MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of:

PERKINS BRIDGE AND LAKE BRIDGE
LAKE ROAD OVER BLACK STREAM
LEVANT, MAINE

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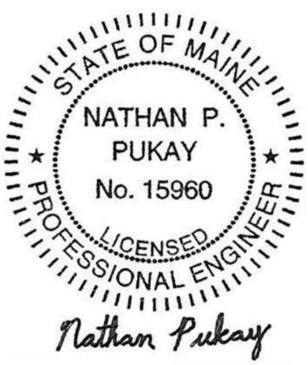

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Soils Report 2024-04
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1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present subsurface information and provide geotechnical design recommendations for the replacement of Perkins Bridge and Lake Bridge which carry Lake Road over Black Stream in Levant, Maine. This report presents the subsurface information obtained at the site during the subsurface investigations, geotechnical design recommendations, and construction recommendations for the new substructures.

The existing Perkins Bridge and Lake Bridge were constructed in 1986, and both structures consist of twin steel structural plate pipe arches with mitered ends. Perkins Bridge is aligned along the main stream channel with each pipe spanning 15-foot 10-inch and rising 10-foot 8-inch. Lake Bridge, installed for overflow during high water conditions, consists of smaller pipes each measuring 11-foot 10-inch span by 7-foot 7-inch rise. Perkins Bridge failed in April 2023 resulting in the closure of Lake Road. According to the 2022 Maine Department of Transportation (MaineDOT) Bridge Inspection Report, the FHWA Sufficiency Rating of Lake Bridge is 71.9. The condition rating of Lake Bridge pipe arches is a 4 (poor condition) due to rusting and pitting above the flow line.

Available as-built drawings indicate previous structures at both bridges consisted of a steel beam superstructure on stacked granite abutments.

The proposed replacement structure for Perkins Bridge consists of a 84-foot, single-span steel girder bridge with horizontal and vertical alignments that will closely match the existing. The bridge will be founded on pile-supported integral abutments with cantilevered, in-line wingwalls. Piles will be driven to bedrock. 1.75H:1V (horizontal:vertical) riprap slopes will be constructed in front of the new integral abutments. A wildlife shelf will be built into the riprap at Abutment No. 1. Due to the significant increase in hydraulic opening of the new Perkins Bridge in conjunction with consultations with the MaineDOT Environmental Office, Lake Bridge will be reduced to a single 8-foot diameter HDPE or aluminum culvert. To expedite the construction of this project, a separate contract allowing the Department to pre-buy the steel girders and bearing plates for Perkins Bridge was established and bid in November 2023.

Traffic is currently being detoured onto State Aid and Town roads. The existing detour will be maintained during construction.

2.0 GEOLOGIC SETTING

Perkins and Lake Bridges carries Lake Road over Black Stream as shown on Sheet 1 – Location Map.

The Maine Geological Survey (MGS) Surficial Geology Map of the Hermon Quadrangle, Maine, Open-File No. 13-13 (2013), indicates the surficial soils in the vicinity of the bridge project consist of stream alluvium, glaciomarine deposits (Presumpscot Formation), and glacial till.

Stream alluvium consists of sand, gravel, and silt deposited on flood plains and stream beds by postglacial streams and may include some wetland deposits. Glaciomarine deposits consist of silt, clay, and sand, deposited on the late-glacial sea floor. Glacial till is a heterogeneous mixture of sand, silt, clay, and stones deposited by glacial ice.

The MGS Reconnaissance Bedrock Geology of the Bangor Quadrangle, Maine, Open-File No. 76-23 (1976) maps the bedrock at the site as Feldspathic Wacke of the Vassalboro Formation, with thick interbeds of dark grey Phyllite. The bedrock cored in the test borings drilled at the site consisted of Graywacke with abundant layers of Phyllite.

3.0 SUBSURFACE INVESTIGATION

Seven test borings were drilled to explore subsurface conditions at the project location. Borings BB-LBS-101 and BB-LBS-101A, were drilled at the proposed location of Perkins Bridge Abutment No. 1. BB-LBS-101A was drilled adjacent to BB-LBS-101 after the hole was abandoned due to broken drilling equipment. BB-LBS-102 and BB-LBS-201 were drilled at the proposed location of Perkins Bridge Abutment No. 2. BB-LBS-103, BB-LBS-202 and BB-LBS-203 were drilled at Lake Bridge. Four of the borings terminated in bedrock cores. The remaining borings explored the surficial soils and probed the apparent bedrock surface. The boring locations are shown on Sheet 2 – Boring Location Plan.

The 100-series borings were drilled in June 2023 by the MaineDOT drill crew. The crew returned to the project site in July 2023 and drilled the 200-series borings. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring logs provided in Appendix A – Boring Logs and on Sheets 4 and 5 – Boring Logs.

Borings were performed by using a combination of solid stem auger, cased wash boring and rock coring techniques. The borings were completed by backfilling and compacting the borehole with drill cuttings. Soil samples were typically obtained at 5-foot intervals using Standard Penetration Test (SPT) methods. During SPT sampling, the sampler is driven 24 inches and the hammer blows for each 6-inch interval of penetration are recorded. The sum of the blows for the second and third intervals is the N-value, or standard penetration resistance. The drill rig used in the subsurface investigation is equipped with an automatic hammer to drive the split spoon. The hammer was calibrated per ASTM D 4633 "Standard Test Method for Energy Measurement for Dynamic Penetrometers" in November 2022. All N-values discussed in this report are corrected values computed by applying an average energy transfer of 0.906 to the raw field N-values. This hammer efficiency factor (0.906) and both the raw field N-value and corrected N-value (N60) are shown on the boring logs.

Bedrock was cored in the borings using NQ-2" core barrels and the Rock Quality Designation (RQD) of the cores calculated. The MaineDOT geotechnical engineer selected the boring locations and drilling methods, designated type and depth of sampling techniques, identified field-testing requirements, and logged the subsurface conditions encountered in the borings. The borings were located in the field using taped measurements at the completion of the drilling programs and then located by MaineDOT Survey.

4.0 Laboratory Testing

A laboratory testing program was conducted on selected soil samples recovered from the test borings to assist in soil classification, evaluation of engineering properties of the soils, and geologic assessment of the project site. Laboratory testing on soil samples consisted of five standard grain size analyses with natural water content, seven grain size analysis with hydrometer and natural water content, eight Atterberg limits tests, two loss on ignition (organic content) tests and one pH test.

All soil laboratory testing was performed at the MaineDOT Lab in Bangor, Maine with exception of the pH test, which was performed by GeoTesting Express of Acton, Massachusetts. The results of soil tests are included in Appendix C – Laboratory Test Results. Moisture content information and other soil test results are also presented on the boring logs provided in Appendix A – Boring Logs and on Sheets 4 and 5 – Boring Logs.

5.0 Subsurface Conditions

Subsurface conditions encountered in the test borings generally consisted of Fill, Stream Alluvium with Wetland Deposits, Glacial Till, and Bedrock. The boring logs are provided in Appendix A – Boring Logs and on Sheets 4 and 5 – Boring Logs. A generalized subsurface profile is shown on Sheet 3 – Interpretive Subsurface Profile. The following paragraphs discuss the subsurface conditions encountered.

5.1 Fill

A layer of Fill was encountered in the test borings. The thickness of the fill unit encountered was approximately 9 to 14 feet. The fill materials encountered consisted of:

- Brown, SILT, little to some sand, little gravel; and
- Brown to grey-brown, Gravelly SAND, little silt.

Cobbles were encountered in the fill layer in boring BB-LBS-102.

Corrected SPT N-values in the fine-grained fill ranged from 27 to 45 blows per foot (bpf) indicating the fine-grained fill is very stiff to hard in consistency.

Corrected SPT N-values in the coarse-grained fill ranged from 23 to greater than 50 bpf, indicating the coarse-grained fill is medium dense to very dense in consistency.

Three grain size analyses performed on samples recovered from the granular fill unit indicated the material is classified as A-4 and A-1-a under the AASHTO Soil Classification System and CL-ML and SM under the Unified Soil Classification System (USCS). The natural water contents of the samples tested ranged from 4 to 16 percent.

5.2 Stream Alluvium with Wetland Deposits

Stream Alluvium with Wetland Deposits were encountered in BB-LBS-102, -103, -201, -202, and -203 beneath the fill unit. The encountered thickness was approximately 6 to 8 feet. The deposit was variable and consisted of:

- Grey, SAND, little silt, trace gravel;
- Grey, Gravelly SAND, little silt, trace clay;
- Grey, Sandy SILT, trace clay;
- Grey to dark brown, SILT, trace to some sand, trace clay;
- Grey-brown, Silty CLAY, trace gravel;
- Dark-brown to black PEAT; and
- Wood.

Corrected SPT N-values in the fine-grained Stream Alluvium and Wetland Deposits ranged from 5 to 20 bpf indicating those subunits are medium stiff to very stiff in consistency.

Corrected SPT N-values in the coarse-grained Stream Alluvium and Wetland Deposits ranged from 11 to 29 bpf indicating those subunits are medium dense in consistency.

A in-situ vane shear test was conducted with a Geonor rectangular vane in the Stream Alluvium deposit. A 16 x 32 mm vane was used. The maximum measurable vane torque was reached indicating an undrained shear strength exceeding 4181 psf. A disturbed sample of the material tested yielded a Gravelly SAND, therefore the undrained shear strength measured is not representative of the cohesive or organic soils found within this deposit.

Three grain size analyses conducted on samples of the deposit indicated the material is classified as A-2-4, A-1-b, and A-7-5 under the AASHTO Soil Classification System and SM, SC-SM, and OH under the USCS.

Atterberg limits tests were conducted on three samples of the Stream Alluvium with Wetland Deposits, and are summarized below:

Boring No. and Sample No.	Soil Description	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
BB-LBS-102, 3D	Gravelly SAND	5	-	-	NP[1]	-
BB-LBS-201, 3D	SILT	-	-	-	NP[1]	-
BB-LBS-202, 4D	Silty CLAY	50	62	45	17	0.29

The plasticity indices of the samples indicate that the Stream Alluvium and Wetland Deposits vary from non-plastic to medium in plasticity (Burmister, 1949).

[1] Non-plastic (NP)

The natural water content of the silty clay sample was less than the liquid limit, with a liquidity index less than 1.0. Interpretation of these results is that the deposit is overconsolidated.

Loss on ignition tests performed on two samples containing peat indicated the samples had an organic content of 14 and 67 percent. One pH test conducted on a sample of peat measured a pH of 5.22. The natural water content of all test samples recovered from the deposit ranged from 5 to 431 percent.

5.3 Glacial Till

Glacial Till was encountered beneath either the Fill, Stream Alluvium or Wetland Deposits in the majority of the borings. The thickness of the Glacial Till encountered was approximately 4 to 57 feet. The Glacial Till subunits encountered generally consisted of:

- Brown, grey or olive-grey, SILT, little to some sand, trace to some gravel, trace to some clay;
- Olive-grey, Sandy SILT, trace to little gravel, trace clay;
- Olive-grey, SAND, some silt, some gravel, little clay; and
- Grey, Silty SAND, some gravel, trace clay;
- Grey, Clayey SILT, trace sand.
- Cobbles and boulders.

Corrected SPT N-values in the fine-grained Glacial Till ranged from 17 to greater than 50 bpf indicating those subunits are very stiff to hard in consistency.

Corrected SPT N-values in the coarse-grained Glacial Till ranged from 32 to greater than 50 bpf, indicating those subunits are dense to very dense in consistency.

Seven grain size analysis performed on samples recovered from the deposit resulted in the material being classified as A-4 under the AASHTO Soil Classification System and CL and CL-ML under the USCS.

Atterberg limits tests were conducted on five samples of the Glacial Till and are summarized below:

Boring No. and Sample No.	Soil Description	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
BB-LBS-101, 3D	SILT	11	20	14	6	-0.50
BB-LBS-101, 4D	SAND	10	20	14	6	-0.67
BB-LBS-101, 6D	SILT	12	21	14	7	-0.29
BB-LBS-102, 4D	SILT	23	20	15	5	1.60
BB-LBS-202, 7D/A	Clayey SILT	31	28	20	8	1.38

The plasticity indices of the samples tested indicate the fine-grained Glacial Till soils have low plasticity (Burmister, 1949). The natural water content of the samples measured 10 to 34 percent and liquid limits ranged from 20 to 28. The resulting liquidity indices range from less than 0 to greater than 1.0. Generally the natural water contents were less than, or close to, the liquid limits, indicating the deposit is primarily normally consolidated to slightly overconsolidated. Those subunits with liquidity indices greater than 1.0 and intermediate water contents are somewhat unconsolidated soils but have a low potential to liquefy.

5.4 Bedrock

Bedrock was encountered and cored in borings BB-LBS-101A, -102, -103, and -201. The table below summarizes the depth to bedrock, corresponding top of bedrock elevations and RQD's.

Boring	Station	Offset (feet)	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock Surface (feet)	RQD (%) (R1, R2, R3)
BB-LBS-101A	13+36	8.3 Rt	66.2	63.1	77, 77
BB-LBS-102	14+17.2	7.4 Rt	50.8	78.9	75, 78
BB-LBS-103	15+50.4	8.2 Rt	21.3	107.5	0, 69, 63
BB-LBS-201	14+21.2	7.3 Lt	47.2	82.7	83, 75

The bedrock of the site consisted of grey to dark grey, very fine to medium-grained, GRAYWACKE interbedded with layers of PHYLLITE, moderately soft to hard, fresh, with joint sets dipping at low to steep angles, spaced close to moderately close, with quartz or calcite annealed fractures. The RQD of the bedrock cores ranged from 0 to 83 percent, corresponding to a rock quality of very poor to good.

Detailed bedrock descriptions and RQD's are provided in Appendix A – Boring Logs and on Sheets 4 and 5 – Boring Logs. Rock core photographs are provided in Appendix B – Rock Core Photographs.

5.5 Groundwater

Groundwater was measured at depths ranging from 7 to 10 feet below the roadway surface upon completion of the borings. Note that water was introduced into the boreholes during drilling operations and the measured levels may not represent stabilized groundwater elevations. Groundwater levels will fluctuate with seasonal changes, precipitation, runoff, river levels and construction activities.

6.0 FOUNDATION ALTERNATIVES

Based on the depth of bedrock and the span length requirement, integral abutments founded on driven H-piles was the preferred substructure type, allowing for a jointless bridge at Perkins Bridge. A new upstream alignment was considered to improve the roadway geometry, but the peat encountered in the preliminary borings indicated the potential need for costly settlement mitigation. A box culvert was initially considered for the replacement of Lake Bridge, but it was determined that an 8-foot culvert pipe would provide adequate overflow due to the increased size of Perkins Bridge.

7.0 GEOTECHNICAL DESIGN CONSIDERATIONS AND RECOMMENDATIONS

The following sections provide geotechnical design considerations and recommendations for H-pile supported integral abutments which is the proposed substructure type for the Perkins Bridge replacement project. Additional considerations are provided for the culvert pipe that will replace Lake Bridge.

7.1 Integral Abutment H-Piles

Abutments No. 1 and 2 will be integral abutments founded on a single row of H-piles. Piles will be driven to the required nominal resistance on or within bedrock.

Piles may be HP 14x89 or 14x117 depending on the factored design axial loads and ability to resist lateral loads. H-piles shall be 50 ksi, Grade A572 steel. The piles shall be fitted with driving pile points conforming to MaineDOT Standard Specification 711.10 to protect pile tips and improve penetration into bedrock.

Pile lengths at the proposed abutments may be estimated based on the following table.

Abutment	Approximate Bottom Elevation of Proposed Abutment (feet)	Approximate Top of Bedrock Elevation (feet)	Estimated Pile Lengths[1] (feet)
Abutment No. 1	119.0	63.1	58
Abutment No. 2	119.0	78.9	43

The estimated pile lengths in the table above do not take into account damaged pile, the additional five feet of pile required for dynamic testing instrumentation (per ASTM D4945), additional pile length needed to accommodate leads and driving equipment or variations in the bedrock surface.

[1] Estimated pile lengths include 2-foot embedment into the pile cap.

The design of piles at the strength limit state shall consider;

- compressive axial geotechnical resistance of piles,
- drivability resistance of piles,
- structural resistance of piles in axial compression, and
- structural resistance of piles in combined axial loading and flexure.

The pile groups should be designed to resist all lateral earth loads, vehicular loads, dead and live loads, and lateral forces transferred through the pile caps.

Per AASHTO LRFD Bridge Design Specifications 9th Edition (LRFD) Article 6.5.4.2, at the strength limit state, the axial resistance factor $\phi_c = 0.50$ (severe driving conditions) shall be applied to the structural compressive resistance of the pile. Since the H-piles will be subjected to lateral loading, the piles shall also be checked for combined axial compression and flexure as prescribed in LRFD Articles 6.9.2.2 and 6.15.2. This design axial load may govern the design. Per LRFD Article 6.5.4.2, at the strength limit state, the axial resistance factor $\phi_c = 0.70$ and the flexural resistance factor $\phi_f = 1.0$ shall be applied to the combined axial and flexural resistance of the pile in the interaction equation (LRFD Eq. 6.9.2.2-1 or -2). H-piles shall also be analyzed for fixity using LPile® v2016 (LPile) software, or similar.

7.1.1 Axial Pile Resistance – Strength Limit State

Structural Resistance. Preliminary estimates of the factored structural axial resistance of two H-pile sections were calculated for the lower braced pile segment in pure axial compression. The factored structural axial resistance shown in the table below is for the lower braced pile segment, using a resistance factor, $\phi_c = 0.50$, for severe driving conditions. It is the responsibility of the structural engineer to calculate the factored axial structural compressive resistances based on the lengths of the upper and lower unbraced pile segments, as determined from LPile, using a resistance factor of $\phi_c = 0.70$ for combined axial and bending and appropriate effective length factors (K). These resistances may be the controlling values.

Geotechnical Resistance. The nominal axial geotechnical resistance of driven piles at the strength limit state was calculated using the guidance in LRFD Article 10.7.3.2.3, which states the nominal bearing resistance of piles driven to point bearing on hard rock shall not exceed the nominal structural pile resistances obtained from LRFD Article 6.9.4.1 with a resistance factor, ϕ_c, of 0.50, for severe driving conditions applied. The resulting limiting factored geotechnical axial compressive resistances are provided in the table below.

Drivability Analyses. Drivability analyses were performed to determine the pile resistance that might be achieved considering available diesel hammers. LRFD 10.7.8 limits driving stresses to $0.90f_y$, which for 50 ksi steel piles is 45 ksi. The drivability resistances were calculated using the resistance factor, φ_{dyn}, of 0.65, for a single pile in axial compression when a dynamic test is performed as specified in LRFD Table 10.5.5.2.3-1.

The calculated factored axial compressive structural, geotechnical, and drivability resistances of driven H-piles at the strength limit states are summarized on the following page.

Strength Limit State Factored Axial Pile Resistance					
Pile Section	Structural Resistance[1] ϕ_c=0.50 (kips)	Controlling Geotechnical Resistance[2] ϕ_c=0.50 (kips)	Drivability Resistance[3] φ_{dyn} = 0.65 (kips)		Governing Axial Pile Resistance (kips)
HP 14 x 89	652	652	409[4]	449[5]	409[4]
HP 14 x 117	860	860	474[4]	514[5]	474[4]

LRFD Article 10.7.3.2.3 states that the nominal axial compressive resistance of piles driven to hard rock is typically controlled by the structural resistance with a resistance factor for severe driving conditions applied. However, for the site conditions, the estimated factored axial pile resistances from the drivability analyses for the H-pile sections are less than the controlling factored axial compressive resistances. Local experience also supports the estimated factored resistances from the drivability analyses. Therefore, drivability controls and the recommended governing resistances for pile design are the resistances provided in the rightmost column "Governing Axial Pile Resistance (kips)" in the table.

The maximum applied factored axial pile load should not exceed the governing factored axial pile resistance shown in the table above.

7.1.1 Axial Pile Resistance – Service and Extreme Limit State

The design of H-piles at the service limit state shall consider tolerable transverse and longitudinal movement of the piles and pile group movements/stability. For the service limit state, resistance factors of ϕ = 1.0 should be used in accordance with LRFD Article 10.5.5.1. The exception is the overall global stability of the foundation which should be investigated at the Service I load combination and a resistance factor, ϕ, of 0.65.

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[1] Structural resistances were calculated for a braced pile segment in pure axial compression, using a resistance factor, ϕ_c, for severe driving conditions. Factored structural resistances should be calculated for upper and lower unbraced pile segments based upon L-Pile results using a resistance factor of $\phi_{c\,=}$ 0.70 for combined axial loading and bending. These resistances may be the controlling values.

[2] Based on guidance in LRFD Article 10.7.3.2.3., *Piles Driven to Hard Rock.* The nominal axial geotechnical resistance in the strength limit state was calculated using the guidance in LRFD Article 10.7.3.2.3 which states the nominal bearing resistance of piles driven to point bearing on hard rock shall not exceed the nominal structural resistance values obtained from LRFD Article 6.9.4.1 with a resistance factor ϕ_c, of 0.50, for severe driving conditions applied when computing the factored resistance.

[3] Drivability analyses were performed to determine the pile resistance that might be achieved considering available diesel hammers. Nominal drivability resistances were determined based on a limiting driving criteria of 15 bpi and a maximum driving stress of 45 ksi. The drivability resistances were calculated using the resistance factor, φ_{dyn}, of 0.65, for a single pile in axial compression when a dynamic test is performed as specified in LRFD Table 10.5.5.2.3-1.

[4] Drivability resistance based on a APE D19-42 Pile Hammer at Fuel Setting 4, Abutment 1 pile controls.

[5] Drivability resistance based on a APE D25-42 Pile Hammer at Fuel Setting 4. Abutment 1 pile controls.

Extreme limit state design checks for the driven H-piles shall include pile axial compressive resistance, overall global stability of the pile group, pile failure by uplift in tension, and structural failure. The extreme event load combinations are those related to seismic forces and vehicle collision. Resistance factors for extreme limit states, per LRFD Article 10.5.5.3, shall be taken as $\phi = 1.0$ with the exception of uplift of piles, for which the resistance factor, φ_{up}, shall be 0.80 or less per LRFD Article 10.5.5.3.2.

The calculated factored axial structural, geotechnical and drivability resistances of two (2) H-pile sections for the service and extreme limit states are summarized below.

Service and Extreme Limit State Factored Axial Pile Resistance					
Pile Section	Structural Resistance[1] $\phi = 1.0$ (kips)	Controlling Geotechnical Resistance[2] $\phi = 1.0$ (kips)	Drivability Resistance[3] $\phi = 1.0$ (kips)		Governing Axial Pile Resistance (kips)
HP 14 x 89	1,305	1,305	630[4]	690[5]	630[4]
HP 14 x 117	1,720	1,720	730[4]	790[5]	730[4]

LRFD Article 10.7.3.2.3 states that the nominal axial compressive resistance of piles driven to hard rock is typically controlled by the structural resistance. However, the estimated factored axial pile resistances from the drivability analyses for the H-pile sections are less than the controlling factored axial geotechnical resistance and the structural resistance calculated for a braced pile segment. Therefore, drivability controls and the recommended governing resistances for pile design are the resistances provided in the rightmost column "Governing Axial Pile Resistance (kips)" in the table above.

The maximum applied factored axial pile load for the service and extreme limit states shall not exceed the governing factored axial pile resistance shown in the table above.

[1] Nominal structural resistances were calculated for the lower, braced pile segment in pure axial compression. Factored structural resistances should be calculated for upper and lower unbraced pile segments in combined axial loading and bending, based on LPile results. These resistances may be the controlling values.

[2] Based on guidance in LRFD Article 10.7.3.2.3., *Piles Driven to Hard Rock.* The nominal axial geotechnical resistance in the strength limit state was calculated using the guidance in LRFD Article 10.7.3.2.3 which states the nominal bearing resistance of piles driven to point bearing on hard rock shall not exceed the nominal structural resistance values obtained from LRFD Article 6.9.4.1

[3] Drivability analyses were performed to determine the pile resistance that might be achieved considering available diesel hammers. Nominal drivability resistances were determined based on a limiting driving criteria of 15 bpi and a maximum driving stress of 45 ksi.

[4] Drivability resistance based on a APE D19-42 Pile Hammer at Fuel Setting 4, Abutment 1 pile controls.

[5] Drivability resistance based on a APE D25-42 Pile Hammer at Fuel Setting 4, Abutment 1 pile controls.

7.1.2 Lateral Pile Resistance/Behavior

In accordance with LRFD Article 6.15.1, the structural analysis of pile groups subjected to lateral loads shall include explicit consideration of soil-structure interaction effects as specified in LRFD Article 10.7.3.12. Assumptions regarding a fixed or pinned condition at the pile tip should be also confirmed with soil-structure interaction analyses.

A series of lateral pile resistance analyses will be performed to evaluate pile behavior at the abutments using LPile, or similar, software. The designer should utilize the lateral pile analyses to evaluate the associated pile stresses, bending moments, and fixity due to factored pile head loads and displacements.

Geotechnical parameters for generation of soil-resistance (p-y) curves in lateral pile analyses are provided in the tables below. The models developed will emulate appropriate structural parameters and pile-head boundary conditions for the pile section(s) being analyzed.

LPile Input Parameters Abutment No. 1						
Soil Layer	Soil/Rock Model	Top Elevation of Layer (ft)	Layer Thickness (ft)	γ_e[1] (pcf)	ϕ'[2] (deg)	k_s[3] (pci)
Granular Borrow	Reese Sand	130	11	125	32	90
Glacial Till	Reese Sand	119	56	83	38	125

LPile Input Parameters Abutment No. 2						
Soil Layer	Soil/Rock Model	Top Elevation of Layer (ft)	Layer Thickness (ft)	γ_e[1] (pcf)	ϕ'[2] (deg)	k_s[3] (pci)
Granular Borrow	Reese Sand	130	11	125	32	90
Stream Alluvium	Reese Sand	119	5	63	28	40
Glacial Till	Reese Sand	114	35	73	36	90

[1] Effective unit weight.
[2] Effective internal angle of friction.
[3] Soil modulus constant.

7.1.3 Driven Pile Quality Control

The contract plans shall require the contractor to perform a wave equation analysis of the proposed pile-hammer system and conduct dynamic pile load tests with signal matching. The first pile driven at each abutment should be dynamically tested to confirm nominal pile resistance and verify the stopping criteria developed by the contractor in the wave equation analysis. Minimum 24-hour restrike tests will be required to verify time-dependent loss of pile resistance does not occur. If a loss in pile resistance does occur, the driving criteria shall be adjusted. Restrikes or additional dynamic tests may be required as part of the pile field quality control program should pile behavior vary radically between adjacent piles, should the pile tip be not firmly embedded in bedrock, or if piles “walk” out of position.

With this level of quality control, the ultimate resistance that must be achieved in the wave equation analysis and dynamic testing will be the factored axial pile load divided by a resistance factor, ϕ_{dyn}, of 0.65. The maximum factored axial pile load should be shown on the plans.

Piles should be driven to an acceptable penetration resistance as determined by the contractor based on the results of a wave equation analysis and as approved by the Resident. Driving stresses in the pile determined in the drivability analysis shall be less than 45 ksi, in accordance with LRFD Article 10.7.8. A hammer should be selected which provides the required pile resistance when the penetration resistance for the final 3 to 6 inches is 3 to 15 blows per inch (bpi). If an abrupt increase in driving resistance is encountered, the driving may be terminated when the penetration is less than 0.5-inch in 10 consecutive blows.

7.1.4 Corrosion Mitigation

Per LRFD Article 10.7.5, soils with a pH less than 5.5 should be considered as indicative of a potential corrosion situation. A pH test conducted on a representative sample of wetland deposits measured a pH of 5.22. Corrosion mitigation countermeasures for piles driven through the wetland deposits are therefore recommended. The borings conducted at Abutment No. 2 indicate the piles will be driven through the corrosive deposit.

The risk of corrosion will be substantially mitigated by predrilling oversized holes at the pile locations, installing an HDPE isolation casing to provide a barrier from the corrosive soils, and backfilling the casing with clean sand. The casing should extend two feet into the non-corrosive glacial till deposit. Other recommended corrosion mitigation countermeasures include upsizing the piles and designing for an assumed section loss or extending the concrete pile jacket into non-corrosive soils and requiring the concrete meet the permeability requirements of low permeability concrete as specified in MaineDOT Specification 502.05 – Composition and Proportioning.

Corrosive wetland deposits were also encountered at the plan installation location of the culvert pipe that will replace the existing Lake Bridge. An HDPE or aluminum pipe is recommended to increase the design life of the culvert.

7.2 Integral Abutment and Wingwall Design

Integral abutment sections shall be designed for all relevant strength, service, and extreme limit states and load combinations specified in LRFD Articles 3.4.1 and 11.5.5. A resistance factor (ϕ) of 1.0 shall be used to assess abutment design at the service limit state, including: settlement and excessive horizontal movement. The overall stability of the foundation should be investigated at the Service I Load Combination and a resistance factor, ϕ, of 0.65. Resistance factors for extreme limit state shall be taken as 1.0.

The designer may assume Soil Type 4 (MaineDOT Bridge Design Guide (BDG) Section 3.6.1) for abutment backfill material soil properties. The backfill properties are as follows:

- Internal Friction Angle (ϕ) = 32°
- Total Unit Weight (γ) = 125 pcf
- Soil-Concrete Interface Friction Angle (δ) = 17° (ref: LRFD Table 3.11.5.3-1)

Integral abutments and in-line wingwalls shall be designed to withstand a lateral earth load equal to the passive pressure state. Estimation of passive earth pressure should consider LRFD C3.11.5.4, which states that the relative wall movement to induce full passive pressure is approximately 0.05 for dense backfill, and FHWA NHI-06-089 Figure 10-4 which supports a K_p of 6.0 and greater for dense backfills and wall rotations equal to or greater than 0.02. Using Rankine Theory, a lateral earth pressure coefficient of 3.25 is recommended, assuming a ratio of thermal expansion to abutment height (δ/H) of 0.003 and a level backfill. In general, when the calculated ratio of lateral movement to wall height exceeds 0.0036, a passive earth pressure coefficient can be estimated using MassDOT LRFD Bridge Design Manual Figure 3.10.8-1. This figure is reproduced in Appendix D – Calculations. A load factor for passive earth pressure is not specified in LRFD. For purposes of the integral abutment backwall reinforcing steel design, use a maximum load factor (γ_{EH}) of 1.50 to calculate factored passive earth pressures.

Additional lateral earth pressure due to live load surcharge is required per Section 3.6.8 of the MaineDOT BDG for abutments if an approach slab is not specified. When a structural approach slab is specified, reduction, not elimination of the surcharge load, is permitted per LRFD Article 3.11.6.5. The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}) taken from the table, below:

Abutment Height (feet)	h_{eq} (feet)
5	4.0
10	3.0
≥20	2.0

In-line wingwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil of 2.0 feet. An at-rest earth pressure coefficient, K_o, of 0.47 should be used for live load surcharge loads placed upon wingwalls cantilevered off of abutments with the top of the wall restrained from movement.

7.3 Abutment Sections

The abutment design shall include a drainage system behind the abutment to intercept any groundwater. Drainage behind the structure shall be in accordance with MaineDOT BDG Section 5.4.2.13.

Backfill within 10 feet of the abutments and side slope fill shall conform to MaineDOT Specification 703.19 – Granular Borrow for Underwater Backfill. The gradation of this material specifies 7 percent or less of the material passing the No. 200 sieve. Limiting the amount of fines is intended to minimize frost action and eliminate the need to design for hydrostatic forces by promoting drainage behind the structure.

Slopes in front of the pile-supported integral abutments should be constructed with riprap and erosion control geotextile. The slopes should not exceed 1.75H:1V in accordance with MaineDOT Standard Detail 610(03).

7.4 Settlement and Embankment Stability

The vertical alignment of the new Perkins Bridge will closely match the existing. The bridge approach embankments will be constructed using granular borrow placed and compacted over generally very stiff fine-grained and dense coarse-grained fill. Any loose soils encountered at the subgrade elevation shall be thoroughly compacted prior to backfill operations. With these provisions, any settlement of the final roadway embankments is anticipated to be small and immediate.

The 8-foot culvert pipe replacing Lake Bridge will be installed on a 12-inch bed of granular borrow on a subgrade consisting of generally dense granular fill. The replacement pipe will be smaller and fabricated from a material lighter than the existing. Therefore, any settlement of the culvert pipe is anticipated to be minimal.

Conventional earth fill embankments constructed over the existing soils using MaineDOT Standard Specifications, with side slopes of 2H:1V or flatter, are anticipated to satisfy stability requirements. Slopes steeper than 2H:1V should be treated with riprap using MaineDOT Standard Details.

The project will require moderate widening and raising of the upstream sideslopes at the start of the project, then east of Perkins Bridge, there is moderate widening and raising of both sideslopes for the remainder of the project. Any peat or wetland deposits encountered at the subgrade of toes of reconstructed side slopes and abutment foreslopes should be excavated to a nominal depth of 1-foot and replaced with granular borrow.

Settlement of the steel H-piles bearing on bedrock will be limited to elastic compression of the piles and is anticipated to be minimal.

7.5 Frost Protection

Foundations placed on soil should be designed with an appropriate embedment for frost protection. According to MaineDOT BDG Figure 5-1, Maine Design Freezing Index Map, Levant has a design freezing index (DFI) of approximately 1825 F-degree days. Fill soils are anticipated to be present at the abutments and embankments, either as reworked silty fill or granular fill. Based on the coarse-grained fill with a water content of 10 percent, the estimated depth of frost penetration is approximately 7.6 feet. It is recommended that any foundation bearing on soils be embedded 7.6 feet for frost protection.

