	0.00
1.3840	0.3816	-1618840.	44285.	-0.00257	37544.	1.29E+10	-145.354	790.7064	0.00
1.5570	0.3760	-1525223.	43971.	-0.00283	35974.	1.29E+10	-157.742	870.9120	0.00
1.7300	0.3699	-1432106.	43631.	-0.00307	34413.	1.29E+10	-169.050	948.7964	0.00
1.9030	0.3633	-1339547.	43270.	-0.00329	32861.	1.29E+10	-179.520	1026.	0.00
2.0760	0.3562	-1247602.	42886.	-0.00350	31320.	1.29E+10	-190.284	1109.	0.00
2.2490	0.3488	-1156330.	42481.	-0.00369	29790.	1.29E+10	-199.794	1189.	0.00
2.4220	0.3409	-1065781.	42058.	-0.00387	28272.	1.29E+10	-207.877	1266.	0.00
2.5950	0.3327	-976002.	41618.	-0.00403	26766.	1.29E+10	-215.395	1344.	0.00
2.7680	0.3242	-887035.	41164.	-0.00418	25275.	1.29E+10	-221.985	1422.	0.00
2.9410	0.3153	-798919.	40630.	-0.00432	23798.	1.29E+10	-292.983	1929.	0.00
3.1140	0.3062	-711971.	40011.	-0.00444	22340.	1.29E+10	-302.842	2053.	0.00
3.2870	0.2969	-626244.	39375.	-0.00455	20903.	1.29E+10	-310.288	2170.	0.00
3.4600	0.2873	-541780.	38721.	-0.00464	19486.	1.29E+10	-319.376	2308.	0.00
3.6330	0.2776	-458628.	38051.	-0.00472	18092.	1.29E+10	-326.579	2442.	0.00
3.8060	0.2677	-376829.	37368.	-0.00479	16721.	1.29E+10	-331.354	2570.	0.00
3.9790	0.2577	-296414.	36675.	-0.00485	15373.	1.29E+10	-336.164	2708.	0.00
4.1520	0.2476	-217412.	35969.	-0.00489	14048.	1.29E+10	-344.193	2886.	0.00
4.3250	0.2374	-139867.	35248.	-0.00492	12748.	1.29E+10	-350.156	3062.	0.00
4.4980	0.2272	-63815.	34517.	-0.00493	11473.	1.29E+10	-353.796	3233.	0.00
4.6710	0.2169	10720.	33782.	-0.00494	10583.	1.29E+10	-354.920	3397.	0.00
4.8440	0.2067	83724.	33047.	-0.00493	11807.	1.29E+10	-353.346	3549.	0.00
5.0170	0.1965	155195.	32380.	-0.00491	13005.	1.29E+10	-288.610	3050.	0.00
5.1900	0.1863	225404.	31780.	-0.00488	14182.	1.29E+10	-289.428	3225.	0.00
5.3630	0.1762	294338.	31177.	-0.00484	15338.	1.29E+10	-291.919	3439.	0.00
5.5360	0.1662	361980.	30568.	-0.00478	16472.	1.29E+10	-294.190	3675.	0.00
5.7090	0.1563	428311.	29956.	-0.00472	17584.	1.29E+10	-295.709	3927.	0.00
5.8820	0.1466	493316.	29341.	-0.00465	18674.	1.29E+10	-296.441	4198.	0.00
6.0550	0.1370	556986.	28726.	-0.00456	19741.	1.29E+10	-296.357	4490.	0.00
6.2280	0.1277	619312.	28112.	-0.00447	20786.	1.29E+10	-295.426	4804.	0.00
6.4010	0.1185	680291.	27500.	-0.00436	21809.	1.29E+10	-293.623	5144.	0.00
6.5740	0.1095	739924.	26894.	-0.00425	22808.	1.29E+10	-290.922	5513.	0.00
6.7470	0.1009	798215.	26293.	-0.00412	23786.	1.29E+10	-287.304	5914.	0.00
6.9200	0.09242	855174.	25702.	-0.00399	24741.	1.29E+10	-282.752	6351.	0.00
7.0930	0.08428	910812.	25120.	-0.00385	25674.	1.29E+10	-277.254	6829.	0.00
7.2660	0.07644	965147.	24552.	-0.00370	26584.	1.29E+10	-270.802	7355.	0.00
7.4390	0.06892	1018200.	23997.	-0.00354	27474.	1.29E+10	-263.395	7933.	0.00
7.6120	0.06175	1069998.	23459.	-0.00337	28342.	1.29E+10	-255.040	8574.	0.00
7.7850	0.05493	1120569.	22939.	-0.00319	29190.	1.29E+10	-245.752	9287.	0.00
7.9580	0.04849	1169948.	22440.	-0.00301	30018.	1.29E+10	-235.556	10085.	0.00
8.1310	0.04244	1218173.	21962.	-0.00282	30827.	1.29E+10	-224.492	10981.	0.00
8.3040	0.03680	1265286.	21520.	-0.00262	31616.	1.29E+10	-201.665	11378.	0.00
8.4770	0.03158	1311379.	21127.	-0.00241	32389.	1.29E+10	-176.659	11615.	0.00
8.6500	0.02679	1356556.	20785.	-0.00219	33147.	1.29E+10	-152.965	11852.	0.00
8.8230	0.02247	1400912.	20490.	-0.00197	33890.	1.29E+10	-130.821	12089.	0.00
8.9960	0.01861	1444537.	20240.	-0.00174	34622.	1.29E+10	-110.470	12326.	0.00
9.1690	0.01523	1487516.	20029.	-0.00151	35342.	1.29E+10	-92.162	12563.	0.00

9.3420	0.01235	1529920.	19855.	-0.00126	36053.	1.29E+10	-76.150	12800.	0.00
9.5150	0.00998	1571815.	19711.	-0.00101	36756.	1.29E+10	-62.695	13037.	0.00
9.6880	0.00814	1613253.	19591.	-7.57E-04	37450.	1.29E+10	-52.060	13274.	0.00
9.8610	0.00684	1654275.	19491.	-4.94E-04	38138.	1.29E+10	-44.516	13511.	0.00
10.0340	0.00609	1694908.	14957.	-3.50E-04	0.00	1.71E+11	-4324.	1473727.	0.00
10.2070	0.00539	1716891.	6407.	-3.30E-04	0.00	1.71E+11	-3912.	1508185.	0.00
