MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of:

MILFORD STREET BRIDGE OVER GRAND LAKE STREAM
GRAND LAKE STREAM, MAINE

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GEOTECHNICAL DESIGN SUMMARY

This report provides geotechnical recommendations for the replacement of the Milford Street Bridge over Grand Lake Stream in Grand Lake Stream, Maine. The proposed replacement bridge will be single-span, approximately 86 foot long, concrete box beam superstructure founded on precast, pile-supported integral abutments along the existing alignment. The design and construction recommendations below are discussed in greater detail in Section 7.0 Foundation Considerations and Recommendations.

Integral Abutment H-Piles – The abutments will be precast concrete stub abutments with “butterfly” return wings. The abutments will be supported on driven integral H-piles. The piles should be end bearing, driven to the required resistance on or within the bedrock. The piles should be oriented for weak axis bending. Driven piles should be fitted with driving points to protect the pile tips and improve penetration.

Piles will be 50 ksi, A572 steel H-piles. The factored structural resistance of the piles exceeds the factored static and drivability axial pile resistances. The drivability axial pile resistances from our analyses provide the best estimates of factored pile resistances. We recommend that the resistances from the drivability analyses be used for design. The contractor is required to perform a wave equation analysis and dynamic pile test. The nominal pile resistance that must be achieved in the wave equation analysis and dynamic testing is the maximum factored axial pile load divided by a resistance factor of $\varphi_{dyn} = 0.52$. The maximum factored pile load should be as shown on the plans. We present the design factored pile axial resistances in Section 7.1.1, Strength Limit State.

Precast Integral Stub Abutment and Wingwalls – Precast integral abutments and wingwalls shall be designed to resist and/or absorb lateral earth loads, vehicular loads, superstructure loads, creep, and temperature and shrinkage deformations of the superstructure. They shall be designed for all relevant service and strength limit states. Current plans include stub abutments with “butterfly” wingwalls. Thus, the designer should size the piles to account for the additional bending moment stress resulting from the wingwall configuration.

Integral abutment and integral wingwall sections should be designed to resist passive earth pressure using a Coulomb earth pressure coefficient, K_p, equal to 6.89. Coulomb theory considers wall friction, which acts downward against the passive soil wedge and increases passive pressures. Developing full passive earth pressure requires displacements on the order of 2 to 5 percent of the abutment or wingwall height. Only if the calculated displacements are less than 0.5 percent of the wall or abutment height, may the designer consider using a Rankine earth pressure coefficient of 3.25, which assumes no wall friction. Wingwall sections that are independent of the abutment should be designed using the Rankine active earth pressure coefficient, K_a, equal to 0.31. This assumes level backslope. The earth pressure coefficient may change if backslope conditions are different.

Scour Protection - The designer shall consider scour at pile-supported abutments, wingwalls and retaining walls in accordance with the MaineDOT Bridge Design Guide (BDG) Section

2.3.11 and AASHTO LRFD Bridge Design Specifications, 4th Edition, with 2008 Interims (herein referred to as LRFD) Article 3.7.5. The designer shall consider the consequences of changes in foundation conditions at the strength and service limit states resulting from scour due to the design flood event using appropriate resistance factors. For the extreme event limit state, the designer shall consider scour due to the check flood event and shall determine that there is adequate foundation resistance to support all applicable unfactored loads with a resistance factor of 1.0.

Integral abutment piles rely on the stability of slopes to provide lateral support. Therefore scour protection and armoring of the 1.75H:1V slopes in front of the abutments and along the approach embankments is critical. For the Grand Lake Stream site, the designer has specified the use of supplier-designed anchored flexible concrete matting for scour protection. For abutments and wingwalls, the flexible concrete mat stabilization shall extend 1.5 feet horizontally in front of the structure before sloping at maximum 1.75H:1V slope to the existing ground surface. The toe of the stabilization mat sections shall be constructed 1 foot below the streambed elevation. The flexible concrete matting shall be underlain by soil and geosynthetic materials specified in the supplier-design.

Settlement – The plans indicate a grade rise less than one foot for a short distance in the west bridge approach. Thus settlement as a result of fill placement over glacial till subgrade will be negligible. Settlement of the bridge abutments will be limited to the axial compression of the piles which will occur as the bridge is constructed and will be negligible.

Seismic Design Considerations – In accordance with LRFD Article 4.7.4.2, seismic analysis is not required for single-span bridges regardless of seismic zone. However, superstructure connections and bridge seat dimensions must satisfy LRFD Article 3.10.9 and 4.7.4.4, respectively.

Construction Considerations –

<u>Excavation</u>

- Construction of new abutment structures will require soil excavation. Earth support systems may be required.
- Remove the old abutments and backfill down to the top of existing footings at approximate elevation 284 feet.
- Protect the excavated subgrade from exposure to water and unnecessary construction traffic. Remove and replace water-softened, disturbed, or rutted subgrade soil with compacted gravel borrow.

<u>Dewatering</u>

- Control groundwater and surface water infiltration to permit construction in-the-dry.
- Temporary ditches, pumping from sumps, granular drainage blankets, stone ditch protection, or hand-laid riprap with geotextile underlayment may be needed to divert groundwater if significant seepage is encountered during excavation.

<u>Installing Piles</u>

- There is a potential that cobbles, boulders, timber cribbing, or quarried stone from old foundations may obstruct pile driving operations at the proposed abutment locations. Obstructions may be cleared by conventional excavation methods, pre-drilling, or spudding. Alternative methods to clear obstructions may be used as approved by the Resident.

Reuse of Excavated Soil and Bedrock

- Do not use excavated existing subbase aggregate for pavement structure construction or to re-base shoulders. Excavated subbase sand and gravel may be used as fill below subgrade elevation in fill embankment areas.
- Do not use excavated glacial till soils for fill anywhere beneath the pavement structure or dressing slopes. Use these soils to dress slopes only below the bottom elevation of the shoulder subbase gravel.
- Glacial till may be used as common borrow in accordance with Maine Department of Transportation (MaineDOT) Standard Specification Sections 203 and 703. It may be necessary to spread out and dry portions of these soils that are excessively moist.

Embankment Fill Areas

- Bench existing fill slope soils in accordance with MaineDOT Standard Specification 203.09, Preparation of Embankment Area, where new fill slope extensions are constructed over existing slopes.

Erosion Control

- Use MaineDOT Best Management Practices February 2008 to minimize erosion of fine-grained soils found on the project site.

1.0 INTRODUCTION

MaineDOT plans to replace the Milford Street Bridge over Grand Lake Stream in the Town of Grand Lake Stream, Washington County, Maine. We show the project location on Sheet 1, Site Location Map, appended to this report. We conducted subsurface investigations at the bridge site to develop geotechnical recommendations for the bridge replacement. This report summarizes our findings, discusses our evaluation of the subsurface conditions and presents our geotechnical recommendations for design and construction of the bridge foundations.

The existing single-span bridge was built in 1939. The plans for that bridge indicate that the stone abutments predated the 1939 construction. The bridge constructed in 1939 simply capped the pre-existing mortared granite abutments with a new concrete abutment section. The abutments were constructed over unreinforced concrete footings formed and cast over soil. The existing span length is approximately 38 feet. The bridge has sustained significant undermining due to scour which has been repaired numerous times with grout bagging and/or formed and cast concrete methods. The bridge had a sufficiency rating of 11.8 in 2007.

MaineDOT is proposing a replacement bridge that will be single-span, approximately 86 foot long, with a concrete box beam superstructure founded on precast pile supported integral abutments. The new bridge will be on the same alignment as the existing bridge with a minor grade rise at the west abutment location. The new bridge will have an out-to-out width of 32 feet. Current plans include armoring the approach and abutment fill embankments with flexible concrete block matting.

2.0 GEOLOGIC SETTING

The Maine Geologic Survey "Surficial Geology of Wabassus Lake Quadrangle, Maine, Open-file No. 86-25" (1986) indicates that surficial soils in the vicinity of the Milford Street Bridge consists of bedrock outcrops and glacial till. The glacial till is typically a heterogeneous mixture of sand, silt, clay, and stones.

According to the "Bedrock Geologic Map of Maine" (1985), the bedrock at the Milford Street Bridge site consists of Devonian-Ordovician calcareous sandstone, interbedded sandstone, and impure limestone of the Flume Ridge Formation.

3.0 SUBSURFACE INVESTIGATION

We investigated subsurface conditions at the site by drilling four test borings, BB-GLS-101 through BB-GLS-104, conducted by the MaineDOT drill crew. Borings BB-GLS-101, BB-GLS-102 and BB-GLS-104 were terminated with bedrock cores. The boring locations are shown on Sheet 2, Boring Location Plan. We present the soil profile on Sheet 3, Interpretive Subsurface Profile. The borings were conducted on July 8, 9 and 10, 2008. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented on Sheet 4, Boring Logs, and in Appendix A, Boring Logs, provided at the end of this report.

We used solid stem auger and cased wash boring techniques to conduct the borings. Soil samples were obtained, where possible, at 5-foot intervals using Standard Penetration Test (SPT) methods. The standard penetration resistances, or N-values, discussed in this report are corrected for average hammer energy transfer. We compute the corrected or, N_{60}-values, by applying an average hammer energy transfer factor of 0.77 to the raw field N-values obtained with the MaineDOT drill rig. Bedrock was cored using an NQ-2 core barrel producing a 2.0-inch diameter rock core. The MaineDOT survey crew determined the boring location coordinates in the field when they collected the project survey data.

4.0 LABORATORY TESTING

We conducted a laboratory soil testing program on selected samples recovered from the test borings to evaluate soil classification, material reuse, and subgrade soil properties. Laboratory testing consisted of twenty-one (21) standard grain size analyses with natural water contents. We present results of laboratory testing in Appendix B, Laboratory Test Data. The AASHTO and Unified Soil Classification System (USCS) soil classification and water content data are also presented on the boring logs in Appendix A. We performed a grain size analysis test on a sample from the streambed. We present the results of that test in Appendix B also.

5.0 SUBSURFACE CONDITIONS

Regional surficial geology maps show that the bridge site is situated in an area of bedrock outcrops and glacial till deposits. We typically found glacial till soils over bedrock. However, the bridge itself is situated at the end of short fill extensions built into the Grand Lake Steam flood plain. Consequently, the soil behind the existing abutments is predominantly granular fill and cobbles overlying approximately 20 to 34 feet of glacial till. All of the boring locations are underlain by metamorphic siltstone, shale or sandstone bedrock. We present a profile depicting the generalized soil stratigraphy at the bridge site on Sheet 3, Interpretive Subsurface Profile, provided at the end of this report. A summary description of the subsurface conditions follows:

5.1 Granular Fill

We encountered granular fill to a depth of approximately 10.0, 11.7 and 8.5 feet below ground surface (bgs) in BB-GLS-101, BB-GLS-102 and BB-GLS-103, respectively. Based on the boring logs, the fill layer is generally comprised of fine to coarse sand with some gravel and little silt. At BB-GLS-102, we encountered a layer of predominantly cobbles between 6 and 11.7 feet bgs based on drill attitude observations. The SPT N_{60}-values in the granular fill ranged from 9 to 47 blows per foot (bpf) indicating that the unit is loose to dense in consistency.

The granular fill samples had water contents ranging between 4 and 16 percent. Grain size analyses conducted on selected samples of the fill soils indicate that the soils are classified as A-1-b and A-1-a by the AASHTO Classification System and SM and GM under the Unified Soil Classification System.

5.2 Glacial Till

The glacial till found in the borings comprised of sandy silt or silt with some sand and trace to some gravel with occasional cobbles. The thickness of this soil unit ranged from approximately 20 feet in boring BB-GLS-101 to 34 feet in boring BB-GLS-102. SPT N_{60}-values ranged from 15 to 132 bpf, indicating these deposits are medium dense to very dense in consistency. We observed the glacial till unit over bedrock in each of the borings except BB-GLS-103 which was terminated early due to equipment failure.

The glacial till samples had water contents ranging between 9 and 13 percent. Grain size analyses conducted on selected samples of the till soils indicate that the soils are classified as A-1-b, A-2-4, and A-4 by the AASHTO Classification System and SM and ML and CL-ML under the Unified Soil Classification System.

5.3 Bedrock

We encountered bedrock at approximate depths of 30.3, 39.0 and 41.4 feet bgs at BB-GLS-101, BB-GLS-102 and BB-GLS-104, respectively. Locally, the bedrock is mapped as the Flume Ridge Formation which is made up of calcareous sandstone, interbedded sandstone and impure limestone. Visual identification of rock cores indicates that the bedrock is a grey and brown, fine-grained, siltstone/shale or sandstone, moderately hard and highly to moderately fractured. We determined that the rock quality designation (RQD) of the bedrock ranged from 0 to 38 percent which correlates to a very poor to poor rock mass quality. The table below summarizes the top of bedrock elevations at the boring locations:

Substructure	Boring	Station	Depth to Bedrock (feet bgs)	Elevation of Bedrock Surface (feet)
Abutment No. 1	BB-GLS-101	5+07, 12.0 RT	30.3	268.1
Abutment No. 2	BB-GLS-102	5+96, 3.4 RT	39.0	259.2

Bedrock Depth and Elevation at the Boring Locations

5.4 Groundwater

We interpreted groundwater levels at the boring locations based on field observations. Groundwater occurred at approximate depths of 10.0, 11.7 and 5.0 feet bgs at BB-GLS-101, BB-GLS-102 and BB-GLS-103, respectively. However, the groundwater level will fluctuate with seasonal changes, runoff, and adjacent construction activities.

For a more detailed description of the subsurface conditions, please refer to Appendix A, Boring Logs attached to this report.

6.0 FOUNDATION ALTERNATIVES

A preliminary Design Report Meeting for the Milford Street Bridge replacement was held on 15 October 2008. Foundation alternatives were presented by the geotechnical team member at this meeting. The project team selected H-pile supported precast integral abutments for the replacement structure. The following section presents geotechnical design recommendations for precast, H-pile supported integral abutments and wingwalls.

7.0 FOUNDATION CONSIDERATIONS AND RECOMMENDATIONS

The design team has selected a single-span, integral abutment structure to replace the bridge at the Grand Lake Stream site. The proposed replacement bridge will be approximately 86 feet long and consist of a concrete box beam superstructure founded on precast, H-pile supported integral abutments. The new bridge will be on the same alignment as the existing bridge with a minor grade rise at the west abutment location. The new bridge will have an out-to-out width of 32 feet. The design methodology used in the following evaluation is referenced from the AASHTO LRFD Bridge Design Specifications, 4th Edition, 2007, with 2008 Interims.

7.1 Integral Abutment H-piles

The piles should be end bearing, driven to the required resistance on or within the bedrock, and oriented for weak axis bending (perpendicular to superstructure beams). Piles may be HP 12x53, HP 14x73, HP 14x89, or HP 14x117 depending on the factored design axial loads. Foundation piles should consist of 50 ksi, Grade A572 steel H-piles fitted with driving points to protect the tips, improve penetration, and improve friction at the pile tip.

The contractor may estimate the required pile lengths based on the following data. The estimated pile length below does not include embedment in the pile cap (embedment can range from 2 to 6 feet) or lead length required for installation.

Location	Estimated Bottom of Pile Cap Elevation (feet)	Top of Bedrock Elevation (feet)	First Run RQD (%)	Estimated Pile Length (feet)[1]
Abutment 1 BB-GLS-101	290	268	38	22
Abutment 2 BB-GLS-102	289	259	0	30

[1] pile length does not include embedment in the pile cap (2 to 6 feet anticipated) or lead length required for installation

Estimated Pile Lengths for Piles Installed to Depth of Bedrock Surface

Typically, the designer will design the H-piles at the strength limit state considering the combined axial and flexural structural resistance of the piles, and the axial geotechnical resistance of the piles. The structural resistance check should include checking axial, lateral, and flexural resistance. Resistance factors for use in the design of piles at the strength limit state are discussed below.

The design of H-piles at the service limit state should consider tolerable horizontal movement of the piles, and overall stability of the pile group. Since the abutment piles will be subjected to lateral loading, the pile should be analyzed for axial loading and combined axial and lateral loading as defined in LRFD Article 6.15.2.

7.1.1 Strength Limit State

The nominal structural compressive resistance (P_n) in the strength limit state for piles loaded in compression shall be as specified in LRFD Article 6.9.4.1. For preliminary analysis, the factored structural axial compressive resistances of the four proposed H-pile sections were calculated using a resistance factor, ϕ_c, of 0.60 and column slenderness factor, λ, of 0. It is the responsibility of the designer to recalculate λ for the upper and lower portions of the H-pile based on unbraced lengths and k-values from project specific analyses and then recalculate the structural resistances.

The nominal geotechnical axial compressive resistance in the strength limit state was calculated using the Pell, Turner, Tomlinson method referenced in Tomlinson (1994). Since there are less than five piles in each substructure, they are deemed "non-redundant" in LRFD Article 10.5.5.2.3. Thus, the resistance factor from LRFD Table 10.5.5.2.3-1, φ_{stat}, of 0.45 must be reduced 20 percent in accordance with Article 10.5.5.2.3. Consequently, the factored geotechnical compressive resistances of the four proposed H-pile sections were calculated using a resistance factor φ_{stat}, of 0.36 for end bearing. Skin friction was not considered due to insufficient overburden.

We also calculated the nominal geotechnical compressive resistance in a wave equation drivability analysis using GRLWEAP. The maximum driving stresses in the pile, assuming the use of 50 ksi steel, shall be less than 45 ksi. The resistance factor for a single pile in axial compression with the driving resistance established by a dynamic load test per LRFD Table 10.5.5.2.3-1 is $\varphi_{dyn} = 0.65$. Table 10.5.5.2.3-3 requires that no less than 3 or 4 dynamic tests be conducted for sites with low to medium variability. Since we typically perform only two tests per bridge, one per abutment, and the pile group is non-redundant, we have reduced this factor by 20 percent resulting in a resistance factor of $\varphi_{dyn} = 0.52$.

We present the factored axial compressive structural, geotechnical and drivability resistances for the four proposed H-pile sections in the table below. Supporting calculations are provided in Appendix C, Calculations. Based on our analysis, we recommend that the factored drivability resistance be used for strength limit state design.

H-Pile Section	Strength Limit State Factored Axial Pile Resistance (kips)			
	Structural Resistance	Geotechnical Static Resistance	Drivability Resistance	Governing Pile Resistance
12 x 53	465	97	217	217
14 x 73	642	134	345	345
14 x 89	783	163	400	400
14 x 117	1032	215	422	422

Factored Axial Pile Resistances at the Strength Limit State

In accordance with LRFD Article 6.5.4.2 at the strength limit state, H-piles in compression and bending, the axial resistance factor $\phi_c = 0.7$ 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. For the strength limit state, the combined axial compression and flexure should be evaluated as shown in LRFD Article 6.9.2.2. The structural designer should evaluate the capacity of the pile in combined axial load and flexure when the loads and moments are calculated. Moments resulting from the abutment wingwalls must also be considered in design of the piles.

7.1.2 Service and Extreme Limit States

In accordance with LRFD Article 10.5.5, Resistance Factors, the resistance factors for the service and extreme limit states for structural and geotechnical pile resistances is 1.0. We present the factored axial compressive structural, geotechnical and drivability resistances for the four proposed H-pile sections at the service/extreme limit state in the table below. Supporting calculations are provided in Appendix C, Calculations. Based on our analysis, we recommend that the factored drivability resistance be used for service/extreme limit state design.

H-Pile Section	Service/Extreme Limit State Factored Axial Pile Resistance (kips)			
	Structural Resistance	Geotechnical Static Resistance	Drivability Resistance	Governing Pile Resistance
12 x 53	775	269	417	417
14 x 73	1070	371	663	663
14 x 89	1305	452	770	770
14 x 117	1720	596	811	811

Factored Axial Pile Resistances at the Service/Extreme Limit State

7.1.3 Pile Resistance and Pile Quality Control

The contractor is required to perform a wave equation analysis of the proposed pile-hammer system and a dynamic pile test at each abutment. The first pile driven at each abutment should be dynamically tested to confirm capacity and verify the stopping criteria developed by the contractor in the wave equation analysis. The nominal pile resistance that must be achieved in the wave equation analysis and dynamic testing will be the maximum factored axial pile load divided by a resistance factor of 0.52. The maximum factored 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, the dynamic test results, 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. The contractor should select a hammer that provides the required nominal resistance when the penetration resistance for the final 3 to 6 inches is 3 to 15 blows per inch. If an abrupt increase in driving resistance is encountered, the driving could be terminated when the pile penetration is less than 0.5-inch in 10 consecutive blows.

7.1.4 L-Pile Analysis Parameters

We have performed L-Pile analysis for both abutment Nos. 1 and 2 using their respective subsurface conditions. We present the results of that analysis in Appendix C, Calculations.

7.2 Integral Stub Abutments and Wingwalls

Integral stub abutments and wingwalls should 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 and 11.6.1.3. The design of abutments and wingwalls at the strength limit state shall consider structural failure. Integral abutments and wingwalls shall be designed to resist and/or absorb lateral earth loads, vehicular loads, superstructure loads, creep, and temperature and shrinkage deformations of the superstructure. Current plans include stub abutments with "butterfly" wingwalls. Thus, the designer should size the piles to account for the additional bending moment stress resulting from the wingwall configuration.

Integral abutment and integral wingwall sections should be designed to resist passive earth pressure using a Coulomb earth pressure coefficient, K_p, equal to 6.89. Coulomb theory considers wall friction, which acts downward against the passive soil wedge and increases passive pressures. Developing full passive earth pressure requires displacements on the order of 2 to 5 percent of the abutment or wingwall height. Only if the calculated displacements are less than 0.5 percent of the wall or abutment height, may the designer consider using a Rankine earth pressure coefficient of 3.25, which assumes no wall friction. Wingwall sections that are independent of the abutment should be designed using the Rankine active earth pressure coefficient, K_a, equal to 0.31. This assumes level backslope. The earth pressure coefficient may change if backslope conditions are different.

To minimize water intrusion behind the abutment, the approach slab should connect directly to the abutment, and appropriate provisions should be made to provide for drainage for any entrapped water.

Backfill that is within 10 feet of the abutments and wingwalls and side slope fill should conform to MaineDOT Standard Specification 709.19, Granular Borrow for Underwater Backfill. This material requires 10 percent or less material passing the No. 200 which will help minimize frost action behind the structure.

The existing granite abutments will be removed down to the top of footing which is estimated from the 1939 bridge plans to be elevation 284 feet.