Pile-supported integral abutments shall be embedded a minimum of 4.0 feet for frost protection per MaineDOT BDG Section 5.2.1.

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

7.6 Seismic Design Considerations

The United States Geological Survey Seismic Design CD (Version 2.1) provided with the 2014 LRFD Code (7th Edition), and LRFD Articles 3.10.3.1 and 3.10.6 were used to develop parameters for seismic design. Based on site coordinates, the software provided the recommended AASHTO Response Spectra for a 7 percent probability of exceedance in 75 years. These results are summarized in the table below:

Parameter	Design Value
Peak Ground Acceleration (PGA)	0.07g
Acceleration Coefficient (A_S)	0.11g
S_{DS} (Period = 0.2 sec)	0.24g
S_{D1} (Period = 1.0 sec)	0.11g
Site Class	D
Seismic Zone	1

In conformance with LRFD Table 4.7.4.3-1 seismic analysis is not required for single-span bridges regardless of seismic zone. However, superstructure connections and minimum support length requirements shall be designed per LRFD Articles 3.10.9.2 and 4.7.4.4, respectively.

8.0 Construction Recommendations and Considerations

Any peat, organics, soft or loose soils encountered at the subgrade elevation at either abutment shall be excavated in its entirety and replaced with Granular Borrow – Material for Underwater Backfill and the exposed subgrade then thoroughly compacted.

Any peat or wetland deposits encountered at the subgrade of toes of reconstructed side slopes and abutment foreslopes should be excavated to a nominal depth of 1-foot and replaced with granular borrow.

Excavation for the abutments is anticipated to be accomplished using sloped open cut methods in accordance with MaineDOT and OSHA requirements. Excavations will expose fine-grained soils that may become saturated and water seepage may occur during construction. There may be localized sloughing and instability in some excavations and cut slopes. The contractor should control groundwater, surface water infiltration, and soil erosion. Water should be controlled by pumping from sumps.

Cobbles and boulders were encountered in the glacial till deposit. There is potential for these obstructions to cause difficulties during pile driving operations. If obstructions are encountered prior to reaching the maximum required penetration resistance on bedrock, then they may be cleared by conventional excavation methods, pre-augering, predrilling, spudding, use of rock chisels, or down-hole hammers.

9.0 CLOSURE

This report has been prepared for the use of the MaineDOT Bridge Program for specific application to the proposed replacement of Perkins Bridge and Lake Bridge in Levant, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

In the event that any changes in the nature, design, or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendations as appropriate to reflect the changes in design. These analyses and recommendations are based in part upon limited subsurface investigations at discrete exploratory locations completed at the site. If variations from the conditions encountered during the investigation appear evident during construction, it may also become necessary to re-evaluate the recommendations made in this report.

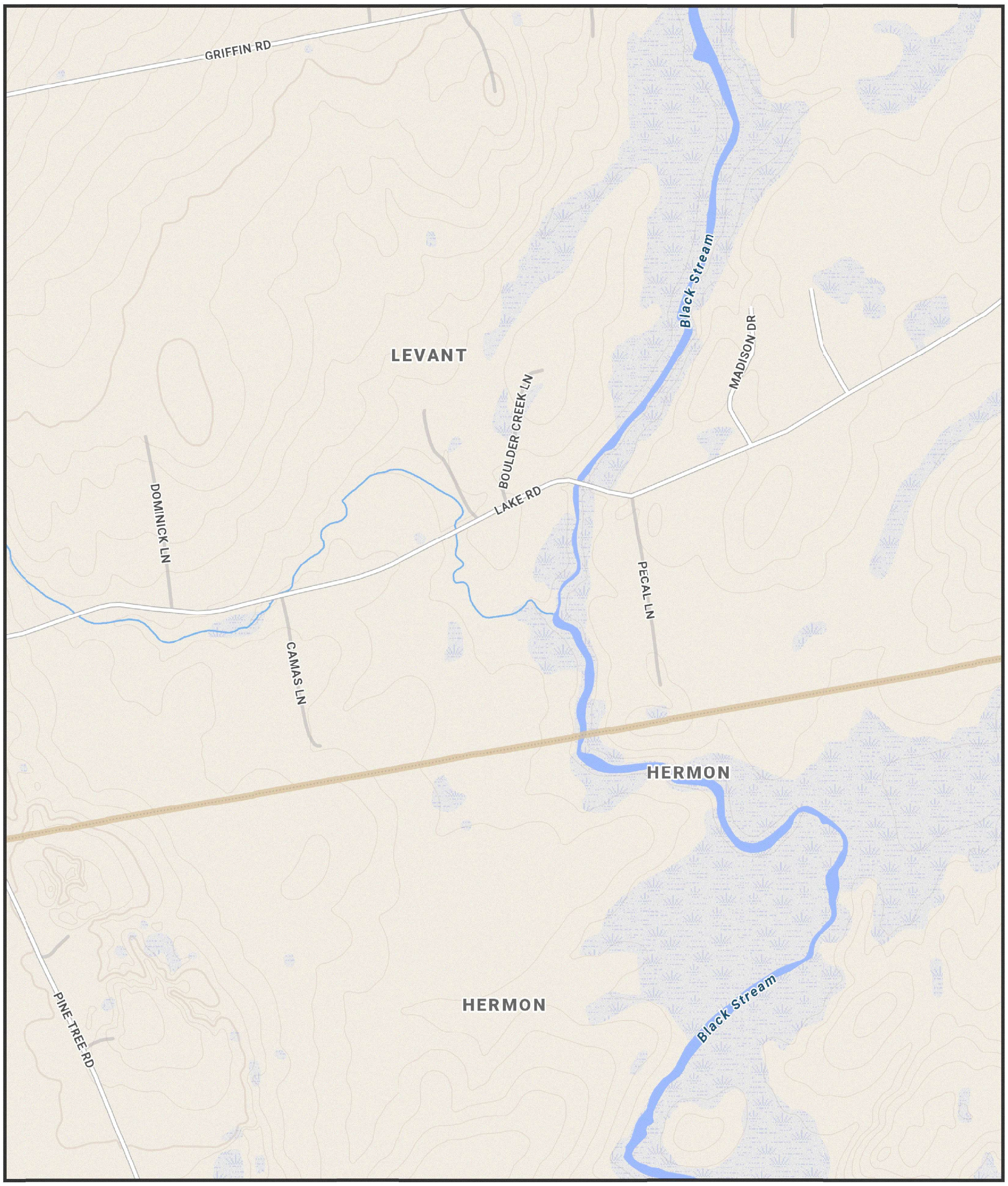
It is recommended that a geotechnical engineer be provided the opportunity for a review of the final design and specifications in order that the earthwork and foundation recommendations and construction considerations presented in this report are properly interpreted and implemented in the design and specifications.

Sheets

Date:3/11/2024

Username: Nathan.P.Pukay Division: GEOTECH

LEVANT, MAINE



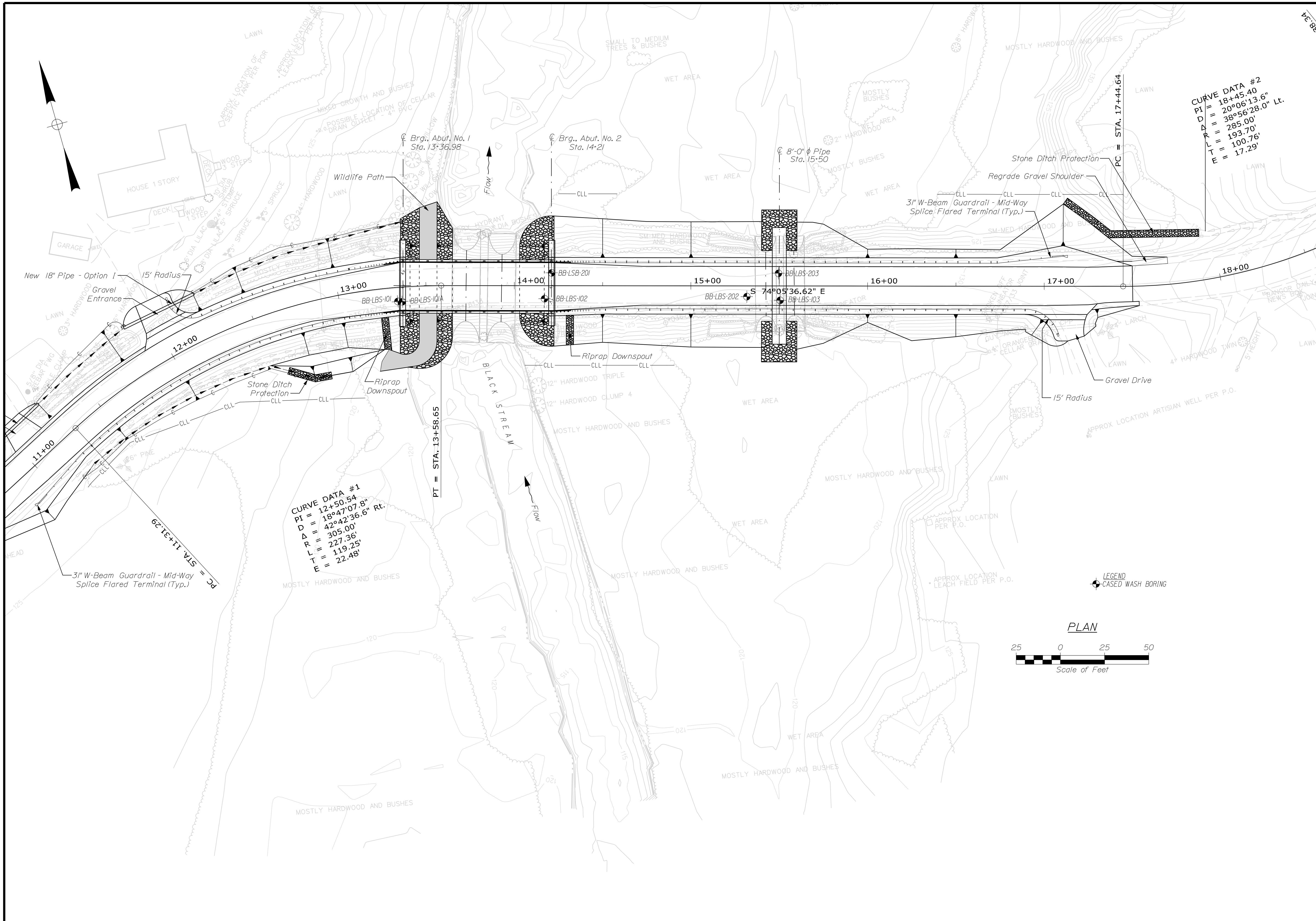
The Maine Department of Transportation provides this publication for information only. Reliance upon this information is at user risk. It is subject to revision and may be incomplete depending upon changing conditions. The Department assumes no liability if injuries or damages result from this information. This map is not intended to support emergency dispatch.

0.25 Miles

1 inch = 0.28 miles

Date: 2/5/2024
Time: 7:40:46 AM

SHEET NUMBER	PERKINS AND LAKE BRIDGES	STATE OF MAINE
1	BLACK STREAM	DEPARTMENT OF TRANSPORTATION
OF 5	LEVANT PENOBSCOT COUNTY	2709800
	LOCATION MAP	WIN
		BRIDGE NO. 6133 & 3359 27098.00 BRIDGE PLANS



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

2709800

WIN 27098.00

BRIDGE NOS. 6133 & 3359

BRIDGE PLANS

PROJ. MANAGER	J. STETSON		
DESIGN-DETAILED	B. BARTLETT	D. SHAW	
CHECKED-REVIEWED			
DESIGN2-DETAILED2	N. PUKAY	T. WHITE	JUN 2023
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

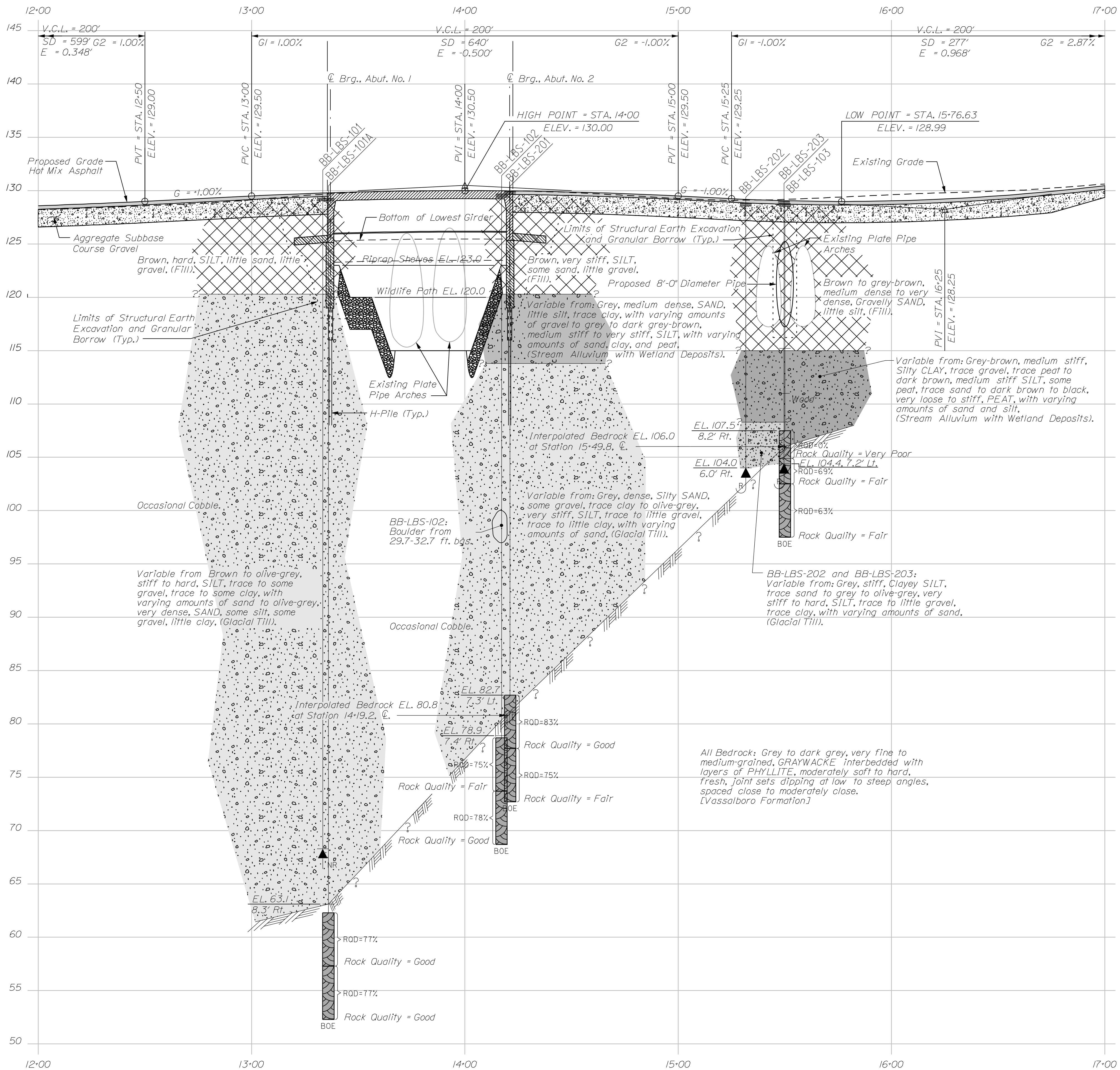
DATE

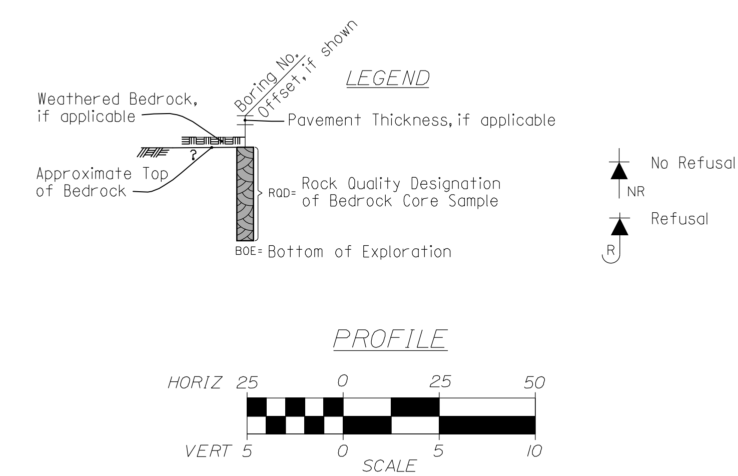
PERKINS AND LAKE BRIDGES
BLACK STREAM
LEVANT PENOBSCOT COUNTY

BORING LOCATION PLAN

SHEET NUMBER 2 OF 5

Filename: ...\00\GEOTECH\MSTA\005_BLP1.dgn Division: GEOTECH Username: Nathan.P.Pukay Date:2/27/2024





Notes: 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 and bedrock transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

"Varying Amounts" term = Portion is 0 to 50 percent of Total.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

2709800

WIN 27098.00

BRIDGE NOS. 6133 & 3359

BRIDGE PLANS

		BY	DATE
PROJ. MANAGER	J. STETSON		
DESIGN-DETAILED	B. BARTLETT	D. SHAW	
CHECKED-REVIEWED			
DESIGN2-DETAILED2	N.PUKAY	T.WHITE	FEB 2024
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

PERKINS AND LAKE BRIDGES
BLACK STREAM
LEVANT PENOBSCOT COUNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

3

OF 5

Filename: ...\OD\GEOTECH\MSTA\006_ISP1.dgn Division: GEOTECH Username: Nathan.P.Pukay Date:2/28/2024

Filename: ...\MSTA\007_BORING LOGS1.dgn Division: GEOTECH Username: Nathan.P.Pukay Date:2/28/2024

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over
Location: Levant, Maine

Boring No.: BB-LBS-101
WIN: 27098.00

Driller:	MaineDOT	Elevation (ft.)	129.3	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrie	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	N. Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	6/7,12/2023	Drilling Method:	Cased Wash Boring	Core Barrel:	N/A
Boring Location:	13+33.4, 7.9 ft Rt.	Casing ID/OD:	NW(3.0"/3.5")	Water Level*:	8.0 ft bgs.
Hammer Efficiency Factor: 0.906		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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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.)
0							SSA	129.1
5	1D	24/17	5.00 - 7.00	15/15/15/20	30	45	34	
							48	
							25	
							27	
							14	120.3
10	MD	24/0	10.00 - 12.00	8/5/10/7	15	23	RC	
	2D	12/3	13.00 - 14.00	5/50(6")	---		7	
							35	
15	3D	24/10	15.00 - 17.00	8/13/12/20	25	38	41	
							46	
							187	
							176	
							188	
20	4D	24/12	20.00 - 22.00	12/19/19/17	38	57	RC	
25	5D	24/5	25.00 - 27.00	11/23/30/37	53	80		
30	6D	24/9	30.00 - 32.00	8/11/20/16	31	47		
35	7D	24/8	35.00 - 37.00	9/14/18/20	32	48		
40	8D	24/2	40.00 - 42.00	12/13/14/36	27	41		
45	9D	24/17	45.00 - 47.00	23/38/35/38	73	110		
50	10D	24/17	50.00 - 52.00	31/30/28/40	58	88		
55	11D	24/20	55.00 - 57.00	30/43/54/66	97	146	OPEN HOLE	
60	12D	12/12	60.00 - 61.00	47/95(6")	---			68.3

Visual Description and Remarks / Laboratory Testing Results/ AASHTO and Unified Class:

- 3" HMA. —0.3
- Brown, moist, hard, SILT, little sand, little gravel, (Fill). — G#380926 A-4, CL-ML WC=16.1
- —9.0
- Medium dense.
- Olive-grey, wet, SILT, some gravel, some sand, little clay, (Glacial Till).
- Olive-grey, wet, hard, SILT, some gravel, some sand, little clay, (Glacial Till). — G#380927 A-4, CL-ML WC=10.8% LL=20 PL=14 PI=6
- Olive-grey, wet, very dense, SAND, some silt, some gravel, little clay, (Glacial Till). — G#380928 A-4, CL-ML WC=10.2% LL=20 PL=14 PI=6
- Similar to 4D. Rock in tip of spoon.
- Occasional cobble.
- Olive-grey, wet, hard, SILT, some sand, little gravel, little clay, (Glacial Till). — G#380929 A-4, CL-ML WC=11.5% LL=21 PL=14 PI=7
- Occasional cobble.
- Similar to 6D.
- Occasional cobble.
- Olive-grey, wet, hard, SILT, some sand, little gravel, trace clay, (Glacial Till). Rock in tip of spoon.
- Occasional cobble.
- Olive-grey, wet, hard, SILT, some sand, little gravel, trace clay, (Glacial Till).
- Occasional cobble.
- Similar to 9D, (Glacial Till).
- Cobble from 54.2-54.8 ft bgs.
- Olive grey, wet, hard, SILT, some sand, little gravel, trace clay, (Glacial Till). Steel cuttings in wash at 55.0 ft bgs. due to damaged casing shoe.
- Olive-grey, wet, Sandy SILT, little gravel, trace clay, (Glacial Till). —61.0
- Bottom of Exploration at 61.0 feet below ground surface. HOLE ABANDONED. NW sized steel casing shoe broke off and left in hole with the tip at 55.0 ft bgs (El. 74.3). Casing shoe measures 0.4 ft long. Moved to BB-LBS-101A.

Remarks:
1) Water level measured before resuming drilling on 6/12/2023.
2) NW sized steel casing shoe left in hole with the tip at 55.0 ft bgs (El. 74.3). Casing shoe measures 0.4 ft long.

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.

Page 1 of 1
Boring No.: BB-LBS-101

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over
Location: Levant, Maine

Boring No.: BB-LBS-101A
WIN: 27098.00

Driller:	MaineDOT	Elevation (ft.)	129.3	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrie	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	N. Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	6/13-14/2023	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	13+36, 8.3 ft Rt.	Casing ID/OD:	NW(3.0"/3.5")	Water Level*:	8.0 ft bgs.
Hammer Efficiency Factor: 0.906		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
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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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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.)
0							SSA	129.1
	S1	12/4	9.00 - 10.00					120.3
10	MD	24/0	10.00 - 12.00	7/7/8/7	15	23	DRIVE NW	
20							OPEN HOLE	
25							SPUN NW	
65							OH	63.1
	R1	60/58	67.00 - 72.00	RQD = 77%			NQ-2	
	R2	60/58	72.00 - 77.00	RQD = 77%				

Visual Description and Remarks / Laboratory Testing Results/ AASHTO and Unified Class:

- 3" HMA. Reference BB-LBS-101 for additional exploration information, samples, and casing blow counts up to 61.0 ft bgs. —0.3
- —9.0
- S1 (Auger sample off flights): Brown, wet, SILT, some clay, little sand, trace gravel, (Glacial Till). Collected from bottom of auger from 9.0-10.0 ft bgs. — G#380930 A-4, CL WC=34.0%
- Stiff.
- Occasional cobble.
- Pulled NW casing to install spinning shoe due to many cobbles. Spun casing to 30.0 ft bgs and roller coned ahead to 40.0 ft bgs.
- Occasional cobble.
- Spun casing to 45.0 ft bgs, then roller coned ahead to 57.0 ft bgs.
- —66.2
- Top of Bedrock at Elev. 63.1 ft. Roller coned ahead to 67.0 ft bgs.
- R1: Bedrock: Grey to dark grey, very fine to medium-grained, GRAYWACKE, interbedded with abundant layers of PHYLLITE, moderately hard, competent, fresh, joint set dipping at low angles, spaced moderately close, with quartz or calcite annealed fractures.
  [Vassalboro Formation]
  Rock Quality = Good
  R1: Core Times (min:sec)
  67.0-68.0 ft (2:10)
  68.0-69.0 ft (2:00)
  69.0-70.0 ft (1:53)
  70.0-71.0 ft (2:01)
  71.0-72.0 ft (2:33)
  97% Recovery
- R2: Bedrock: Similar to R1.
  [Vassalboro Formation]
  Rock Quality = Good

Remarks:

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.

Page 1 of 2
Boring No.: BB-LBS-101A

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over
Location: Levant, Maine

Boring No.: BB-LBS-101A
WIN: 27098.00

Driller:	MaineDOT	Elevation (ft.)	129.3	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrie	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	N. Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	6/13-14/2023	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	13+36, 8.3 ft Rt.	Casing ID/OD:	NW(3.0"/3.5")	Water Level*:	8.0 ft bgs.
Hammer Efficiency Factor: 0.906		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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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 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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.)
75								52.3

Visual Description and Remarks:

- R2: Core Times (min:sec)
  72.0-73.0 ft (3:59)
  73.0-74.0 ft (6:19)
  74.0-75.0 ft (6:06)
  75.0-76.0 ft (5:10)
  76.0-77.0 ft (4:39)
  97% Recovery —77.0
- Bottom of Exploration at 77.0 feet below ground surface.

Remarks:

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.

Page 2 of 2
Boring No.: BB-LBS-101A

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over
Location: Levant, Maine

Boring No.: BB-LBS-102
WIN: 27098.00

Driller:	MaineDOT	Elevation (ft.)	129.7	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrie	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	N. Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	6/5/2023-6/6/2023	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	14+17.2, 7.4 ft Rt.	Casing ID/OD:	HW(4.0"/4.5"), NW(3.0"/3.5")	Water Level*:	10.0 ft bgs.
Hammer Efficiency Factor: 0.906		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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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.)
0							SSA	129.4
5	1D	24/17	5.00 - 7.00	14/8/10/12	18	27	38	
							47	
							48	
							55	
							40	
10							3	119.7
	2D	24/12	11.00 - 13.00	4/2/5/3	7	11	10	
							10	
							15	
							25	
15	3D V1	24/10	15.00 - 17.00 15.00 - 16.00	1/5/14/30 Su Ø4181 psf	19	29	OPEN HOLE	113.7
20	4D	24/8	20.00 - 22.00	4/4/7/10	11	17	31	
							38	
							54	
							81	
							136	
25	5D	24/6	25.00 - 27.00	6/8/12/15	20	30	77	
							90	
							86	
							97	
							159	
30							OPEN HOLE	
35	6D	24/8	35.00 - 37.00	15/11/6/10	17	26		
40	7D	24/9	40.00 - 42.00	8/10/9/11	19	29		
45	8D	24/15	45.00 - 47.00	11/6/9/24	15	23	41	
							66	
							131	
							149	
							164	
50	9D	9.6/5	50.00 - 50.80	13/50(3.6")	---		130	78.9
	R1	60/60	51.00 - 56.00	RQD = 75%			NQ-2	
	R2	60/60	56.00 - 61.00	RQD = 78%				68.7

Visual Description and Remarks / Laboratory Testing Results/ AASHTO and Unified Class:

- 4" HMA. —0.3
- Occasional cobble.
- Brown, moist, very stiff, SILT, some sand, little gravel, (Fill). Broken cobble in spoon. Set NW casing at 5.0 ft bgs.
- —10.0
- Grey, wet, medium dense, SAND, little silt, trace gravel, trace organics, (Stream Alluvium with Wetland Deposits). — G#380931 A-2-4, SM WC=36.3%
- Clay in wash from 13.0-14.0 ft bgs.
- Wash went from grey to dark brown from 14.0-14.5 ft bgs.
- Grey, wet, medium dense, Gravelly SAND, little silt, trace clay, (Stream Alluvium with Wetland Deposits). 16x32 mm vane raw torque readings: V1: Ø26.6 in-lbs. —16.0 — G#380932 A-1-b, SC-SM WC=5.4% Non-Plastic
- Olive-grey, wet, very stiff, SILT, some sand, little clay, trace gravel, (Glacial Till). — G#380933 A-4, CL-ML WC=22.7% LL=20 PL=15 PI=5
- Similar to 4D.
- Boulder from 29.7-32.7 ft bgs. Cored through boulder. Pulled NW casing and installed HW casing.
- Olive-grey, wet, very stiff, SILT, some sand, little gravel, trace clay, (Glacial Till).
- Similar to 6D.
- Occasional Cobble.
- Olive-grey, wet, very stiff, SILT, some sand, little gravel, (Glacial Till). Artisan water pressure at 45.0 ft bgs. Hole collapsed back to 40.0 ft after 8D sample. Set NW casing to telescope through boulder at 29.7 ft bgs. — G#380934 A-4, CL-ML WC=13.7%
- Olive-grey, wet, SILT, some sand, little gravel, trace clay, (Glacial Till). Bedrock in tip of spoon. —50.8
- Top of Bedrock at Elev. 78.9 ft. Roller Coned ahead to 51.0 ft bgs.
- R1: Bedrock: Grey to dark grey, fine to medium-grained GRAYWACKE and thinly bedded PHYLLITE, moderately soft to hard, fresh, joint sets dipping at low to steep angles, closely spaced, with quartz or calcite annealed fractures.
  [Vassalboro Formation]
  Rock Quality = Fair
  R1: Core Times (min:sec)
  51.0-52.0 ft (1:36)
  52.0-53.0 ft (1:36)
  53.0-54.0 ft (1:35)
  54.0-55.0 ft (1:34)
  55.0-56.0 ft (1:57)
  100% Recovery
- R2: Bedrock: Similar to R1.
  [Vassalboro Formation]
  Rock Quality = Good
  R2: Core Times (min:sec)
  56.0-57.0 ft (2:04)
  57.0-58.0 ft (2:28)
  58.0-59.0 ft (2:23)
  59.0-60.0 ft (2:28)
  60.0-61.0 ft (3:53)
  100% Recovery —61.0
- Bottom of Exploration at 61.0 feet below ground surface.

Remarks:
1) Water level measured 6/6/2023 before resuming drilling.

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.

Page 1 of 1
Boring No.: BB-LBS-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
2709800
WIN 27098.00
BRIDGE PLANS
BRIDGE NOS. 6133 & 3359

		BY	DATE
PROJ. MANAGER	J. STETSON		
DESIGN-DETAILED	B. BARTLETT	D. SHAW	
CHECKED-REVIEWED	-------	-------	-------
DESIGN2-DETAILED2	N.PUKAY	T.WHITE	FEB 2024
DESIGN3-DETAILED3			
REVISIONS 1	-------		-------
REVISIONS 2	-------		-------
REVISIONS 3	-------		-------
REVISIONS 4	-------		-------
FIELD CHANGES	-------		-------

SIGNATURE
P.E. NUMBER
DATE

PERKINS AND LAKE BRIDGES
BLACK STREAM
LEVANT PENOBSCOT COUNTY

BORING LOGS

SHEET NUMBER
4
OF 5

Filename: ...\MSTA\008_BORING LOGS2.dgn   Division: GEOTECH   Username: Nathan.P.Pukay   Date:2/28/2024

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over
Location: Levant, Maine

Boring No.: BB-LBS-103
WIN: 27098.00

Driller:	MaineDOT	Elevation (ft.)	128.8	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrie	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	N. Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	6/7/2023; 08:00-12:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	15+50.4, 8.2 ft Rt.	Casing ID/OD:	NW-3"	Water Level*:	7.0 ft bgs.
Hammer Efficiency Factor: 0.906		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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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

Sample Information

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	128.5		3.5" HMA. 0.3	
5	1D	24/14	5.00 - 7.00	13/13/8/9	21	32	44			Brown, moist, dense, Gravelly SAND, little silt, (Fill).	
							35				
							31				
							30				
							33				
10	2D	24/8	10.00 - 12.00	11/10/10/15	20	30	25			Brown, wet, medium dense, Gravelly SAND, little silt, (Fill).	
							49				
							55				
							108	115.2		13.6 Wood in wash at 13.6 ft bgs.	
	3D	24/1	14.00 - 16.00	1/1/2/2	3	5	25			Dark brown, wet, medium stiff, PEAT, (Stream Alluvium with Wetland Deposits). Roller Coned ahead to 16.0 ft bgs.	
15							35				
	4D	24/1	16.00 - 18.00	2/2/3/3	5	8	19			Dark brown, wet, loose, Silty WOOD, trace gravel, trace sand, (Stream Alluvium with Wetland Deposits).	
							23				
							36			Wood chips and occasional dark brown coloring (presumed peat) in wash.	
							30				
20	5D	14.4/1	20.00 - 21.20	4/4/50(2.4")	---		25			Dark brown, wet, WOOD, little silt, trace gravel, trace sand, (Stream Alluvium with Wetland Deposits). a60 blows for 0.3 ft.	
	R1	31.2/18	21.30 - 23.90	RQD = 0%			a60 NQ-2	107.5		21.3 Top of Bedrock at Elev. 107.5 ft. R1: Bedrock: Grey to dark grey, fine to medium-grained, GRAYWACKE interbedded with PHYLLITE, moderately soft to moderately hard, fresh, thinly bedded, steeply dipping joint set, closely spaced, with small quartz or calcite annealed fractures. [Vassalboro Formation] Rock Quality = Very Poor R1: Core Times (min:sec) 21.3-22.3 ft (2:27) 22.3-24.3 ft (4:48) Lost water at 22.8 ft bgs. 23.3-23.9 ft (3:15) 58% Recovery	
	R2	28.8/27	23.90 - 26.30	RQD = 69%						R2: Bedrock: Similar to R1. [Vassalboro Formation] Rock Quality = Fair R2: Core Times (min:sec) 23.9-24.3 ft (1:11) 24.3-25.3 ft (2:00) 25.3-26.3 ft (1:48) 93% Recovery	
25											
	R3	60/58	26.30 - 31.30	RQD = 63%							
30											
								97.5		R3: Bedrock: Grey to dark grey, very fine to medium-grained, GRAYWACKE interbedded with zones of PHYLLITE, moderately hard, fresh, joint sets moderately dipping to steep, closely spaced, with quartz or calcite annealed fractures, sulfide-rich zone highlighted by weakly oxidized base metal minerals. [Vassalboro Formation] Rock Quality = Fair R3: Core Times (min:sec) 26.3-27.3 ft (2:05) 27.3-28.3 ft (2:24) 28.3-29.3 ft (3:16) 29.3-30.3 ft (3:03) 30.3-31.3 ft (3:19) 97% Recovery 31.3 Bottom of Exploration at 31.3 feet below ground surface.	
35											
40											
45											
50											

Remarks:

1) Water level measured immediately after drilling.

