O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

J3325-01-01
February 26, 2021

Ms. Sherry Patch, Town Administer
Town of Princeton
6 Town Hall Drive
Princeton Massachusetts 01541

Re: Geotechnical Engineering Recommendations
New Public Safety Complex Project
Princeton, Massachusetts

Dear Ms. Patch:

O'Reilly Talbot & Okun Associates, Inc. (OTO) is pleased to provide this report summarizing our geotechnical engineering recommendations for the new public safety complex project, to be located at 18 Boylston Avenue in Princeton, Massachusetts. A Site Locus is provided as Figure 1. A Site Plan is provided as Figure 2.

Our geotechnical recommendations are based upon subsurface conditions observed in soil borings at eight locations around the Site. We note that shallow refusal was encountered at each of the borings. Our services consisted of the full-time observation of the borings, review of the logs and soil samples, engineering analyses, and preparation of this report. This report is subject to the attached limitations.

PROJECT AND SITE DESCRIPTION

The Site is located at 18 Boylston Avenue in Princeton, Massachusetts. It is bounded to the north, east and west by residential properties, and to the south by Boylston Avenue. An existing building (former school) and asphalt paved parking areas are located in the central and southern portions of the Site. An athletic field is located to the north of the existing building and parking area.

The existing building has a footprint of approximately 6,000 square feet and is a two-story masonry structure with a basement. A single-story addition is located along the western side of the building, which also contains a basement.. Project plans call for the demolition of the existing building and the construction of an approximate 13,000 (footprint) square foot, single story building. The proposed building will be a slab on grade, wood framed structure with a masonry veneer. The locations of the existing building and the proposed construction (approximate) are shown on Figure 2.

In general, the ground surface at the Site slopes downward from the east (approximate elevation 1100 feet) to the west (elevation 1090 feet). In the immediate area of the proposed new building, the ground surface is relatively flat, between elevation 1096 (west) and 1099 (east). We note that existing topography slopes steeply downward (approximate 2H:1V slope) along the western edge of the proposed new building. In addition, the topography immediately to the north of the parking area slopes downward towards the athletic field, which is at an elevation of approximately 1094. The existing ground surface topography is shown on Figure 2.

We have assumed that the proposed building will have a slab elevation near existing grade (about 1099). Therefore, we expect cuts on the order of five feet or less to construct the foundation. Fills up to 8 feet may be needed along the western and northern edges of the new building, and to fill the basement of the former building footprint.

We expect building loads will be supported on both isolated column and continuous strip footings. Structural loads are unknown at this time; however, it is expected that loads will be relatively light. Maximum column loads should be on the order of 100 kips, or less. We anticipate loads on bearing walls will be on the order of two kips per linear foot. These assumptions should be confirmed by the design team.

SUBSURFACE EXPLORATIONS AND TESTING

Subsurface investigations consisted of soil borings at eight locations (designated PS-1 through PS-8). Multiple borings were attempted at each location (designated PS-1a, PS-1b... etc.). In total, 20 borings were performed at the eight locations. In addition, a hydraulic permeability test was performed at boring location PS-6 to obtain information for the design of subsurface infiltration systems.

The boring locations proposed in the RFP were adjusted in the field due to the presence of subsurface and overhead utilities and other Site features.

Soil Borings

The borings were performed on February 10 and 11, 2021 by Seaboard Drilling of Chicopee, Massachusetts. The borings were performed using a Mobile B-53 truck mounted drill rig, using hollow stem auger drilling techniques. Each of the borings were performed within or near the footprint of the proposed new building and extended to auger refusal, between a depth of 4 and 11.3 feet below ground surface. We note that multiple borings were attempted at each of the boring locations due to shallow refusal on a boulder or bedrock.

In general, soil samples were collected continuously from the ground surface to a depth of four feet below ground surface, at a depth of five feet, and every five feet thereafter. Soil samples were collected using a two-inch diameter split spoon sampler, driven 24 inches with a 140-pound automatic hammer falling 30 inches (American Society for Testing and Materials Test Method D1586-99 “Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils”). The number of blows required to drive the sampler each six inches was recorded. The standard penetration resistance, or N-value, is the number of blows required to drive the sampler the middle 12 inches. Soil properties, such as strength and density, are related to the N-value.

An O’Reilly, Talbot & Okun Associates, Inc. (OTO) representative observed and logged the borings. Samples were classified according to a modified version of the Burmister Soil Classification System. After drilling, bore holes were backfilled with soil cuttings and patched with asphalt, where applicable. Boring locations are shown on Figure 2. Boring logs are attached.

Photo-Ionization Detector (PID) Screening

The headspace of each soil sample collected from the borings was screened using a MiniRAE Lite Photo-Ionization Detector (PID). PID screening provides an assessment of volatile organic content of the samples. PID readings are provided on the attached boring logs.

Hydraulic Conductivity Testing

To aid in the design of the proposed storm water infiltration system, an in-Situ hydraulic conductivity (or permeability) test was performed in soil boring PS-6. The test was performed using a Guelph Permeameter, which allows the rate of water recharge into an unsaturated soil to be measured, while maintaining a constant water head. Calculations are then made to estimate the saturated permeability of the soil for storm water infiltration. The permeability tests were performed by auguring a shallow hole into the soil, adding water to the apparatus and then recording the change in the rate of water flow from a reservoir over time. This data was then used to estimate the coefficient of permeability or hydraulic conductivity. Results are discussed below.

Grain Size Analysis

Composite soil samples were collected from the upper five feet in two soil borings. These samples were analyzed for grain size distribution by Allied Testing Laboratories of Springfield, Massachusetts to evaluate the suitability of on-Site soils for use as engineered fill. Results are discussed below.

SUBSURFACE CONDITIONS

Subsurface conditions were interpreted based upon the soil borings. In general, subsurface conditions consisted of the following, in order of increasing depth: a surface layer of topsoil or asphalt; granular fill (where present); and native granular soils containing numerous cobbles and boulders. Soil conditions are favorable for the proposed construction.

Soil Conditions

Asphalt Pavement: Pavement was present at the ground surface at boring locations PS-1, PS-2, and PS-8. The pavement consisted of 2.5 inches of asphalt over approximately 4 inches of gravel base course. The granular base course consisted of medium to coarse sand, some gravel and trace amounts of silt.

Topsoil: Approximately one to nine inches of topsoil was present at the ground surface at boring locations PS-3 through PS-7. The topsoil generally consisted of dark brown or brown, fine to medium sand containing some silt and little to trace amounts of organics (roots). We note that testing for nutrient content, pH, or organic content was not part of this study.

Granular Fill: With the exception of borings PS-1, PS-2 and PS-6, near surface granular fill was observed in each of the borings to a depth of between 0.5 and 7 feet. The fill generally consisted of medium dense to very dense, fine to medium sand with varying amounts of silt and gravel, little amounts of coarse sand, and little to trace amounts of debris (brick, ash, coal, asphalt). We note that portions of the Site, specifically in the area of borings PS-3 and PS-4, may have been filled to allow for construction of the paved parking areas. Deeper fill is also likely present against the basement walls around the perimeter of the existing Site building. Trace organics (roots) were encountered at a depth of between 3.5 and 4 feet in borings PS-3 and PS-5. The organics appeared to be associated with a former topsoil layer or are present in reworked site soils. Thus, the overlying soils are likely fill.

Native Granular Soils: The surficial soils and granular fill are underlain by native granular soils. The native granular soils consisted of medium dense to very dense, fine to medium sand, with little to some amounts of silt and gravel, and varying amounts of coarse sand. Numerous cobbles and boulders were observed during drilling and in the drill cuttings. Each of the borings encountered drilling refusal at a depth of between 0.8 and 11.3 feet below ground surface. The drilling refusals were likely upon either a large boulder or possibly bedrock. The depth to and elevation of drilling refusals are presented in Table 1.

Table 1
Subsurface Information

Boring Location	Ground Surface Elevation (ft)	Refusal	
		Depth (ft)	Elevation (ft)
PS-1	1099.0	4.0	1095
PS-1a	1099.0	2.1	1096.9
PS-1b	1099.0	2.1	1096.9
PS-2	1099.0	6.1	1092.9
PS-2a	1099.0	8.2	1090.8
PS-3	1097.0	5.1	1091.9
PS-3a	1097.0	5.1	1091.9
PS-4	1095.0	11.3	1083.7
PS-4a	1095.0	0.9	1094.1
PS-5	1093.5	2.9	1090.6
PS-5a	1093.5	2.5	1091.0
PS-5b	1093.5	4.4	1089.1
PS-6	1094.0	6.0	1088.0
PS-7	1094.0	1.5	1092.5
PS-7a	1094.0	4.2	1089.8
PS-8	1098.0	0.8	1097.2
PS-8a	1098.0	0.9	1097.1
PS-8b	1098.0	4.7	1093.3
PS-8c	1098.0	8.1	1089.9
PS-8d	1098.0	6.6	1091.4

Notes:
1. Elevations were developed by referring to the Site Plan provided by Caolo & Bieniek Associates, Inc. Data shown in this table should be considered approximate only to the degree implied by the method(s) used.

Groundwater Conditions

Groundwater was encountered in boring PS-6 at a depth of 5 feet below ground surface at the time of drilling. This level corresponds to an elevation of 1089 feet. No groundwater was observed in the remaining borings. Since the observed groundwater is well below the proposed slab elevation, we do not anticipate significant amounts of groundwater to be encountered during construction or during the service life of the building. We note that groundwater levels may vary in the future due to factors such as changes in precipitation or surface infiltration, or due to the future discharges of storm water in the subsurface.

Environmental Field Screening

The headspace of each soil sample was screened using a photoionization detector (PID). PID screening provides an assessment of volatile organic compounds (VOCs) of the samples. The PID readings ranged from 0 parts per million by volume (ppmv) to 0.7 ppmv. PID readings are presented on the boring logs.

Hydraulic Conductivity Testing

Hydraulic conductivity (K) testing was performed within the proposed stormwater management area, located in the athletic field in the northern portion of the Site. The test was performed using a Guelph Permeameter set into a shallow auger hole adjacent to soil boring location PS-6. The test was performed by adding water to the apparatus, and by recording the change in the rate of water flow from a reservoir over time. These data were then used to estimate the coefficient of permeability or hydraulic conductivity.