7.3 Scour Protection

In accordance with AASHTO 3.7.5, the designer shall consider the consequences of changes in foundation conditions at the strength and service limit states resulting from scour due to the design flood event using appropriate resistance factors. For the extreme event limit state, the designer shall consider scour due to the check flood event and shall determine that there is adequate foundation resistance to support all applicable unfactored loads with a resistance factor of 1.0. Changes in foundation conditions shall be investigated at pile-supported abutments and wingwalls. Integral abutment piles rely on the stability of slopes to provide lateral support. Therefore scour protection and armoring of the 1.75H:1V slopes in front of the abutments and along the approach embankments is critical. For the Grand Lake Stream site, the designer has specified the use of flexible concrete matting for scour protection. Refer to BDG Section 2.3.11 for additional information regarding scour design.

For abutments and wingwalls, the flexible concrete mat stabilization shall extend 1.5 feet horizontally in front of the structure before sloping at maximum 1.75H:1V slope to the existing ground surface. The toe of the stabilization mat sections shall be constructed 1 foot below the streambed elevation. The flexible concrete matting shall be underlain by soil and a geotextile specified in the supplier-design.

7.4 Settlement

The current bridge replacement plans include very minor profile changes. Thus we expect settlement as a result of fill placement over glacial till subgrade will be negligible. We expect that any settlement of the bridge abutments will be due to the elastic compression of the piles and will be negligible.

7.5 Frost Protection

We have evaluated the potential frost depth at the Grand Lake Stream bridge site. Based on State of Maine frost depth maps, MaineDOT Bridge Design Guide (BDG) Figure 5-1, the site has a design-freezing index of approximately 1700 F-degree days. This correlates to a frost depth of 5.0 feet. Consequently, we recommend that any foundations or leveling pads constructed at the site be founded a minimum of 5.0 feet below finished exterior grade. This minimum embedment applies only to foundations constructed on soil and not those founded on bedrock. We recommend that integral abutments be embedded a minimum of 4 feet for frost protection.

7.6 Seismic Design Considerations

The Milford Street Bridge is not classified as a major structure since construction costs will be less than $10 million dollars, nor is it on the National Highway System. Thus the bridge is not classified as functionally important or essential in the BDG or LRFD. In conformance with LRFD Article 4.7.4.2, seismic analysis is not required for single-span bridges, regardless of seismic zone. However, superstructure connections and bridge seat dimensions shall be satisfied per LRFD 3.10.9 and 4.7.4.4, respectively. Seismic earth loads do not need to be considered in bridge substructure design.

7.7 Construction Considerations

7.7.1 Installing Piles

There is a potential that cobbles, boulders, timber cribbing, or quarried stone from old foundations may obstruct pile driving operations at the proposed abutment locations. Obstructions may be cleared by conventional excavation methods, pre-drilling, or spudding. Alternative methods to clear obstructions may be used as approved by the Resident.

7.7.2 Excavation

Construction of the new abutment structures will require soil excavation. Earth support systems may be required. The fill and glacial till soils at the site will be susceptible to disturbance and rutting as a result of exposure to water or construction traffic. We recommend that the contractor protect any glacial till subgrade from exposure to water and any unnecessary construction traffic. If disturbance and rutting occur, we recommend that the contractor remove and replace the disturbed materials and replace with compacted gravel borrow. If the subgrade soil contains cobbles or boulders, we recommend that the contractor remove any cobbles and boulders larger than 6 inches in diameter. After excavating to the subgrade level, the contractor should proof-roll the surface to identify weak soil areas.

If encountered, unsuitable soils should also be excavated from the subgrade to a depth of one foot and replaced with compacted gravel borrow. Gravel borrow should conform to MaineDOT Standard Specification 703.20, Gravel Borrow. The gravel borrow should be compacted to 95 percent of the Modified Proctor maximum dry density (AASHTO T-180).

7.7.3 Dewatering

The native fill and glacial till soils within the project area are both poorly drained and moderately to highly frost susceptible. In some locations, these soil units may be saturated and significant water seepage may be encountered during excavation. The groundwater may be trapped in layers and lenses of coarse-grained soil overlying marine sediments, glacial till, or from bedrock fractures and joints. We anticipate that this seepage will be temporary but there may be localized sloughing and near-surface instability of some soil slopes.

The contractor should control groundwater and surface water infiltration to permit construction in-the-dry. We recommend that the contractor use temporary ditches, sumps, granular drainage blankets, stone ditch protection, or hand-laid riprap with geotextile underlayment to divert groundwater if significant seepage is encountered during construction. We also recommend using French drains daylighted to nearby ditches if significant seepage is encountered in the subgrade along the construction areas. If the amount of seepage is significant, we anticipate that pumping from sumps will likely be needed to control the water.

7.7.4 Reuse of Excavated Soil and Bedrock

The project plans call for excavation of the existing approach areas to achieve planned grades. In the process, the contractor will excavate both the existing subbase gravel, and subgrade fill soils. We do not recommend using the excavated subbase aggregate to re-base the bridge approaches. Excavated subbase and subgrade sand and gravel may be used as fill below subgrade elevation in fill embankment areas provided all other requirements of MaineDOT Standard Specification Sections 203 and 703 are met.

We do not recommend using any glacial till soil excavation as fill beneath the pavement structure. The glacial till may be used as common borrow in accordance with MaineDOT Standard Specification Sections 203 and 703. Contractors should expect that, prior to placement and compaction, it may be necessary to spread out and dry portions of these soils that are excessively moist. This soil may also be used for dressing slopes, but only below the bottom elevation of the shoulder subbase gravel.

7.7.5 Embankment Fill Areas

The current project plans require construction of fill extensions along the bridge approaches and in front of the abutments. The plans indicate that the side slopes will be constructed to 1.75: 1 (H:V) grades and will be armored with supplier-designed flexible concrete matting. We recommend benching the existing fill slope soils in accordance with MaineDOT Standard Specification 203.09, Preparation of Embankment Area, where new fill slope extensions are constructed over existing slopes in preparation for construction of the concrete mat slope stabilization.

7.7.6 Erosion Control Recommendations

The fine-grained soils along the project are susceptible to erosion. We recommend using appropriate erosion control measures during construction as described in the MaineDOT Best Management Practices February 2008 guidelines to minimize erosion of the fine-grained soils at the site.

8.0 CLOSURE

This report has been prepared for use by the MaineDOT Bridge Program for specific application to the replacement of the Milford Street Bridge over Grand Lake Stream in Grand Lake Stream, Maine. We have prepared the report in accordance with generally accepted soil 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. Further, the analyses and recommendations are based in part upon limited soil explorations completed at discrete locations on the project 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.

We recommend that we be provided the opportunity for a general review of the final design drawings and specifications in order that we may verify that the earthwork and foundation recommendations have been properly interpreted and implemented in the design.

REFERENCES

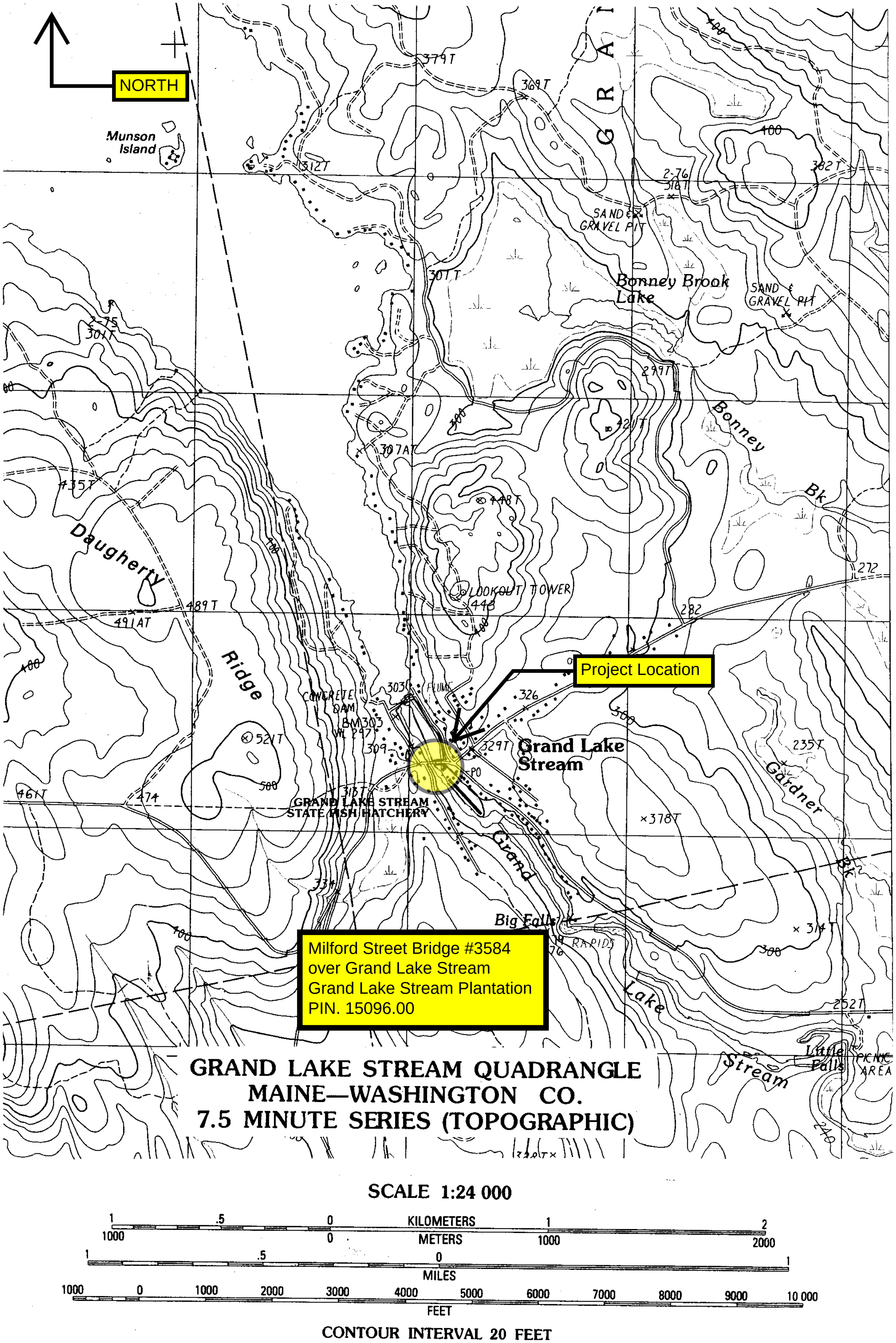
AASHTO, (2007), LRFD Bridge Design Specifications, Fourth Edition, with 2008 Interims, AASHTO, Washington, D.C.

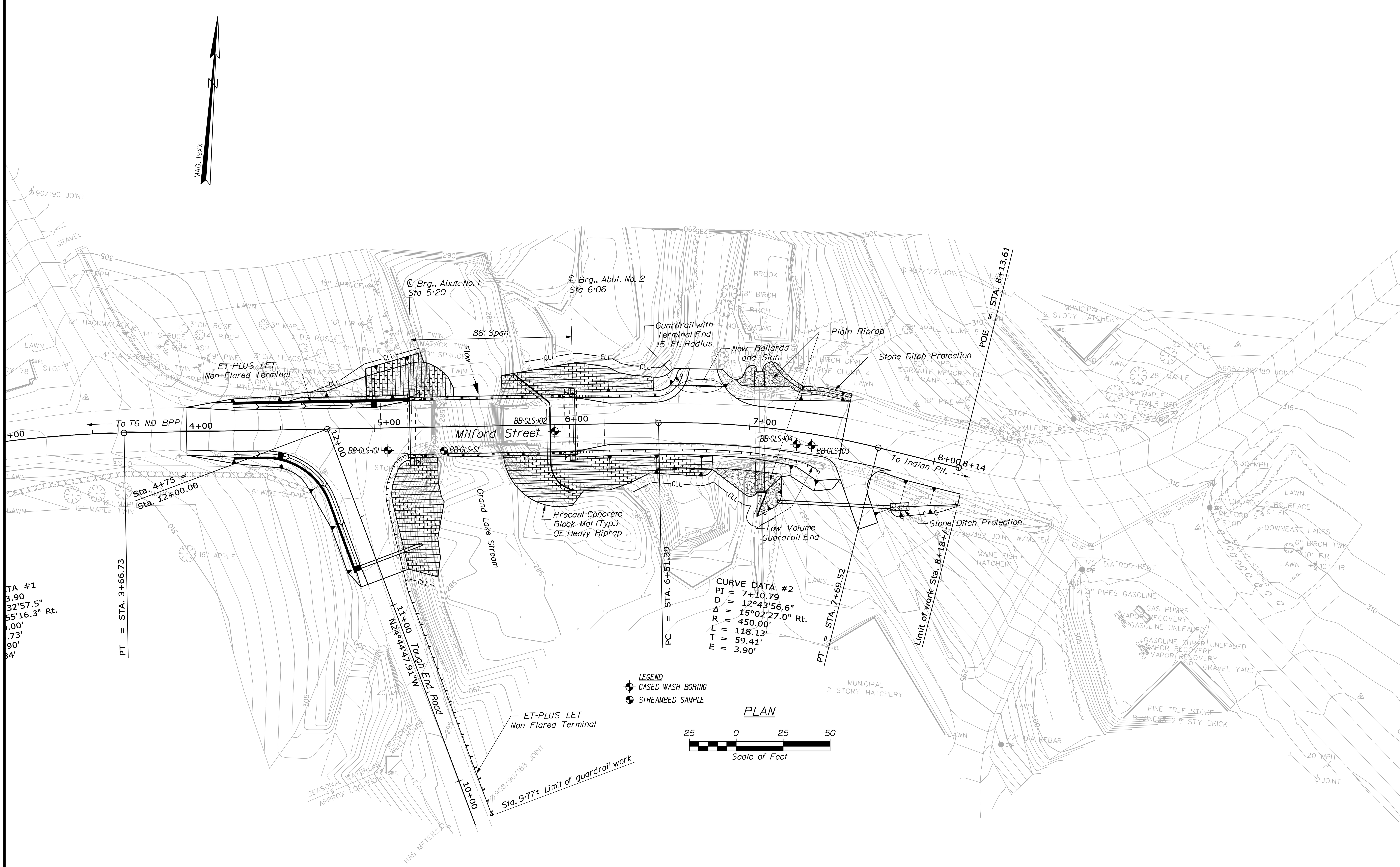
Fang, Hsai-Yang (1991), Foundation Engineering Handbook, Second Edition, Van Nostrand Reinhold, New York, NY.

MaineDOT, (2003), Bridge Design Guide, MaineDOT Bridge Program, Augusta, ME.

Tomlinson, M. J., (1994), Pile Design and Construction Practice, Fourth Edition, E & FN Spon, New York, NY.

Sheets


NORTH
Project Location
Milford Street Bridge #3584
over Grand Lake Stream
Grand Lake Stream Plantation
PIN. 15096.00
Munson Island
Bonney Brook Lake
SAND & GRAVEL PIT
Bonney Bk
Daugherty Ridge
LOOKOUT TOWER
CONCRETE DAM
FLUME
Grand Lake Stream
GRAND LAKE STREAM STATE FISH HATCHERY
Gardner Bk
Big Falls
RAPIDS
Grand Lake Stream
Little Falls
PICNIC AREA
GRAND LAKE STREAM QUADRANGLE
MAINE—WASHINGTON CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
SCALE 1:24 000
KILOMETERS
METERS
MILES
FEET
CONTOUR INTERVAL 20 FEET



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STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BR-1509(600)X

BRIDGE NO. 3584 PIN 15096.00 BRIDGE PLANS

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED	M. MOREAU	T. WHITE	SEPT 2008
CHECKED-REVIEWED		
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

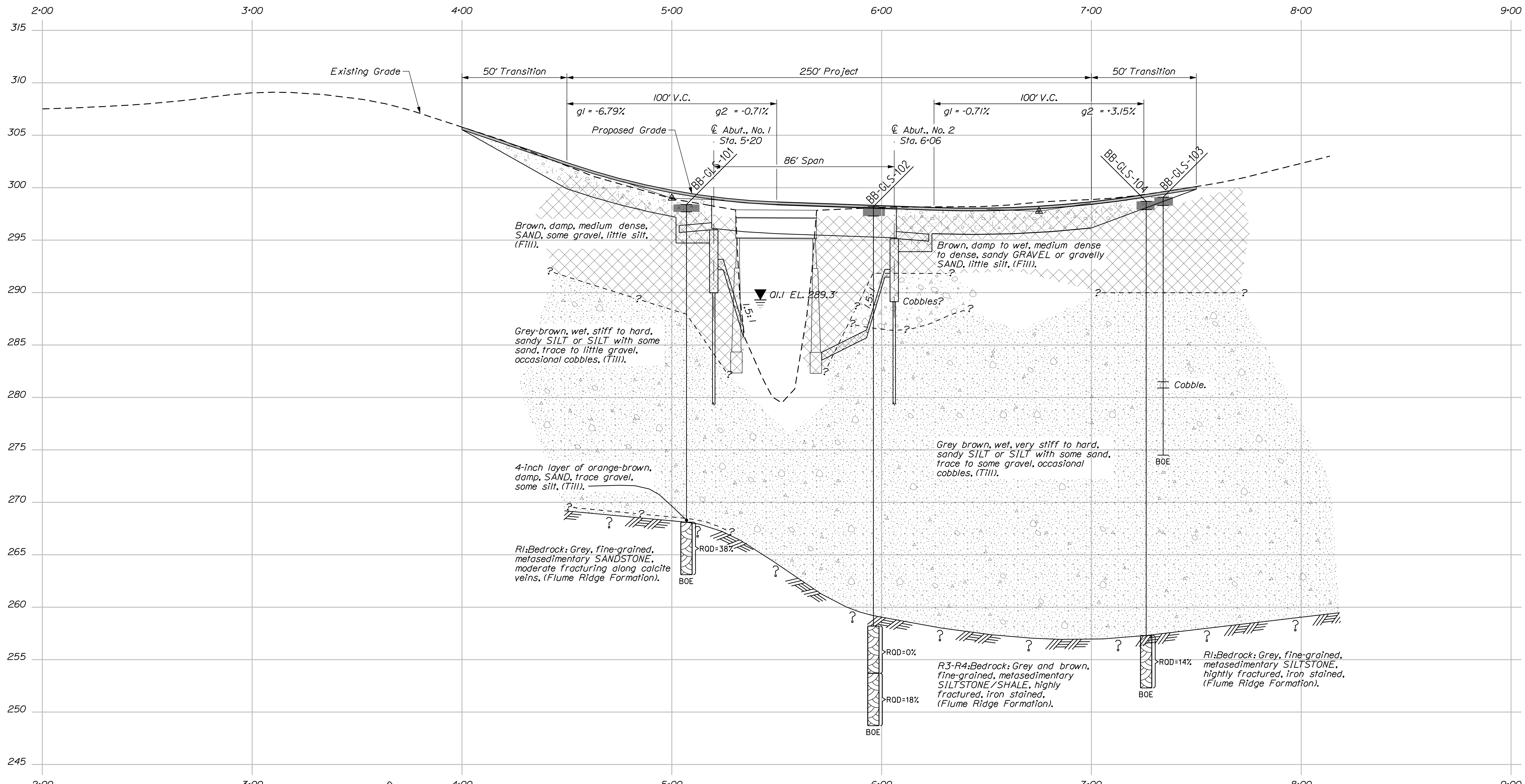
MILFORD STREET BRIDGE
GRAND LAKE STREAM
GRAND LAKE STREAM PLT. WASHINGTON COUNTY

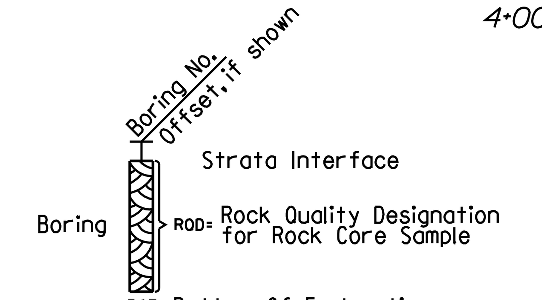
BORING LOCATION PLAN

SHEET NUMBER

2

OF 4





PROFILE

Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

Filename: ...\00\geotech\msta\007_ISP1.dgn Division: GEOTECH Username: terry.white Date:5/12/2009

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BR-1509(600)X

PIN 15096.00

BRIDGE NO. 3584

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED	M. MOREAU	
CHECKED-REVIEWED	T. WHITE	SEPT 2008
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

MILFORD STREET BRIDGE
GRAND LAKE STREAM
GRAND LAKE STREAM PLT. WASHINGTON COUNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

3

OF 4

Filename: ...\msta\008_BORING LOGS1.dgn   Division: GEOTECH   Username: terry.white   Date:5/12/2009

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

Project: Milford Street Bridge #3584	Location: Grand Lake Stream Plantation	Boring No.: BB-GLS-101	PIN: 15096.00
Driller: MaineDOT	Elevation (ft.) 298.4	Auger ID/OD: 5" Solid Stem	
Operator: E. Giguere/C. Giles	Datum: NAVD 88	Sampler: 24" Standard Split Spoon	
Logged By: C. Beebe	Rig Type: CME 45C	Hammer Wt./Fall: 140#/30"	
Date Start/Finish: 7/9/08	Drilling Method: Cased Wash Boring	Core Barrel: NQ-2"	
Boring Location: 5+07, 12.0 Rt.	Casing ID/OD: HW	Water Level*: 10.0' bgs	
Hammer Efficiency Factor: 0.77	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 = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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.)	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
0							SSA		PAVEMENT.	
0.70								297.70		
1	1D	24/10	1.00 - 3.00	8/10/10/9	20	26			Brown, damp, medium dense, well graded fine to coarse SAND, some rounded gravel, little silt, (Fill).	G#210728 A-1-b, SM WC=3.9%
5	2D	24/15	5.00 - 7.00	3/3/4/6	7	9			Brown and orange, loose, fine to coarse SAND, some fine to medium subrounded gravel, little silt (Fill).	G#210729 A-1-b, SM WC=16.1%
10.00	3D	24/19	10.00 - 12.00	2/3/14/5	17	22	SPUN HW	288.40	Grey-brown, wet, very stiff sandy SILT, trace fine gravel, occasional cobbles, (Fine Till).	G#210730 A-4, ML WC=12.5%
12							aRC		aRC = Roller Coned Ahead of HW Casing, no casing blow counts recorded.	
15.00	4D	24/12	15.00 - 17.00	4/7/7/13	14	18		283.40	Grey, wet, stiff to hard, SILT, sandy to some fine to coarse sand, little gravel, bonded, occasional cobbles, (Basal Till).	G#210731 A-4, ML WC=10.9%
20	5D	24/6	20.00 - 22.00	4/3/9/8	12	15			Similar to 4D, (Basal Till).	G#210732 A-4, ML WC=11.6%
25	6D	24/10	25.00 - 27.00	8/17/11/6	28	36			Similar to 4D, (Basal Till).	G#210733 A-4, ML WC=9.8%
30.00	7D R1	3.6/7 60/60	30.00 - 30.30 30.30 - 35.30	40(3.6") RQD = 38%	---		NQ-2 CORE	268.40 268.10	Orange brown, damp, well graded fine to coarse SAND, trace angular well graded gravel, some silt (Till).	G#210734 A-2-4, SM WC=9.2%
30.30									Top of Bedrock at Elev. 268.1' Bedrock: Grey, fine grained, metasedimentary, SANDSTONE, moderately hard, very slight weathering, numerous calcite veins, some fractures occur along calcite veins. Joints and bedding plains dip at 30 to 60 degrees. [Flume Ridge Formation] R1:Core imes (min:sec) 30.3-31.3' (2:56) 31.3-32.3' (4:00) 32.3-33.3' (2:48) 33.3-34.3' (3:26) 34.3-35.3' (2:30) 100% Recovery	
35.30								263.10	Bottom of Exploration at 35.30 feet below ground surface.	

