15 April 2020

Mr. Israel Lopez
Managing Director of Development
The Gutierrez Company
200 Summit Drive
Burlington, MA 01803

Re: Geotechnical Engineering Letter Report
Copley Parcel H
Northborough, Massachusetts
Langan Project No.: 151011301

Dear Israel:

This letter report presents our geotechnical engineering study for the proposed development known as the Copley Parcel H project in Northborough, Massachusetts. The purposes of this study were to explore subsurface conditions, evaluate feasible foundation options, and develop geotechnical engineering recommendations. Services were performed in accordance with our authorized proposal (13 January 2020, revised 21 January 2020).

Our approach and recommendations were developed considering the plans submitted for Site Plan Approval (24 February 2020) prepared by Allen & Major Associates, Inc. (A&M), and subsequent correspondence with A&M, and The Gutierrez Company. Any changes to the design scheme must be reviewed by Langan for effects on our recommendations.

Elevations are referenced from a plan titled "Existing Conditions" (24 December 2020) prepared by A&M referencing the North American Vertical Datum of 1988 (NAVD88).

SITE DESCRIPTION

The about 66-acre site is located on the north side of Bartlett Street and consists of two parcels identified as 0 and 301 Bartlett Street, which are identified on the Town of Northborough Assessors Tax Maps as Map 51 Lot 3 (59 acres) and Map 66 Lot 16 (7.08 acres), respectively. The wooded site is currently undeveloped and bound by Bartlett Street to the south, a residential area to the west, and industrial lots to the east. The Stirrup Brook runs along the northerly edge of the site, beyond which is wooded land owned by the Northborough-Southborough Regional School District. Figure 1 shows the site location and surrounding properties.

The two parcels are bisected by the Wachusett Aqueduct, which is a secondary aqueduct managed by the Massachusetts Water Resources Authority (MWRA). The aqueduct is subsurface and within a recessed cut about 60-feet wide. The main development parcel (Map 51 Lot 3) lies north of aqueduct. The secondary development parcel (Map 66, Lot 16) lies south

of the aqueduct and will support access to Bartlett Street for the project. Currently, access across the recessed cut over the subsurface aqueduct is accommodated by an existing earthen berm about 8 feet high and about 70-feet wide. The existing easement right-of-way is about 50-feet wide and is shown on Figure 2.

The site topography for the main development parcel varies, but generally slopes down from the southwest to the north, west, and east. The on-site topography varies from a maximum of about elevation (el.) +290 along the southwestern property line with the aqueduct to about el. +241 at the northern portion of the site. There is an approximately 3 horizontal to 1 vertical (3H:1V) slope leading down from the center of the site to the edges of the bordering vegetated wetland area, with some portions of the slopes steeper than 3H:1V. The site topography for secondary development parcel varies, but generally slopes down from Bartlett Street to the aqueduct and wetlands to the north. The elevations vary from a maximum of about el. +290 to a minimum of about el. +285.

Various dirt paths are present at the site and the wooded areas include mature trees and low vegetation. We observed one concrete foundation located about 130 feet north of the existing easement right-of-way and two additional concrete foundations located along the property line adjacent to the aqueduct.

Existing utilities include water, gas, telecommunication, and sanitary within Bartlett Street and overhead electric runs along Bartlett Street and within the existing aqueduct alignment.

PROPOSED DEVELOPMENT

The proposed development consists of the construction of a 150,900-square foot (sf) warehouse facility. The building is anticipated to be 1-story, no basement, with a finished floor elevation (FFE) of about el. +275. Cuts and fills of about 11 to 15 feet, respectively, are anticipated to achieve the proposed FFE.

Stormwater management areas are proposed to the northwest and east of the proposed building. The proposed bottom elevation of the northwest stormwater area is about el. +268 and will require cuts and fills of about 6 to 9 feet, respectively. The proposed bottom of the eastern stormwater area is about el. +253 and will require cuts and fills of about 5 to 7 feet, respectively.

Proposed paved areas include truck access roads from Bartlett Street to the loading dock areas on the southern side of the warehouse, parking areas to the west of the proposed building and a gravel maintenance path to the east and north of the proposed building.

Proposed utilities include storm drains, municipal water, underground electric, telecommunications, sewer and natural gas connecting to the existing lines on Bartlett Street.

Underground utilities will pass through the existing soil berm right-of-way easement. The proposed storm drains will flow into the two stormwater management areas on-site.

Structural loads were not available, but based on our experience on similar developments, we anticipate typical column loads will range from about 200 to 300 kips. Langan should review the structural information when available to confirm our recommendations herein.

REVIEW OF AVAILABLE INFORMATION

Regional Geology

The 2018 "Surficial Materials Map of the Marlborough Quadrangle" (Figure 2) indicates the overburden consists of gravel and sand deposits to the west and glacial till or bedrock to the east. The 1983 "Bedrock Geologic Map of Massachusetts" (Figure 3) indicates the bedrock below the site is a Marlborough formation consisting of schist and gneiss. Both maps were prepared by prepared by the U.S. Geological Survey.

Federal Emergency Management Agency Flood Map

We reviewed the Flood Insurance Rate Map (FIRM) for the Town of Northborough published by the Federal Emergency Management Agency (FEMA), Map No. 25027C0653F effective 16 July 2014 (Figure 4). The majority of the site is in Zone X, "area of minimal flood hazard" which are areas determined to be out of the 500-year flood zones. The most northern portion of the site is located in Zone A, "area subject to the 1-percent-annual-chance flood"; however, there are no Base Flood Elevations (BFE) associated with a Zone A Flood Zone. No portion of the site development is proposed within the Zone A area.

Wachusett Aqueduct

The proposed point of crossing for the Wachusett Aqueduct is within an existing right-of-way, across an existing earthen berm about 8 feet high and about 70-feet wide. Historical documentation indicates that the subsurface portion of the Wachusett Aqueduct is masonry construction consisting of a horseshoe-shaped concrete lined sections with three to six rings of brick.

A ground penetrating radar (GPR) survey conducted by Hager Richter Geoscience, Inc. (HRGS) was performed on 21 February 2020 across the earthen berm and within the recessed cut area. Based on the survey, the aqueduct was estimated to be about 8 feet wide and the estimated depths to the top of the structure are provided in the summary table below.

Table 1. Summary of Wachusett Aqueduct GPR Survey

Approximate Location	Estimated Depth to Top of Aqueduct (feet)
West of existing earthen berm	
About 50 feet west of berm	5.5 +/- 1
About 5 feet west of berm	6 +/- 1
Top of existing earthen berm	
West side of berm	13.5 +/- 1
East side of berm	14.5 +/- 1
East of existing earthen berm	
About 5 feet east of berm	5 +/- 1
About 50 feet east of berm	5.5 +/- 1

SUBSURFACE EXPLORATION

Langan performed a subsurface exploration program consisting of 9 borings and 3 test pits within and adjacent to the proposed building footprint. An additional 7 test pits were performed within stormwater areas under the direction of A&M. Following the exploration programs, a geophysical survey was conducted within the building limits. A boring and test pit location plan is shown in Figure 5.

Borings

Nine borings (LB-01 through LB-09) were drilled by Northern Drill Services, Inc. between 27 and 28 February 2020, under full-time Langan observation. The borings were advanced with a Mobile Drill B-48 ATV Rig using hollow-stem-auger drilling techniques. Borings were advanced between about 10 feet and 27 feet below the existing grades (about el. +257 to about el. +243).

Standard Penetration Test (SPT) N-values[1] were documented and soil samples were generally obtained continuously to a depth of about 12 feet and every 5 feet thereafter. Disturbed soil samples were obtained using a standard 2-inch-outer-diameter split-spoon sampler driven by a 140-pound safety hammer in accordance with ASTM D1586, Standard Penetration Test.

[1] The Standard Penetration Test (SPT) is an in situ testing technique used to infer soil density and consistency. The SPT N-value is defined as the number of blows required to drive a 2-inch-diameter split-barrel sampler 12 inches after an initial penetration of 6-inches using a 140-pound hammer falling freely from 30 inches.

Recovered soil samples were visually examined and classified in the field in general accordance with the Unified Soil Classification System (USCS). Soil classifications, N-values, and other field observations were recorded on our field logs provided in Appendix A.

Test Pits

Three test pits (TP-001 through TP-003) were performed by Boggaard Construction Corp. on 25 February 2020, under full-time Langan observation. Langan also observed 7 test pits performed under the direction of A&M (TP-101 through TP-107). Soil classifications and other field observations were recorded on our field logs provided in Appendix B. The test pits were performed with a Hitachi 450 Excavator to about 9 to 12 feet below existing grades (about el. +244 to el. +276). Photographs of the test pits are provided in Appendix C.

Groundwater Observation Well

Groundwater observation wells were installed at boring locations LB-05(OW) and LB-08(OW). The bottom of the wells extend about 25 feet below existing grades (about el. +246/LB-08(OW) to el. +259/LB-05(OW)). Monitoring well construction logs are provided in Appendix D.

Geophysical Survey

Langan conducted a geophysical survey at the project site on 10 April 2020. The geophysical survey consisted of Refraction Microtremor (ReMi) seismic testing that uses ambient noise and surface induced waves to generate a vertical shear wave velocity profile for the subsurface soils. The ReMi equipment used for the data collection included: (1) a SeisDaq ReMi recording unit, (2) a 300-foot length with twelve 10-Hz vertical geophone array, and (3) a laptop with the "VScope" software used for storing the raw data.

A geophone array about 300 feet long was located along the building alignment with a northeast-southwest orientation. The geophone array consisted of low frequency (10-Hz) geophones installed 25 feet apart and connected to the ReMi recording unit and laptop using the geophone cable. We collected eight unfiltered 30-second-long records as detailed below for each array setup:

- Four records were collected using ambient vibrations;
- Two records were collected using vibrations induced by a hammer striking a steel plate about 15 feet apart from geophone number 1; and,
- Two records were collected using vibrations induced by a hammer striking a steel plate about 15 feet apart from geophone number 12.

A total of eight geophone arrays were set up for the project site and eight unfiltered 30-second-long records were collected for each array. Generally for each array, the overall line was shifted by 50 feet to the northeast (i.e., the first geophone is relocated to the third geophone position etc.) following the building alignment. Our sub-consultant Subterraseis processed the data sets. ReMi results are summarized in the "Seismic Design" Section of this report.

Lab Testing

Selected samples were sent to a testing laboratory to confirm visual classifications and to determine index properties (physical and mechanical). Four grain-size analyses, four moisture-content determinations, and two grain size passing #200 sieve were performed; the results are provided in Appendix E.

SUBSURFACE CONDITIONS

The subsurface conditions generally consist of a surficial layer of topsoil and subsoil underlain by layers of sand and glacial till. A discontinuous layer of fill was encountered in the vicinity of an existing concrete foundation. Groundwater was first encountered from about 8 to 15 feet below existing grade (about el. +274 to el. +255). A detailed description of subsurface materials encountered is provided below in order of increasing depth.

Surficial Materials – A surficial layer of topsoil and subsoil was encountered in all borings, except LB-05(OW) and LB-07, and in all test pits. The surficial layer was observed to be about 6 to 12 inches thick. The topsoil generally consists of dark brown fine to medium sand with varying proportions of fine gravel, organics, and silt. The subsoil generally consists of fine to medium sand with varying amounts of gravel and silt with roots.

Fill – An about 18 foot thick layer of fill extending to about el. +266 was encountered at boring location LB-05 adjacent to the existing concrete foundation. The fill is generally composed of orange to grayish brown sand with varying amounts of silt and coal ash. SPT N-values within the fill layer vary from about 4 blows per foot (bpf) to 10 bpf. Laboratory testing of samples reported a fines content of about 43%. The measured moisture content was about 20%. The fill layer is generally classified as SM (silty sand) in accordance with the Unified Soil Classification System (USCS).

Sand and Silt – Below the surficial layer an about 1 to 16 foot thick layer of sand and silt was encountered in borings LB-02 through LB-04, and LB-06 through LB-09, TP-001 through TP-002, TP-101 through TP-103 and TP-105 through TP-107. The material is generally composed of grayish to orangish brown fine to coarse sand with varying amounts of fine gravel and having silt lenses throughout. SPT N-values within the sand and silt layer vary from about 3 to 19 bpf. Laboratory testing of samples within the sand and silt layer reported a fines content between

about 4 and 79%. The measured moisture content was between about 4 and 15%. The sand layer is generally classified as SP (poorly graded sand) and the silt is generally classified as ML (silt/very-fine sand) in accordance with the USCS.

Glacial Till – Below the fill and sand glacial till was encountered in all borings and all test pits; explorations were terminated within the soil stratum. The glacial till is generally composed of gray to grayish brown fine sand with varying amounts of silt and fine gravel. SPT N-values within the glacial till layer vary from about 3 bpf to18 bpf. Auger refusal was encountered about 10 feet below existing site grades at LB-01 (about el. +257) on assumed cobbles; coring was not performed as part of the exploration program. Laboratory testing of samples within the glacial till layer reported a fines content between about 25% and 89%. The measured moisture content was about 25%. The glacial till layer is generally classified as ML (silt) in accordance with the USCS.

Groundwater – Groundwater was first encountered in the borings from about 8 to 15 feet below existing grade (about el. +274 to el. +255). Groundwater measurements from installed observation wells ranged from about 13 to 17 feet below grade (about el. +271 to el. +253). Groundwater elevations within the proposed building footprint range from about el. +255 to el. +267, or about 8 to 20 feet below proposed FFE. Groundwater, if encountered, should be expected to fluctuate with seasons, precipitation, construction activities, etc.

GEOTECHNICAL DESIGN RECOMMENDATIONS

Our geotechnical evaluation and recommendations for seismic design, foundations, floor-slabs, retaining walls, pavement design, slope design, and aqueduct crossing design are provided below.

The following key geotechnical issues have been identified:

- Building foundations: the proposed building can be supported by conventional, shallow spread footings with the ground floor constructed as a slab-on-grade.
- Aqueduct crossing: prior to earthwork on the larger development parcel, an over-excavation of the existing earthen berm and replacement with lightweight fill is a recommended approach to minimize the impact of new traffic loading. Requirements will be subject to review and approval from MWRA.
- Organic topsoil and subsoil containing roots: surface soils containing organic material such as topsoil and subsoil containing roots should be considered unsuitable. This report provides the contractor the option to screen and reuse the subsoil as described in the Site Preparation section of this report.

Seismic Design

This section presents seismic design recommendations per the 9th Edition of the Massachusetts State Building Code (MSBC), CMR 780, which incorporates the International Building Code (IBC) 2015 by reference with state specific amendments. We have considered the soil conditions encountered in the borings to be consistent and representative of the soil conditions in the top 100 feet of soil at this site. The soil conditions found in the borings and a subsequent geophysical survey were used to determine site class and recommendations.

The average shear wave velocity ($\overline{V_s}$) for each individual array (8 in total) within the upper 100 feet was determined in accordance with the MSBC. The individual arrays were estimated to range from about 1,084 to 1,141 feet per second (ft/sec), with an average of about 1,115 ft/sec. The Vs profile for each array is provided in Figure "A" below.

Figure A. Interpreted Shear Wave Velocities

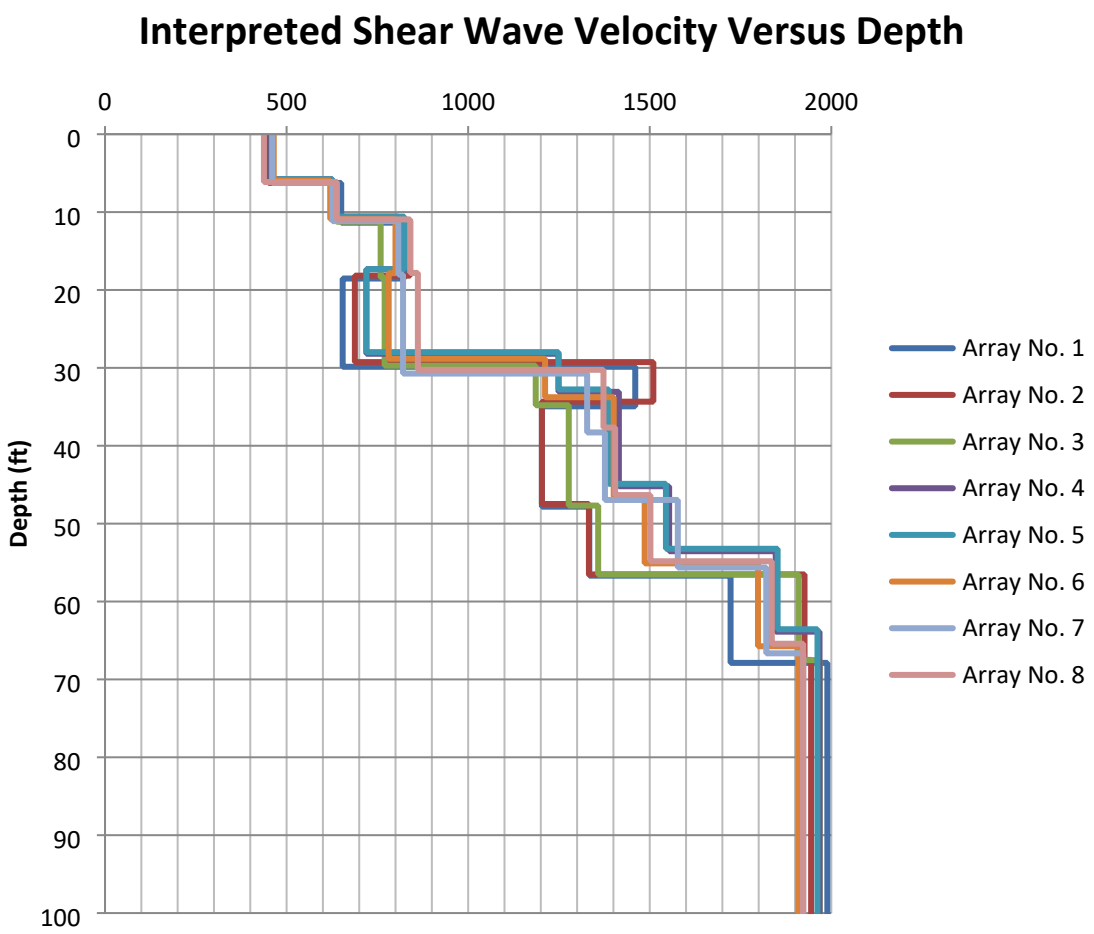


Table 2. Seismic Design Values

Description	Parameter	Recommended Value
Mapped Spectral Acceleration for short periods:	S_s	0.188 g
Mapped Spectral Acceleration for 1-sec period:	S_1	0.067 g
Site Class:	--	**D – Stiff Soil Profile**
Site Coefficient:	F_a	1.6
Site Coefficient:	F_v	2.4
5% damped design spectral response acceleration at short periods:	**S_{DS}**	**0.201 g**
5% damped design spectral response acceleration at 1-sec period:	**S_{D1}**	**0.107 g**
Anticipated Risk Category	--	**II**
Seismic Design Category	**--**	**B**
Seismically Induced Lateral Earth Pressures H is the height of the wall measured as the difference in elevation of finished ground surface or floor in front of and behind the wall. The earthquake force from the backfill shall be distributed as an inverted triangle over the height of the wall. For wall strength design, a load factor of 1.43 shall be applied to the earthquake force in accordance with Section 1610.2 of the building code.	**E_q**	**7.5H**

Based on the above spectral accelerations and the anticipated risk category we have estimated the Seismic Design Category (SDC). The structural engineer is responsible for confirming the appropriate use group, occupancy category, and final SDC for the proposed structure.

