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REPORT ON

SUBSURFACE INVESTIGATIONS AND GEOTECHNICAL DESIGN RECOMMENDATIONS
1 CORPORATE DRIVE
ANDOVER, MASSACHUSETTS

by
Haley & Aldrich, Inc.
Boston, Massachusetts

for
IQHQ, Inc.
Boston, Massachusetts

File No. 0203691-000
January 2022

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Attention: Bryan Gubbins
Matt Formicola

Subject: Subsurface Investigations and Geotechnical Design Recommendations
1 Corporate Drive
Andover, Massachusetts

Ladies and Gentlemen:

This report summarizes the results of subsurface investigations conducted in association with and provides recommendations for geotechnical design and construction for the proposed addition to the existing 1 Corporate Drive building in Andover, Massachusetts. Our work was performed in accordance with our proposal dated 29 October 2021 and your subsequent authorization.

We appreciate the opportunity to serve on your team. Please feel free to contact us if you wish to discuss the contents of this report or any aspect of this project.

Sincerely yours,
HALEY & ALDRICH, INC.

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1. Introduction

1.1 ELEVATION DATUM

Elevations reported herein are in feet (ft) and reference the National Geodetic Vertical Datum of 1929 (NGVD).

1.2 EXISTING SITE CONDITIONS

The subject site is located in Andover, Massachusetts, as shown on Figure 1 – Project Locus. The site is occupied by the existing 1 Corporate Drive building, which consists of a two-story structure with no below-grade space. The recent test pit explorations conducted at the site indicate the existing building is supported on shallow footing foundations deriving support in the naturally deposited glacial soils underlying the site. The site of the proposed building addition is currently occupied by an at-grade parking lot to the east of the existing 1 Corporate Drive building. Existing site grades are variable, generally ranging from elevation (El.) 163 to El. 140; site grades within the footprint of the proposed building addition are less variable, gently sloping from about El. 155 in the southwest building corner to about El. 152 at the northeast building corner.

1.3 PROPOSED DEVELOPMENT

Our current understanding of the proposed development is based on review of the most recent drawing set for the project, dated 22 December 2021, as well as on-going project team coordination meetings. The proposed redevelopment is planned to include construction of a new two-story building addition immediately to the east of the existing 1 Corporate Drive building. The building addition is planned to be connected to the existing 1 Corporate Drive building via an atrium structure. No below-grade space is planned. The proposed building addition is planned to be supported on conventional footing foundations deriving support in the naturally deposited glacial soils underlying the site. We understand the proposed development also includes stormwater infiltration structures to be installed outside the proposed building limits.

2. Summary of Subsurface Explorations and Subsurface Conditions

2.1 GENERAL

A series of test pit explorations was recently undertaken at the site in association with the proposed new addition to the existing 1 Corporate Drive building. The purpose of the test pits was to 1) determine the nature and thickness of the site fill soils, 2) determine the depth to naturally deposited soils suitable for foundation bearing (Glacial Till), 3) observe existing foundation conditions of the existing 1 Corporate Drive building, 4) observe site groundwater conditions, 5) obtain information on the suitability of the site soils for on-site infiltration, and 6) obtain information on the nature of the soils at the site to evaluate the potential for reuse during construction.

2.2 SUBSURFACE EXPLORATIONS

2.2.1 Previous Test Borings

Numerous previous exploration programs were conducted in association with the development of the nearby 4 Corporate Drive property generally located north of the subject Site. Two (2) previous test borings, designated B98-1 (OW) and B98-6, from a series of geotechnical explorations conducted in May 1998 in association with the 4 Corporate Drive property, are located at the 1 Corporate Drive project site, as shown on Figure 2, Site and Subsurface Exploration Location Plan. Logs of test borings B98-1 (OW) and B98-6, as well as an observation well installation record for B98-1 (OW) are provided in Appendix A for reference.