The soil encountered at the test interval consisted of fine sand, with little to some silt, and little amounts of fine gravel and medium sand. As noted above, auger refusal was encountered at a depth of 6 feet at the test location, likely upon a boulder or bedrock. The in-situ test performed indicated a low hydraulic conductivity and little of no water infiltration. This result does not appear to be consistent with observed conditions in other explorations and is likely the result of localized silty soils, cobbles and/or bedrock at the test location. Therefore, it is our opinion that the single test is not representative of overall Site conditions. Therefore, we recommend that additional test pits be performed at the stormwater management location to confirm the soil conditions and possible limiting layer encountered at 6 feet. The saturated hydraulic conductivity (K) value determined by this test, along with the soil conditions, are presented in Table 2.

Table 2
Hydraulic Conductivity Test Results

Soil Boring	Test Depth/ Approx. Elevation (feet)	Soil Conditions	K Value (feet/day)
TP-6	2.6 / 1091.4	Fine sand, little to some silt, little medium sand, little fine gravel	<0.1
Note: Elevations presented in this table were developed by referring to a topography survey plan and referring to measurements taken from existing Site features. Data shown in this table should be considered approximate only to the degree implied by the method(s) used.			

Grain Size Distribution

A grain size distribution analysis was performed on the near surface granular soils observed beneath the Site, at boring locations PS-1 and PS-4, to evaluate their potential re-use as engineered fill. These soils were observed at each boring location and were observed to be similar throughout the Site. The grain size distribution analysis indicates the soils consist of a fine to medium sand with little to trace amounts of silt, and little to some amounts of gravel. The sample collected from PS-4 appears to be suitable for re-use as Sand and Gravel or Gravel Base Course. The sample collected from PS-1 meets requirements for granular fill. Laboratory data sheets are attached.

SIGNIFICANT GEOTECHNICAL ISSUES

The significant geotechnical issues for the proposed construction addressed in this report include the following: the presence of granular fill within the footprint of the proposed building; the potential presence of large boulders and cobbles; foundation bearing capacity and settlement; seismic design considerations; pavement design; and the suitability of on-Site materials for use in engineered fills.

DESIGN RECOMMENDATIONS

The recommendations in this report refer to the 9th Edition of the Massachusetts State Building Code (MSBC). We note that the 9th Edition of the MSBC includes amendments to the 2015 International Building Code (IBC).

Granular Fill

As was discussed above, granular fill was encountered in the near surface soils in borings PS-3 through PS-5, PS-7, and PS-8. In addition, fill is likely present locally around the perimeter of the existing building. The granular fill was likely placed during past Site construction activities, to fill around the existing building, and for construction of the paved parking areas. In general, the fill consists of medium dense to very dense, fine to medium sand with varying amounts of silt and gravel, little amounts of coarse sand, and little to trace amounts of debris (brick, ash, coal, asphalt). In addition, former topsoil layers were present in borings PS-3 and PS-5 at a depth of between 3.5 and 4 feet.

Based upon the nature, variability and density of the fill layer, we recommend that the contractor remove the granular fill from beneath the new building foundations. Based upon our understanding of the project, we anticipate that the majority of the fill will be removed during excavations to construct the new building foundations. It may be possible to re-use some of the excavated material, provided over-sized and deleterious materials (debris and former topsoil) are removed.

To treat any loose areas at the base of the excavation and within the building pad, we recommend that the entire addition footprint be thoroughly proof compacted, prior to the placement of any engineered fill. Proof compaction should be accomplished by a minimum of six passes with a 6,000-pound vibratory roller. This will ensure that the footings bear on a firm dense surface and will limit differential settlement.

Demolition of Existing Building

We understand that the existing building will be demolished to prepare the Site for the new construction. Any foundation walls, slabs, basements, or utilities that are located within the footprint of the new building should be removed in their entirety. These excavations will likely extend below the planned slab and footing levels. The basement for the existing building, and any excavations resulting from the removal of existing foundations and/or slabs, should be backfilled with compacted engineered fills, consistent with the recommendations provided below and in the Earthwork Considerations section.

Abandoned buried utilities containing asbestos (such as electrical conduit insulation or transite pipe) are commonly found during construction excavations. Given the age of the existing site building, it is possible that such materials will be found during the new construction. Furthermore, former structures (pipes, conduits, foundation walls) may include materials containing asbestos. Such materials should be handled in accordance with Federal and State asbestos regulations. We recommend that suspect materials be managed appropriately and tested by a DLS certified asbestos inspector prior to disturbances. We recommend that the owner carry a contingency to address any undiscovered asbestos containing materials.

Foundation Recommendations

Provided the recommendations presented in this section are followed, a maximum allowable bearing pressure of 4,000 pounds per square foot may be used for the design of exterior and isolated column footings.

As described above, any unsuitable soils (debris) and topsoil layers should be removed from beneath the building foundations. The unsuitable soils should be replaced with compacted engineered fill as recommended below. Any debris, topsoil or organic soils stripped from the excavation should not be reused as fill beneath the structure. In addition, we recommend that the entire building footprint be thoroughly proof compacted, to treat any near surface loose areas. Proof compaction should be accomplished by a minimum of six passes with a 6,000 pound (or heavier) vibratory roller.

The near surface soils contain significant amounts of gravel, cobbles and boulders. If large boulders or cobbles are present within one foot of footing subgrades, they should be removed and replaced with compacted Sand and Gravel or Crushed Stone. The Sand and Gravel or Crushed Stone fill beneath the footings should meet the grain size distribution characteristics outlined in Table 4.

If competent bedrock is encountered at the footing subgrade level, the following recommendations are provided. For footings bearing on competent bedrock, the allowable bearing capacity will not govern design, and the footings should be designed based upon minimum widths contained in the building code. If bedrock is encountered, we recommend that a geotechnical engineer visit the Site to observe subgrades and to document that the footing base is bedrock and not a large boulder. Prior to placement of footings on bedrock, the contractor should remove any loose or weathered rock. Voids and/or uneven bedrock surfaces can be leveled using Crushed Stone.

We estimate that settlement of footings and slabs bearing on the densified native soils or compacted engineered fill should be small and largely elastic in nature. Maximum post-construction building settlement should be less than ½ inch and should occur relatively quickly after load application (during construction).

Exterior footings should be embedded a minimum of 48 inches below the lowest adjacent grade for frost protection. Interior footings should bear at least two feet below the surrounding floor slab. Strip footings, beneath the load bearing walls, should be at least 18 inches wide. Isolated column footings should be at least 24 inches wide. All other applicable requirements of the Massachusetts State Building Code (MSBC) should be followed.

If winter construction occurs, footings should not be placed on frozen soils. Footing excavations should be free of loose or disturbed materials. Any boulders or cobbles larger than four inches in diameter should be removed from within one foot of the bottom of the footings and replaced with Sand and Gravel fill. The footing subgrades should be densified immediately prior to placement of footing concrete with at least three passes with a vibrating plate compactor. If loose materials are present in the excavations, they should be recompacted to form a firm, dense bearing surface.

Concrete Slabs

We recommend that concrete floor slabs bear on at least 12 inches of compacted Sand and Gravel fill or Crushed Stone to provide uniform support and a capillary moisture break. The subgrade surface should also be free of large boulders or cobbles, if encountered. Therefore, we recommend that any large boulders of cobbles (greater than 6-inches in diameter) be removed from the exposed subgrade prior to placement of the Sand and Gravel layer beneath floor slabs. The fill beneath the concrete slabs should meet the grain size distribution characteristics outlined in Table 4.

The subgrade within the footprint of the proposed building should also be stripped of topsoil, asphalt, and any non-engineered fill. Prior to the placement of any engineered fills, we recommend that the building footprint be thoroughly densified to treat any loose areas present. If non-engineered fill, soft, or disturbed areas are present, these materials should be removed and recompacted or replaced with compacted, Sand and Gravel or Crushed Stone. Fill supporting slabs should be placed in accordance with the recommendations presented on Sheet 1.

Seismic Considerations

Earthquake loadings must be considered under requirements in Section 1613 and 1806 of the 9th Edition (October 2017) of the Massachusetts State Building Code (MSBC). The 9th Edition of the MSBC is based upon the International Building Code 2015 (IBC) with Massachusetts amendments. Note that the IBC refers to ASCE-7 (2010), *Minimum Design Loads for Buildings and Other Structures*.

Site Class and Earthquake Design Factors

Section 1613 of the IBC covers lateral forces imposed on structures from earthquake shaking and requires that every structure be designed and constructed to resist the effects of earthquake motions in accordance with ASCE-7. Lateral forces are dependent on the type and properties of soils present beneath the Site, along with the geographic location. Per Table 1604.11, the maximum considered earthquake spectral response acceleration at short periods (S_s) and at 1-sec (S_1) was determined to be 0.188 and 0.068, respectively, for Princeton, Massachusetts.
Soil properties are represented through Site Classification. Procedures for the Site-specific determination of Site Classification are provided in Chapter 20 of ASCE-7. At this Site, we evaluated Site Classification using one of the parameters allowed, Standard Penetration Resistance (N-value). The Site Class was determined to be Class C based upon soil data collected. Furthermore, the Site coefficients F_a and F_v were determined according to Tables 1613.3.3(1) and 1613.3.3(2) of the IBC (2015), using both the S_s and S_1 values and the Site Class. For this Site, F_a and F_v were determined to be 1.2 and 1.7, respectively.

Liquefaction

Section 1806.4 relates to the liquefaction potential of the underlying soils. Based upon the observed density, liquefaction is unlikely to occur during the design earthquake. In addition, loose soil layers below the maximum depth explored are not anticipated.

Exterior Slabs and Pavements

This section provides recommendations for exterior entryways, slabs, and sidewalks, as well as flexible and rigid pavements.

Entryways and Sidewalks

Exterior concrete slabs, such as those at entryways and sidewalks adjacent to the building, should be designed to mitigate differential frost movement between adjacent slabs, doorways, and pavements. To address this concern, we recommend that concrete slabs at entryways be underlain by four feet of non-frost susceptible Sand and Gravel fill. Where exterior slabs butt against hard surfaces (such as concrete curbs), we recommend that for the area beyond the edges of the slab, the bottom of Sand and Gravel fill should transition gradually upward at a slope of 3H:1V or flatter (zone of influence).