10.3800	0.00472	1721998.	-1248.	-3.09E-04	0.00	1.71E+11	-3463.	1522362.	0.00
10.5530	0.00410	1712163.	-7994.	-2.88E-04	0.00	1.71E+11	-3036.	1535844.	0.00
10.7260	0.00353	1689231.	-13876.	-2.67E-04	0.00	1.71E+11	-2631.	1548595.	0.00
10.8990	0.00299	1654944.	-18943.	-2.47E-04	0.00	1.71E+11	-2250.	1560587.	0.00
11.0720	0.00250	1610943.	-23245.	-2.27E-04	0.00	1.71E+11	-1894.	1571799.	0.00
11.2450	0.00205	1558764.	-26834.	-2.08E-04	0.00	1.71E+11	-1563.	1582222.	0.00
11.4180	0.00164	1499835.	-29761.	-1.89E-04	0.00	1.71E+11	-1257.	1591854.	0.00
11.5910	0.00126	1435477.	-32077.	-1.72E-04	0.00	1.71E+11	-975.056	1600699.	0.00
11.7640	9.27E-04	1366904.	-33834.	-1.55E-04	0.00	1.71E+11	-718.009	1608769.	0.00
11.9370	6.23E-04	1295224.	-35083.	-1.38E-04	0.00	1.71E+11	-484.907	1616083.	0.00
12.1100	3.52E-04	1221443.	-35872.	-1.23E-04	0.00	1.71E+11	-275.040	1622663.	0.00
12.2830	1.12E-04	1146465.	-36248.	-1.09E-04	0.00	1.71E+11	-87.546	1628536.	0.00
12.4560	-9.98E-05	1071100.	-36258.	-9.53E-05	0.00	1.71E+11	78.3186	1628826.	0.00
12.6290	-2.84E-04	996063.	-35946.	-8.28E-05	0.00	1.71E+11	222.4306	1624318.	0.00
12.8020	-4.44E-04	921975.	-35355.	-7.12E-05	0.00	1.71E+11	346.3185	1620447.	0.00
12.9750	-5.80E-04	849372.	-34527.	-6.05E-05	0.00	1.71E+11	451.7083	1617157.	0.00
13.1480	-6.95E-04	778708.	-33497.	-5.06E-05	0.00	1.71E+11	540.2303	1614396.	0.00
13.3210	-7.90E-04	710366.	-32300.	-4.16E-05	0.00	1.71E+11	613.4220	1612117.	0.00
13.4940	-8.67E-04	644661.	-30965.	-3.34E-05	0.00	1.71E+11	672.7289	1610273.	0.00
13.6670	-9.28E-04	581849.	-29520.	-2.59E-05	0.00	1.71E+11	719.5090	1608822.	0.00
13.8400	-9.75E-04	522133.	-27989.	-1.92E-05	0.00	1.71E+11	755.0357	1607722.	0.00
14.0130	-0.00101	465667.	-26395.	-1.33E-05	0.00	1.71E+11	780.5008	1606938.	0.00
14.1860	-0.00103	412560.	-24758.	-7.93E-06	0.00	1.71E+11	797.0160	1606433.	0.00
14.3590	-0.00104	362884.	-23094.	-3.24E-06	0.00	1.71E+11	805.6160	1606174.	0.00
14.5320	-0.00104	316677.	-21420.	8.82E-07	0.00	1.71E+11	807.2604	1606133.	0.00
14.7050	-0.00104	273946.	-19749.	4.46E-06	0.00	1.71E+11	802.8359	1606281.	0.00
14.8780	-0.00102	234674.	-18092.	7.54E-06	0.00	1.71E+11	793.1584	1606592.	0.00
15.0510	-0.00101	198817.	-16460.	1.02E-05	0.00	1.71E+11	778.9754	1607043.	0.00
15.2240	-9.83E-04	166315.	-14862.	1.24E-05	0.00	1.71E+11	760.9675	1607613.	0.00
15.3970	-9.55E-04	137092.	-13304.	1.42E-05	0.00	1.71E+11	739.7513	1608282.	0.00
15.5700	-9.24E-04	111056.	-11793.	1.57E-05	0.00	1.71E+11	715.8807	1609033.	0.00
15.7430	-8.90E-04	88104.	-10334.	1.69E-05	0.00	1.71E+11	689.8496	1609850.	0.00
15.9160	-8.53E-04	68124.	-8931.	1.79E-05	0.00	1.71E+11	662.0939	1610721.	0.00
16.0890	-8.15E-04	50998.	-7586.	1.86E-05	0.00	1.71E+11	632.9935	1611632.	0.00
16.2620	-7.76E-04	36598.	-6304.	1.91E-05	0.00	1.71E+11	602.8747	1612574.	0.00
16.4350	-7.36E-04	24797.	-5084.	1.95E-05	0.00	1.71E+11	572.0127	1613539.	0.00
16.6080	-6.95E-04	15461.	-3929.	1.97E-05	0.00	1.71E+11	540.6333	1614518.	0.00
16.7810	-6.54E-04	8454.	-2840.	1.99E-05	0.00	1.71E+11	508.9158	1615508.	0.00
16.9540	-6.13E-04	3641.	-1816.	2.00E-05	0.00	1.71E+11	476.9951	1616503.	0.00
17.1270	-5.71E-04	883.9219	-869.912	2.00E-05	0.00	1.58E+11	434.7109	1580229.	0.00
17.3000	-5.30E-04	0.00	0.00	2.00E-05	0.00	1.58E+11	403.3550	790591.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

```
Pile-head deflection            =     0.40440000 inches
Computed slope at pile head     =       0.000000 radians
Maximum bending moment          =      -2377062. inch-lbs
Maximum shear force             =         45645. lbs
Depth of maximum bending moment =       0.000000 feet below pile head
Depth of maximum shear force    =       0.000000 feet below pile head
Number of iterations            =              6
Number of zero deflection points =             1
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.3370	S, rad	0.00	355000.	0.3370	0.00	39188.	-2008193.