It is our opinion that the soils at the site are not susceptible to liquefaction as defined in Section 1806.4 of the MSBC.

Foundations

The materials encountered at the anticipated footing elevation (about el. +271) consist of topsoil, fill, sand and silt or glacial till. The existing fill and topsoil are not suitable for foundation support. The proposed structure can be supported on shallow foundations bearing on compacted structural fill or natural inorganic granular soils (sand or glacial till) using an allowable bearing pressure of 3,000 pounds per square foot (psf). Footing subgrades should be prepared in accordance with the Subgrade Preparation section of this report.

All exterior footings should be constructed 48 inches or deeper below the lowest adjacent grade for frost protection. Interior footings in heated spaces may be constructed at a convenient depth below the slab; however, all bottoms of footings should be at least 1.5 feet below the finished-floor elevation. Isolated column footings should have a minimum dimension of 3 feet and strip

footings should have a minimum width of 2 feet even if smaller dimensions can be justified using the recommended allowable bearing pressure.

Foundations should not be located so that one foundation is within the zone of influence of an adjacent foundation. The zone of influence is taken as a 1H:1V projection extending outward and downward from the edge of the foundation.

Settlement

Total settlement of the structure is estimated to be on the order of 1 inch or less, provided the bearing pressure recommended here is used and the subgrade preparation work described here is performed. Differential settlements of adjacent new structure columns are expected to be about ½ inch. The majority of the settlement is expected to take place during construction.

Floor Slabs

We recommend that ground-floor slabs be constructed as a slab-on-grade bearing on natural granular soils, structural fill, or compacted existing fill prepared in accordance with the recommendations herein. The slab-on-grade should be designed for a modulus of subgrade reaction of 125 pounds per cubic inch.

We recommend a minimum 6-inch-thick layer of ¾-inch clean crushed stone be included beneath the slabs to protect the prepared subgrade and to serve as a capillary break. A vapor barrier should be used below the ground-floor slab to limit transmission of water vapor through the slab. We recommend a robust membrane such as the Florprufe product by WR Grace. Omission of a vapor barrier can lead to floor-covering problems including delamination and mold.

Permanent Groundwater Control

Perimeter wall and footing drains should be installed to divert groundwater flow away from the structure during prolonged precipitation, snowmelt, or utility breaks. Manufactured geocomposite drainage panels or a 12-inch-wide layer of ¾-inch clean crushed stone should be installed against the outside of all perimeter walls and should extend to within 1 foot of adjacent surface grade. The drainage panels (or crushed stone) should connect to a perforated footing drain pipe, having a minimum diameter of 6 inches, at the base of the footing. The footing drains should be connected to the site stormwater system and where possible drain by gravity. Where used, drainage panels should be secured in place and the filter-fabric side must face the soil. If clean crushed stone is used, it should be wrapped with a geotextile filter fabric.

Site Retaining Walls

We understand that site retaining walls may be necessary to achieve proposed site grades. Site fill-retaining walls may be designed as segmental retaining walls (SRW) consisting of geogrid reinforced modular block walls (such as Mesa, Keystone, Versa-lok, or Redi-Rock type walls) or gravity-type retaining walls in cut areas, depending on the location and size of the proposed wall. Segmental walls are not designed to withstand hydrostatic pressure (water buildup) behind the wall and surface water runoff should be diverted away from the retaining wall area. Foundation drains should be installed in accordance with the manufacturer's recommendations. Maintaining adequate drainage behind retaining walls is critical to their long-term performance. We recommend the following design criteria for a SRW system presented in Table 3.

Table 3. Recommended Segmental Retaining Wall Design Criteria

Material	Unit Weight (pcf)	Internal Friction Angle (degrees)	Cohesion (psf)
Reinforced Fill (structural fill)	130	32	0
Retained Soil (existing soil)	130	32	0
Foundation Soil (native soil)	130	32	0
Other Design Criteria: Backfill Slope Angle Behind Wall – Varies- See Grading Plans. Traffic Surcharge Design Load Behind Wall – 300 psf (adjacent to access roads only) or a minimum of 200 psf for all walls. Min. Factor of Safety Against Overturning – 2.0 Min. Factor of Safety Against Sliding – 1.5 Min. Factor of Safety Against Geogrid Tensile Overstress – 1.5 Min. Factor of Safety Against Geogrid Pullout from Soil – 1.5 Seismic Design Load – Per IBC 2015 and MSBC9. Preliminary Net Allowable Soil Bearing Pressure – Not to exceed 4,000 psf			

The final retaining wall design, including design parameters, calculations, and construction means and methods must be signed and sealed by a professional engineer licensed in the Commonwealth of Massachusetts.

Pavement Design

We have provided recommendations for minimum asphalt pavement sections using assumed daily traffic loading of: 250 cars, 10 light trucks/busses, and 284 heavy trucks. The pavement sections were designed using a 20-year life expectancy and a California Bearing Ratio (CBR) of 10 for proofrolled site soils or properly placed compacted fill. CBR testing must be performed by the contractor in pavement areas at the start of construction to confirm the design assumptions. Pavement design calculations are provided in Appendix F. Refer to subsequent sections for subgrade preparation procedures.

Table 4: Recommended Standard & Heavy Duty Flexible Pavement Sections

Material	Thickness	
	Standard Duty (Car Parking Areas)	Heavy Duty (Drive Aisles & Truck Areas)
Top (Finish) Course (MassDOT Item M3.11.03):	1.5 inches	2 inches
Asphalt Pavement Binder Course (MassDOT Item M3.11.03):	1.5 inches	2.5 inches
Based Course (Dense Graded Crushed Stone for Subbase, MassDOT Item M2.01.7 or Processed Gravel for Subbase, Item M1.03.1):	10 inches	16 inches
Refer to Standard Specifications for Highways and Bridges, latest edition.		

Slope Design and Construction

We recommend that the inboard slopes for stormwater detention ponds be design with a slope angle of 3H:1V, or flatter. Outboard slopes of detention basins, and cut/fill slopes for site grading should have a slope angle of 2H:1V, or flatter if the slope face is to be reseeded to establish vegetative cover or stabilized with riprap. Cut or fill slopes steeper than 2H:1V should be stabilized with riprap underlain by a non-woven geotextile. Temporary stabilization or other measures may be required during construction until the final condition is completed. Slope angles steeper than 1.5H:1V are not recommended.

In areas where fill slopes, or fill embankments for the stormwater detention pond, are being constructed, the organic topsoil and subsoil containing roots should be removed from the full width of the fill area. The Geotechnical Engineer should be notified after the subgrade has been prepared, so that a field inspection can be made before fill placement.

Vegetative cover should be established on the slope surface as soon as practical after final grading to reduce erosion and the potential for sloughing failures. The thickness of organic topsoil on the surface of vegetated slopes should be 12 inches or less, unless otherwise approved by the geotechnical engineer.

Surface water swales or curbing should be provided at the crest of soil cut and fill slopes to intercept and divert runoff from the slope face. The slope design recommendations above are based on an average angle of internal friction of 32 degrees for on-site fill materials and natural soils in the slope areas.

Aqueduct Crossing Design and Construction

Langan has performed an analysis of the existing conditions in the vicinity of the aqueduct in relation to the proposed development. Our analysis included the review of (1) existing soil loads,

(2) anticipated static and transient temporary construction loads (i.e., heavy equipment and fully loaded concrete trucks), and (3) anticipated static and transient development design loads (i.e., tractor trailer trucks and fire emergency vehicles). Conventional earth pressures were calculated based on a typical soil total unit weight of 120 to 130 pounds per cubic foot (pcf) and groundwater is estimated to be about 15 feet below ground surface based on inferred boring observations.

To create a net reduction in existing loading conditions, subject to review and approval from the MRWA, to reduce the potential traffic loads on the underlying aqueduct structure, we suggest reducing the existing overburden stresses on the aqueduct by a removal and replacement program consisting of lightweight fill. This mitigation approach provides a low-impact and low-cost measure without the need for relying on continued long-term maintenance throughout the life of the development (i.e., pavement maintenance not relied on as part design, sub-surface bridge maintenance, etc.).

Based on our analysis, point (static) loads during construction result in the greatest stress increase of about 20% along the top of the aqueduct alignment. The greatest static load evaluated is a fully loaded concrete truck (56,000 pounds) parked stationary on the top of the aqueduct alignment resulting in a surcharge pressure of about 300 pounds per square foot (psf) at the top of the aqueduct. Our analysis was performed using a computer-based program, Zee-Stress, to compute vertical stress increases with depth due to surface loads. We recommend the over-excavation of soil along the aqueduct alignment and replacement with a lightweight fill to off-set the potential load increase condition by reducing the existing loading condition. Replacing the existing soil with about 4 feet of lightweight fill (such as AeroAggregates UL-FGA G15 Ultra-Lightweight Foam Glass Aggregate) directly below the pavement drive aisle within the existing earthen berm can decrease the existing loads about 30% and will off-set the anticipated 20% traffic load increase from the greatest loading scenario analyzed.

The AeroAggregates lightweight fill product is about 85% lighter than quarried aggregates having an uncompacted dry bulk density of no more than 15 pcf. The product is made in North America from 100% post-consumer recycled materials and typical gradations range from about ½ to 2-inches. The material has a long history of use in projects that require fill to be placed over soft compressible soils or over underground utilities.

As part of the development we recommend completing the over-excavation prior to commencing earthwork on the main development site. Proposed utilities from Bartlett Street for the development will need to be coordinated with the proposed over-excavation. The limits of excavation will extend for the full width of the drive aisle (about 24-feet) and extend laterally beyond the aqueduct by about 1-foot (i.e., total excavation width of about 10 feet). The lightweight fill should be fully wrapped in a non-woven geotextile (such as a Mirafi 140N, Contech C-40NW, or an approved equivalent). About 12-inches of dense graded aggregate should be placed over the fully wrapped lightweight fill and should be maintained throughout construction,

or until a flexible pavement binder course has been placed. A cross-section of the proposed over-excavation is included on Figure 6.

GEOTECHNICAL CONSTRUCTION RECOMMENDATIONS

Site Preparation

Following the aqueduct crossing earthwork activities outlined above, clearing and grubbing of trees and vegetation designated for removal (including root systems) should be performed. Buried debris should be completely removed beneath proposed building slab and footing locations. Topsoil should be stripped from the proposed building and pavement areas, and should be stockpiled and protected from erosion. Topsoil should be evaluated by a landscape architect for reuse in landscape areas (if permitted by the environmental engineer). All clearing and stripping activities should be performed in strict accordance with the approved soil-erosion and sediment-control plan and the environmental reports prepared for the project.

Topsoil and subsoil is considered unsuitable for support of building and paved areas in its present condition because of its organic content. Due to the large volume of excavated subsoil expected to be generated by this project, special consideration needs to be given to methods to process and possibly reuse this material. If the Contractor screens the subsoil to remove tree roots, the screened material is expected to be primarily inorganic silty sand (provided the overlying organic topsoil is carefully removed and not mixed in). If the resulting product after screening is an inorganic silty sand it could be reused as compacted fill more than 3 feet below finished grade in proposed pavement areas. Alternatively, the subsoil containing roots may be hauled off-site and not processed.

All demolition and site-clearing work should be performed in accordance with any environmental requirements established for the site, and all local, state, and federal regulations. All debris and trees and other vegetation should be properly disposed of off site in accordance with applicable regulations. All construction work should be performed so as not to adversely impact the neighboring buildings, off site structures or utilities, including the existing utilities and trees that are to remain. Protection of these elements should be provided as necessary. Before beginning grading or placing fill, any miscellaneous trash, debris, or other unsuitable materials should be removed from the site.

Subgrade Preparation

All footing and utility-trench subgrades should be proofrolled with six overlapping coverages of a double-drum 1-ton walk-behind vibratory roller (such as a Bomag BW75 or equivalent). All slab subgrade areas should be proofrolled before placing any concrete or structural fill with six overlapping coverages of a vibratory drum roller having a minimum static drum weight of 5 tons.

Soft areas identified during proofrolling should be excavated and replaced with approved structural fill as described in the Removal and Replacement section. The actual extent of necessary removal and replacement should be determined by a qualified Langan geotechnical engineer. Care should be taken when proofrolling near any existing underground utilities that are to remain.

Soil footing subgrades should be excavated level and if any cobbles or boulders are encountered at the footing subgrade level such that a relatively level subgrade is not achieved, the cobbles or boulders should be removed and replaced with compacted structural fill, compacted ¾-inch crushed stone, or lean concrete. All soil subgrades for footings or slabs should be compacted to the project specified compaction criteria.

If foundations are not poured in a timely manner, the subgrade should be protected with a lean concrete mud mat to protect the footing subgrades.

Steps should be taken by the contractor to control and remove surface-water runoff and precipitation. When soil is wet and subjected to construction traffic, previously acceptable subgrades can soften and become unacceptable. A smooth drum roller should be used to seal the surface and provide for better drainage. We also recommend crowning or sloping the subgrade to provide positive drainage off the subgrades.

Excavation, Fill, Placement, and Compaction Criteria

Excavation through the fill and the underlying glacial till can likely be performed using conventional earthmoving equipment (e.g., backhoes, excavators, dozers, etc.). Excavations made for footings and utilities should be conducted to minimize disturbance to the subgrade (i.e., backhoe with a smooth-edge bucket).

All excavations should be properly sloped or braced and conform with applicable OSHA regulations including, but not limited to, temporary shoring, trench boxes, temporary rock stabilization, or proper benching or both.

The following types of fill can be used.

> Structural Fill – Structural fill should be well-graded sand and gravel having a maximum particle size of 3 inches and no more than 10% passing the No. 200 sieve. Additionally, the structural fill should be free of organics, clay, roots, concrete, other non-soil constituents, and other deleterious or compressible materials. Any approved imported structural fill should be "certified clean fill" free of hazardous substances and meeting all local, state, and federal regulations.

Material Reuse – The contractor may reuse the on-site fill, natural sand, or glacial till as structural fill provided the soils meet the requirements for structural fill outlined above and is approved by the environmental engineer. Note that samples obtained within the fill, sand, and till layers have a fines content (material passing the No. 200 sieve) between about 4 and 89%; therefore, the soil will be sensitive to moisture. The overall amount of soil that can be reused will be dependent on the amount of fines present within the soil, the time of year the earthwork is carried out (e.g., potentially inclement weather), and the earthwork contractor's ability to stage, aerate and process the material to facilitate placement and compaction.

General Fill – On-site soils not meeting the requirements for structural fill can be used as general fill for site landscape and other nonstructural areas (e.g., landscaped areas) if environmentally suitable for reuse. The fill and silt layers may be used as general fill, if required.

Compaction Criteria – All fill should be placed in uniform 12-inch-thick loose lifts and compacted. Fill in landscaped areas should be compacted to 90% of its maximum dry unit weight as determined by ASTM D1557; all other fill should be compacted to at least 95%. In restricted areas where only hand-operated compactors can be used, the maximum lift thickness should be limited to 8 inches. The appropriate water content at the time of compaction should be plus or minus 2% points of optimum as determined by the laboratory compaction tests of proposed fill. No backfill should be placed on areas where free water is standing or on frozen subsoil areas.

Temporary Groundwater Control

Groundwater was first encountered in the borings from about 8 to 15 feet below existing grade in all borings (about el. +274 to el. +255). Measurements within the proposed building footprint range from about 8 to 20 feet below existing grade (about el. +255 to el. +267).

We anticipate that dewatering will be required during construction for deeper excavations and to manage rainwater runoff. Water infiltration can likely be controlled using gravity-fed sump pumps via gravel trenches or sumps assisted with collector trenches; however, the final dewatering measures required should be evaluated and designed by the contractor. The dewatering measures implemented should adequately dewater all foundation-related excavations such that compaction of footing subgrades is feasible. Water runoff is expected to be controlled with the use of gravel-lined collection trenches, pits and submersible pumps. Care should be taken to ensure that drainage is provided during all phases of excavation work.

Environmental pretreatment of groundwater, if necessary, is beyond the scope of this work. Collected water should be discharged in accordance with applicable regulations.

SERVICES DURING DESIGN, CONSTRUCTION DOCUMENTS AND CONSTRUCTION QUALITY ASSURANCE

During final design, Langan should be retained to consult with the design team as geotechnical questions arise. Technical specifications and design drawings should incorporate our recommendations. When authorized, we will assist the design team in preparing specification sections related to geotechnical issues such as earthwork, shallow foundations, and backfill. Langan should also, when authorized, review the project plans and contractor submittals relating to materials and construction procedures for geotechnical work to confirm the designs incorporate the intent of our recommendations.

Langan has explored and interpreted the site subsurface conditions and developed the foundation design recommendations contained here, and is therefore best suited to perform quality-assurance observation and testing of geotechnical-related work during construction. The work requiring quality-assurance confirmation or special inspections per the Building Code includes, but is not limited to, earthwork, shallow foundations, and backfill.

Recognizing that construction observation is the final stage of geotechnical design, quality-assurance observation during construction by Langan is necessary to confirm the design assumptions and design elements, to maintain our continuity of responsibility on this project, and allow us to make changes to our recommendations, as necessary. The foundation system and general geotechnical construction methods recommended herein are predicated upon Langan's assisting with the final design and providing construction observation services for the owner. If Langan is not retained for these services, we cannot assume the role of geotechnical engineer of record, and the entity providing the final design and construction observation services must serve as the engineer of record.

LIMITATIONS

The conclusions and recommendations provided in this report result from our interpretation of the geotechnical conditions existing at the site inferred from a limited number of borings and test pits. Actual subsurface conditions may vary. Recommendations provided are dependent upon one another and no recommendation should be followed independent of the others.

Any proposed changes in structures or their locations should be brought to Langan's attention as soon as possible so we can determine whether such changes affect our recommendations. Information on subsurface strata and groundwater levels shown on the logs represent conditions encountered only at the locations indicated and at the time of our exploration. If different conditions are encountered during construction, they should immediately be brought to Langan's attention for evaluation because they might affect our recommendations.