We recommend that concrete sidewalks that are outside the zone of influence of the building and entryways, as well as areas where differential frost movement would not cause a tripping hazard, bear on at least 12 inches of imported, compacted Sand and Gravel to provide uniform support and a capillary moisture break. Fill should be placed in accordance with the recommendations for compaction provided on Sheet 1. Subgrades should also be free of large cobbles or boulders. We recommend that the entire subgrade of the sidewalk be proof compacted with a heavy vibrating roller to treat any loose areas. The Sand and Gravel fill beneath the concrete slabs and sidewalks should meet the grain size distribution characteristics described in Table 4.

Flexible Pavement Design

We understand that the proposed pavements will likely experience loads from light passenger vehicles and an occasional delivery truck. The proposed flexible asphalt design section is provided in Table 3.

Table 3
Pavement Design Sections

Layer	Thickness
Asphalt Finish Course	1.5 inches
Asphalt Binder Course	1.5 inches
Gravel Base Course	12 inches

We recommend that the pavement subgrade be proof compacted to treat any loose areas present.

Table 4 presents recommendations for gradation requirements for the Sand and Gravel sub-base (structural fill), and Gravel Base Course materials. Please note that the Sand and Gravel specification is approximately that for Mass Highway M1.03.0, Type B Gravel Borrow; and Gravel Base Course specification is Mass Highway M1.03.1, Processed Gravel for Subbase.

Stormwater Management Recommendations

As described above, a single hydraulic conductivity (K) test indicated an infiltration rate which may not be representative of overall Site conditions. This is likely due the presence of local silty soil layers, cobbles and boulders at the test interval. Based upon our observations in the borings, it appears that gravel, with lesser amounts of silt, and cobbles and boulders are present throughout the soil profile; however, this cannot be confirmed based upon the limited information collected.

Therefore we recommend additional explorations be performed to assess stormwater infiltration design values. We recommend backhoe test pits to identify more representative soil layers, evaluate soil conditions in the areas of the proposed storm water management system, and evaluate the continuity and presence of silty soil layers and/or a limiting layer. It may be appropriate to relocate infiltration systems to more favorable areas. In our opinion, additional permeability testing is likely warranted in more favorable areas. In addition, we recommend that the conditions be documented during installation of the storm water structures to ensure that actual conditions are similar to those observed during these or subsequent investigations and values assumed for design. Furthermore, we recommend that if any pockets and/or layers of silty soils are encountered near the base of the structures, that these be removed and replaced with a permeable sand.

Earthwork Considerations

We anticipate that earthwork for this project will include the following: placement of engineered fill to backfill the existing building basement following demolition; removal of non-engineered fill (if encountered); excavations for footings; placement of compacted engineered fills beneath the building, floor slabs and pavements (as needed); and the treatment of the existing soils to address any localized loose areas that may be present.

Based upon the limited subsurface data, we do not anticipate that bedrock will be encountered during excavations for footings, slabs, or below grade structures. However, we note that although the drilling refusals encountered appear to be attributable to large cobbles or boulders, the bedrock surface may vary locally. Additional investigations are recommended if the footprint of the building changes or if footing elevations extend deeper than the elevations anticipated in this report.

Large cobbles or boulders may be encountered during excavations, and large excavations may be necessary for their removal. If needed, excavations should be backfilled with compacted Sand and Gravel or Crushed Stone.

Engineered Fill Recommendations

Four engineered fill types are recommended:

- Sand and Gravel for use immediately below footings, slabs, and beneath sidewalks;
- Crushed Stone for use as an alternative to Sand and Gravel;
- Gravel Base Course for use beneath pavements; and
- Granular Fill for use as miscellaneous fill and to form the building pads at depths greater than 12 inches beneath floor slabs and footings.

Grain size distribution requirements are presented in Table 4. On-Site soils may be suitable for re-use as engineered fills, if free from deleterious and/or oversized material. We note that many large boulders and cobbles were observed in the Site explorations. These materials would need to be screened from Site soils in order for Site soils to be reused as engineered fill. It may be possible to crush oversized cobble and boulders, burry them outside of pavement or building areas, or re-use them in surface treatments. If the contractor elects to use the on-Site material as fill, we recommend that a representative sample be collected, and a grain size distribution analysis be performed to obtain approval by the engineer.

Table 4
Grain Size Distribution Requirements

Size	Sand and Gravel	Gravel Base Course	Granular Fill	Crushed Stone
	Percent Finer by Weight			
3 inch	100	100	100	---
1 ½ inch	---	70-100	---	---
1 inch	---	---	---	100
¾ inch	---	50-85	---	90-100
½ inch	50-85	---	---	10-50
⅜ inch	---	---	---	0-20
No. 4	40-75	30-60	---	0-5
No. 10	---	---	30-90	---
No. 40	10-35	---	10-70	---
No. 200	0-10	0-10	0-15	---

Compaction Recommendations

Fill, debris, topsoil, or organic soils should be removed from beneath the footprint of the building and should not be re-used as fill beneath structures. To avoid point loads, any cobbles or boulders larger than four inches in diameter, encountered at the subgrade should also be removed. As noted, large boulders may be located within the footprint of the proposed additions. Large excavations may result from the removal of the boulders. The resulting excavations should be backfilled with compacted Sand and Gravel or Crushed Stone fill.

Prior to the placement of any engineered fill, we recommend that the entire building footprint be stripped of asphalt, concrete, topsoil, and non-engineered fill. The subgrade should be thoroughly proof compacted, prior to the placement of engineered fills. Proof compaction should be accomplished by a minimum of six passes with a 6,000-pound vibratory roller. To facilitate compaction, the moisture content of the on-Site material should be maintained at or near the optimum moisture content as determine by ASTM D1557.

Compacted fills should be placed in lifts ranging in thickness between 6 and 12 inches depending on the size and type of equipment. Recommended degrees of compaction and compaction means and methods are presented on Sheet 1.

Compaction within five feet of foundation or retaining walls should be performed using a hand-operated roller or vibratory plate compactor. If the new walls are to be backfilled on both sides, placement and compaction of engineered fills should proceed on both sides of the wall so that the difference in top of the fill on either side does not exceed two feet. For basement or retaining walls (walls where backfill is only on one side), the walls should be designed for unbalanced loading conditions, and the engineered fill within ten feet of the wall should be compacted using hand-operated plate or drum rollers weighing 250 pounds or less.

SUPPLEMENTAL INVESTIGATIONS

As described above, we recommend that additional test pits be performed within the proposed stormwater management area(s). At that time, additional test pits can also be performed at other areas of the Site to supplement information provided in this report and to investigate the amount and nature of oversized cobbles and boulders and confirm the cause of the relatively shallow drilling refusals. In our experience, such explorations provide for project savings as they result in more competitive bids.

FINAL DESIGN AND CONSTRUCTION PHASE SERVICES

It is recommended that O'Reilly, Talbot & Okun Associates, Inc. (OTO) be retained during final design to prepare and/or review appropriate specification sections and drawings, if necessary. During construction phases, we recommend that OTO be retained to provide engineering support and to document subgrade conditions and preparation.

We appreciated the opportunity to be of service on this project. If you have any questions, please do not hesitate to contact the undersigned.

Sincerely yours,
O'Reilly, Talbot & Okun Associates, Inc.

Stephen McLaughlin, E.I.T
Project Manager

Michael J. Talbot, P.E.
Principal

Attachments: Limitations, Site Locus, Site Plan, Sheet 1, Boring Logs, Laboratory Data Sheets

LIMITATIONS

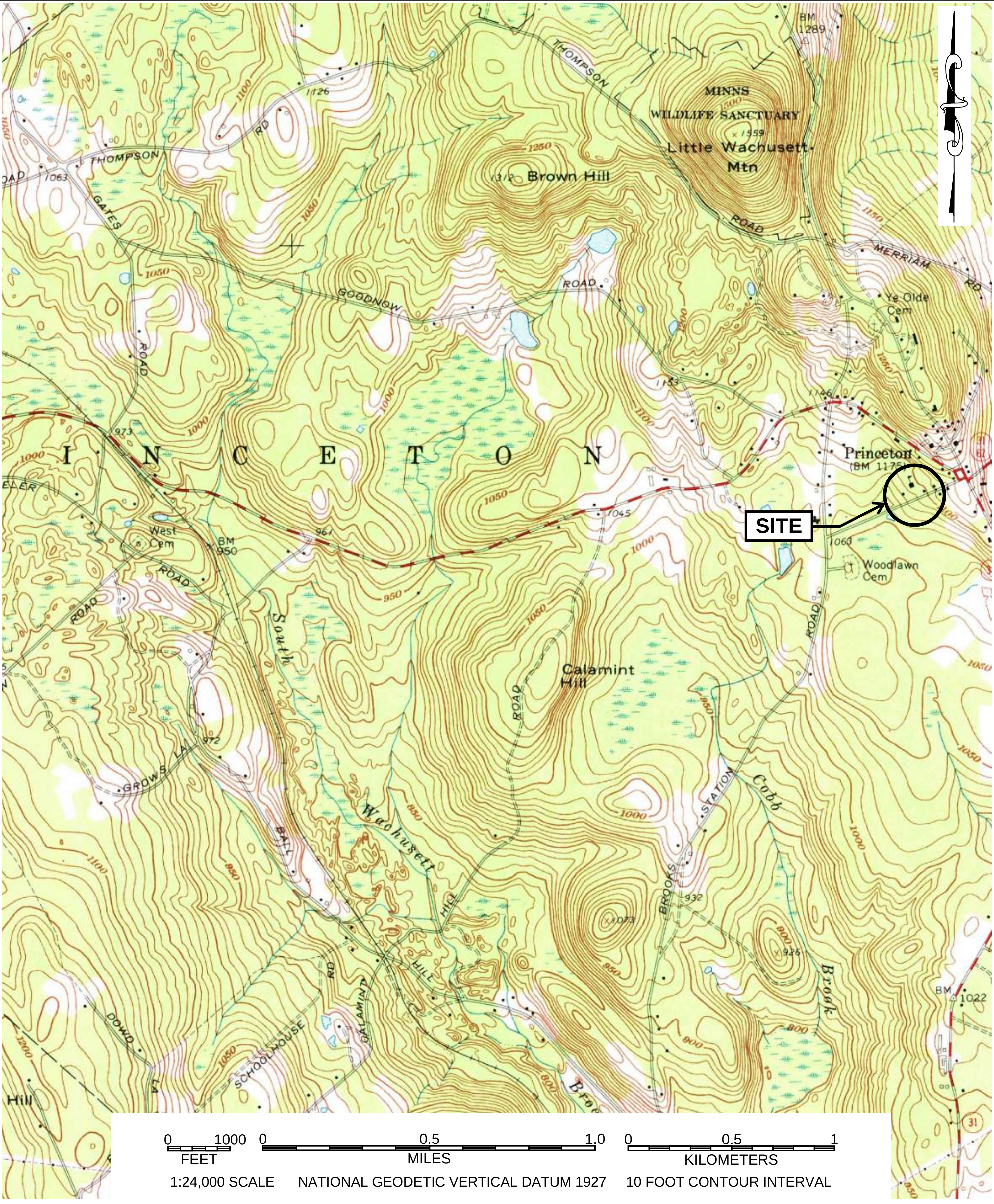
1. The observations presented in this report were made under the conditions described herein. The conclusions presented in this report were based solely upon the services described in the report and not on scientific tasks or procedures beyond the scope of the project or the time and budgetary constraints imposed by the client. The work described in this report was carried out in accordance with the Statement of Terms and Conditions attached to our proposal.