2	y, in	0.4044	S, rad	0.00	355000.	0.4044	0.00	45645.	-2377062.

Maximum pile-head deflection = 0.4044000000 inches
Maximum pile-head rotation   = 0.0000000000 radians = 0.000000 deg.

The analysis ended normally.

D.6. End Bearing Calculation for Rock Socketed Piles

GEI Consultants			
Client:	Thornton Tomasetti	**Prepared By:**	M. Johnescu
Project:	Benjamin Lincoln Bridge (#6740)	**Date:**	7/22/2025
Project No.:	2502334	**Checked By:**	N. Betancur
Subject:	Rock Socketed Piles Axial Resistance - Side Resistance (Abut. 1)	**Date:**	7/24/2025

Objective: Calculate the axial resistance of rock socketed HP piles from side resistance based on subsurface data collected from the Phase 1 and 2 exploration programs for proposed Abutment 1.

References: 1) American Association of State Highway and Transportation Officials (AASHTO) "LRFD Bridge Design Specifications, 9th Edition, 2020"

Equations:

Ref. 1 Eqn. No.	Equation	
10.8.3.5.4b-1	$$\frac{q_s}{p_a} = C\sqrt{\frac{q_u}{p_a}}$$	where: q_s = Nominal unit side resistance q_u = Uniaxial compressive strength of rock or compressive strength of concrete (f'c), whichever is lower C = Regression Coefficient taken as 1.0 for normal conditions p_a = Atmospheric pressure taken as 2.12 ksf
10.8.3.5.4b-2 (Only use for fractured rock that caves and cannot be drilled with some type of artificial support)	$$\frac{q_s}{p_a} = 0.65\alpha_E\sqrt{\frac{q_u}{p_a}}$$	where: q_s = Nominal unit side resistance q_u = Uniaxial compressive strength of rock or compressive strength of concrete (f'c), whichever is lower p_a = Atmospheric pressure taken as 2.12 ksf α_E = Joint Modification Factor, Table 10.8.3.5.4b-1

Table 10.8.3.5.4b-1—Estimation of α_E (O'Neill and Reese, 1999)

	Joint Modification Factor, α_E	
RDQ (%)	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

Variables:

Rock Type:	**Mudstone**		
q_{ur}:	**29,282**	psi	Avg. from lab test results
f'_c	**4,000**	psi	Compressive strength of grout in socket
q_u:	4,000	psi	Use the lesser value of qu or f'c for calc
q_u:	576	ksf	
Weighted RQD:	**52**	%	Avg. from rock cores
Joint Modification Factor α_E:	**0.6**	dim	Table 10.8.3.5.4b-1
C:	1	dim	Regression Coefficient
p_a:	2.12	ksf	Atmospheric pressure
Rock Socket Length:	**3.3**	ft	Only the Grouted Portion of the Socket
Rock Socket Diameter:	**2.5**	ft	Based on HP Pile Size
Rock Socket Circumfrence:	7.85	ft	

Calculations:

q_s:	34.9	ksf	AASHTO Eq. 10.8.3.5.4b-1
R_s:	906	kip	Nominal Side Resistance
q_s:	13.6	ksf	AASHTO Eq. 10.8.3.5.4b-2
R_s:	353	kip	Nominal Side Resistance
R_s to be used:	**353**	Nominal Side Resistance	

Side Resistance Summary:

Maximum Factored Load:	**355**	kip	From the client
Geotechnical Resistance Factor:	**0.55**	dim	AASHTO Table 10.5.5.2.4-1
Rqd. Geotechnical Nominal Resistance:	**645**	kip	

Notes: Verify that side resistance should be used. The AASHTO and FHWA tabs give examples of when you should omit the use of side resistance.

GEI Consultants	**Client:** Thornton Tomasetti **Project:** Benjamin Lincoln Bridge (#6740) **Project No.:** 2502334 **Subject:** Rock Socketed Piles Axial Resistance - Tip Resistance (Abut. 1)	**Prepared By:** M. Johnescu **Date:** 7/22/2025 **Checked By:** N. Betancur **Date:** 7/24/2025

Objective: Calculate the axial resistance of rock socketed HP piles from tip resistance based on subsurface data collected from the Phase 1 and 2 exploration programs for proposed Abutment 1.