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.

Page 1 of 1

Boring No.: BB-LBS-103

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over
Location: Levant, Maine

Boring No.: BB-LBS-201
WIN: 27098.00

Driller:	MaineDOT	Elevation (ft.)	129.9	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrie	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	N. Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	7/26/2023; 08:30-14:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	14+21.2, 7.3 ft Lt.	Casing ID/OD:	NW(3.0"/3.5")	Water Level*:	None Observed
Hammer Efficiency Factor: 0.906		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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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

Sample Information

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	129.6		3.5" HMA. 0.3	
5	1D	24/14	5.00 - 7.00	6/9/12/16	21	32	SPUN NW			Brown, moist, hard, SILT, little sand, little gravel, (Fill).	
								120.9		9.0	
10	2D	24/12	10.00 - 12.00	2/2/3/3	5	8				Grey, wet, medium stiff, SILT, trace clay, trace sand, (Stream Alluvium with Wetland Deposits).	
	3D/A	24/16	12.00 - 14.00	3/4/5/5	9	14				3D (Top 8") Grey, wet, stiff, SILT, some fine sand, trace clay, (Stream Alluvium with Wetland Deposits). 3D/A (Bottom 8") Dark grey-brown, wet, stiff, SILT, little peat, little sand, (Stream Alluvium with Wetland Deposits).	#380876 Non-Plastic #380877 WC=70.5% Ignition Loss 13.7%
	4D	24/4	14.00 - 16.00	6/8/5/4	13	20				Grey, wet, very stiff, Sandy SILT, trace clay, (Stream Alluvium with Wetland Deposits).	
15								113.9		16.0	
	5D	24/6	16.00 - 18.00	3/8/13/18	21	32				Grey, wet, dense, Silty SAND, some gravel, trace clay, (Glacial Till).	
	6D	24/8	18.00 - 20.00	6/8/10/14	18	27				Olive-grey, wet, very stiff, Sandy SILT, trace clay, trace gravel, (Glacial Till).	
20											
25										Artesian water pressure at 25.0 ft bgs.	
30										Artesian water pressure at 30.0 ft bgs.	
35											
										Cored through cobble from 38.5-38.9 ft bgs.	
40											
45											
	R1	60/60	47.20 - 52.20	RQD = 83%			NQ-2	82.7		47.2 Top of Bedrock at Elev. 82.7 ft. R1: Bedrock: Grey to dark grey, fine to medium-grained, GRAYWACKE interbedded with PHYLLITE, moderately hard, fresh, thinly bedded, joint sets dipping at low to moderate angles, closely spaced, with significant quartz or calcite annealed fractures. [Vassalboro Formation] Rock Quality = Good R1: Core Times (min:sec) 47.2-48.2 ft (4:02) 48.2-49.2 ft (3:12) 49.2-50.2 ft (3:31) 50.2-51.2 ft (3:02) 51.2-52.2 ft (4:47) 100% Recovery	
50											
	R2	60/60	52.20 - 57.20	RQD = 75%						R2: Bedrock: Grey to dark grey, fine to medium-grained, GRAYWACKE interbedded with PHYLLITE, moderately hard, fresh, joint sets steeply dipping, closely spaced, with quartz or calcite annealed fractures. [Vassalboro Formation] Rock Quality = Fair	
55								72.7		R2: Core Times (min:sec) 52.2-53.2 ft (3:16) 53.2-54.2 ft (2:51) 54.2-55.2 ft (1:58) 55.2-56.2 ft (1:52) 56.2-57.2 ft (1:55) 100% Recovery 57.2 Bottom of Exploration at 57.2 feet below ground surface.	
60											
65											
70											
75											

Remarks:

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.

Page 1 of 1

Boring No.: BB-LBS-201

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over
Location: Levant, Maine

Boring No.: BB-LBS-202
WIN: 27098.00

Driller:	MaineDOT	Elevation (ft.)	128.8	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrie	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	N. Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	7/25/2023; 13:15-15:15	Drilling Method:	Cased Wash Boring	Core Barrel:	N/A
Boring Location:	15+31.7, 6.0 ft Rt.	Casing ID/OD:	NW(3.0"/3.5")	Water Level*:	10.0 ft bgs.
Hammer Efficiency Factor: 0.906		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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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

Sample Information

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	128.6		3" HMA. 0.3	
5	1D	24/14	5.00 - 7.00	8/8/9/8	17	26	32			Brown, moist, medium dense, Gravelly SAND, little silt, (Fill).	G#380878 A-1-a, SM WC=4.3%
							37				
							35				
							37				
							29				
10	2D	24/8	10.00 - 12.00	5/5/10/11	15	23	NW			Brown, wet, medium dense, Gravelly SAND, little silt, (Fill).	
	3D/A	24/14	12.00 - 14.00	10/7/15/13	22	33				3D (Top 8") Similar to 2D, except dense. 3D/A (Bottom 6") Brown, wet, dense, Silty GRAVEL, little sand, little peat, trace wood, (Fill).	
								114.8		14.0	
	4D/A	24/8	14.00 - 16.00	3/3/2/2	5	8				4D (Top 5") Grey-brown, wet, medium stiff, Silty CLAY, trace gravel, trace peat, (Stream Alluvium with Wetland Deposits). 4D/A (Bottom 3") Dark brown, wet, medium stiff, SILT, some peat, trace sand, (Stream Alluvium with Wetland Deposits).	#380879 A-7-5, OH WC=50.0% LL=62 PL=45 PI=17
15	5D	24/24	16.00 - 18.00	1/1/2/3	3	5				5D Black, wet, medium stiff, PEAT, some silt, trace sand, (Stream Alluvium with Wetland Deposits).	#380880 WC=431% Ignition Loss 67.4% #317731 pH=5.22
	6D	24/21	18.00 - 20.00	1/2/1/2	3	5				6D Similar to 5D.	
20	7D/A	24/17	20.00 - 22.00	4/8/2/4	10	15				7D (Top 8") Black, wet, stiff, Silty PEAT, trace sand, (Stream Alluvium with Wetland Deposits).	
								107.8		21.0 7D/A (Bottom 9") Grey, wet, stiff, Clayey SILT, trace sand, (Glacial Till).	G#380881 A-4, CL WC=31.3% LL=28 PL=20 PI=8
	8D	24/8	22.00 - 24.00	7/17/17/18	34	51				Grey, wet, hard, Sandy SILT, little gravel, trace clay, (Glacial Till).	
	9D	9.6/9	24.00 - 24.80	18/50(3.6")	---			104.0		Grey, wet, SILT, some sand, trace clay, trace gravel, (Glacial Till). 24.8 Bottom of Exploration at 24.8 feet below ground surface. REFUSAL, presumed Top of Rock at El. 104.0 ft.	
25											
30											
35											
40											
45											
50											

Remarks:

1) Water level measured immediately after drilling.

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.

Page 1 of 1

Boring No.: BB-LBS-202

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over
Location: Levant, Maine

Boring No.: BB-LBS-203
WIN: 27098.00

Driller:	MaineDOT	Elevation (ft.)	129.0	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrie	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	N. Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	7/25/2023; 09:30-13:00	Drilling Method:	Cased Wash Boring	Core Barrel:	N/A
Boring Location:	15+49.6, 7.2 ft Lt.	Casing ID/OD:	NW(3.0"/3.5")	Water Level*:	9.0 ft bgs.
Hammer Efficiency Factor: 0.906		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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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

Sample Information

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	128.8		3" HMA. 0.3	
5	1D	24/5	5.00 - 7.00	9/11/13/13	24	36				Brown, moist, dense, Gravelly SAND, little silt, (Fill).	
10	2D	24/8	10.00 - 12.00	9/12/14/14	26	39	NW			Similar to 1D, except wet.	
	3D	24/12	12.00 - 14.00	22/18/26/22	44	66				Grey-brown, wet, very dense, Gravelly SAND, little silt, (Fill).	G#380882 A-1-a, SM WC=8.4%
								115.0		14.0	
	4D	24/4	14.00 - 16.00	15/19/9/9	28	42				Brown, wet, WOOD, trace sand, (Stream Alluvium with Wetland Deposits).	
15	5D	24/15	16.00 - 18.00	6/6/6/4	12	18				Black, wet, stiff, Silty PEAT, trace sand, (Stream Alluvium with Wetland Deposits).	
	MD		18.00 - 20.00	5/6/3/3	9	14				PEAT and WOOD in wash.	
	MD		19.00 - 21.00								
20							OPEN HOLE	108.7		20.3	
	6D	24/11	21.00 - 23.00	2/3/8/13	11	17				Olive-grey, wet, very stiff, Sandy SILT, trace clay, trace gravel, (Glacial Till).	
	7D	19.2/8	23.00 - 24.60	9/12/10/50(1.2")	22	33				Similar to 6D, except hard. Presumed bedrock in tip of spoon.	
								104.4		24.6 Bottom of Exploration at 24.6 feet below ground surface. REFUSAL, presumed Top of Rock at El. 104.4 ft.	
25											
30											
35											
40											
45											
50											

Remarks:

1) Water level measured immediately after drilling.

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.

Page 1 of 1

Boring No.: BB-LBS-203

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
2709800
WIN 27098.00
BRIDGE NOS. 6133 & 3359
BRIDGE PLANS

		BY	DATE
PROJ. MANAGER	J. STETSON		
DESIGN-DETAILED	B. BARTLETT	D. SHAW	
CHECKED-REVIEWED	------	------	------
DESIGN2-DETAILED2	N.PUKAY	T.WHITE	FEB 2024
DESIGN3-DETAILED3	------	------	------
REVISIONS 1	------	------	------
REVISIONS 2	------	------	------
REVISIONS 3	------	------	------
REVISIONS 4	------	------	------
FIELD CHANGES	------	------	------

SIGNATURE
P.E. NUMBER
DATE

PERKINS AND LAKE BRIDGES
BLACK STREAM
LEVANT   PENOBSCOT COUNTY

BORING LOGS

SHEET NUMBER
5
OF 5

Appendix A

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-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-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):

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

*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: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-101
WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/7,12/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	13+33.4, 7.9 ft Rt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor:	0.906	**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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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	129.1		3" HMA. 0.3	
5	1D	24/17	5.00 - 7.00	15/15/15/20	30	45	34			Brown, moist, hard, SILT, little sand, little gravel, (Fill).	G#380926 A-4, CL-ML WC=16.1
							48				
							25				
							27				
							14	120.3		9.0	
10	MD	24/0	10.00 - 12.00	8/5/10/7	15	23	RC			Medium dense.	
	2D	12/3	13.00 - 14.00	5/50(6")	---		7			Olive-grey, wet, SILT, some gravel, some sand, little clay, (Glacial Till).	
							35				
15	3D	24/10	15.00 - 17.00	8/13/12/20	25	38	41			Olive-grey, wet, hard, SILT, some gravel, some sand, little clay, (Glacial Till).	G#380927 A-4, CL-ML WC=10.8% LL=20 PL=14 PI=6
							46				
							187				
							176				
							188				
20	4D	24/12	20.00 - 22.00	12/19/19/17	38	57	RC			Olive-grey, wet, very dense, SAND, some silt, some gravel, little clay, (Glacial Till).	G#380928 A-4. CL-ML WC=10.2% LL=20 PL=14 PI=6
25											

Remarks:

1) Water level measured before resuming drilling on 6/12/2023.
2) NW sized steel casing shoe left in hole with the tip at 55.0 ft bgs (El. 74.3). Casing shoe measures 0.4 ft long.

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: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-101
WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/7,12/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	13+33.4, 7.9 ft Rt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
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N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
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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	5D	24/5	25.00 - 27.00	11/23/30/37	53	80				Similar to 4D. Rock in tip of spoon.	
										Occasional cobble.	
30	6D	24/9	30.00 - 32.00	8/11/20/16	31	47				Olive-grey, wet, hard, SILT, some sand, little gravel, little clay, (Glacial Till).	G#380929 A-4, CL-ML WC=11.5% LL=21 PL=14 PI=7
										Occasional cobble.	
35	7D	24/8	35.00 - 37.00	9/14/18/20	32	48				Similar to 6D.	
										Occasional cobble.	
40	8D	24/2	40.00 - 42.00	12/13/14/36	27	41				Olive-grey, wet, hard, SILT, some sand, little gravel, trace clay, (Glacial Till). Rock in tip of spoon.	
										Occasional cobble.	
45	9D	24/17	45.00 - 47.00	23/38/35/38	73	110				Olive-grey, wet, hard, SILT, some sand, little gravel, trace clay, (Glacial Till). Occasional cobble.	
50											

Remarks:

1) Water level measured before resuming drilling on 6/12/2023.
2) NW sized steel casing shoe left in hole with the tip at 55.0 ft bgs (El. 74.3). Casing shoe measures 0.4 ft long.

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: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream Location: Levant, Maine	Boring No.: BB-LBS-101 WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/7,12/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	13+33.4, 7.9 ft Rt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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.
50	10D	24/17	50.00 - 52.00	31/30/28/40	58	88				Similar to 9D, (Glacial Till).	
										Cobble from 54.2-54.8 ft bgs.	
55	11D	24/20	55.00 - 57.00	30/43/54/66	97	146	OPEN HOLE			Olive grey, wet, hard, SILT, some sand, little gravel, trace clay, (Glacial Till). Steel cuttings in wash at 55.0 ft bgs. due to damaged casing shoe.	
60	12D	12/12	60.00 - 61.00	47/95(6")	---			68.3		Olive-grey, wet, Sandy SILT, little gravel, trace clay, (Glacial Till). 61.0	
										Bottom of Exploration at 61.0 feet below ground surface. HOLE ABANDONED, NW sized steel casing shoe broke off and left in hole with the tip at 55.0 ft bgs (El. 74.3). Casing shoe measures 0.4 ft long. Moved to BB-LBS-101A.	
65											
70											
75											

Remarks:

1) Water level measured before resuming drilling on 6/12/2023.
2) NW sized steel casing shoe left in hole with the tip at 55.0 ft bgs (El. 74.3). Casing shoe measures 0.4 ft long.

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-101A
WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/13-14/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	13+36, 8.3 ft Rt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
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WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
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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	129.1		3" HMA.	
										Reference BB-LBS-101 for additional exploration information, samples, and casing blow counts up to 61.0 ft bgs. 0.3	
5											
	S1	12/4	9.00 - 10.00					120.3		9.0 S1 (Auger sample off flights): Brown, wet, SILT, some clay, little sand, trace gravel, (Glacial Till). Collected from bottom of auger from 9.0-10.0 ft bgs.	G#380930 A-4, CL WC=34.0%
10	MD	24/0	10.00 - 12.00	7/7/8/7	15	23	DRIVE NW			Stiff.	
										Occasional cobble.	
15											
20							OPEN HOLE				
25											

Remarks:

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: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-101A
WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/13-14/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	13+36, 8.3 ft Rt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor:	0.906	**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
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RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
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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
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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.
25							SPUN NW			Pulled NW casing to install spinning shoe due to many cobbles. Spun casing to 30.0 ft bgs and roller coned ahead to 40.0 ft bgs.	
										Occasional cobble.	
30											
35											
40										Spun casing to 45.0 ft bgs, then roller coned ahead to 57.0 ft bgs.	
45											
50											

Remarks:

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:	Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream	**Location:**	Levant, Maine	**Boring No.:**	BB-LBS-101A
				WIN:	27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/13-14/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	13+36, 8.3 ft Rt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor:	0.906	**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 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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.
50											
55											
60											
65							OH				
								63.1		66.2	
										Top of Bedrock at Elev. 63.1 ft. Roller coned ahead to 67.0 ft bgs.	
	R1	60/58	67.00 - 72.00	RQD = 77%			NQ-2			R1: Bedrock: Grey to dark grey, very fine to medium-grained, GRAYWACKE, interbedded with abundant layers of PHYLLITE, moderately hard, competent, fresh, joint set dipping at low angles, spaced moderately close, with quartz or calcite annealed fractures. [Vassalboro Formation] Rock Quality = Good R1: Core Times (min:sec) 67.0-68.0 ft (2:10) 68.0-69.0 ft (2:00) 69.0-70.0 ft (1:53) 70.0-71.0 ft (2:01) 71.0-72.0 ft (2:33) 97% Recovery	
70											
	R2	60/58	72.00 - 77.00	RQD = 77%						R2: Bedrock: Similar to R1.	
75											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-101A

WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/13-14/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	13+36, 8.3 ft Rt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor:	0.906	**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 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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.
75								52.3		[Vassalboro Formation] Rock Quality = Good R2: Core Times (min:sec) 72.0-73.0 ft (3:59) 73.0-74.0 ft (6:19) 74.0-75.0 ft (6:06) 75.0-76.0 ft (5:10) 76.0-77.0 ft (4:39) 97% Recovery 77.0 **Bottom of Exploration at 77.0 feet below ground surface.**	
80											
85											
90											
95											
100											

Remarks:

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-102
WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/5/2023-6/6/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	14+17.2, 7.4 ft Rt.	**Casing ID/OD:**	HW(4.0"/4.5"), NW(3.0"/3.5")	**Water Level*:**	10.0 ft bgs.
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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	129.4		4" HMA. 0.3	
										Occasional cobble.	
5	1D	24/17	5.00 - 7.00	14/8/10/12	18	27	38			Brown, moist, very stiff, SILT, some sand, little gravel, (Fill). Broken cobble in spoon. Set NW casing at 5.0 ft bgs.	
							47				
							48				
							55				
							40				
10							3	119.7		10.0	
	2D	24/12	11.00 - 13.00	4/2/5/3	7	11	10			Grey, wet, medium dense, SAND, little silt, trace gravel, trace organics, (Stream Alluvium with Wetland Deposits).	G#380931 A-2-4, SM WC=36.3%
							10				
							15			Clay in wash from 13.0-14.0 ft bgs.	
							25			Wash went from grey to dark brown from 14.0-14.5 ft bgs.	
15	3D	24/10	15.00 - 17.00	1/5/14/30	19	29	OPEN			Grey, wet, medium dense, Gravelly SAND, little silt, trace clay, (Stream Alluvium with Wetland Deposits).	G#380932 A-1-b, SC-SM WC=5.4% Non-Plastic
	V1		15.00 - 16.00	Su >4181 psf			HOLE	113.7		16x32 mm vane raw torque readings: V1: >26.6 in-lbs. 16.0	
20	4D	24/8	20.00 - 22.00	4/4/7/10	11	17	31			Olive-grey, wet, very stiff, SILT, some sand, little clay, trace gravel, (Glacial Till).	G#380933 A-4, CL-ML WC=22.7% LL=20 PL=15 PI=5
							38				
							54				
							81				
							136				
25											

Remarks:

1) Water level measured 6/6/2023 before resuming drilling.

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: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-102
WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/5/2023-6/6/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	14+17.2, 7.4 ft Rt.	**Casing ID/OD:**	HW(4.0"/4.5"), NW(3.0"/3.5")	**Water Level*:**	10.0 ft bgs.
Hammer Efficiency Factor:	0.906	**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 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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	5D	24/6	25.00 - 27.00	6/8/12/15	20	30	77			Similar to 4D.	
							90				
							86				
							97				
							159				
30							OPEN HOLE			Boulder from 29.7-32.7 ft bgs. Cored through boulder. Pulled NW casing and installed HW casing.	
35	6D	24/8	35.00 - 37.00	15/11/6/10	17	26				Olive-grey, wet, very stiff, SILT, some sand, little gravel, trace clay, (Glacial Till).	
40	7D	24/9	40.00 - 42.00	8/10/9/11	19	29				Similar to 6D.	
										Occasional Cobble.	
45	8D	24/15	45.00 - 47.00	11/6/9/24	15	23	41			Olive-grey, wet, very stiff, SILT, some sand, little gravel, (Glacial Till). Artisan water pressure at 45.0 ft bgs. Hole collapsed back to 40.0 ft after 8D sample. Set NW casing to telescope through boulder at 29.7 ft bgs.	G#380934 A-4, CL-ML WC=13.7%
							66				
							131				
							149				
							164				
50											

Remarks:

1) Water level measured 6/6/2023 before resuming drilling.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-102
WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/5/2023-6/6/2023	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	14+17.2, 7.4 ft Rt.	**Casing ID/OD:**	HW(4.0"/4.5"), NW(3.0"/3.5")	**Water Level*:**	10.0 ft bgs.
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
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S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
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N-uncorrected = Raw Field SPT N-value
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N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
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WC = Water Content, percent
LL = Liquid Limit
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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.
50	9D	9.6/5	50.00 - 50.80	13/50(3.6")	---		130	78.9		Olive-grey, wet, SILT, some sand, little gravel, trace clay, (Glacial Till). Bedrock in tip of spoon. — 50.8	
	R1	60/60	51.00 - 56.00	RQD = 75%			NQ-2			Top of Bedrock at Elev. 78.9 ft. Roller Coned ahead to 51.0 ft bgs. R1: Bedrock: Grey to dark grey, fine to medium-grained GRAYWACKE and thinly bedded PHYLLITE, moderately soft to hard, fresh, joint sets dipping at low to steep angles, closely spaced, with quartz or calcite annealed fractures. [Vassalboro Formation] Rock Quality = Fair R1: Core Times (min:sec) 51.0-52.0 ft (1:36) 52.0-53.0 ft (1:36) 53.0-54.0 ft (1:35) 54.0-55.0 ft (1:34) 55.0-56.0 ft (1:57) 100% Recovery	
55											
	R2	60/60	56.00 - 61.00	RQD = 78%						R2: Bedrock: Similar to R1. [Vassalboro Formation] Rock Quality = Good R2: Core Times (min:sec) 56.0-57.0 ft (2:04) 57.0-58.0 ft (2:28) 58.0-59.0 ft (2:23) 59.0-60.0 ft (2:28) 60.0-61.0 ft (3:53) 100% Recovery — 61.0	
60								68.7		**Bottom of Exploration at 61.0 feet below ground surface.**	
65											
70											
75											

Remarks:

1) Water level measured 6/6/2023 before resuming drilling.

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: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-103
WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	128.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/7/2023; 08:00-12:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	15+50.4, 8.2 ft Rt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	7.0 ft bgs.
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
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N-uncorrected = Raw Field SPT N-value
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N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
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WC = Water Content, percent
LL = Liquid Limit
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PI = Plasticity Index
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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	128.5		3½" HMA. 0.3	
5	1D	24/14	5.00 - 7.00	13/13/8/9	21	32	44			Brown, moist, dense, Gravelly SAND, little silt, (Fill).	
							35				
							31				
							30				
							33				
10	2D	24/8	10.00 - 12.00	11/10/10/15	20	30	25			Brown, wet, medium dense, Gravelly SAND, little silt, (Fill).	
							49				
							55				
							108	115.2		13.6 Wood in wash at 13.6 ft bgs.	
	3D	24/1	14.00 - 16.00	1/1/2/2	3	5	25			Dark brown, wet, medium stiff, PEAT, (Stream Alluvium with Wetland Deposits). Roller Coned ahead to 16.0 ft bgs.	
15							35				
	4D	24/1	16.00 - 18.00	2/2/3/3	5	8	19			Dark brown, wet, loose, Silty WOOD, trace gravel, trace sand, (Stream Alluvium with Wetland Deposits).	
							23				
							36			Wood chips and occasional dark brown coloring (presumed peat) in wash.	
							30				
20	5D	14.4/1	20.00 - 21.20	4/4/50(2.4")	---		25			Dark brown, wet, WOOD, little silt, trace gravel, trace sand, (Stream Alluvium with Wetland Deposits). a60 blows for 0.3 ft.	
	R1	31.2/18	21.30 - 23.90	RQD = 0%			a60 NQ-2	107.5		21.3 Top of Bedrock at Elev. 107.5 ft.	
	R2	28.8/27	23.90 - 26.30	RQD = 69%						R1: Bedrock: Grey to dark grey, fine to medium-grained, GRAYWACKE interbedded with PHYLLITE, moderately soft to moderately hard, fresh, thinly bedded, steeply dipping joint set, closely spaced, with small quartz or calcite annealed fractures. [Vassalboro Formation]	
25											

Remarks:

1) Water level measured immediately after drilling.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-103

WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	128.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/7/2023; 08:00-12:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	15+50.4, 8.2 ft Rt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	7.0 ft bgs.
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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HSA = Hollow Stem Auger
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WOR/C = Weight of Rods or Casing
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S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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										Rock Quality = Very Poor R1: Core Times (min:sec) 21.3-22.3 ft (2:27) 22.3-24.3 ft (4:48) Lost water at 22.8 ft bgs. 23.3-23.9 ft (3:15) 58% Recovery	
	R3	60/58	26.30 - 31.30	RQD = 63%						R2: Bedrock: Similar to R1. [Vassalboro Formation] Rock Quality = Fair R2: Core Times (min:sec) 23.9-24.3 ft (1:11) 24.3-25.3 ft (2:00) 25.3-26.3 ft (1:48) 93% Recovery	
30								97.5		R3: Bedrock: Grey to dark grey, very fine to medium-grained, GRAYWACKE interbedded with zones of PHYLLITE, moderately hard, fresh, joint sets moderately dipping to steep, closely spaced, with quartz or calcite annealed fractures, sulfide-rich zone highlighted by weakly oxidized base metal minerals. [Vassalboro Formation] Rock Quality = Fair R3: Core Times (min:sec) 26.3-27.3 ft (2:05) 27.3-28.3 ft (2:24) 28.3-29.3 ft (3:16) 29.3-30.3 ft (3:03) 30.3-31.3 ft (3:19) 97% Recovery	
35										31.3 **Bottom of Exploration at 31.3 feet below ground surface.**	
40											
45											
50											

Remarks:

1) Water level measured immediately after drilling.

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: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-201

WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.9	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/26/2023; 08:30-14:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	14+21.2, 7.3 ft Lt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.906	**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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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	129.6		3½" HMA. 0.3	
5	1D	24/14	5.00 - 7.00	6/9/12/16	21	32	SPUN NW			Brown, moist, hard, SILT, little sand, little gravel, (Fill).	
								120.9		9.0	
10	2D	24/12	10.00 - 12.00	2/2/3/3	5	8				Grey, wet, medium stiff, SILT, trace clay, trace sand, (Stream Alluvium with Wetland Deposits).	
	3D/A	24/16	12.00 - 14.00	3/4/5/5	9	14				3D (Top 8") Grey, wet, stiff, SILT, some fine sand, trace clay, (Stream Alluvium with Wetland Deposits). 3D/A (Bottom 8") Dark grey-brown, wet, stiff, SILT, little peat, little sand, (Stream Alluvium with Wetland Deposits).	#380876 Non-Plastic #380877 WC=70.5% Ignition Loss 13.7%
	4D	24/4	14.00 - 16.00	6/8/5/4	13	20				Grey, wet, very stiff, Sandy SILT, trace clay, (Stream Alluvium with Wetland Deposits).	
15								113.9		16.0	
	5D	24/6	16.00 - 18.00	3/8/13/18	21	32				Grey, wet, dense, Silty SAND, some gravel, trace clay, (Glacial Till).	
	6D	24/8	18.00 - 20.00	6/8/10/14	18	27				Olive-grey, wet, very stiff, Sandy SILT, trace clay, trace gravel, (Glacial Till).	
20											
25											

Remarks:

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

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream **Location:** Levant, Maine	**Boring No.:** BB-LBS-201 **WIN:** 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.9	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/26/2023; 08:30-14:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	14+21.2, 7.3 ft Lt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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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 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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										Artesian water pressure at 25.0 ft bgs.	
30										Artesian water pressure at 30.0 ft bgs.	
35											
										Cored through cobble from 38.5-38.9 ft bgs.	
40											
45											
								82.7		47.2	
	R1	60/60	47.20 - 52.20	RQD = 83%			NQ-2			Top of Bedrock at Elev. 82.7 ft. R1: Bedrock: Grey to dark grey, fine to medium-grained, GRAYWACKE interbedded with PHYLLITE, moderately hard, fresh, thinly bedded, joint sets dipping at low to moderate angles, closely	
50											

Remarks:

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:** Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream **Location:** Levant, Maine	**Boring No.:** BB-LBS-201 **WIN:** 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.9	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/26/2023; 08:30-14:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	14+21.2, 7.3 ft Lt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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
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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.
50										spaced, with significant quartz or calcite annealed fractures. [Vassalboro Formation] Rock Quality = Good R1: Core Times (min:sec) 47.2-48.2 ft (4:02) 48.2-49.2 ft (3:12) 49.2-50.2 ft (3:31) 50.2-51.2 ft (3:02) 51.2-52.2 ft (4:47) 100% Recovery	
	R2	60/60	52.20 - 57.20	RQD = 75%							
55										R2: Bedrock: Grey to dark grey, fine to medium-grained, GRAYWACKE interbedded with PHYLLITE, moderately hard, fresh, joint sets steeply dipping, closely spaced, with quartz or calcite annealed fractures. [Vassalboro Formation] Rock Quality = Fair R2: Core Times (min:sec) 52.2-53.2 ft (3:16) 53.2-54.2 ft (2:51) 54.2-55.2 ft (1:58) 55.2-56.2 ft (1:52) 56.2-57.2 ft (1:55) 100% Recovery	
								72.7		57.2 **Bottom of Exploration at 57.2 feet below ground surface.**	
60											
65											
70											
75											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream	**Boring No.:**	BB-LBS-202
Location:	Levant, Maine	**WIN:**	27098.00

Driller:	MaineDOT	**Elevation (ft.)**	128.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/25/2023; 13:15-15:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	15+31.7, 6.0 ft Rt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	10.0 ft bgs.
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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	128.6		3" HMA. 0.3	
5	1D	24/14	5.00 - 7.00	8/8/9/8	17	26	32			Brown, moist, medium dense, Gravelly SAND, little silt, (Fill).	G#380878 A-1-a, SM WC=4.3%
							37				
							35				
							37				
							29				
10	2D	24/8	10.00 - 12.00	5/5/10/11	15	23	NW			Brown, wet, medium dense, Gravelly SAND, little silt, (Fill).	
	3D/A	24/14	12.00 - 14.00	10/7/15/13	22	33				3D (Top 8") Similar to 2D, except dense. 3D/A (Bottom 6") Brown, wet, dense, Silty GRAVEL, little sand, little peat, trace wood, (Fill).	
								114.8		14.0	
	4D/A	24/8	14.00 - 16.00	3/3/2/2	5	8				4D (Top 5") Grey-brown, wet, medium stiff, Silty CLAY, trace gravel, trace peat, (Stream Alluvium with Wetland Deposits). 4D/A (Bottom 3") Dark brown, wet, medium stiff, SILT, some peat, trace sand, (Stream Alluvium with Wetland Deposits).	#380879 A-7-5, OH WC=50.0% LL=62 PL=45 PI=17
15											
	5D	24/24	16.00 - 18.00	1/1/2/3	3	5				5D Black, wet, medium stiff, PEAT, some silt, trace sand, (Stream Alluvium with Wetland Deposits).	#380880 WC=431% Ignition Loss 67.4%
	6D	24/21	18.00 - 20.00	1/2/1/2	3	5				6D Similar to 5D.	#317731 pH=5.22
20	7D/A	24/17	20.00 - 22.00	4/8/2/4	10	15				7D (Top 8") Black, wet, stiff, Silty PEAT, trace sand, (Stream Alluvium with Wetland Deposits).	
								107.8		21.0 7D/A (Bottom 9") Grey, wet, stiff, Clayey SILT, trace sand, (Glacial Till).	G#380881 A-4, CL WC=31.3% LL=28 PL=20 PI=8
	8D	24/8	22.00 - 24.00	7/17/17/18	34	51				Grey, wet, hard, Sandy SILT, little gravel, trace clay, (Glacial Till).	
	9D	9.6/9	24.00 - 24.80	18/50(3.6")	---					Grey, wet, SILT, some sand, trace clay, trace gravel, (Glacial Till).	
25								104.0		24.8	

Remarks:

1) Water level measured immediately after drilling.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-202

WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	128.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/25/2023; 13:15-15:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	15+31.7, 6.0 ft Rt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	10.0 ft bgs.
Hammer Efficiency Factor:	0.906	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
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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 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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										**Bottom of Exploration at 24.8 feet below ground surface.** REFUSAL, presumed Top of Rock at El. 104.0 ft.	
30											
35											
40											
45											
50											

Remarks:

1) Water level measured immediately after drilling.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream
Location: Levant, Maine

Boring No.: BB-LBS-203
WIN: 27098.00

Driller:	MaineDOT	**Elevation (ft.)**	129.0	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/25/2023; 09:30-13:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	15+49.6, 7.2 ft Lt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	9.0 ft bgs.
Hammer Efficiency Factor:	0.906	**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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
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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	128.8		3" HMA. 0.3	
5	1D	24/5	5.00 - 7.00	9/11/13/13	24	36				Brown, moist, dense, Gravelly SAND, little silt, (Fill).	
10	2D	24/8	10.00 - 12.00	9/12/14/14	26	39	NW			Similar to 1D, except wet.	
	3D	24/12	12.00 - 14.00	22/18/26/22	44	66				Grey-brown, wet, very dense, Gravelly SAND, little silt, (Fill).	G#380882 A-1-a, SM WC=8.4%
	4D	24/4	14.00 - 16.00	15/19/9/9	28	42		115.0		14.0 Brown, wet, WOOD, trace sand, (Stream Alluvium with Wetland Deposits).	
15	5D	24/15	16.00 - 18.00	6/6/6/4	12	18				Black, wet, stiff, Silty PEAT, trace sand, (Stream Alluvium with Wetland Deposits).	
	MD		18.00 - 20.00	5/6/3/3	9	14				PEAT and WOOD in wash.	
	MD		19.00 - 21.00								
20							OPEN HOLE	108.7		20.3	
	6D	24/11	21.00 - 23.00	2/3/8/13	11	17				Olive-grey, wet, very stiff, Sandy SILT, trace clay, trace gravel, (Glacial Till).	
	7D	19.2/8	23.00 - 24.60	9/12/10/50(1.2")	22	33				Similar to 6D, except hard. Presumed bedrock in tip of spoon.	
25								104.4		24.6	

Remarks:

1) Water level measured immediately after drilling.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Perkins Bridge #6133, Lake Bridge #3359 carries Lake Road over Black Stream	**Boring No.:**	BB-LBS-203		
Location:	Levant, Maine	**WIN:**	27098.00		
Driller:	MaineDOT	**Elevation (ft.)**	129.0	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	N. Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/25/2023; 09:30-13:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	15+49.6, 7.2 ft Lt.	**Casing ID/OD:**	NW(3.0"/3.5")	**Water Level*:**	9.0 ft bgs.
Hammer Efficiency Factor:	0.906	**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 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained 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										**Bottom of Exploration at 24.6 feet below ground surface.** REFUSAL, presumed Top of Rock at El. 104.4 ft.	
30											
35											
40											
45											
50											

Remarks:

1) Water level measured immediately after drilling.