2. The analysis and recommendations submitted in this report are based in part upon the data obtained from widely spaced subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it may be necessary to reevaluate the recommendations of this report.

3. The generalized soil profile described in the text 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 are probably more erratic. For specific information, refer to the boring logs.

4. In the event that any changes in the nature, design or location of the proposed structures are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by O'Reilly, Talbot & Okun Associates Inc. It is recommended that we be retained to provide a general review of final plans and specifications.

5. Our report was prepared for the exclusive benefit of our client. Reliance upon the report and its conclusions is not made to third parties or future property owners.



0 1000 FEET
0 0.5 1.0 MILES
0 0.5 1 KILOMETERS

1:24,000 SCALE NATIONAL GEODETIC VERTICAL DATUM 1927 10 FOOT CONTOUR INTERVAL

O:\J3300\3325 Town of Princeton\01 Public Safety Complex\Figures

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

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PUBLIC SAFETY COMPLEX

18 BOYLSTON AVENUE
PRINCETON, MASSACHUSETTS

SITE LOCUS

Topographic Map Quadrant: WACHUSETT, MA

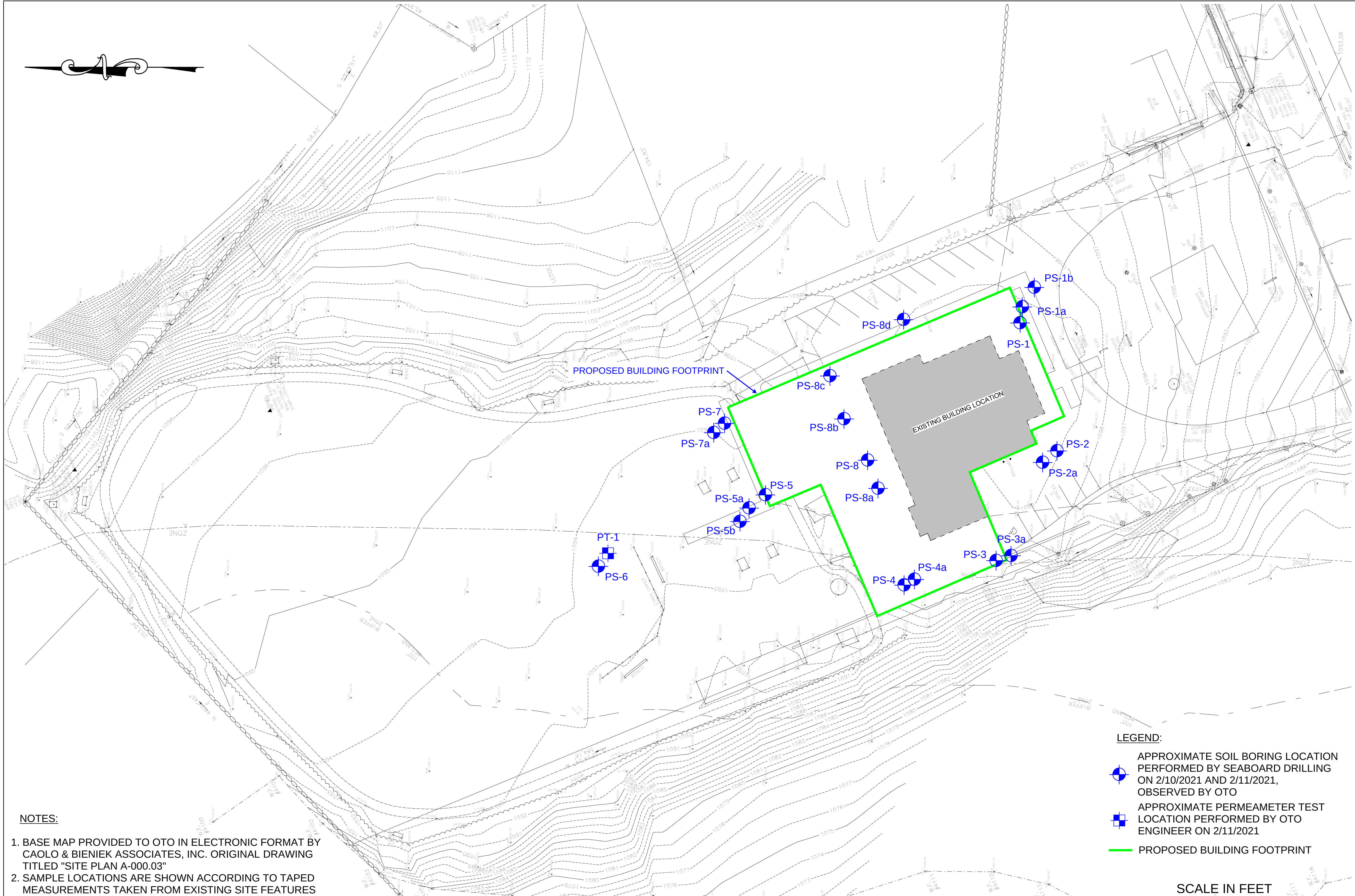
Map Version: 1972

Current As Of: 1974

Date: February 2021

PROJECT No. J3325-01-01

FIGURE No. 1



NOTES:

1. BASE MAP PROVIDED TO OTO IN ELECTRONIC FORMAT BY CAOLO & BIENIEK ASSOCIATES, INC. ORIGINAL DRAWING TITLED "SITE PLAN A-000.03"
2. SAMPLE LOCATIONS ARE SHOWN ACCORDING TO TAPED MEASUREMENTS TAKEN FROM EXISTING SITE FEATURES
3. ALL DATA IS TO BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHODS USED IN THE DEVELOPMENT OF THIS PLAN

LEGEND:

- APPROXIMATE SOIL BORING LOCATION PERFORMED BY SEABOARD DRILLING ON 2/10/2021 AND 2/11/2021, OBSERVED BY OTO
- APPROXIMATE PERMEAMETER TEST LOCATION PERFORMED BY OTO ENGINEER ON 2/11/2021
- PROPOSED BUILDING FOOTPRINT

SCALE IN FEET
1" = 50'
0' 25' 50' 100'

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Designed By: SLR
Drawn By: SLR
Checked By: SMM
Date: 2/12/2021
Revised Date:

PRINCETON PUBLIC SAFETY BUILDING

18 BOYLSTON AVENUE
PRINCETON, MASSACHUSETTS

SITE PLAN

PROJECT NO.
J3325-01-01

FIGURE NO.
2

O:\J3300\J3325 Town of Princeton\01 Public Safety Complex\Figures

Table 1-1
Degree of Compaction Recommendations

Location	Minimum Compaction
Below Structures (Foundations and Slabs)	95%
Below Pavements/Sidewalks/Exterior Slabs	95%
Against Basement Walls/Retaining Walls	92%
Utility Trenches	95%
General Landscaped Areas	90%

Notes.
1. Percentage of the maximum dry density as determined by Modified Proctor ASTM D1557, Method C.
2. When location falls into two or more categories, the engineer should be notified to determine appropriate compaction efforts and/or methods.
3. Crushed stone should be compacted in lifts of 12 inches to form a dense matrix using either traditional compaction methods (vibratory plate and/or roller) or tamping with an excavator bucket in deep excavations. It is generally not necessary to perform laboratory or field density testing on crushed stone.

Table 1-2
General Guidelines for Compaction Means and Methods

Compaction Method	Maximum Stone Size (Inches Diameter)	Maximum Lift Thickness (Inches)		Minimum Number of Passes	
		Below Structures & Pavement	Non-Critical Areas	Below Structures & Pavement	Non-Critical Areas
Hand-operated Vibratory Plate and confined spaces	3	6	8	6	4
Hand-operated vibratory drum roller (less than 1000 pounds)	3	6	8	6	4
Hand-operated vibratory drum roller (at least 1,000 pounds)	6	8	10	6	4
Light vibratory drum roller (minimum 3000 pounds)	6	10	14	6	4
Heavy vibratory drum roller (minimum 6000 pounds)	6	12	18	6	4

Note: The contractor should reduce or stop drum vibration if pumping of the subgrade is observed.

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BORING LOGS

SUMMARY OF THE BURMISTER SOIL CLASSIFICATION SYSTEM (MODIFIED)

RELATIVE DENSITY (of non-plastic soils) OR CONSISTENCY (of plastic soils)

STANDARD PENETRATION TEST (SPT)
Method: Samples were collected in accordance with ASTM D1586, using a 2" diameter split spoon sampler driven 24 inches. If samples were collected using direct push methodology (Geoprobe), SPTs were not performed and relative density/consistency were not reported. N-Value: The number of blows with a 140 lb. hammer required to drive the sampler the middle 12 inches. WOR: Weight Of Rod (depth dependent) WOH: Weight Of Hammer (140 lbs.)