References: 1) American Association of State Highway and Transportation Officials (AASHTO) "LRFD Bridge Design Specifications, 9th Edition, 2020"
2) Hoek, E., et al (Hoek 2002) "Hoek-Brown Failure Criterion - 2002 Edition"

Equations:

Ref. 1 Eqn. No.	Equation	Where
10.8.3.5.4C-2	$q_p = A + q_u\left[m_b\left(\frac{A}{q_u}\right)+s\right]^a$	where: q_p = Nominal unit tip resistance A = Refer to eq. 10.8.3.5.4C-3 s, a, m_b = Hoek-Brown strength parameters for the fractured rock mass determined by GSI q_u = Uniaxial compressive strength of intact rock
10.8.3.5.4C-3	$A = \sigma'_{vb} + q_u\left[m_b\frac{(\sigma'_{v,b})}{q_u}+s\right]^a$	where: q_u = Uniaxial compressive strength of intact rock s, a, m_b = Hoek-Brown strength parameters for the fractured rock mass determined by GSI σ'_{vb} = vertical effective stress at the socket bearing elevation "tip elevation" (ksf)
10.4.6.4-4	$m_b = m_i e^{\left(\frac{GSI-100}{28-14D}\right)}$	where: GSI = Geological Strength Index (AASHTO Fig. 10.4.6.4-1) D = Disturbance Factor (Hoek 2002, Table 1) m_i = Rock Group Constant (AASHTO Table 10.4.6.4-1)
10.4.6.4-2	$s = e^{\left(\frac{GSI-100}{9-3D}\right)}$	where: GSI = Geological Strength Index (AASHTO Fig. 10.4.6.4-1) D = Disturbance Factor (Hoek 2002, Table 1)
10.4.6.4-3	$a = \frac{1}{2} + \frac{1}{6}\left(e^{\frac{-GSI}{15}} - e^{\frac{-20}{3}}\right)$	where: GSI = Geological Strength Index (AASHTO Fig. 10.4.6.4-1)

Variables:

Rock Type:	Mudstone		
q_u:	29,282	psi	Avg. from lab test results
q_u:	4,217	ksf	Avg. from lab test results
GSI:	45		Fig. 10.4.6.4-1 (very blocky, fair)
m_i:	4		Table 10.4.6.4-1, mudstone
D:	0		Table 1 (Hoek 2002)
Overburden Thickness:	13.8	ft	Borings BB-DWS-101 and -201A
Depth to GWT:	8.4	ft	Boring BB-DWS-201A
Avg. Unit Weight of Overburden:	125	pcf	
Avg. Unit Weight of Overburden Below GWT:	62.6	pcf	
Avg. Unit Weight of Bedrock Below GWT:	109.4	pcf	Avg. from lab test results
Approximate Rock Socket Depth:	4.3	ft	Lpile Rock Socket Depth
Shaft Diameter:	2.5	ft	

Calculations:

a:	0.508086	dim	AASHTO 10.4.6.4-3
s:	0.002218	dim	AASHTO 10.4.6.4-2
m_b:	0.561024	dim	AASHTO 10.4.6.4-4
σ'_{vb}:	1.9	ksf	Vertical effective stress
A:	201.3	ksf	AASHTO 10.8.3.5.4C-3
q_p:	899.1	ksf	AASHTO 10.8.3.5.4C-2
R_p:	4,414	kip	Nominal Tip Resistance
Maximum Factored Load:	355	kip	From the client
Geotechnical Resistance Factor:	0.5	dim	AASHTO Table 10.5.5.2.4-1
Rqd. Geotechnical Nominal Resistance:	710	kip	

Notes: Verify that tip resistance should be used. The AASHTO and FHWA tabs give examples of when tip resistance should be omitted.

Objective: Calculate the axial resistance of rock socketed HP piles from side resistance based on subsurface data collected from the Phase 1 and 2 exploration programs for proposed Abutment 2.

References: 1) American Association of State Highway and Transportation Officials (AASHTO) "LRFD Bridge Design Specifications, 9th Edition, 2020"

Equations:

Ref. 1 Eqn. No.	Equation
10.8.3.5.4b-1	$$\frac{q_s}{p_a} = C\sqrt{\frac{q_u}{p_a}}$$
10.8.3.5.4b-2 (Only use for fractured rock that caves and cannot be drilled with some type of artificial support)	$$\frac{q_s}{p_a} = 0.65\alpha_E\sqrt{\frac{q_u}{p_a}}$$

where (10.8.3.5.4b-1):
- q_s = Nominal unit side resistance
- q_u = Uniaxial compressive strength of rock or compressive strength of concrete (f'c), whichever is lower
- C = Regression Coefficient taken as 1.0 for normal conditions
- p_a = Atmospheric pressure taken as 2.12 ksf

where (10.8.3.5.4b-2):
- q_s = Nominal unit side resistance
- q_u = Uniaxial compressive strength of rock or compressive strength of concrete (f'c), whichever is lower
- p_a = Atmospheric pressure taken as 2.12 ksf
- α_E = Joint Modification Factor, Table 10.8.3.5.4b-1

Table 10.8.3.5.4b-1—Estimation of α_E (O'Neill and Reese, 1999)

	Joint Modification Factor, α_E	
RDQ (%)	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

Variables:

Rock Type:	Mudstone		
q_{ur}:	29,282	psi	Avg. from lab test results
f'_c	4,000	psi	Compressive strength of grout in socket
q_u:	4,000	psi	Use the lesser value of qu or f'c for calc
q_u:	576	ksf	
Weighted RQD:	52	%	Avg. from rock cores
Joint Modification Factor α_E:	0.6	dim	Table 10.8.3.5.4b-1
C:	1	dim	Regression Coefficient
p_a:	2.12	ksf	Atmospheric pressure
Rock Socket Length:	7.3	ft	Only the Grouted Portion of the Socket
Rock Socket Diameter:	2.5	ft	Based on HP Pile Size
Rock Socket Circumfrence:	7.85	ft	

Calculations:

q_s:	34.9	ksf	AASHTO Eq. 10.8.3.5.4b-1
R_s:	2,004	kip	Nominal Side Resistance
q_s:	13.6	ksf	AASHTO Eq. 10.8.3.5.4b-2
R_s:	781	kip	Nominal Side Resistance
R_s to be used:	781		Nominal Side Resistance

Side Resistance Summary:

Maximum Factored Load:	355	kip	From the client
Geotechnical Resistance Factor:	0.55	dim	AASHTO Table 10.5.5.2.4-1
Rqd. Geotechnical Nominal Resistance:	645	kip	

Notes: Verify that side resistance should be used. The AASHTO and FHWA tabs give examples of when you should omit the use of side resistance.