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.

<u>Appendix B</u>

Rock Core Photographs

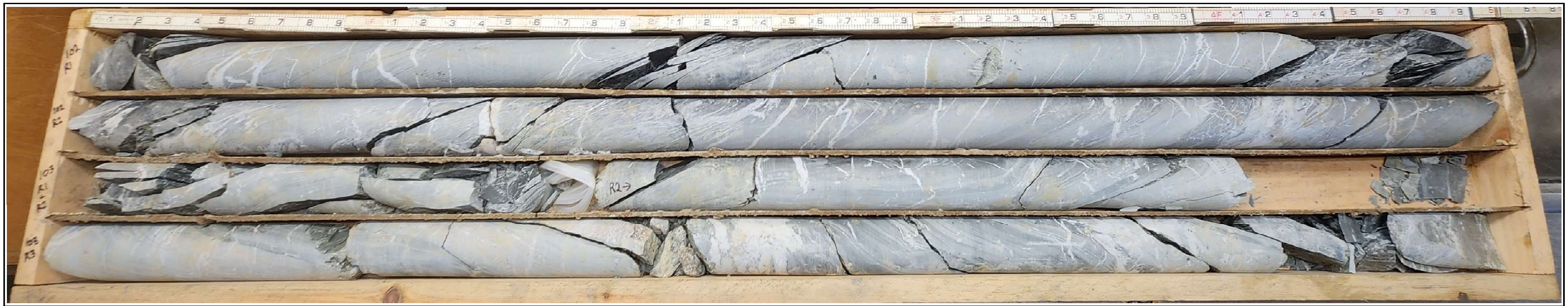
MaineDOT
Perkins Bridge #6133, Lake Bridge #3359 Carries Lake Road Over Black Stream
Levant, ME
Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-LBS-101A	R1	67.0-72.0	60	58	46	77	GRAYWACKE/PHYLLITE	1
BB-LBS-101A	R2	72.0-77.0	60	58	46	77	GRAYWACKE/PHYLLITE	2

Notes: 1. “Box row” indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Top of each core run is on the left and increases with depth to the right.

MaineDOT
Perkins Bridge #6133, Lake Bridge #3359 Carries Lake Road Over Black Stream
Levant, ME
Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-LBS-102	R1	51.0-56.0	60	60	45	75	GRAYWACKE/PHYLLITE	1
BB-LBS-102	R2	56.0-61.0	60	60	47	78	GRAYWACKE/PHYLLITE	2
BB-LBS-103	R1	21.3-23.9	31.2	18	0	0	GRAYWACKE/PHYLLITE	3
BB-LBS-103	R2	23.9-26.3	28.8	27	20	69	GRAYWACKE/PHYLLITE	3
BB-LBS-103	R3	26.3-31.3	60	58	38	63	GRAYWACKE/PHYLLITE	4



Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Top of each core run is on the left and increases with depth to the right.

MaineDOT

MaineDOT
Perkins Bridge #6133, Lake Bridge #3359 Carries Lake Road Over Black Stream
Levant, ME
Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-LBS-201	R1	47.2-52.2	60	60	50	83	GRAYWACKE/PHYLLITE	1
BB-LBS-201	R2	52.2-57.2	60	60	45	75	GRAYWACKE/PHYLLITE	2

Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Top of each core run is on the left and increases with depth to the right.

Appendix C

Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Levant Work Number: 27098.00

Boring & Sample Identification Number	Station (Feet)	Offset (Feet)	Depth (Feet)	Reference Number	G.S.D.C. Sheet	W.C. %	L.L.	P.I.	Classification		
									Unified	AASHTO	Frost
BB-LBS-101, 1D	13+33.4	7.9 Rt.	5.0-7.0	380926	1	16.1			CL-ML	A-4	IV
BB-LBS-101, 3D	13+33.4	7.9 Rt.	15.0-17.0	380927	1	10.8	20	6	CL-ML	A-4	IV
BB-LBS-101, 4D	13+33.4	7.9 Rt.	20.0-22.0	380928	1	10.2	20	6	CL-ML	A-4	IV
BB-LBS-101, 6D	13+33.4	7.9 Rt.	30.0-32.0	380929	1	11.5	21	7	CL-ML	A-4	IV
BB-LBS-101A, S1	13+36	8.3 Rt.	9.0-10.0	380930	1	34.0			CL	A-4	IV
BB-LBS-102, 2D	14+17.2	7.4 Rt.	11.0-13.0	380931	2	36.3			SM	A-2-4	II
BB-LBS-102, 3D	14+17.2	7.4 Rt.	15.0-17.0	380932	2	5.4	-N	P-	SC-SM	A-1-b	II
BB-LBS-102, 4D	14+17.2	7.4 Rt.	20.0-22.0	380933	2	22.7	20	5	CL-ML	A-4	IV
BB-LBS-102, 8D	14+17.2	7.4 Rt.	45.0-47.0	380934	2	13.7			CL-ML	A-4	IV
BB-LBS-201, 3D	14+21.2	7.3 Lt.	12.0-12.67	380876	---	---	-N	P-	---	---	---
BB-LBS-201, 3D/A	14+21.2	7.3 Lt.	13.3-14.0	380877	---	70.5	Loss on Ignition (T 267) 13.7%				
BB-LBS-202, 1D	15+31.7	6.0 Rt.	5.0-7.0	380878	3	4.3			SM	A-1-a	II
BB-LBS-202, 4D	15+31.7	6.0 Rt.	14.0-14.42	380879	---	50.0	62	17	OH	A-7-5	III
BB-LBS-202, 5D	15+31.7	6.0 Rt.	16.0-18.0	380880	---	431	Loss on Ignition (T 267) 67.4%				
BB-LBS-202, 6D	15+31.7	6.0 Rt.	18.0-20.0	317731	---	pH 5.22 by GeoTesting Express					
BB-LBS-202, 7D/A	15+31.7	6.0 Rt.	21.25-22.0	380881	3	31.3	28	8	CL	A-4	IV
BB-LBS-203, 3D	15+49.6	7.2 Lt.	12.0-14.0	380882	3	8.4			SM	A-1-a	II

Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MaineDOT and Corps of Engineers Classification Systems.

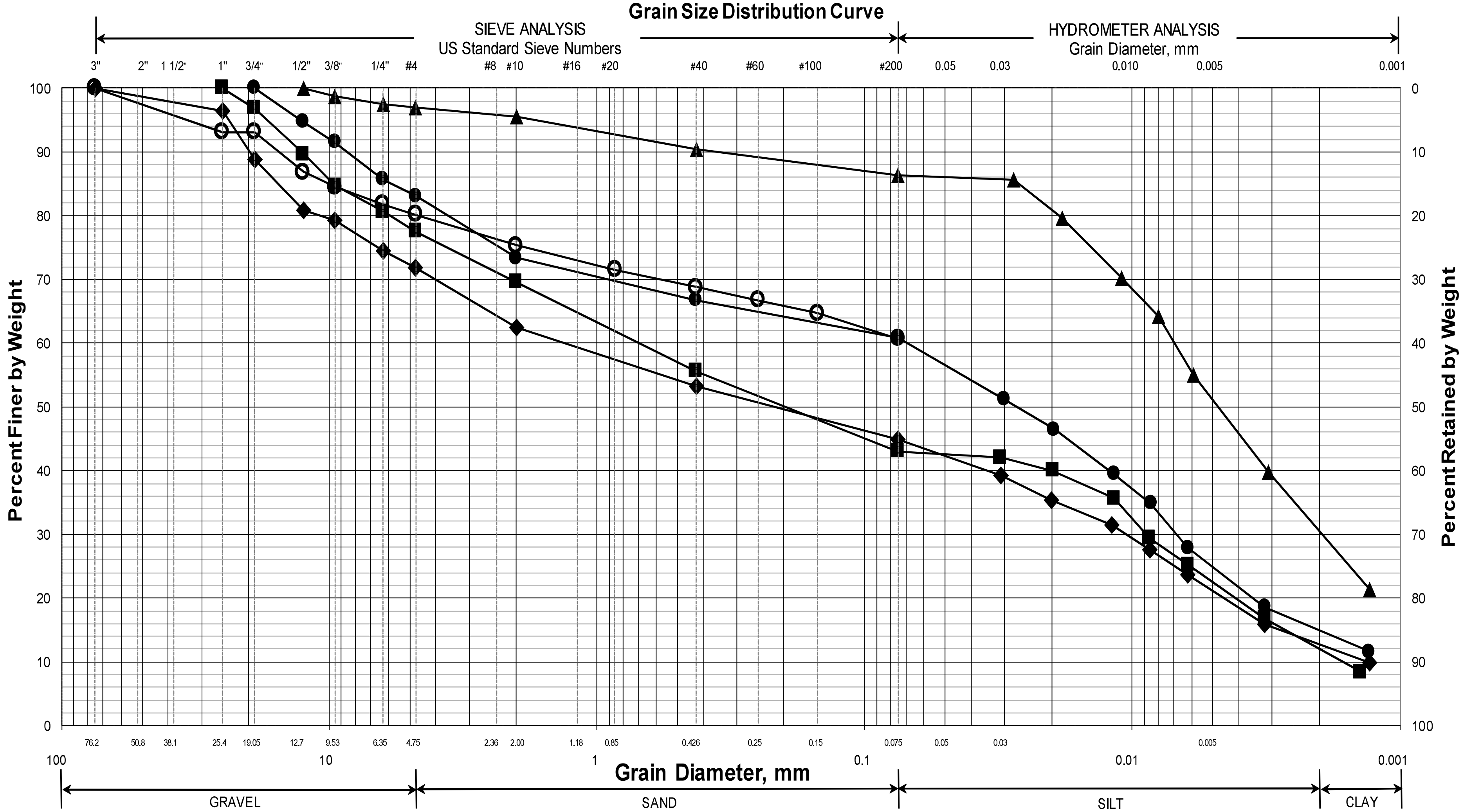
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

LL = Liquid limit as determined by AASHTO T 89-96 and/or ASTM D 4318-98 NP = Non Plastic

PI = Plasticity Index as determined by AASHTO 90-96 and/or ASTM D4318-98

Maine Department of Transportation
Grain Size Distribution Curve



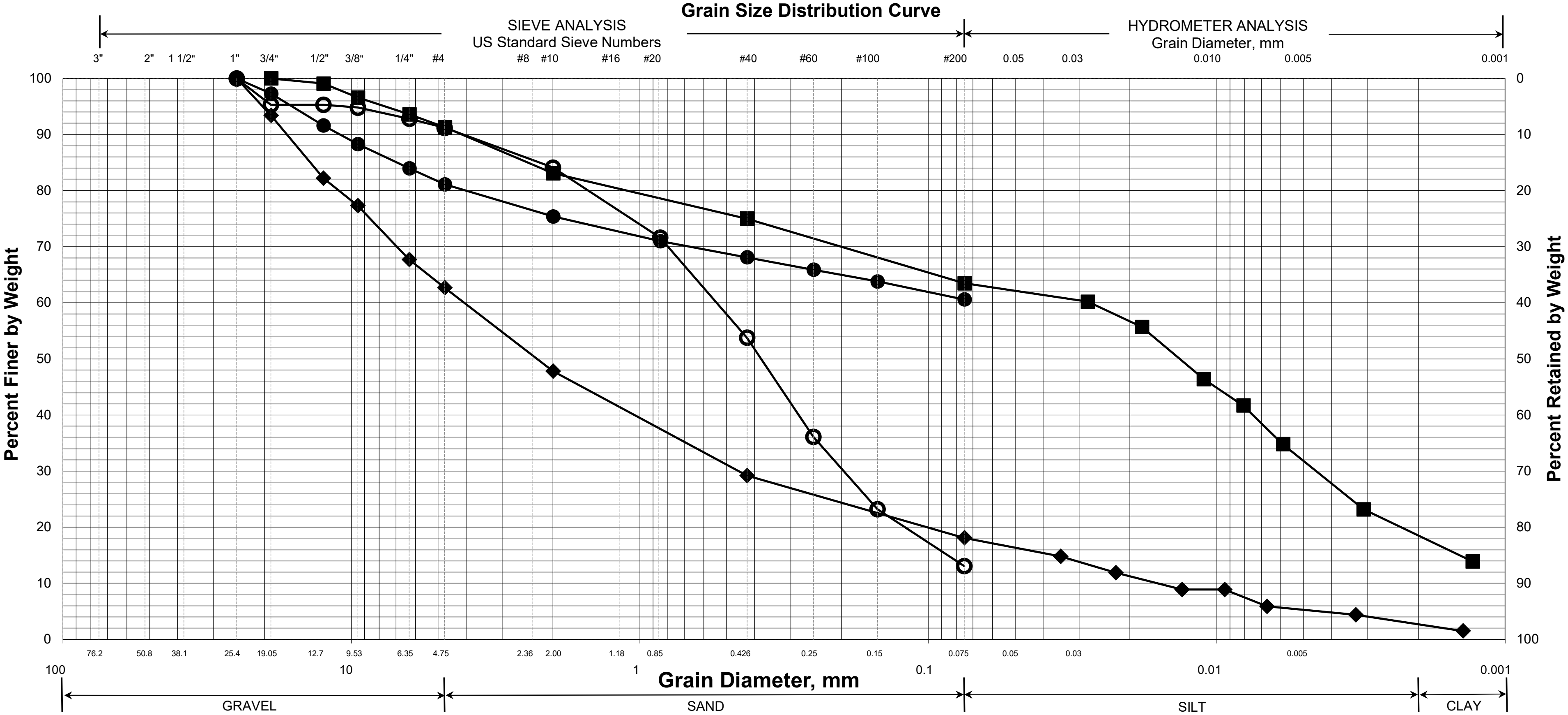
UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	BB-LBS-101/1D	13+33.4	7.9 RT	5.0-7.0	SILT, little sand, little gravel.	16.1			
◆	BB-LBS-101/3D	13+33.4	7.9 RT	15.0-17.0	SILT, some gravel, some sand, little clay.	10.8	20	14	6
■	BB-LBS-101/4D	13+33.4	7.9 RT	20.0-22.0	SAND, some silt, some gravel, little clay.	10.2	20	14	6
●	BB-LBS-101/6D	13+33.4	7.9 RT	30.0-32.0	SILT, some sand, little gravel, little clay.	11.5	21	14	7
▲	BB-LBS-101A/S1	13+36	8.3 RT	9.0-10.0	SILT, some clay, little sand, trace gravel.	34			
×									

WIN	
027098.00	
Town	
Levant	
Reported by/Date	
WHITE, TERRY A	7/18/2023

SHEET 1

Maine Department of Transportation
Grain Size Distribution Curve



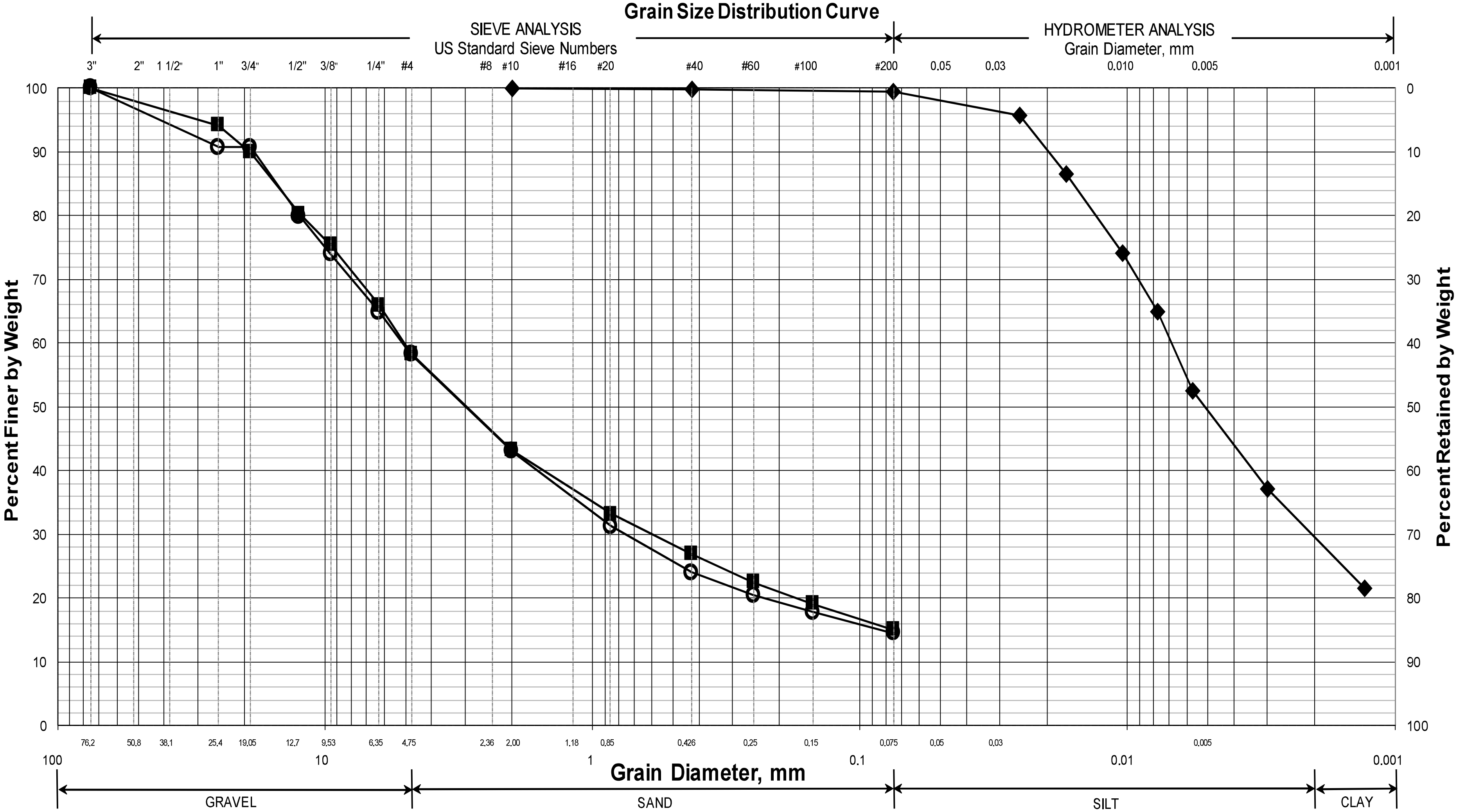
UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	BB-LBS-102/2D	14+17.2	7.4 RT	11.0-13.0	SAND, little silt, trace gravel.	36.3			
◆	BB-LBS-102/3D	14+17.2	7.4 RT	15.0-17.0	Gravelly SAND, little silt, trace clay.	5.4			NP
■	BB-LBS-102/4D	14+17.2	7.4 RT	20.0-22.0	SILT, some sand, little clay, trace gravel.	22.7	20	15	5
●	BB-LBS-102/8D	14+17.2	7.4 RT	45.0-47.0	SILT, some sand, little gravel.	13.7			
▲									
×									

WIN	
027098.00	
Town	
Levant	
Reported by/Date	
WHITE, TERRY A	7/18/2023

SHEET 2

Maine Department of Transportation
Grain Size Distribution Curve



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	BB-LBS-202/1D	15+31.7	6.0 RT	5.0-7.0	Gravelly SAND, little silt.	4.3			
◆	BB-LBS-202/7D(A)	15+31.7	6.0 RT	21.25-22.0	Clayey SILT, trace sand.	31.3	28	20	8
■	BB-LBS-203/3D	15+49.6	7.2 LT	12.0-14.0	Gravelly SAND, little silt.	8.4			
●									
▲									
×									

WIN	
027098.00	
Town	
Levant	
Reported by/Date	
WHITE, TERRY A	9/14/2023

SHEET 3

12 Desert Rd, Freeport   MaineDOT TESTING LABORATORIES   219 Hogan Rd, Bangor

MaineDOT

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380927	BB-LBS-101/3D	GEOTECHNICAL (DISTURBED)	6/7/2023	6/26/2023

Sample Type: **GEOTECHNICAL** Location: Station: **13+33.4** Offset, ft: **7.9** **RT** Dbfg, ft: **15.0-17.0**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	100.0
1 in. [25.0 mm]	96.5
¾ in. [19.0 mm]	88.9
½ in. [12.5 mm]	80.9
⅜ in. [9.5 mm]	79.2
¼ in. [6.3 mm]	74.4
No. 4 [4.75 mm]	71.9
No. 10 [2.00 mm]	62.5
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	53.3
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	44.9
[0.0310 mm]	39.3
[0.0201 mm]	35.4
[0.0119 mm]	31.4
[0.0086 mm]	27.6
[0.0062 mm]	23.6
[0.0032 mm]	15.8
[0.0013 mm]	9.8

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	20
Plastic Limit (T 90), %	14
Plasticity Index (T 90), %	6
Specific Gravity, Corrected to 20°C (T 100)	2.60
Loss on Ignition, % (T 267)	
Water Content (T 265), %	10.8

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

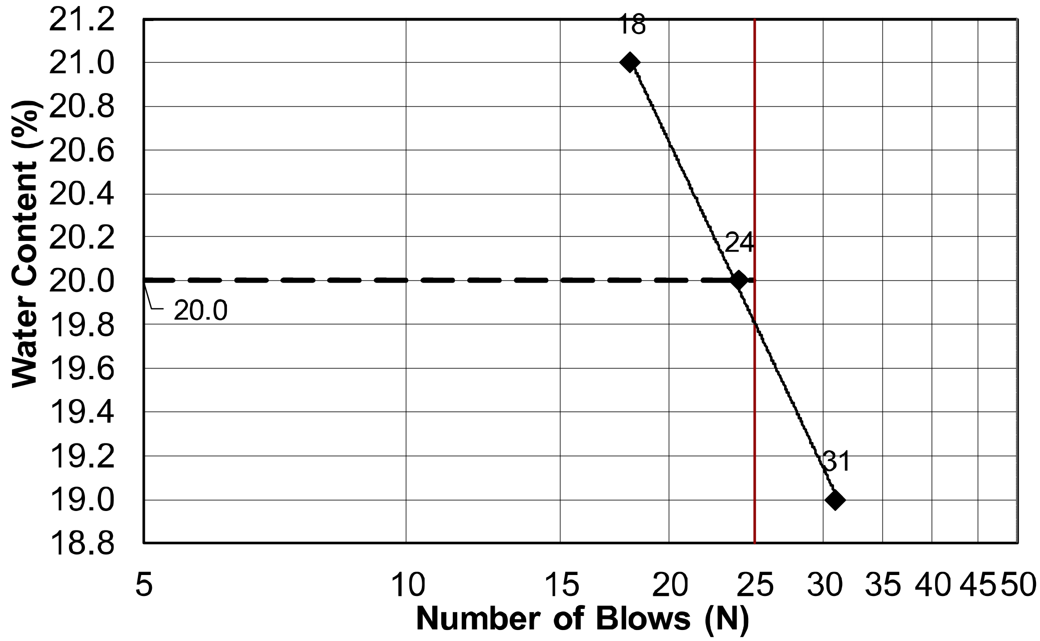
Comments:

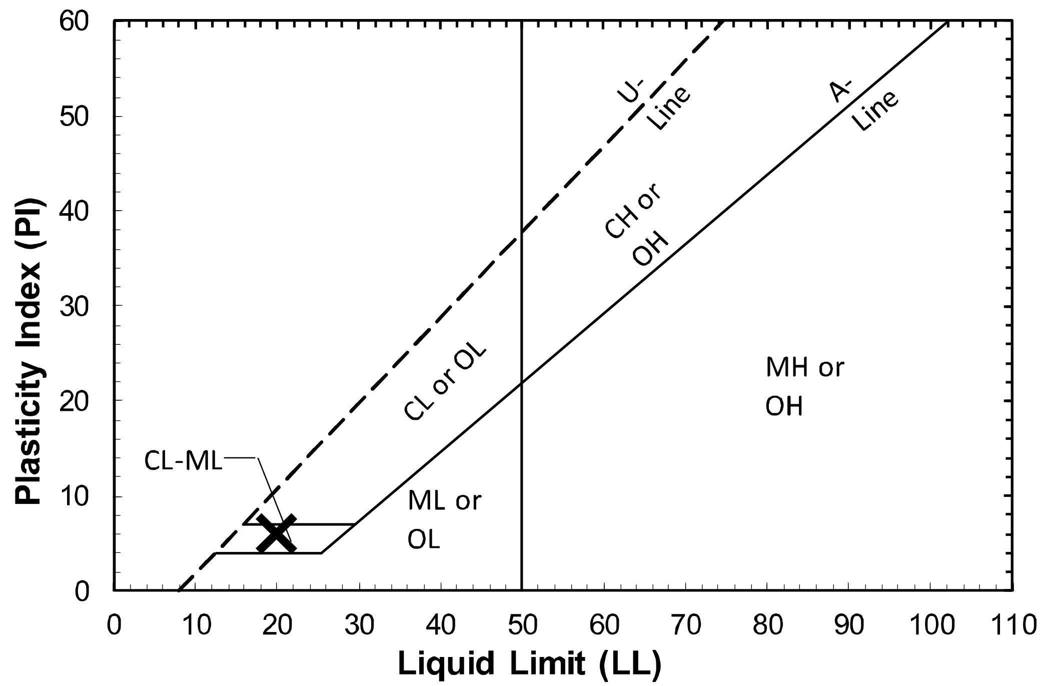
AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **7/14/2023**

Paper Copy: Lab File; Project File; Geotech File

TOWN	Levant	Reference No.	380927
WIN	027098.00	Water Content, %	10.8
Sampled	6/7/2023	Liquid Limit @ 25 blows (T 89), %	20
Boring No./Sample No.	BB-LBS-101/3D	Plastic Limit (T 90), %	14
Station	13+33.4	Plasticity Index (T 90), %	6
Depth	15.0-17.0	Tested By	BBURR





GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380928	BB-LBS-101/4D	GEOTECHNICAL (DISTURBED)	6/7/2023	6/26/2023

Sample Type: **GEOTECHNICAL** Location: Station: **13+33.4** Offset, ft: **7.9** **RT** Dbfg, ft: **20.0-22.0**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	100.0
¾ in. [19.0 mm]	96.8
½ in. [12.5 mm]	89.7
⅜ in. [9.5 mm]	84.7
¼ in. [6.3 mm]	80.6
No. 4 [4.75 mm]	77.5
No. 10 [2.00 mm]	69.6
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	55.6
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	43.0
[0.0310 mm]	42.0
[0.0198 mm]	40.0
[0.0117 mm]	35.7
[0.0086 mm]	29.4
[0.0062 mm]	25.2
[0.0032 mm]	16.8
[0.0014 mm]	8.4

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	20
Plastic Limit (T 90), %	14
Plasticity Index (T 90), %	6
Specific Gravity, Corrected to 20°C (T 100)	2.58
Loss on Ignition, % (T 267)	
Water Content (T 265), %	10.2

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

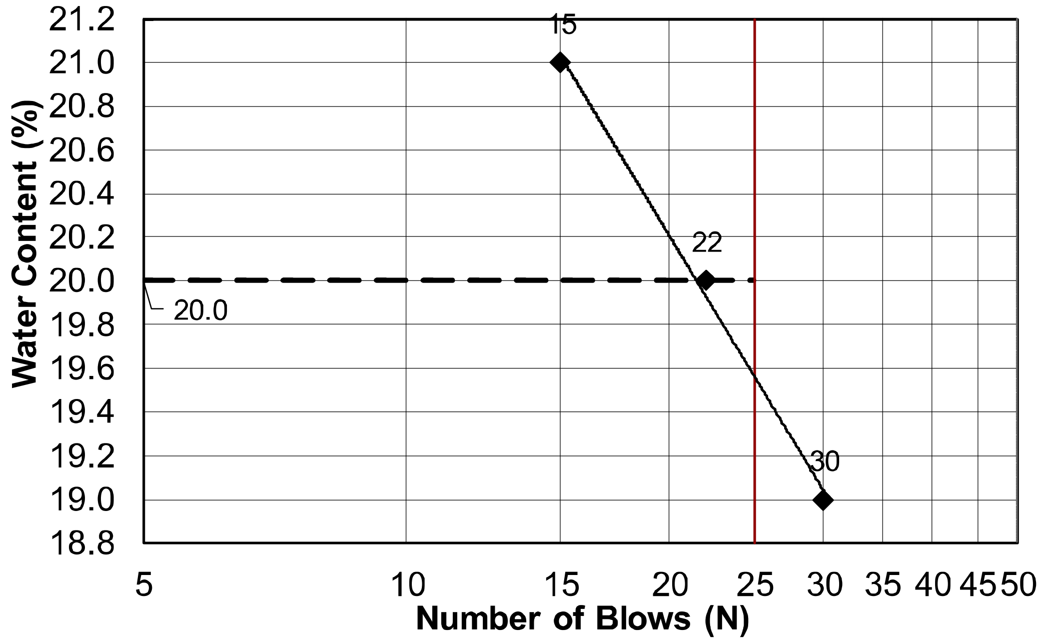
Comments:

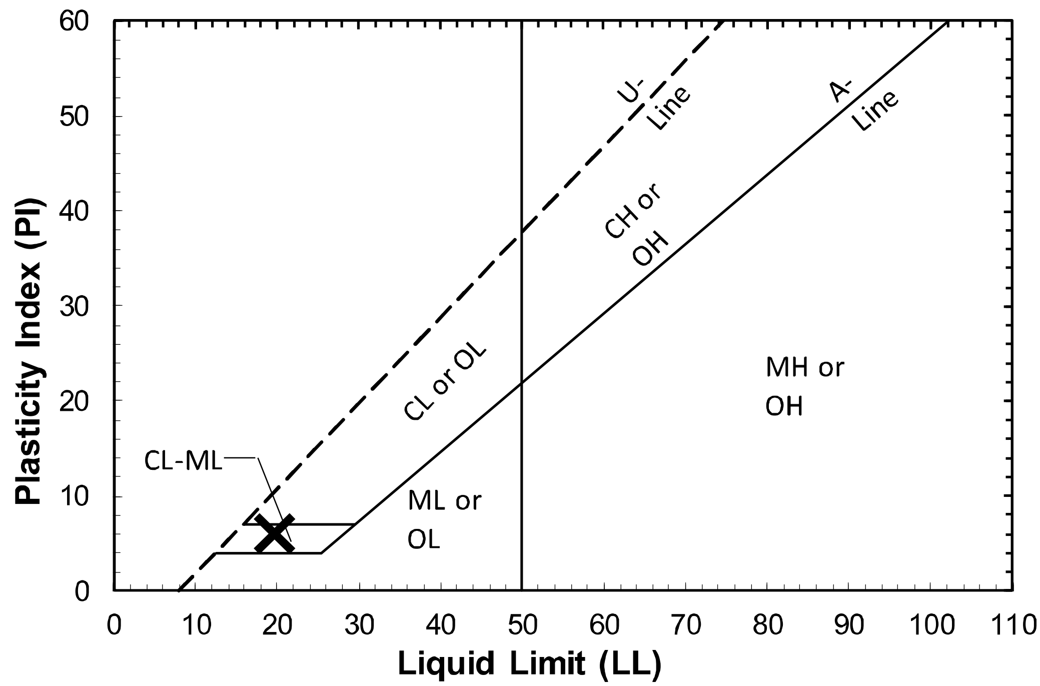
AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **7/14/2023**

Paper Copy: Lab File; Project File; Geotech File

TOWN	Levant	Reference No.	380928
WIN	027098.00	Water Content, %	10.2
Sampled	6/7/2023	Liquid Limit @ 25 blows (T 89), %	20
Boring No./Sample No.	BB-LBS-101/4D	Plastic Limit (T 90), %	14
Station	13+33.4	Plasticity Index (T 90), %	6
Depth	20.0-22.0	Tested By	BBURR





GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380929	**BB-LBS-101/6D**	**GEOTECHNICAL (DISTURBED)**	**6/7/2023**	**6/26/2023**

Sample Type: **GEOTECHNICAL** Location: Station: **13+33.4** Offset, ft: **7.9** **RT** Dbfg, ft: **30.0-32.0**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	**100.0**
½ in. [12.5 mm]	**94.7**
⅜ in. [9.5 mm]	**91.5**
¼ in. [6.3 mm]	**85.7**
No. 4 [4.75 mm]	**83.1**
No. 10 [2.00 mm]	**73.4**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**66.7**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**60.8**
[0.0300 mm]	**51.2**
[0.0196 mm]	**46.5**
[0.0117 mm]	**39.5**
[0.0085 mm]	**34.9**
[0.0062 mm]	**27.9**
[0.0032 mm]	**18.6**
[0.0013 mm]	**11.6**