Remarks:
Streambed sample BB-GLS-S1, Sta. 5+37, 12.7 Rt. (Ref: #G210748) (A-1-b, SM, WC=11.1%), taken in front of abutment near BB-GLS-101, Elev. 287.0'.

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-GLS-101

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

Project: Milford Street Bridge #3584	Location: Grand Lake Stream Plantation	Boring No.: BB-GLS-102	PIN: 15096.00
Driller: MaineDOT	Elevation (ft.) 298.2	Auger ID/OD: 5" Solid Stem	
Operator: E. Giguere/C. Giles	Datum: NAVD 88	Sampler: 24" Standard Split Spoon	
Logged By: C. Beebe	Rig Type: CME 45C	Hammer Wt./Fall: 140#/30"	
Date Start/Finish: 7/10/08	Drilling Method: Cased Wash Boring	Core Barrel: NQ-2"	
Boring Location: 5+96.1, 3.4 Rt.	Casing ID/OD: HW & NW	Water Level*: 11.7	
Hammer Efficiency Factor: 0.77	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 = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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.)	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
0							SSA		PAVEMENT.	
0.90	1D	24/16	1.00 - 3.00	9/6/4/4	10	13		297.30	Brown and orange, damp, medium dense, well graded SAND, some fine to medium gravel, little silt, (Fill).	G#210735 A-1-b, SM WC=6.25
5	2D	24/6	5.00 - 7.00	4/3/34/7	37	47			Brown, damp, dense, fine to medium sandy GRAVEL, little silt, (Fill).	G#210736 A-1-a, GM WC=7.9%
6.00								292.20	Auger encountering resistance, possible cobbles from 6.0-11.7' bgs.	
10	MD	0/0	10.00 - 10.00	50(0")	---		aR/S		Failed sample attempt. aR/S = Roller Coned Ahead of HW Casing, then Spun HW Casing, no casing blow counts recorded.	
11.70								286.50		
15	3D	24/8	15.00 - 17.00	13/14/8/6	22	28			Black, wet, very stiff, SILT, some fine to coarse sand and gravel, occasional cobbles, (Till).	G#210737 A-4, SM WC=12.3%
16							60			
17							98			
18							155			
19							bRC		bRC = Roller Coned Ahead of telescoped NW Casing, no casing blow counts recorded.	
20	4D	24/10	20.00 - 22.00	10/18/21/23	39	50			Grey, moist, hard, SILT, sandy to some fine to coarse sand, trace to little gravel, bonded, (Basal Till).	G#210738 A-4, ML WC=8.7%
25	5D	16.8/16	25.00 - 26.40	37/80/50(4.8")	---				Similar to 4D, (Basal Till).	G#210739 A-4, ML WC=8.5%
30	6D R1	8.4/8.4 60/50.4	30.00 - 30.70 30.70 - 35.70	30/50(2.4")	---		NQ-2 CORE		Similar to 4D, (Basal Till). R1: Grey, moist, hard, well graded SAND and GRAVEL, some silt, two large cobbles, (Basal Till). R1:Core Times (min:sec) 30.7-31.7' (1:35) 31.7-32.7' (3:37) 32.7-33.7' (2:01) 33.7-34.7' (1:15) 34.7-35.7' (2:12) 84% Recovery	G#210740 A-4, ML WC=10.6%
35	R2	51.6/?	35.70 - 40.00						R2: Large gravel to cobble size rock fragments, subrounded particles indicates likely Glacial Till with the matrix washed away. Bedrock surface approximately at 39.0'. R2 Core Times not recorded.	
39.00								259.20	Top of Bedrock at Elev. 259.2' Bedrock: Grey and brown, fine-grained, metasedimentary SILTSTONE to SHALE with beds of fine sandstone, moderalely hard, severe weathering, minor calcite veins in R3 becoming more numerous in R4, iron and manganese staining throughout, R3 is highly fractured and broken into fragments. R4 has bedding/jointing that dips from 20 to 30 degrees with many small irregular pieces. [Flume Ridge Formation]	
40	R3	54/48	40.00 - 44.50	RQD = 0%					R3:Core Times (min:sec) 40.0-41.0' (5:46) 41.0-42.0' (5:15) 42.0-43.0' (4:45) 43.0-44.0' (3:48) 44.0-44.5' (3:25) 88% Recovery Core Blocked	
44.5	R4	60/60	44.50 - 49.50	RQD = 18%					R4:Core Times (min:sec) 44.5-45.5' (3:11) 45.5-46.5' (3:45) 46.5-47.5' (3:19) 47.5-48.5' (2:30) 48.5-49.5' (5:22) 100% Recovery	
49.50								248.70	Bottom of Exploration at 49.50 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 1 of 1 — Boring No.: BB-GLS-102

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

Project: Milford Street Bridge #3584	Location: Grand Lake Stream Plantation	Boring No.: BB-GLS-104	PIN: 15096.00
Driller: MaineDOT	Elevation (ft.) 298.7	Auger ID/OD: 5" Solid Stem	
Operator: E. Giguere/C. Giles	Datum: NAVD 88	Sampler: 24" Standard Split Spoon	
Logged By: C. Beebe	Rig Type: CME 45C	Hammer Wt./Fall: 140#/30"	
Date Start/Finish: 7/9/08; 07:30-?	Drilling Method: Cased Wash Boring	Core Barrel: NQ-2"	
Boring Location: 7+26.1, 6.6 Rt.	Casing ID/OD: HW	Water Level*: None Observed	
Hammer Efficiency Factor: 0.77	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 = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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.)	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
0							SSA		No material description given, see Remarks.	
10							SPUN HW			
15							aRC		aRoller Coned ahead of HW Casing.	
25.00	1D	1/1	25.00 - 25.08	50(1")	---		aRC	273.70	Grey, wet, hard, bonded, sandy SILT, some subrounded and angular well graded gravel, (Basal Till). aRoller Coned ahead of HW Casing.	
30	2D	16.8/13	30.00 - 31.40	7/7/15/40	22	28			Grey, wet, very stiff, SILT, some fine to coarse sand, little fine to coarse subangular gravel, bonded, (Basal Till).	G#210746 A-4, ML WC=10.0%
35	3D	24/24	35.00 - 37.00	21/46/50/55(4.8)	96	123			Grey, wet, hard, SILT, some fine to coarse sand, trace fine subangular gravel, bonded, (Basal Till).	G#210747 A-4, ML WC=9.9%
40	4D	6/6	40.00 - 40.50	55(6")	---				Grey and brown, wet, hard SILT, some well graded sand, trace fine subangular gravel, (Basal Till).	
41.40	R1	60/60	41.40 - 46.40	RQD = 14%			NQ-2	257.30	Top of Bedrock at Elev. 257.3' Bedrock: Grey, fine-grained, metasedimentary, SILTSTONE, with calcite bands and traces of pyrite, moderately hard, moderately weathered along bedding plains, the bedding/cleavage dips at 30 to 45 degrees, very close fractures, slight iron staining on some joints, some joints filled with calcite are healed. [Flume Ridge Formation] R1:Core Times (min:sec) 41.4-42.4' (4:27) 42.4-43.4' (4:03) 43.4-44.4' (4:01) 44.4-45.4' (4:12) 45.4-46.4' (4:00) 100% recovery	
46.40								252.30	Bottom of Exploration at 46.40 feet below ground surface.	

Remarks:
BB-GLS-104 was taken adjacent to BB-GLS-103, due to hole failure at 24. 6' bgs, sampling for BB-GLS-104 begins at 25.0' bgs.

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-GLS-104

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

Project: Milford Street Bridge #3584	Location: Grand Lake Stream Plantation	Boring No.: BB-GLS-103	PIN: 15096.00
Driller: MaineDOT	Elevation (ft.) 299.1	Auger ID/OD: 5" Solid Stem	
Operator: E. Giguere/C. Giles	Datum: NAVD 88	Sampler: 24" Standard Split Spoon	
Logged By: C. Beebe	Rig Type: CME 45C	Hammer Wt./Fall: 140#/30"	
Date Start/Finish: 7/8/08; 10:30-16:00	Drilling Method: Cased Wash Boring	Core Barrel: NQ-2"	
Boring Location: 7+34.2, 6.0 Rt.	Casing ID/OD: HW	Water Level*: 5.0' bgs	
Hammer Efficiency Factor: 0.77	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 = Insitu Vane Shear Test, PP = Pocket Penetrometer; MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf); T_v = Pocket Torvane Shear Strength (psf); q_p = Unconfined Compressive Strength (ksf); N-uncorrected = Raw field SPT N-value; Hammer Efficiency Factor = Annual Calibration Value; N_{60} = SPT N-uncorrected corrected for hammer efficiency; N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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.)	Visual Description and Remarks	Laboratory Testing Results/AASHTO and Unified Class.
0							SSA		PAVEMENT.	
0.80	1D	24/16	1.00 - 3.00	6/6/4/4	10	13		298.30	Brown with some orange, damp, medium dense, fine to coarse SAND, some angular and subangular fine to medium gravel, little silt, (Fill).	G#210741 A-1-b, SM WC=8.9%
5	2D	24/7	5.00 - 7.00	9/8/6/6	14	18			Brown, wet, medium dense, gravelly subangular SAND, little silt, gravel is subangular and subrounded, (Fill).	G#210742 A-1-b, SM WC=10.5%
8.50								290.60		
10	3D	24/16	10.00 - 12.00	14/16/18/18	34	44	17		Brown, wet, dense, well sorted fine to medium SAND, some coarse sand, trace gravel, little silt, (Alluvial Deposit?)	G#210743 A-1-b, SM WC=12.9%
11							39			
12							109			
13							88 100		HW casing blow count 88 from 13.0' to 13. 8' and 100 from 13.8' to 14.0'.	
13.80								285.30		
14.90	4D	24/24	14.90 - 16.90	33/48/55/52	103	132	RC		Grey, moist, hard, sandy SILT, trace to little fine to medium angular gravel, bonded, (Basal Till). a97 blows for 0.8'.	G#210744 A-4, SM WC=8.5%
15							50			
16							a97 RC			
17.60	R1	60/30	17.60 - 22.60				RC NQ-2	281.50 280.90	R1: 0.6' Grey, pink, black Granite COBBLE, then grey, bonded, fine to coarse silty subangular and subrounded GRAVEL, little well graded sand. R1:Core Times (min:sec) 17.6-18.6' (1:31) 18.6-19.6' (1:09) 19.6-20.6' (1:30) 20.6-21.6' (1:12) 21.6-22.6' (1:15) 50% recovery	
18							127 CORE			
19							490			
18.20 / 20.10							875	279.00	Empty Core Barrel.	
22.60	5D	24/13	22.60 - 24.60	28/30/44/53	74	95		276.50	Similar to 4D, (Basal Till).	G#210745 A-4, SM WC=8.9%
24.60								274.50	Bottom of Exploration at 24.60 feet below ground surface.	

Remarks:
Boring terminated at 24.6' bgs, casing bent, shoe destroyed.

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-GLS-103

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
BR-1509(600)X
PIN 15096.00
BRIDGE PLANS
BRIDGE NO. 3584

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED	T. WHITE	SEPT 2008
CHECKED-REVIEWED		
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

M. MOREAU
SIGNATURE
P.E. NUMBER
DATE

MILFORD STREET BRIDGE
GRAND LAKE STREAM
GRAND LAKE STREAM PLT. WASHINGTON COUNTY

BORING LOGS

SHEET NUMBER
4
OF 4

Appendix A

Boring Logs

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Milford Street Bridge #3584
Location: Grand Lake Stream Plantation

Boring No.: BB-GLS-101
PIN: 15096.00

Driller:	MaineDOT	**Elevation (ft.)**	298.4	**Auger ID/OD:**	5" Solid Stem
Operator:	E. Giguere/C. Giles	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	C. Beebe	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/9/08	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	5+07, 12.0 Rt.	**Casing ID/OD:**	HW	**Water Level*:**	10.0' bgs

Hammer Efficiency Factor: 0.77 **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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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	297.70		PAVEMENT. 0.70	
	1D	24/10	1.00 - 3.00	8/10/10/9	20	26				Brown, damp, medium dense, well graded fine to coarse SAND, some rounded gravel, little silt, (Fill).	G#210728 A-1-b, SM WC=3.9%
5	2D	24/15	5.00 - 7.00	3/3/4/6	7	9				Brown and orange, loose, fine to coarse SAND, some fine to medium subrounded gravel, little silt (Fill).	G#210729 A-1-b, SM WC=16.1%
10	3D	24/19	10.00 - 12.00	2/3/14/5	17	22	SPUN HW	288.40		10.00 Grey-brown, wet, very stiff sandy SILT, trace fine gravel, occasional cobbles, (Fine Till).	G#210730 A-4, ML WC=12.5%
							aRC			aRC = Roller Coned Ahead of HW Casing, no casing blow counts recorded.	
15	4D	24/12	15.00 - 17.00	4/7/7/13	14	18		283.40		15.00 Grey, wet, stiff to hard, SILT, sandy to some fine to coarse sand, little gravel, bonded, occasional cobbles, (Basal Till).	G#210731 A-4, ML WC=10.9%
20	5D	24/6	20.00 - 22.00	4/3/9/8	12	15				Similar to 4D, (Basal Till).	G#210732 A-4, ML WC=11.6%
25											

Remarks:

Streambed sample BB-GLS-S1, Sta. 5+37, 12.7 Rt. (Ref: #G210748) (A-1-b, SM, WC=11.1%), taken in front of abutment near BB-GLS-101, Elev. 287.0'.

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: Milford Street Bridge #3584
Location: Grand Lake Stream Plantation

Boring No.: BB-GLS-101
PIN: 15096.00

Driller:	MaineDOT	**Elevation (ft.)**	298.4	**Auger ID/OD:**	5" Solid Stem
Operator:	E. Giguere/C. Giles	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	C. Beebe	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/9/08	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	5+07, 12.0 Rt.	**Casing ID/OD:**	HW	**Water Level*:**	10.0' bgs
Hammer Efficiency Factor:	0.77	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
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MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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	6D	24/10	25.00 - 27.00	8/17/11/6	28	36				Similar to 4D, (Basal Till).	G#210733 A-4, ML WC=9.8%
30	7D	3.6/7	30.00 - 30.30	40(3.6")	---		NQ-2	268.40		30.00	G#210734 A-2-4, SM WC=9.2%
								268.10		Orange brown, damp, well graded fine to coarse SAND, trace angular well graded gravel, some silt (Till). 30.30	
	R1	60/60	30.30 - 35.30	RQD = 38%			CORE			Top of Bedrock at Elev. 268.1' Bedrock: Grey, fine grained, metasedimentary, SANDSTONE, moderately hard, very slight weathering, numerous calcite veins, some fractures occur along calcite veins. Joints and bedding plains dip at 30 to 60 degrees. [Flume Ridge Formation] R1:Core imes (min:sec) 30.3-31.3' (2:56) 31.3-32.3' (4:00) 32.3-33.3' (2:48) 33.3-34.3' (3:26) 34.3-35.3' (2:30) 100% Recovery 35.30	
35								263.10		**Bottom of Exploration at 35.30 feet below ground surface.**	
40											
45											
50											

Remarks:

Streambed sample BB-GLS-S1, Sta. 5+37, 12.7 Rt. (Ref: #G210748) (A-1-b, SM, WC=11.1%), taken in front of abutment near BB-GLS-101, Elev. 287.0'.

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: Milford Street Bridge #3584
Location: Grand Lake Stream Plantation

Boring No.: BB-GLS-102
PIN: 15096.00

Driller:	MaineDOT	**Elevation (ft.)**	298.2	**Auger ID/OD:**	5" Solid Stem
Operator:	E. Giguere/C. Giles	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	C. Beebe	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/10/08	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	5+96.1, 3.4 Rt.	**Casing ID/OD:**	HW & NW	**Water Level*:**	11.7
Hammer Efficiency Factor:	0.77	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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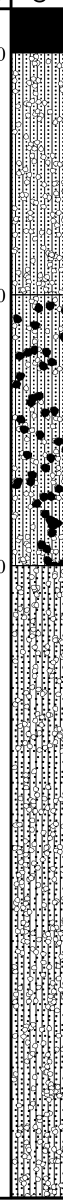
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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			PAVEMENT.	
								297.30		0.90	
	1D	24/16	1.00 - 3.00	9/6/4/4	10	13				Brown and orange, damp, medium dense, well graded SAND, some fine to medium gravel, little silt, (Fill).	G#210735 A-1-b, SM WC=6.25
5	2D	24/6	5.00 - 7.00	4/3/34/7	37	47				Brown, damp, dense, fine to medium sandy GRAVEL, little silt, (Fill).	G#210736 A-1-a, GM WC=7.9%
								292.20		6.00	
										Auger encountering resistance, possible cobbles from 6.0-11.7' bgs.	
10	MD	0/0	10.00 - 10.00	50(0")	---		aR/S			Failed sample attempt. aR/S = Roller Coned Ahead of HW Casing, then Spun HW Casing, no casing blow counts recorded.	
								286.50		11.70	
15	3D	24/8	15.00 - 17.00	13/14/8/6	22	28				Black, wet, very stiff, SILT, some fine to coarse sand and gravel, occasional cobbles, (Till).	G#210737 A-4, SM WC=12.3%
							60				
							98				
							155				
							bRC			bRC = Roller Coned Ahead of telescoped NW Casing, no casing blow counts recorded.	
20	4D	24/10	20.00 - 22.00	10/18/21/23	39	50				Grey, moist, hard, SILT, sandy to some fine to coarse sand, trace to little gravel, bonded, (Basal Till).	G#210738 A-4, ML WC=8.7%
25											

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Milford Street Bridge #3584			**Boring No.:**	BB-GLS-102
Location:	Grand Lake Stream Plantation			**PIN:**	15096.00
Driller:	MaineDOT	**Elevation (ft.)**	298.2	**Auger ID/OD:**	5" Solid Stem
Operator:	E. Giguere/C. Giles	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	C. Beebe	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/10/08	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	5+96.1, 3.4 Rt.	**Casing ID/OD:**	HW & NW	**Water Level*:**	11.7
Hammer Efficiency Factor:	0.77	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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	16.8/16	25.00 - 26.40	37/80/50(4.8")	---					Similar to 4D, (Basal Till).	G#210739 A-4, ML WC=8.5%
30	6D	8.4/8.4	30.00 - 30.70	30/50(2.4")	---		NQ-2			Similar to 4D, (Basal Till).	G#210740 A-4, ML WC=10.6%
	R1	60/50.4	30.70 - 35.70				CORE			R1: Grey, moist, hard, well graded SAND and GRAVEL, some silt, two large cobbles, (Basal Till). R1:Core Times (min:sec) 30.7-31.7' (1:35) 31.7-32.7' (3:37) 32.7-33.7' (2:01) 33.7-34.7' (1:15) 34.7-35.7' (2:12) 84% Recovery	
35	R2	51.6/?	35.70 - 40.00							R2: Large gravel to cobble size rock fragments, subrounded particles indicates likely Glacial Till with the matrix washed away. Bedrock surface approximately at 39.0'. R2 Core Times not recorded.	
39.00								259.20		Top of Bedrock at Elev. 259.2' Bedrock: Grey and brown, fine-grained, metasedimentary SILTSTONE to SHALE with beds of fine sandstone, moderalely hard, severe weathering, minor calcite veins in R3 becoming more numerous in R4, iron and manganese staining throughout, R3 is highly fractured and broken into fragments. R4 has bedding/jointing that dips from 20 to 30 degrees with many small irregular pieces. [Flume Ridge Formation]	
40	R3	54/48	40.00 - 44.50	RQD = 0%						R3:Core Times (min:sec) 40.0-41.0' (5:46) 41.0-42.0' (5:15) 42.0-43.0' (4:45) 43.0-44.0' (3:48) 44.0-44.5' (3:25) 88% Recovery Core Blocked	
45	R4	60/60	44.50 - 49.50	RQD = 18%						R4:Core Times (min:sec) 44.5-45.5' (3:11) 45.5-46.5' (3:45) 46.5-47.5' (3:19) 47.5-48.5' (2:30) 48.5-49.5' (5:22) 100% Recovery	
50								248.70			