2.2.2 Recent Test Pits

During the period 10 to 16 November 2021, Earthwork Industries, Inc., a subcontractor to Haley & Aldrich, Inc. (Haley & Aldrich), excavated 14 test pits designated HA21-TP1 to HA21-TP8, HA21-TP10 to HA21-TP15. Due to site constraints that limited site access, HA21-TP9 was omitted from the exploration program. The test pits were advanced to depths ranging from approximately 5.5 to 11.6 ft below ground surface (bgs). A summary of recent test pit explorations is included in Table I. Test pit logs are included in Appendix B. Refer to Appendix C for an annotated photographic summary of the conditions encountered in the recent test pits.

2.3 SUBSURFACE SOIL AND GROUNDWATER CONDITIONS

2.3.1 Soil Conditions

In general, subsurface soil conditions encountered in the recent test pits included various Fill soils overlying naturally deposited inorganic Glacial Till Deposits as described below:

- Fill: A layer of heterogeneous fill material was encountered at each test pit location ranging from about 1.5 to 7.5 ft in thickness. In paved areas of the site, a 0.3- to 0.4-ft thick layer of asphalt pavement was encountered above the fill. The fill generally consisted of SAND with varying amounts of silt, gravel and cobbles or SILT with varying amounts of sand, gravel, cobbles and boulders. Deleterious materials, including roots, wood, organic soils, and scrap building materials, were encountered within the fill. At test pit locations HA21-TP2 through HA21-TP5, HA21-TP7, HA21-TP11 and HA21-TP13, remnant topsoil and subsoil were observed at the bottom of the fill layer and above the naturally deposited Glacial Deposits.

- Glacial Till Deposits: Glacial Till Deposits were encountered beneath the fill, topsoil and subsoil (where encountered) at each test pit location at depths ranging from approximately 1.5 to 7.5 ft bgs, corresponding to about El. 159.2 to El. 139.1. The Glacial Till Deposits generally consisted of silty SAND with varying amounts of gravel, cobbles and boulders.

2.3.2 Groundwater Conditions

Groundwater levels observed during excavation of the recent test pit explorations ranged from approximately 7.4 to 11.0 ft bgs, corresponding to about El. 153.2 to El. 134.1, and were determined by observing seepage into the test pit excavations. The estimated seasonal high groundwater table was observed to range from about 5.5 to 10.0 ft bgs, corresponding to El. 154.9 to El. 136.0, based on redoximorphic features observed within the test pits. The bottom of proposed infiltration systems should be set a minimum of 2 ft above seasonal high groundwater.

Groundwater levels should be anticipated to fluctuate with season, precipitation, nearby construction activities, nearby below-grade structures (such as utilities/infiltration systems) and other environmental factors. Area groundwater levels will also be influenced by rainfall, local construction activity, surface runoff, leakage into and out of sewers, storms drains, and other below-grade structures, pumping of dewatering systems, season, temperature, and other factors. As a result, groundwater levels observed during and following construction may vary from those reported herein.

2.4 EXISTING FOUNDATION CONDITIONS

Three (3) of the recent test pit excavations, designated HA21-TP1, HA21-TP14, and HA21-TP15, were completed along a perimeter wall of the existing 1 Corporate Drive building to observe and document existing building foundation conditions adjacent to the proposed 1 Corporate building addition. In general, the results of the test pits indicate the existing 1 Corporate Drive building is supported by footing foundations deriving support in the naturally deposited Glacial soils at the site, or in imported structural Fill placed above the naturally deposited Glacial soils. Existing foundation conditions observed in the recent test pits varied but in general the existing footings were found to bear about 4 to 6 ft +/- bgs; refer to Appendix C for photographs of conditions encountered. Existing foundation conditions along the entire perimeter wall adjacent to the proposed 1 Corporate Drive building addition will need to be verified in the field during construction.