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	**21**
Plastic Limit (T 90), %	**14**
Plasticity Index (T 90), %	**7**
Specific Gravity, Corrected to 20°C (T 100)	**2.61**
Loss on Ignition, % (T 267)	
Water Content (T 265), %	**11.5**

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

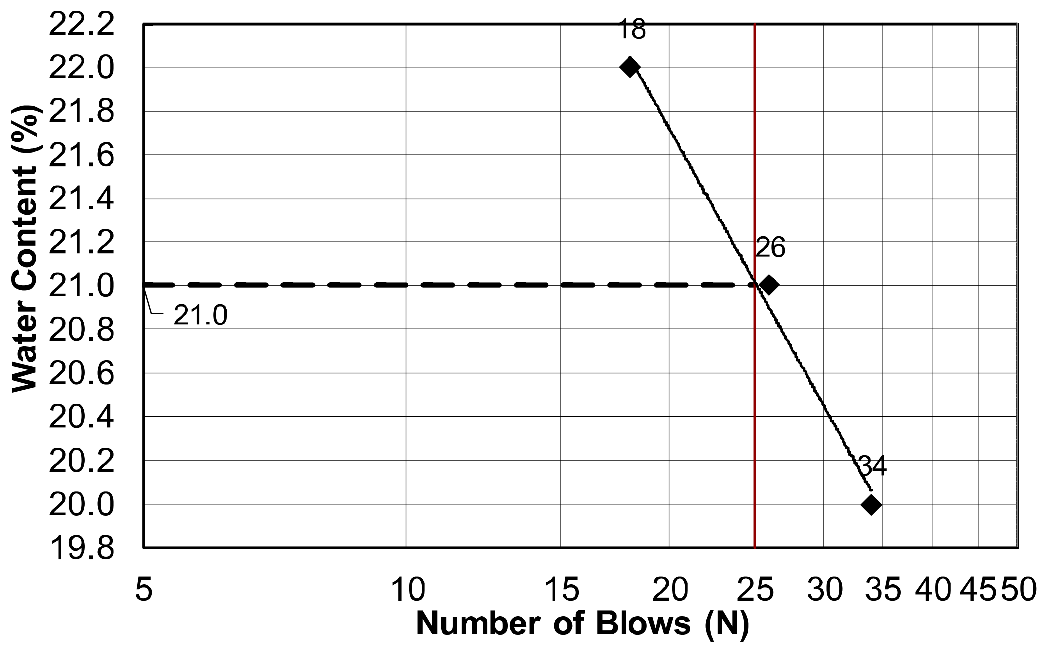
Comments:

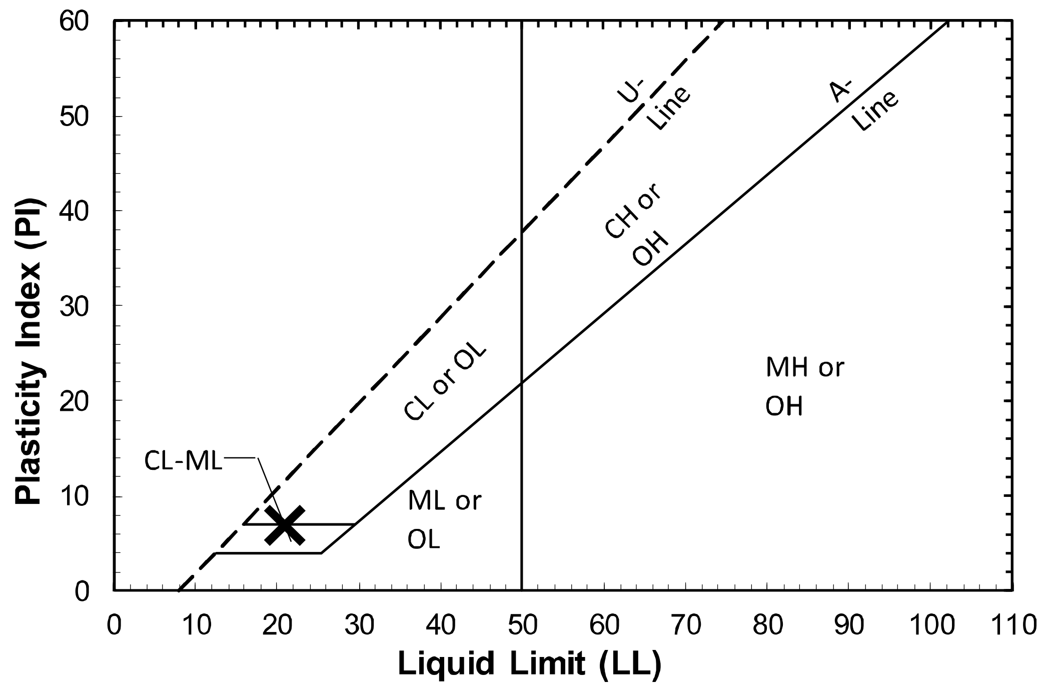
AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **7/15/2023**

Paper Copy: Lab File; Project File; Geotech File

TOWN	Levant	Reference No.	380929
WIN	027098.00	Water Content, %	11.5
Sampled	6/7/2023	Liquid Limit @ 25 blows (T 89), %	21
Boring No./Sample No.	BB-LBS-101/6D	Plastic Limit (T 90), %	14
Station	13+33.4	Plasticity Index (T 90), %	7
Depth	30.0-32.0	Tested By	BBURR





GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380932	**BB-LBS-102/3D**	**GEOTECHNICAL (DISTURBED)**	**6/5/2023**	**6/26/2023**

Sample Type: **GEOTECHNICAL** Location: Station: **14+17.2** Offset, ft: **7.4** **RT** Dbfg, ft: **15.0-17.0**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	**100.0**
¾ in. [19.0 mm]	**93.4**
½ in. [12.5 mm]	**82.2**
⅜ in. [9.5 mm]	**77.3**
¼ in. [6.3 mm]	**67.7**
No. 4 [4.75 mm]	**62.7**
No. 10 [2.00 mm]	**47.8**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**29.2**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**18.1**
[0.0348 mm]	**14.8**
[0.0224 mm]	**11.9**
[0.0132 mm]	**8.9**
[0.0094 mm]	**8.9**
[0.0067 mm]	**5.9**
[0.0033 mm]	**4.4**
[0.0014 mm]	**1.5**

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	**NP**
Specific Gravity, Corrected to 20°C (T 100)	**2.59**
Loss on Ignition, % (T 267)	
Water Content (T 265), %	**5.4**

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **7/14/2023**

Paper Copy: Lab File; Project File; Geotech File

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380933	**BB-LBS-102/4D**	**GEOTECHNICAL (DISTURBED)**	**6/5/2023**	**6/26/2023**

Sample Type: **GEOTECHNICAL** Location: Station: **14+17.2** Offset, ft: **7.4** **RT** Dbfg, ft: **20.0-22.0**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	**100.0**
½ in. [12.5 mm]	**99.1**
⅜ in. [9.5 mm]	**96.6**
¼ in. [6.3 mm]	**93.6**
No. 4 [4.75 mm]	**91.3**
No. 10 [2.00 mm]	**83.1**
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	**75.0**
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	**63.5**
[0.0280 mm]	**60.2**
[0.0182 mm]	**55.7**
[0.0111 mm]	**46.4**
[0.0081 mm]	**41.7**
[0.0059 mm]	**34.8**
[0.0031 mm]	**23.2**
[0.0013 mm]	**13.9**

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	**20**
Plastic Limit (T 90), %	**15**
Plasticity Index (T 90), %	**5**
Specific Gravity, Corrected to 20°C (T 100)	**2.63**
Loss on Ignition, % (T 267)	
Water Content (T 265), %	**22.7**

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

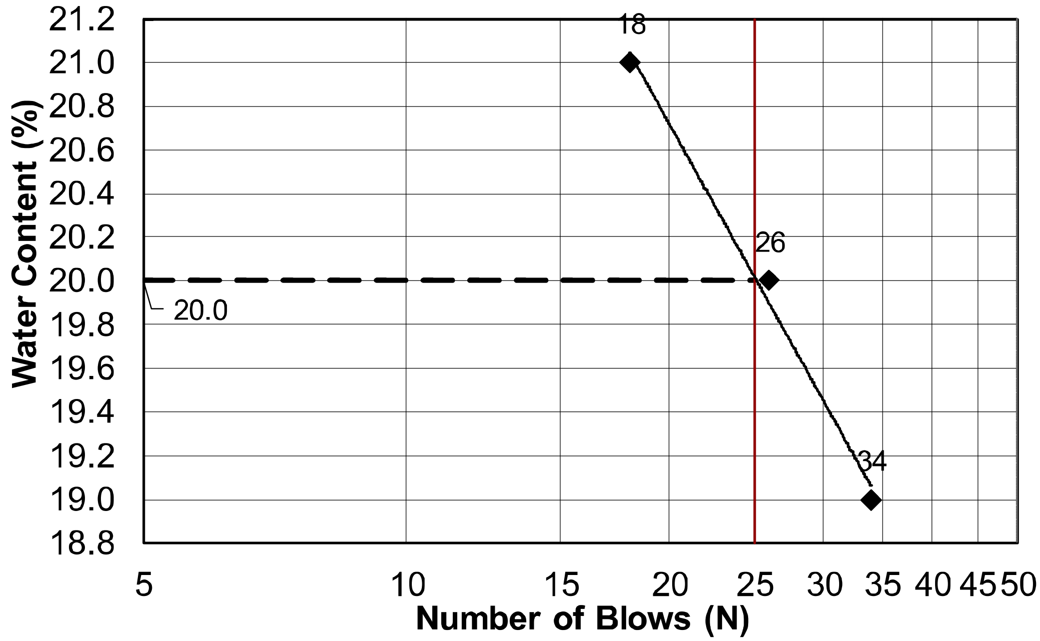
Comments:

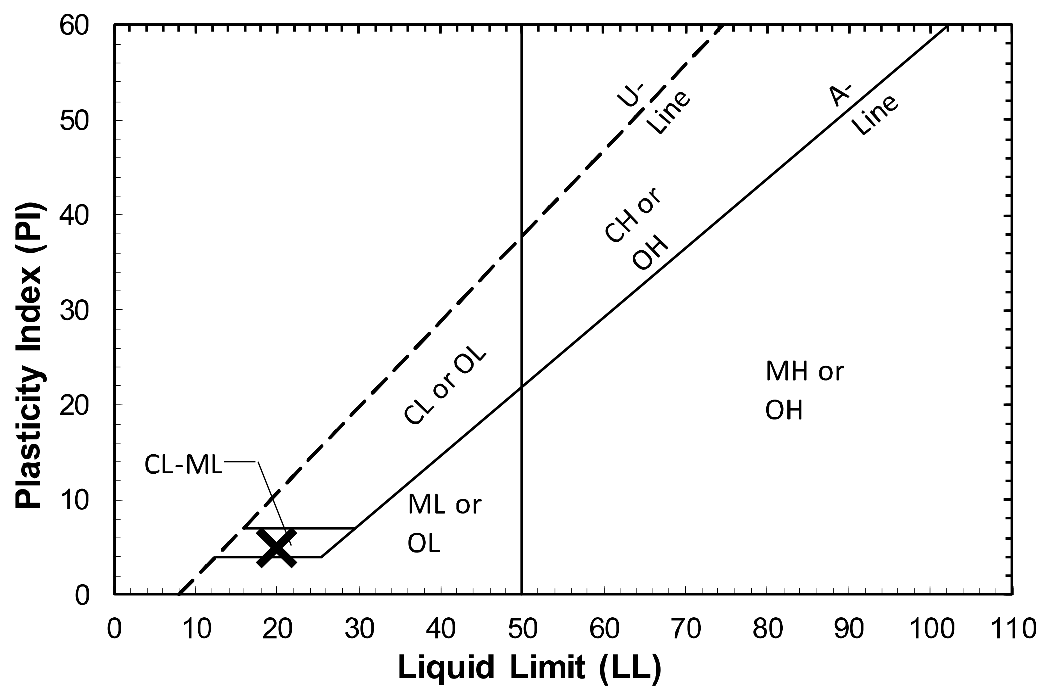
AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **7/15/2023**

Paper Copy: Lab File; Project File; Geotech File

TOWN	Levant	Reference No.	380933
WIN	027098.00	Water Content, %	22.7
Sampled	6/5/2023	Liquid Limit @ 25 blows (T 89), %	20
Boring No./Sample No.	BB-LBS-102/4D	Plastic Limit (T 90), %	15
Station	14+17.2	Plasticity Index (T 90), %	5
Depth	20.0-22.0	Tested By	BBURR





GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380876	BB-LBS-201/3D	GEOTECHNICAL (DISTURBED)	7/26/2023	8/11/2023

Sample Type: **GEOTECHNICAL** Location: Station: **14+21.2** Offset, ft: **7.3 LT** Dbfg, ft: **12.0-12.67**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 27)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	NP
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition, % (T 267)	
Water Content (T 265), %	

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

Sampler request to prioritize Limits. Insufficient material to run T 88 and T 100

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **9/13/2023**

Paper Copy: Lab File; Project File; Geotech File

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380877	BB-LBS-201/3D(A)	GEOTECHNICAL (DISTURBED)	7/26/2023	8/11/2023

Sample Type: **GEOTECHNICAL** Location: Station: **14+21.2** Offset, ft: **7.3** **LT** Dbfg, ft: **13.3-14.0**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition, % (T 267)	13.7
Water Content (T 265), %	70.5

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **8/28/2023**

Paper Copy: Lab File; Project File; Geotech File

MaineDOT

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380879	BB-LBS-202/4D	GEOTECHNICAL (DISTURBED)	7/25/2023	8/11/2023

Sample Type: **GEOTECHNICAL** Location: Station: **15+31.7** Offset, ft: **6.0** **RT** Dbfg, ft: **14.0-14.42**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 27)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	

Miscellaneous Tests

Test	Result
Liquid Limit @ 25 blows (T 89), %	62
Plastic Limit (T 90), %	45
Plasticity Index (T 90), %	17
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition, % (T 267)	
Water Content (T 265), %	50.0

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

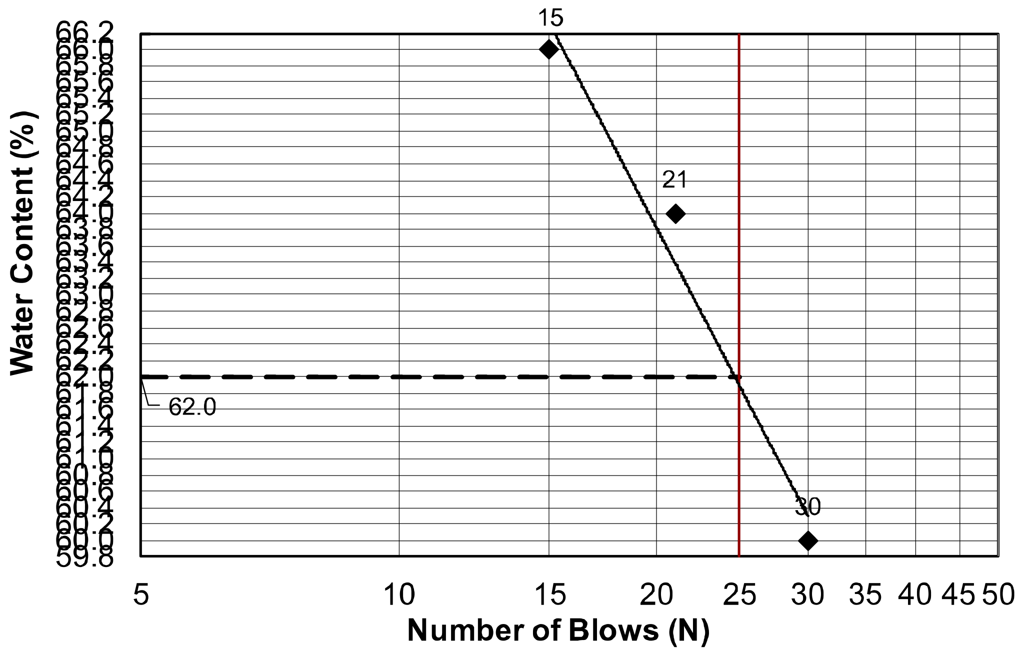
Sampler requested to prioritize Limits. Insufficient amount of material to run T 88 and T 100.

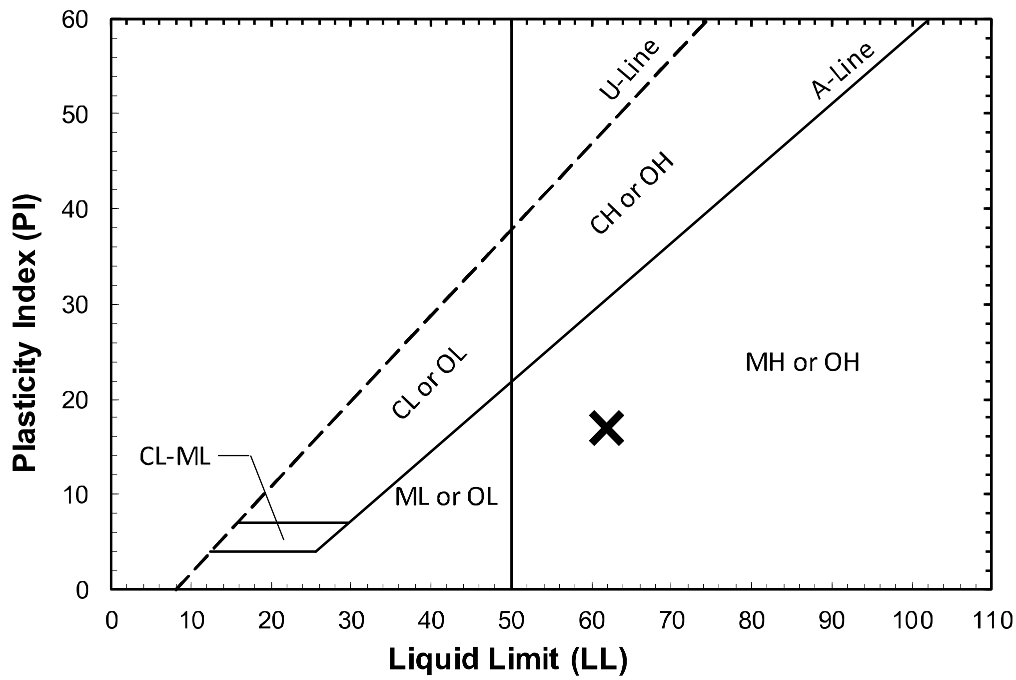
AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **9/13/2023**

Paper Copy: Lab File; Project File; Geotech File

TOWN	Levant	Reference No.	380879
WIN	027098.00	Water Content, %	50
Sampled	7/25/2023	Liquid Limit @ 25 blows (T 89), %	62
Boring No./Sample No.	BB-LBS-202/4D	Plastic Limit (T 90), %	45
Station	15+31.7	Plasticity Index (T 90), %	17
Depth	14.0-14.42	Tested By	BBURR





GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380880	BB-LBS-202/5D	GEOTECHNICAL (DISTURBED)	7/25/2023	8/11/2023

Sample Type: **GEOTECHNICAL** Location: Station: **15+31.7** Offset, ft: **6.0** **RT** Dbfg, ft: **16.0-18.0**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 27)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %	
Plastic Limit (T 90), %	
Plasticity Index (T 90), %	
Specific Gravity, Corrected to 20°C (T 100)	
Loss on Ignition, % (T 267)	67.4
Water Content (T 265), %	431.0

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In. U. Shear tons/ft²	3 In. Remold tons/ft²	6 In. U. Shear tons/ft²	6 In. Remold tons/ft²	Water Content, %	Description of Material Sampled at the Various Tube Depths

Comments:

There are 2 sample cups. Please combine for tests.

AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **8/28/2023**

Paper Copy: Lab File; Project File; Geotech File

MaineDOT

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
380881	BB-LBS-202/7D(A)	GEOTECHNICAL (DISTURBED)	7/25/2023	8/11/2023

Sample Type: **GEOTECHNICAL** Location: Station: **15+31.7** Offset, ft: **6.0** **RT** Dbfg, ft: **21.25-22.0**

WIN/Town **027098.00 - LEVANT** Sampler: **NATHAN PUKAY**

TEST RESULTS

Sieve Analysis (T 88)

Wash Method

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	
½ in. [12.5 mm]	
⅜ in. [9.5 mm]	
¼ in. [6.3 mm]	
No. 4 [4.75 mm]	
No. 10 [2.00 mm]	100.0
No. 20 [0.850 mm]	
No. 40 [0.425 mm]	99.8
No. 60 [0.250 mm]	
No. 100 [0.150 mm]	
No. 200 [0.075 mm]	99.4
[0.0254 mm]	95.8
[0.0170 mm]	86.5
[0.0104 mm]	74.2
[0.0077 mm]	64.9
[0.0057 mm]	52.5
[0.0030 mm]	37.1
[0.0013 mm]	21.6

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %	28
Plastic Limit (T 90), %	20
Plasticity Index (T 90), %	8
Specific Gravity, Corrected to 20°C (T 100)	2.64
Loss on Ignition, % (T 267)	
Water Content (T 265), %	31.3

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

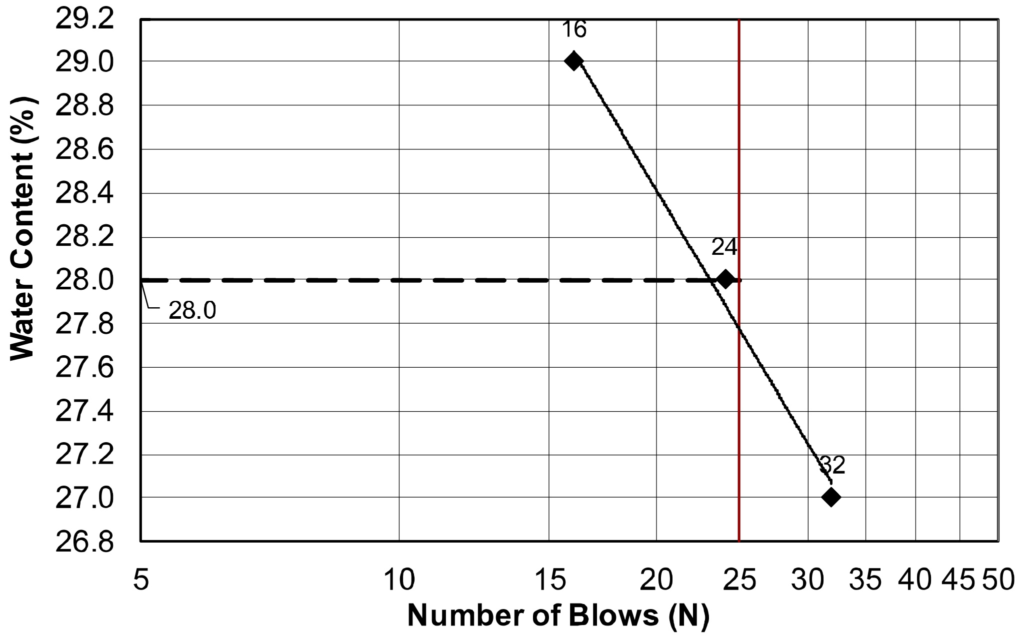
Comments:

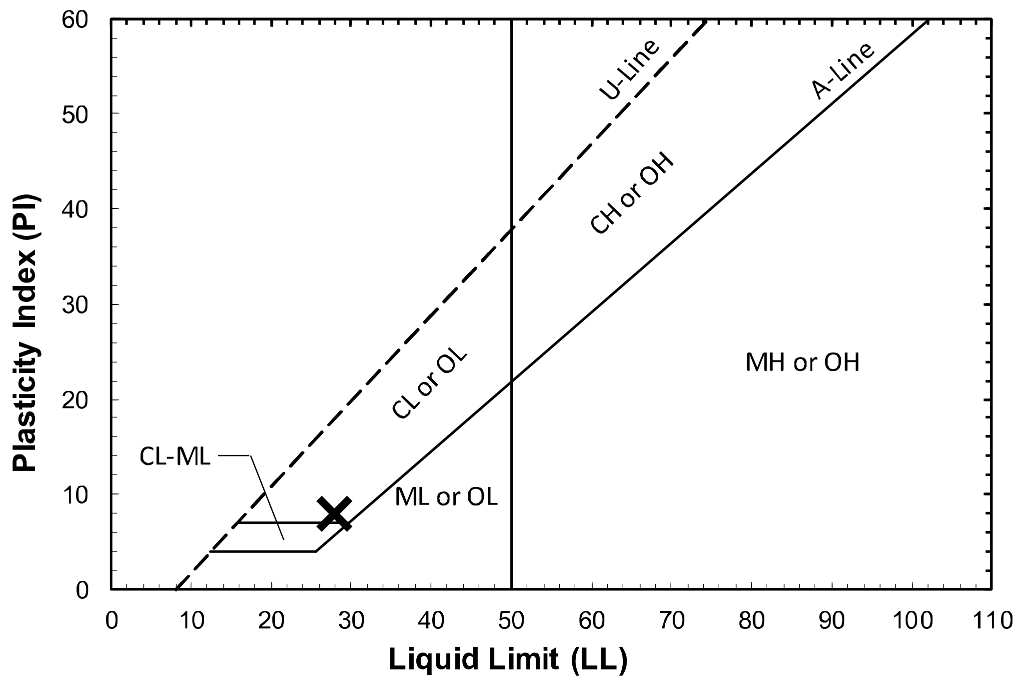
AUTHORIZATION AND DISTRIBUTION

Reported by: **GREGORY LIDSTONE** Date Reported: **9/13/2023**

Paper Copy: Lab File; Project File; Geotech File

TOWN	Levant	Reference No.	380881
WIN	027098.00	Water Content, %	31.3
Sampled	7/25/2023	Liquid Limit @ 25 blows (T 89), %	28
Boring No./Sample No.	BB-LBS-202/7D(A)	Plastic Limit (T 90), %	20
Station	15+31.7	Plasticity Index (T 90), %	8
Depth	21.25-22.0	Tested By	BBURR





Client:	Maine Department of Transportation
Project Name:	Perkins Bridge 6133 & Lake Bridge 3359
Project Location:	Levant. ME
GTX #:	317731
Test Date:	08/28/23
Tested By:	nlb
Checked By:	ank

Laboratory pH of Soil by ASTM G51

Boring ID	Sample ID	Depth, ft	Description	Soil Temperature, ° C	Average pH Reading
BB-LBS-202	6D	18-20	Moist, black silt with sand	23	5.22

Notes:

<u>Appendix D</u>

Calculations

Liquidity Index

Liquidity Index

$$LI := \frac{WC - PL}{LL - PL}$$

Das, Principles of Engineering, 7th Edition, Equation 4.16

Stream Alluvium - Wetland Deposit

BB-LBS-202, 4D

$WC := 50$

$LL := 62$

$PL := 45$

$$LI := \frac{WC - PL}{LL - PL} = 0.29$$

Glacial Till

BB-LBS-101, 3D

$WC := 11$

$LL := 20$

$PL := 14$

$$LI := \frac{WC - PL}{LL - PL} = -0.5$$

BB-LBS-101, 4D

$WC := 10$

$LL := 20$

$PL := 14$

$$LI := \frac{WC - PL}{LL - PL} = -0.67$$

BB-LBS-101, 6D

$WC := 12$

$LL := 21$

$PL := 14$

$$LI := \frac{WC - PL}{LL - PL} = -0.29$$

BB-LBS-102, 4D

$WC := 23$

$LL := 20$

$PL := 15$

$$LI := \frac{WC - PL}{LL - PL} = 1.6$$

BB-LBS-202, 7D/A

$WC := 31$

$LL := 28$

$PL := 20$

$$LI := \frac{WC - PL}{LL - PL} = 1.38$$

Driven H-Pile Resistance

Design of H-piles

Reference: AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.

Bedrock Properties

BB-LBS-101A, R1 RQD = 77%, R2 RQD = 77%
Rock Type: GRAYWACKE (hard) and PHYLLITE (moderately hard), fresh

BB-LBS-102, R1 RQD = 75%, R2 RQD = 78%
Rock Type: GRAYWACKE (hard) and PHYLLITE (moderately soft), fresh

BB-LBS-201, R1 RQD = 83%, R2 RQD = 75%
Rock Type: GRAYWACKE (moderately hard) and PHYLLITE (moderately hard), fresh

Sandstone Co = 9,700-25,000 psi
Phyllite Co = 3,500-35,000 psi

(AASHTO Standard Specifications for Bridges 17th Edition, Table 4.4.8.1.2B)

For Design Purposes: RQD = 75%, Co = 12000 psi

Pile Properties

Use the following piles: 14x89, 14x117

$A_g := \begin{pmatrix} 26.1 \\ 34.4 \end{pmatrix} \cdot in^2$ $\quad d := \begin{pmatrix} 13.8 \\ 14.2 \end{pmatrix} \cdot in$ $\quad b := \begin{pmatrix} 14.7 \\ 14.9 \end{pmatrix} \cdot in$ $\quad t_f := \begin{pmatrix} 0.615 \\ 0.805 \end{pmatrix} in$ $\quad t_w := t_f$

$A_{box} := \overrightarrow{(d \cdot b)}$ $\quad A_{box} = \begin{pmatrix} 202.86 \\ 211.58 \end{pmatrix} \cdot in^2$

Note: All matrices set up in this order
14x89
14x117

r_s= radius of gyration $\quad r_s := \begin{pmatrix} 3.53 \\ 3.59 \end{pmatrix} \cdot in$

radius of gyration about the Y-Y or weak axis per LRFD Article C6.9.4.1.2.

Pile yield strength $\quad F_y := 50 \cdot ksi$

E = Elastic Modulus $\quad E := 29000 \cdot ksi$

Check For Slender Members

Check that pile selections are composed of nonslender elements per LRFD 6.9.4.2

LRFD eq. 6.9.4.2.1-1

$$\frac{b}{t} \le \lambda_r$$

From Table 6.9.4.2.1-1:

For flanges: $\lambda_{rf} := 0.56 \cdot \sqrt{\frac{E}{F_y}}$ where b_f = Half-flange width

$\lambda_{rf} = 13.487$ $b_f := 0.5 \cdot b$ $b_f = \begin{pmatrix} 7.35 \\ 7.45 \end{pmatrix} \cdot in$

$\frac{b_f}{t_f} = \begin{pmatrix} 11.951 \\ 9.255 \end{pmatrix}$ Both H-pile sizes are nonslender for flange members

For webs: $\lambda_{rw} := 1.09 \sqrt{\frac{E}{F_y}}$ where b_w = Web height/distance between flanges

$\lambda_{rw} = 26.251$ $b_w := d - 2 \cdot t_f$ $b_w = \begin{pmatrix} 12.57 \\ 12.59 \end{pmatrix} \cdot in$

$\frac{b_w}{t_w} = \begin{pmatrix} 20.439 \\ 15.64 \end{pmatrix}$ Both H-Pile sizes are nonslender for web members

1. Nominal and Factored Structural Compressive Resistance of H-piles

Use LRFD Equation 6.9.2.1-1 $Pr = \varphi_c Pn$

Nominal Axial Structural Resistance

Determine equivalent yield resistance $P_o := F_y \cdot A_g$ LRFD Article 6.9.4.1.1.

$$P_o = \begin{pmatrix} 1305 \\ 1720 \end{pmatrix} \cdot kip$$

Per VTrans Integral Abutment Design Guideline, the controlling SPR (Structural Pile Resistance) will be the lowest axial capacity (P_r) of the top segment or the second segment of the upper zone or the lower zone of the pile. The SPR will be compared with the applied axial load.

A. Structural Resistance of lower "braced" segment of pile

Determine elastic critical buckling resistance P_e, LRFD eq. 6.9.4.1.2-1

K = effective length factor $\quad K_{eff} := 0.65 \quad$ LRFD Table C4.6.2.5-1. Use K=0.65 for assumed segment in pure compression. Fixed top and bottom

l = "unbraced" length $\quad l_{unbraced\_bot} := 0.1 \cdot ft \quad$ Assume in pure compression

LRFD eq. 6.9.4.1.2-1

$$P_e := \overrightarrow{\left[\frac{\pi^2 \cdot E}{\left(\frac{K_{eff} \cdot l_{unbraced\_bot}}{r_s}\right)^2} \cdot A_g\right]} \qquad P_e = \begin{pmatrix} 2 \times 10^8 \\ 2 \times 10^8 \end{pmatrix} \cdot kip$$

LRFD Article 6.9.4.1.1 For compressive members with nonslender element cross-sections:

$$\frac{P_o}{P_e} = \begin{pmatrix} 8.529 \times 10^{-6} \\ 8.247 \times 10^{-6} \end{pmatrix}$$

If Po/Pe < or = 2.25, then:

$$P_n := \overrightarrow{\left(0.658^{\frac{P_o}{P_e}} \cdot P_o\right)}$$

LRFD Eq. 6.9.4.1.1-1

then:

this applies to all pile sizes $\boxed{P_n = \begin{pmatrix} 1305 \\ 1720 \end{pmatrix} \cdot kip}$

Factored Axial Structural Resistance for the Strength Limit State

Resistance factor for H-pile in pure compression, severe driving conditions, per LRFD 6.5.4.2 for the case where pile tip is necessary $\quad \phi_c := 0.5$

The Factored Structural Resistance (Pr) per LRFD 6.9.2.1-1 is $\quad P_r := \phi_c \cdot P_n$

Factored structural compressive resistance, P_r $\quad \boxed{P_r = \begin{pmatrix} 652 \\ 860 \end{pmatrix} \cdot kip}$

LRFD 10.7.3.2.3 - Piles Driven to Hard Rock -

Article 10.7.3.2.3 states "The nominal resistance of piles driven to point bearing on hard rock where pile penetration into the rock formation is minimal is controlled by the structural limit state. The nominal bearing resistance shall not exceed the values obtained from Article 6.9.4.1 with the resistance factors specified in Article 6.5.4.2 and Article 6.15 for severe driving conditions. A pile driving acceptance criteria shall be developed that will prevent pile damage."