This report has been prepared to assist the owner, architect, and structural engineer in the design process and is only applicable to the design of the specific project identified. The information in this report cannot be used or depended on by engineers or contractors involved in evaluations or designs of facilities (including underpinning, grouting, stabilization, etc.) on adjacent properties beyond the limits of that which is the specific subject of this report.

Environmental issues (such as permitting or potentially contaminated soil and groundwater) are outside the scope of this study and should be addressed in a separate evaluation.

CLOSING

We have appreciated being of service on this project, and look forward to working with you to successfully complete this project.

Sincerely,
Langan MA, Inc.

Clayton Patterson
Associate

Amy Blomeke, PE
Senior Project Manager

cc: Doug Landry (Langan)

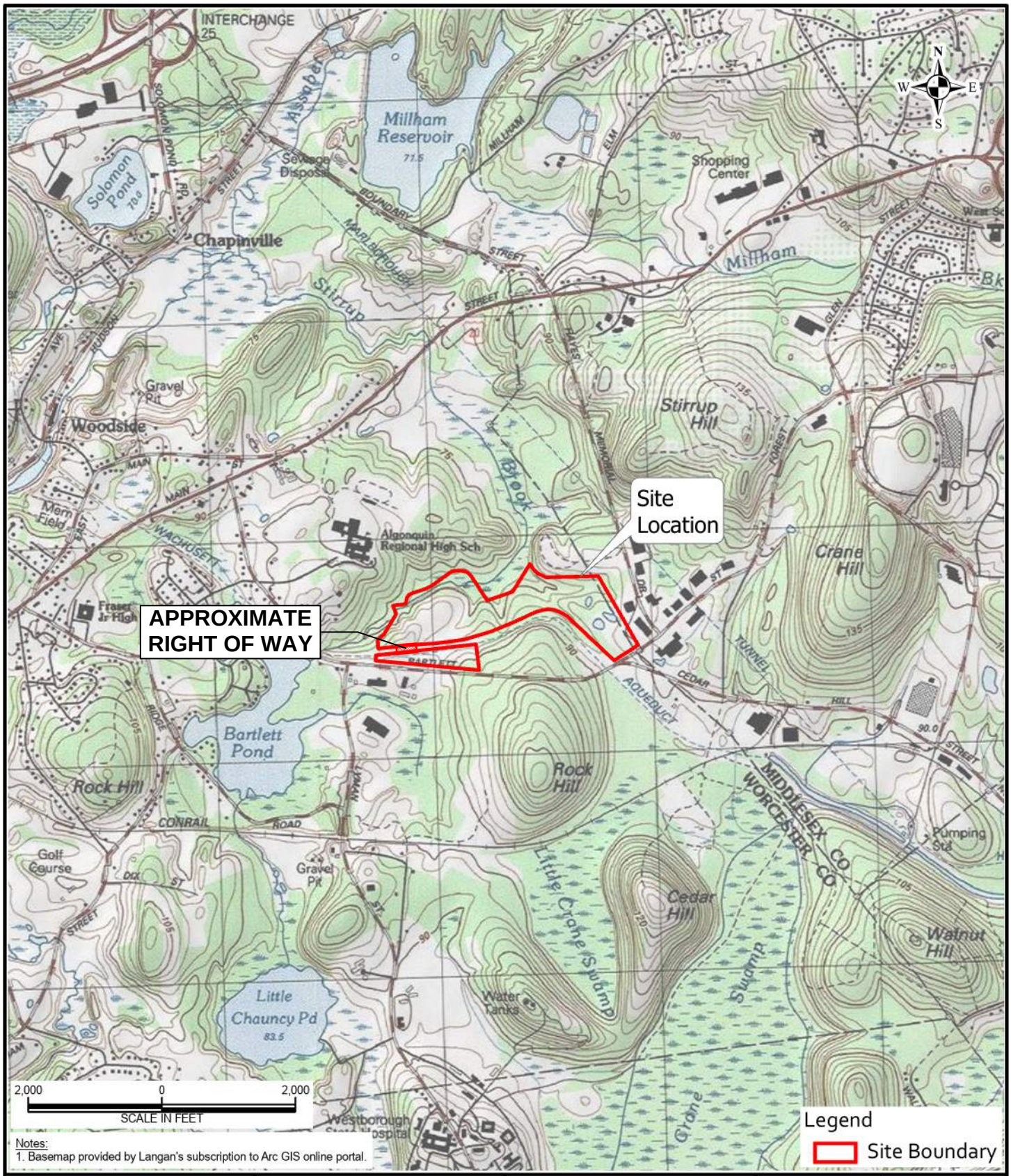
ACB: acb/cp/dll

\\langan.com\data\BOS\data3\151011301\Project Data_Discipline\Geotechnical\Reports\Geotechnical Report\15011301 Geotech Report-Final.docx

Attachments:

Figure 1	Site Location
Figure 2	Surficial Geology Map
Figure 3	Bedrock Geology Map
Figure 4	Effective FEMA FIRM
Figure 5	Exploration Location Plan
Figure 6	Wachusett Aqueduct Crossing
Appendix A	Langan Boring Logs
Appendix B	Langan Test Pit Logs
Appendix C	Langan Test Pit Photographs
Appendix D	Well Construction Logs
Appendix E	Laboratory Testing Results
Appendix F	Pavement Design

FIGURES



Notes:
1. Basemap provided by Langan's subscription to Arc GIS online portal.

LANGAN
555 Long Wharf Drive
New Haven, CT 06511-6107
T: 203.562.5771 F: 203.789.6142 www.langan.com

Langan Engineering & Environmental Services, Inc.
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan International LLC

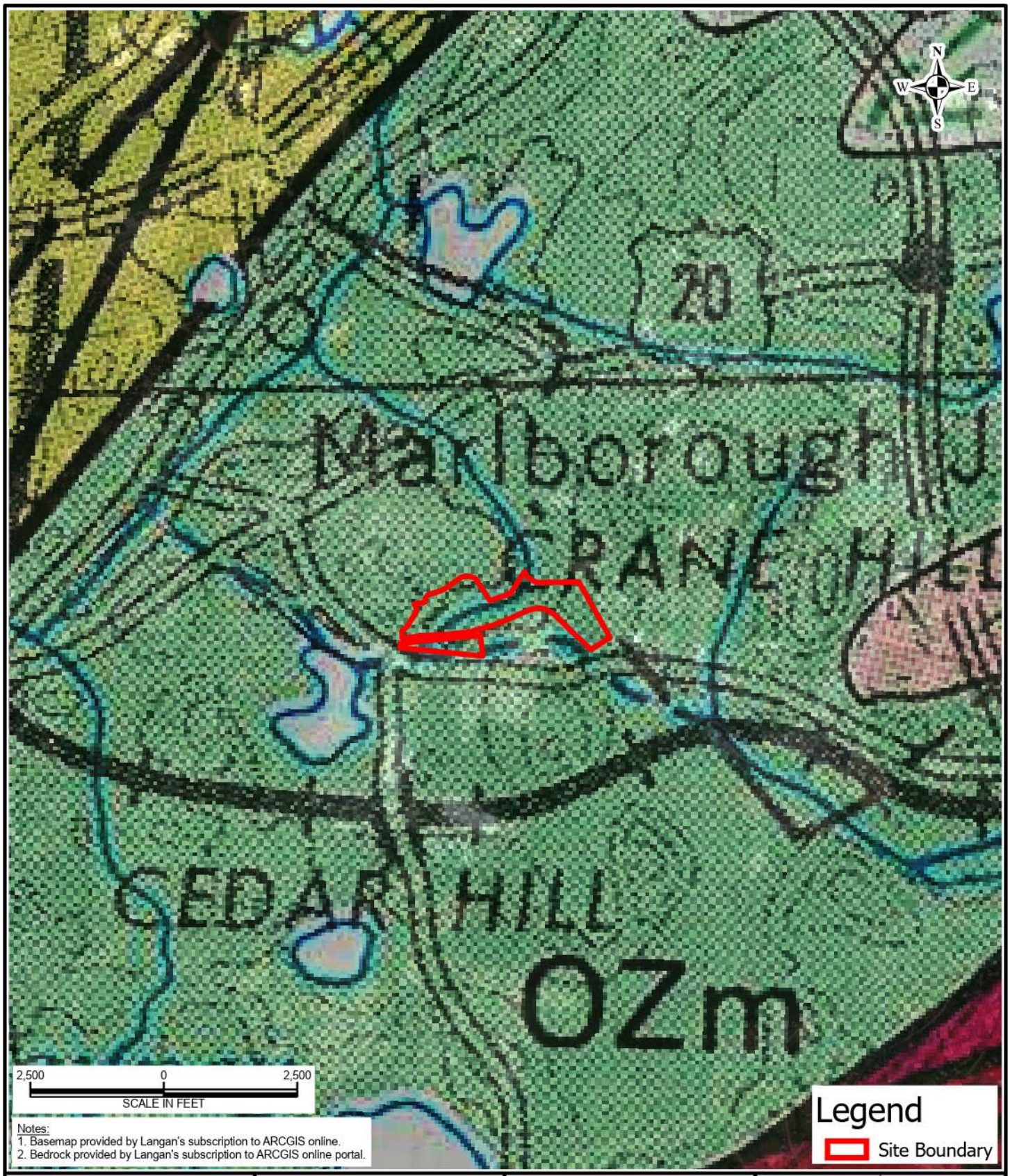
Collectively known as Langan

Project
COPLEY PARCEL H
NORTHBOROUGH
WORCHESTER COUNTY MA

Drawing Title
SITE LOCATION

Project No.	151011301
Date	04/03/2020
Scale	1"= 2000'
Drawn By	EB
Figure	1

Path: \\langan.com\data\NHV\other\EBurns\Projects\Internal\BOS\151011301\151011301.aprx Date: 4/3/2020 User: eburns Time: 1:23 PM



LANGAN
555 Long Wharf Drive
New Haven, CT 06511-6107
T: 203.562.5771 F: 203.789.6142 www.langan.com

Langan Engineering & Environmental Services, Inc.
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan International LLC

Collectively known as Langan

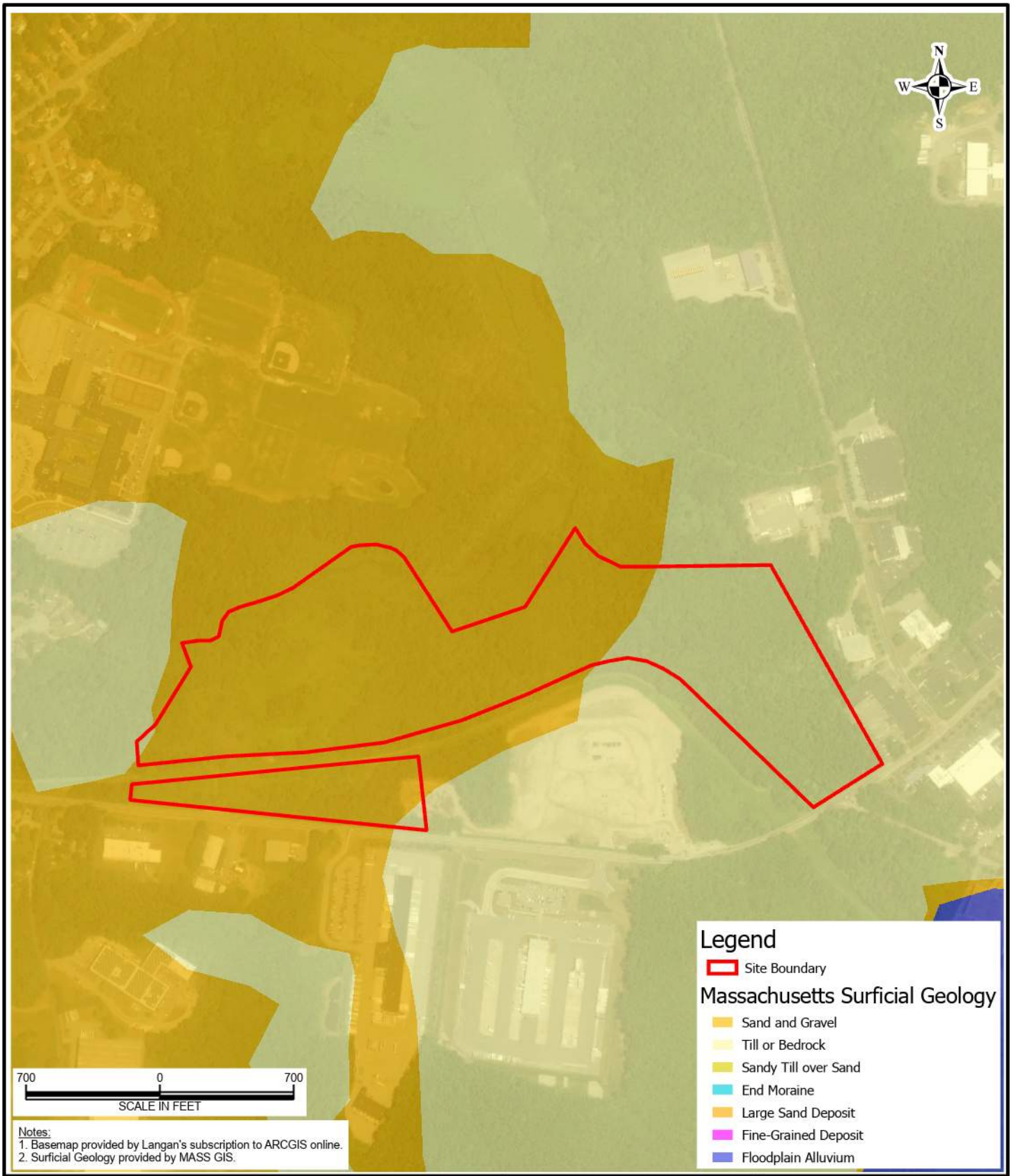
Project
COPLEY PARCEL H
NORTHBOROUGH
WORCHESTER COUNTY MA

Drawing Title
BEDROCK MAP

Project No.	151011301
Date	03/10/2020
Scale	1" = 2500'
Drawn By	EB

Figure
2

Path: \\langan.com\data\NHV\other\EBurns\Projects\Internal\BOS\151011301\151011301.aprx Date: 4/3/2020 User: eburns Time: 1:15 PM



LANGAN
555 Long Wharf Drive
New Haven, CT 06511-6107
T: 203.562.5771 F: 203.789.6142 www.langan.com

Langan Engineering & Environmental Services, Inc.
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan International LLC

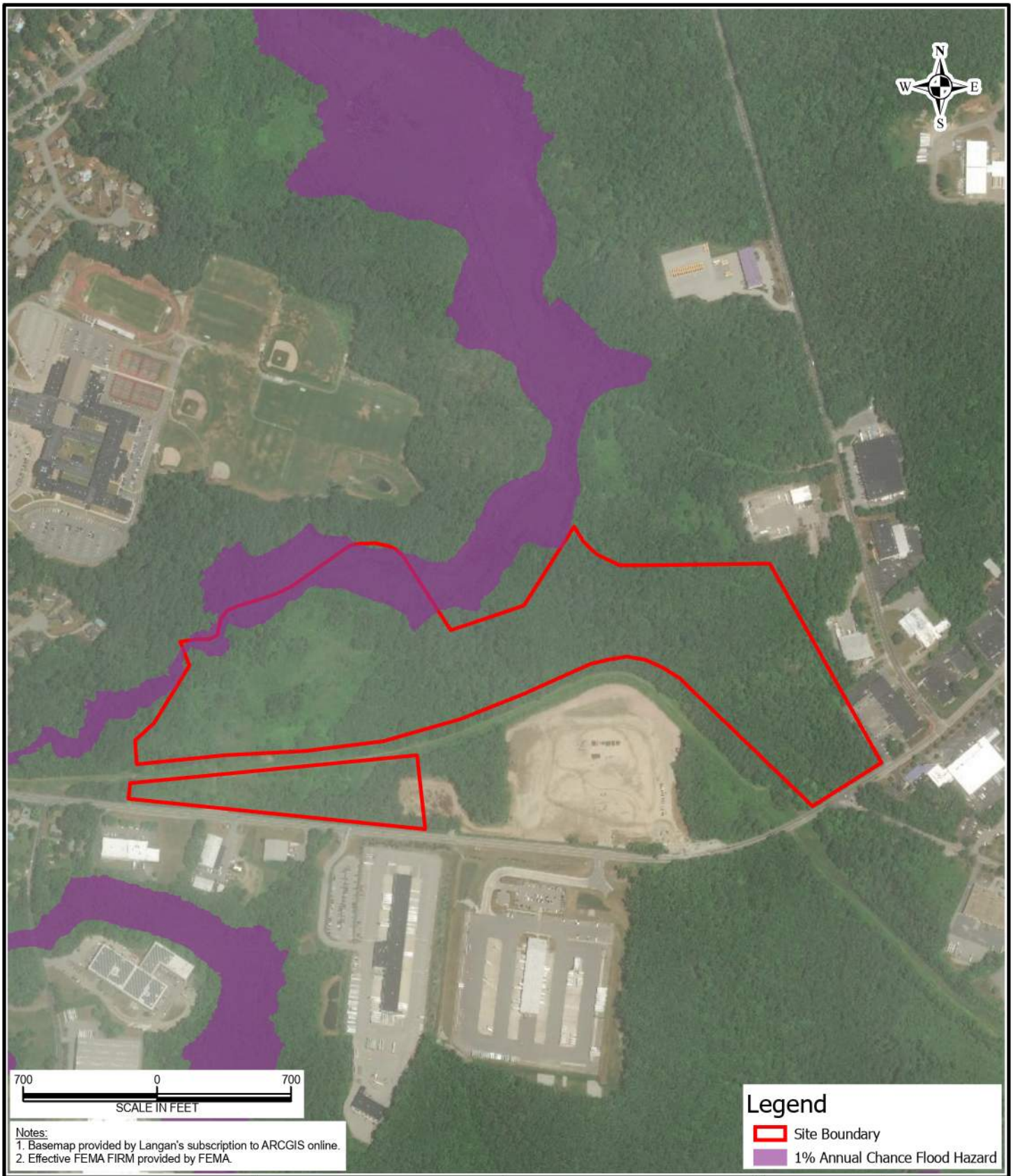
Collectively known as Langan

Project
COPLEY PARCEL H
NORTHBOROUGH
WORCHESTER COUNTY MA

Drawing Title
SURFICIAL GEOLOGY

Project No.	151011301
Date	03/10/2020
Scale	1" = 700'
Drawn By	EB
Figure	3

Path: \\langan.com\data\NHV\other\EBurns\Projects\Internal\BOS\151011301\151011301.aprx Date: 4/3/2020 User: eburns Time: 1:16 PM