COHESIONLESS SOILS		COHESIVE SOILS	
BLOWS/FOOT (SPT N-Value)	RELATIVE DENSITY	BLOWS/FOOT (SPT N-Value)	CONSISTENCY
0-4	Very loose	<2	Very soft
4-10	Loose	2-4	Soft
10-30	Medium dense	4-8	Medium Stiff
30-50	Dense	8-15	Stiff
>50	Very dense	15-30	Very stiff
*Based upon uncorrected field N-values		>30	Hard

MATERIAL: (major constituent identified in CAPITAL letters)

COHESIONLESS SOILS		
MATERIAL	FRACTION	GRAIN SIZE RANGE
GRAVEL	Coarse	3/4" to 3"
	Fine	1/4" to 3/4"
SAND	Coarse	1/16" to 1/4"
	Medium	1/64" to 1/16"
	Fine	Finest visible & distinguishable particles
SILT/CLAY	see adjacent table	Cannot distinguish individual particles
COBBLES	3" to 6" in diameter	
BOULDERS	> 6" in diameter	
Note: Boulders and cobbles are observed in test pits and/or auger cuttings.		

COHESIVE SOILS		
SMALLEST DIAMETER	PLASTICITY	IDENTITY
None	Non-plastic	**SILT**
1/4" (pencil)	Slight	**Clayey SILT**
1/8"	Low	**SILT & CLAY**
1/16"	Medium	**CLAY & SILT**
1/32"	High	**Silty CLAY**
1/64"	Very High	**CLAY**
Wetted sample is rolled in hands to smallest possible diameter before breaking.		

ORGANIC SILT: Typically gray to dark gray, often has strong H2S odor. May contain shells or shell fragments. Light weight.
Fibrous PEAT: Light weight, spongy, mostly visible organic matter, water squeezed readily from sample. Typically near top of layer.
Fine grained PEAT: Light weight, spongy, little visible organic matter, water squeezed from sample. Typically below fibrous peat.
DEBRIS: Detailed contents described in parentheses (wood, glass, ash, crushed brick, metal, etc.)
BEDROCK: Underlying rock beneath loose soil, can be weathered (easily crushed) or competent (difficult to crush).

ADDITIONAL CONSTITUENTS

TERM	% OF TOTAL
and	35-50%
some	20-35%
little	10-20%
trace	1-10%

COMMON TERMS

Glacial till: Very dense/hard, heterogeneous mixture of sand, silt, clay, sub-angular gravel. Deposited at base of glaciers, which covered all of New England.
Varved clay: Fine-grained, post-glacial lake sediments characterized by alternating layers (or varves) of silt, sand and clay.
Fill: Material used to raise ground, can be engineered or non-engineered.

COMMON FIELD MEASUREMENTS

Torvane: Undrained shear strength is estimated using an E285 Pocket Torvane (TV). Values in tons/ft2.
Penetrometer: Unconfined compressive strength is estimated using a Pocket Penetrometer (PP). Values in tons/ft2.
RQD: Rock Quality Designation is determined by measuring total length of pieces of core 4" or greater and dividing by the total length of the run, expressed as %. 100-90% excellent; 90-75% good; 75-50% fair; 50-25% poor; 25-0% very poor.
PID: Soil screened for volatile organic compounds (VOCs) using a photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.

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LOG OF BORING PS-1

PROJECT	New Public Safety Building			CONTRACTOR	Seaboard Environmental Drilling				
JOB NUMBER	3325-01-01	FINAL DEPTH (ft)	4.0	DRILLING EQUIPMENT	B-53 Truck Mounted Rig				
LOCATION	Princeton, MA	SURFACE ELEV (ft)	1099.0	FOREMAN	Dale G.	CASING			
START DATE	2/10/2021	DISTURBED SAMPLES	4	HELPER	Mike K.	CASE DIAMETER	N/A		
FINISH DATE	2/10/2021	UNDISTURBED SAMPLES	0	BIT TYPE	Hollow Stem Auger	HAMMER WGT	N/A		
ENGINEER/SCIENTIST	Shannon Raymond	WATER LEVEL		ROD TYPE	A (1 5/8" O.D.)	HAMMER DROP	N/A		
BORING LOCATION	Southeast corner of proposed building	FIRST (ft)	N/E	SAMPLER	2" O.D. Split Spoon	ROCK CORING INFORMATION			
		LAST (ft)	N/A	HAMMER TYPE	Automatic	TYPE	N/A		
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"	SIZE	N/A		

DEPTH (ft)/ SAMPLES	SAMPLES: PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
					Top 2.5" : Asphalt	ASPHALT	1., 2.
					Bottom 4" : Grey, medium to coarse SAND, some fine gravel, little fine sand, trace silt, dry	FINE TO MEDIUM SAND	
	6/6/6/7	4/24	S-1 (0.5'-2.5')	0.4	Medium dense, brown, fine to medium SAND, little silt, little coarse sand, little gravel, dry		7. 5.
						2.5 1096.5	3. , 6. , 8.
	15/50 for 5"	11/11	S-2 (2.5'-3.4')	0.1	Very dense, red-brown, fine SAND, some silt, little medium sand, little gravel, trace coarse sand, dry	FINE SAND	
						3.4 1095.6	4.
					Refusal at 4', upon likely boulder		
5'							
					Offset PS-1a:		
	50 for 1"	1/1	(2'-2.1')	0.4	Very dense, white-grey, fine SAND and GRAVEL, dry (fractured rock) Refusal at 2.1', upon likely boulder		
					Offset PS-1b:		
	50 for 1"	1/1	(2'-2.1')	0.7	Very dense, white-grey, fine SAND and GRAVEL, dry (fractured rock) Refusal at 2.1', upon likely boulder		
10'							
15'							
20'							
25'							

Remarks:

1. Soil screened in field using MiniRAE Lite photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.
2. Difficulty drilling between ground surface to 2 feet below ground surface.
3. Very difficult drilling conditions between 2 and 4 feet.
4. Refusal at 4 feet, offset PS-1 7 feet east.
5. PS-1a : Very difficult drilling conditions between 1.5 and 2 feet.
6. Refusal at 2 feet, offset PS-1a 10 feet south, 7 feet east.
7. PS-1b : Very difficult drilling conditions between 1 and 2 feet.
8. Refusal at 2 feet.
9. Cobbles and boulders observed in cuttings

PROJECT NO. 3325-01-01

LOG OF BORING PS-1

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LOG OF BORING PS-2

PROJECT	New Public Safety Building			CONTRACTOR	Seaboard Environmental Drilling
JOB NUMBER	3325-01-01	FINAL DEPTH (ft)	8.2	DRILLING EQUIPMENT	B-53 Truck Mounted Rig
LOCATION	Princeton, MA	SURFACE ELEV (ft)	1099.0	FOREMAN	Dale G.
START DATE	2/11/2021	DISTURBED SAMPLES	4	HELPER	Mike K.
FINISH DATE	2/11/2021	UNDISTURBED SAMPLES	0	BIT TYPE	Hollow Stem Auger
ENGINEER/SCIENTIST	Shannon Raymond	WATER LEVEL		ROD TYPE	A (1 5/8" O.D.)
BORING LOCATION	Southwest corner of proposed building	FIRST (ft)	N/E	SAMPLER	2" O.D. Split Spoon
		LAST (ft)	N/A	HAMMER TYPE	Automatic
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"

CASING	
CASE DIAMETER	N/A
HAMMER WGT	N/A
HAMMER DROP	N/A
ROCK CORING INFORMATION	
TYPE	N/A
SIZE	N/A

DEPTH (ft)/ SAMPLES	PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE (DEPTH (ft) ELEV.)	REMARKS/ WELL CONSTRUCTION
					Top 2.5" : Asphalt	ASPHALT	1.
0.5'-2.5'	8/10/7/19	14/24	S-1 (0.5'-2.5')	0.2	Bottom 4" : Grey, medium to coarse SAND, some fine gravel, little fine sand, trace silt, dry Top 6" : Medium dense, brown, fine to medium SAND, some silt, little coarse sand, trace gravel, dry Middle 7" : Medium dense, red-brown, fine to medium SAND, little to some silt, little fine gravel, trace coarse sand, dry Bottom 1" : Medium dense, white-grey, fine SAND and GRAVEL, dry (fractured rock)	FINE TO MEDIUM SAND 2.5 1096.5	2. , 6. 3. , 4.
5'	24/55/50 for 2"	12/14	S-2 (5'-6.1')	0.1	Very dense, white-grey, fine SAND and GRAVEL, little medium sand, dry (fractured rock)	FINE SAND AND GRAVEL 6.1 1092.9	7. 5.
					Refusal at 6.1', upon likely boulder		
					Offset PS-2a:		
	2/1/1/1	16/24	(3'-5')	0.2	Top 4" : Loose, brown, fine to medium SAND, some to little coarse sand, trace fine gravel, trace silt, dry Bottom 12" : Loose, light brown, medium SAND, some fine sand, little coarse sand, trace silt, dry		
10'	12/34/50 for 3"	4/15	(7'-8.2')	0.1	Very dense, fine SAND and GRAVEL, dry (fractured rock) Refusal at 8.2', upon likely boulder		
15'							
20'							
25'							

Remarks:

1. Soil screened in field using MiniRAE Lite photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.
2. Difficulty drilling between at 1 to 2 feet below ground surface.
3. Spoon deflected at 2 feet, upon likely cobble or boulder.
4. Very difficult drilling conditions between 2 and 4.5 feet.
5. Refusal at 6.1 feet, offset PS-2 8 feet north, 1 feet west.
6. PS-2a : Difficulty drilling conditions between 1 and 2 feet.
7. PS-2a : Very difficult drilling conditions between 5 and 7 feet.
8. PS-2a : Refusal at 8.2 feet.
9. Cobbles and boulders observed in cuttings