Objective: Calculate the axial capacity of rock socketed HP piles from tip resistance based on subsurface data collected from the Phase 1 and 2 exploration programs for proposed Abutment 2.

References: 1) American Association of State Highway and Transportation Officials (AASHTO) "LRFD Bridge Design Specifications, 9th Edition, 2020"
2) Hoek, E., et al (Hoek 2002) "Hoek-Brown Failure Criterion - 2002 Edition"

Equations:

Ref. 1 Eqn. No.	Equation	Where
10.8.3.5.4C-2	$q_p = A + q_u\left[m_b\left(\frac{A}{q_u}\right)+s\right]^a$	where: A = Refer to eq. 10.8.3.5.4C-3 *s, a, m_b* = Hoek-Brown strength parameters for the fractured rock mass determined by GSI q_u = Uniaxial compressive strength of intact rock
10.8.3.5.4C-3	$A = \sigma'_{vb} + q_u\left[m_b\frac{(\sigma'_{v,b})}{q_u}+s\right]^a$	where: q_u = Uniaxial compressive strength of intact rock *s, a, m_b* = Hoek-Brown strength parameters for the fractured rock mass determined by GSI σ'_{vb} = vertical effective stress at the socket bearing elevation "tip elevation" (ksf)
10.4.6.4-4	$m_b = m_i e^{\left(\frac{GSI-100}{28-14D}\right)}$	where: GSI = Geological Strength Index (AASHTO Fig. 10.4.6.4-1) D = Disturbance Factor (Hoek 2002, Table 1) m_i = Rock Group Constant (AASHTO Table 10.4.6.4-1)
10.4.6.4-2	$s = e^{\left(\frac{GSI-100}{9-3D}\right)}$	where: GSI = Geological Strength Index (AASHTO Fig. 10.4.6.4-1) D = Disturbance Factor (Hoek 2002, Table 1)
10.4.6.4-3	$a = \frac{1}{2}+\frac{1}{6}\left(e^{\frac{-GSI}{15}} - e^{\frac{-20}{3}}\right)$	where: GSI = Geological Strength Index (AASHTO Fig. 10.4.6.4-1)

Variables:

Rock Type:	**Mudstone**		
q_u:	**29,282**	psi	Avg. from lab test results
q_u:	4,217	ksf	Avg. from lab test results
GSI:	**45**		Fig. 10.4.6.4-1 (very blocky, fair)
m_i:	**4**		Table 10.4.6.4-1, mudstone
D:	**0**		Table 1 (Hoek 2002)
Overburden Thickness:	**5**	ft	Borings BB-DWS-103, -103A, and -202
Depth to GWT:	**0.7**	ft	Borings BB-DWS-103 and -202
Avg. Unit Weight of Overburden:	**125**	pcf	
Avg. Unit Weight of Overburden Below GWT:	62.6	pcf	
Avg. Unit Weight of Bedrock Below GWT:	**110.6**	pcf	Avg. from lab test results
Approximate Rock Socket Depth:	**12.3**	ft	Lpile Rock Socket Depth
Shaft Diameter:	**2.5**	ft	

Calculations:

a:	0.508086	dim	AASHTO 10.4.6.4-3
s:	0.002218	dim	AASHTO 10.4.6.4-2
m_b:	0.561024	dim	AASHTO 10.4.6.4-4
σ'_{vb}:	1.7	ksf	Vertical effective stress
A:	200.4	ksf	AASHTO 10.8.3.5.4C-3
q_p:	896.7	ksf	AASHTO 10.8.3.5.4C-2
R_p:	**4,402**	kip	Nominal Tip Resistance
Maximum Factored Load:	**355**	kip	From the client
Geotechnical Resistance Factor:	**0.5**	dim	AASHTO Table 10.5.5.2.4-1
Rqd. Geotechnical Nominal Resistance:	**710**	kip	

Notes:
Verify that tip resistance should be used. The AASHTO and FHWA tabs give examples of when tip resistance should be omitted.

From AASHTO LRFD 2020:

10.8.3.5.4c—Tip Resistance

End-bearing for drilled shafts in rock may be taken as follows:

- If the rock below the base of the drilled shaft to a depth of 2.0*B* is either intact or tightly jointed, i.e., no compressible material or gouge-filled seams, and the depth of the socket is greater than 1.5*B*:

$$q_p = 2.5q_u \qquad (10.8.3.5.4c\text{-}1)$$

- If the rock below the base of the shaft to a depth of 2.0*B* is jointed, the joints have random orientation, and the condition of the joints can be evaluated as:

$$q_p = A + q_u\left[m_b\left(\frac{A}{q_u}\right) + s\right]^a \qquad (10.8.3.5.4c\text{-}2)$$

In which:

$$A = \sigma'_{vb} + q_u\left[m_b\frac{(\sigma'_{v,b})}{q_u} + s\right]^a \qquad (10.8.3.5.4c\text{-}3)$$

where:

σ'_{vb} = vertical effective stress at the socket bearing elevation (tip elevation)

s, a, and m_b = Hoek–Brown strength parameters for the fractured rock mass determined from GSI (see Article 10.4.6.4)

q_u = uniaxial compressive strength of intact rock

Eq. 10.8.3.5.4c-1 should be used as an upper-bound limit to base resistance calculated by Eq. 10.8.2.5.4c-2, unless local experience or load tests can be used to validate higher values.