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Milford Street Bridge #3584	**Boring No.:**	BB-GLS-102		
Location:	Grand Lake Stream Plantation	**PIN:**	15096.00		
Driller:	MaineDOT	**Elevation (ft.)**	298.2	**Auger ID/OD:**	5" Solid Stem
Operator:	E. Giguere/C. Giles	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	C. Beebe	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/10/08	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	5+96.1, 3.4 Rt.	**Casing ID/OD:**	HW & NW	**Water Level*:**	11.7
Hammer Efficiency Factor:	0.77	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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SSA = Solid Stem Auger
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N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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										49.50 **Bottom of Exploration at 49.50 feet below ground surface.**	
55											
60											
65											
70											
75											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Milford Street Bridge #3584			**Boring No.:**	BB-GLS-103
Location:	Grand Lake Stream Plantation			**PIN:**	15096.00
Driller:	MaineDOT	**Elevation (ft.)**	299.1	**Auger ID/OD:**	5" Solid Stem
Operator:	E. Giguere/C. Giles	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	C. Beebe	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/8/08; 10:30-16:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+34.2, 6.0 Rt.	**Casing ID/OD:**	HW	**Water Level*:**	5.0' bgs
Hammer Efficiency Factor:	0.77	**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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
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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	298.30		PAVEMENT. 0.80	
	1D	24/16	1.00 - 3.00	6/6/4/4	10	13				Brown with some orange, damp, medium dense, fine to coarse SAND, some angular and subangular fine to medium gravel, little silt, (Fill).	G#210741 A-1-b, SM WC=8.9%
5	2D	24/7	5.00 - 7.00	9/8/6/6	14	18				Brown, wet, medium dense, gravelly subangular SAND, little silt, gravel is subangular and subrounded, (Fill).	G#210742 A-1-b, SM WC=10.5%
								290.60		8.50	
10	3D	24/16	10.00 - 12.00	14/16/18/18	34	44	17			Brown, wet, dense, well sorted fine to medium SAND, some coarse sand, trace gravel, little silt, (Alluvial Deposit?)	G#210743 A-1-b, SM WC=12.9%
							39				
							109				
							88 100	285.30		HW casing blow count 88 from 13.0' to 13. 8' and 100 from 13.8' to 14.0'. 13.80	
	4D	24/24	14.90 - 16.90	33/48/55/52	103	132	RC				
15							50			Grey, moist, hard, sandy SILT, trace to little fine to medium angular gravel, bonded, (Basal Till).	G#210744 A-4, SM WC=8.5%
							a97 RC			a97 blows for 0.8'.	
	R1	60/30	17.60 - 22.60				RC NQ-2	281.50		17.60	
							127 CORE	280.90		R1: 0.6' Grey, pink, black Granite COBBLE, then grey, bonded, fine to coarse silty subangular and subrounded GRAVEL, little well graded sand.	
							490			R1:Core Times (min:sec) 17.6-18.6' (1:31)	
20							875	279.00		18.6-19.6' (1:09) 19.6-20.6' (1:30)	
										20.6-21.6' (1:12) 21.6-22.6' (1:15) 50% recovery 18.20	
	5D	24/13	22.60 - 24.60	28/30/44/53	74	95		276.50		20.10 Empty Core Barrel. 22.60	G#210745 A-4, SM WC=8.9%
										Similar to 4D, (Basal Till).	
25								274.50		24.60	

Remarks:

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Milford Street Bridge #3584 Location: Grand Lake Stream Plantation	Boring No.: BB-GLS-103 PIN: 15096.00
Driller: MaineDOT	Elevation (ft.) 299.1	Auger ID/OD: 5" Solid Stem
Operator: E. Giguere/C. Giles	Datum: NAVD 88	Sampler: 24" Standard Split Spoon
Logged By: C. Beebe	Rig Type: CME 45C	Hammer Wt./Fall: 140#/30"
Date Start/Finish: 7/8/08; 10:30-16:00	Drilling Method: Cased Wash Boring	Core Barrel: NQ-2"
Boring Location: 7+34.2, 6.0 Rt.	Casing ID/OD: HW	Water Level*: 5.0' bgs
Hammer Efficiency Factor: 0.77	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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MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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 24.60 feet below ground surface.** Boring terminated at 24.6' bgs, casing bent, shoe destroyed.	
30											
35											
40											
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:** Milford Street Bridge #3584 **Location:** Grand Lake Stream Plantation	**Boring No.:** BB-GLS-104 **PIN:** 15096.00

Driller:	MaineDOT	**Elevation (ft.)**	298.7	**Auger ID/OD:**	5" Solid Stem
Operator:	E. Giguere/C. Giles	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	C. Beebe	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/9/08; 07:30-?	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+26.1, 6.6 Rt.	**Casing ID/OD:**	HW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.77	**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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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			No material description given, see Remarks.	
5											
10							SPUN HW				
15							aRC			aRoller Coned ahead of HW Casing.	
20											
25											

Remarks:

BB-GLS-104 was taken adjacent to BB-GLS-103, due to hole failure at 24. 6' bgs, sampling for BB-GLS-104 begins at 25.0' bgs.

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:	Milford Street Bridge #3584			**Boring No.:**	BB-GLS-104
Location:	Grand Lake Stream Plantation			**PIN:**	15096.00
Driller:	MaineDOT	**Elevation (ft.)**	298.7	**Auger ID/OD:**	5" Solid Stem
Operator:	E. Giguere/C. Giles	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	C. Beebe	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/9/08; 07:30-?	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+26.1, 6.6 Rt.	**Casing ID/OD:**	HW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.77	**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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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	1D	1/1	25.00 - 25.08	50(1")	---		aRC	273.70		25.00 Grey, wet, hard, bonded, sandy SILT, some subrounded and angular well graded gravel, (Basal Till). aRoller Coned ahead of HW Casing.	
30	2D	16.8/13	30.00 - 31.40	7/7/15/40	22	28				Grey, wet, very stiff, SILT, some fine to coarse sand, little fine to coarse subangular gravel, bonded, (Basal Till).	G#210746 A-4, ML WC=10.0%
35	3D	24/24	35.00 - 37.00	21/46/50/55(4.8)	96	123				Grey, wet, hard, SILT, some fine to coarse sand, trace fine subangular gravel, bonded, (Basal Till).	G#210747 A-4, ML WC=9.9%
40	4D	6/6	40.00 - 40.50	55(6")	---					Grey and brown, wet, hard SILT, some well graded sand, trace fine subangular gravel, (Basal Till).	
	R1	60/60	41.40 - 46.40	RQD = 14%			NQ-2	257.30		41.40 Top of Bedrock at Elev. 257.3' Bedrock: Grey, fine-grained, metasedimentary, SILTSTONE, with calcite bands and traces of pyrite, moderately hard, moderately weathered along bedding plains, the bedding/cleavage dips at 30 to 45 degrees, very close fractures, slight iron staining on some joints, some joints filled with calcite are healed. [Flume Ridge Formation] R1:Core Times (min:sec) 41.4-42.4' (4:27) 42.4-43.4' (4:03) 43.4-44.4' (4:01) 44.4-45.4' (4:12) 45.4-46.4' (4:00) 100% recovery	
45								252.30		46.40 **Bottom of Exploration at 46.40 feet below ground surface.**	
50											

Remarks:

BB-GLS-104 was taken adjacent to BB-GLS-103, due to hole failure at 24. 6' bgs, sampling for BB-GLS-104 begins at 25.0' bgs.

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.

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)
Color (Munsell color chart)
Moisture (dry, damp, moist, wet, saturated)
Density/Consistency (from above right hand side)
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., if applicable)
Cementation (weak, moderate, or strong, if applicable, ASTM D 2488)
Geologic Origin (till, marine clay, alluvium, etc.)
Unified Soil Classification Designation
Groundwater level

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. Consistency is rated according to standard penetration resistance.

Modified Burmister System

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

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 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):

$$RQD = \frac{\text{sum of the lengths of intact pieces of core* > 100 mm}}{\text{length of core advance}}$$

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

Correlation of RQD to Rock Mass Quality

Rock Mass Quality	RQD
Very Poor	<25%
Poor	26% - 50%
Fair	51% - 75%
Good	76% - 90%
Excellent	91% - 100%

Desired Rock Observations: (in this order)
Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Lithology (igneous, sedimentary, metamorphic, 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, low angle - 5-35, mod. dipping - 35-55, steep - 55-85, vertical - 85-90)
- -spacing (very close - <5 cm, close - 5-30 cm, mod. close 30-100 cm, wide - 1-3 m, very wide >3 m)
- -tightness (tight, open or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock mass quality (very poor, poor, etc.)
ref: AASHTO Standard Specification for Highway Bridges 17th Ed. Table 4.4.8.1.2A
Recovery

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

Sample Container Labeling Requirements:

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

Appendix B

Laboratory Test Data

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Grand Lake Stream Plt. Project Number: 15096.00

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-GLS-S1	5+37	12.7 Rt.	Streambed	210748	1	11.1			SW	A-1-b	0
BB-GLS-101, 1D	5+07	12.0 Rt.	1.0-3.0	210728	2	3.9			SM	A-1-b	II
BB-GLS-101, 2D	5+07	12.0 Rt.	5.0-7.0	210729	2	16.1			SM	A-1-b	II
BB-GLS-101, 3D	5+07	12.0 Rt.	10.0-12.0	210730	2	12.5			ML	A-4	IV
BB-GLS-101, 4D	5+07	12.0 Rt.	15.0-17.0	210731	2	10.9			ML	A-4	IV
BB-GLS-101, 5D	5+07	12.0 Rt.	20.0-22.0	210732	3	11.6			ML	A-4	IV
BB-GLS-101, 6D	5+07	12.0 Rt.	25.0-27.0	210733	3	9.8			ML	A-4	IV
BB-GLS-101, 7D	5+07	12.0 Rt.	30.0-30.3	210734	3	9.2			SM	A-2-4	II
BB-GLS-102, 1D	5+96.1	3.4 Rt.	1.0-3.0	210735	4	6.2			SM	A-1-b	II
BB-GLS-102, 2D	5+96.1	3.4 Rt.	5.0-7.0	210736	4	7.9			GM	A-1-a	0
BB-GLS-102, 3D	5+96.1	3.4 Rt.	15.0-17.0	210737	4	12.3			SM	A-4	III
BB-GLS-102, 4D	5+96.1	3.4 Rt.	20.0-22.0	210738	4	8.7			ML	A-4	IV
BB-GLS-102, 5D	5+96.1	3.4 Rt.	25.0-26.4	210739	4	8.5			ML	A-4	IV
BB-GLS-102, 6D	5+96.1	3.4 Rt.	30.0-30.7	210740	4	10.6			ML	A-4	IV
BB-GLS-103, 1D	7+34.2	6.0 Rt.	1.0-3.0	210741	5	8.9			SM	A-1-b	II
BB-GLS-103, 2D	7+34.2	6.0 Rt.	5.0-7.0	210742	5	10.5			SM	A-1-b	II
BB-GLS-103, 3D	7+34.2	6.0 Rt.	10.0-12.0	210743	5	12.9			SM	A-1-b	II
BB-GLS-103, 4D	7+34.2	6.0 Rt.	14.9-16.9	210744	5	8.5			SM	A-4	III
BB-GLS-103, 5D	7+34.2	6.0 Rt.	22.6-24.6	210745	5	8.9			SM	A-4	III
BB-GLS-104, 2D	7+26.1	6.6 Rt.	30.0-31.4	210746	6	10.0			ML	A-4	IV
BB-GLS-104, 3D	7+26.1	6.6 Rt.	35.0-37.0	210747	6	9.9			ML	A-4	IV

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 MDOT 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)

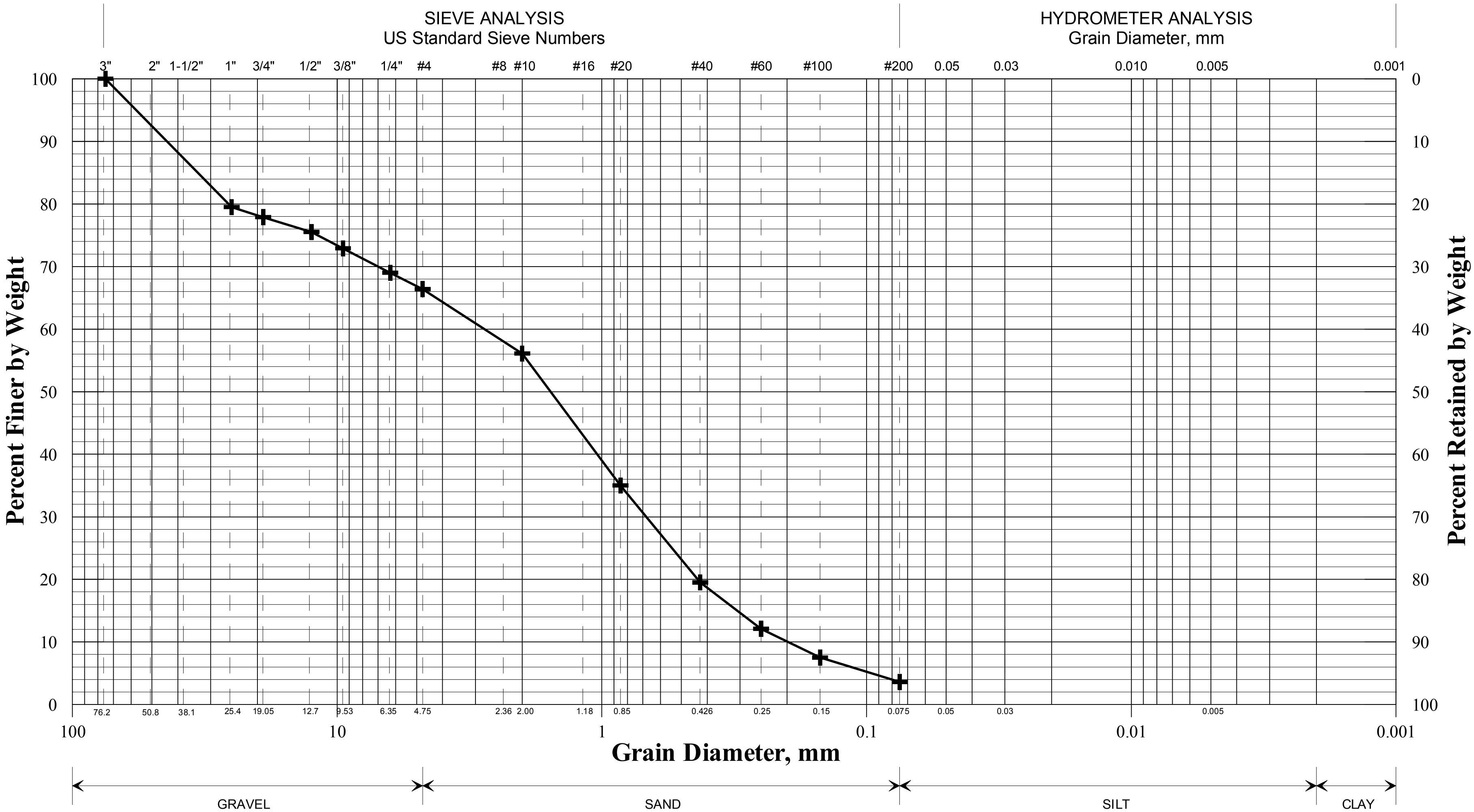
WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

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

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

State of Maine Department of Transportation

GRAIN SIZE DISTRIBUTION CURVE



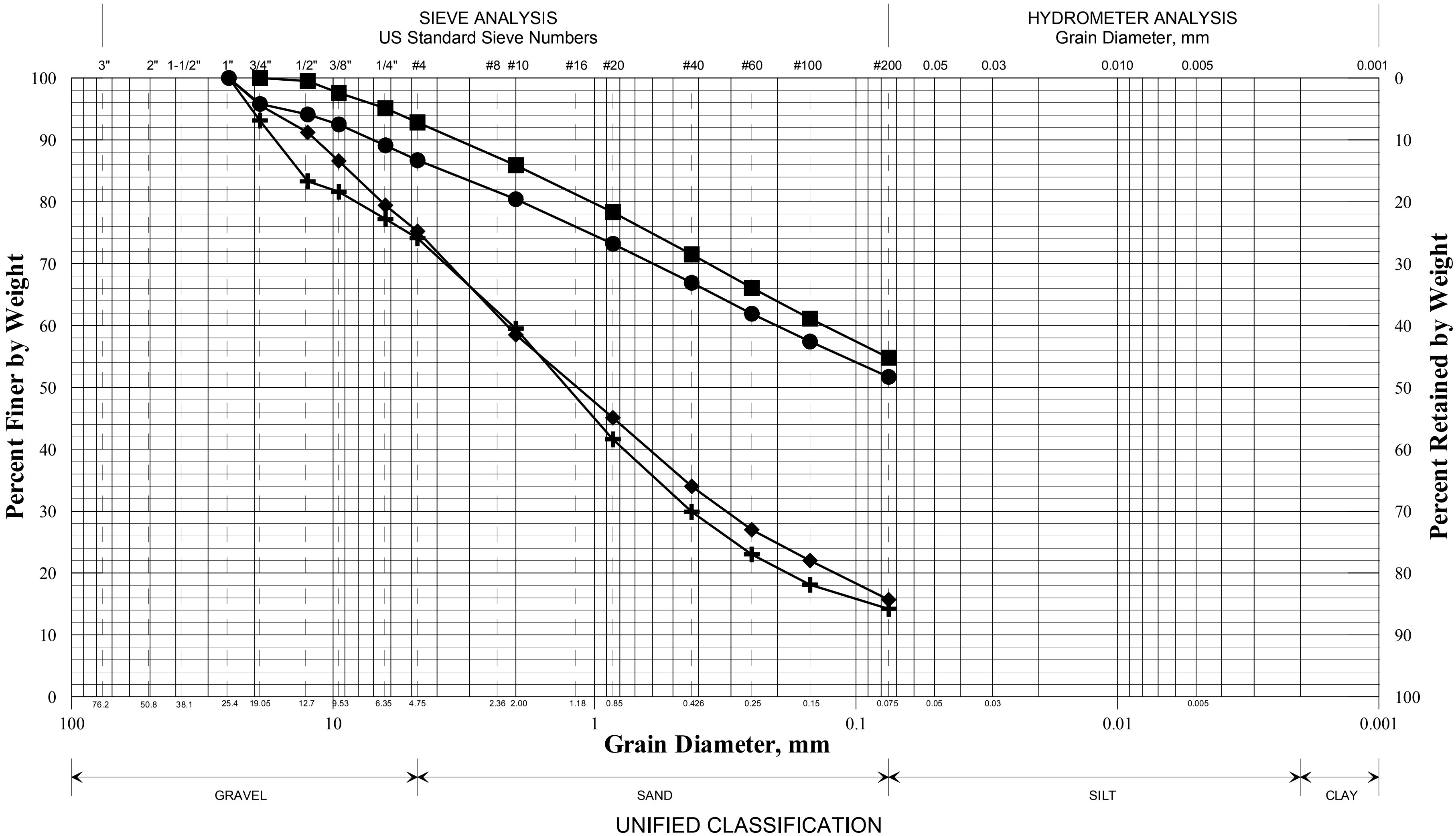
UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-GLS-S1	5+37	12.7 RT.	STREAM BED	SAND, some gravel, trace silt.	11.1			
◆									
■									
●									
▲									
✖									

PIN
015096.00
Town
Grand Lake Stream Plt
Reported by/Date
WHITE, TERRY A 8/11/2008

SHEET 1

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE

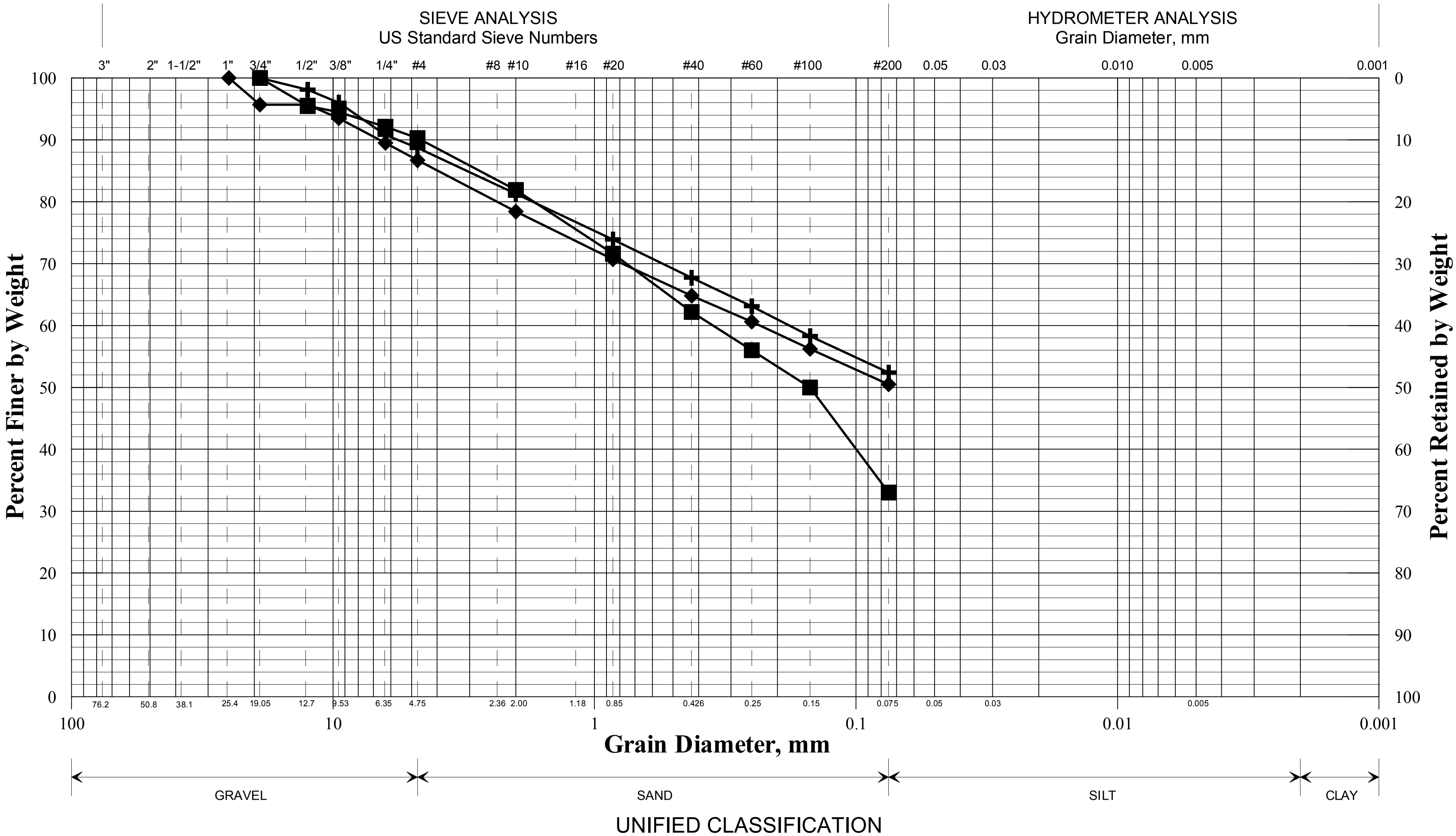


	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-GLS-101/1D	5+07	12.0 RT.	1.0-3.0	SAND, some gravel, little silt.	3.9			
◆	BB-GLS-101/2D	5+07	12.0 RT.	5.0-7.0	SAND, some gravel, little silt.	16.1			
■	BB-GLS-101/3D	5+07	12.0 RT.	10.0-12.0	Sandy SILT, trace gravel.	12.5			
●	BB-GLS-101/4D	5+07	12.0 RT.	15.0-17.0	SILT, some sand, little gravel.	10.9			
▲									
✖									

PIN
015096.00
Town
Grand Lake Stream Plt
Reported by/Date
WHITE, TERRY A 8/11/2008