Therefore limit the nominal axial geotechnical pile resistance to the nominal structural resistance with a resistance factor for severe driving conditions of 0.50 applied per 10.7.3.2.3.

Nominal Structural Resistance Previously Calculated:

$$P_n = \begin{pmatrix} 1305 \\ 1720 \end{pmatrix} \cdot kip$$

The factored geotechnical compressive resistance (P_r) for the **Strength Limit State**, per LRFD 6.9.2.1-1 is

$$\phi_c := 0.5$$

$$P_r := \phi_c \cdot P_n$$

$$\boxed{P_r = \begin{pmatrix} 652 \\ 860 \end{pmatrix} \cdot kip}$$

14x89
14x117

The factored geotechnical compressive resistance (P_r) for the **Extreme Service Limit States**, per LRFD 6.9.2.1-1 is

$$\phi_c := 1.0$$ LRFD 6.5.5

$$P_{r\_ee} := \phi_c \cdot P_n$$

$$\boxed{P_{r\_ee} = \begin{pmatrix} 1305 \\ 1720 \end{pmatrix} \cdot kip}$$

14x89
14x117

Drivability Analyses

Ref: LRFD Article 10.7.8

For steel piles in compression or tension, driving stresses are limited to 90% of f_y

$\phi_{da} := 1.0$ Resistance factor from LRFD Table 10.5.5.2.3-1, Drivablity Analysis, steel piles

$\sigma_{dr} := 0.90 \cdot 50 \cdot (\text{ksi}) \cdot \phi_{da}$

$\sigma_{dr} = 45 \cdot \text{ksi}$ Driving stress cannot exceed 45 ksi

Limit driving stress to 45 ksi or limit blow count to 15 blows per inch (bpi).

Compute the resistance that can be achieved in a drivability analysis:

The resistance that must be achieved in a drivablity analysis will be the maximum factored pile load divided by the appropriate resistance factor for wave equation analysis and dynamic test which will be required for construction.

$\phi_{dyn} := 0.65$ Reference LRFD Table 10.5.5.2.3-1 - for Strength Limit State

$\phi := 1.0$ For Extreme and Service Limit States

GRLWeap Soil and Pile Model Assumptions

Abutment #1:
Based on proposed bottom of footing of elevation 119 at abutment #1, the estimated pile length will be approx. 56 feet. Assume contractor drives pile lengths of 65 ft (extra length accommodates for attachment of dynamic testing equipment, embedment into abutment, variation in bedrock surface).

Use constant shaft resistances so that GRLWeap will assign approx. 200 kips as skin friction based on local experience in similar deposits.

Abutment #2:
Based on proposed bottom of footing of elevation 119 at abutment #2, the estimated pile length will be approx. 40 feet. Assume contractor drives pile lengths of 45 ft (extra length accommodates for attachment of dynamic testing equipment, embedment into abutment, variation in bedrock surface).

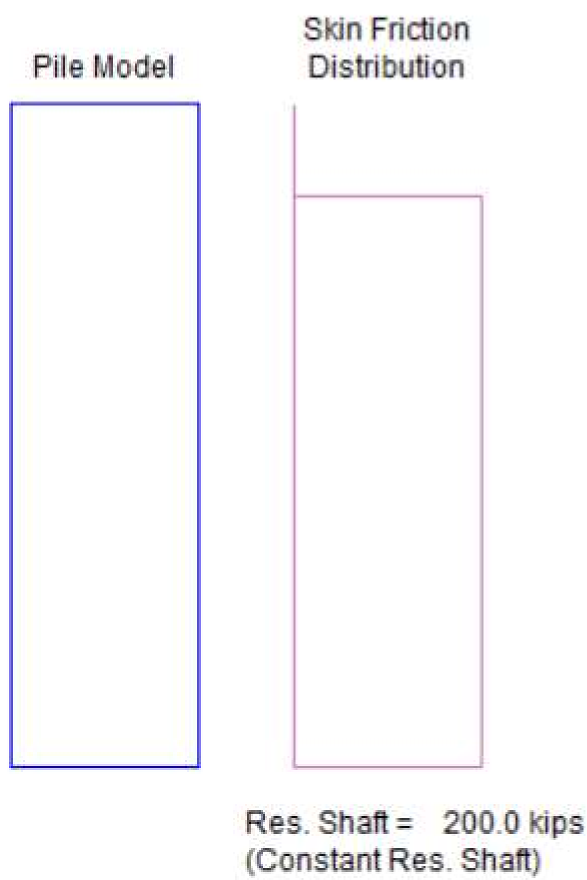
Use constant shaft resistances so that GRLWeap will assign approx. 120 kips as skin friction based on local experience in similar deposits.

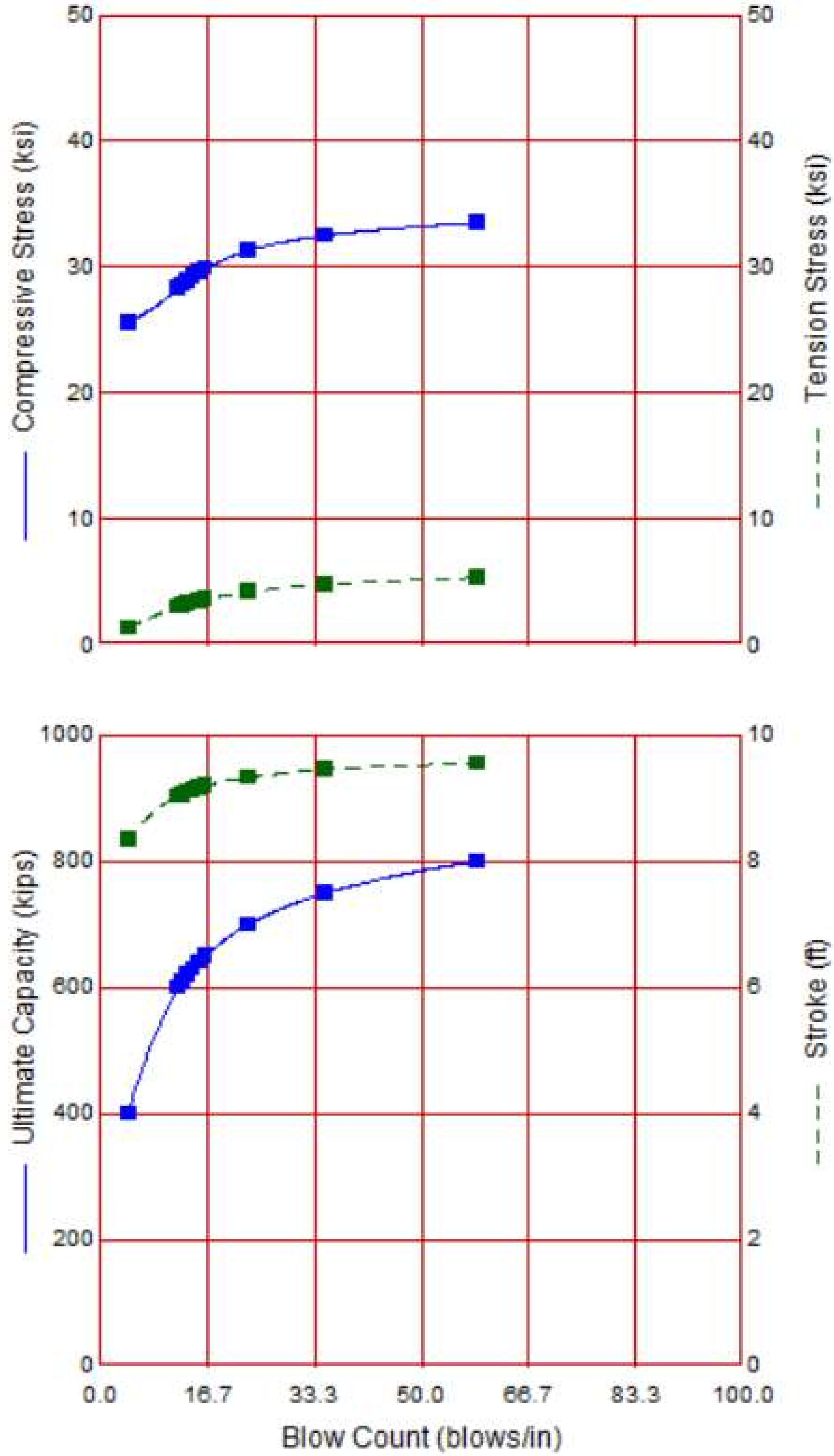
Abutment 1, Pile Size is 14 x 89, APE D19-42 Hammer

The 14x89 pile can be driven to the resistances below with an APE D19-42 hammer at fuel setting 4 (100% of Max) and 3.0 kip helmet at a reasonable blow count and level of driving stress. See GRLWEAP results below:

APE D 19-42

Ram Weight	4.19	kips
Efficiency	0.800	
Pressure	1710 (100%)	psi
Helmet Weight	3.00	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.100	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	65.00	ft
Pile Penetration	56.00	ft
Pile Top Area	26.10	in2




Compressive Stress (ksi)
Tension Stress (ksi)
Ultimate Capacity (kips)
Stroke (ft)
Blow Count (blows/in)
0.0
16.7
33.3
50.0
66.7
83.3
100.0

Maine DOT
27098 Levant 14x89 ABT #1 D19-42

30-Nov-2023
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
400.0	25.61	1.37	4.5	8.34	20.49
600.0	28.30	3.07	12.2	9.04	22.36
610.0	28.61	3.18	12.9	9.06	22.46
620.0	28.94	3.30	13.6	9.11	22.56
630.0	29.27	3.41	14.4	9.13	22.67
640.0	29.60	3.53	15.4	9.16	22.71
650.0	29.89	3.65	16.3	9.20	22.80
700.0	31.32	4.25	23.0	9.33	23.17
750.0	32.51	4.85	35.0	9.46	23.52
800.0	33.54	5.38	58.8	9.56	23.77

Limit to 15 bpi

$R_{ndr} := 630 \cdot kip$

Strength Limit State

$R_{fdr} := R_{ndr} \cdot \phi_{dyn}$

$\boxed{R_{fdr} = 409 \cdot kip}$

Extreme and
Service Limit States

$R_{dr} := R_{ndr} \cdot \phi$

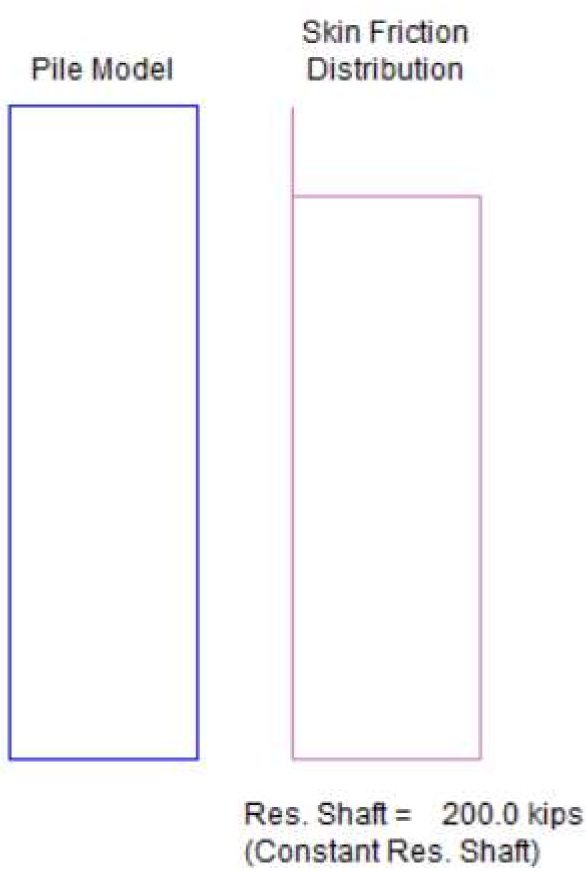
$\boxed{R_{dr} = 630 \cdot kip}$

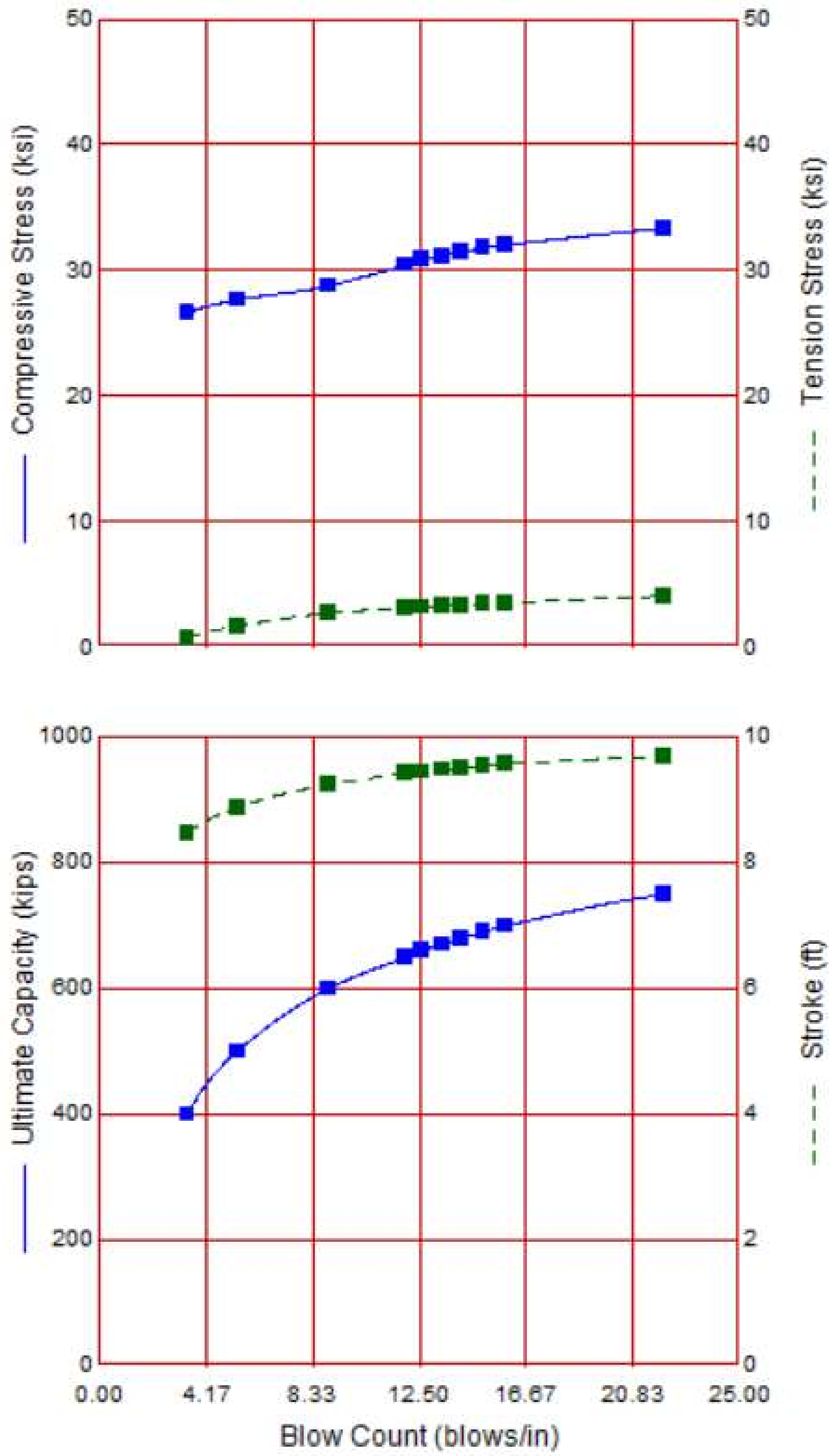
Abutment 1, Pile Size is 14 x 89, APE D25-42 Hammer

The 14x89 pile can be driven to the resistances below with a APE D25-42 hammer at fuel setting 4 (100% of max) and 3.0 kip helmet at a reasonable blow count and level of driving stress. See GRLWEAP results below:

APE D 25-42

Ram Weight	5.51	kips
Efficiency	0.800	
Pressure	1425 (100%)	psi
Helmet Weight	3.00	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.100	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	65.00	ft
Pile Penetration	56.00	ft
Pile Top Area	26.10	in2




Compressive Stress (ksi)
Tension Stress (ksi)
Ultimate Capacity (kips)
Stroke (ft)
Blow Count (blows/in)
0.00
4.17
8.33
12.50
16.67
20.83
25.00

Maine DOT
27098 Levant 14x89 ABT #1 D25-42

01-Dec-2023
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
400.0	26.65	0.79	3.4	8.46	23.92
500.0	27.68	1.71	5.4	8.88	25.33
600.0	28.80	2.75	8.9	9.24	26.61
650.0	30.47	3.15	11.9	9.42	27.19
660.0	30.89	3.23	12.6	9.45	27.37
670.0	31.16	3.30	13.4	9.48	27.40
680.0	31.45	3.37	14.2	9.51	27.52
690.0	31.79	3.46	15.0	9.54	27.63
700.0	32.04	3.54	15.9	9.57	27.74
750.0	33.34	4.10	22.1	9.69	28.16

Limit to 15 bpi

$R_{ndr} := 690 \cdot kip$

Strength Limit State

$R_{fdr} := R_{ndr} \cdot \phi_{dyn}$

$\boxed{R_{fdr} = 449 \cdot kip}$

Extreme and
Service Limit States

$R_{dr} := R_{ndr} \cdot \phi$

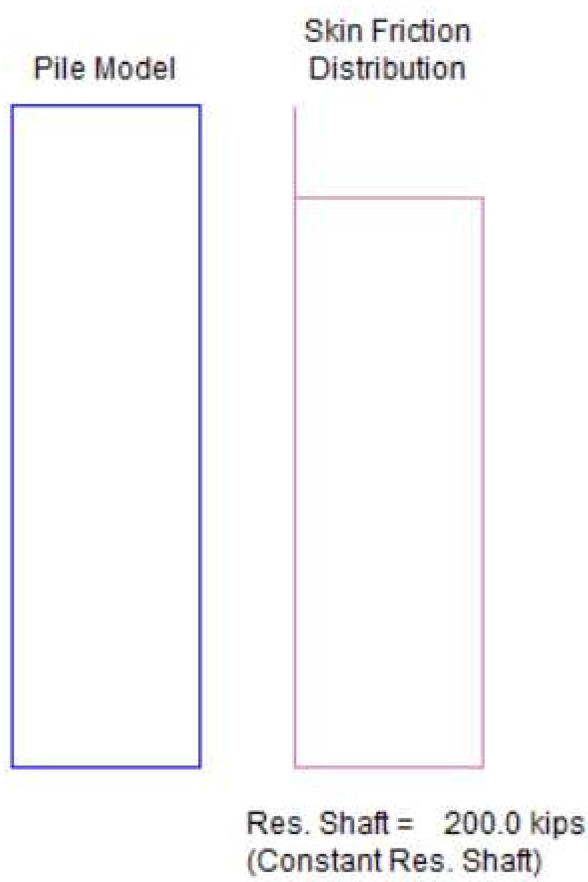
$\boxed{R_{dr} = 690 \cdot kip}$

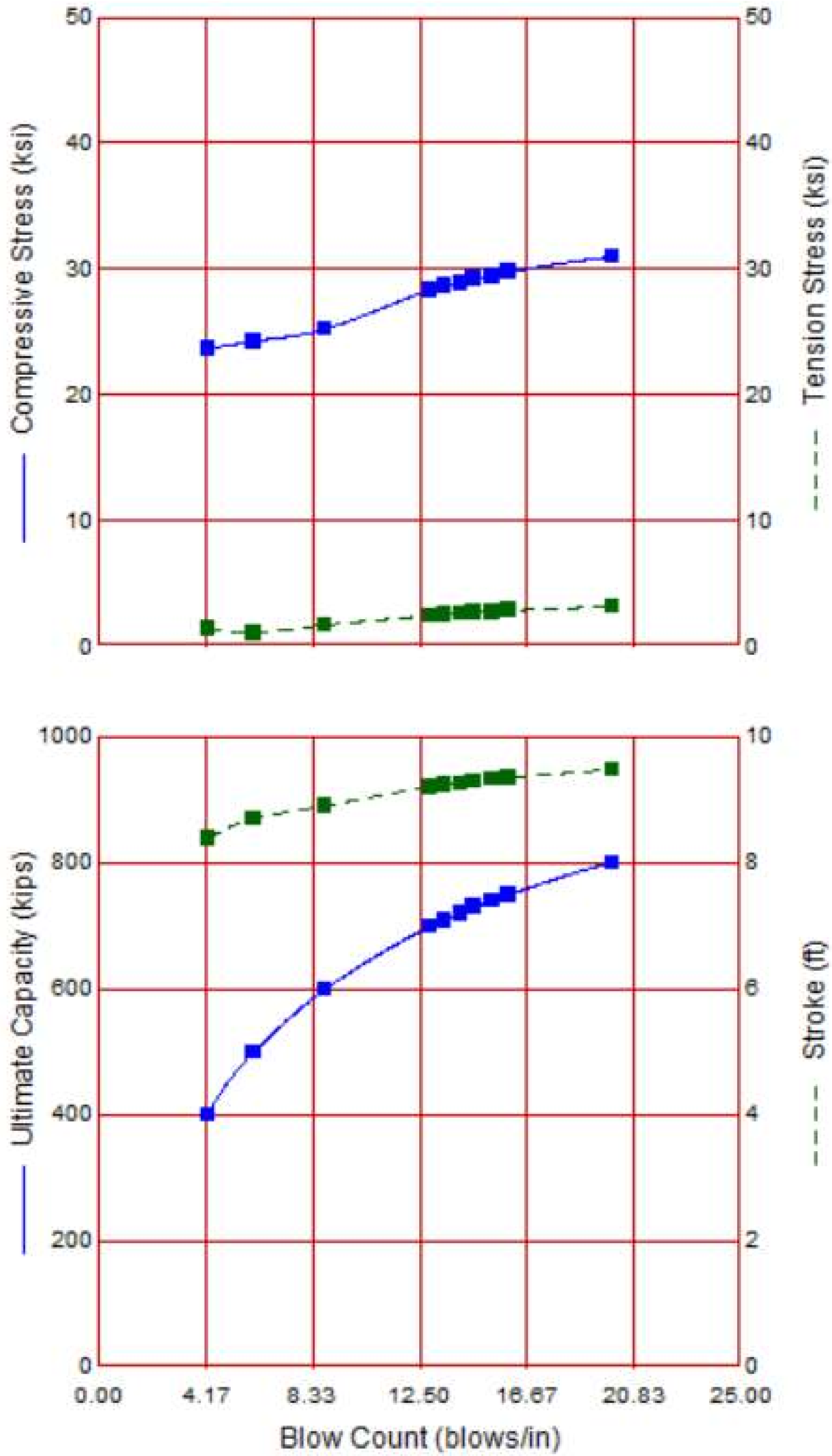
Abutment 1, Pile Size is 14 x 117, APE D19-42 Hammer

The 14x117 pile can be driven to the resistances below with a APE D19-42 hammer at fuel setting 4 (100% of max) and 3.0 kip helmet at a reasonable blow count and level of driving stress. See GRLWEAP results below:

APE D 19-42

Ram Weight	4.19	kips
Efficiency	0.800	
Pressure	1710 (100%)	psi
Helmet Weight	3.00	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.100	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	65.00	ft
Pile Penetration	56.00	ft
Pile Top Area	34.40	in2




50
40
30
20
10
0
Compressive Stress (ksi)
Tension Stress (ksi)
1000
800
600
400
200
0
10
8
6
4
2
Ultimate Capacity (kips)
Stroke (ft)
0.00
4.17
8.33
12.50
16.67
20.83
25.00
Blow Count (blows/in)

Maine DOT
27098 Levant 14x117 ABT #1 D19-42

01-Dec-2023
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
400.0	23.71	1.44	4.2	8.39	19.58
500.0	24.30	1.12	6.0	8.70	20.38
600.0	25.25	1.75	8.8	8.91	20.91
700.0	28.35	2.52	12.9	9.21	21.79
710.0	28.68	2.60	13.4	9.24	21.88
720.0	28.91	2.68	14.1	9.26	21.90
730.0	29.26	2.75	14.6	9.30	22.05
740.0	29.44	2.83	15.3	9.33	22.06
750.0	29.76	2.89	15.9	9.35	22.16
800.0	30.99	3.23	20.0	9.48	22.50

Limit to 15 bpi

$R_{ndr} := 730 \cdot kip$

Strength Limit State

$R_{fdr} := R_{ndr} \cdot \phi_{dyn}$

$\boxed{R_{fdr} = 474 \cdot kip}$

Extreme and
Service Limit States

$R_{dr} := R_{ndr} \cdot \phi$

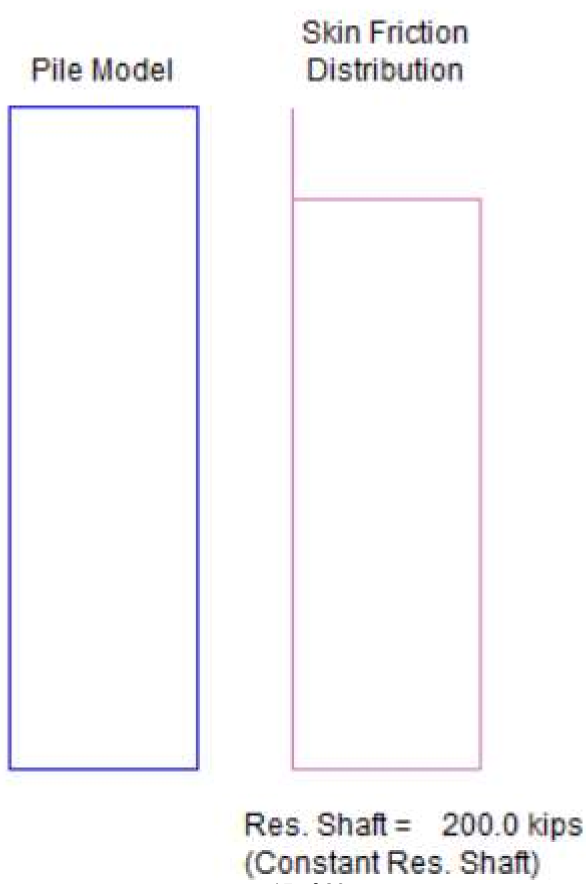
$\boxed{R_{dr} = 730 \cdot kip}$

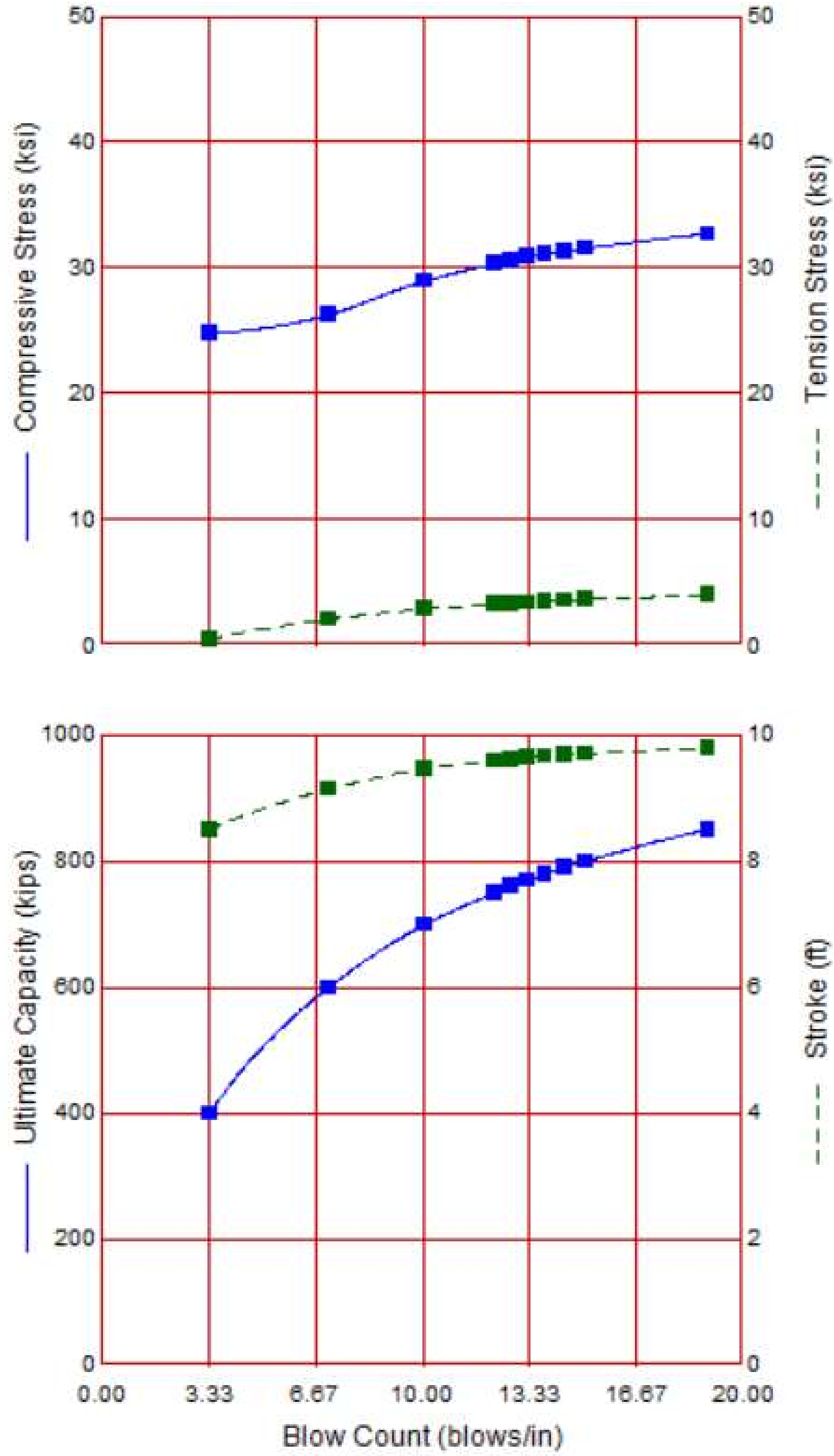
Abutment 1, Pile Size is 14 x 117, APE D25-42 Hammer

The 14x117 pile can be driven to the resistances below with a APE D25-42 hammer at fuel setting 4 (100% of max) and 3.0 kip helmet at a reasonable blow count and level of driving stress. See GRLWEAP results below:

APE D 25-42

Ram Weight	5.51	kips
Efficiency	0.800	
Pressure	1425 (100%)	psi
Helmet Weight	3.00	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.100	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	65.00	ft
Pile Penetration	56.00	ft
Pile Top Area	34.40	in2




50
40
30
20
10
0
Compressive Stress (ksi)
Tension Stress (ksi)
1000
800
600
400
200
0
10
8
6
4
2
Ultimate Capacity (kips)
Stroke (ft)
0.00
3.33
6.67
10.00
13.33
16.67
20.00
Blow Count (blows/in)

Maine DOT
27098 Levant 14x117 ABT #1 D25-42

01-Dec-2023
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
400.0	24.77	0.53	3.4	8.51	22.67
600.0	26.28	2.12	7.1	9.14	24.58
700.0	28.98	2.90	10.1	9.47	25.68
750.0	30.32	3.29	12.3	9.59	26.05
760.0	30.58	3.37	12.8	9.61	26.10
770.0	30.87	3.44	13.3	9.64	26.22
780.0	31.06	3.52	13.8	9.66	26.30
790.0	31.34	3.59	14.4	9.68	26.35
800.0	31.55	3.67	15.1	9.70	26.42
850.0	32.70	4.02	18.9	9.80	26.76