LANGAN
555 Long Wharf Drive
New Haven, CT 06511-6107
T: 203.562.5771 F: 203.789.6142 www.langan.com

Langan Engineering & Environmental Services, Inc.
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan International LLC

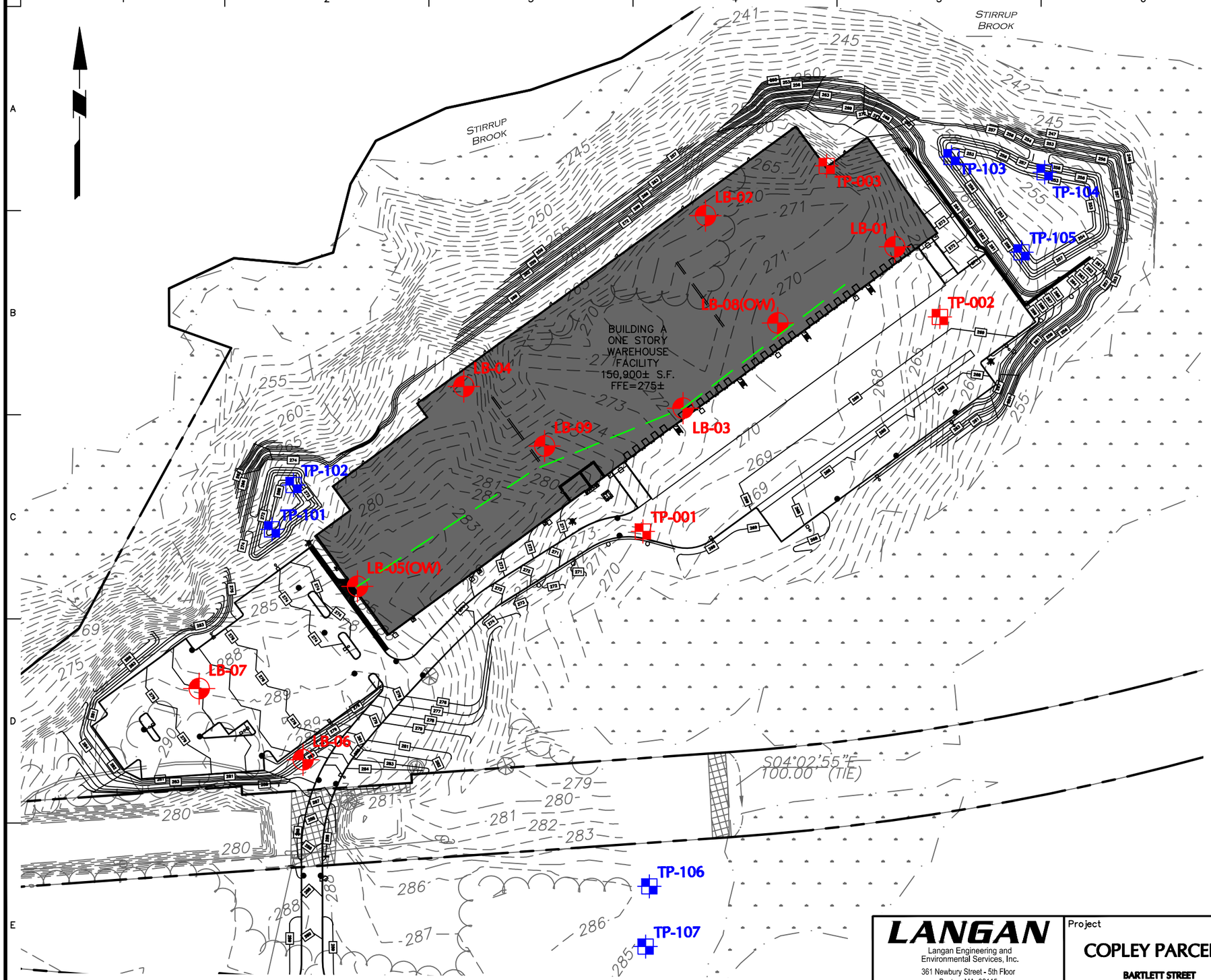
Collectively known as Langan

Project
COPLEY PARCEL H
NORTHBOROUGH
WORCHESTER COUNTY MA

Drawing Title
FEMA FIRM MAP

Project No.	151011301
Date	03/10/2020
Scale	1" = 700'
Drawn By	EB
Figure	4

Path: \\langan.com\data\NHV\other\EBurns\Projects\Internal\BOS\151011301\151011301.aprx Date: 4/3/2020 User: eburns Time: 1:17 PM



GENERAL NOTES

1. BOUNDARY AND TOPOGRAPHIC INFORMATION OBTAINED FROM A PLAN TITLED "EXISTING CONDITIONS" PREPARED BY ALLEN & MAJOR ASSOCIATES, INC. DATED 24 DECEMBER 2019.
2. SITE PLAN INFORMATION OBTAINED FROM A PLAN TITLED "LAYOUT & MATERIALS PLAN" PREPARED BY ALLEN & MAJOR ASSOCIATES, INC. DATED 24 DECEMBER 2020.
3. ELEVATIONS REFERENCE THE NAVD88 DATUM.
4. TEST PITS WERE PERFORMED BY BORGGAARD CONSTRUCTION CORP. ON 25 FEBRUARY 2020, UNDER THE OBSERVATION OF A LANGAN FIELD ENGINEER.
5. BORINGS WERE PERFORMED BY NORTHERN DRILLING SERVICES, INC. BETWEEN 27 AND 28 FEBRUARY 2020, UNDER THE FULLTIME OBSERVATION OF A LANGAN FIELD ENGINEER.
6. ALL BORING AND TEST PIT LOCATIONS ARE APPROXIMATE.
7. REFRACTION MICROTREMOR (REMI) SEISMIC TESTING WAS PERFORMED BY LANGAN ON 10 APRIL 2020. THE REMI ALIGNMENT INCLUDED 8 ARRAYS IN TOTAL AND THE LOCATION IS APPROXIMATE.

LEGEND

LANGAN BORING	LB-01
LANGAN TEST PIT	TP-001
LANGAN TEST PIT	TP-101
PROPERTY LINE	
REMI ALIGNMENT	

120 0 60 120

SCALE: 1 INCH = 120 FEET

LANGAN
Langan Engineering and Environmental Services, Inc.
361 Newbury Street - 5th Floor
Boston, MA 02115
T: 800.952.6426 www.langan.com

Project
COPLEY PARCEL H
BARTLETT STREET
NORTHBOROUGH
WORCESTER MASSACHUSETTS

Drawing Title
EXPLORATION LOCATION PLAN

Project No.	151011301
Date	30 MARCH 2020
Drawn By	OAC
Checked By	AB
Drawing No.	5
Sheet	1 of 2

Filename: \\langan.com\data\BOS\data3\151011301\Project Data\CAD\01\SheetFiles\Figures\FG01-151011301-BL101-0101.dwg Date: 4/15/2020 Time: 12:33 User: ochasse Style Table: Langan.stb Layout: ANSIB-BL

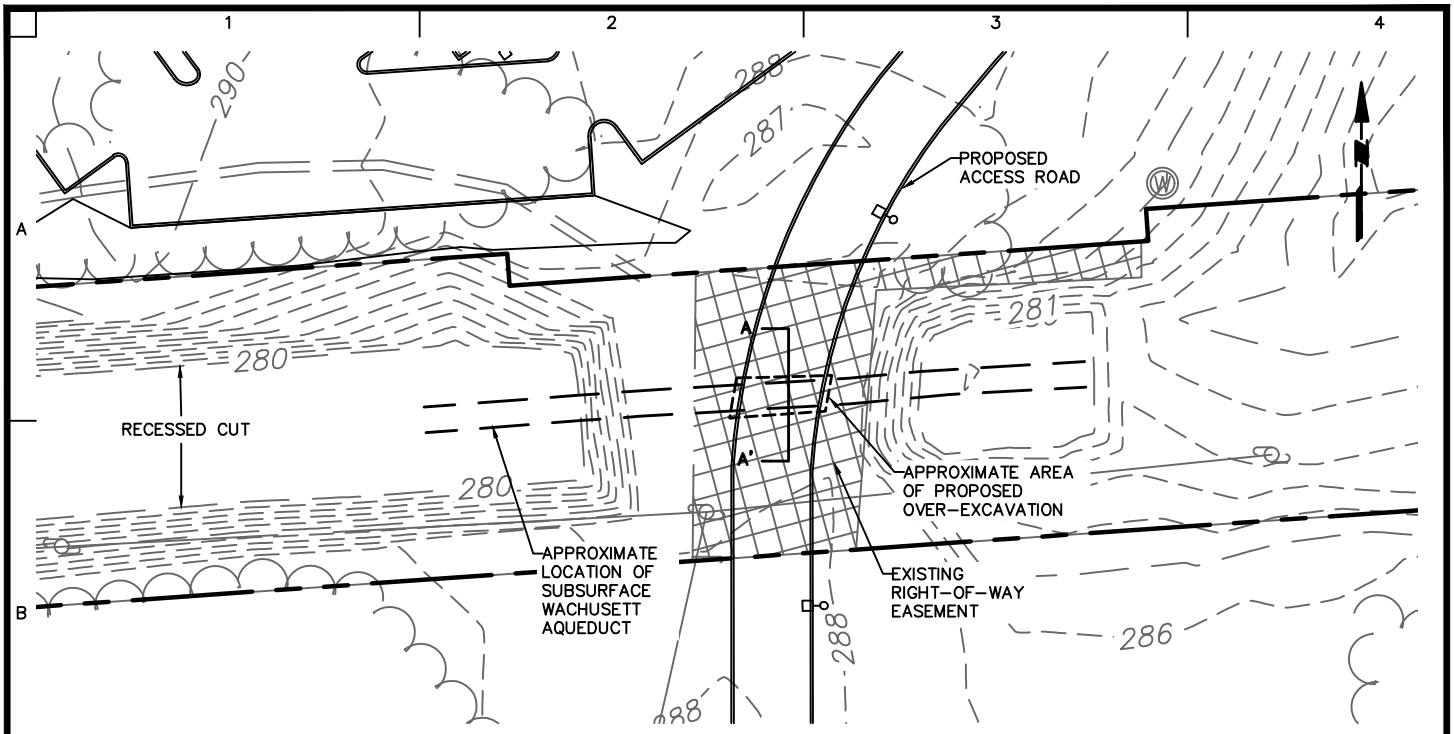
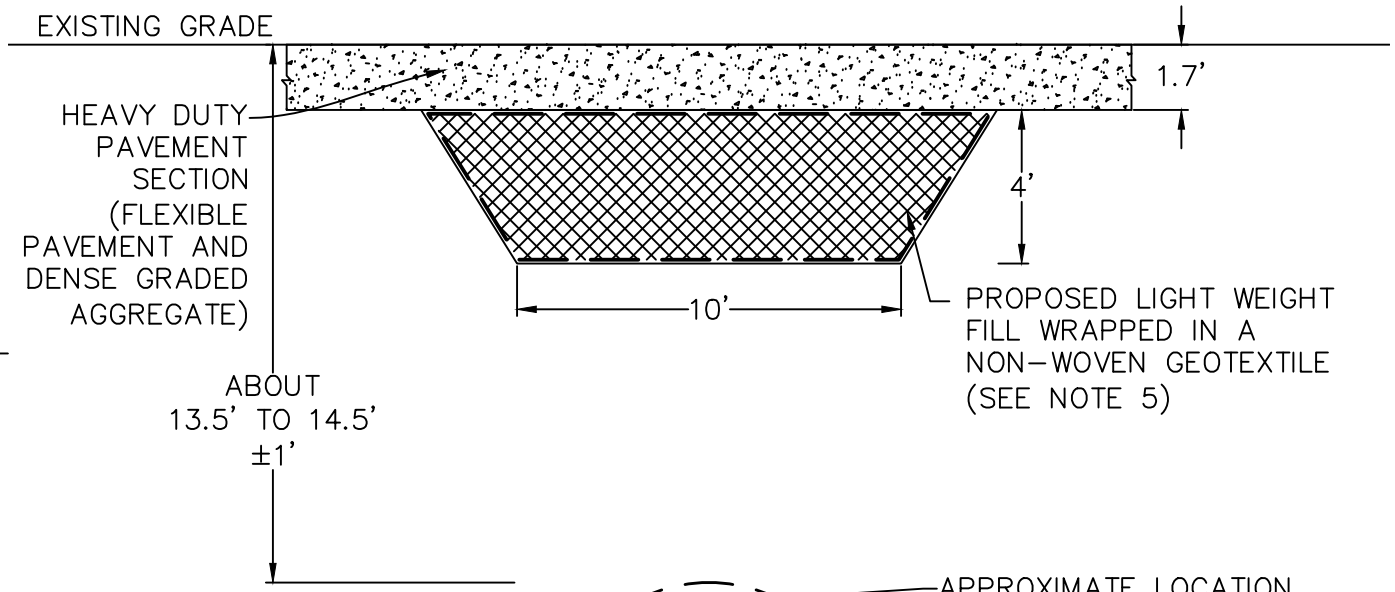


FIGURE 1 - EXISTING EARTHEN BERM

SCALE: 1" = 60'



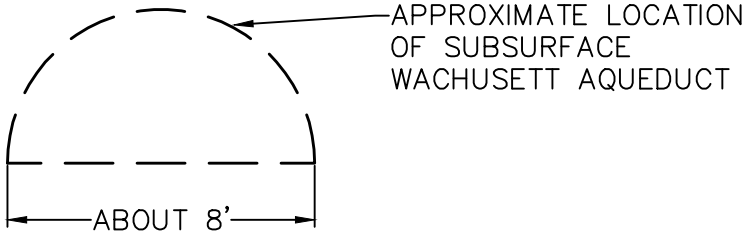


FIGURE 2 - PROFILE A-A'

SCALE: 1" = 5'

GENERAL NOTES

1. BOUNDARY AND TOPOGRAPHIC INFORMATION OBTAINED FROM A PLAN TITLED "EXISTING CONDITIONS" PREPARED BY ALLEN & MAJOR ASSOCIATES, INC. (A&M) DATED 24 DECEMBER 2019.
2. SITE PLAN INFORMATION OBTAINED FROM A PLAN TITLED "LAYOUT & MATERIALS PLAN" PREPARED BY A&M DATED 24 DECEMBER 2019.
3. ELEVATIONS REFERENCE THE NAVD88 DATUM.
4. APPROXIMATE LOCATION OF SUBSURFACE WACHUSETT AQUEDUCT REPORTED BY HAGER-RICHTER GEOSCIENCE, INC. FROM A GEOPHYSICAL SURVEY CONDUCTED ON 21 FEBRUARY 2020.
5. ALL EXCAVATIONS AND SLOPES SHOULD CONFIRM WITH APPLICABLE OSHA REGULATIONS.

LANGAN
Langan Engineering and Environmental Services, Inc.
361 Newbury Street - 5th Floor
Boston, MA 02115
T: 800.952.6426 www.langan.com

Project
COPLEY PARCEL H
BARTLETT STREET
NORTHBOROUGH
WORCESTER MASSACHUSETTS

Drawing Title
WACHUSETT AQUEDUCT CROSSING

Project No. 151011301	Drawing No. 6
Date 1 APRIL 2020	
Drawn By OAC	
Checked By AB	Sheet 1 of 1

Filename: \\langan.com\data\BOS\data3\151011301\Project Data\CAD\01\SheetFiles\Figures\Aqueduct Figures.dwg Date: 4/15/2020 Time: 12:15 User: ochasse Style Table: Langan.stb Layout: ANSIA-BP

APPENDIX A
LANGAN BORING LOGS

LANGAN

Log of Boring **LB-01** Sheet 1 of 1

Project: Copley Parcel H	Project No.: 151011301
Location: Bartlett St, Northborough, MA	Elevation and Datum: Approx. 267 (NAVD88)
Drilling Company: Northern Drill Services	Date Started: 2/28/20 — Date Finished: 2/28/20
Drilling Equipment: Mobile Drill B-48 ATV Rig	Completion Depth: 10.3 ft — Rock Depth: N/E
Size and Type of Bit: 4-1/4" ID Hollow Stem Auger	Number of Samples: Disturbed 6 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ N/E — Completion ▼ N/A — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Tim Tucker
Sampler: 2-inch-diameter split spoon	Field Engineer: Olivia Chasse
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	267.0		0						
		Dark brown f-m SAND, some organics, trace silt, trace fine gravel (dry) [TOPSOIL]		S-1A	SS	14	WOH		S-1 at 0ft
	266.0		1				1	3	
		Orangish brown f-c SAND, some fine gravel, trace silt (dry) [TILL]		S-1B			2		
		Grayish brown fine SAND, some silt (dry) [TILL]	2				3		
				S-2	SS	20	2		S-2 at 2ft Auger to 4ft Smooth drilling
			3				3	7	
							4		
		Gray fine SAND, some silt (moist) [TILL]	4				4		S-3 at 4ft
				S-3	SS	22	5		
			5				7	12	
							9		
		Gray fine SAND, some silt (moist) [TILL]	6				7		S-4 at 6ft Auger to 8ft Smooth drilling
				S-4	SS	24	7		
			7				9	16	
							9		
		Gray fine SAND, some silt (moist) [TILL]	8				3		S-5 at 8ft
				S-5	SS	20	8		
			9				7	15	
							17		
	257.0		10	S-6	SS	1	50/4	50/4	S-6 at 10ft Rock in tip of spoon Split spoon and auger refusal. Boring offset 5ft NE. Blind auger to 10ft. Auger refusal. Boring backfilled with auger cuttings.
	256.7	Grayish brown f-m SAND, some fine gravel, some silt (dry) [COBBLES]							
		Bottom of Boring at 10.3ft	11						
			12						
			13						
			14						
			15						
			16						
			17						
			18						
			19						
			20						