SHEET 2

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE

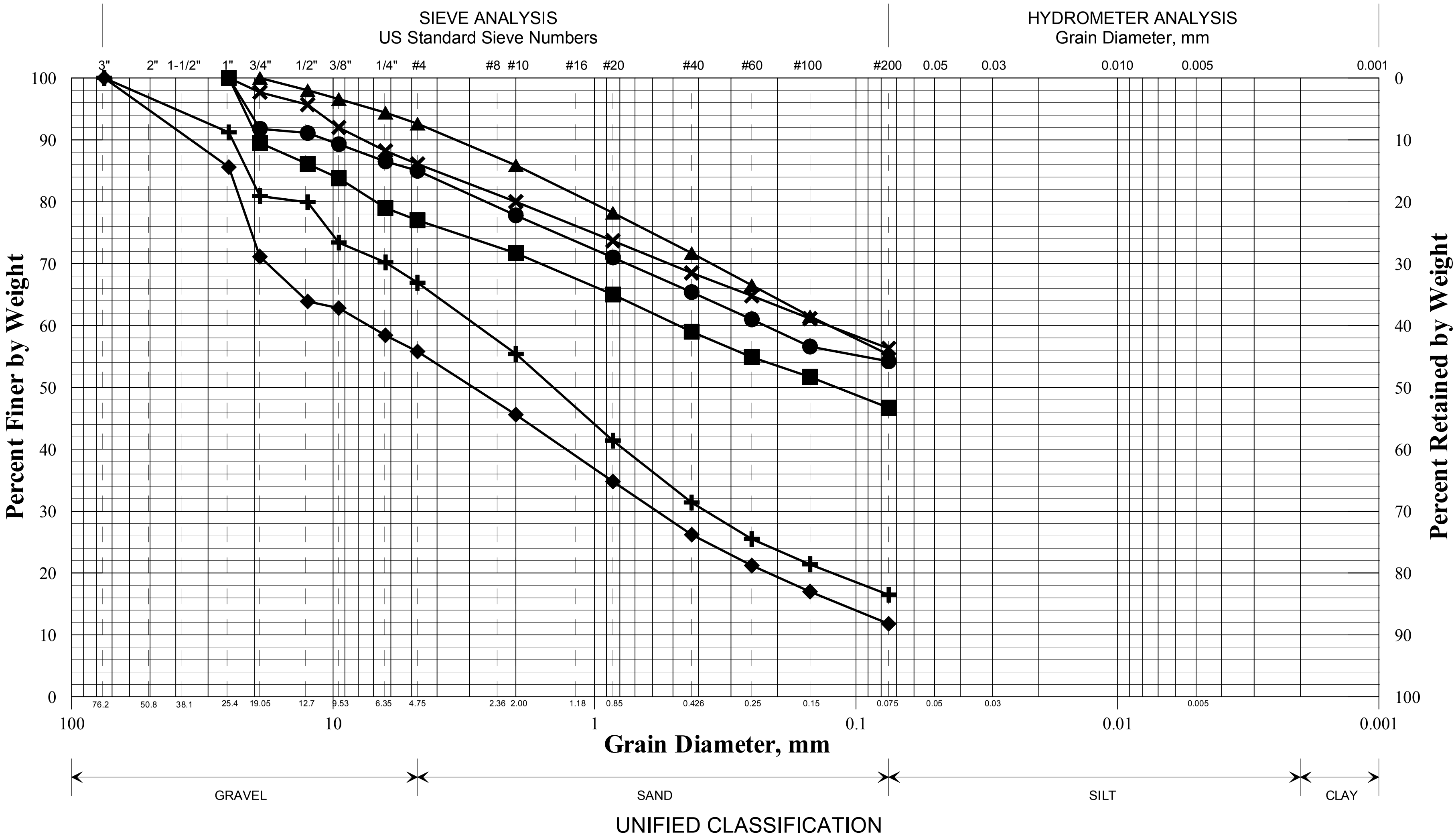


	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-GLS-101/5D	5+07	12.0 RT.	20.0-22.0	Sandy SILT, little gravel.	11.6			
◆	BB-GLS-101/6D	5+07	12.0 RT.	25.0-27.0	SILT, some sand, little gravel.	9.8			
■	BB-GLS-101/7D	5+07	12.0 RT.	30.0-30.3	SAND, some silt, trace gravel.	9.2			
●									
▲									
✖									

PIN
015096.00
Town
Grand Lake Stream Plt
Reported by/Date
WHITE, TERRY A 8/11/2008

SHEET 3

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE

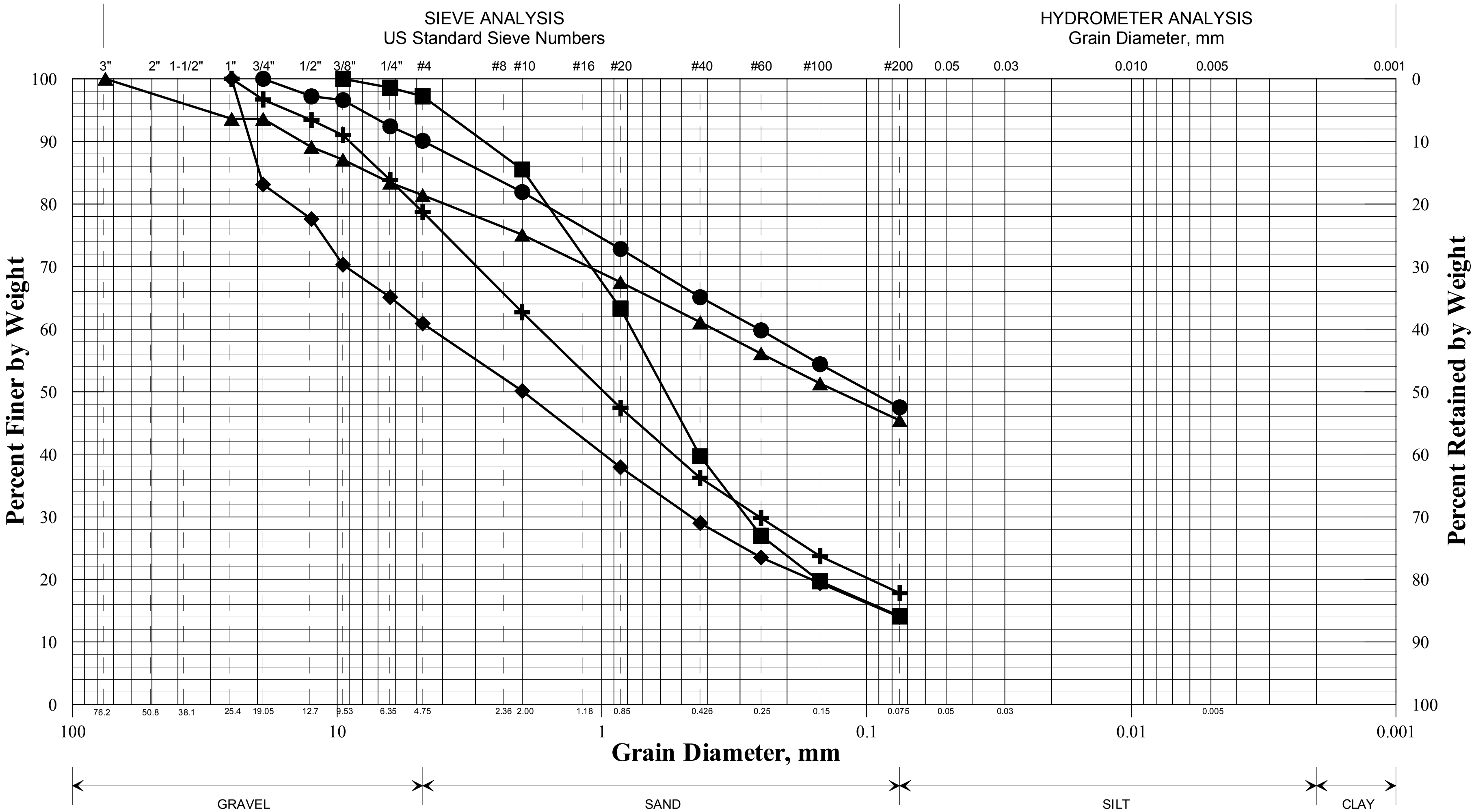


	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-GLS-102/1D	5+96.1	3.4 RT.	1.0-3.0	SAND, some gravel, little silt.	6.2			
◆	BB-GLS-102/2D	5+96.1	3.4 RT.	5.0-7.0	Sandy GRAVEL, little silt.	7.9			
■	BB-GLS-102/3D	5+96.1	3.4 RT.	15.0-17.0	SILT, some sand, some gravel.	12.3			
●	BB-GLS-102/4D	5+96.1	3.4 RT.	20.0-22.0	SILT, some sand, little gravel.	8.7			
▲	BB-GLS-102/5D	5+96.1	3.4 RT.	25.0-26.4	Sandy SILT, trace gravel.	8.5			
✖	BB-GLS-102/6D	5+96.1	3.4 RT.	30.0-30.7	SILT, some sand, little gravel.	10.6			

PIN
015096.00
Town
Grand Lake Stream Plt
Reported by/Date
WHITE, TERRY A 8/11/2008

SHEET 4

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



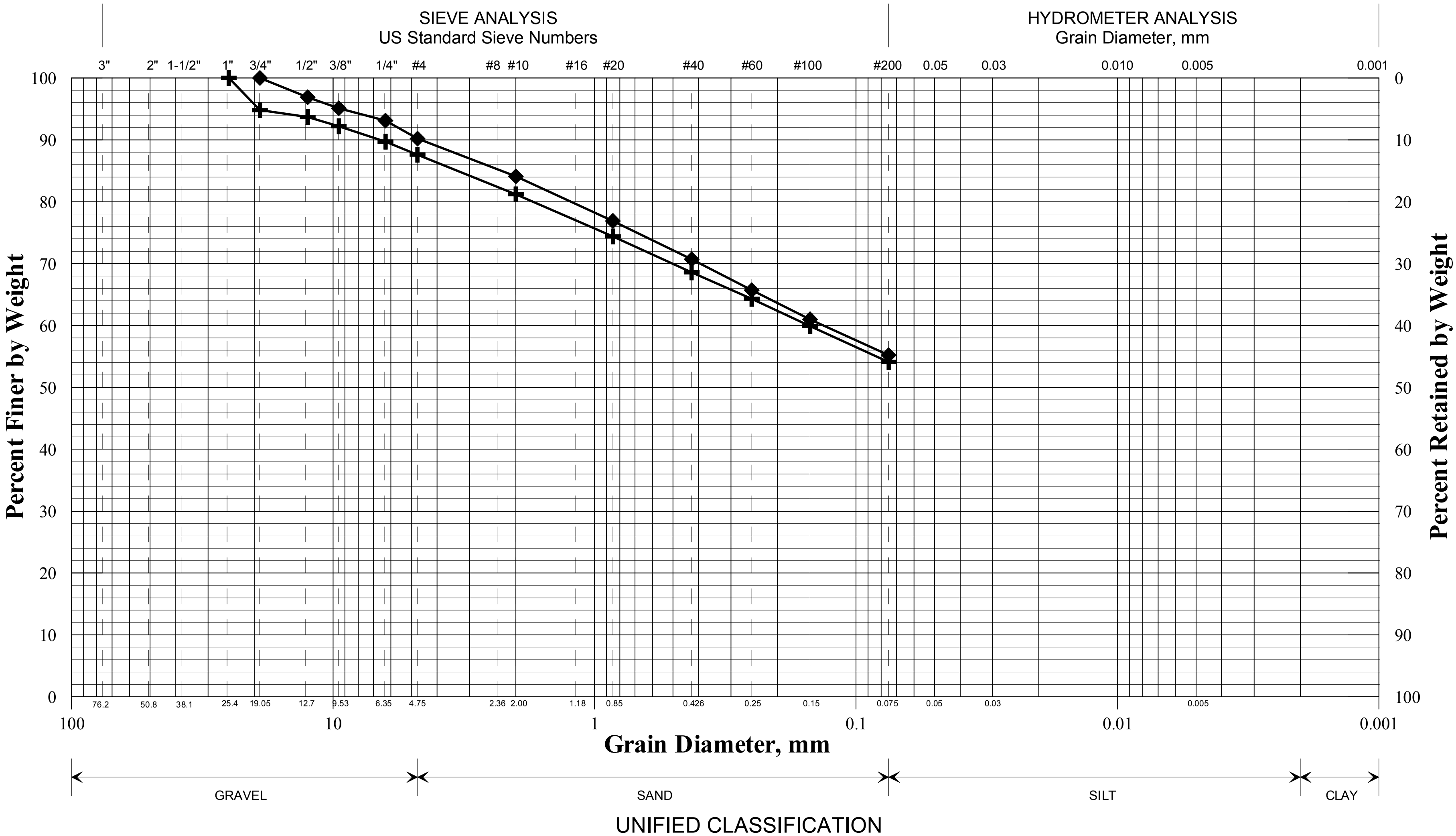
	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-GLS-103/1D	7+34.2	6.0 RT.	1.0-3.0	SAND, some gravel, little silt.	8.9			
◆	BB-GLS-103/2D	7+34.2	6.0 RT.	5.0-7.0	Gravelly SAND, little silt.	10.5			
■	BB-GLS-103/3D	7+34.2	6.0 RT.	10.0-12.0	SAND, little silt, trace gravel.	12.9			
●	BB-GLS-103/4D	7+34.2	6.0 RT.	14.9-16.9	Sandy SILT, trace gravel.	8.5			
▲	BB-GLS-103/5D	7+34.2	6.0 RT.	22.6-24.6	Sandy SILT, little gravel.	8.9			
✖									

PIN
015096.00
Town
Grand Lake Stream Plt
Reported by/Date
WHITE, TERRY A 8/11/2008

SHEET 5

State of Maine Department of Transportation

GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-GLS-104/2D	7+26.1	6.6 RT.	30.0-31.4	SILT, some sand, little gravel.	10.0			
◆	BB-GLS-104/3D	7+26.1	6.6 RT.	35.0-37.0	SILT, some sand, trace gravel.	9.9			
■									
●									
▲									
✖									

PIN
015096.00
Town
Grand Lake Stream Plt
Reported by/Date
WHITE, TERRY A 8/11/2008

SHEET 6

Appendix C

Calculations

FROST PROTECTION:

Reference: MaineDOT Bridge Design Guide, Design Freezing Index (DFI) Map and Depth of Frost Penetration Table 5-1.

Grand Lake Stream
DFI = 1700 degree-days
Site has Fine-Grained Soils.
Use Fine-Grained for design With typical W_n = 8% to 12%. Use W_n = 10%

From the 2003 Bridge Design Guide Table 5-1:

$\text{Frost\_depth} := (1.0 \cdot 62.2in)$

$\text{Frost\_depth} = 62.2 \cdot in$

$\text{Frost\_depth} = 5.18 \cdot ft$

Use 5 feet

INTEGRAL ABUTMENT DRIVEN H-PILES:

Ref: AASHTO LRFD Bridge Design Specifications 4th Edition 2007

1. STRUCTURAL AXIAL RESISTANCE OF INDIVIDUAL H-PILES

STRENGTH LIMIT STATE:

Look at the following piles:

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Note: All matrices are set up in this order

H-Pile Steel Area: $A_s := \begin{pmatrix} 15.5 \\ 21.4 \\ 26.1 \\ 34.4 \end{pmatrix} \cdot in^2$ Yield Strength: $F_y := 50ksi$

Nominal Compressive Resistance:

Nominal Compressive Resistance: $P_n = 0.66^{\lambda} * F_y * A_s$ eq. 6.9.4.1-1 pg. 6-73

Where λ = normalized column slenderness factor

$\lambda = (K\ell/r_s\pi)2*F_y/E$ eq. 6.9.4.1-3 pg. 6-74

$\lambda := 0$ Where the unbraced length ℓ is 0

So: $P_n := 0.66^{\lambda} \cdot F_y \cdot A_s$ $P_n = \begin{pmatrix} 775 \\ 1070 \\ 1305 \\ 1720 \end{pmatrix} \cdot kip$

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Factored Compressive Resistance:

Factor for piles in compression under good driving conditions:

From Article 6.5.4.2 $\phi_c := 0.6$

Factored Compressive Resistance for Strength Limit State:

$P_f = \phi_c * P_n$ eq. 6.9.2.1-1 pg. 6-71

$P_f := \phi_c \cdot P_n$ $\quad P_f = \begin{pmatrix} 465 \\ 642 \\ 783 \\ 1032 \end{pmatrix} \cdot kip$

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Strength Limit State
Factored Compressive Resistance

SERVICE/EXTREME LIMIT STATES:

Nominal Compressive Resistance:

Nominal Compressive Resistance: $P_n = 0.66^{\lambda} * F_y * A_s$ eq. 6.9.4.1-1 pg. 6-73

Where λ = normalized column slenderness factor

$\lambda = (K\ell/r_s\pi)2*F_y/E$ eq. 6.9.4.1-3 pg. 6-74

$\lambda := 0$ Where the unbraced length ℓ is 0

So: $P_n := 0.66^{\lambda} \cdot F_y \cdot A_s$ $\quad P_n = \begin{pmatrix} 775 \\ 1070 \\ 1305 \\ 1720 \end{pmatrix} \cdot kip$

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Factored Compressive Resistance:

Resistance Factors for Service and Extreme Limit States:

From Articles 105.5.1 and 105.5.3 $\quad \phi := 1.0$

Factored Compressive Resistance for Service and Extreme Limit States:

$P_f = \phi * P_n$ eq. 6.9.2.1-1 pg. 6-71

$P_f := \phi \cdot P_n$ $\quad P_f = \begin{pmatrix} 775 \\ 1070 \\ 1305 \\ 1720 \end{pmatrix} \cdot kip$

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Service and Extreme Limit State
Factored Compressive Resistance

2. GEOTECHNICAL AXIAL RESISTANCE OF INDIVIDUAL H-PILES FROM STATIC ANALYSIS

Assume piles will be end bearing on bedrock driven through overlying granular fill and till.

Bedrock Type: Devonian siltstone to sandstone (predominantly siltstone) of the Flume Ridge Formation.
RQD ranges from 0 to 38%,
Average RQD = 18% and ϕ = 27 to 34 deg (Tomlinson 4th Ed. pg. 139)

Look at the following piles:

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Note: All matrices are set up in this order

H-Pile Steel Area: $A_s := \begin{pmatrix} 15.5 \\ 21.4 \\ 26.1 \\ 34.4 \end{pmatrix} \cdot in^2$

Pile Depth: $d := \begin{pmatrix} 11.78 \\ 13.61 \\ 13.83 \\ 14.21 \end{pmatrix} \cdot in$

Pile Width: $b := \begin{pmatrix} 12.05 \\ 14.59 \\ 14.70 \\ 14.89 \end{pmatrix} \cdot in$

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Calculate pile box area:

$A_{box} := \overrightarrow{(d \cdot b)}$ $\qquad A_{box} = \begin{pmatrix} 141.95 \\ 198.57 \\ 203.3 \\ 211.59 \end{pmatrix} \cdot in^2$

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

End bearing resistance of piles on bedrock:

REF: "Pile Design and Construction Practice," Tomlinson, 4th Ed., page 139.

Average compressive strength of rock core from
AASHTO Standard Specification for Highway Bridges, 17th Ed., 2002
Table 4.4.8.1.2B pg 64:

q_{uc} for metamorphosed siltstone ranges between 1,400 and 17,000 psi
Although some RQD values are low, rock jointing at this sight is tight with generally good core recovery indicating relatively intact rock

Assume $q_{uc} := 10000 \cdot psi$

Correct for wedge failure under strip footing:

for Nc multiply cNc by 1.25 - square piles
1.2 for circular piles

for $N\gamma$ multiply $\gamma N\gamma$ by 0.8 - square piles
0.7 for circular

For RQD 0-70 %

qc = 0.33 x Quc
c = 0.1 x Quc
ϕ = 30 deg

Tomlinson, PG. 139

For RQD 70-100 %

qc = 0.33 to 0.88 x Quc
c = 0.1 x Quc
ϕ = 30 to 60 deg

Max RQD = 38%, Therefore:
ϕ = 30
c = 0.1 x Quc   Assume pile penetrates 6 inches into bedrock
qc = 0.33 x Quc

$Q_{uc} := q_{uc}$ $c := 0.1Q_{uc}$ $c = 1000 \cdot psi$

$D := 6in$

$B_{min} := 12in$

$\gamma := 145pcf$ $q_c := 0.33 \cdot Q_{uc}$ $q_c = 3300 \cdot psi$ Bedrock Unit Wt: Fang, p.95

$N_c := 13.86$ $N_q := 9.0$ $N_\gamma := 13.86$ Tomlinson Figure 4.35, p. 140

$$q_{ub} := 1.25 \cdot c \cdot N_c + \left(\gamma \cdot B_{min} \cdot \frac{N_\gamma}{2}\right) \cdot 0.8 + \gamma \cdot D \cdot N_q$$

$q_{ub} = 17.34 \cdot ksi$

Nominal Geotechnical Tip Resistance:

$R_{p\_nom} := q_{ub} \cdot A_s$ $R_{p\_nom} = \begin{pmatrix} 269 \\ 371 \\ 452 \\ 596 \end{pmatrix} \cdot kip$

Factored Geotechnical Tip Resistance:

Resistance factor for Single Pile in Axial Compression End Bearing in Rock:

$\phi_{stat} := 0.45$ LRFD Table 10.5.5.2.3-1, pg. 10-38/39

For Grand Lake Stream, only 4 piles per abutment, so need to reduce ϕstat by 20%

$\phi_{stat80\%} := \phi_{stat} \cdot 0.8$ $\phi_{stat80\%} = 0.36$

$R_{tipf} := R_{p\_nom} \cdot \phi_{stat80\%}$

$$R_{tipf} = \begin{pmatrix} 97 \\ 134 \\ 163 \\ 215 \end{pmatrix} \cdot kip$$

Axial Geotechnical Skin Resistance of Single H-Piles:

IGNORE SKIN FRICTION FOR THESE PILES -
There is insufficient soil at some locations to develop significant skin friction

$R_{skin} := 0 \cdot kip$

$R_{sf} := R_{skin} \cdot \phi_{stat}$ $\quad R_{sf} = 0 \cdot kip$

STRENGTH LIMIT STATE:

Strength Limit State Factored Geotechnical Resistance, R_{gf}:

$R_{gf} := R_{tipf} + R_{sf}$

$$R_{gf} = \begin{pmatrix} 97 \\ 134 \\ 163 \\ 215 \end{pmatrix} \cdot kip$$

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Strength Limit State **Factored** Geotechnical Resistance, R_{gf}

SERVICE/EXTREME LIMIT STATES:

Resistance Factors for Service and Extreme Limit States ϕ = 1.0
LRFD 10.5.5.1, pg. 10-30 and 10.5.5.3, pg. 10-43

$\phi := 1.0$

Nominal Geotechnical Tip Resistance, R_p, as before:

$R_p := \overrightarrow{(q_{ub} \cdot A_s)}$

$$R_p = \begin{pmatrix} 269 \\ 371 \\ 452 \\ 596 \end{pmatrix} \cdot kip$$

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Ignore Skin Friction:

$R_{sf} = 0 \cdot kip$

Service/Extreme Limit State Factored Geotechnical Resistance, R_g:

$R_g := (R_p + R_{sf}) \cdot \phi$ $\qquad R_g = \begin{pmatrix} 269 \\ 371 \\ 452 \\ 596 \end{pmatrix} \cdot kip$

HP 12 x 53
HP 14 x 73
HP 14 x 89
HP 14 x 117

Service/Extreme Limit State **Factored** Geotechnical Resistance, R_g

3. GEOTECHNICAL AXIAL RESISTANCE OF INDIVIDUAL H-PILES FROM WAVE EQUATION DRIVABILITY ANALYSIS

Ref. LRFD Article 10.7.8 pg. 10-121

$\sigma_{dr} = 0.9 \times \phi_{da} \times f_y$ (eq. 10.7.8.1)

$f_y := 50ksi$ yield strength of steel

$\phi_{da} := 1.0$

Resistance factor from LRFD Table 10.5.5.2.3-1 pg. 10-38/39
Pile Drivability Analysis, Steel Piles (Refers to Article 6.5.4.2, p. 6-28: $\phi da = 1.0$)

$\sigma_{dr} := 0.9 \cdot \phi_{da} \cdot f_y$ $\qquad \sigma_{dr} = 45 \cdot ksi$ $\qquad$ Driving stresses in pile cannot exceed 45 ksi

Compute resistance that must be achieved in a drivability analysis:

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

LRFD Table 10.5.5.2.3-1, pg. 10-38, gives resistance factor for dynamic test, ϕ_{dyn}:

$\phi_{dyn} := 0.65$

Table 10.5.5.2.3-1 requires no less than 3 to 4 piles dynamically tested for a site with low to medium site variability. Additionally there are only 4 piles per substructure at this site. There will probably be only 2 piles tested per bridge - one per abutment will be requested. Therefore, reduce ϕ_{dyn} by 20%.