Limit to 15 bpi

$$R_{ndr} := 790 \cdot kip$$

Strength Limit State

$$R_{fdr} := R_{ndr} \cdot \phi_{dyn}$$

$$\boxed{R_{fdr} = 514 \cdot kip}$$

Extreme and
Service Limit States

$$R_{dr} := R_{ndr} \cdot \phi$$

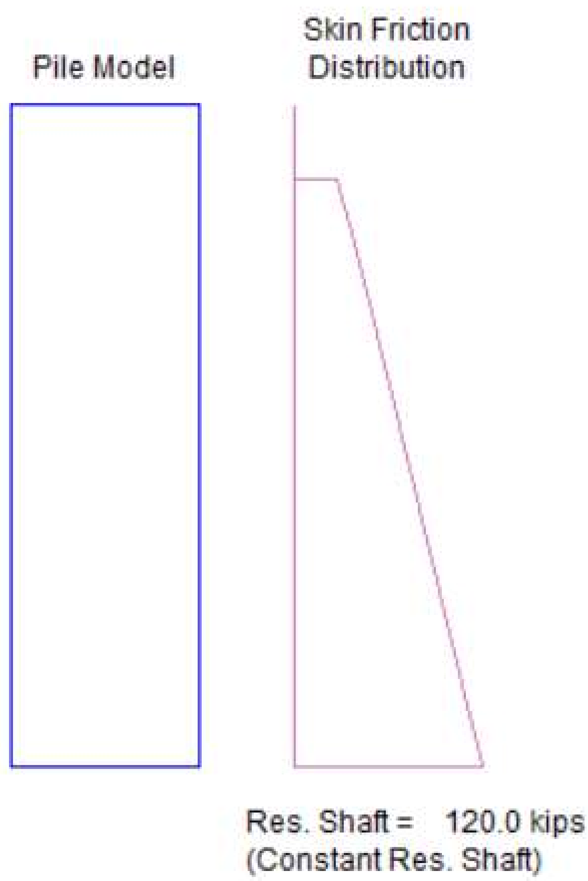
$$\boxed{R_{dr} = 790 \cdot kip}$$

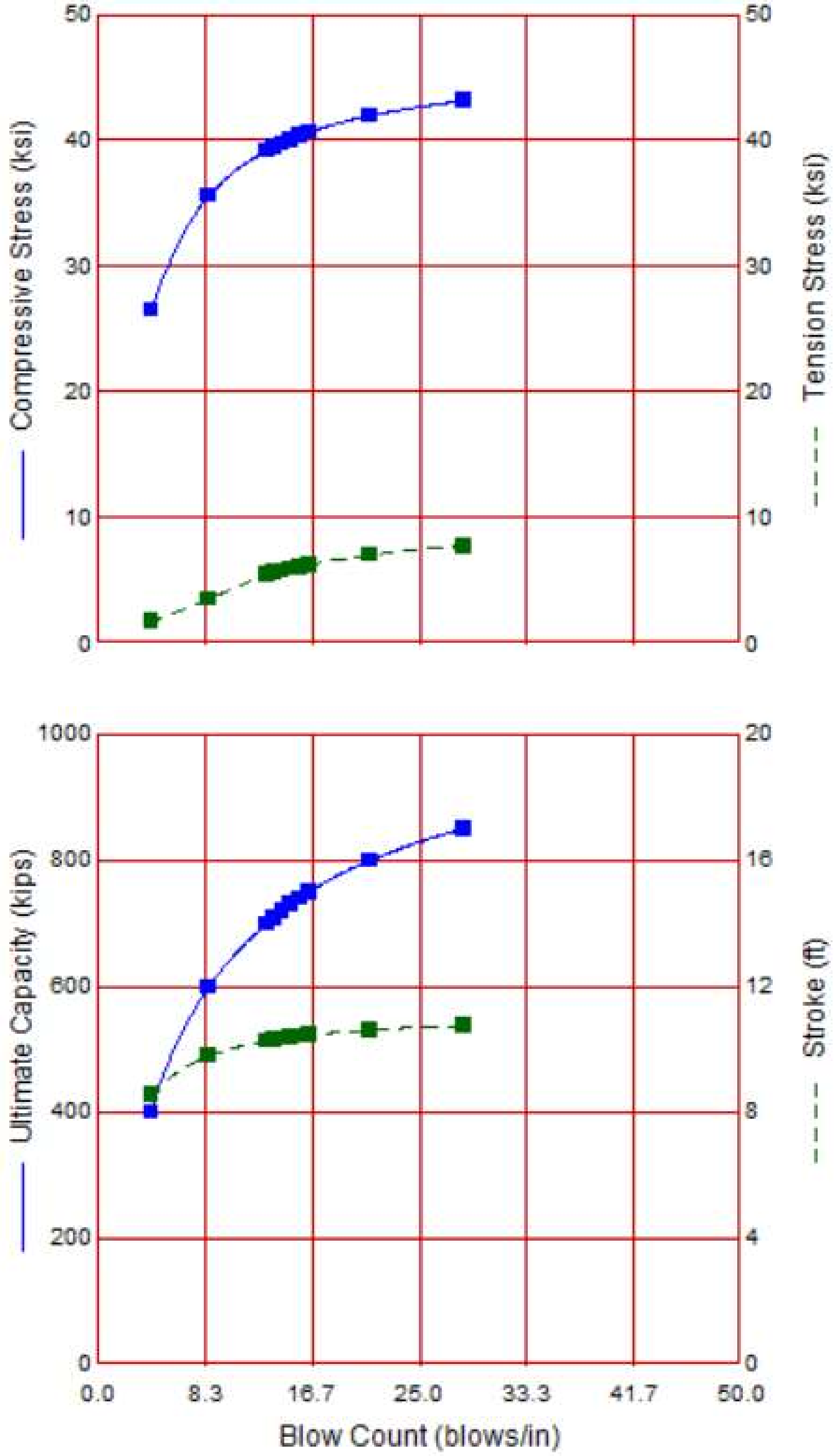
Abutment 2, Pile Size is 14 x 89, APE D19-42 Hammer

The 14x89 pile can be driven to the resistances below with a APE D19-42 hammer at fuel setting 4 (100% of max) and 3.0 kip helmet at a reasonable blow count and level of driving stress. See GRLWEAP results below:

APE D 19-42

Ram Weight	4.19	kips
Efficiency	0.800	
Pressure	1710 (100%)	psi
Helmet Weight	3.00	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.100	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	45.00	ft
Pile Penetration	40.00	ft
Pile Top Area	26.10	in2




Compressive Stress (ksi)
Tension Stress (ksi)
Ultimate Capacity (kips)
Stroke (ft)
Blow Count (blows/in)
0.0
8.3
16.7
25.0
33.3
41.7
50.0

Maine DOT
27098 Levant 14x89 ABT #2 D19-42

01-Dec-2023
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
400.0	26.56	1.78	4.1	8.56	20.72
600.0	35.63	3.62	8.6	9.80	23.47
700.0	39.17	5.49	13.1	10.30	24.67
710.0	39.47	5.67	13.7	10.33	24.76
720.0	39.74	5.83	14.3	10.37	24.84
730.0	40.04	6.00	15.0	10.41	24.94
740.0	40.34	6.16	15.7	10.44	25.03
750.0	40.64	6.32	16.4	10.48	25.17
800.0	41.95	7.10	21.1	10.64	25.57
850.0	43.13	7.83	28.5	10.78	25.91

Limit to 15 bpi

$$R_{ndr} := 730 \cdot kip$$

Strength Limit State

$$R_{fdr} := R_{ndr} \cdot \phi_{dyn}$$

$$\boxed{R_{fdr} = 474 \cdot kip}$$

Extreme and
Service Limit States

$$R_{dr} := R_{ndr} \cdot \phi$$

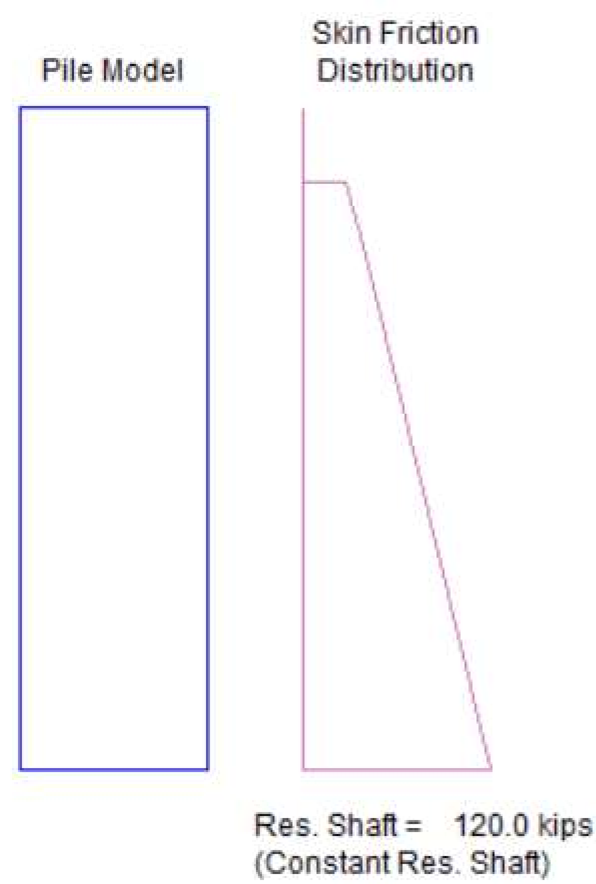
$$\boxed{R_{dr} = 730 \cdot kip}$$

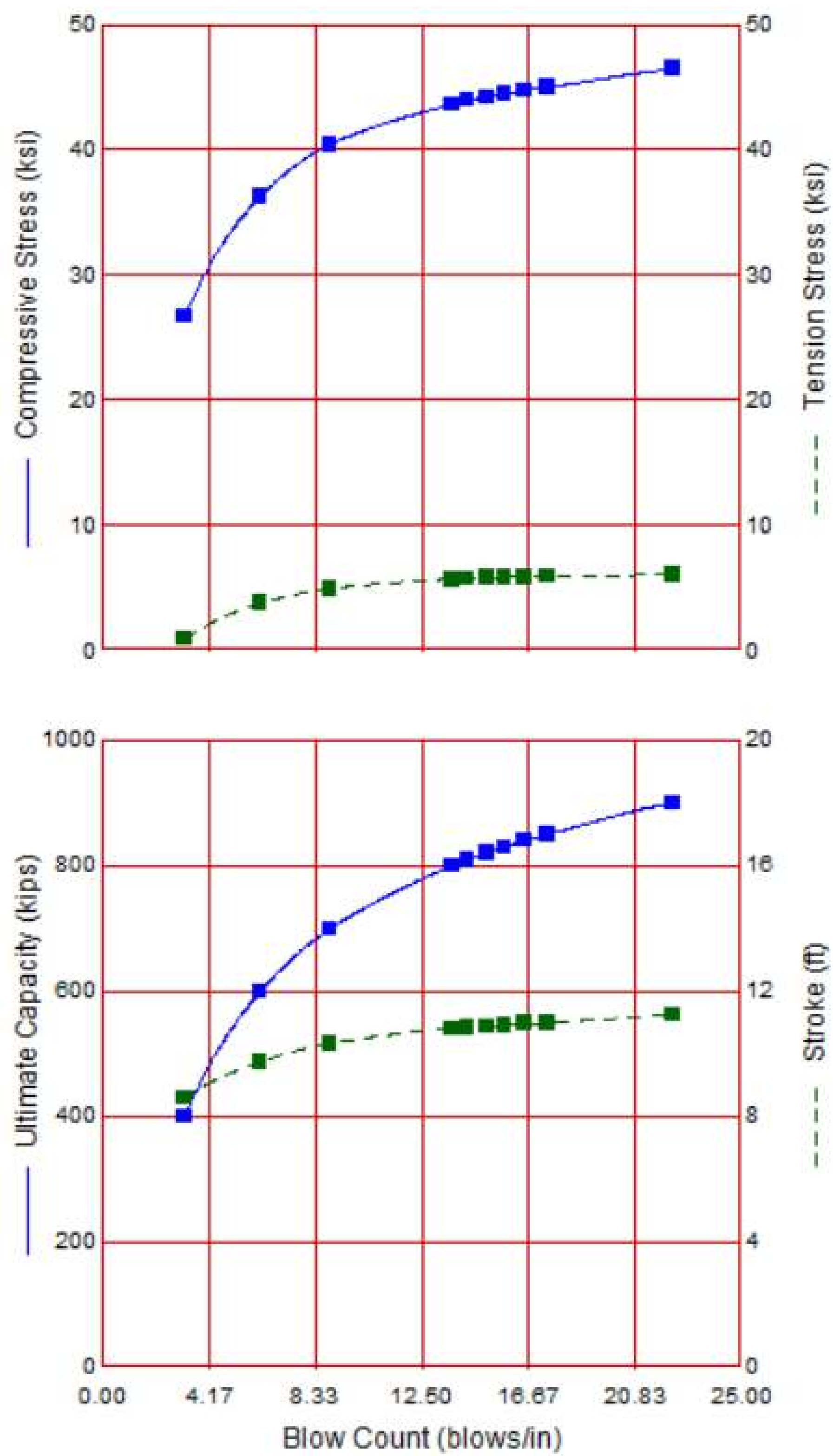
Abutment 2, Pile Size is 14 x 89, APE D25-42 Hammer

The 14x89 pile can be driven to the resistances below with a APE D25-42 hammer at fuel setting 4 (100% of max) and 3.0 kip helmet at a reasonable blow count and level of driving stress. See GRLWEAP results below:

APE D 25-42

Ram Weight	5.51	kips
Efficiency	0.800	
Pressure	1425 (100%)	psi
Helmet Weight	3.00	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.100	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	45.00	ft
Pile Penetration	40.00	ft
Pile Top Area	26.10	in2




Compressive Stress (ksi)
Tension Stress (ksi)
Ultimate Capacity (kips)
Stroke (ft)
Blow Count (blows/in)
0.00
4.17
8.33
12.50
16.67
20.83
25.00

Maine DOT
27098 Levant 14x89 ABT #2 D25-42

01-Dec-2023
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
400.0	26.75	1.00	3.2	8.60	23.89
600.0	36.30	3.84	6.2	9.75	26.56
700.0	40.41	5.03	8.9	10.35	28.26
800.0	43.63	5.78	13.6	10.82	29.70
810.0	43.97	5.82	14.3	10.86	29.84
820.0	44.20	5.86	15.0	10.89	29.92
830.0	44.47	5.90	15.7	10.93	30.07
840.0	44.75	5.95	16.5	10.97	30.21
850.0	44.98	5.97	17.4	11.00	30.29
900.0	46.43	6.14	22.3	11.25	31.06

Limit to 15 bpi

$R_{ndr} := 820 \cdot kip$

Strength Limit State

$R_{fdr} := R_{ndr} \cdot \phi_{dyn}$

$\boxed{R_{fdr} = 533 \cdot kip}$

Extreme and
Service Limit States

$R_{dr} := R_{ndr} \cdot \phi$

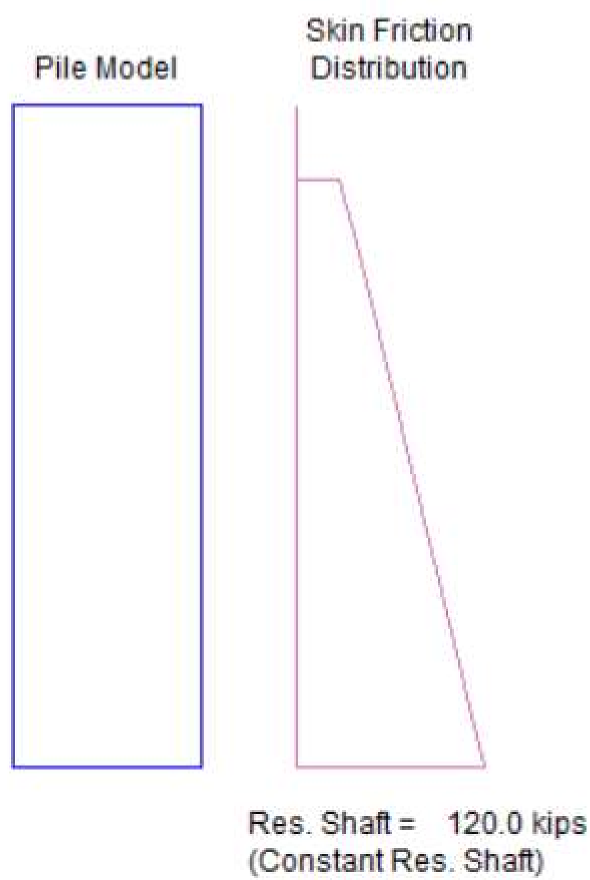
$\boxed{R_{dr} = 820 \cdot kip}$

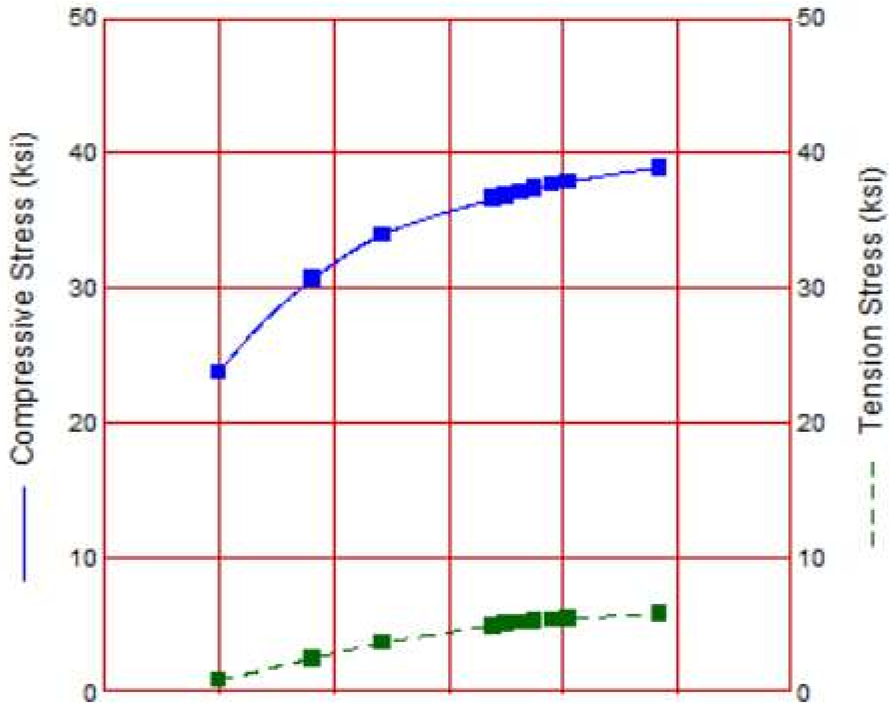
Abutment 2, Pile Size is 14 x 117, APE D19-42 Hammer

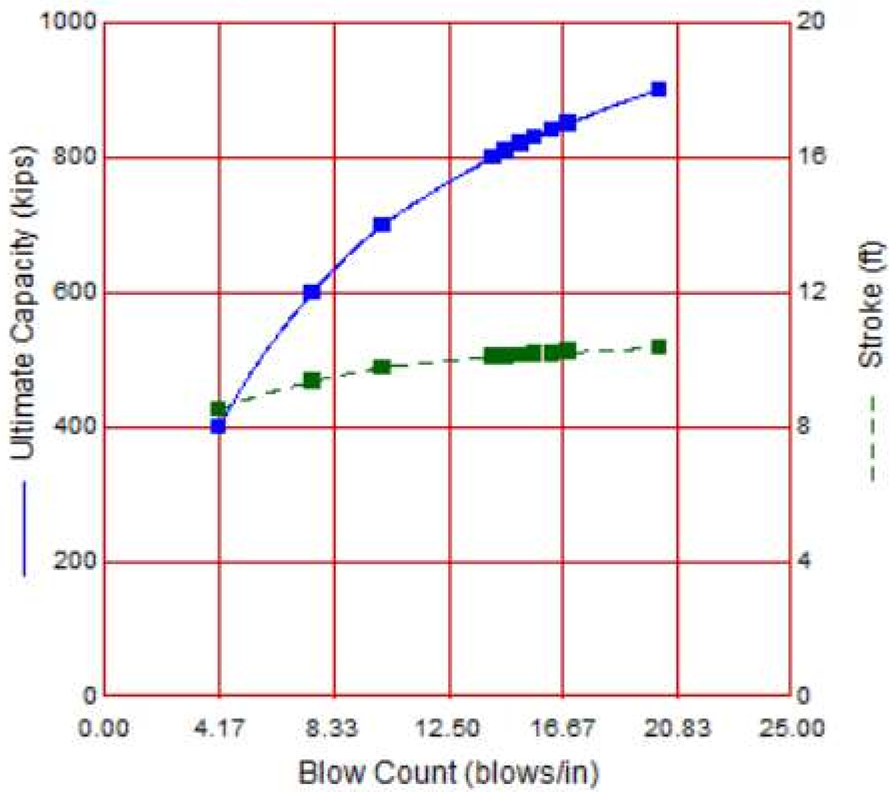
The 14x117 pile can be driven to the resistances below with a APE D19-42 hammer at fuel setting 4 (100% of max) and 3.0 kip helmet at a reasonable blow count and level of driving stress. See GRLWEAP results below:

APE D 19-42

Ram Weight	4.19	kips
Efficiency	0.800	
Pressure	1710 (100%)	psi
Helmet Weight	3.00	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.100	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	45.00	ft
Pile Penetration	40.00	ft
Pile Top Area	34.40	in2




Compressive Stress (ksi)
Tension Stress (ksi)
0
10
20
30
40
50


Ultimate Capacity (kips)
Stroke (ft)
0
200
400
600
800
1000
0
4
8
12
16
20
0.00
4.17
8.33
12.50
16.67
20.83
25.00
Blow Count (blows/in)

Maine DOT
27098 Levant 14x117 ABT #2 D19-42

01-Dec-2023
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
400.0	23.79	0.99	4.2	8.52	19.98
600.0	30.70	2.62	7.6	9.36	21.73
700.0	34.00	3.77	10.1	9.78	22.86
800.0	36.63	5.01	14.1	10.09	23.60
810.0	36.89	5.14	14.6	10.12	23.70
820.0	37.15	5.26	15.1	10.15	23.78
830.0	37.39	5.38	15.6	10.18	23.87
840.0	37.66	5.47	16.3	10.20	23.91
850.0	37.88	5.55	16.8	10.23	23.99
900.0	38.92	5.94	20.2	10.36	24.32

Limit to 15 bpi

$R_{ndr} := 810 \cdot kip$

Strength Limit State

$R_{fdr} := R_{ndr} \cdot \phi_{dyn}$

$\boxed{R_{fdr} = 527 \cdot kip}$

Extreme and
Service Limit States

$R_{dr} := R_{ndr} \cdot \phi$

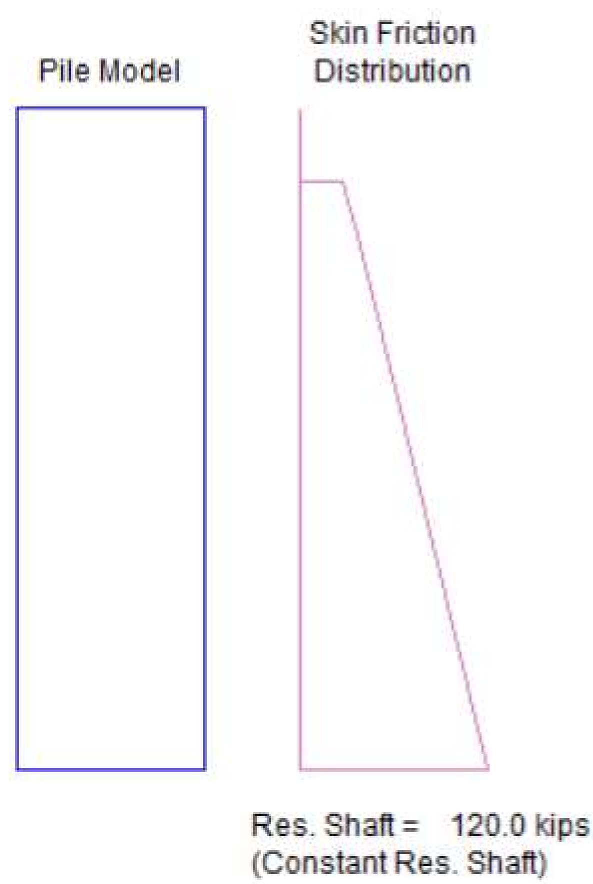
$\boxed{R_{dr} = 810 \cdot kip}$

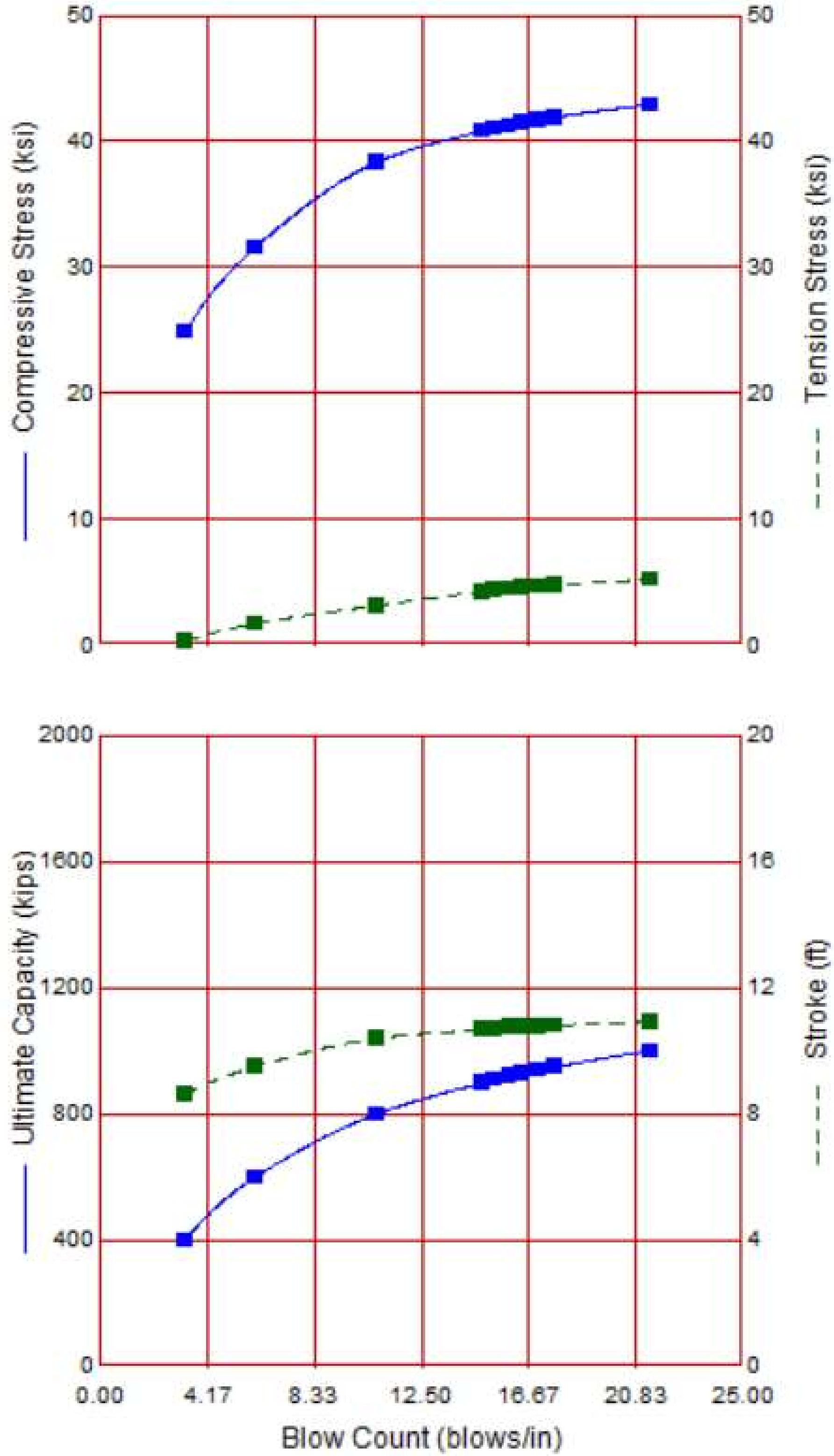
Abutment 2, Pile Size is 14 x 117, APE D25-42 Hammer

The 14x117 pile can be driven to the resistances below with a APE D25-42 hammer at fuel setting 4 (100% of max) and 3.0 kip helmet at a reasonable blow count and level of driving stress. See GRLWEAP results below:

APE D 25-42

Ram Weight	5.51	kips
Efficiency	0.800	
Pressure	1425 (100%)	psi
Helmet Weight	3.00	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.100	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	45.00	ft
Pile Penetration	40.00	ft
Pile Top Area	34.40	in2




Compressive Stress (ksi)
Tension Stress (ksi)
0
10
20
30
40
50
Ultimate Capacity (kips)
Stroke (ft)
0
400
800
1200
1600
2000
0
4
8
12
16
20
0.00
4.17
8.33
12.50
16.67
20.83
25.00
Blow Count (blows/in)

Maine DOT
27098 Levant 14x117 ABT #2 D25-42

01-Dec-2023
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
400.0	24.89	0.41	3.3	8.63	22.79
600.0	31.56	1.75	6.0	9.51	24.78
800.0	38.31	3.19	10.8	10.41	27.58
900.0	40.82	4.30	14.8	10.69	28.44
910.0	41.04	4.41	15.3	10.72	28.56
920.0	41.23	4.50	15.9	10.75	28.62
930.0	41.50	4.61	16.4	10.77	28.74
940.0	41.68	4.70	17.0	10.79	28.79
950.0	41.91	4.79	17.7	10.82	28.85
1000.0	42.89	5.26	21.4	10.93	29.21

Limit to 15 bpi

$R_{ndr} := 900 \cdot kip$

Strength Limit State

$R_{fdr} := R_{ndr} \cdot \phi_{dyn}$

$\boxed{R_{fdr} = 585 \cdot kip}$

Extreme and
Service Limit States

$R_{dr} := R_{ndr} \cdot \phi$

$\boxed{R_{dr} = 900 \cdot kip}$

27098.00 Levant - Perkins Bridge #6133

GRL WEAP INPUT + RESULT SUMMARY

NPP 11/21/23

	Abutment	Pile Size	Pile Length	Hammer	Fuel Setting	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Skin Friction	Ultimate Capacity	Max Comp Stress	Max Tension Stress	Blows/In	Stroke	Energy
Abutment #1 14x89 APE D19-42	1	HP 14x89	65	APE D19-42	3	0.10	0.04	0.05	0.15	200	620	29.12	4.28	14.4	8.19	19.70
	1	HP 14x89	65	APE D19-42	3	0.10	0.04	0.10	0.15	200	580	26.06	2.76	14.5	8.12	19.23
	1	HP 14x89	65	APE D19-42	3	0.10	0.07	0.05	0.15	200	610	27.88	3.06	15.0	8.09	19.46
	1	HP 14x89	65	APE D19-42	3	0.10	0.07	0.10	0.15	200	570	24.99	1.75	15.0	8.03	19.03
	1	HP 14x89	65	APE D19-42	4	0.10	0.04	0.05	0.15	200	680	32.92	5.29	15.0	9.23	23.20
	1	HP 14x89	65	APE D19-42	4	0.10	0.04	0.10	0.15	200	630	29.27	3.41	14.4	9.13	22.67
	1	HP 14x89	65	APE D19-42	4	0.10	0.07	0.05	0.15	200	660	31.47	3.80	14.7	9.10	22.88
	1	HP 14x89	65	APE D19-42	4	0.10	0.07	0.10	0.15	200	620	27.89	2.39	15.0	9.04	22.43
Abutment #1 14x89 APE D25-42	1	HP 14x89	65	APE D25-42	3	0.10	0.04	0.05	0.15	200	660	30.45	4.18	14.9	8.43	22.89
	1	HP 14x89	65	APE D25-42	3	0.10	0.04	0.10	0.15	200	620	27.40	2.94	14.6	8.43	22.56
	1	HP 14x89	65	APE D25-42	3	0.10	0.07	0.05	0.15	200	650	28.99	3.04	14.9	8.42	23.03
	1	HP 14x89	65	APE D25-42	3	0.10	0.07	0.10	0.15	200	610	26.38	1.86	15.0	8.35	22.38
	1	HP 14x89	65	APE D25-42	4	0.10	0.04	0.05	0.15	200	730	35.40	4.83	14.4	9.64	28.37
	1	HP 14x89	65	APE D25-42	4	0.10	0.04	0.10	0.15	200	690	31.79	3.46	15.0	9.54	27.63
	1	HP 14x89	65	APE D25-42	4	0.10	0.07	0.05	0.15	200	710	33.39	3.65	14.3	9.51	28.02
	1	HP 14x89	65	APE D25-42	4	0.10	0.07	0.10	0.15	200	670	29.63	2.25	14.8	9.43	27.30
Abutment #1 14x117 APE D19-42	1	HP14x117	65	APE D19-42	3	0.10	0.04	0.05	0.15	200	710	28.34	3.04	14.6	8.32	19.06
	1	HP14x117	65	APE D19-42	3	0.10	0.04	0.10	0.15	200	670	26.02	2.29	14.7	8.25	18.70
	1	HP14x117	65	APE D19-42	3	0.10	0.07	0.05	0.15	200	680	26.63	1.99	14.3	8.18	18.70
	1	HP14x117	65	APE D19-42	3	0.10	0.07	0.10	0.15	200	640	24.02	1.50	14.4	8.13	18.34
	1	HP14x117	65	APE D19-42	4	0.10	0.04	0.05	0.15	200	780	32.05	3.65	14.9	9.39	22.48
	1	HP14x117	65	APE D19-42	4	0.10	0.04	0.10	0.15	200	730	29.26	2.75	14.6	9.30	22.05
	1	HP14x117	65	APE D19-42	4	0.10	0.07	0.05	0.15	200	750	30.45	2.31	14.7	9.25	22.15
	1	HP14x117	65	APE D19-42	4	0.10	0.07	0.10	0.15	200	700	27.40	1.85	14.4	9.16	21.66
Abutment #1 14x117 APE D25-42	1	HP14x117	65	APE D25-42	3	0.10	0.04	0.05	0.15	200	760	29.89	3.66	14.8	8.63	22.13
	1	HP14x117	65	APE D25-42	3	0.10	0.04	0.10	0.15	200	720	27.48	2.90	14.8	8.58	21.71
	1	HP14x117	65	APE D25-42	3	0.10	0.07	0.05	0.15	200	730	27.78	2.58	14.4	8.50	21.79
	1	HP14x117	65	APE D25-42	3	0.10	0.07	0.10	0.15	200	690	25.17	2.07	14.5	8.46	21.30
	1	HP14x117	65	APE D25-42	4	0.10	0.04	0.05	0.15	200	840	34.30	4.19	14.7	9.75	26.95
	1	HP14x117	65	APE D25-42	4	0.10	0.04	0.10	0.15	200	790	31.34	3.59	14.4	9.68	26.35
	1	HP14x117	65	APE D25-42	4	0.10	0.07	0.05	0.15	200	820	32.62	3.16	15.0	9.66	26.81
	1	HP14x117	65	APE D25-42	4	0.10	0.07	0.10	0.15	200	770	29.44	2.58	14.8	9.58	26.13
Abutment #2 14x89 APE D19-42	2	HP 14x89	45	APE D19-42	3	0.10	0.04	0.05	0.15	120	690	37.99	5.67	15.0	9.22	21.37
	2	HP 14x89	45	APE D19-42	3	0.10	0.04	0.10	0.15	120	660	35.58	5.11	14.7	9.08	20.97
	2	HP 14x89	45	APE D19-42	4	0.10	0.04	0.05	0.15	120	760	42.73	6.56	14.8	10.57	25.43
	2	HP 14x89	45	APE D19-42	4	0.10	0.04	0.10	0.15	120	730	40.04	6.00	15.0	10.41	24.94
Abutment #2 14x89 APE D25-42	2	HP 14x89	45	APE D25-42	3	0.10	0.04	0.05	0.15	120	760	41.03	4.99	14.9	9.55	24.74
	2	HP 14x89	45	APE D25-42	3	0.10	0.04	0.10	0.15	120	730	38.50	4.91	15.0	9.42	24.29
	2	HP 14x89	45	APE D25-42	4	0.10	0.04	0.05	0.15	120	850	46.99	5.93	14.7	11.03	30.39
	2	HP 14x89	45	APE D25-42	4	0.10	0.04	0.10	0.15	120	820	44.20	5.86	15.0	10.89	29.92
Abutment #2 14x117 APE D19-42	2	HP14x117	45	APE D19-42	3	0.10	0.04	0.05	0.15	120	770	34.93	4.96	14.7	9.08	20.58
	2	HP14x117	45	APE D19-42	3	0.10	0.04	0.10	0.15	120	750	33.44	4.50	15.0	9.00	20.34
	2	HP14x117	45	APE D19-42	4	0.10	0.04	0.05	0.15	120	840	38.86	5.72	14.7	10.24	24.10
	2	HP14x117	45	APE D19-42	4	0.10	0.04	0.10	0.15	120	810	36.89	5.14	14.6	10.12	23.70
Abutment #2 14x117 APE D25-42	2	HP14x117	45	APE D25-42	3	0.10	0.04	0.05	0.15	120	830	37.23	3.77	14.9	9.35	23.41
	2	HP14x117	45	APE D25-42	3	0.10	0.04	0.10	0.15	120	800	35.35	3.46	14.7	9.25	23.00
	2	HP14x117	45	APE D25-42	4	0.10	0.04	0.05	0.15	120	930	42.92	4.54	14.8	10.81	28.97
	2	HP14x117	45	APE D25-42	4	0.10	0.04	0.10	0.15	120	900	40.82	4.30	14.8	10.69	28.44