N-Value (Blows/ft) scale: 10 20 30 40

LANGAN

Log of Boring **LB-02** Sheet 1 of 2

Project: Copley Parcel H	Project No.: 151011301
Location: Bartlett St, Northborough, MA	Elevation and Datum: Approx. 270 (NAVD88)
Drilling Company: Northern Drill Services	Date Started: 2/27/20 — Date Finished: 2/27/20
Drilling Equipment: Mobile Drill B-48 ATV Rig	Completion Depth: 27 ft — Rock Depth: N/E
Size and Type of Bit: 3-1/4" ID Hollow Stem Auger	Number of Samples: Disturbed 9 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ 15 — Completion ▼ N/A — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Tim Tucker
Sampler: 2-inch-diameter split spoon	Field Engineer: Olivia Chasse
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	270.0		0						
	269.5	Dark brown f-m SAND, some silt, some organics, trace fine gravel (moist) [TOPSOIL]	1	S-1A	SS	10	9 3 2 1	5	S-1 at 0ft
		Orangish brown f-m SAND, some fine gravel, trace silt (dry)		S-1B					
		Orangish brown f-m SAND, trace silt, trace fine gravel (dry)	2	S-2	SS	12	1 1 2 1	3	S-2 at 2ft Auger to 4ft Smooth drilling
		Light brown fine SAND, trace silt (dry)	4	S-3	SS	24	3 4 5 6	9	S-3 at 4ft
		Orangish brown fine SAND, trace silt (dry)	6	S-4	SS	24	6 7 6 9	13	S-4 at 6ft Auger to 8ft Smooth drilling
	262.0		8						
		Gray fine SAND, some silt (moist) [TILL]		S-5	SS	24	8 7 8 7	15	S-5 at 8ft
		Grayish brown fine SAND, some silt (moist) [TILL]	10	S-6	SS	22	7 7 8 9	15	S-6 at 10ft Auger to 15ft Smooth drilling
		Gray fine SAND, some silt (wet) [TILL]	15	S-7	SS	14	4 5 5 8	10	S-7 at 15ft Auger to 20ft Smooth drilling
			20						

LANGAN

Log of Boring **LB-02** Sheet 2 of 2

Project	Project No.
Copley Parcel H	151011301
Location	**Elevation and Datum**
Bartlett St, Northborough, MA	Approx. 270 (NAVD88)

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+250.0		20					10 20 30 40	
		Grayish brown fine SAND, some silt (wet) [TILL]	21	S-8	SS	16	4 3 3 6	6	S-8 at 20ft Auger to 25ft Smooth drilling
			22						
			23						
			24						
		Grayish brown fine SAND, some silt (wet) [TILL]	25	S-9	SS	16	4 3 3 6	6	S-9 at 25ft
	+243.0		26						
		Bottom of Boring at 27ft	27						Bottom of boring at 27ft. Boring backfilled with auger cuttings.
			28						
			29						
			30						
			31						
			32						
			33						
			34						
			35						
			36						
			37						
			38						
			39						
			40						
			41						
			42						
			43						
			44						
			45						

LANGAN

Log of Boring **LB-03** Sheet 1 of 2

Project: Copley Parcel H	Project No.: 151011301
Location: Bartlett St, Northborough, MA	Elevation and Datum: Approx. 272 (NAVD88)
Drilling Company: Northern Drill Services	Date Started: 2/27/20 — Date Finished: 3/2/20
Drilling Equipment: Mobile Drill B-48 ATV Rig	Completion Depth: 27 ft — Rock Depth: N/E
Size and Type of Bit: 3-1/4" ID Hollow Stem Auger	Number of Samples: Disturbed 9 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ 9 — Completion ▼ N/A — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Tim Tucker
Sampler: 2-inch-diameter split spoon	Field Engineer: Olivia Chasse
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Elev. (ft)	Sample Description	PID Reading (ppm)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	272.0			0						
	271.0	Dark brown f-m SAND, some silt, some organics, trace fine gravel (moist) [TOPSOIL]		1	S-1A	SS	16	1 1	2	S-1 at 0ft
		Orangish brown f-m SAND, some fine sand, trace silt (dry)			S-1B			1 2		
		Grayish black f-c SAND, some fine gravel (dry)		2	S-2	SS	12	2 3	7	S-2 at 2ft Auger to 4ft Smooth drilling
				3				4 3		
		Grayish black f-c SAND, some fine gravel (dry)	0.1	4	S-3	SS	13	3 5	9	S-3 at 4ft
			0.1	5				4 6		
		Grayish black f-c SAND, some fine gravel (dry)		6	S-4A	SS	16	4 5	12	S-4 at 6ft Auger to 8ft Smooth drilling
	265.0			7	S-4B			7 8		
		Grayish brown fine SAND, some silt (moist) [TILL]		8	S-5	SS	20	5 6	14	S-5 at 8ft
		Grayish brown fine SAND, some silt (wet) [TILL] ▽		9				8 8		
		Grayish brown fine SAND, some silt (wet) [TILL]		10	S-6	SS	24	7 7	16	S-6 at 10ft Auger to 15ft Smooth drilling
				11				9 9		
				12						
				13						
				14						
		Grayish brown fine SAND, some silt (wet) [TILL]		15	S-7	SS	19	4 3	6	S-7 at 15ft Auger to 20ft Smooth drilling
				16				3 2		
				17						
				18						
				19						
				20						

N-Value (Blows/ft) scale: 10 20 30 40

LANGAN

Log of Boring **LB-03** Sheet 2 of 2

Project	Project No.
Copley Parcel H	151011301
Location	**Elevation and Datum**
Bartlett St, Northborough, MA	Approx. 272 (NAVD88)

Material Symbol	Elev. (ft)	Sample Description	PID Reading (ppm)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+252.0	Grayish brown fine SAND, some silt (wet) [TILL]		20	S-8	SS	21	3 4 3 4	7	S-8 at 20ft Auger to 25ft Smooth drilling
				21						
				22						
				23						
				24						
		Grayish brown fine SAND, some silt (wet) [TILL]		25	S-9	SS	20	3 4 4 5	8	S-9 at 25ft
	+245.0			26						
		Bottom of Boring at 27ft		27						Bottom of boring at 27ft. Boring backfilled with auger cuttings.
				28						
				29						
				30						
				31						
				32						
				33						
				34						
				35						
				36						
				37						
				38						
				39						
				40						
				41						
				42						
				43						
				44						
				45						

N-Value (Blows/ft) scale: 10 20 30 40

\\LANGAN.COM\DATA\BOS\DATA3\151011301\PROJECT DATA_DISCIPLINE\GEOTECHNICAL\GINTLOGS\151011301_ENTERPRISE.GPJ ... 3/27/2020 5:02:43 PM ... Report: Log - LANGAN

LANGAN

Log of Boring **LB-04** Sheet 1 of 2

Project: Copley Parcel H	Project No.: 151011301
Location: Bartlett St, Northborough, MA	Elevation and Datum: Approx. 275 (NAVD88)
Drilling Company: Northern Drill Services	Date Started: 2/27/20 — Date Finished: 2/27/20
Drilling Equipment: Mobile Drill B-48 ATV Rig	Completion Depth: 27 ft — Rock Depth: N/E
Size and Type of Bit: 3-1/4" ID Hollow Stem Auger	Number of Samples: Disturbed 9 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ 8 — Completion ▼ N/A — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Tim Tucker
Sampler: 2-inch-diameter split spoon	Field Engineer: Olivia Chasse
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	275.0	Dark brown f-m SAND, some silt, some organics, trace fine gravel (dry)[TOPSOIL]	0	S-1A	SS	18	WOH		S-1 at 0ft
	274.0	Orangish brown f-m SAND, some silt, trace fine gravel, trace roots (dry)	1	S-1B	SS		WOH		
		Orangish brown f-m SAND, some fine gravel, trace silt (dry)	2	S-2	SS	18	1		
			3				1		S-2 at 2ft Auger to 4ft Smooth drilling
			4	S-3	SS	14	3	11	
		Grayish to orangish brown f-m SAND, some fine gravel, trace silt (dry)	5				5		
	269.0		6	S-4	SS	24	6	10	S-3 at 4ft
		Grayish brown fine SAND, some silt (moist) [TILL]	7				2		
			8	S-5	SS	15	5	10	S-4 at 6ft Auger to 8ft Smooth drilling
		Grayish brown fine SAND, some silt (wet) [TILL]	9				6		
			10	S-6	SS	24	4	5	S-5 at 8ft
		Grayish brown fine SAND, some silt (wet) [TILL]	11				3		
			12				1		
			13				2		
			14				3		
			15				5		S-6 at 10ft Auger to 15ft Smooth drilling
			16				5		
			17	S-7	SS	17	6	11	
		Grayish brown fine SAND, some silt (wet) [TILL]	18				7		
			19				3		
			20				3		
							4	7	S-7 at 15ft Auger to 20ft Smooth drilling
							5		

N-Value (Blows/ft) scale: 10 20 30 40

LANGAN

Log of Boring **LB-04** Sheet 2 of 2

Project	Project No.
Copley Parcel H	151011301
Location	**Elevation and Datum**
Bartlett St, Northborough, MA	Approx. 275 (NAVD88)

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+255.0	Grayish brown fine SAND, some silt (wet) [TILL]	20	S-8	SS	16	3 4 4 5	8	S-8 at 20ft Auger to 25ft Smooth drilling
			21						
			22						
			23						
			24						
		Grayish brown fine SAND, some silt (wet) [TILL]	25	S-9	SS	18	4 5 5 9	10	S-9 at 25ft
	+248.0		26						
		Bottom of Boring at 27ft	27						Bottom of boring at 27ft. Boring backfilled with auger cuttings.
			28						
			29						
			30						
			31						
			32						
			33						
			34						
			35						
			36						
			37						
			38						
			39						
			40						
			41						
			42						
			43						
			44						
			45						

N-Value (Blows/ft) scale: 10 20 30 40

\\LANGAN.COM\DATA\BOS\DATA3\151011301\PROJECT DATA_DISCIPLINE\GEOTECHNICAL\GINTLOGS\151011301_ENTERPRISE.GPJ ... 3/27/2020 5:02:49 PM ... Report: Log - LANGAN

LANGAN

Log of Boring **LB-05** Sheet 1 of 2

Project: Copley Parcel H	Project No.: 151011301
Location: Bartlett St, Northborough, MA	Elevation and Datum: Approx. 284 (NAVD88)
Drilling Company: Northern Drill Services	Date Started: 2/28/20 — Date Finished: 2/28/20
Drilling Equipment: Mobile Drill B-48 ATV Rig	Completion Depth: 27 ft — Rock Depth: N/E
Size and Type of Bit: 4-1/4" ID Hollow Stem Auger	Number of Samples: Disturbed 9 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ 12 — Completion ▼ 12.5 — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Tim Tucker
Sampler: 2-inch-diameter split spoon	Field Engineer: Olivia Chasse
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+284.0	Orangish brown f-m SAND, trace silt (dry)	0–1	S-1	SS	18	1 1 3 3	4	S-1 at 0ft
		Orangish brown fine SAND, trace silt (dry)	2–3	S-2	SS	24	4 5 4 5	9	S-2 at 2ft Auger to 4ft Smooth drilling
		Orangish brown fine SAND, trace silt (dry)	4–5	S-3	SS	20	2 4 3 5	7	S-3 at 4ft
		Grayish brown fine SAND, trace silt (dry)	6–7	S-4	SS	24	4 4 4 4	8	S-4 at 6ft Auger to 8ft Smooth drilling
		Grayish brown fine SAND, trace silt (moist)	8–9	S-5	SS	20	3 2 3 4	5	S-5 at 8ft
		Grayish brown fine SAND, trace silt (moist)	10–11	S-6	SS	22	5 4 4 5	8	S-6 at 10ft Auger to 15ft Smooth drilling
		Orangish to reddish brown f-c SAND, trace coal ash, trace silt (wet)	15–16	S-7	SS	12	3 5 5 4	10	S-7 at 15ft Auger to 20ft Smooth drilling
	+266.0	? ? ? ?	18						

N-Value (Blows/ft) scale: 10 20 30 40

\\LANGAN COM\DATA\BOS\DATA3\151011301\PROJECT DATA_DISCIPLINE\GEOTECHNICAL\GINTLOGS\151011301_ENTERPRISE.GPJ ... 3/27/2020 5:02:53 PM ... Report: Log - LANGAN

LANGAN

Log of Boring **LB-05** Sheet 2 of 2

Project	Project No.
Copley Parcel H	151011301
Location	**Elevation and Datum**
Bartlett St, Northborough, MA	Approx. 284 (NAVD88)

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+264.0	Grayish brown fine SAND, some silt (wet) [TILL]	20	S-8	SS	19	4 6 4 4	10	S-8 at 20ft Auger to 25ft Smooth drilling
			21						
			22						
			23						
			24						
		Grayish brown fine SAND, some silt (wet) [TILL]	25	S-9	SS	15	3 6 5 7	11	S-9 at 25ft
	+257.0		26						
		Bottom of Boring at 27ft	27						Bottom of boring at 27ft. Observation well installed. Refer to well costruction log.
			28						
			29						
			30						
			31						
			32						
			33						
			34						
			35						
			36						
			37						
			38						
			39						
			40						
			41						
			42						
			43						
			44						
			45						

N-Value (Blows/ft) scale: 10 20 30 40

LANGAN

Log of Boring **LB-06** Sheet 1 of 2

Project: Copley Parcel H	Project No.: 151011301
Location: Bartlett St, Northborough, MA	Elevation and Datum: Approx. 287 (NAVD88)
Drilling Company: Northern Drill Services	Date Started: 2/27/20 — Date Finished: 2/27/20
Drilling Equipment: Mobile Drill B-48 ATV Rig	Completion Depth: 27 ft — Rock Depth: N/E
Size and Type of Bit: 3-1/4" ID Hollow Stem Auger	Number of Samples: Disturbed 9 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ 15 — Completion ▼ N/A — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Tim Tucker
Sampler: 2-inch-diameter split spoon	Field Engineer: Olivia Chasse
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	287.0		0					10 20 30 40	
		Dark brown f-m SAND, some silt, some organics, trace fine gravel (dry) [TOPSOIL]							S-1 at 0ft
	286.0	Orangish brown f-m SAND, some silt, trace gravel (dry)	1	S-1A	SS	12	1 1	2	
				S-1B			1		
		Orangish brown f-m SAND, some silt, trace gravel (dry)	2						S-2 at 2ft Auger to 4ft Smooth drilling
			3	S-2A	SS	9	WOH WOH		
		Grayish black f-c SAND, trace fine gravel (dry)		S-2B			WOH 5		
		Grayish brown fine SAND, some silt (dry)	4						S-3 at 4ft
			5	S-3	SS	18	6 4 4 5	8	
		Grayish brown fine SAND, trace silt (dry)	6						S-4 at 6ft Auger to 8ft Smooth drilling
			7	S-4	SS	21	5 5 4 3	9	
		Grayish brown fine SAND, trace silt (dry)	8						S-5 at 8ft
			9	S-5	SS	20	2 2 2 2	4	
		Grayish brown fine SAND, trace silt (moist)	10						S-6 at 10ft Auger to 15ft Smooth drilling
			11	S-6	SS	22	3 2 3 2	5	
			12						
			13						
			14						
			15 ▽						
		Grayish brown fine SAND, trace silt (wet)	16	S-7	SS	20	7 9 9 9	18	S-7 at 15ft Auger to 20ft Smooth drilling
	270.0		17						
			18						
			19						
			20						

LANGAN

Log of Boring **LB-06** Sheet 2 of 2

Project	Project No.
Copley Parcel H	151011301
Location	**Elevation and Datum**
Bartlett St, Northborough, MA	Approx. 287 (NAVD88)

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+267.0	Grayish brown fine SAND, some silt (wet) [TILL]	20	S-8	SS	24	4 4 4 4	8	S-8 at 20ft Water introduced to augers Auger to 25ft Smooth drilling
			21						
			22						
			23						
			24						
		Grayish brown fine SAND, some silt (wet) [TILL]	25	S-9	SS	24	3 4 4 4	8	S-9 at 25ft Water introduced to augers
	+260.0		26						
		Bottom of Boring at 27ft	27						Bottom of boring at 27ft. Boring backfilled with auger cuttings.
			28						
			29						
			30						
			31						
			32						
			33						
			34						
			35						
			36						
			37						
			38						
			39						
			40						
			41						
			42						
			43						
			44						
			45						

N-Value (Blows/ft) scale: 10 20 30 40

LANGAN

Log of Boring **LB-07** Sheet 1 of 2

Project: Copley Parcel H	Project No.: 151011301
Location: Bartlett St, Northborough, MA	Elevation and Datum: Approx. 289 (NAVD88)
Drilling Company: Northern Drill Services	Date Started: 2/27/20 — Date Finished: 2/27/20
Drilling Equipment: Mobile Drill B-48 ATV Rig	Completion Depth: 22 ft — Rock Depth: N/E
Size and Type of Bit: 3-1/4" ID Hollow Stem Auger	Number of Samples: Disturbed 8 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ 15 — Completion ▼ N/A — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Tim Tucker
Sampler: 2-inch-diameter split spoon	Field Engineer: Olivia Chasse
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+289.0	Orangish brown f-c SAND, some silt, some fine gravel (dry)	0	S-1	SS	13	1 1 4 6	5	S-1 at 0ft
		Orangish brown f-c SAND, some fine gravel, trace silt (dry)	2	S-2	SS	18	6 6 6 9	12	S-2 at 2ft Auger to 4ft Smooth drilling
		Orangish brown f-c SAND, some fine gravel, trace silt (dry)	4	S-3A	SS	16	4 6 5 6	11	S-3 at 4ft
		Grayish brown f-m SAND, trace silt (dry)	5	S-3B					
		Grayish brown fine SAND, trace silt (dry)	6	S-4	SS	20	5 6 5 8	11	S-4 at 6ft Auger to 8ft Smooth drilling
		Grayish brown fine SAND, trace silt (dry)	8	S-5	SS	19	4 9 10 10	19	S-5 at 8ft
	+279.0	Grayish brown fine SAND, some silt (moist) [TILL]	10	S-6	SS	24	9 9 7 6	16	S-6 at 10ft Auger to 15ft Smooth drilling
		Grayish brown fine SAND, some silt (wet) [TILL]	15 ▽	S-7	SS	16	3 5 5 7	10	S-7 at 15ft Auger to 20ft Smooth drilling
			20						

N-Value (Blows/ft) scale: 10 20 30 40

\\LANGAN.COM\DATA\BOS\DATA3\151011301\PROJECT DATA_DISCIPLINE\GEOTECHNICAL\GINTLOGS\151011301_ENTERPRISE.GPJ ... 3/27/2020 5:03:03 PM ... Report: Log - LANGAN

LANGAN

Log of Boring **LB-07** Sheet 2 of 2

Project	Project No.
Copley Parcel H	151011301
Location	**Elevation and Datum**
Bartlett St, Northborough, MA	Approx. 289 (NAVD88)

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+269.0		20					10 20 30 40	
		Grayish brown fine SAND, some silt (wet) [TILL]	21	S-8	SS	21	7 3 3 2	6	S-8 at 20ft
	+267.0		22						
		Bottom of Boring at 22ft	23						Bottom of boring at 22ft. Boring backfilled with auger cuttings.
			24						
			25						
			26						
			27						
			28						
			29						
			30						
			31						
			32						
			33						
			34						
			35						
			36						
			37						
			38						
			39						
			40						
			41						
			42						
			43						
			44						
			45						