$\phi_{dyn80\%} := 0.65 \cdot 0.8$ $\qquad \phi_{dyn80\%} = 0.52$

Use GRLWeap to perform drivability analysis.

Limit Driving Stress to 45 ksi

Limit Blow Count to less than 15 bpi

HP 12 x 53

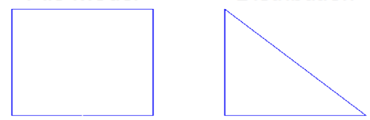
State of Maine Dept. Of Transportation — 05-May-2009
15100 LDB Drivability w Delmag D 19-42 — GRLWEAP (TM) Version 2003

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke feet	Energy kips-ft
410.0	44.47	3.24	5.0	8.50	18.09
411.0	44.53	3.26	5.1	8.51	18.07
412.0	44.62	3.28	5.1	8.52	18.12
413.0	44.69	3.29	5.1	8.53	18.17
414.0	44.75	3.30	5.1	8.54	18.16
415.0	44.84	3.32	5.1	8.56	18.19
416.0	44.94	3.34	5.1	8.57	18.23
417.0	45.00	3.35	5.2	8.58	18.23
418.0	45.06	3.37	5.2	8.59	18.27
419.0	45.14	3.38	5.2	8.60	18.26

DELMAG D 19-42

Efficiency	0.800
Helmet	4.00 kips
Hammer Cushion	39129 kips/in
Skin Quake	0.100 in
Toe Quake	0.040 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	30.00 ft
Pile Penetration	30.00 ft
Pile Top Area	15.50 in2

Pile Model — Skin Friction Distribution



Res. Shaft = 10 %
(Proportional)

HP 12 x 74

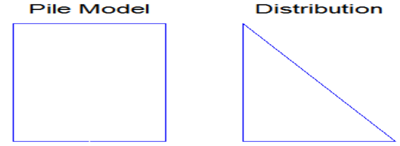
State of Maine Dept. Of Transportation — 05-May-2009
15100 LDB Drivability w Delmag D 19-42 — GRLWEAP (TM) Version 2003

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke feet	Energy kips-ft
680.0	44.96	3.71	12.0	10.08	19.65
681.0	45.01	3.71	12.1	10.09	19.67
682.0	45.04	3.72	12.1	10.09	19.68
683.0	45.08	3.72	12.2	10.10	19.70
684.0	45.09	3.72	12.2	10.11	19.71
685.0	45.15	3.73	12.3	10.11	19.72
686.0	45.20	3.72	12.3	10.12	19.74
687.0	45.24	3.73	12.4	10.13	19.75
688.0	45.27	3.73	12.4	10.13	19.76
689.0	45.29	3.73	12.4	10.14	19.78

DELMAG D 19-42

Efficiency	0.800
Helmet	4.00 kips
Hammer Cushion	39129 kips/in
Skin Quake	0.100 in
Toe Quake	0.040 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	30.00 ft
Pile Penetration	30.00 ft
Pile Top Area	21.80 in2

Pile Model — Skin Friction Distribution



Res. Shaft = 10 %
(Proportional)

HP 14 x 73

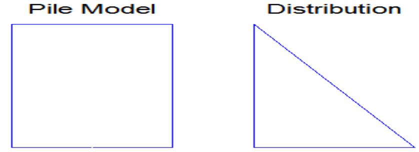
State of Maine Dept. Of Transportation — 05-May-2009
15100 LDB Drivability w Delmag D 19-42 — GRLWEAP (TM) Version 2003

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke feet	Energy kips-ft
660.0	44.90	3.75	11.2	9.97	19.54
661.0	44.91	3.75	11.3	9.97	19.51
662.0	44.97	3.75	11.4	9.98	19.53
663.0	45.02	3.75	11.4	9.98	19.54
664.0	45.05	3.76	11.5	9.99	19.56
665.0	45.08	3.76	11.5	10.00	19.58
666.0	45.12	3.77	11.5	10.01	19.59
667.0	45.17	3.77	11.6	10.01	19.61
668.0	45.23	3.77	11.6	10.02	19.62
669.0	45.25	3.78	11.7	10.03	19.64

DELMAG D 19-42

Efficiency	0.800
Helmet	4.00 kips
Hammer Cushion	39129 kips/in
Skin Quake	0.100 in
Toe Quake	0.040 in
Skin Damping	0.050 sec/ft
Toe Damping	0.150 sec/ft
Pile Length	30.00 ft
Pile Penetration	30.00 ft
Pile Top Area	21.40 in2

Pile Model — Skin Friction Distribution



Res. Shaft = 10 %
(Proportional)

HP 14 x 89

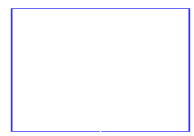
State of Maine Dept. Of Transportation — 05-May-2009
15100 LDB Drivability w Delmag D 19-42 — GRLWEAP (TM) Version 2003

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke feet	Energy kips-ft
765.0	40.80	5.55	14.7	10.32	19.44
766.0	40.83	5.56	14.7	10.32	19.44
767.0	40.86	5.56	14.8	10.33	19.44
768.0	40.90	5.57	14.9	10.33	19.45
769.0	40.92	5.58	14.9	10.34	19.45
770.0	40.95	5.59	15.0	10.35	19.46
771.0	41.00	5.60	15.0	10.35	19.51
772.0	41.03	5.62	15.1	10.36	19.51
773.0	41.06	5.62	15.2	10.36	19.51
774.0	41.09	5.63	15.2	10.37	19.52

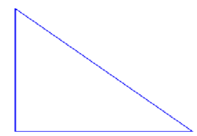
DELMAG D 19-42

Efficiency	0.800	
Helmet	4.00	kips
Hammer Cushion	39129	kips/in
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	30.00	ft
Pile Penetration	30.00	ft
Pile Top Area	26.10	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 10 %
(Proportional)

HP 14 x 117

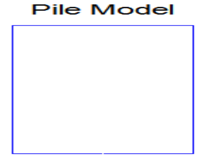
State of Maine Dept. Of Transportation — 05-May-2009
15100 LDB Drivability w Delmag D 19-42 — GRLWEAP (TM) Version 2003

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke feet	Energy kips-ft
805.0	35.72	3.74	14.8	10.02	18.41
807.0	35.83	3.77	14.8	10.03	18.45
809.0	35.85	3.77	14.9	10.04	18.48
811.0	35.90	3.78	15.0	10.04	18.52
813.0	35.92	3.78	15.1	10.05	18.51
815.0	35.99	3.79	15.2	10.07	18.55
817.0	36.05	3.80	15.3	10.08	18.58
819.0	36.07	3.81	15.4	10.08	18.57
821.0	36.13	3.82	15.5	10.10	18.61
823.0	36.16	3.85	15.6	10.11	18.63

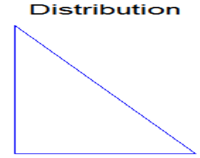
DELMAG D 19-42

Efficiency	0.800	
Helmet	4.00	kips
Hammer Cushion	39129	kips/in
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	30.00	ft
Pile Penetration	30.00	ft
Pile Top Area	34.40	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 10 %
(Proportional)

R_{driv} from GRLWeap Analysis:

$$R_{driv} := \begin{pmatrix} 417 \\ 681 \\ 663 \\ 770 \\ 811 \end{pmatrix} \cdot kip$$

STRENGTH LIMIT STATE:

Strength Limit State Factored Geotechnical Resistance:

$R_{driv\_factored} := R_{driv} \cdot \phi_{dyn80\%}$

$$R_{driv\_factored} = \begin{pmatrix} 217 \\ 354 \\ 345 \\ 400 \\ 422 \end{pmatrix} \cdot kip$$

Strength Limit State **Factored** Drivability Resistance

SERVICE/EXTREME LIMIT STATES:

Service and Extreme Limit State:

Resistance Factors for Service and Extreme Limit States $\phi = 1.0$
LRFD 10.5.5.1, pg. 10-30 and 10.5.5.3, pg. 10-43

$\phi_{serv\_ext} := 1.0$

$R_{driv\_serv\_ext} := R_{driv} \cdot \phi_{serv\_ext}$

$$R_{driv\_serv\_ext} = \begin{pmatrix} 417 \\ 681 \\ 663 \\ 770 \\ 811 \end{pmatrix} \cdot kip$$

HP 12 x 53
HP 12 x 74
HP 14 x 73
HP 14 x 89
HP 14 x 117

Service Limit State **Factored** Drivability Resistance

Factored Resistances from Static Analysis appear conservative. Recommend using Factored Resistances from Drivability Analysis.

ABUTMENT AND WINGWALL PASSIVE AND ACTIVE EARTH PRESSURES:

Coulomb Theory - Active Earth Pressure from MaineDOT Bridge Design Guide Section 3.6.5.2, pg. 3-7

Angle of back face of wall: $\alpha := 90\text{deg}$

Soil angle of internal friction: $\phi := 32\text{deg}$

Slope angle of backfill soil from horizontal: $\beta := 0\text{deg}$

For Walls, $\delta = \beta$ $\delta := \beta$

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

$K_a = 0.31$

Rankine Theory - Active Earth Pressure from MaineDOT Bridge Design Guide Section 3.6.5.2, pg. 3-7

Soil angle of internal friction: $\phi := 32\text{deg}$

Slope angle of backfill soil from horizontal: $\beta := 0\text{deg}$

$$K_a := \tan\left[45\text{deg} - \left(\frac{\phi}{2}\right)\right]^2$$

$K_a = 0.31$

Coulomb Theory - Passive Earth Pressure from MaineDOT Bridge Design Guide Section 3.6.6, pg. 3-8

For gravity walls , semi-gravity walls, prefabricated modular walls, and cantilever walls and abutments with short heels where wall and backfill interface friction is considered, use Coulomb Theory

Soil angle of internal friction: $\phi := 32\text{deg}$

Friction angle between fill and wall:
From LRFD Table 3.11.5.3-1, pg. 3-74, δ ranges from 17 to 22 $\delta := 20\text{deg}$

Angle of backfill from horizontal: $\beta := 0\text{deg}$

$$K_p := \frac{\sin(\alpha-\phi)^2}{\sin(\alpha)^2 \cdot \sin(\alpha+\delta)\cdot\left(1-\sqrt{\dfrac{\sin(\phi+\delta)\cdot\sin(\phi-\beta)}{\sin(\alpha-\delta)\cdot\sin(\beta+\alpha)}}\right)^2}$$

$K_p = 6.89$

Rankine Theory - Passive Earth Pressure from Bowles 5th Edition Section 11-5, pg 602

Soil angle of internal friction: $\phi := 32\text{deg}$

Slope angle of backfill soil from horizontal: $\beta := 0\text{deg}$

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

$K_{p\_rank} = 3.25$

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

                LPILE Plus for Windows, Version 5.0 (5.0.39)

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

                        (c) 1985-2007 by Ensoft, Inc.
                             All Rights Reserved

===============================================================================


This program is licensed to:

Mike Moreau
MaineDOT

Path to file locations:      C:\MyFiles\L-Pile5\
Name of input data file:     15096 Grand Lake Stream Abut1.lpd
Name of output file:         15096 Grand Lake Stream Abut1.lpo
Name of plot output file:    15096 Grand Lake Stream Abut1.lpp
Name of runtime file:        15096 Grand Lake Stream Abut1.lpr


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

               Date:  July 29, 2009     Time:   8:27:56


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

15096 Grand Lake Stream Abut 1


-------------------------------------------------------------------------------
                                Program Options
-------------------------------------------------------------------------------

Units Used in Computations - US Customary Units: Inches, Pounds

Basic Program Options:

Analysis Type 1:
- Computation of Lateral Pile Response Using User-specified Constant EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output pile response for full length of pile
- Analysis assumes no soil movements acting on pile
- No additional p-y curves to be computed at user-specified depths

Solution Control Parameters:
- Number of pile increments            =          100
- Maximum number of iterations allowed =          100
- Deflection tolerance for convergence =   1.0000E-05 in
- Maximum allowable deflection         =   1.0000E+02 in

Printing Options:
- Values of pile-head deflection, bending moment, shear force, and
  soil reaction are printed for full length of pile.
- Printing Increment (spacing of output points) =  1


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

Pile Length                               =     286.00 in

Depth of ground surface below top of pile =    -116.00 in

Slope angle of ground surface             =        .00 deg.

Structural properties of pile defined using  2 points
```

Point	Depth X in	Pile Diameter in	Moment of Inertia in**4	Pile Area Sq.in	Modulus of Elasticity lbs/Sq.in
1	0.0000	13.83000000	326.0000	26.1000	30000000.
2	286.0000	13.83000000	326.0000	26.1000	30000000.

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974
Distance from top of pile to top of layer = -116.000 in
Distance from top of pile to bottom of layer = 77.000 in
p-y subgrade modulus k for top of soil layer = 60.000 lbs/in**3
p-y subgrade modulus k for bottom of layer = 60.000 lbs/in**3

Layer 2 is silt with cohesion and friction
Distance from top of pile to top of layer = 77.000 in
Distance from top of pile to bottom of layer = 286.000 in
p-y subgrade modulus k for top of soil layer = 125.000 lbs/in**3
p-y subgrade modulus k for bottom of layer = 125.000 lbs/in**3

(Depth of lowest layer extends .00 in below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 4 points

Point No.	Depth X in	Eff. Unit Weight lbs/in**3
1	-116.00	.06944
2	77.00	.06944
3	77.00	.07813
4	286.00	.07813

Shear Strength of Soils

Shear strength parameters with depth defined using 4 points

Point No.	Depth X in	Cohesion c lbs/in**2	Angle of Friction Deg.	E50 or k_rm	RQD %
1	-116.000	.00000	30.00	------	------
2	77.000	.00000	30.00	------	------
3	77.000	1.40000	35.00	.00400	.0
4	286.000	1.40000	35.00	.00400	.0

Notes:

(1) Cohesion = uniaxial compressive strength for rock materials.
(2) Values of E50 are reported for clay strata.
(3) Default values will be generated for E50 when input values are 0.
(4) RQD and k_rm are reported only for weak rock strata.

Loading Type

Static loading criteria was used for computation of p-y curves.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load Case Number 1

Pile-head boundary conditions are Displacement and Moment (BC Type 4)
Deflection at pile head = .230 in
Bending moment at pile head = .000 in-lbs
Axial load at pile head = 314660.000 lbs

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

Pile-head boundary conditions are Displacement and Moment (BC Type 4)
Specified deflection at pile head = .230000 in
Specified moment at pile head = .000 in-lbs
Specified axial load at pile head = 314660.000 lbs

Depth X in	Deflect. y in	Moment M lbs-in	Shear V lbs	Slope S Rad.	Total Stress lbs/in**2	Soil Res. p lbs/in	Es*h F/L lbs/in
0.000	.230000	0.0000	36228.0895	-.0048691	12055.9387	-1040.3601	6468.3260
2.860	.216074	103739.	33241.7567	-.0048539	14256.4211	-1047.9845	13871.3121
5.720	.202236	198879.	30238.4782	-.0048097	16274.4960	-1052.2104	14880.2780
8.580	.188563	285360.	27228.0374	-.0047389	18108.8993	-1052.9930	15971.1002
11.440	.175129	363153.	24220.3196	-.0046440	19759.0123	-1050.3062	17152.3363
14.300	.161999	432259.	21225.2578	-.0045277	21224.8669	-1044.1426	18433.7263
17.160	.149231	492711.	18252.7808	-.0043925	22507.1468	-1034.5126	19826.4086
20.020	.136874	544571.	15312.7632	-.0042408	23607.1854	-1021.4438	21343.1898
22.880	.124973	587932.	12414.9783	-.0040752	24526.9607	-1004.9792	22998.8874
25.740	.113564	622919.	9596.7767	-.0038982	25269.0872	-965.7912	24322.5840
28.600	.102675	649842.	6941.8348	-.0037121	25840.1689	-890.8115	24813.3600
31.460	.092331	669308.	4499.8019	-.0035192	26253.0646	-816.9037	25304.1360
34.320	.082545	681915.	2267.0027	-.0033216	26520.4889	-744.4943	25794.9120
37.180	.073331	688253.	238.6010	-.0031213	26654.9348	-673.9685	26285.6880
40.040	.064692	688898.	-1591.2811	-.0029199	26668.6031	-605.6694	26776.4640
42.900	.056629	684407.	-3229.4432	-.0027191	26573.3405	-539.8985	27267.2400
45.760	.049138	675319.	-4683.4880	-.0025203	26380.5835	-476.9160	27758.0160
48.620	.042213	662153.	-5961.7043	-.0023248	26101.3103	-416.9416	28248.7920
51.480	.035841	645403.	-7072.9526	-.0021336	25746.0003	-360.1552	28739.5680
54.340	.030008	625536.	-8026.5539	-.0019477	25324.5995	-306.6988	29230.3440
57.200	.024700	602997.	-8832.1824	-.0017681	24846.4937	-256.6777	29721.1200
60.060	.019895	578199.	-9499.7632	-.0015954	24320.4874	-210.1620	30211.8960
62.920	.015574	551529.	-10039.3749	-.0014302	23754.7899	-167.1888	30702.6720
65.780	.011714	523347.	-10461.1567	-.0012730	23157.0058	-127.7635	31193.4480
68.640	.008292	493983.	-10775.2223	-.0011243	22534.1329	-91.8628	31684.2240
71.500	.005283	463737.	-10991.5787	-.0009843	21892.5640	-59.4354	32175.0000
74.360	.002662	432883.	-11120.0510	-.0008532	21238.0943	-30.4053	32665.7760
77.220	.000403	401666.	-11176.3898	-.0007311	20575.9326	-8.9925	63805.6685
80.080	-.001520	370270.	-11139.9796	-.0006183	19909.9685	34.4542	64828.1185
82.940	-.003133	339058.	-10987.5421	-.0005145	19247.9154	72.1455	65850.5685
85.800	-.004463	308347.	-10735.1393	-.0004199	18596.4871	104.3599	66873.0185
88.660	-.005535	278409.	-10397.9985	-.0003341	17961.4442	131.4029	67895.4685
91.520	-.006374	249472.	-9990.4424	-.0002569	17347.6459	153.6013	68917.9185
94.380	-.007005	221726.	-9525.8375	-.0001880	16759.1053	171.2973	69940.3685
97.240	-.007450	195322.	-9016.5573	-.0001270	16199.0476	184.8427	70962.8185
100.100	-.007731	170380.	-8473.9618	-7.3562E-05	15669.9702	194.5947	71985.2685
102.960	-.007870	146984.	-7908.3896	-2.7158E-05	15173.7045	200.9104	73007.7185
105.820	-.007887	125192.	-7329.1624	1.2639E-05	14711.4768	204.1435	74030.1685
108.680	-.007798	105038.	-6744.6011	4.6302E-05	14283.9697	204.6406	75052.6185
111.540	-.007622	86529.9407	-6162.0503	7.4313E-05	13891.3821	202.7376	76075.0685
114.400	-.007373	69657.3707	-5587.9122	9.7150E-05	13533.4869	198.7576	77097.5185
117.260	-.007066	54392.2266	-5027.6868	.0001153	13209.6879	193.0084	78119.9685
120.120	-.006714	40691.5000	-4486.0179	.0001292	12919.0728	185.7810	79142.4185
122.980	-.006327	28499.6788	-3966.7442	.0001393	12660.4641	177.3475	80164.8685
125.840	-.005917	17750.9893	-3472.9527	.0001461	12432.4666	167.9611	81187.3185
128.700	-.005492	8371.4832	-3007.0363	.0001499	12233.5117	157.8546	82209.7685
131.560	-.005059	280.9613	-2570.7506	.0001512	12061.8984	147.2403	83232.2185
134.420	-.004627	-6605.2681	-2165.2737	.0001502	12196.0474	136.3100	84254.6685
137.280	-.004200	-12374.7978	-1791.2640	.0001475	12318.4287	125.2353	85277.1185
140.140	-.003784	-17116.6962	-1448.9177	.0001431	12419.0122	114.1676	86299.5685
143.000	-.003381	-20920.2443	-1138.0259	.0001376	12499.6917	103.2393	87322.0185
145.860	-.002997	-23873.8310	-858.0276	.0001310	12562.3422	92.5638	88344.4685
148.720	-.002632	-26064.0004	-608.0624	.0001237	12608.7993	82.2371	89366.9185
151.580	-.002289	-27574.6442	-387.0193	.0001159	12640.8426	72.3385	90389.3685
154.440	-.001969	-28486.3310	-193.5826	.0001077	12660.1810	62.9319	91411.8185
157.300	-.001673	-28875.7634	-26.2749	9.9303E-05	12668.4415	54.0665	92434.2685
160.160	-.001401	-28815.3542	116.5037	9.0868E-05	12667.1601	45.7786	93456.7185
163.020	-.001153	-28372.9107	236.4393	8.2506E-05	12657.7751	38.0924	94479.1685

165.880	-.000929	-27611.4195	335.2722	7.4320E-05	12641.6226	31.0214	95501.6185
168.740	-.000728	-26588.9187	414.7674	6.6395E-05	12619.9337	24.5696	96524.0685
171.600	-.000549	-25358.4511	476.6894	5.8799E-05	12593.8334	18.7325	97546.5185
174.460	-.000392	-23968.0853	522.7799	5.1587E-05	12564.3415	13.4986	98568.9685
177.320	-.000254	-22460.9991	554.7383	4.4798E-05	12532.3737	8.8500	99591.4185
180.180	-.000135	-20875.6124	574.2063	3.8462E-05	12498.7450	4.7640	100614.
183.040	-3.41E-05	-19245.7645	582.7541	3.2595E-05	12464.1732	1.2135	101636.
185.900	5.10E-05	-17600.9257	581.8703	2.7208E-05	12429.2835	-1.8316	102659.
188.760	.000121	-15966.4364	572.9535	2.2299E-05	12394.6133	-4.4039	103681.
191.620	.000179	-14363.7675	557.3070	1.7865E-05	12360.6180	-6.5377	104704.
194.480	.000224	-12810.7945	536.1343	1.3891E-05	12327.6769	-8.2683	105726.
197.340	.000258	-11322.0814	510.5381	1.0363E-05	12296.0988	-9.6312	106749.
200.200	.000283	-9909.1679	481.5191	7.2583E-06	12266.1286	-10.6618	107771.
203.060	.000300	-8580.8560	449.9779	4.5548E-06	12237.9529	-11.3950	108793.
205.920	.000309	-7343.4924	416.7168	2.2264E-06	12211.7063	-11.8645	109816.
208.780	.000312	-6201.2430	382.4437	2.4591E-07	12187.4773	-12.1027	110838.
211.640	.000310	-5156.3569	347.7760	-1.4148E-06	12165.3136	-12.1404	111861.
214.500	.000304	-4209.4178	313.2458	-2.7842E-06	12145.2274	-12.0066	112883.
217.360	.000294	-3359.5801	279.3051	-3.8909E-06	12127.2010	-11.7281	113906.
220.220	.000282	-2604.7893	246.3324	-4.7630E-06	12111.1906	-11.3297	114928.
223.080	.000267	-1941.9859	214.6381	-5.4278E-06	12097.1314	-10.8341	115951.
225.940	.000251	-1367.2901	184.4714	-5.9117E-06	12084.9412	-10.2615	116973.
228.800	.000233	-876.1695	156.0264	-6.2397E-06	12074.5237	-9.6301	117996.
231.660	.000215	-463.5885	129.4488	-6.4356E-06	12065.7722	-8.9556	119018.
234.520	.000197	-124.1389	104.8421	-6.5215E-06	12058.5719	-8.2519	120040.
237.380	.000178	147.8461	82.2733	-6.5181E-06	12059.0748	-7.5305	121063.
240.240	.000159	358.1961	61.7794	-6.4441E-06	12063.5366	-6.8009	122085.
243.100	.000141	512.8228	43.3725	-6.3167E-06	12066.8165	-6.0710	123108.
245.960	.000123	617.6559	27.0452	-6.1514E-06	12069.0402	-5.3467	124130.
248.820	.000106	678.5930	12.7755	-5.9619E-06	12070.3328	-4.6321	125153.
251.680	8.91E-05	701.4624	.5313024	-5.7601E-06	12070.8179	-3.9303	126175.
254.540	7.29E-05	691.9994	-9.7257	-5.5564E-06	12070.6172	-3.2425	127198.
257.400	5.73E-05	655.8321	-18.0362	-5.3593E-06	12069.8500	-2.5691	128220.
260.260	4.23E-05	598.4782	-24.4403	-5.1759E-06	12068.6334	-1.9093	129242.
263.120	2.77E-05	525.3495	-28.9746	-5.0116E-06	12067.0822	-1.2616	130265.
265.980	1.36E-05	441.7634	-31.6704	-4.8702E-06	12065.3092	-.6236016	131287.
268.840	-1.59E-07	352.9602	-32.5517	-4.7540E-06	12063.4256	.0073661	132310.
271.700	-1.36E-05	264.1244	-31.6339	-4.6637E-06	12061.5412	.6343984	133332.
274.560	-2.68E-05	180.4082	-28.9240	-4.5987E-06	12059.7655	1.2607	134355.
277.420	-3.99E-05	106.9563	-24.4196	-4.5567E-06	12058.2074	1.8893	135377.
280.280	-5.29E-05	48.9296	-18.1102	-4.5339E-06	12056.9766	2.5229	136400.
283.140	-6.58E-05	11.5265	-9.9780	-4.5251E-06	12056.1832	3.1639	137422.
286.000	-7.88E-05	0.0000	0.0000	-4.5234E-06	12055.9387	3.8137	69222.2592

Output Verification:

Computed forces and moments are within specified convergence limits.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =      .23000000 in
Computed slope at pile head      =     -.00486909
Maximum bending moment           =   688897.84629 lbs-in
Maximum shear force              =    36228.08949 lbs
Depth of maximum bending moment  =    40.04000000 in
Depth of maximum shear force     =        0.00000 in
Number of iterations             =              5
Number of zero deflection points =              3
```