Hammer Information:

APE D19-42	Fuel Setting #3	39,119 ft-lbs
APE D19-42	Fuel Setting #4	47,132 ft-lbs
APE D25-42	Fuel Setting #3	55,814 ft-lbs
APE D25-42	Fuel Setting #4	62,016 ft-lbs

D19-42
#1 1247 psi
#2 1385 psi
#3 1539 psi
#4 1710 psi

D25-42
#1 1040 psi
#2 1155 psi
#3 1280 psi
#4 1425 psi

TABLE 4.4.8.1.2B Typical Range of Uniaxial Compressive Strength (C_o) as a Function of Rock Category and Rock Type

Rock Category	General Description	Rock Type	C_o[1] (ksf)	C_o[1] (psi)
A	Carbonate rocks with well-developed crystal cleavage	Dolostone	700- 6,500	4,800-45,000
		Limestone	500- 6,000	3,500-42,000
		Carbonatite	800- 1,500	5,500-10,000
		Marble	800- 5,000	5,500-35,000
		Tactite-Skarn	2,700- 7,000	19,000-49,000
B	Lithified argillaceous rock	Argillite	600- 3,000	4,200-21,000
		Claystone	30- 170	200- 1,200
		Marlstone	1,000- 4,000	7,600-28,000
		Phyllite	500- 5,000	3,500-35,000
		Siltstone	200- 2,500	1,400-17,000
		Shale[2]	150- 740	1,000- 5,100
		Slate	3,000- 4,400	21,000-30,000
C	Arenaceous rocks with strong crystals and poor cleavage	Conglomerate	700- 4,600	4,800-32,000
		Sandstone	1,400- 3,600	9,700-25,000
		Quartzite	1,300- 8,000	9,000-55,000
D	Fine-grained igneous crystalline rock	Andesite	2,100- 3,800	14,000-26,000
		Diabase	450-12,000	3,100-83,000
E	Coarse-grained igneous and metamorphic crystalline rock	Amphibolite	2,500- 5,800	17,000-40,000
		Gabbro	2,600- 6,500	18,000-45,000
		Gneiss	500- 6,500	3,500-45,000
		Granite	300- 7,000	2,100-49,000
		Quartzdiorite	200- 2,100	1,400-14,000
		Quartzmonzonite	2,700- 3,300	19,000-23,000
		Schist	200- 3,000	1,400-21,000
		Syenite	3,800- 9,000	26,000-62,000

[1]Range of Uniaxial Compressive Strength values reported by various investigations.
[2]Not including oil shale.

$$\rho = q_o (1 - \nu^2) B I_p / E_m, \text{ with } I_p = (L/B)^{1/2}/\beta_z \quad (4.4.8.2.2\text{-}2)$$

Values of I_p may be computed using the β_z values presented in Table 4.4.7.2.2B from Article 4.4.7.2.2 for rigid footings. Values of Poisson's ratio (υ) for typical rock types are presented in Table 4.4.8.2.2A. Determination of the rock mass modulus (E_m) should be based on the results of in-situ and laboratory tests. Alternatively, values of E_m may be estimated by multiplying the intact rock modulus (E_o) obtained from uniaxial compression tests by a reduction factor (α_E) which accounts for frequency of discontinuities by the rock quality designation (RQD), using the following relationships (Gardner, 1987):

$$E_m = \alpha_E E_o \quad (4.4.8.2.2\text{-}3)$$

$$\alpha_E = 0.0231(RQD) - 1.32 \geq 0.15 \quad (4.4.8.2.2\text{-}4)$$

For preliminary design or when site-specific test data cannot be obtained, guidelines for estimating values of E_o (such as presented in Table 4.4.8.2.2B or Figure 4.4.8.2.2A) may be used. For preliminary analyses or for final design when in-situ test results are not available, a value of $\alpha_E = 0.15$ should be used to estimate E_m.

4.4.8.2.3 Tolerable Movement

Refer to Article 4.4.7.2.3.

4.4.9 Overall Stability

The overall stability of footings, slopes, and foundation soil or rock shall be evaluated for footings located on

Earth Pressure

Earth Pressure:

Backfill engineering strength parameters

Soil Type 4 Properties from MaineDOT Bridge Design Guide (BDG)

Unit weight $\gamma_1 := 125 \cdot \text{pcf}$

Internal friction angle $\phi' := 32 \cdot \text{deg}$

Cohesion $c_1 := 0 \cdot \text{psf}$

Integral Abutment - Passive Earth Pressure - Coulomb Theory

α = Angle of fill slope to the horizontal $\alpha := -0.57 \cdot \text{deg}$

ϕ_1 = Angle of internal friction $\phi' = 32 \cdot \text{deg}$

β = Angle of back face of wall to the horizontal $\beta := 90 \cdot \text{deg}$

Use Coulomb for cases where interface friction is considered; typically gravity shaped structures, and integral abutments where the ratio of wall height to wall movement is .020 or greater. Coulomb should also be used when the fill slope is greater than horizontal.

For formed concrete IAB abutment against clean sand, silty sand-gravel mixture use δ = 17 - 22, per LRFD Table 3.11.5.3-1

δ = friction angle between fill and wall taken as specified in LRFD Table 3.11.5.3-1 (degrees)

$\delta' := 17 \cdot \text{deg}$

$$K_{p\_coulomb} := \frac{\sin(\beta - \phi')^2}{\sin(\beta)^2 \cdot \sin(\beta + \delta') \cdot \left(1 - \sqrt{\frac{\sin(\phi' + \delta') \cdot \sin(\phi' + \alpha)}{\sin(\beta + \delta') \cdot \sin(\beta + \alpha)}}\right)^2}$$

Das, Principles of Foundation Engineering 7th Ed. p. 366 Eq. 7.71

$\boxed{K_{p\_coulomb} = 5.85}$

Integral Abutment and Wingwall - Passive Earth Pressure - Rankine Theory

Per the BDG, use Rankine only if the ratio of wall height to wall movement is 0.005 or less and the fill slope is horizontal to the top of the wall. Bowles does not recommend use of Rankine method for K_p when α > 0.

α = Angle of fill slope to the horizontal $\alpha := -0.57 \cdot \text{deg}$

$$K_{p\_rank} := \cos(\alpha) \cdot \frac{\cos(\alpha) + \sqrt{\cos(\alpha)^2 - \cos(\phi')^2}}{\cos(\alpha) - \sqrt{\cos(\alpha)^2 - \cos(\phi')^2}}$$

Das, Principles of Foundation Engineering 7th Ed. p. 363 Eq. 7.67

$\boxed{K_{p\_rank} = 3.25}$

P_p is oriented at an angle of α to the vertical plane

Integral Abutment - Passive Pressure Coefficient per MassDOT LRFD Bridge Manual Part 1

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

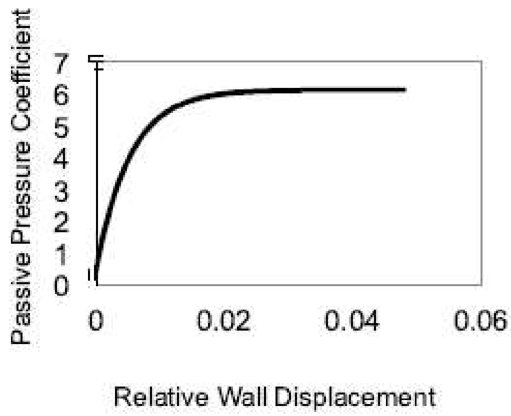


Figure 3.10.8-1: Plot of Passive Pressure Coefficient, K, vs. Relative Wall Displacement, δ_T/H.

Thermal displacement at each abutment: $\delta := 0.43\text{in}$

Abutment height: $h := 11\text{ft}$ $h = 132 \cdot \text{in}$

Relative wall displacement: $\dfrac{\delta}{h} = 0.0033$

$K := 0.43 + 5.7 \cdot [1 - \exp[-190(0.0033)]]$

$\boxed{K = 3.09}$ **< K_{p_rank} of 3.25, therefore recommend K=3.25**

Table 3.11.5.3-1—Friction Angle for Dissimilar Materials (U.S. Department of the Navy, 1982a)

Interface Materials	Friction Angle, δ (degrees)	Coefficient of Friction, tan δ (dim.)
Mass concrete on the following foundation materials:		
• Clean sound rock	35	0.70
• Clean gravel, gravel-sand mixtures, coarse sand	29 to 31	0.55 to 0.60
• Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel	24 to 29	0.45 to 0.55
• Clean fine sand, silty or clayey fine to medium sand	19 to 24	0.34 to 0.45
• Fine sandy silt, nonplastic silt	17 to 19	0.31 to 0.34
• Very stiff and hard residual or preconsolidated clay	22 to 26	0.40 to 0.49
• Medium stiff and stiff clay and silty clay	17 to 19	0.31 to 0.34
Masonry on foundation materials has same friction factors.		
Steel sheet piles against the following soils:		
• Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls	22	0.40
• Clean sand, silty sand-gravel mixture, single-size hard rock fill	17	0.31
• Silty sand, gravel or sand mixed with silt or clay	14	0.25
• Fine sandy silt, nonplastic silt	11	0.19
Formed or precast concrete or concrete sheet piling against the following soils:		
• Clean gravel, gravel-sand mixture, well-graded rock fill with spalls	22 to 26	0.40 to 0.49
• Clean sand, silty sand-gravel mixture, single-size hard rock fill	$\boxed{\text{17 to 22}}$	0.31 to 0.40
• Silty sand, gravel or sand mixed with silt or clay	17	0.31
• Fine sandy silt, nonplastic silt	14	0.25
Various structural materials:		
• Masonry on masonry, igneous and metamorphic rocks:		
o dressed soft rock on dressed soft rock	35	0.70
o dressed hard rock on dressed soft rock	33	0.65
o dressed hard rock on dressed hard rock	29	0.55
• Masonry on wood in direction of cross grain	26	0.49
• Steel on steel at sheet pile interlocks	17	0.31

3.11.5.4—Passive Lateral Earth Pressure Coefficient, k_p

For noncohesive soils, values of the coefficient of passive lateral earth pressure may be taken from Figure 3.11.5.4-1 for the case of a sloping or vertical wall with a horizontal backfill or from Figure 3.11.5.4-2 for the case of a vertical wall and sloping backfill. For conditions that deviate from those described in Figures 3.11.5.4-1 and 3.11.5.4-2, the passive pressure may be calculated by using a trial procedure based on wedge theory, e.g., see Terzaghi et al. (1996). When wedge theory is used, the limiting value of the wall friction angle should not be taken larger than one-half the angle of internal friction, ϕ_f.

For cohesive soils, passive pressures may be estimated by:

C3.11.5.4

The movement required to mobilize passive pressure is approximately 10.0 times as large as the movement needed to induce earth pressure to the active values. The movement required to mobilize full passive pressure in loose sand is approximately five percent of the height of the face on which the passive pressure acts. For dense sand, the movement required to mobilize full passive pressure is smaller than five percent of the height of the face on which the passive pressure acts, and five percent represents a conservative estimate of the movement required to mobilize the full passive pressure. For poorly compacted cohesive soils, the movement required to mobilize full passive pressure is larger than five percent of the height of the face on which the pressure acts.

Table 7.9 (*Continued*)

		$c'/\gamma z$			
ϕ' (deg)	α (deg)	0.025	0.050	0.100	0.500
30	0	3.087	3.173	3.346	4.732
	5	3.042	3.129	3.303	4.674
	10	2.907	2.996	3.174	4.579
	15	2.684	2.777	2.961	4.394

7.12 Coulomb's Passive Earth Pressure

Coulomb (1776) also presented an analysis for determining the passive earth pressure (i.e., when the wall moves *into* the soil mass) for walls possessing friction (δ' = angle of wall friction) and retaining a granular backfill material similar to that discussed in Section 7.5.

To understand the determination of Coulomb's passive force, P_p, consider the wall shown in Figure 7.25a. As in the case of active pressure, Coulomb assumed that the potential failure surface in soil is a plane. For a trial failure wedge of soil, such as ABC_1, the forces per unit length of the wall acting on the wedge are

1. The weight of the wedge, W
2. The resultant, R, of the normal and shear forces on the plane BC_1, and
3. The passive force, P_p

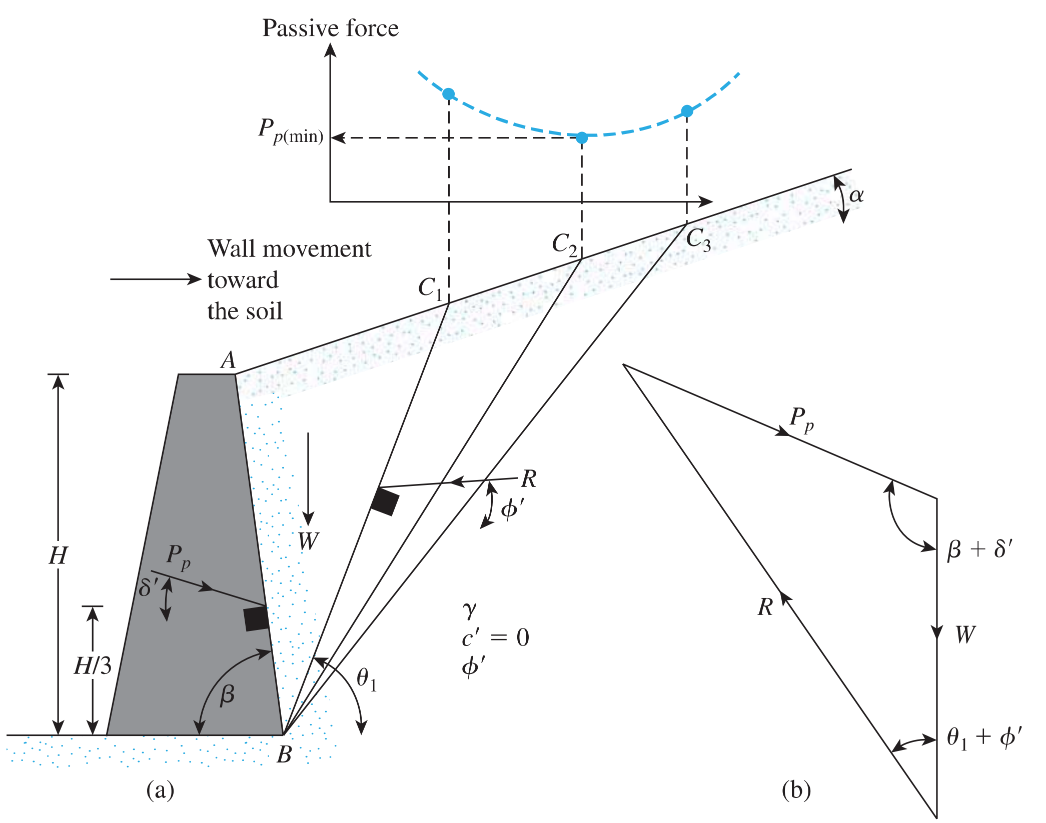


Figure 7.25 Coulomb's passive pressure

Table 7.10 Values of K_p [from Eq. (7.71)] for $\beta = 90°$ and $\alpha = 0°$

	δ' (deg)				
ϕ' (deg)	0	5	10	15	20
15	1.698	1.900	2.130	2.405	2.735
20	2.040	2.313	2.636	3.030	3.525
25	2.464	2.830	3.286	3.855	4.597
30	3.000	3.506	4.143	4.977	6.105
35	3.690	4.390	5.310	6.854	8.324
40	4.600	5.590	6.946	8.870	11.772

Figure 7.25b shows the force triangle at equilibrium for the trial wedge ABC_1. From this force triangle, the value of P_p can be determined, because the direction of all three forces and the magnitude of one force are known.

Similar force triangles for several trial wedges, such as ABC_1, ABC_2, ABC_3, . . . , can be constructed, and the corresponding values of P_p can be determined. The top part of Figure 7.25a shows the nature of variation of the P_p values for different wedges. The *minimum value of* P_p in this diagram is *Coulomb's passive force,* mathematically expressed as

$$P_p = \frac{1}{2}\gamma H^2 K_p \tag{7.70}$$

where

$$K_p = \text{Coulomb's passive pressure coefficient}$$
$$= \frac{\sin^2(\beta - \phi')}{\sin^2\beta \sin(\beta + \delta')\left[1 - \sqrt{\dfrac{\sin(\phi' + \delta')\sin(\phi' + \alpha)}{\sin(\beta + \delta')\sin(\beta + \alpha)}}\right]^2} \tag{7.71}$$

The values of the passive pressure coefficient, K_p, for various values of ϕ' and δ' are given in Table 7.10 $(\beta = 90°, \alpha = 0°)$.

Note that the resultant passive force, P_p, will act at a distance $H/3$ from the bottom of the wall and will be inclined at an angle δ' to the normal drawn to the back face of the wall.

7.13 Comments on the Failure Surface Assumption for Coulomb's Pressure Calculations

Coulomb's pressure calculation methods for active and passive pressure have been discussed in Sections 7.5 and 7.12. The fundamental assumption in these analyses is the acceptance of *plane failure surface*. However, for walls with friction, this assumption does not hold in practice. The nature of *actual* failure surface in the soil mass for active and passive pressure is shown in Figure 7.26a and b, respectively (for a vertical wall with a horizontal backfill). Note that the failure surface BC is curved and that the failure surface CD is a plane.

Although the actual failure surface in soil for the case of active pressure is somewhat different from that assumed in the calculation of the Coulomb pressure, the results are not greatly different. However, in the case of passive pressure, as the value of δ' increases, Coulomb's

At this depth, that is $z = 2$ m, for the bottom soil layer

$$\sigma'_p = \sigma'_o K_{p(2)} + 2c'_2\sqrt{K_{p(2)}} = 31.44(2.56) + 2(10)\sqrt{2.56}$$
$$= 80.49 + 32 = 112.49 \text{ kN/m}^2$$

Again, at $z = 3$ m,

$$\sigma'_o = (15.72)(2) + (\gamma_{sat} - \gamma_w)(1)$$
$$= 31.44 + (18.86 - 9.81)(1) = 40.49 \text{ kN/m}^2$$

Hence,

$$\sigma'_p = \sigma'_o K_{p(2)} + 2c'_2\sqrt{K_{p(2)}} = 40.49(2.56) + (2)(10)(1.6)$$
$$= \mathbf{135.65\ kN/m^2}$$

Note that, because a water table is present, the hydrostatic stress, u, also has to be taken into consideration. For $z = 0$ to 2 m, $u = 0$; $z = 3$ m, $u = (1)(\gamma_w) = 9.81$ kN/m^2.

The passive pressure diagram is plotted in Figure 6.24b. The passive force per unit length of the wall can be determined from the area of the pressure diagram as follows:

Area no.	Area	
1	$(\frac{1}{2})$ (2)(94.32)	= 94.32
2	(112.49)(1)	= 112.49
3	$(\frac{1}{2})$ (1)(135.65 − 112.49)	= 11.58
4	$(\frac{1}{2})$ (9.81)(1)	= 4.905
		$P_P \approx 223.3$ **kN/m**

7.11 Rankine Passive Earth Pressure: Vertical Backface and Inclined Backfill

Granular Soil

For a frictionless vertical retaining wall (Figure 7.10) with a *granular backfill* $(c' = 0)$, the Rankine passive pressure at any depth can be determined in a manner similar to that done in the case of active pressure in Section 7.4. The pressure is

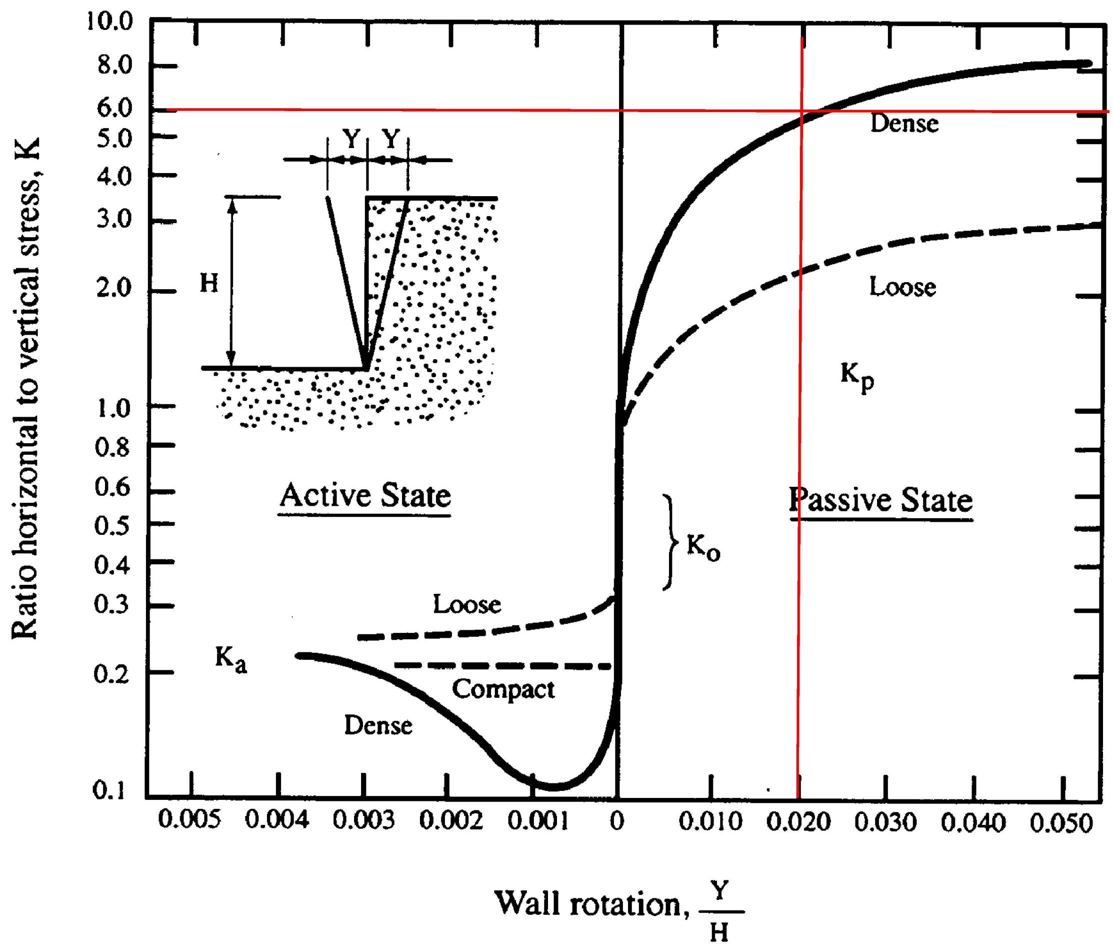
$$\sigma'_p = \gamma z K_p \tag{7.65}$$

and the passive force is

$$P_p = \tfrac{1}{2}\gamma H^2 K_p \tag{7.66}$$

where

$$K_p = \cos\alpha \frac{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}} \tag{7.67}$$



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).

Frost Depth

Method 1 - MaineDOT Design Freezing Index (DFI) Map and Depth of Frost Penetration Table, BDG Section 5.2.1.

From Design Freezing Index Map: Levant, Maine
DFI = 1825 degree-days.
Fine-Grained Fill w=16% (BB-LBS-101 1D)
Coarse-Grained Fill w=10% (BB-LBS-203 3D)

Fine-Grained Fill

For DFI = 1800, Fine-Grained Soil, w=10%

d=Depth of Frost Penetration

$d_1 := 64.0\text{in} \qquad DFI_1 := 1800$

For DFI = 1900, Fine-Grained Soil, w=10%

$d_2 := 65.8\text{in} \qquad DFI_2 := 1900$

Interpolate for DFI = 1825, Fine-Grained Soil, w=10%

$DFI_3 := 1825$

$$d_{f10} := d_1 + (DFI_3 - DFI_1)\cdot\frac{(d_2 - d_1)}{(DFI_2 - DFI_1)}$$

$d_{f10} = 64.5\cdot\text{in} \qquad d_{f10} = 5.4\cdot\text{ft}$

For DFI = 1800, Fine-Grained Soil, w=20%

$d_1 := 55.1\text{in} \qquad DFI_1 := 1800$

For DFI = 1900, Fine-Grained Soil, w=20%

$d_2 := 56.7\text{in} \qquad DFI_2 := 1900$

Interpolate for DFI = 1825, Fine-Grained Soil, w=20%

$DFI_3 := 1825$

$$d_{f20} := d_1 + (DFI_3 - DFI_1)\cdot\frac{(d_2 - d_1)}{(DFI_2 - DFI_1)}$$

$d_{f20} = 55.5\cdot\text{in} \qquad d_{f20} = 4.6\cdot\text{ft}$

Interpolate for DFI = 1825, Fine-Grained Soil, w=16%

$$d_{f16} := d_{f10} + (0.16 - 0.10)\cdot\frac{(d_{f20} - d_{f10})}{(0.20 - 0.10)}$$

$\boxed{d_{f16} = 59.1\cdot\text{in}} \qquad \boxed{d_{f16} = 4.9\cdot\text{ft}}$ **for Fine-Grained Fill**

Coarse-Grained Fill

For DFI = 1800, Coarse-Grained Soil, w=10%

$d_1 := 90.1\text{in} \qquad DFI_1 := 1800$

For DFI = 1900, Coarse-Grained Soil, w=10%

$d_2 := 92.6\text{in} \qquad DFI_2 := 1900$

Interpolate for DFI = 1825, Coarse-Grained Soil, w=10%

$DFI_3 := 1825$

$$d_{c10} := d_1 + \left(DFI_3 - DFI_1\right)\cdot\frac{\left(d_2 - d_1\right)}{\left(DFI_2 - DFI_1\right)}$$

$\boxed{d_{c10} = 90.7\cdot\text{in}}$ $\boxed{d_{c10} = 7.6\cdot\text{ft}}$ **for Coarse-Grained Fill**

Recommend any foundation bearing on soils be embedded **7.6 feet** for frost protection.

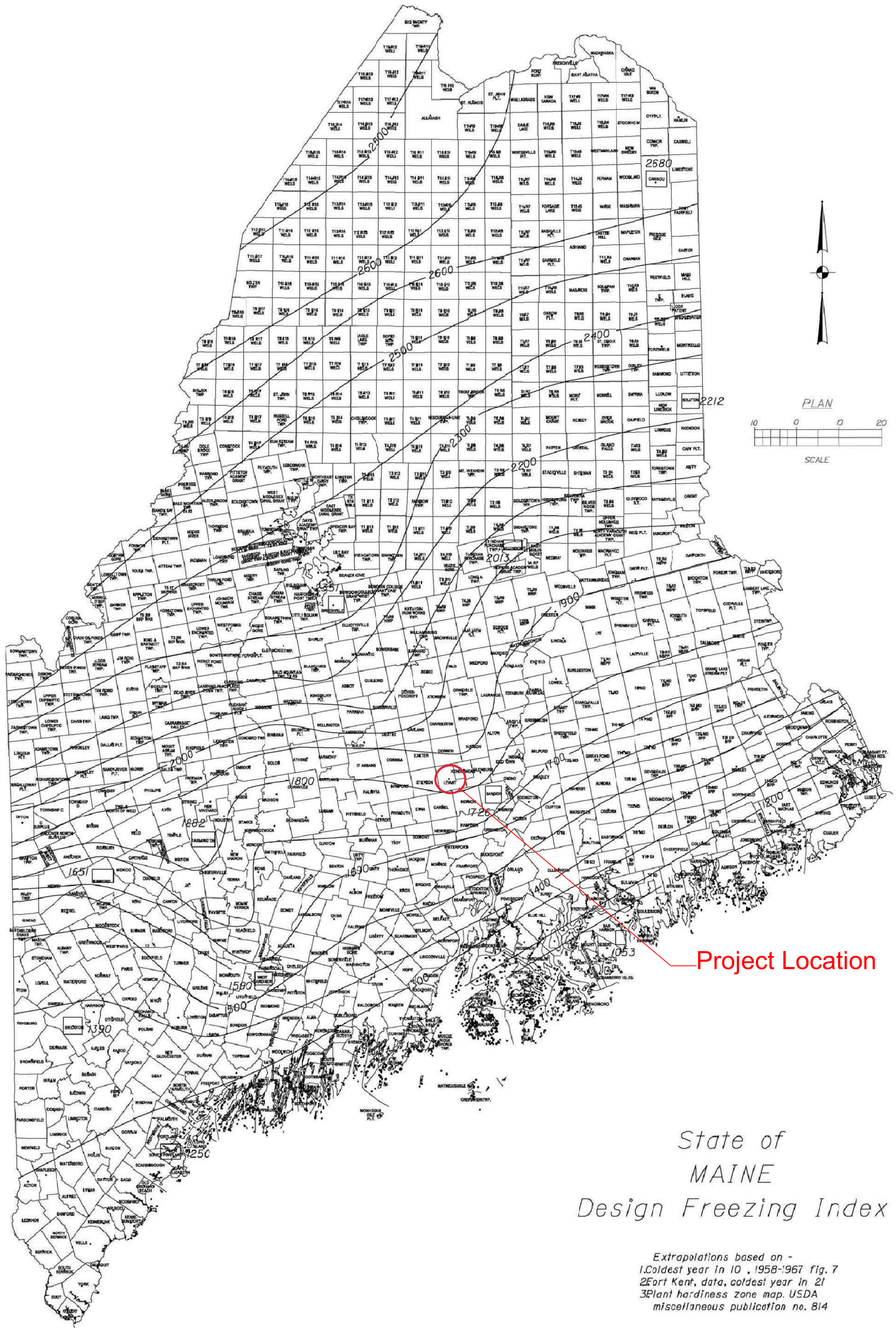


Figure 5-1 Maine Design Freezing Index Map

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

Seismic Parameters

BB-LBS-101/101A			
Depth	N_{60}	di	di/N
5	45	9	0.20
10	23	4	0.17
15	38	7	0.18
20	57	5	0.09
25	80	5	0.06
30	47	5	0.11
35	48	5	0.10
40	41	5	0.12
45	100	5	0.05
50	88	5	0.06
55	100	5	0.05
60	100	40	0.40
SUM		**100**	**1.60**
		di/di/N	**62.59**

BB-LBS-102			
Depth	N_{60}	di	di/N
5	27	10	0.37
11	11	5	0.45
15	29	1	0.03
20	17	8	0.47
25	30	8	0.27
35	26	8	0.31
40	29	5	0.17
45	23	5	0.22
50	100	50	0.50
SUM		**100**	**2.79**
		di/di/N	**35.79**

SUM	**Nav.**	**49.19**

15 < Nav. < 50 bpf

Conclusion: Site Class D

Site Classification per LRFD Table C3.10.3.1-1 - Method B

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Abutment No. 1 and 2 Seismic Parameters

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
AASHTO Spectrum for 7% PE in 75 years
Latitude = 44.857917
Longitude = -068.954583
Site Class B
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.070	PGA - Site Class B
0.2	0.150	Ss - Site Class B
1.0	0.045	S1 - Site Class B

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Spectral Response Accelerations SDs and SD1
Latitude = 44.857917
Longitude = -068.954583
As = FpgaPGA, SDs = FaSs, and SD1 = FvS1
Site Class D - Fpga = 1.60, Fa = 1.60, Fv = 2.40
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.111	As - Site Class D
0.2	0.239	SDs - Site Class D
1.0	0.108	SD1 - Site Class D

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