2.5 IN-SITU FIELD TESTING

Haley & Aldrich conducted in-situ hydraulic conductivity testing using a Guelph Permeameter in accordance with standard testing methods specified in ASTM D5126 at three (3) test pits (HA21-TP2, HA21-TP7 and HA21-TP11) located in areas of proposed stormwater infiltration systems. The Guelph Permeameter is an in-hole constant-head permeameter which operates on the Mariotte siphon principle. The method involves measuring the steady-state rate of water recharge into unsaturated soil from a cylinder hole in which a constant depth or head of water is maintained. The rate of this constant outflow of water, together with the diameter of the hole, can be used to determine the field saturated hydraulic conductivity of the soil. The Guelph Permeameter was installed in the test pits to measure the in-situ hydraulic conductivity at the depths and elevations indicated below. Guelph Permeameter calculations are included as Appendix D for reference. The results are as follows:

- HA21-TP2, 4.7 to 5.2 ft (El. 147.6 to El. 147.1): Infiltration Rate = 1.4×10^{-3} centimeters per second (cm/s) (2.0 in/hr)

- HA21-TP7, 3.5 to 4 ft (El. 150.3 to El. 149.8): Infiltration Rate = 3.0×10^{-4} cm/s (0.43 in/hr)
- HA21-TP11, 4.3 to 4.8 ft (El. 157.4 to El. 156.9): Infiltration Rate = 7.6×10^{-4} cm/s (1.1 in/hr)

For application in the design of the proposed stormwater infiltration systems, a factor of safety of 2 should be applied to the field-measured hydraulic conductivity results. Based on these results, the Glacial Deposits are in Hydrologic Soil Group B.

Additionally, at the request of Linden Engineering and in accordance with Town of Andover stormwater regulations, Haley & Aldrich provided a Soil Evaluator to observe test pits conducted at potential locations of stormwater infiltration systems including HA21-TP2, HA21-TP5, HA21-TP6, HA21-TP7, HA21-TP8, HA21-TP11 and HA21-TP12. The Soil Evaluator prepared Form 11 – Soil Suitability Assessments for these test pit locations. The Soil Suitability Assessment forms are also included in Appendix D and include United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soil classifications and estimated seasonal high groundwater table observations, among other details.

2.6 GEOTECHNICAL LABORATORY TESTING

Geotechnical laboratory testing was performed on select soil samples obtained from the recent test pits. Grain size and hydrometer testing was performed on three soil samples (HA21-TP2, 4.7 to 5.2 ft; HA21-TP7, 2.3 to 6 ft; and HA21-TP11, 4 to 5 ft) to assist with permeability evaluations for future infiltration systems at the site and to assess the potential for reuse of on-site materials during construction; compaction testing (modified proctor) was also performed on two samples (HA21-TP15, 6 to 8 ft; and HA21-TP5, 0.4 to 3 ft). All geotechnical laboratory testing was performed at GeoTesting Express in Acton, Massachusetts, a subconsultant to Haley & Aldrich. The results of the recent geotechnical laboratory testing are included in Appendix E.

3. Geotechnical Design Recommendations

3.1 GENERAL

Building foundations should be designed and constructed in accordance with the Massachusetts State Building Code (Building Code). Recommendations provided herein are intended to be consistent with the 9th Edition of the Building Code.

Recommendations presented herein are based on the proposed building layout and site development plan as understood at this time. As further information is developed by the architect and/or structural engineer concerning these items, the design criteria should be reviewed by Haley & Aldrich for continued applicability.