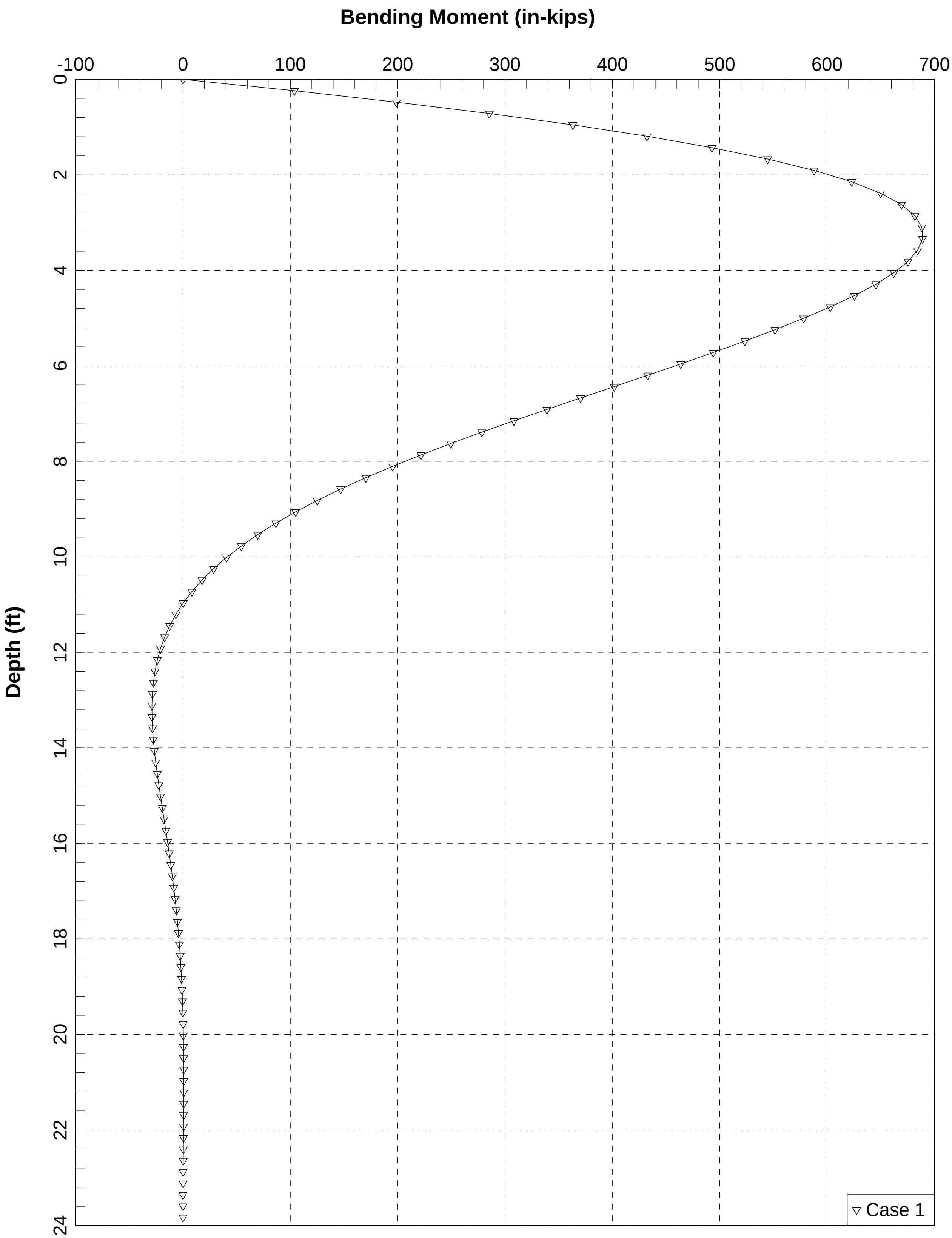
Summary of Pile Response(s)

Definition of Symbols for Pile-Head Loading Conditions:

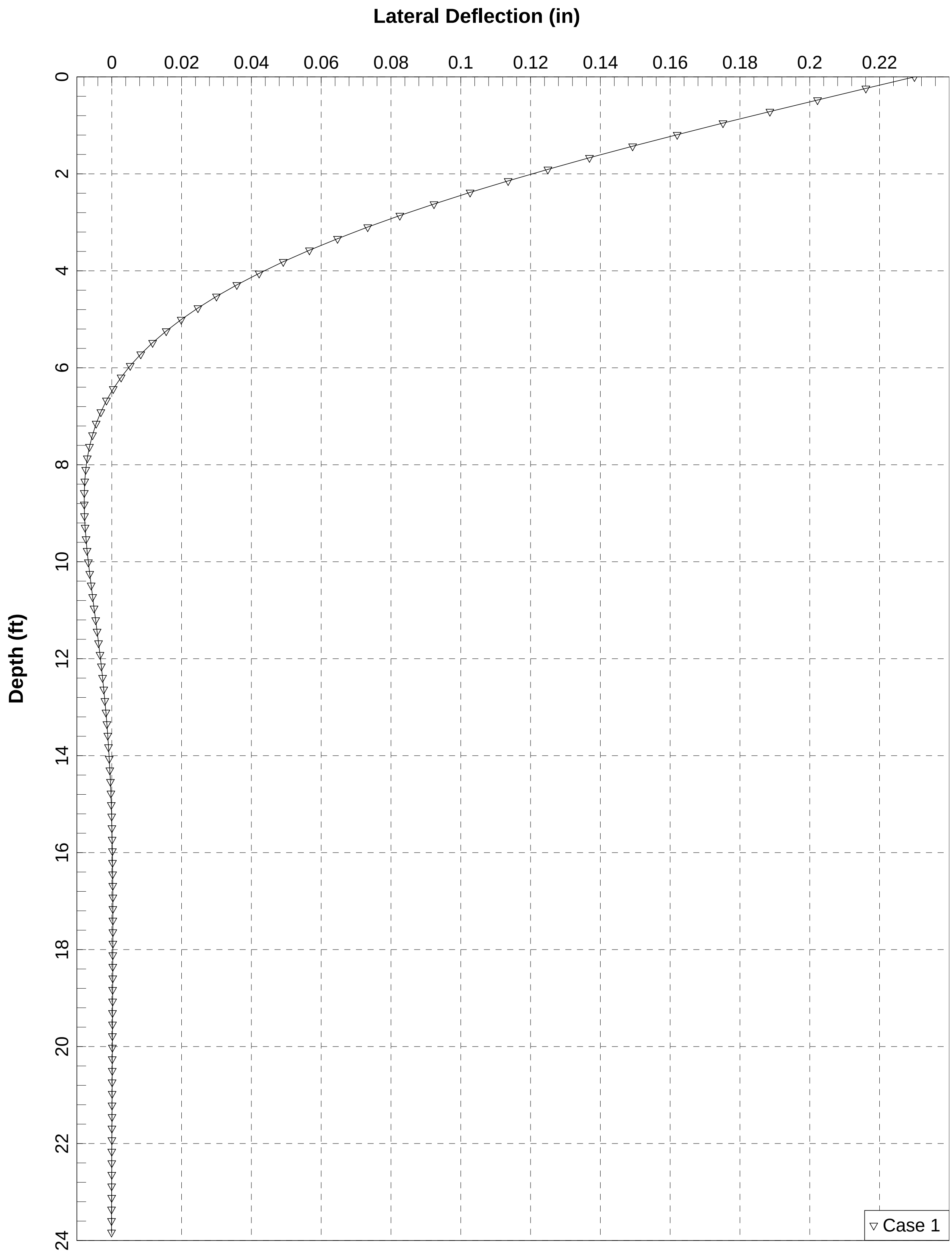
```
Type 1 = Shear and Moment,          y = pile-head displacment in
Type 2 = Shear and Slope,           M = Pile-head Moment lbs-in
Type 3 = Shear and Rot. Stiffness,  V = Pile-head Shear Force lbs
Type 4 = Deflection and Moment,     S = Pile-head Slope, radians
Type 5 = Deflection and Slope,      R = Rot. Stiffness of Pile-head in-lbs/rad
```

Load Type	Pile-Head Condition 1	Pile-Head Condition 2	Axial Load lbs	Pile-Head Deflection in	Maximum Moment in-lbs	Maximum Shear lbs
4	y= .230000	M= 0.000	314660.	.2300000	688898.	36228.0895

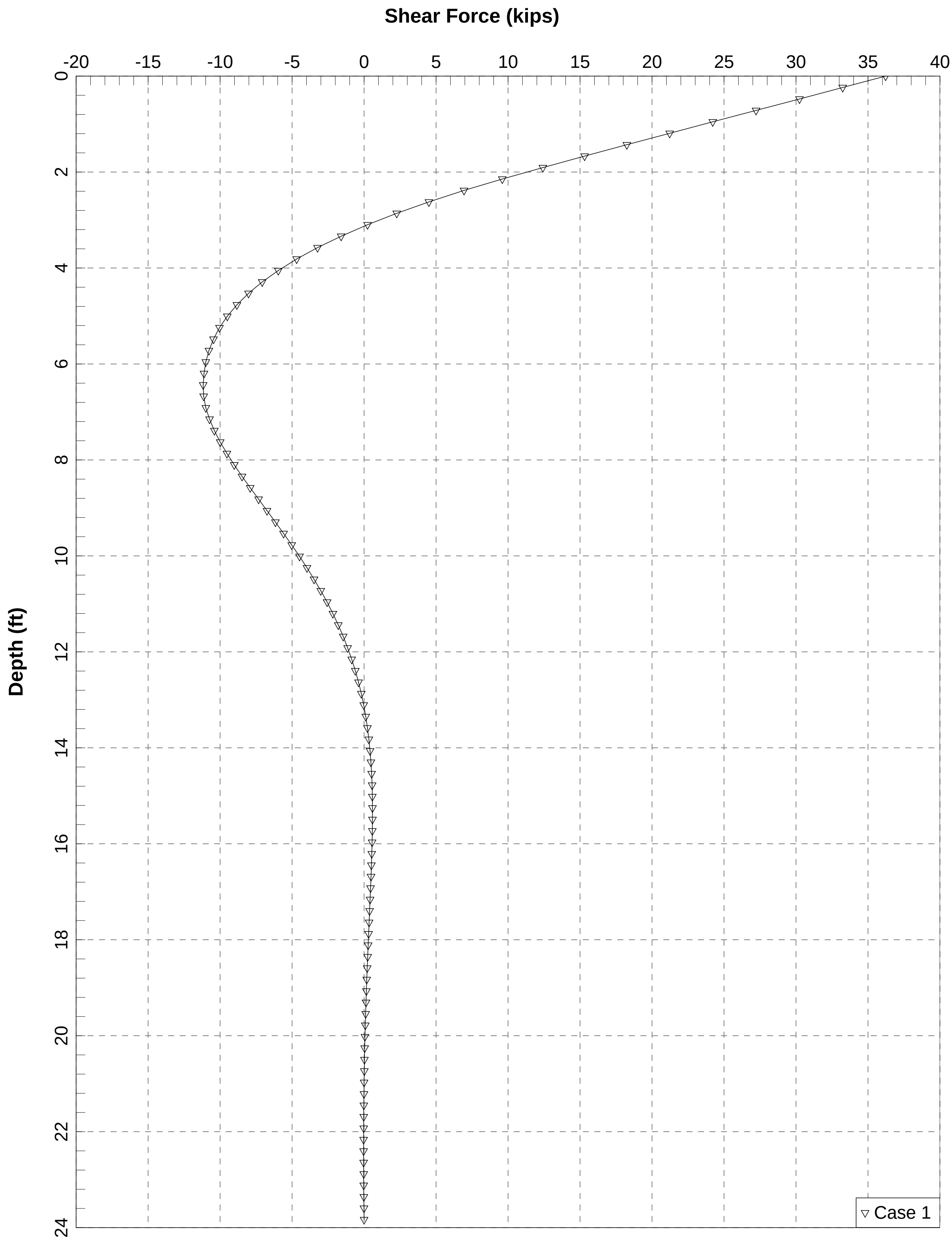
The analysis ended normally.



15096 Grand Lake Stream Abut 1



15096 Grand Lake Stream Abut 1



15096 Grand Lake Stream Abut 1

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

                LPILE Plus for Windows, Version 5.0 (5.0.39)

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

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                             All Rights Reserved

================================================================================


This program is licensed to:

Mike Moreau
MaineDOT

Path to file locations:      C:\MyFiles\L-Pile5\
Name of input data file:     15096 Grand Lake Stream Abut 2.lpd
Name of output file:         15096 Grand Lake Stream Abut 2.lpo
Name of plot output file:    15096 Grand Lake Stream Abut 2.lpp
Name of runtime file:        15096 Grand Lake Stream Abut 2.lpr


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

               Date:  July 29, 2009     Time:   8:29:51


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

15096 Grand Lake Stream Abut 1


--------------------------------------------------------------------------------
                                Program Options
--------------------------------------------------------------------------------

Units Used in Computations - US Customary Units: Inches, Pounds

Basic Program Options:

Analysis Type 1:
- Computation of Lateral Pile Response Using User-specified Constant EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output pile response for full length of pile
- Analysis assumes no soil movements acting on pile
- No additional p-y curves to be computed at user-specified depths

Solution Control Parameters:
- Number of pile increments            =          100
- Maximum number of iterations allowed =          100
- Deflection tolerance for convergence =   1.0000E-05 in
- Maximum allowable deflection         =   1.0000E+02 in

Printing Options:
- Values of pile-head deflection, bending moment, shear force, and
  soil reaction are printed for full length of pile.
- Printing Increment (spacing of output points) =  1


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

Pile Length                               =     394.00 in

Depth of ground surface below top of pile =    -116.00 in

Slope angle of ground surface             =        .00 deg.