PROJECT NO. 3325-01-01

LOG OF BORING PS-2

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LOG OF BORING PS-3

PROJECT	New Public Safety Building			CONTRACTOR	Seaboard Environmental Drilling
JOB NUMBER	3325-01-01	FINAL DEPTH (ft)	5.1	DRILLING EQUIPMENT	B-53 Truck Mounted Rig
LOCATION	Princeton, MA	SURFACE ELEV (ft)	1097.0	FOREMAN	Dale G.
START DATE	2/11/2021	DISTURBED SAMPLES	3	HELPER	Mike K.
FINISH DATE	2/11/2021	UNDISTURBED SAMPLES	0	BIT TYPE	Hollow Stem Auger
ENGINEER/SCIENTIST	Shannon Raymond	WATER LEVEL		ROD TYPE	A (1 5/8" O.D.)
BORING LOCATION	Western side of proposed building	FIRST (ft)	N/E	SAMPLER	2" O.D. Split Spoon
		LAST (ft)	N/A	HAMMER TYPE	Automatic
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"

CASING	
CASE DIAMETER	N/A
HAMMER WGT	N/A
HAMMER DROP	N/A
ROCK CORING INFORMATION	
TYPE	N/A
SIZE	N/A

DEPTH (ft)/ SAMPLES	PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
					Top 5" : brown, fine to medium SAND, some silt, little organics (roots), damp (frozen)	TOPSOIL	1. , 2. , 5.
					Bottom 19" : Brown, fine to medium SAND, some silt, little gravel, trace coarse sand, dry	GRANULAR FILL	3.
	5/6/7/6	17/24	S-1 (2'-4')	0.1	Top 4" : Medium dense, dark brown, fine to medium SAND, some silt, little coarse sand, little to trace debris (ash), dry (FILL)		
					Middle 6" : Medium dense, light brown, medium SAND, some fine sand, some to little coarse sand, trace fine gravel, trace silt, dry		2.
					Bottom 4" : Medium dense, dark brown, fine to medium SAND, some silt, dry		5.
5'	4/4/50 for 1"	6/13	S-2 (4'-5.1')	0.1	Top 4" : Very dense, dark brown, fine to medium SAND, some silt, trace organics (roots), dry (FORMER TOPSOIL)	FORMER TOPSOIL	
					Bottom 2" : Very dense, white-grey, fine SAND and GRAVEL, little silt, dry (fractured rock)	FINE SAND AND GRAVEL	4. , 6.
					Refusal at 5.1, upon likely boulder		
					Offset PS-3a:		
	50 for 1"	1/1	(5'-5.1')	0.1	Very dense, white-grey, fine SAND and GRAVEL, dry (fractured rock)		
					Refusal at 5.1', upon likely boulder		
10'							
15'							
20'							
25'							

Remarks:
1. Soil screened in field using MiniRAE Lite photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.
2. Very difficult drilling conditions between the ground surface and 0.5 feet, 3.5 and 5 feet below ground surface.
3. Very easy drilling conditions between 0.5 and 2 feet.
4. Refusal at 5.1 feet, offset PS-3 8 feet south.
5. PS-3a : Very difficult drilling conditions between the ground surface and 1 feet, 4 and 5 feet.
6. Refusal at 5.1 feet.
7. Cobbles and boulders observed in cuttings.

PROJECT NO. 3325-01-01

LOG OF BORING PS-3

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LOG OF BORING PS-4

PROJECT	New Public Safety Building			CONTRACTOR	Seaboard Environmental Drilling		
JOB NUMBER	3325-01-01	FINAL DEPTH (ft)	11.3	DRILLING EQUIPMENT	B-53 Truck Mounted Rig		
LOCATION	Princeton, MA	SURFACE ELEV (ft)	1095.0	FOREMAN	Dale G.	CASING	
START DATE	2/10/2021	DISTURBED SAMPLES	3	HELPER	Mike K.	CASE DIAMETER	N/A
FINISH DATE	2/10/2021	UNDISTURBED SAMPLES	0	BIT TYPE	Hollow Stem Auger	HAMMER WGT	N/A
ENGINEER/SCIENTIST	Shannon Raymond	WATER LEVEL		ROD TYPE	A (1 5/8" O.D.)	HAMMER DROP	N/A
BORING LOCATION	Northwestern corner of proposed building	FIRST (ft)	N/E	SAMPLER	2" O.D. Split Spoon	ROCK CORING INFORMATION	
		LAST (ft)	N/A	HAMMER TYPE	Automatic	TYPE	N/A
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"	SIZE	N/A

DEPTH (ft)/ SAMPLES	PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
	38/34/13/13	20/24	S-1 (0'-2')	0.1	Top 1" : Dense, brown, fine to medium SAND, some silt, little coarse sand, trace fine gravel, trace organics (roots), dry (TOPSOIL) Bottom 9" : Dense, light brown with rust staining, fine SAND, some gravel, little medium sand, trace coarse sand, trace silt, dry	TOPSOIL GRANULAR FILL	1. , 5. 6.
	8/6/6/6	0/24	S-2 (2'-4')	--	No Recovery ; rock in tip		2.
5'	3/4/4/2	12/24	S-3 (5'-7')	0.5	Loose, dark brown with little rust staining, fine SAND, some gravel, little medium sand, trace coarse sand, trace to little silt, dry		3.
						7.0 1088.0 FINE SAND AND GRAVEL	
10'	33/50/50 for 4"	15/16	S-4 (10'-11.3')	0.3	Very dense, white-grey, fine SAND and GRAVEL, trace to little silt, dry (fractured rock)	11.3 1083.7	4.
					Refusal at 11.3', upon likely boulder		
	50 for 5"	5/5	(0.5'-0.9')	--	Offset PS-4a: No Recovery Refusal at 0.9', upon likely boulder		
15'							
20'							
25'							

Remarks:
1. Soil screened in field using MiniRAE Lite photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.
2. Difficulty drilling between 2 and 5 feet below ground surface.
3. Very difficult drilling conditions between 5 and 10 feet.
4. Refusal at 11.3 feet, offset 5 feet south
5. PS-4a : Very difficult drilling conditions between the ground surface and 0.9 feet.
6. Refusal at 0.9 feet.
7. Cobbles and boulders observed in cuttings.

PROJECT NO. 3325-01-01

LOG OF BORING PS-4

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LOG OF BORING PS-5

PROJECT	New Public Safety Building			CONTRACTOR	Seaboard Environmental Drilling
JOB NUMBER	3325-01-01	FINAL DEPTH (ft)	4.4	DRILLING EQUIPMENT	B-53 Truck Mounted Rig
LOCATION	Princeton, MA	SURFACE ELEV (ft)	1093.5	FOREMAN	Dale G.
START DATE	2/10/2021	DISTURBED SAMPLES	4	HELPER	Mike K.
FINISH DATE	2/11/2021	UNDISTURBED SAMPLES	0	BIT TYPE	Hollow Stem Auger
ENGINEER/SCIENTIST	Shannon Raymond	WATER LEVEL		ROD TYPE	A (1 5/8" O.D.)
BORING LOCATION	Northern portion of proposed building	FIRST (ft)	N/E	SAMPLER	2" O.D. Split Spoon
		LAST (ft)	N/A	HAMMER TYPE	Automatic
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"

CASING	
CASE DIAMETER	N/A
HAMMER WGT	N/A
HAMMER DROP	N/A
ROCK CORING INFORMATION	
TYPE	N/A
SIZE	N/A

DEPTH (ft)/ SAMPLES	PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
	16/15/6/8	20/24	S-1 (0'-2')	0.1	Top 9" : Medium dense, dark brown, fine to medium SAND, some silt, little coarse sand, trace organics (roots), dry (TOPSOIL)	TOPSOIL	1., 2.
					Bottom 11" : Medium dense, brown with rust staining, fine to medium SAND, some to little silt, little fine gravel, little coarse sand, trace debris (coal), dry (FILL)	GRANULAR FILL	5. / 6. , 9.
	15/50 for 5"	11/11	S-2 (2'-2.9')	0.1	Top 6" : Very dense, red-brown, fine SAND, little to some silt, little fine gravel, little medium sand, trace coarse sand, dry	2.0 1091.5	3. , 10.
					Bottom 5" : Very dense, white-grey, fine SAND and GRAVEL, trace to little silt, dry	FINE SAND AND GRAVEL	7. , 8. / 4.
					Refusal at 2.9', upon likely boulder		
5'	24/4/6/12	8/24	(2'-4')	0.3	Offset PS-5a: Medium dense, grey-white, fine SAND and GRAVEL, trace silt, dry (fractured rock) Refusal at 2.5', upon likely boulder		
	6/4/50 for 5"	12/17	(3-4.4')	0.2	Offset PS-5b: Top 6" : Very dense, brown, fine to medium SAND, some silt, little coarse sand, trace (+) fine gravel, dry. Middle 5" : Very dense, very dark brown, fine SAND, some silt, little medium sand, trace coarse sand, trace organics (roots), dry (FORMER TOPSOIL). Bottom 11" : Very dense white-grey, fine SAND and GRAVEL, trace silt, dry (fractured rock)		
10'					Refusal at 4.4', upon likely boulder		
15'							
20'							
25'							

Remarks:
1. Soil screened in field using MiniRAE Lite photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.
2. Difficulty drilling between ground surface to 2 feet below ground surface.
3. Very difficult drilling conditions between 2 and 2.5 feet.
4. Refusal at 2.9 feet, offset PS-5 10 feet north, 2 feet west.
5. PS-5a : Difficulty drilling between 0.5 and 1 feet.
6. PS-5a : Very difficult drilling conditions between 1 and 2.5 feet.
7. PS-5a : Spoon deflected at 2.5', upon likely cobble or boulder.
8. Refusal at 2.5 feet, offset PS-5a 3 feet north, 6 feet west.
9. PS-5b : Difficult drilling conditions between 1 and 2 feet.
10. PS-5b : Very difficult drilling conditions between 2 and 4 feet.
11. PS-1b : Refusal at 4 feet.
12. Cobbles and boulders observed in cuttings

PROJECT NO. 3325-01-01

LOG OF BORING PS-5

O'Reilly, Talbot & Okun
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LOG OF BORING PS-6