LANGAN

Log of Boring **LB-08** Sheet 1 of 2

Project: Copley Parcel H	Project No.: 151011301
Location: Bartlett St, Northborough, MA	Elevation and Datum: Approx. 270 (NAVD88)
Drilling Company: Northern Drill Services	Date Started: 2/28/20 — Date Finished: 2/28/20
Drilling Equipment: Mobile Drill B-48 ATV Rig	Completion Depth: 27 ft — Rock Depth: N/E
Size and Type of Bit: 4-1/4" ID Hollow Stem Auger	Number of Samples: Disturbed 9 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ 9 — Completion ▼ 16.7 — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Tim Tucker
Sampler: 2-inch-diameter split spoon	Field Engineer: Olivia Chasse
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Elev. (ft)	Sample Description
	270.0	Dark brown f-m SAND, some silt, some fine gravel (dry) [TOPSOIL]
	268.0	Grayish brown f-c SAND, some fine gravel, trace silt (dry)
	267.0	Gray fine SAND, some silt (dry) [TILL]
		Gray fine SAND, some silt (dry) [TILL]
		Gray fine SAND, some silt (dry) [TILL]
		Gray fine SAND, some silt (wet) [TILL]
		Gray fine SAND, some silt (wet) [TILL]
		Gray fine SAND, some silt (wet) [TILL]

Depth Scale: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Sample Data

Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)
S-1	SS	12	WOH 1 2 2	3
S-2A	SS	9	5 3 3 3	6
S-2B				
S-3	SS	17	3 4 6 5	10
S-4	SS	20	4 7 8 8	15
S-5	SS	18	5 6 7 10	13
S-6	SS	23	9 9 9 10	18
S-7	SS	21	3 3 2 2	5

N-Value (Blows/ft) 10 20 30 40

Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)

S-1 at 0ft

S-2 at 2ft
Auger to 4ft
Smooth drilling

S-3 at 4ft

S-4 at 6ft
Auger to 8ft
Smooth drilling

S-5 at 8ft

S-6 at 10ft
Auger to 15ft
Smooth drilling

S-7 at 15ft
Auger to 20ft
Smooth drilling

LANGAN

Log of Boring **LB-08** Sheet 2 of 2

Project	Project No.
Copley Parcel H	151011301
Location	**Elevation and Datum**
Bartlett St, Northborough, MA	Approx. 270 (NAVD88)

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+250.0	Gray fine SAND, some silt (wet) [TILL]	20	S-8	SS	19	3 2 3 2	5	S-8 at 20ft Auger to 25ft Smooth drilling
			21						
			22						
			23						
			24						
		Gray fine SAND, some silt (wet) [TILL]	25	S-9	SS	20	3 4 3 3	7	S-9 at 25ft
	+243.0		26						
		Bottom of Boring at 27ft	27						Bottom of boring at 27ft. Observation well installed. Refer to well costruction log.
			28						
			29						
			30						
			31						
			32						
			33						
			34						
			35						
			36						
			37						
			38						
			39						
			40						
			41						
			42						
			43						
			44						
			45						

N-Value (Blows/ft) scale: 10 20 30 40

\\LANGAN.COM\DATA\BOS\DATA3\151011301\PROJECT DATA_DISCIPLINE\GEOTECHNICAL\GINTLOGS\151011301_ENTERPRISE.GPJ ... 3/27/2020 5:03:09 PM ... Report: Log - LANGAN

LANGAN

Log of Boring **LB-09** Sheet 1 of 2

Project: Copley Parcel H	Project No.: 151011301
Location: Bartlett St, Northborough, MA	Elevation and Datum: Approx. 277 (NAVD88)
Drilling Company: Northern Drill Services	Date Started: 2/28/20 — Date Finished: 2/28/20
Drilling Equipment: Mobile Drill B-48 ATV Rig	Completion Depth: 27 ft — Rock Depth: N/E
Size and Type of Bit: 4-1/4" ID Hollow Stem Auger	Number of Samples: Disturbed 9 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ 10 — Completion ▼ N/A — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Tim Tucker
Sampler: 2-inch-diameter split spoon	Field Engineer: Olivia Chasse
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	277.0		0						
		Dark brown f-m SAND, some fine gravel, some organics, trace silt (dry) [TOPSOIL]		S-1A	SS	14	WOH WOH		S-1 at 0ft
	276.0		1	S-1B			1 2		
		Orangish brown fine SAND, some silt (dry)	2						
		Gray fine SAND, trace silt (dry)		S-2	SS	15	2 4 6 7	10	S-2 at 2ft Auger to 4ft Smooth drilling
			3						
		Gray fine SAND, trace silt (dry)	4	S-3	SS	18	3 3 4 3	7	S-3 at 4ft
	271.0		5						
		Gray fine SAND, some silt (dry) [TILL]	6	S-4	SS	22	4 3 5 4	8	S-4 at 6ft Auger to 8ft Smooth drilling
		Gray fine SAND, some silt (moist) [TILL]	7	S-5	SS	22	3 4 3 4	7	S-5 at 8ft
			8						
		Grayish brown fine SAND, some silt (wet) [TILL]	9	S-6	SS	24	5 5 4 6	9	S-6 at 10ft Auger to 15ft Smooth drilling
			10						
			11						
			12						
			13						
			14						
		Grayish brown fine SAND, some silt (wet) [TILL]	15	S-7	SS	17	3 7 6 6	13	S-7 at 15ft Auger to 20ft Smooth drilling
			16						
			17						
			18						
			19						
			20						

LANGAN

Log of Boring **LB-09** Sheet 2 of 2

Project	Project No.
Copley Parcel H	151011301
Location	**Elevation and Datum**
Bartlett St, Northborough, MA	Approx. 277 (NAVD88)

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	+257.0		20					10 20 30 40	
		Grayish brown fine SAND, some silt (wet) [TILL]	21	S-8	SS	15	3 4 5 5	9	S-8 at 20ft Auger to 25ft Smooth drilling
			22						
			23						
			24						
		No Recovery	25	S-9	SS	0	3 4 3 2	7	S-9 at 25ft
	+250.0		26						
		Bottom of Boring at 27ft	27						Bottom of boring at 27ft. Boring backfilled with auger cuttings.
			28						
			29						
			30						
			31						
			32						
			33						
			34						
			35						
			36						
			37						
			38						
			39						
			40						
			41						
			42						
			43						
			44						
			45						

APPENDIX B
LANGAN TEST PIT LOGS

LOG OF TEST PIT TP-001

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020
LOCATION	**ELEVATION**	
Bartlett St, Northborough, MA	Approx. 272 (NAVD88)	
EXCAVATION CONTRACTOR	**DEPTH**	**WATER LEVEL - First** / **WATER LEVEL - Completion**
Borggaard	9.5 ft	4.5 ft ▽ / N/A ▼
EQUIPMENT	**FOREMAN**	**LANGAN PERSONNEL**
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+272.0	Dark brown f-m SAND, some fine gravel, some roots, trace silt (dry) [TOPSOIL]	0	S-1	GRAB	Vertical side walls maintained during excavation Minimal bucket resistance
	+271.0	Orangish brown f-m SAND, some fine gravel, some silt (dry)	1			
			2	S-2	GRAB	Roots encountered from about 0ft to 1.5ft
	+269.8	Gray fine SAND, some silt, trace fine gravel (moist) [TILL]	3			
			4			
		▽	5			Water encountered seeping in from side walls at 4.5ft
			6			
			7	S-3	GRAB	
			8			
			9			
	+262.5	Bottom of Test Pit at 9.5ft	10			Bottom of test pit at 9.5ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.
			11			
			12			
			13			
			14			

LANGAN

LOG OF TEST PIT TP-002

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020
LOCATION	**ELEVATION**	
Bartlett St, Northborough, MA	Approx. 264 (NAVD88)	
EXCAVATION CONTRACTOR	**DEPTH**	**WATER LEVEL - First** / **WATER LEVEL - Completion**
Borggaard	9 ft	N/E ▽ / N/A ▼
EQUIPMENT	**FOREMAN**	**LANGAN PERSONNEL**
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+264.0	Dark brown f-m SAND, some fine gravel, some organics, some silt (dry) [TOPSOIL]	0	S-1	GRAB	Vertical side walls maintained during excavation Some bucket resistance No groundwater encountered
	+263.0	Orangish brown f-m SAND, some f-m gravel, some silt, trace roots (dry)	1 2	S-2	GRAB	
	+261.0	Gray fine SAND, some silt, some f-m gravel, trace cobbles (moist) [TILL]	3 4 5	S-3	GRAB	Roots encountered from about 0ft-3ft Some redox striations between 3ft-5ft
			6 7 8			
	+255.0	Bottom of Test Pit at 9ft	9 10 11 12 13 14			Bottom of test pit at 9ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.

LANGAN

LOG OF TEST PIT TP-003

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020
LOCATION	**ELEVATION**	
Bartlett St, Northborough, MA	Approx. 269 (NAVD88)	
EXCAVATION CONTRACTOR	**DEPTH**	**WATER LEVEL - First** / **WATER LEVEL - Completion**
Borggaard	9 ft	N/E ▽ / N/A ▼
EQUIPMENT	**FOREMAN**	**LANGAN PERSONNEL**
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+269.0	Dark brown f-m SAND, some fine gravel, some organics, trace silt (dry) [TOPSOIL]	0	S-1	GRAB	Vertical side walls maintained during excavation Minimal bucket resistance No groundwater encountered
	+268.0	Orangish brown f-m SAND, some fine gravel, some silt, trace roots (dry)	1			
			2	S-2	GRAB	
	+266.3	Gray fine SAND, some silt (moist) [TILL]	3			Roots encountered from about 0ft-2.5ft
			4			
			5			
			6	S-3	GRAB	
			7			
			8			
	+260.0	Bottom of Test Pit at 9ft	9			Bottom of test pit at 9ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.
			10			
			11			
			12			
			13			
			14			

LANGAN

LOG OF TEST PIT TP-101

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020
LOCATION	**ELEVATION**	
Bartlett St, Northborough, MA	Approx. 273 (NAVD88)	
EXCAVATION CONTRACTOR	**DEPTH**	**WATER LEVEL - First** / **WATER LEVEL - Completion**
Borggaard	12 ft	N/E ▽ / N/A ▼
EQUIPMENT	**FOREMAN**	**LANGAN PERSONNEL**
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+273.0	Dark brown f-m SAND, some fine gravel, some roots, trace silt (dry) [TOPSOIL]	0			Vertical side walls maintained during excavation Minimal bucket resistance No groundwater encountered
	+271.7	Orangish brown f-m SAND, some silt, some roots, some fine gravel (dry)	1			
			2			Roots encountered from about 0ft-2.5ft
			3			
				S-1	GRAB	
		Dark brown to black f-c SAND, some fine gravel (dry)	4			
	+268.7		5			
		Gray fine SAND, some silt, trace fine gravel (moist) [TILL]	6			
			7			
			8			
			9			
			10			
			11			Redox striations at about 11.5ft
	+261.0		12			Bottom of test pit at 12ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.
		Bottom of Test Pit at 12ft	13			
			14			

LANGAN

LOG OF TEST PIT TP-102

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020
LOCATION	**ELEVATION**	
Bartlett St, Northborough, MA	Approx. 271 (NAVD88)	
EXCAVATION CONTRACTOR	**DEPTH**	**WATER LEVEL - First** / **WATER LEVEL - Completion**
Borggaard	11.4 ft	N/E ▽ / N/A ▼
EQUIPMENT	**FOREMAN**	**LANGAN PERSONNEL**
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+271.0	Dark brown f-m SAND, some roots, trace silt, trace fine gravel (dry) [TOPSOIL]	0			Vertical side walls maintained during excavation Minimal bucket resistance No groundwater encountered
	+269.6	Orangish brown f-m SAND, some silt, some fine gravel, some roots (dry)	1			
		Grayish brown to black f-c SAND, some fine gravel (dry)	2			
	+266.8	Grayish brown f-m SAND, some silt, some f-m gravel (moist) [TILL]	3			Roots encountered from about 0ft-3ft
	+259.6	Bottom of Test Pit at 11.4ft	4			Bottom of test pit at 11.4ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.
			5			
			6			
			7			
			8			
			9			
			10			
			11			
			12			
			13			
			14			

LANGAN

LOG OF TEST PIT TP-103

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020
LOCATION	**ELEVATION**	
Bartlett St, Northborough, MA	Approx. 259 (NAVD88)	
EXCAVATION CONTRACTOR	**DEPTH**	**WATER LEVEL - First** / **WATER LEVEL - Completion**
Borggaard	9 ft	N/E ▽ / N/A ▼
EQUIPMENT	**FOREMAN**	**LANGAN PERSONNEL**
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+259.0	Dark brown f-m SAND, some roots, trace fine gravel, trace silt (dry) [TOPSOIL]	0			Vertical side walls maintained during excavation Minimal bucket resistance No groundwater encountered
	+258.0	Orangish brown f-m SAND, some f-m gravel, some silt, trace roots (dry)	1			
	+257.0	Gray fine SAND, some silt, trace fine gravel (moist) [TILL]	2 3 4 5 6 7 8 9			Roots encountered from about 0ft-5ft
	+250.0	Bottom of Test Pit at 9ft	10 11 12 13 14			Bottom of test pit at 9ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.

LANGAN

LOG OF TEST PIT TP-104

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020
LOCATION	**ELEVATION**	
Bartlett St, Northborough, MA	Approx. 254 (NAVD88)	
EXCAVATION CONTRACTOR	**DEPTH**	**WATER LEVEL - First** / **WATER LEVEL - Completion**
Borggaard	9.5 ft	N/E ▽ / N/A ▼
EQUIPMENT	**FOREMAN**	**LANGAN PERSONNEL**
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+254.0	Dark brown f-m SAND, some organics, trace silt, trace fine gravel (dry) [TOPSOIL]	0			Vertical side walls maintained during excavation Minimal bucket resistance No groundwater encountered
	+253.0		1			
			2			Roots encountered from about 0ft-2ft
		Gray fine SAND, some silt, trace fine gravel, trace roots (moist) [TILL]	3			
			4			
			5			
			6			
			7			
			8			
			9			Redox striation at about 9ft
	+244.5					Bottom of test pit at 9.5ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.
		Bottom of Test Pit at 9.5ft	10			
			11			
			12			
			13			
			14			

LANGAN

LOG OF TEST PIT TP-105

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020
LOCATION	**ELEVATION**	
Bartlett St, Northborough, MA	Approx. 259 (NAVD88)	
EXCAVATION CONTRACTOR	**DEPTH**	**WATER LEVEL - First** / **WATER LEVEL - Completion**
Borggaard	9 ft	N/E ▽ / N/A ▼
EQUIPMENT	**FOREMAN**	**LANGAN PERSONNEL**
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+259.0	Dark brown f-m SAND, some organics, some fine gravel, trace silt (dry) [TOPSOIL]	0			Vertical side walls maintained during excavation Moderate bucket resistance No groundwater encountered
	+258.0	Orangish brown f-m SAND, some silt, some fine gravel, trace roots (dry)	1			
			2			Roots encountered from about 0ft-2ft
	+256.0		3			
		Gray fine SAND, some silt, trace f-c gravel, trace boulders (moist) [TILL]	4			
			5			
			6			
			7			
			8			
	+250.0		9			Possible boulders at bottom of test pit. Heavy bucket resistance Bottom of test pit at 9ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.
		Bottom of Test Pit at 9ft	10			
			11			
			12			
			13			
			14			

LANGAN

LOG OF TEST PIT TP-106

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020

LOCATION	ELEVATION
Bartlett St, Northborough, MA	Approx. 285 (NAVD88)

EXCAVATION CONTRACTOR	DEPTH	WATER LEVEL - First	WATER LEVEL - Completion
Borggaard	9 ft	N/E ▽	N/A ▼

EQUIPMENT	FOREMAN	LANGAN PERSONNEL
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+285.0	Dark brown f-m SAND, some organics, trace silt (dry) [TOPSOIL]	0			Vertical side walls maintained during excavation Minimal bucket resistance No groundwater encountered
	+284.0	Orangish brown f-m SAND, some silt, some fine gravel (dry)	1			
			2			
	+282.0		3			
		Gray fine SAND, some silt, trace fine gravel (moist) [TILL]	4			
			5			Roots encountered from about 0ft-5ft
			6			
			7			
			8			
	+276.0		9			Bottom of test pit at 9ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.
		Bottom of Test Pit at 9ft	10			
			11			
			12			
			13			
			14			

LANGAN

LOG OF TEST PIT TP-107

PROJECT NAME	PROJECT NUMBER	DATE
Copley Parcel H	151011301	2/25/2020
LOCATION	**ELEVATION**	
Bartlett St, Northborough, MA	Approx. 285 (NAVD88)	
EXCAVATION CONTRACTOR	**DEPTH**	**WATER LEVEL - First** / **WATER LEVEL - Completion**
Borggaard	9 ft	N/E ▽ / N/A ▼
EQUIPMENT	**FOREMAN**	**LANGAN PERSONNEL**
Hitachi Excavator 450	Chris Merrill	Olivia Chasse

Symbol	ELEV (feet)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+285.0	Dark brown f-m SAND, some organics, trace silt, trace fine gravel (dry) [TOPSOIL]	0			Vertical side walls maintained during excavation Minimal bucket resistance No groundwater encountered
	+284.0	Orangish brown f-m SAND, some silt, trace fine gravel, trace roots (dry) Brown to blackish brown f-c SAND, some fine gravel (moist)	1 2 3 4 5			Roots encountered from about 0ft-2ft
	+279.5	Gray fine SAND, some silt, trace fine gravel (moist) [TILL]	6 7 8 9			
	+276.0	Bottom of Test Pit at 9ft	10 11 12 13 14			Bottom of test pit at 9ft. Test pit backfilled with excavated material in 1-2 foot lifts and compacted with the excavator bucket.