Structural properties of pile defined using  2 points
```

Point	Depth X in	Pile Diameter in	Moment of Inertia in**4	Pile Area Sq.in	Modulus of Elasticity lbs/Sq.in
1	0.0000	13.83000000	326.0000	26.1000	30000000.
2	394.0000	13.83000000	326.0000	26.1000	30000000.

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974
Distance from top of pile to top of layer = -116.000 in
Distance from top of pile to bottom of layer = 19.000 in
p-y subgrade modulus k for top of soil layer = 60.000 lbs/in**3
p-y subgrade modulus k for bottom of layer = 60.000 lbs/in**3

Layer 2 is silt with cohesion and friction
Distance from top of pile to top of layer = 19.000 in
Distance from top of pile to bottom of layer = 394.000 in
p-y subgrade modulus k for top of soil layer = 125.000 lbs/in**3
p-y subgrade modulus k for bottom of layer = 125.000 lbs/in**3

(Depth of lowest layer extends .00 in below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 4 points

Point No.	Depth X in	Eff. Unit Weight lbs/in**3
1	-116.00	.06944
2	19.00	.06944
3	19.00	.07813
4	394.00	.07813

Shear Strength of Soils

Shear strength parameters with depth defined using 4 points

Point No.	Depth X in	Cohesion c lbs/in**2	Angle of Friction Deg.	E50 or k_rm	RQD %
1	-116.000	.00000	30.00	------	------
2	19.000	.00000	30.00	------	------
3	19.000	1.40000	35.00	.00400	.0
4	394.000	1.40000	35.00	.00400	.0

Notes:

(1) Cohesion = uniaxial compressive strength for rock materials.
(2) Values of E50 are reported for clay strata.
(3) Default values will be generated for E50 when input values are 0.
(4) RQD and k_rm are reported only for weak rock strata.

Loading Type

Static loading criteria was used for computation of p-y curves.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load Case Number 1

Pile-head boundary conditions are Displacement and Moment (BC Type 4)
Deflection at pile head = .230 in
Bending moment at pile head = .000 in-lbs
Axial load at pile head = 314660.000 lbs

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

Pile-head boundary conditions are Displacement and Moment (BC Type 4)
Specified deflection at pile head = .230000 in
Specified moment at pile head = .000 in-lbs
Specified axial load at pile head = 314660.000 lbs

Depth X in	Deflect. y in	Moment M lbs-in	Shear V lbs	Slope S Rad.	Total Stress lbs/in**2	Soil Res. p lbs/in	Es*h F/L lbs/in
0.000	.230000	0.0000	44503.0605	-.0054610	12055.9387	-1040.3601	8910.9107
3.940	.208484	174037.	40399.1361	-.0054260	15747.5589	-1042.8502	19708.1669
7.880	.187243	331799.	36300.7633	-.0053241	19093.9442	-1037.5420	21832.0850
11.820	.166530	473288.	32238.8866	-.0051619	22095.1713	-1024.3243	24234.9005
15.760	.146568	598640.	28244.6769	-.0049460	24754.0934	-1003.1933	26967.6064
19.700	.127556	708120.	22480.3900	-.0046828	27076.3406	-1922.8407	59393.5865
23.640	.109668	787397.	15329.2130	-.0043815	28757.9303	-1707.1984	61334.0365
27.580	.093029	839778.	9022.8364	-.0040537	29869.0298	-1494.0080	63274.4865
31.520	.077724	868548.	3545.2513	-.0037096	30479.2836	-1286.4921	65214.9365
35.460	.063798	876913.	-1131.3132	-.0033580	30656.7180	-1087.3986	67155.3865
39.400	.051263	867960.	-5044.5129	-.0030066	30466.8023	-898.9972	69095.8365
43.340	.040106	844617.	-8240.0215	-.0026616	29971.6682	-723.0883	71036.2865
47.280	.030289	809628.	-10769.7173	-.0023284	29229.4866	-561.0212	72976.7365
51.220	.021758	765525.	-12689.9588	-.0020111	28293.9938	-413.7206	74917.1865
55.160	.014442	714618.	-14059.9764	-.0017130	27214.1604	-281.7198	76857.6365
59.100	.008260	658980.	-14940.4041	-.0014363	26033.9912	-165.1979	78798.0865
63.040	.003124	600448.	-15391.9657	-.0011826	24792.4440	-64.0212	80738.5365
66.980	-.001059	540623.	-15474.3249	-.0009527	23523.4545	22.2144	82678.9865
70.920	-.004383	480873.	-15245.1062	-.0007470	22256.0523	94.1403	84619.4365
74.860	-.006945	422344.	-14759.0829	-.0005650	21014.5543	152.5720	86559.8865
78.800	-.008836	365972.	-14067.5326	-.0004062	19818.8210	198.4687	88500.3365
82.740	-.010146	312499.	-13217.7485	-.0002696	18684.5625	232.8938	90440.7865
86.680	-.010960	262485.	-12252.6989	-.0001538	17623.6809	256.9791	92381.2365
90.620	-.011357	216329.	-11210.8226	-5.7306E-05	16644.6368	271.8922	94321.6865
94.560	-.011412	174286.	-10125.9444	2.1376E-05	15752.8299	278.8074	96262.1365
98.500	-.011189	136484.	-9027.2986	8.3975E-05	14950.9827	278.8808	98202.5865
102.440	-.010750	102943.	-7939.6428	.0001322	14239.5197	273.2287	100143.
106.380	-.010147	73591.4484	-6883.4485	.0001678	13616.9352	262.9105	102083.
110.320	-.009428	48284.9566	-5875.1530	.0001923	13080.1426	248.9147	104024.
114.260	-.008632	26818.4004	-4927.4575	.0002074	12624.8014	232.1490	105964.
118.200	-.007793	8942.2380	-4049.6601	.0002146	12245.6184	213.4334	107905.
122.140	-.006940	-5625.1354	-3248.0089	.0002153	12175.2571	193.4961	109845.
126.080	-.006097	-17185.9427	-2526.0664	.0002107	12420.4810	172.9721	111786.
130.020	-.005280	-26053.0162	-1885.0747	.0002020	12608.5663	152.4043	113726.
133.960	-.004505	-32541.2134	-1324.3132	.0001902	12746.1917	132.2462	115667.
137.900	-.003781	-36960.2205	-841.4416	.0001762	12839.9262	112.8663	117607.
141.840	-.003116	-39608.6769	-432.8243	.0001608	12896.1043	94.5537	119548.
145.780	-.002514	-40769.5375	-93.8300	.0001446	12920.7281	77.5247	121488.
149.720	-.001977	-40706.5737	180.8955	.0001282	12919.3926	61.9299	123428.
153.660	-.001504	-39661.9037	397.1852	.0001120	12897.2334	47.8618	125369.
157.600	-.001094	-37854.4365	561.1368	9.6376E-05	12858.8940	35.3623	127309.
161.540	-.000745	-35479.1122	678.9282	8.1604E-05	12808.5094	24.4303	129250.
165.480	-.000451	-32706.8220	756.6628	6.7870E-05	12749.7046	15.0289	131190.
169.420	-.000210	-29684.8935	800.2425	5.5302E-05	12685.6045	7.0928	133131.
173.360	-1.56E-05	-26538.0335	815.2674	4.3977E-05	12618.8543	.5341069	135071.
177.300	.000137	-23369.6277	806.9598	3.3924E-05	12551.6472	-4.7512	137012.
181.240	.000252	-20263.3049	780.1102	2.5135E-05	12485.7570	-8.8781	138952.
185.180	.000335	-17284.6821	739.0426	1.7571E-05	12422.5754	-11.9684	140892.
189.120	.000390	-14483.2183	687.5979	1.1172E-05	12363.1517	-14.1457	142833.
193.060	.000423	-11894.1127	629.1310	5.8592E-06	12308.2325	-15.5330	144773.
197.000	.000436	-9540.1940	566.5200	1.5417E-06	12258.3020	-16.2493	146714.
200.940	.000435	-7433.7579	502.1857	-1.8774E-06	12213.6210	-16.4077	148654.
204.880	.000422	-5578.3157	438.1186	-4.4985E-06	12174.2640	-16.1137	150595.
208.820	.000399	-3970.2293	375.9112	-6.4218E-06	12140.1538	-15.4637	152535.
212.760	.000371	-2600.2124	316.7943	-7.7453E-06	12111.0935	-14.5449	154476.
216.700	.000338	-1454.6858	261.6755	-8.5621E-06	12086.7950	-13.4342	156416.
220.640	.000304	-516.9793	211.1791	-8.9593E-06	12066.9047	-12.1986	158357.
224.580	.000268	231.6199	165.6844	-9.0167E-06	12060.8517	-10.8952	160297.

228.520	.000232	810.9707	125.3644	-8.8067E-06	12073.1407	-9.5718	162237.
232.460	.000198	1241.3275	90.2214	-8.3933E-06	12082.2693	-8.2672	164178.
236.400	.000166	1542.7271	60.1210	-7.8325E-06	12088.6625	-7.0122	166118.
240.340	.000137	1734.5016	34.8218	-7.1724E-06	12092.7304	-5.8300	168059.
244.280	.000110	1834.9072	14.0040	-6.4534E-06	12094.8601	-4.7374	169999.
248.220	8.58E-05	1860.8546	-2.7072	-5.7090E-06	12095.4105	-3.7454	171940.
252.160	6.48E-05	1827.7298	-15.7203	-4.9660E-06	12094.7079	-2.8602	173880.
256.100	4.67E-05	1749.2915	-25.4599	-4.2454E-06	12093.0441	-2.0837	175821.
260.040	3.14E-05	1637.6324	-32.3518	-3.5632E-06	12090.6756	-1.4147	177761.
263.980	1.86E-05	1503.1942	-36.8115	-2.9306E-06	12087.8239	-.8491013	179701.
267.920	8.26E-06	1354.8241	-39.2347	-2.3549E-06	12084.6768	-.3809578	181642.
271.860	6.05E-08	1199.8635	-39.9908	-1.8403E-06	12081.3898	-.0028170	183582.
275.800	-6.24E-06	1044.2599	-39.4177	-1.3882E-06	12078.0892	.2937255	185523.
279.740	-1.09E-05	892.6944	-37.8193	-9.9807E-07	12074.8742	.5176073	187463.
283.680	-1.41E-05	748.7182	-35.4641	-6.6743E-07	12071.8203	.6779444	189404.
287.620	-1.61E-05	614.8921	-32.5846	-3.9276E-07	12068.9816	.7837418	191344.
291.560	-1.72E-05	492.9255	-29.3786	-1.6961E-07	12066.3945	.8436642	193285.
295.500	-1.75E-05	383.8094	-26.0108	6.9924E-09	12064.0799	.8658620	195225.
299.440	-1.71E-05	287.9428	-22.6151	1.4230E-07	12062.0464	.8578465	197166.
303.380	-1.64E-05	205.2493	-19.2971	2.4165E-07	12060.2924	.8264072	199106.
307.320	-1.52E-05	135.2822	-16.1373	3.1024E-07	12058.8083	.7775666	201046.
311.260	-1.39E-05	77.3181	-13.1939	3.5307E-07	12057.5787	.7165649	202987.
315.200	-1.25E-05	30.4390	-10.5059	3.7477E-07	12056.5844	.6478702	204927.
319.140	-1.10E-05	-6.3980	-8.0965	3.7962E-07	12056.0744	.5752081	206868.
323.080	-9.46E-06	-34.3025	-5.9752	3.7142E-07	12056.6663	.5016059	208808.
327.020	-8.03E-06	-54.4031	-4.1410	3.5355E-07	12057.0927	.4294479	210749.
330.960	-6.68E-06	-67.8100	-2.5847	3.2893E-07	12057.3771	.3605368	212689.
334.900	-5.44E-06	-75.5862	-1.2910	3.0005E-07	12057.5420	.2961594	214630.
338.840	-4.31E-06	-78.7272	-.2403876	2.6896E-07	12057.6086	.2371532	216570.
342.780	-3.32E-06	-78.1473	.5892289	2.3736E-07	12057.5963	.1839719	218510.
346.720	-2.44E-06	-74.6726	1.2210	2.0658E-07	12057.5226	.1367488	220451.
350.660	-1.69E-06	-69.0377	1.6783	1.7763E-07	12057.4031	.0953558	222391.
354.600	-1.04E-06	-61.8881	1.9833	1.5126E-07	12057.2514	.0594587	224332.
358.540	-4.97E-07	-53.7845	2.1567	1.2796E-07	12057.0796	.0285676	226272.
362.480	-3.60E-08	-45.2106	2.2171	1.0802E-07	12056.8977	.0020829	228213.
366.420	3.54E-07	-36.5818	2.1805	9.1544E-08	12056.7147	-.0206646	230153.
370.360	6.85E-07	-28.2555	2.0602	7.8484E-08	12056.5380	-.0403754	232094.
374.300	9.72E-07	-20.5419	1.8669	6.8655E-08	12056.3744	-.0577488	234034.
378.240	1.23E-06	-13.7145	1.6084	6.1754E-08	12056.2296	-.0734519	235975.
382.180	1.46E-06	-8.0205	1.2902	5.7376E-08	12056.1088	-.0880910	237915.
386.120	1.68E-06	-3.6899	.9153668	5.5017E-08	12056.0170	-.1021839	239855.
390.060	1.89E-06	-.9437840	.4852809	5.4084E-08	12055.9587	-.1161338	241796.
394.000	2.10E-06	0.0000	0.0000	5.3894E-08	12055.9387	-.1302017	121868.

Output Verification:

Computed forces and moments are within specified convergence limits.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =      .23000000 in
Computed slope at pile head      =     -.00546101
Maximum bending moment           =   876913.09584 lbs-in
Maximum shear force              =    44503.06045 lbs
Depth of maximum bending moment  =    35.46000000 in
Depth of maximum shear force     =        0.00000 in
Number of iterations             =              5
Number of zero deflection points =              4
```

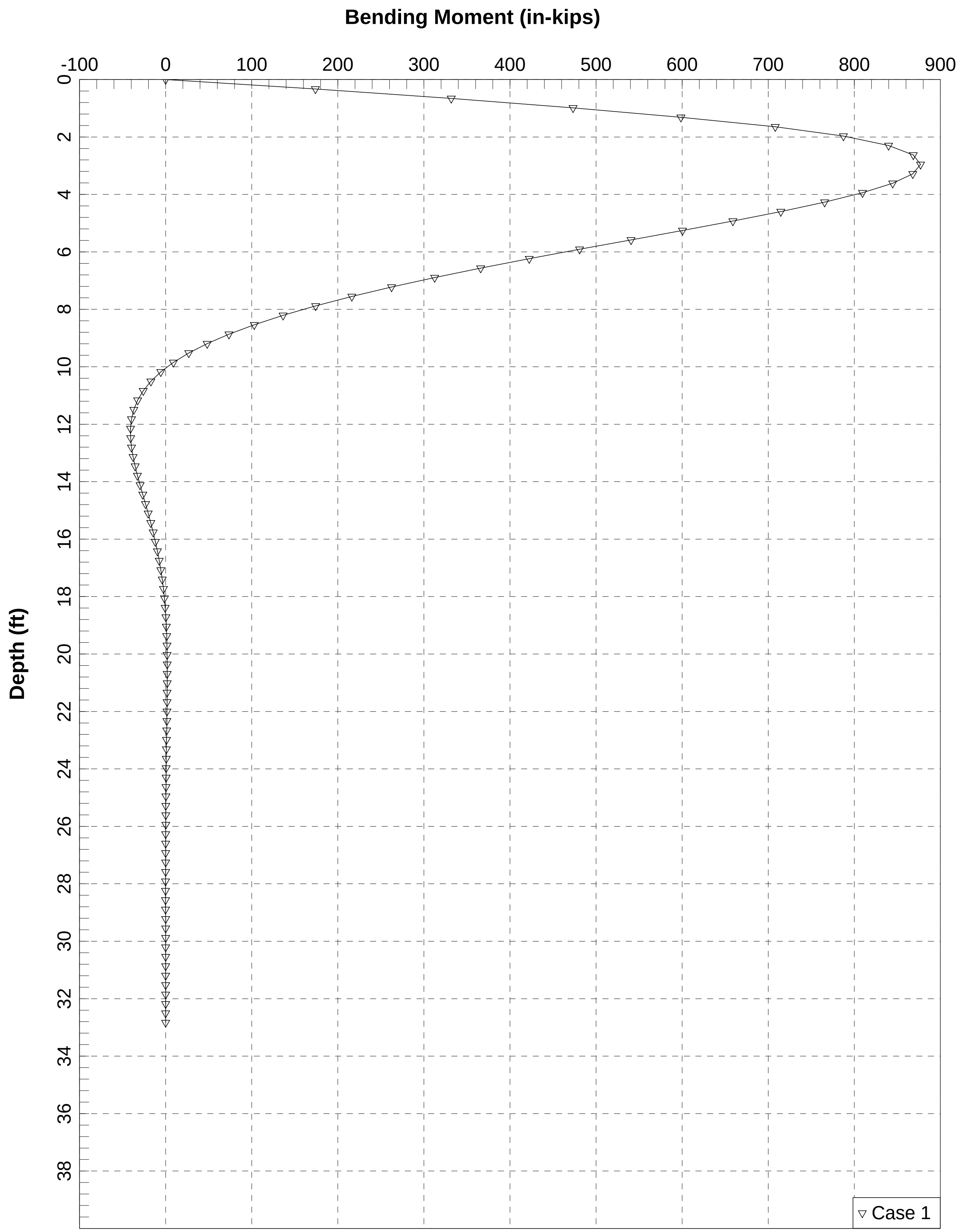
Summary of Pile Response(s)

Definition of Symbols for Pile-Head Loading Conditions:

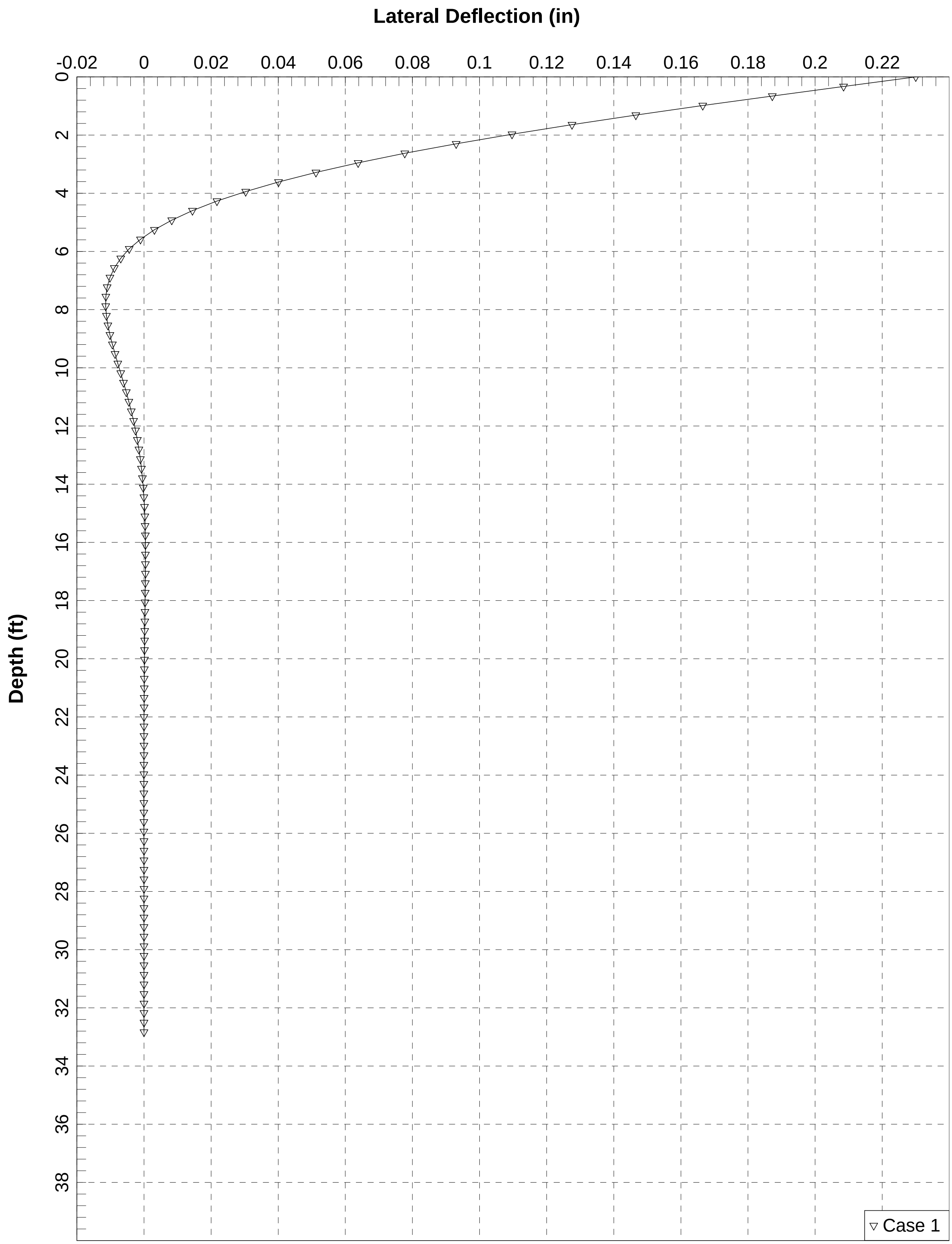
```
Type 1 = Shear and Moment,          y = pile-head displacment in
Type 2 = Shear and Slope,           M = Pile-head Moment lbs-in
Type 3 = Shear and Rot. Stiffness,  V = Pile-head Shear Force lbs
Type 4 = Deflection and Moment,     S = Pile-head Slope, radians
Type 5 = Deflection and Slope,      R = Rot. Stiffness of Pile-head in-lbs/rad
```

Load Type	Pile-Head Condition 1	Pile-Head Condition 2	Axial Load lbs	Pile-Head Deflection in	Maximum Moment in-lbs	Maximum Shear lbs
4	y= .230000	M= 0.000	314660.	.2300000	876913.	44503.0605

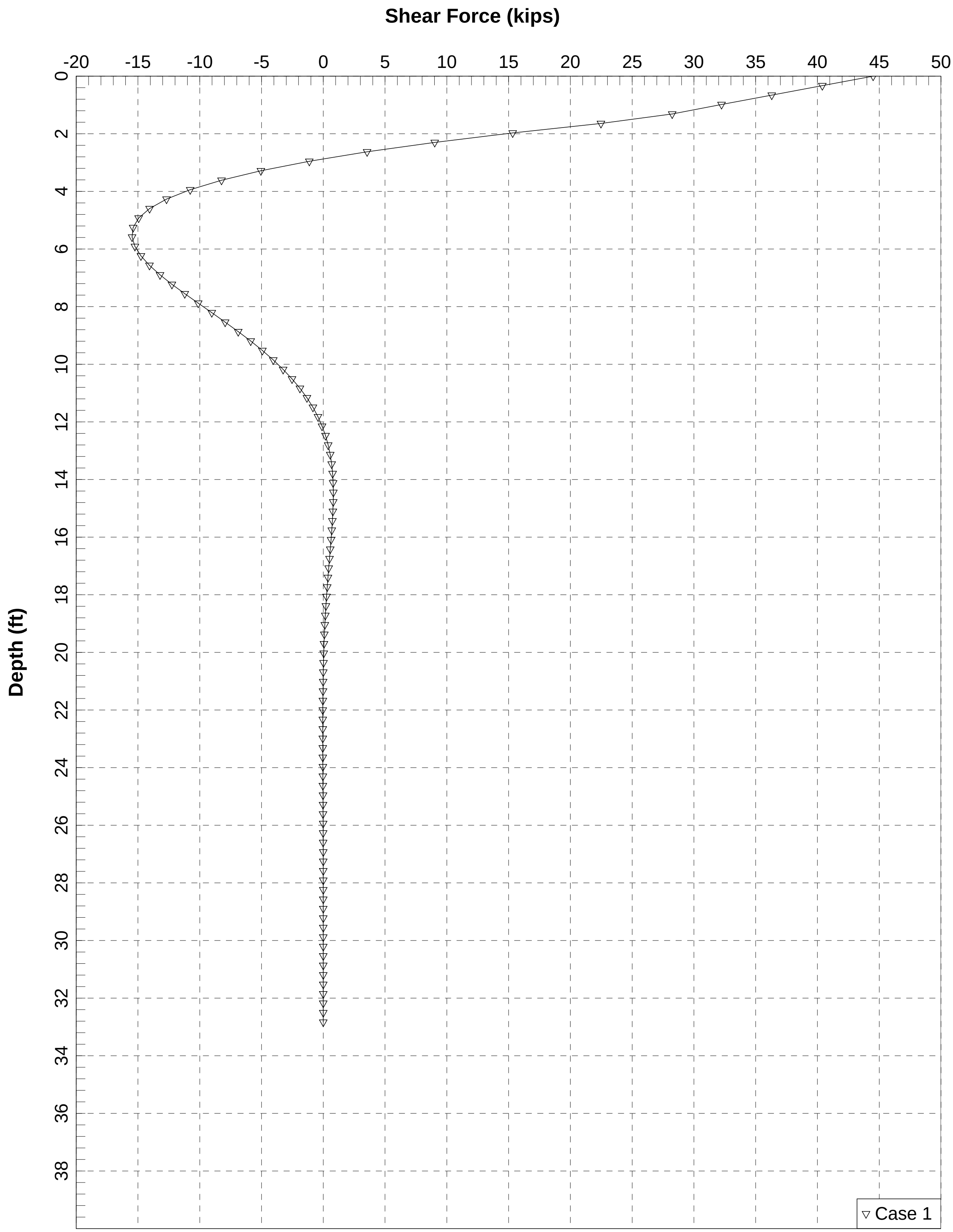
The analysis ended normally.



15096 Grand Lake Stream Abut 2



15096 Grand Lake Stream Abut 2



15096 Grand Lake Stream Abut 2