PROJECT	New Public Safety Building			CONTRACTOR	Seaboard Environmental Drilling				
JOB NUMBER	3325-01-01	FINAL DEPTH (ft)	6.0	DRILLING EQUIPMENT	B-53 Truck Mounted Rig				
LOCATION	Princeton, MA	SURFACE ELEV (ft)	1094.0	FOREMAN	Dale G.	CASING			
START DATE	2/10/2021	DISTURBED SAMPLES	3	HELPER	Mike K.	CASE DIAMETER	N/A		
FINISH DATE	2/10/2021	UNDISTURBED SAMPLES	0	BIT TYPE	Hollow Stem Auger	HAMMER WGT	N/A		
ENGINEER/SCIENTIST	Shannon Raymond	WATER LEVEL		ROD TYPE	A (1 5/8" O.D.)	HAMMER DROP	N/A		
BORING LOCATION	North of proposed building, within proposed stormwater management area	FIRST (ft)	5.0	SAMPLER	2" O.D. Split Spoon	ROCK CORING INFORMATION			
		LAST (ft)	N/A	HAMMER TYPE	Automatic	TYPE	N/A		
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"	SIZE	N/A		

DEPTH (ft)/ SAMPLES	SAMPLES: PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
0'-2'	9/9/96	15/24	S-1 (0'-2')	0.1	Top 5" : Medium dense, brown, fine to medium SAND, some silt, little organics (roots), moist (FROZEN TOPSOIL) Bottom 10" : Medium dense, red brown, fine to medium SAND, little to some silt, little coarse sand, little fine gravel, damp	TOPSOIL FINE TO MEDIUM SAND	1.
2'-4'	8/6/11/14	17/24	S-2 (2'-4')	0.1	Top 7" : Medium dense, red brown, fine SAND, little to some silt, little fine gravel, little medium sand, damp Bottom 10" : Medium dense, light brown with rust staining, fine to medium SAND, some coarse sand, little silt, trace fine gravel, dry		2.
5'						▽ 1089.0	
5'-5.9'	55/50 for 5"	11/11	S-3 (5'-5.9')	0.0	Top 5" : Very dense, grey-brown, fine to medium SAND, some silt, little gravel, little coarse sand, wet Bottom 6" : Very dense, white-grey, fine SAND and GRAVEL, little silt, dry (fractured rock)	FINE SAND AND GRAVEL	3.
					Refusal at 6', upon likely boulder		
10'							
15'							
20'							
25'							

Remarks:
1. Soil screened in field using MiniRAE Lite photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.
2. Difficulty drilling between 2 and 5 feet below ground surface.
3. Very difficult drilling conditions between 5 and 6 feet.
4. Cobbles and boulder fragments observed in boring cuttings.
5. Infiltration test performed adjacent to boring

PROJECT NO. 3325-01-01

LOG OF BORING PS-6

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

LOG OF BORING PS-7

PROJECT	New Public Safety Building			CONTRACTOR	Seaboard Environmental Drilling					
JOB NUMBER	3325-01-01	FINAL DEPTH (ft)	4.0	DRILLING EQUIPMENT	B-53 Truck Mounted Rig					
LOCATION	Princeton, MA	SURFACE ELEV (ft)	1094.0	FOREMAN	Dale G.	CASING	
START DATE	2/10/2021	DISTURBED SAMPLES	2	HELPER	Mike K.	CASE DIAMETER	N/A
FINISH DATE	2/11/2021	UNDISTURBED SAMPLES	0	BIT TYPE	Hollow Stem Auger	HAMMER WGT	N/A
ENGINEER/SCIENTIST	Shannon Raymond	WATER LEVEL		ROD TYPE	A (1 5/8" O.D.)	HAMMER DROP	N/A
BORING LOCATION	Northeast area of proposed building	FIRST (ft)	N/E	SAMPLER	2" O.D. Split Spoon	ROCK CORING INFORMATION	
		LAST (ft)	N/A	HAMMER TYPE	Automatic	TYPE	N/A
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"	SIZE	N/A

DEPTH (ft)/ SAMPLES	SAMPLES: PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
X	9/6/50 for 1"	13/13	S-1 (0'-1.1')	0.0	Top 9" : Very dense, brown, fine to medium SAND, some silt, little coarse sand, little organics (roots), dry (FROZEN TOPSOIL)	TOPSOIL	1.
					Middle 3" : Very dense, brown, fine to medium SAND, some silt, little coarse sand, trace fine gravel, dry	FINE TO MEDIUM SAND	2.
					Bottom 1" : Very dense, grey-white, fine SAND and GRAVEL, dry (fractured rock)	FINE SAND AND GRAVEL	3. , 4.
					Refusal at 1.5', upon likely boulder		
					Offset PS-7a:		
5'	--	--	(0'-4')	--	From auger cuttings: Brown, fine to medium SAND, little silt, little gravel, trace coarse sand, trace debris (brick), dry (FILL)		
	50 for 3"	3/3	(4'-4.2')	0.2	Very dense, white-grey, fine SAND and GRAVEL, little medium sand, little silt, dry (fractured rock)		
					Refusal at 4.2', upon likely boulder		
10'							
15'							
20'							
25'							

Remarks:

1. Soil screened in field using MiniRAE Lite photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.
2. Very difficult drilling conditions between 1 and 1.5 feet below ground surface.
3. Refusal at 1.5 feet, offset PS-7 7 feet north, 3 feet west.
4. Very difficult drilling conditions between 1.5 and 4 feet.
5. PS-5a : Refusal at 4.2 feet.
6. Cobbles and boulders observed in cuttings.

PROJECT NO. 3325-01-01

LOG OF BORING PS-7

O'Reilly, Talbot & Okun
ENGINEERING ASSOCIATES

LOG OF BORING PS-8

PROJECT	New Public Safety Building			CONTRACTOR	Seaboard Environmental Drilling		
JOB NUMBER	3325-01-01	FINAL DEPTH (ft)	8.1	DRILLING EQUIPMENT	B-53 Truck Mounted Rig		
LOCATION	Princeton, MA	SURFACE ELEV (ft)	1098.0	FOREMAN	Dale G.	CASING	
START DATE	2/10/2021	DISTURBED SAMPLES	9	HELPER	Mike K.	CASE DIAMETER	N/A
FINISH DATE	2/11/2021	UNDISTURBED SAMPLES	0	BIT TYPE	Hollow Stem Auger	HAMMER WGT	N/A
ENGINEER/SCIENTIST	Shannon Raymond	WATER LEVEL		ROD TYPE	A (1 5/8" O.D.)	HAMMER DROP	N/A
BORING LOCATION	North side of existing building	FIRST (ft)	N/E	SAMPLER	2" O.D. Split Spoon	ROCK CORING INFORMATION	
		LAST (ft)	N/A	HAMMER TYPE	Automatic	TYPE	N/A
		TIME (hr)	N/A	HAMMER WGT/DROP	140 lb / 30"	SIZE	N/A