LANGAN

APPENDIX C
LANGAN TEST PIT PHOTOGRAPHS

Photo 1: TP-001

Photo 2: TP-001

Photo 3: TP-001

Photo 4: TP-001

Photo 5: TP-002

Photo 6: TP-002

Photo 7: TP-002

Photo 8: TP-003

Photo 9: TP-003

Photo 10: TP-003

Photo 11: TP-101

Photo 12: TP-101

Photo 13: TP-101

Photo 14: TP-101

Photo 15: TP-102

Photo 16: TP-102

Photo 17: TP-102

Photo 18: TP-104

Photo 19: TP-104

Photo 20: TP-105

Photo 21: TP-105

Photo 22: TP-106

Photo 23: TP-106

Photo 24: TP-106

Photo 25: TP-106

Photo 26: TP-107

Photo 27: TP-107

Photo 28: TP-107

APPENDIX D
WELL CONSTRUCTION LOGS

WELL CONSTRUCTION SUMMARY

Well No. LB-05 (OW)

PROJECT	Copley Parcel H	**PROJECT NO.**	151011301
LOCATION	Northborough, MA	**ELEVATION AND DATUM**	Approx. 284 NAVD88
DRILLING AGENCY	Northern Drill Services	**DATE STARTED**	2/28/2020 **DATE FINISHED** 2/28/2020
DRILLING EQUIPMENT	Mobile Drill B-48 Truck Rig	**DRILLER**	Tim Tucker
SIZE AND TYPE OF BIT	4-1/4" ID Hollow Stem Auger	**INSPECTOR**	Olivia Chasse

METHOD OF INSTALLATION

Boring LB-05(OW) was advanced to about 25ft with 4-1/4" HSA. The screen and riser for well was placed into the borehole. #1 sand was poured around the pipe to 2ft. above the screen as the augers were removed. A 2 foot seal of 3/8" Bentonite Chips was placed. The rest of the augers were removed and the remaining of the borehole was backfilled with auger cuttings. A stand pipe was installed over the well.

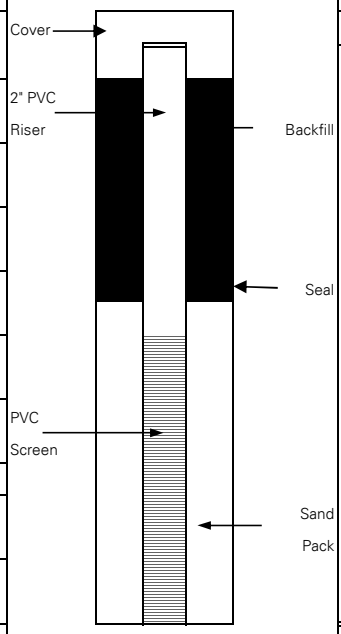
METHOD OF WELL DEVELOPMENT

N/A

TYPE OF CASING	PVC	**DIAMETER**	2in.	**TYPE OF BACKFILL MATERIAL**	Auger cuttings
TYPE OF SCREEN	PVC	**DIAMETER**	2in.	**TYPE OF SEAL MATERIAL**	3/8" Bentonite Chips
BOREHOLE DIAMETER	4-1/4"			**TYPE OF FILTER MATERIAL**	#1 sand

TOP OF CASING	**ELEVATION**	**DEPTH (ft)**
	el. 285.83	-1.83
TOP OF BACKFILL	**ELEVATION**	**DEPTH (ft)**
	el. 284	0
TOP OF SEAL	**ELEVATION**	**DEPTH (ft)**
	el. 273	11
TOP OF FILTER	**ELEVATION**	**DEPTH (ft)**
	el. 271	13
TOP OF SCREEN	**ELEVATION**	**DEPTH (ft)**
	el. 269	15
BOTTOM OF BORING	**ELEVATION**	**DEPTH (ft)**
	el. 259	25
SCREEN LENGTH	10ft.	
SLOT SIZE	.1in.	

WELL DETAILS



SUMMARY SOIL CLASSIFICATION	DEPTH (FT)
Top of Casing	-1.8
Ground Surface	0.0
Fill	1.0
Fill	11.0
Fill	13.0
Till	25.0

GROUNDWATER ELEVATIONS

DATE	ELEVATION	DEPTH TO WATER (ft)
2/28/2020	271.40	12.60

WELL CONSTRUCTION SUMMARY

Well No. LB-08 (OW)

PROJECT	Copley Parcel H	**PROJECT NO.**	151011301
LOCATION	Northborough, MA	**ELEVATION AND DATUM**	Approx. 270 NAVD88
DRILLING AGENCY	Northern Drill Services	**DATE STARTED**	2/28/2020 **DATE FINISHED** 2/28/2020
DRILLING EQUIPMENT	Mobile Drill B-48 Truck Rig	**DRILLER**	Tim Tucker
SIZE AND TYPE OF BIT	4-1/4" ID Hollow Stem Auger	**INSPECTOR**	Olivia Chasse

METHOD OF INSTALLATION

Boring LB-08(OW) was advanced to about 25ft with 4-1/4" HSA. The screen and riser for well was placed into the borehole. #1 sand was poured around the pipe to 2ft. above the screen as the augers were removed. A 2 foot seal of 3/8" Bentonite Chips was placed. The rest of the augers were removed and the remaining of the borehole was backfilled with auger cuttings. A stand pipe was installed over the well.

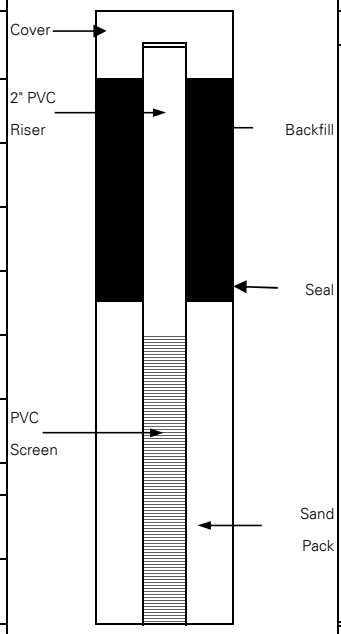
METHOD OF WELL DEVELOPMENT

N/A

TYPE OF CASING	PVC	**DIAMETER**	2in.	**TYPE OF BACKFILL MATERIAL**	Auger cuttings
TYPE OF SCREEN	PVC	**DIAMETER**	2in.	**TYPE OF SEAL MATERIAL**	3/8" Bentonite Chips
BOREHOLE DIAMETER	4-1/4"			**TYPE OF FILTER MATERIAL**	#1 sand

TOP OF CASING	**ELEVATION**	**DEPTH (ft)**
	el. 272.33	-2.33
TOP OF BACKFILL	**ELEVATION**	**DEPTH (ft)**
	el. 270	0
TOP OF SEAL	**ELEVATION**	**DEPTH (ft)**
	el. 259	11
TOP OF FILTER	**ELEVATION**	**DEPTH (ft)**
	el. 257	13
TOP OF SCREEN	**ELEVATION**	**DEPTH (ft)**
	el. 255	15
BOTTOM OF BORING	**ELEVATION**	**DEPTH (ft)**
	el. 245	25
SCREEN LENGTH	10ft.	
SLOT SIZE	.1in.	

WELL DETAILS



SUMMARY SOIL CLASSIFICATION	DEPTH (FT)
Top of Casing	-2.3
Ground Surface	0.0
Topsoil	1.0
Sand	2.0
Till	11.0
Till	13.0
Till	25.0

GROUNDWATER ELEVATIONS

DATE	ELEVATION	DEPTH TO WATER (ft)
2/28/2020	253.30	16.70

APPENDIX E
LABORATORY TESTING RESULTS

Client:	Langan Engineering				
Project:	Copley Parcel H				
Location:	Northborough, MA			Project No:	GTX-311452
Boring ID:	---	Sample Type:	---	Tested By:	ckg
Sample ID:	---	Test Date:	03/21/20	Checked By:	jsc
Depth :	---	Test Id:	550277		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
LB-02	S- 4	6-8 ft	Moist, light yellowish brown silt with sand	15.4
LB-05	S- 3	4-6 ft	Moist, dark yellowish brown silty sand	20.3
LB-07	S- 2	2-4 ft	Moist, dark grayish brown sand with gravel	3.6
LB-08	S- 3	4-6 ft	Moist, olive brown silt	25.1

Notes: Temperature of Drying : 110º Celsius

Client:	Langan Engineering				
Project:	Copley Parcel H				
Location:	Northborough, MA			Project No:	GTX-311452
Boring ID:	---	Sample Type:	---	Tested By:	ckg
Sample ID:	---	Test Date:	03/24/20	Checked By:	jsc
Depth :	---	Test Id:	550278		

Amount of Material Passing #200 Sieve - ASTM D1140

Boring ID	Sample ID	Depth	Visual Description	Fines, %
LB-03	S-6	10-12 ft	Moist, olive brown silt	80.7
LB-08	S-3	4-6 ft	Moist, olive brown silt	88.9

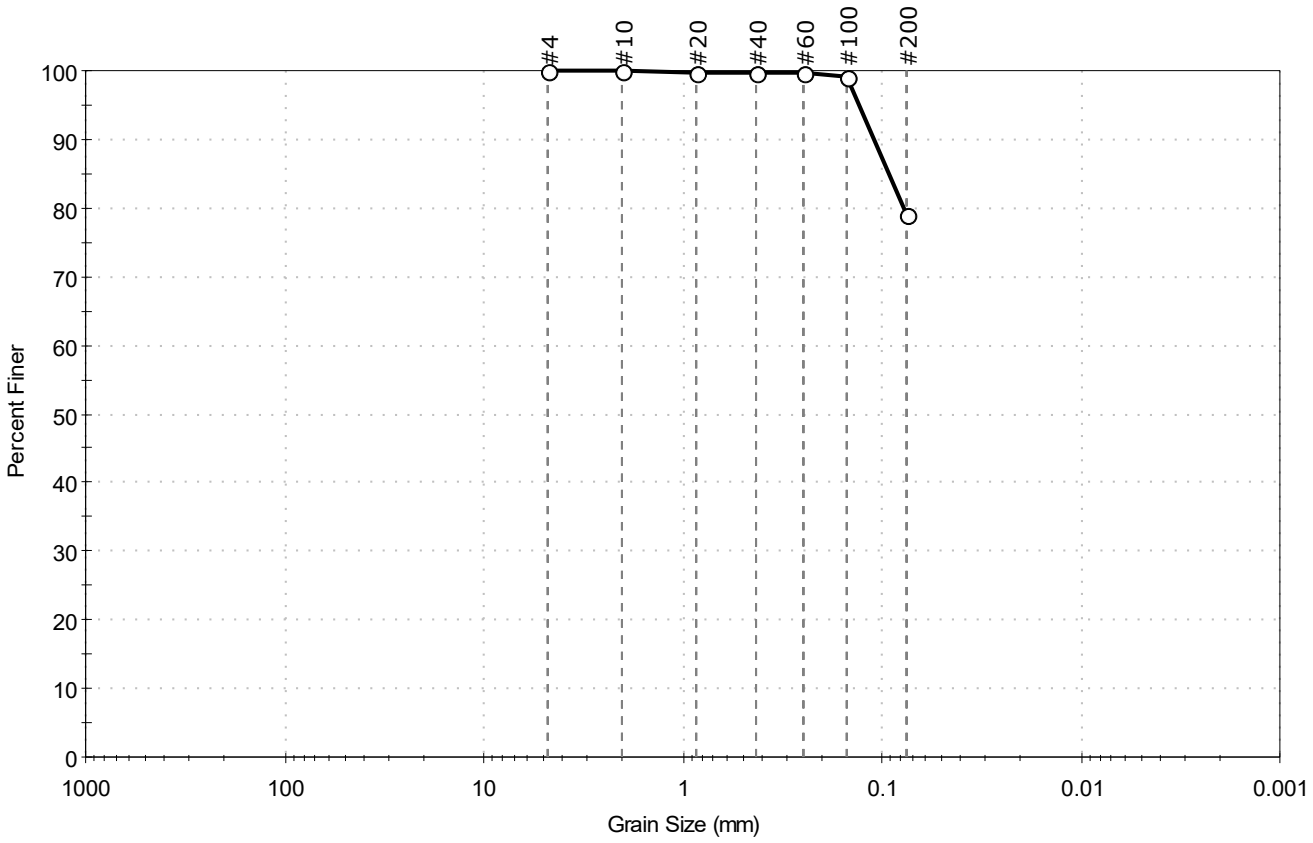
Notes: Tests performed using Method B - washing using a wetting agent
Dry mass of test specimen was determined directly

GeoTesting EXPRESS

Client:	Langan Engineering				
Project:	Copley Parcel H				
Location:	Northborough, MA			Project No:	GTX-311452
Boring ID:	LB-02	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-4	Test Date:	03/24/20	Checked By:	jsc
Depth :	6-8 ft	Test Id:	550271		

Test Comment: ---
Visual Description: Moist, light yellowish brown silt with sand
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	21.1	78.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	99		
#200	0.075	79		

Coefficients

D_{85} = 0.0925 mm D_{30} = N/A
D_{60} = N/A D_{15} = N/A
D_{50} = N/A D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

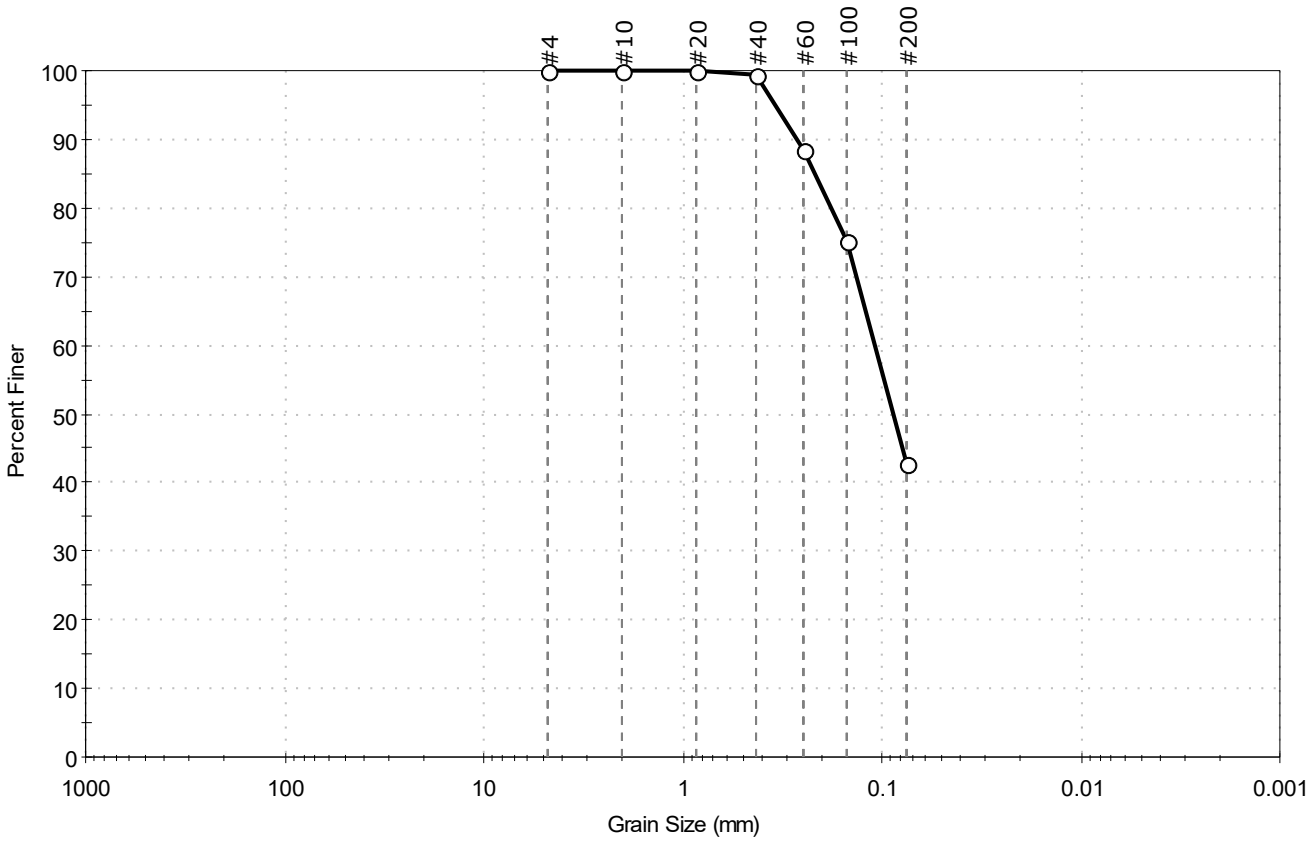
Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

printed 3/24/2020 1:40:05 PM

Client:	Langan Engineering				
Project:	Copley Parcel H				
Location:	Northborough, MA			Project No:	GTX-311452
Boring ID:	LB-05	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-3	Test Date:	03/24/20	Checked By:	jsc
Depth :	4-6 ft	Test Id:	550272		
Test Comment:	---				
Visual Description:	Moist, dark yellowish brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	57.1	42.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	99		
#60	0.25	89		
#100	0.15	75		
#200	0.075	43		

Coefficients

D_{85} = 0.2183 mm D_{30} = N/A

D_{60} = 0.1083 mm D_{15} = N/A

D_{50} = 0.0874 mm D_{10} = N/A

C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

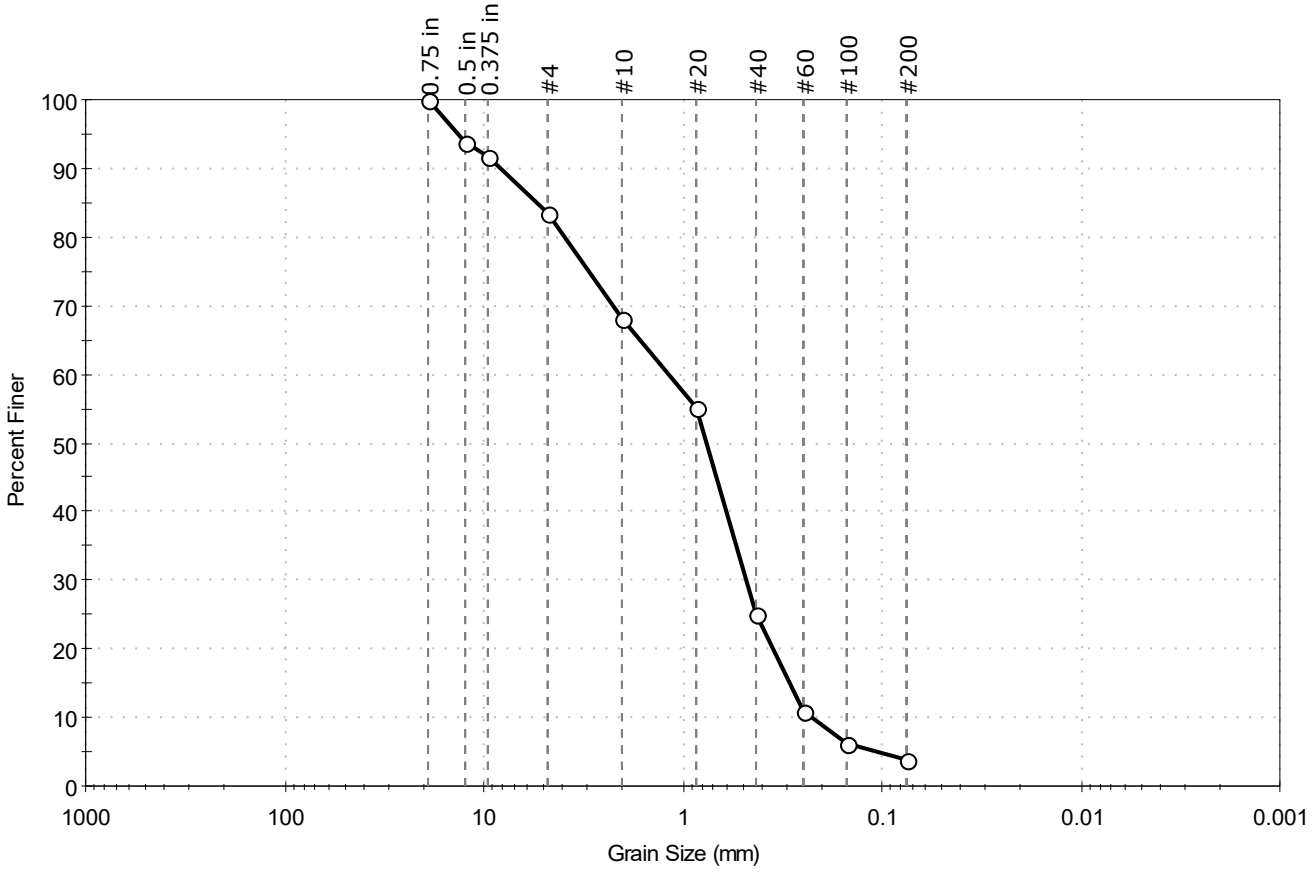
Sand/Gravel Hardness : ---

GeoTesting EXPRESS

Client:	Langan Engineering				
Project:	Copley Parcel H				
Location:	Northborough, MA			Project No:	GTX-311452
Boring ID:	LB-07	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-2	Test Date:	03/24/20	Checked By:	jsc
Depth :	2-4 ft	Test Id:	550270		