3.2 FOUNDATIONS

3.2.1 Foundation Recommendations

The existing Fill soils at the site, including any Subsoil/Topsoil, are not considered a suitable bearing strata to support the building foundations. The proposed building foundations should bear in the naturally deposited inorganic Glacial Till soils at the site (the bearing stratum). We recommend that the proposed building be supported on conventional reinforced concrete footing foundations bearing in the Glacial Till deposit. Concrete footing foundations may bear at "normal" depths on undisturbed, naturally deposited Glacial Till soils or on lean concrete or Structural Fill placed following removal of unsuitable soils. Specific recommended design criteria for concrete footing foundations are as follows:

- Design footings using a maximum allowable bearing pressure of 6 kips per sq ft (ksf).
- Design footings to have a least lateral dimension of 24-in.
- Locate bottoms of footings at least 48-in. below lowest adjacent ground surface exposed to freezing, and a minimum 18-in. below the top of the adjacent ground floor slab at heated interior locations. For construction during winter months, footings and floor slabs will require protection from freezing temperatures at the bearing surfaces until the building is enclosed and heated.
- New foundations to be constructed adjacent to the existing 1 Corporate Drive building should be designed to bear at the same elevation as the existing foundations.

Unsuitable materials must be removed from within the zone of influence (ZOI) beneath foundations. The ZOI is defined as the zone beneath the footing and beneath imaginary lines extending 2 ft laterally beyond the footing outer bottom edges and down and out on a one horizontal to one vertical (1H:1V) slope, to the bearing stratum. Note: Within the entire building footprint, we recommend that all the existing fill soils (including any topsoil/subsoil) be excavated down to the top of the Glacial Till deposit (bearing stratum) and replaced with compacted Granular Fill to the subgrade of the slab on grade (see slab recommendations below).

- Following removal of unsuitable materials from within the ZOI, compacted structural fill could be used to raise the grade, where practical, beneath footings. Alternatively, where it is desirable to limit the excavation required to replace material within the ZOI below a footing, lean concrete (1,500 psi minimum compressive strength) may be used in place of compacted granular fill. The advantage of lean concrete fill is that where the compacted granular fill must occupy the conventional ZOI as defined above, the plan area of lean concrete need only be slightly larger than the footing dimensions (extending 1 ft laterally beyond the outer footing edge on all sides) and can extend nearly vertical downward to the top of the Glacial Till deposit. In addition, systematic placement and compaction of lean concrete is not required.

- Design footings to bear below a reference line drawn upward and outward on a 1.5 horizontal to 1 vertical (1.5H:1V) slope from the bottom of any adjacent utilities or other underground structures. Where possible, footing elevations should be coordinated with utility elevations to allow utilities to pass through the foundation wall (rather than through or beneath the footing). Footings should also be positioned such that a reference line drawn downward and outward on a 2H:1V slope from points 5 ft laterally beyond the footing bottom edges will not "daylight" above ground surface or onto the adjacent slopes. Footing bearing may need to be lowered or stepped locally to achieve these criteria.
- Tops of footings should be positioned a minimum of 4-in. beneath the underside of the overlying floor slab.

3.2.2 Ground Floor Slabs

We understand the proposed ground floor slab is planned to be constructed as a soil-supported concrete slab-on-grade and is generally planned to be finished at about El. 156, corresponding to 1 to 4 ft above existing site grades. The top of the Glacial Till Deposit was encountered in the recent test pit excavations within and around the perimeter of the proposed building addition footprint at elevations varying from about El. 147 to about El. 152, corresponding to about 2 to 8 ft below existing site grades and about 4 to 9 ft below the elevation of the proposed finished floor slab.

To limit the potential for settlement of the ground floor slab, we recommend that with in the entire building footprint the existing fill soils (including any topsoil/subsoil) be excavated down to the top of the Glacial Till deposit (bearing stratum) and replaced with compacted Granular Fill.

Slabs may be designed using a modulus of subgrade reaction equal to 75 pci.

3.2.3 Seismic Design

Based on the subsurface information and our evaluation in accordance with the Building Code, Seismic Site Class C is considered applicable to the site. The soils are not considered liquefaction susceptible during the design earthquake. In accordance with the Building Code, the applicable seismic design criteria are as follows:

S_s = 0.247 (Note 1)
S_1 = 0.075 (Note 1)
F_a = 1.2 (Note 2)
F_v = 1.7 (Note 2)

Notes:
1. Values determined from Table 1604.11 of the Massachusetts State Building Code, 9th Edition.
2. Values determined from Table 1613.5.3(1) and Table 1613.5.3(2) of the International Building Code, 2015.