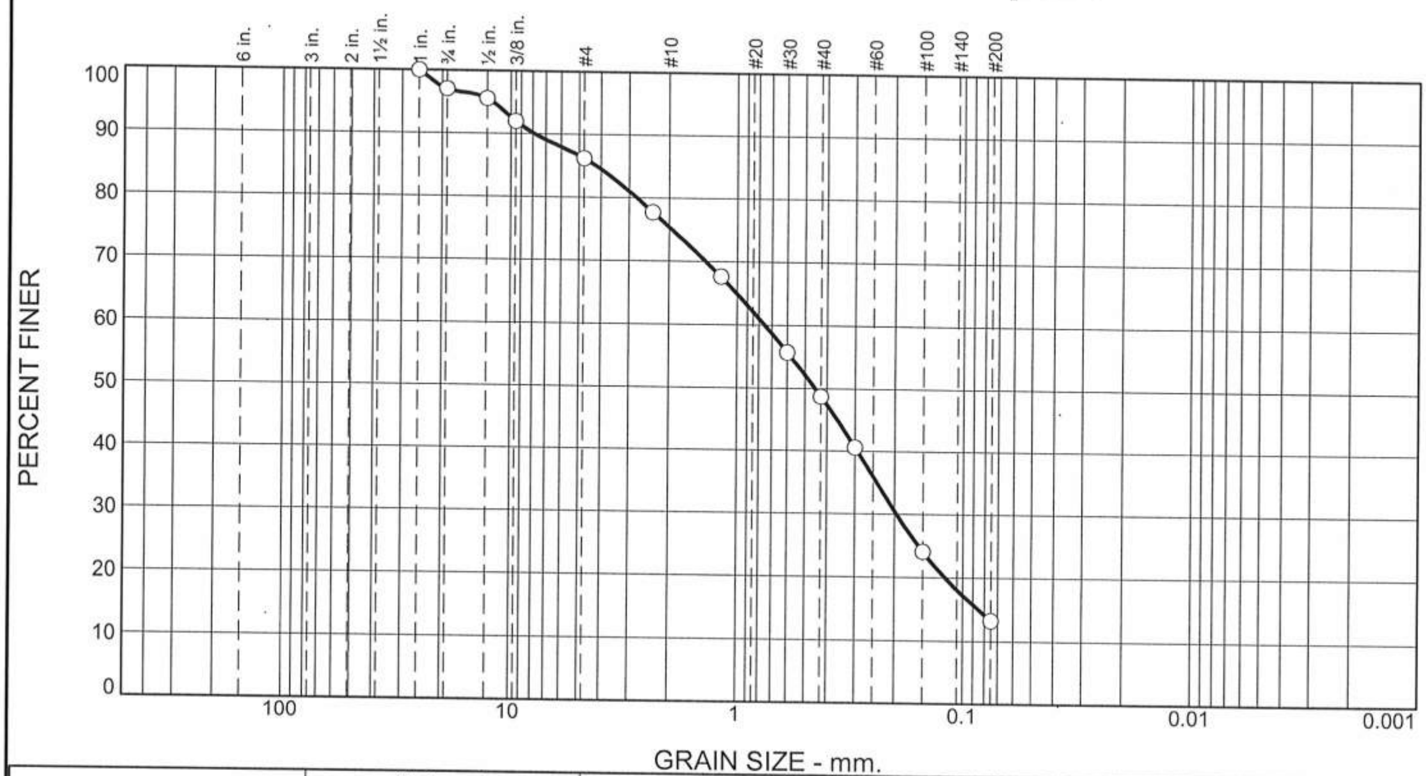
DEPTH (ft)/ SAMPLES	SAMPLES: PENETR. RESIST. (bl / 6 in)	REC. (in)	TYPE/ NO.	FIELD TEST DATA	SAMPLE DESCRIPTION (MODIFIED BURMISTER)	PROFILE DEPTH (ft) ELEV.	REMARKS/ WELL CONSTRUCTION
					Top 2.5" : Asphalt	ASPHALT	1.
					Bottom 4" : Grey, medium to coarse SAND, some fine gravel, little fine sand, trace silt, dry	FINE TO MEDIUM SAND	2.
	50 for 5"	5/5	S-1 (0.5'-0.8')	0.3	Top 3" : Very dense, brown, fine to medium SAND, some silt, little gravel, little coarse sand, dry		3.
					Bottom 2" : Very dense, white-grey, fine SAND and GRAVEL, dry (fractured rock)	FINE SAND AND GRAVEL	
					Refusal at 0.8', upon likely boulder		
					Offset PS-8a:		
5'	50 for 5"	4/6	(0.5'-0.9')	0.4	Top 2" : Very dense, brown, fine to medium SAND, some silt, little gravel, little coarse sand, dry Bottom 2" : Very dense, white-grey, fine SAND and GRAVEL, dry (fractured rock) Refusal at 0.9', upon likely boulder		
					Offset PS-8b:		
	27/25/5/4	24/24	(0.5'-2.5')	0.3	Dense, light brown, fine to medium SAND, some gravel, little silt, little coarse sand, dry		
	5/7/20/16	8/24	(2.5'-4.5')	0.2	Medium dense, red-brown, fine to medium SAND, some silt, some to little fine gravel, little to trace coarse sand, dry		
10'	50 for 3"	1/3	(4.5'-4.7')	0.2	Very dense, white-grey, fine SAND and GRAVEL, dry (fractured rock) Refusal at 4.7', upon likely boulder		
					Offset PS-8c:		
	10/17/23/22	18/24	(5'-7')	0.2	Dense, light brown with rust staining, fine to medium SAND, little to some silt, little gravel, little to trace coarse sand, dry		
	50 for 1"	0/1	(8'-8.1')	--	No Recovery Refusal at 8.1', upon likely boulder		
15'					Offset PS-8d:		
	27/7/6/8	14/24	(0.5'-2.5')	0.3	Medium dense, dark brown, fine to medium SAND, some silt, little fine gravel, little to trace coarse sand, trace debris (asphalt), dry (FILL)		
	7/4/10/11	12/24	(2.5'-4.5')	0.1	Top 4" : Medium dense, dark red brown, fine SAND, some silt, little medium sand, trace coarse sand, dry Bottom 8" : Medium dense, brown with rust staining, fine to medium SAND, little to some silt, little coarse sand, little fine gravel, dry		
20'	9/27/45/ 50 for 1"	19/19	(5'-6.6')	0.1	Top 8" : Very dense, brown with rust staining, fine to medium SAND, little to some silt, little coarse sand, little fine gravel, dry Middle 9" : Very dense, light brown, fine to medium SAND, little to some silt, little gravel, little to trace coarse sand, dry Bottom 2" : Very dense, white-grey, fine SAND and GRAVEL, little silt, dry (fractured rock) Refusal at 6.6', upon likely boulder		
25'							

Remarks:
1. Soil screened in field using MiniRAE Lite photoionization detector (PID) referenced to benzene in air. Readings in parts per million by volume.
2. Very difficult drilling conditions between the ground surface to 0.8 feet.
3. Refusal at 0.8 feet, offset PS-8 15 feet west.
4. PS-8a : Very difficult drilling conditions between the ground surface to 0.9 feet.
5. Refusal at 0.9 feet, offset PS-8a 25 feet east, 2 feet north.
6. PS-8b : Very difficult drilling conditions between 0.5 and 4.5 feet.
7. Refusal at 4.7 feet, offset PS-8b 24 feet east, 1 feet south.
8. PS-8c : Very difficult drilling conditions between 0.5 and 4.5 feet, 6.5 and 8 feet.
9. Refusal at 8.1 feet, offset PS-8c 48 feet south, 13 feet east.
10. PS-8d : Very difficult drilling conditions between the ground surface and 2 feet, 4.5 and 6.5 feet.
11. Refusal at 6.6 feet.
12. Cobbles and boulders observed in cuttings.

PROJECT NO. 3325-01-01

LOG OF BORING PS-8

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	3.0	10.8	10.8	26.7	35.5	13.2	

Test Results (ASTM C 136 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	97.0		
1/2	95.5		
3/8	92.0		
#4	86.2		
#8	77.7		
#16	67.6		
#30	55.7		
#40	48.7		
#50	40.6		
#100	24.1		
#200	13.2		

* (no specification provided)

Material Description

PS-1 (0.5'-2')

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 7.8984 D_{85}= 4.1968 D_{60}= 0.7549
D_{50}= 0.4507 D_{30}= 0.1960 D_{15}= 0.0855
D_{10}= C_u= C_c=

Remarks

This sample was washed.

Date Received: 2/12/2021 **Date Tested:** 2/15/2021

Tested By:

Checked By: John McGreevy

Title: Dir. of Testing Services

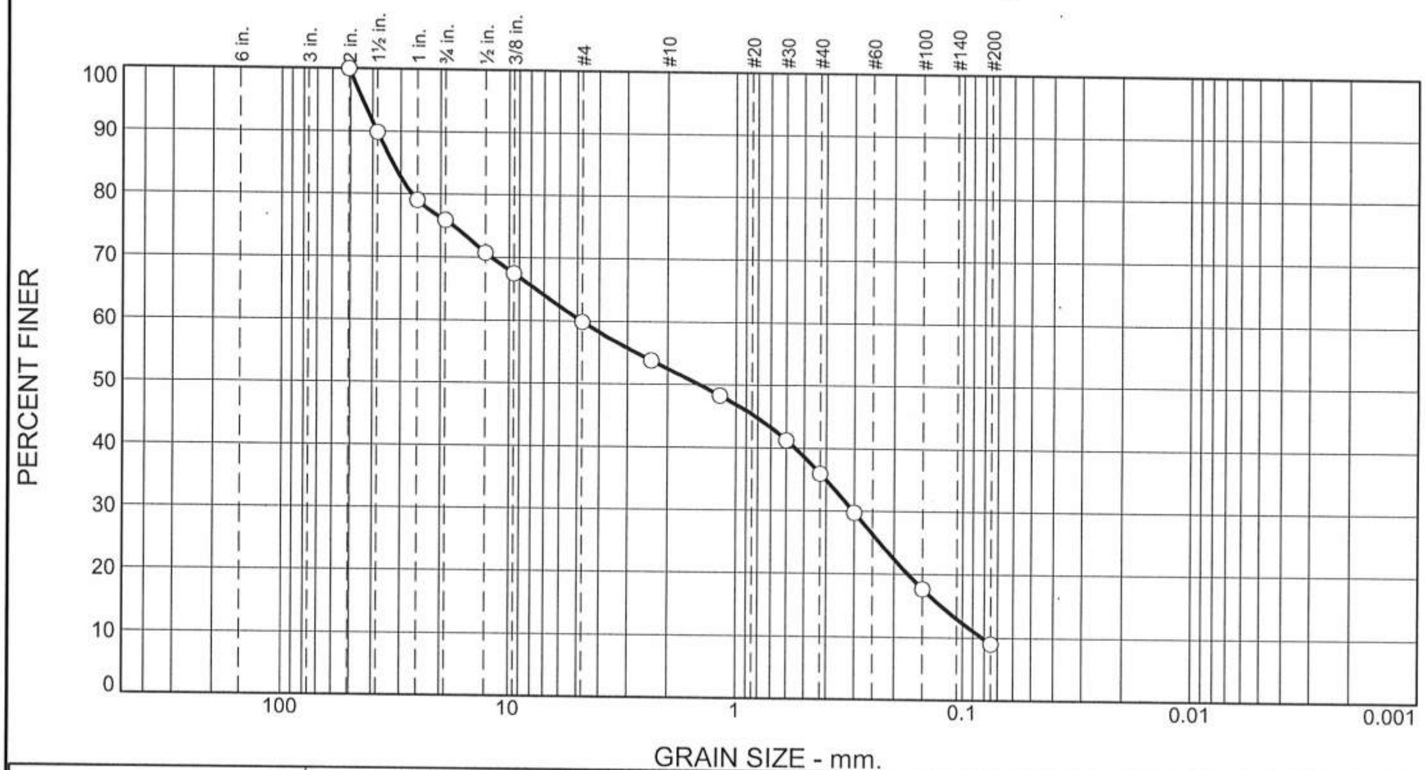
Sample Number: 3016

Date Sampled:

ALLIED TESTING LABORATORIES, INC.
Springfield, Massachusetts

Client: OTO
Project: Princeton Public Safety Complex
Project No: 3325-01-01 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	24.1	16.0	7.4	16.6	26.9	9.0	

Test Results (ASTM C 136 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	89.9		
1	79.0		
3/4	75.9		
1/2	70.7		
3/8	67.5		
#4	59.9		
#8	53.8		
#16	48.3		
#30	41.3		
#40	35.9		
#50	29.8		
#100	17.7		
#200	9.0		

* (no specification provided)

Material Description

PS-4 (0'-5')

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 38.2538 D_{85}= 32.7188 D_{60}= 4.8095
D_{50}= 1.4558 D_{30}= 0.3036 D_{15}= 0.1243
D_{10}= 0.0821 C_u= 58.59 C_c= 0.23

Remarks

This sample was washed.

Date Received: 2/12/2021 **Date Tested:** 2/15/2021

Tested By:

Checked By: John McGreevy

Title: Dir. of Testing Services

Sample Number: 3017

Date Sampled:

ALLIED TESTING LABORATORIES, INC.
Springfield, Massachusetts

Client: OTO
Project: Princeton Public Safety Complex
Project No: 3325-01-01 **Figure**