C10.8.3.5.4c

If end bearing in the rock is to be relied upon, and wet construction methods are used, bottom clean-out procedures such as airlifts should be specified to ensure removal of loose material before concrete placement.

The use of Eq. 10.8.3.5.4c-1 also requires that there are no solution cavities or voids below the base of the drilled shaft.

For further information, see Brown et al. (2010).

Bearing capacity theory provides a framework for evaluation of base resistance for cases where the bearing rock can be characterized by its GSI. Eq. 10.8.3.5.4c-2 (Turner and Ramey, 2010) is a lower bound solution for bearing resistance of a drilled shaft bearing on or socketed into a fractured rock mass. Fractured rock describes a rock mass intersected by multiple sets of intersecting joints such that the strength is controlled by the overall mass response and not by failure along pre-existing structural discontinuities. This generally applies to rock that can be characterized by the descriptive terms shown in Figure 10.4.6.4-1 (e.g., blocky, disintegrated).

From AASHTO LRFD 2020:

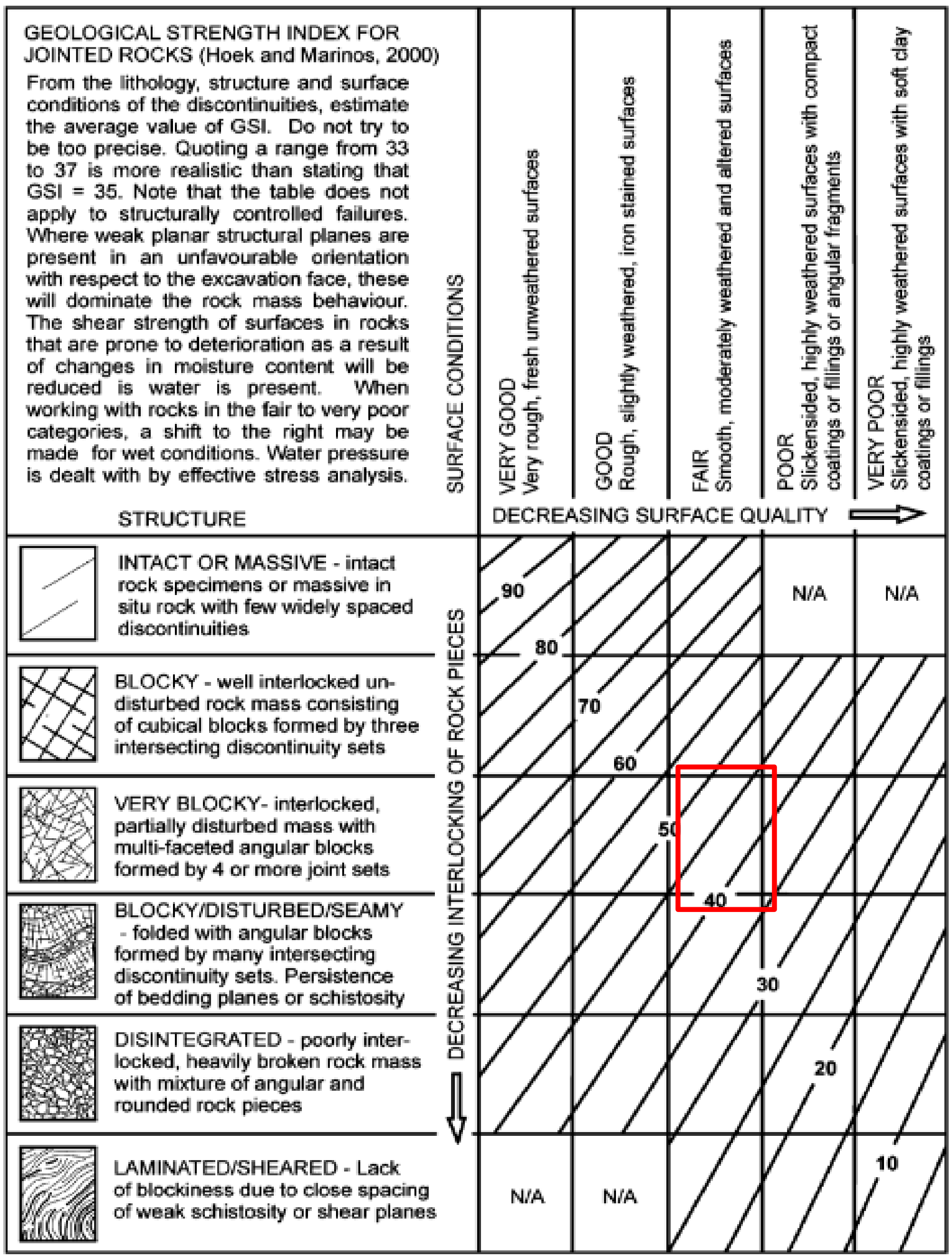


Figure 10.4.6.4-1—Determination of GSI for Jointed Rock Mass (Hoek and Marinos, 2000)

From AASHTO LRFD 2020:

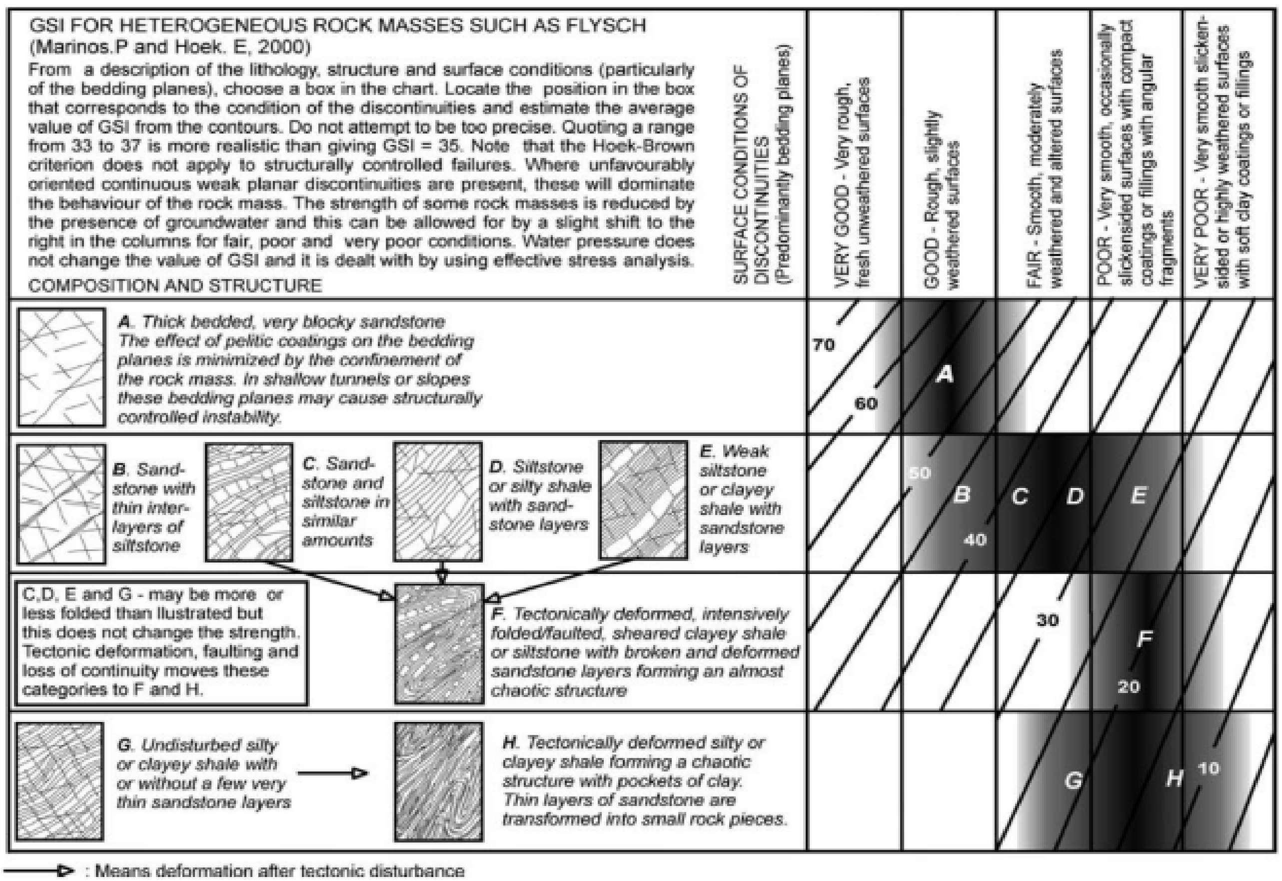


Figure 10.4.6.4-2—Determination of GSI for Tectonically Deformed Heterogeneous Rock Masses (Marinos and Hoek, 2000)

From AASHTO LRFD 2020:

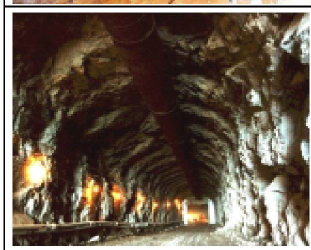