3.3 FOUNDATION SETTLEMENTS

Foundation settlements will depend on final building loadings, footing subgrade preparation, and placement of structural backfills.

Given the design loads and at the recommended allowable bearing pressures, we estimate that settlement of individual footings under static loading conditions, constructed as recommended herein, will not exceed 1-in, with differential settlements between individual footings, or within a 30-ft distance along a continuous strip footing, not exceeding ½-in. Most of the settlement is anticipated to occur during construction as structural dead loads are placed on the foundations.

3.4 DESIGN GROUNDWATER LEVEL

Based on our local experience, water level readings at the site, and subsurface conditions, a design groundwater level equal to El. 155 just below the floor slab is recommended for calculating hydrostatic uplift forces on below-grade structures and placement of waterproofing.

3.5 FOUNDATION DRAINAGE AND WATERPROOFING

The lowest level floors of the proposed buildings are planned to be finished above observed groundwater levels. Accordingly, permanent underslab drainage is not required.

Exterior foundation walls and pits and depressions below the lowest level floor slab are recommended to be waterproofed.

Permanent perimeter foundation drains should be installed. We recommend that perimeter drainage consist of the following:

- Waterstops be provided at all foundation wall joints where the exterior grading immediately adjacent to the building is equal to or higher than the interior floor slab of the building;
- A perimeter foundation drainage system consisting of a continuous loop of 4-in. diameter perforated PVC or slotted corrugated polyethylene pipes placed adjacent to the perimeter footings, laid flat or with a slight pitch (if possible) downward toward the ejection/discharge point(s). The pipe should be surrounded by a minimum thickness of 6 in. of ¾-in. crushed stone, which in turn is surrounded by 6-oz per sq yd non-woven geotextile;
- Where perimeter foundation drainage is provided, below-grade walls should be waterproofed and geocomposite drainage board should be placed against the wall, up to 12-in. bgs, and hydraulically connected to the perimeter drainage pipe;
- Inverts of perimeter drainage pipes should be positioned on top of the perimeter footing;
- All points in the perimeter drainage should have redundant flow paths to the ejection/discharge point(s);
- Discharge from the drainage systems should be directed to at least one reliable gravity outlet. If gravity discharge is not possible, effluent should be directed to a sump system having redundant pumps and emergency backup power;
- The drainage system piping should be provided with cleanouts.

Surface runoff should be directed away from the building. In general, the ground surface within 10 ft immediately around the buildings should be sloped downward away from the structure to divert surface runoff.

We recommend that a moisture vapor retarder membrane be provided directly beneath the ground floor slabs in occupied and finished spaces, in accordance with ACI 302.2R-06, especially if humidity control is desired or relatively vapor-tight coverings will be used on the floors. Water vapor pressures, that can adversely impact highly vapor-tight or vapor-sensitive floor coverings, or adversely affect interior space humidity, can be present even when groundwater is at significant depths. An example retarder membrane would be a 15-mil Stego Wrap Vapor Barrier or equal. The slab concrete design and construction procedures should consider the impacts of the presence of the vapor barrier.

3.6 LATERAL EARTH PRESSURES

Building foundation walls retaining earth should be designed to resist the permanent static, seismic, and surcharge loadings indicated below. The pressures do not include hydrostatic loads; walls should be detailed with perimeter drainage as discussed above.

3.6.1 Restrained Walls (At Rest)

Design walls that are braced or restrained at the top for the following "at-rest" earth pressures:

Static: Use an equivalent fluid weight of soil equal to 70 pcf.

Seismic: Calculate in accordance with the Building Code (Article 1610.2) using a total soil unit weight (γ_t) of 125 pcf.