Test Comment: ---
Visual Description: Moist, dark grayish brown sand with gravel
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	16.6	79.6	3.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	94		
0.375 in	9.50	92		
#4	4.75	83		
#10	2.00	68		
#20	0.85	55		
#40	0.42	25		
#60	0.25	11		
#100	0.15	6		
#200	0.075	3.8		

Coefficients

D_{85} = 5.4156 mm
D_{60} = 1.1674 mm
D_{50} = 0.7546 mm
C_u = 5.111
D_{30} = 0.4767 mm
D_{15} = 0.2924 mm
D_{10} = 0.2284 mm
C_c = 0.852

Classification

ASTM: Poorly graded SAND with Gravel (SP)

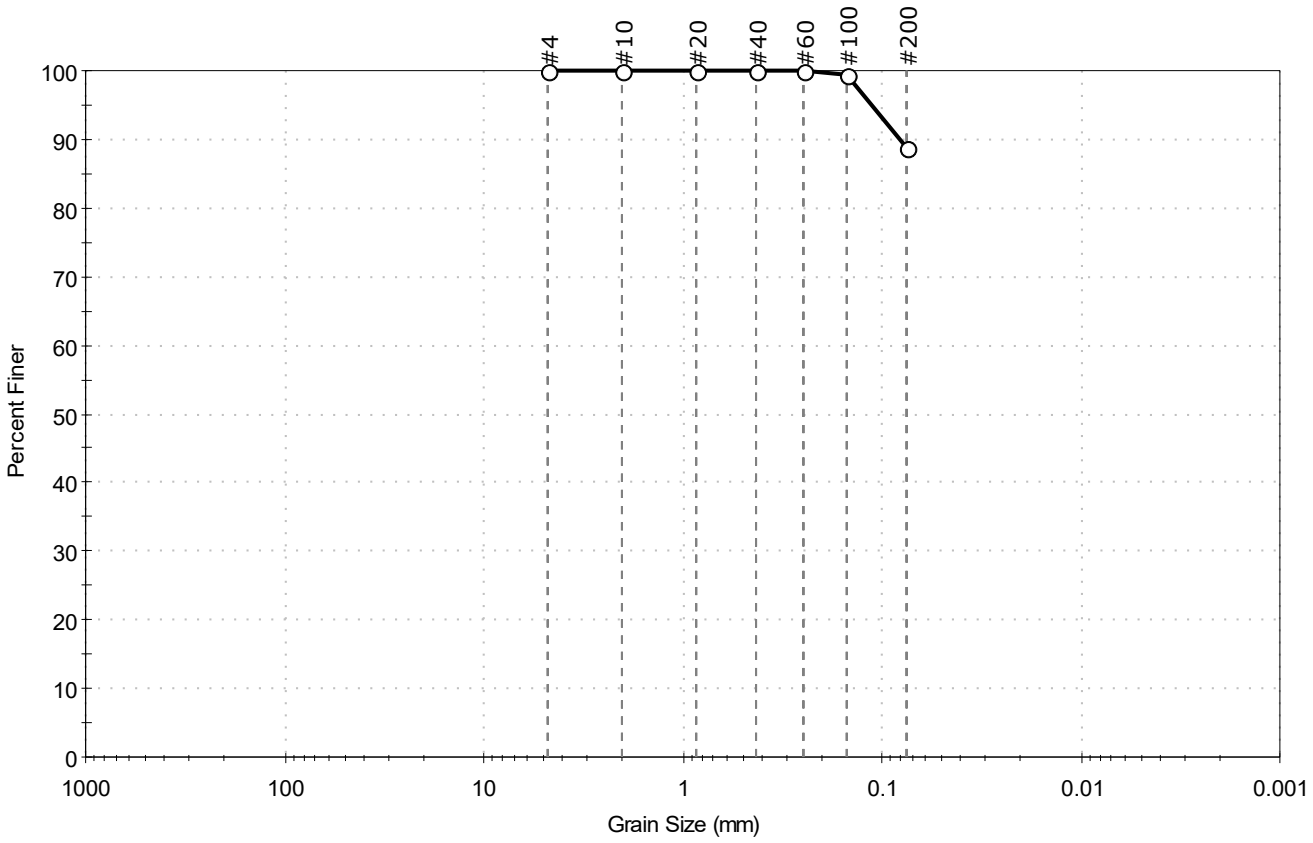
AASHTO: Stone Fragments, Gravel and Sand (A-1-b (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR
Sand/Gravel Hardness : HARD

Client:	Langan Engineering				
Project:	Copley Parcel H				
Location:	Northborough, MA			Project No:	GTX-311452
Boring ID:	LB-08	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-3	Test Date:	03/24/20	Checked By:	jsc
Depth :	4-6 ft	Test Id:	550273		
Test Comment:	---				
Visual Description:	Moist, olive brown silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	11.1	88.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	100		
#200	0.075	89		

Coefficients

D_{85} = N/A	D_{30} = N/A
D_{60} = N/A	D_{15} = N/A
D_{50} = N/A	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

printed 3/24/2020 1:40:08 PM

APPENDIX F
PAVEMENT DESIGN

Project Information:

Project Title: Copley Parcel H
Project Town: Northborough
Project State: Massachusetts
Client: The Gutierrez Company

Project No.: 151011301
Performed By: TDS
Date: 3/19/2020

Design Information:

- Design Life: 20 years
- Initial Servicibility (Po): 4.2
- Terminal Servicibility Index (TSI): 2.0
- Servicibility (Po - TSI): 2.2

- Reliability Factor (R): 0.85
- Standard Deviation (Sd): 0.45
- Direction Distribution Factor (Do): 1.00
- Lane Distribution Factor (Dl): 1.00

- Soil Description: SAND
- USCS Symbol: SP/SM
- California Bearing Ratio (CBR): 10
- Resilient Modulus (MR): 15000 PSI

CBR Based on: Estimated Value
**MR = CBR*1,500*

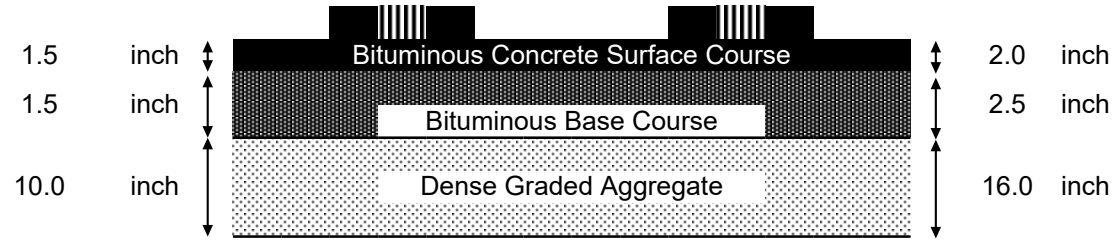
Summary of Results

Standard Section

Design ESAL: 84,783

Heavy Duty Section

Design ESAL: 5,730,532



LANGAN
555 Long Wharf Drive, New Haven, CT 06511
T: 203.562.5771 F: 203.789.6142 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO WASHINGTON, DC FLORIDA TEXAS NORTH DAKOTA CALIFORNIA ABU DHABI ATHENS DOHA DUBAI ISTANBUL PANAMA

Project: Copley Parcel H, Northborough, Massachusetts	Drawing Title: Pavement Design Summary Sheet	Project No.: 151011301	Drawing No.: P.01
		Date: 3/19/2020	
		Scale: Not to Scale	
		Drawn By: TDS	Sheet 1 of 4

Calculate Equivalent 18-kip Single Axle Loading (ESALs)

Equivalent Single Axle Loads per Vehicle

			Load Equivalency Factors:		
○ ***Typical Car:***				Calculated ESALs	
(S)	Front Single Axle:	2 kips	LEF = 0.0004	(1 axle)(0.0004)+(1 axle)(0.0004) =	**0.0008 /car**
(S)	Rear Single Axle:	2 kips	LEF = 0.0004		
○ ***Typical Light Duty Truck (H20):***				Calculated ESALs	
(S)	Front Single Axle:	8 kips	LEF = 0.051	(1 axle)(0.051)+(1 axle)(0.051) =	**0.94 /truck**
(T)	Truck Rear Axle:	32 kips	LEF = 0.889		
○ ***Typical Truck and Trailer (HS20):***				Calculated ESALs	
(S)	Front Single Axle:	8 kips	LEF = 0.051	(Front axle)(0.051)+(Rear axle)(0.889)	
(T)	Truck Rear Axle:	32 kips	LEF = 0.889	+(Trailer Tandem)(0.889))&) =	**1.829 /truck**
(T)	Trailer Axle:	32 kips	LEF = 0.889		

(S) = single axle, (T) = Tandem, (3) = Triple Axles

Traffic Loading ○ Design Life: 20 years (From Sheet P.01)

Standard Pavement Section

Vehicle Types	Current Traffic	Growth Factors	Design Traffic	ESAL Factor	Design ESAL
Passenger Cars	200	2% 24.30	1,773,708	0.0008	1,419
Light Trucks	10	2% 24.30	88,685	0.94	83,364

Standard Design ESAL: **84,783**

Heavy Duty Pavement Section

Vehicle Types	Current Traffic	Growth Factors	Design Traffic	ESAL Factor	Design ESAL
Passenger Cars	200	2% 24.30	1,773,708	0.0008	1,419
Light Trucks	10	2% 24.30	88,685	0.94	83,364
Heavy Trucks	284	4% 29.78	3,086,796	1.829	5,645,749

Heavy Duty Design ESAL: **5,730,532**

LANGAN
555 Long Wharf Drive, New Haven, CT 06511
T: 203.562.5771 F: 203.789.6142 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO WASHINGTON, DC FLORIDA TEXAS NORTH DAKOTA CALIFORNIA ABU DHABI ATHENS DOHA DUBAI ISTANBUL PANAMA

Project	Drawing Title	Project No.	Drawing No.
Copley Parcel H	ESAL Calculation	151011301	P.02
Northborough Massachusetts		Date 3/19/2020	
		Scale Not to Scale	
		Drawn By TDS	Sheet 2 of 4

Design Information (from P.01):

- Reliability Factor (R): 0.85
- Standard Deviation (Sd): 0.45
- Resilient Modulus (MR): 15
- Servicibility (Po - TSI): 2.2

Traffic Information (from P.02):

- Standard ESALs (W18): 84,783
  (millions) 0.085
- Heavy Duty ESALs (W18): 5,730,532
  (millions) 5.73

From Nomograph:

Design Structural Number (SN)

Standard Section:

1.8

Heavy Duty Section:

3.5

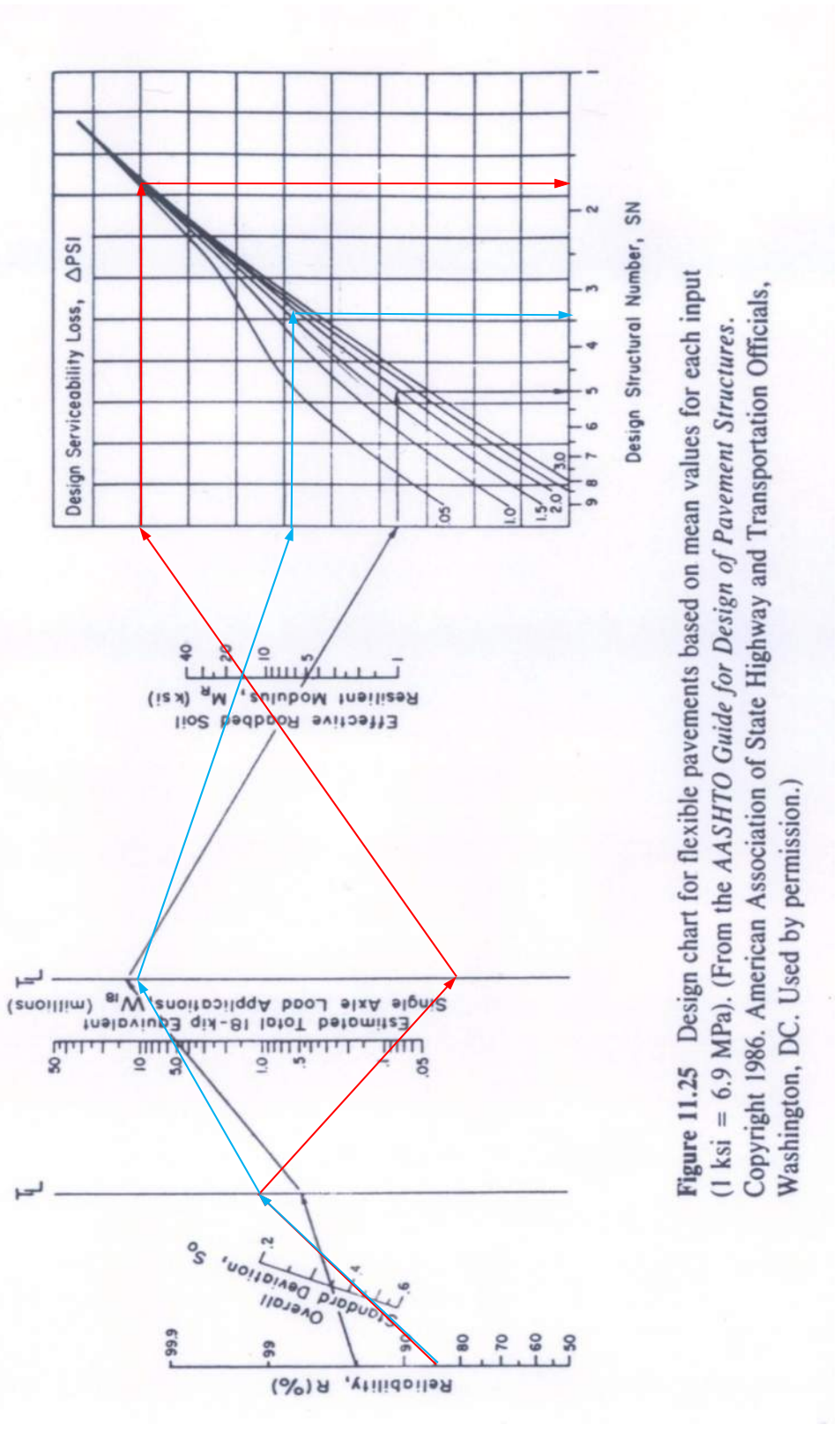


Figure 11.25 Design chart for flexible pavements based on mean values for each input (1 ksi = 6.9 MPa). (From the *AASHTO Guide for Design of Pavement Structures*. Copyright 1986. American Association of State Highway and Transportation Officials, Washington, DC. Used by permission.)

LANGAN
555 Long Wharf Drive, New Haven, CT 06511
T: 203.562.5771 F: 203.789.6142 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO WASHINGTON, DC FLORIDA TEXAS NORTH DAKOTA CALIFORNIA
ABU DHABI ATHENS DOHA DUBAI ISTANBUL PANAMA

Project	Drawing Title	Project No.	Drawing No.
Copley Parcel H Northborough Massachusetts	AASHTO Flexible Pavement Nomograph	151011301	P.03
		Date 3/19/2020	
		Scale As Shown	
		Drawn By TDS	Sheet 3 of 4

Flexible Pavement Section Calculation:

Structural Number:
SN = D1(a1)+D2(a2)+D3(a3)

Standard Section:

Material	Spec	Thickness (inch)		Layer Strength		SN
Bituminuous Concrete Surface Course	Class 2	D1	1.5	a1	0.44	0.66
Bituminuous Concrete Binder Course	Class 1	D2	1.5	a2	0.44	0.66
Dense Graded Aggregate	Subbase	D3	10.0	a3	0.11	1.10
				Calculated Structural Number for Section:		**2.42**
				Check Calculated SN is > Design SN:		OK
				Design Light Duty Structural Number SN:		1.8 (from P.03)

Heavy Duty Section:

Material	Spec	Thickness (inch)		Layer Strength		SN
Bituminuous Concrete Surface Course	Class 2	D1	2.0	a1	0.44	0.88
Bituminuous Concrete Binder Course	Class 1	D2	2.5	a2	0.44	1.10
Dense Graded Aggregate	Subbase	D3	16.0	a3	0.11	1.76
				Calculated Structural Number for Section:		**3.74**
				Check Calculated SN is > Design SN:		OK
				Design Heavy Duty Structural Number SN:		3.5 (from P.03)

**Minimum Recommended Standard Section in Practice = 1.5", 1.5", 6"*
**Minimum Recommended Heavy Section in Practice = 1.5", 2.5", 8"*

LANGAN
555 Long Wharf Drive, New Haven, CT 06511
T: 203.562.5771 F: 203.789.6142 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO WASHINGTON, DC FLORIDA TEXAS NORTH DAKOTA CALIFORNIA ABU DHABI ATHENS DOHA DUBAI ISTANBUL PANAMA

Project: Copley Parcel H, Northborough, Massachusetts	Drawing Title: Flexible Pavement Section Calculation	Project No.: 151011301	Drawing No.: P.04	
		Date: 3/19/2020		
		Scale: As Shown		
		Drawn By: TDS	Sheet 4 of 4	