Table 10.4.6.4-1—Values of the Constant m_i by Rock Group (after Marinos and Hoek 2000; with updated values from Rocscience, Inc., 2007)

Rock type	Class	Group	Texture			
			Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerate (21 ± 3) Breccia (19 ± 5)	Sandstone 17 ± 4	Siltstone 7 ± 2 Greywacke (18 ± 3)	Claystone 4 ± 2 Shale (6 ± 2) Marl (7 ± 2)
SEDIMENTARY	Non-Clastic	Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestone (10 ± 5)	Micritic Limestone (8 ± 3)	Dolomite (9 ± 3)
SEDIMENTARY	Non-Clastic	Evaporites		Gypsum 10 ± 2	Anhydrite 12 ± 2	
SEDIMENTARY	Non-Clastic	Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliated		Marble 9 ± 3	Hornfels (19 ± 4)) Metasandstone (19 ± 3)	Quartzite 20 ± 3	
METAMORPHIC	Slightly foliated		Migmatite (29 ± 3)	Amphibolite 26 ± 6	Gneiss 28 ± 5	
METAMORPHIC	Foliated*			Schist (10 ± 3)	Phyllite (7 ± 3)	Slate 7 ± 4
IGNEOUS	Plutonic	Light	Granite 32 ± 3 Granodiorite (29 ± 3)	Diorite 25 ± 5		
IGNEOUS	Plutonic	Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
IGNEOUS	Hypabyssal		Porphyries (20 ± 5)		Diabase (15 ± 5)	Peridotite (25 ± 5)
IGNEOUS	Volcanic	Lava		Rhyolite (25 ± 5) Andesite 25 ± 5	Dacite (25 ± 3)) Basalt (25 ± 5)	
IGNEOUS	Volcanic	Pyroclastic	Agglomerate (19 ± 3)	Volcanic breccia (19 ± 5)	Tuff (13 ± 5)	

* These values are for intact rock specimens tested normal to bedding or foliation. The value of m_i will be significantly different if failure occurs along a weakness plane.