Surcharge: Calculate based on a uniform lateral pressure equal to 0.5 times the vertical surcharge load (psf), acting on the backside of the wall, applied over the full height of the wall.

3.6.2 Unrestrained Walls (Active)

Design walls that are not restrained at the top (i.e., cantilevered) for the following “active” lateral earth pressures:

Static: Use an equivalent fluid unit weight of soil equal to 40 pcf.

Seismic: Calculate in accordance with the Building Code (Article 1610.2) using a total soil unit weight (γ_t) of 125 pcf.

Surcharge: Calculate based on a uniform lateral pressure equal to 0.33 times the vertical surcharge load (psf), acting on the backside of the wall, applied over the full height of the wall.

The recommended pressures assume that the backfill surface behind the walls is inclined no steeper than 4H:1V, rising up from the wall.

3.7 LATERAL LOAD RESISTANCE

The net (passive minus active) lateral resistance provided by the backfill surrounding footings and foundation walls can be estimated using an equivalent fluid unit weight of 250 lbs per cu ft (pcf). This value assumes that granular backfill is systematically compacted in lifts within 5 ft laterally against structural elements. The top of the assumed passive zone should be 6-in. below the top of the adjacent soil or backfill surface. If the horizontal distance between nearby footings or walls is less than twice the height of the subject structural element, the passive pressure should be discounted proportionately to the distance (full pressure at twice the height away) to accommodate interaction of the elements.

A coefficient of friction of 0.45 may be used to calculate the ultimate sliding resistance between cast-in-place concrete (footing) and the bearing strata (Glacial Till), for the permanent condition. A factor of safety of 1.5 should be applied to this value to calculate allowable frictional resistance.

3.8 UTILITIES AND OTHER SITE DEVELOPMENT CONSIDERATIONS

New below-grade utilities beyond the building limits may be soil-supported in existing Fill or placed Common Fill using conventional installation procedures.

Foundations for light pole bases, guard rails, fences, signs, transformers and similar ancillary structures may be designed utilizing the recommendations provided above.

Stormwater recharge is being evaluated by the project civil engineer. The results of test pits conducted at potential stormwater areas as well as in-situ permeability testing and geotechnical laboratory testing is summarized in previous sections of this report and can be found in Appendices B through E.

4. Construction Considerations

4.1 GENERAL

The primary purpose of this section is to comment on the items related to excavation, dewatering, lateral earth support, foundation construction, earthwork, and related geotechnical engineering aspects of the proposed construction. Prospective contractors for this project should evaluate potential construction issues based on their knowledge and experience with similar soils conditions in the area, taking into account their own proposed construction methods.

In addition to the construction guidelines and recommendations made herein, construction should conform to the requirements of the Occupational and Safety Health Association (OSHA) and all other applicable Municipal and State regulatory agencies.

4.2 EARTHWORK

4.2.1 Excavation

Construction of the proposed building addition will require excavation below ground surface into Fill (including topsoil and subsoil) and Glacial Till. Cobbles and boulders, possibly large in size, should be expected. It is anticipated that excavation can be completed using conventional earth moving equipment.

Over-excavation and replacement of unsuitable Fill soils will be required below proposed footings. We anticipate that the excavations can likely be accomplished using open-cut excavations. Temporary cut slopes typically should be stable if constructed no steeper than about 1.25H:1V.

Excavations adjacent to the existing building will need to be conducted in a manner that does not undermine the existing foundations, which could result in settlement and damage to the existing building.

4.2.2 Construction Dewatering

Given the observed groundwater levels within the recent explorations, it is anticipated that most excavations for the proposed development can be completed in the dry. Locally deeper excavations for features such as elevator pits or for over-excavation of unsuitable bearing materials may require construction dewatering. It is anticipated that temporary construction dewatering activities, including management of precipitation and stormwater runoff into excavations, can be accomplished using shallow sumps. Temporary construction dewatering effluent should be managed on-site by infiltration.