From Hoek 2002:

Table 1: Guidelines for estimating disturbance factor D

Appearance of rock mass	Description of rock mass	Suggested value of D
	Excellent quality controlled blasting or excavation by Tunnel Boring Machine results in minimal disturbance to the confined rock mass surrounding a tunnel.	$D = 0$
	Mechanical or hand excavation in poor quality rock masses (no blasting) results in minimal disturbance to the surrounding rock mass. Where squeezing problems result in significant floor heave, disturbance can be severe unless a temporary invert, as shown in the photograph, is placed.	$D = 0$ $D = 0.5$ No invert
	Very poor quality blasting in a hard rock tunnel results in severe local damage, extending 2 or 3 m, in the surrounding rock mass.	$D = 0.8$
	Small scale blasting in civil engineering slopes results in modest rock mass damage, particularly if controlled blasting is used as shown on the left hand side of the photograph. However, stress relief results in some disturbance.	$D = 0.7$ Good blasting $D = 1.0$ Poor blasting
	Very large open pit mine slopes suffer significant disturbance due to heavy production blasting and also due to stress relief from overburden removal. In some softer rocks excavation can be carried out by ripping and dozing and the degree of damage to the slopes is less.	$D = 1.0$ Production blasting $D = 0.7$ Mechanical excavation

From AASHTO LRFD 2020:

Table 10.5.5.2.3-1—Resistance Factors for Driven Piles

Condition/Resistance Determination Method		Resistance Factor
Nominal Bearing Resistance of Single Pile—Dynamic Analysis and Static Load Test Methods, φ_{dyn}	Driving criteria established by successful static load test of at least one pile per site condition and dynamic testing* of at least two piles per site condition, but no less than 2% of the production piles	0.80
	Driving criteria established by successful static load test of at least one pile per site condition without dynamic testing	0.75
	Driving criteria established by dynamic testing* conducted on 100% of production piles	0.75
	Driving criteria established by dynamic testing,*, quality control by dynamic testing* of at least two piles per site condition, but no less than 2% of the production piles	0.65
	Wave equation analysis, without pile dynamic measurements or load test but with field confirmation of hammer performance	0.50
	FHWA-modified Gates dynamic pile formula (EOD condition only)	0.40
	EN (as defined in Article 10.7.3.8.5) dynamic pile formula (EOD condition only)	0.10
Nominal Bearing Resistance of Single Pile—Static Analysis Methods, φ_{stat}	Side Resistance and End Bearing: Clay and Mixed Soils	
	α-method (Tomlinson, 1987; Skempton, 1951)	0.35
	β-method (Esrig and Kirby, 1979; Skempton, 1951)	0.25
	λ-method (Vijayvergiya and Focht, 1972; Skempton, 1951)	0.40
	Side Resistance and End Bearing: Sand	
	Nordlund/Thurman Method (Hannigan et al., 2006)	0.45
	SPT-method (Meyerhof)	0.30
	CPT-method (Schmertmann, 1970)	0.50
	End bearing in rock (Canadian Geotech. Society, 1985)	0.45
Block Failure, φ_{b1}	Clay	0.60
Uplift Resistance of Single Piles, φ_{up}	Nordlund Method	0.35
	α-method	0.25
	β-method	0.20
	λ-method	0.30
	SPT-method	0.25
	CPT-method	0.40
	Static load test	0.60
	Dynamic test with signal matching	0.50
Group Uplift Resistance, φ_{ug}	All soils	0.50
Lateral Geotechnical Resistance of Single Pile or Pile Group	All soils and rock	1.0
Structural Limit State	Steel piles: See the provisions of Article 6.5.4.2	
	Concrete piles: See the provisions of Article 5.5.4.2	
	Timber piles: See the provisions of Articles 8.5.2.2 and 8.5.2.3	
Pile Drivability Analysis, φ_{da}	Steel piles: See the provisions of Article 6.5.4.2	
	Concrete piles: See the provisions of Article 5.5.4.2	
	Timber piles: See the provisions of Article 8.5.2.2	
	In all three Articles identified above, use φ identified as "resistance during pile driving"	

*Dynamic testing requires signal matching, and best estimates of nominal resistance are made from a restrike. Dynamic tests are calibrated to the static load test, when available.

From AASHTO LRFD 2020:

Table 10.5.5.2.4-1—Resistance Factors for Geotechnical Resistance of Drilled Shafts

Method/Soil/Condition			Resistance Factor
Nominal Axial Compressive Resistance of Single-Drilled Shafts, φ_{stat}	Side resistance in clay	α-method (Brown et al., 2010)	0.45
	Tip resistance in clay	Total Stress (Brown et al., 2010)	0.40
	Side resistance in sand	β-method (Brown et al., 2010)	0.55
	Tip resistance in sand	Brown et al. (2010)	0.50
	Side resistance in cohesive IGMs	Brown et al. (2010)	0.60
	Tip resistance in cohesive IGMs	Brown et al. (2010)	0.55
	Side resistance in rock	Kulhawy et al. (2005) Brown et al. (2010)	0.55
	Side resistance in rock	Carter and Kulhawy (1988)	0.50
	Tip resistance in rock	Canadian Geotechnical Society (1985) Pressuremeter Method (Canadian Geotechnical Society, 1985) Brown et al. (2010)	0.50
Block Failure, φ_{bl}	Clay		0.55
Uplift Resistance of Single-Drilled Shafts, φ_{up}	Clay	α-method (Brown et al., 2010)	0.35
	Sand	β-method (Brown et al., 2010)	0.45
	Rock	Kulhawy et al. (2005) Brown et al. (2010)	0.40
Group Uplift Resistance, φ_{ug}	Sand and clay		0.45
Horizontal Geotechnical Resistance of Single Shaft or Shaft Group	All materials		1.0
Static Load Test (compression), φ_{load}	All Materials		0.70
Static Load Test (uplift), φ_{upload}	All Materials		0.60