4.2.3 Backfilling

In general, we recommend that lean concrete, Compacted Granular Fill (or dense graded crushed stone), or suitable on-site materials meeting Massachusetts Department of Transportation (MassDOT) Specifications be used as backfill beneath and around footings, beneath building slabs-on-grade, and where unsuitable soils are required to be excavated and removed.

Backfill outside the building is anticipated to consist of Common Fill except for special filling required for pavements, landscaping, or other site structures.

4.2.3.1 Compacted Granular Fill

Compacted Granular Fill should consist of clean, well-graded sand and gravel, free of organic material, snow, ice, recycled materials, contaminants, or other objectionable materials and should be well-graded within the following limits:

Sieve Size	Percent Finer By Weight
6-in.	100
No. 4	30 - 80
No. 40	10 - 50
No. 200	0 - 10

4.2.3.2 Common Fill

Common Fill should consist of uncontaminated mineral sandy or gravelly soil, free from organic matter, plastic, metal, wood, ice, snow, debris or other deleterious material and should have the characteristics that it can be readily placed and compacted. Common Fill imported to the site should have a maximum of 80 percent passing the No. 4 sieve and a maximum of 25 percent finer than the No. 200 sieve. Silty common fill soils will likely require moisture control during placement and compaction.

4.2.4 Reuse of On-site Materials

Topsoil and subsoil stripped from the site may be stockpiled and reused as topsoil in landscape areas, subject to the need for soil amendments and other planting requirements.

Use of on-site materials will require judgment and careful monitoring, as quantitative compaction control may be more difficult than normal due to material variability.

The site soils are typically silty and their re-use as Compacted Granular Fill can be significantly affected by their moisture content. Excavated soils should be managed to avoid unnecessary effects of weather. Rainfall or melting snow can readily saturate soil surfaces and stockpiled fill soils. Providing drainage from and covering a stockpile can help limit this potential problem. Limiting the exposure of soils during wet weather can also help limit weather effects. These soils will probably require significant drying if left in an unprotected stockpile for any period during adverse weather.

4.2.5 Compaction Requirements

Recommended compaction requirements are as follows:

Location	Minimum Compaction Requirements
Within ZOI and around footings, and beneath slabs-on-grade	95%
Sidewalks, pavements	92% up to 3 ft below finished grade 95% in the upper 3 ft
Landscaped areas	Per the Landscape Architect

Minimum compaction requirements refer to percentages of the maximum dry density determined in accordance with ASTM D1557.

Compacted fills should be placed in horizontal lifts not more than 12-in. thick prior to compaction. Compaction equipment should consist of a large, self-propelled vibratory roller. Where hand-guided compaction equipment, such as a small vibratory plate compactor, is used in confined areas, the loose lift thickness should not exceed 8-in. Each layer of fill should receive at least four complete coverages with suitable compaction equipment. The maximum particle size should not exceed two-thirds of the loose lift thickness.

4.2.6 Earthwork During Freezing Weather

Precautions should be taken if earthwork will be performed when temperatures fall below freezing. No Fill should be allowed to freeze prior to compaction. Placement of Fill should not be conducted when air temperatures are below freezing. Soil bearing surfaces below slabs and foundations must be protected against freezing, before and after placement of concrete. Frost protection should be provided as soon as possible after foundations are constructed. Fill materials should not be placed on snow, ice, or frozen subgrades.

4.3 FOOTING AND SLAB SUBGRADE PREPARATION

4.3.1 Footing Bearing Surface Preparation

If encountered at design subgrade level, unsuitable materials (Fill, Topsoil, Subsoil, Organic Soils, etc.) must be removed from within the zone of influence of building foundations down to the suitable bearing strata (Glacial Till).

During the excavation and foundation construction operations, precautions should be taken to minimize disturbance to the bearing soils. Disturbance by construction traffic and standing water should be avoided. The following guidelines are recommended:

- Exposed soil subgrades must be observed in the field by a Geotechnical Engineer to confirm suitable foundation bearing conditions in accordance with this report. It may be necessary to require over-excavation and replacement of weak, disturbed, or otherwise unacceptable foundation bearing material to achieve suitable bearing conditions.
- Any over-excavation of disturbed or unsuitable soils below design foundation bearing grade should be backfilled with Compacted Granular Fill, or lean concrete.
- Exposed subgrade soils should be recompacted with at least two passes with a self-propelled vibratory compactor until firm.
- Soil bearing surfaces below completed foundations must be protected against freezing before and after foundation construction. If construction is performed during freezing weather, footings should be backfilled to a sufficient depth (up to 4 ft) as soon as possible after they are constructed. Alternatively, insulating blankets, heating, or other means may be used for protection against freezing. Footing bearing levels could also be lowered such that they are protected from freezing temperatures after backfilling.
- It may be desirable to place a lean concrete "mud mat" beneath footing to protect the bearing surface from weather conditions.

- In areas of excessive weaving or soft and unstable soils, the soft materials will need to be excavated and replaced with Compacted Granular Fill.
- In the event that a boulder becomes partially exposed at subgrade level or at footing bearing level, one of the following options should be utilized: (1) remove the boulder and fill the void with compacted Granular Fill, or lean concrete, or (2) remove the portion of the boulder sufficient to provide placement of six inches of compacted Granular Fill beneath the footing over the boulder.
- Back-blading to smooth the surface should not be permitted. Where the subgrade consists of granular material, the surface should be recompacted with at least four (4) passes of a plate vibratory compactor.

4.3.2 Slab Subgrade Preparation

Based on observations from the recent test pit excavation program, Fill soils, including original Topsoil and Subsoil, are expected to be present below the proposed ground floor slab elevation. Where present, these soils should be removed and replaced with compacted Granular Fill or site Fill soils approved for re-use on-site as compacted Granular Fill. The resulting subgrade should be proof-compacted with a minimum of four passes of a heavy vibratory roller imparting at least 25,000 lbs of dynamic force.

Compacted Granular Fill shall be placed and compacted in accordance with the provisions of Section 4.2.5 herein.

4.4 EXCAVATED SOIL MANAGEMENT

All excavated soils should be re-used on-site to the extent possible. Excess soils to remain on-site should be stockpiled at a location determined by the Owner.

4.5 CONSTRUCTION MONITORING

It is recommended that a geotechnical engineer or technician qualified by training and experience is present during construction to provide monitoring as required by the State Building Code. The field representative should be present to observe and document the following construction activities:

- Excavation for and preparation of foundation and slab bearing surfaces
- Placement of lean concrete and placement and compaction (including testing) of compacted Granular Fill (as required by the Building Code);
- That Fill and backfill materials meet the requirements of project plans and specifications, and help make judgments regarding the suitability of excavated soils for reuse as fill;
- Installation of the foundation systems including the perimeter drainage systems; and
- Backfilling around the foundation systems to proposed finished grades.

We recommend that Haley & Aldrich be retained to provide these monitoring services during construction. This will enable us to observe compliance with the design concepts, assumptions and specifications, and to facilitate design changes in the event that subsurface conditions differ from those anticipated prior to the start of construction.

5. Limitations

This report has been prepared for specific application to construction of a proposed building addition at the existing 1 Corporate Drive site in Andover, Massachusetts in accordance with generally accepted engineering practices. The data presented herein is based in part on information obtained from subsurface explorations, previous studies on and near the site, information on adjacent structures obtained from various sources, and information on the proposed construction that is available to us at this time.

The nature and extent of variations in the subsurface conditions between explorations may not become evident until construction. If the project design and configuration changes prior to construction and/or if significant variations in subsurface conditions appear during construction, it will be necessary to re-evaluate the recommendations contained in this report.

The results and recommendations contained herein were undertaken to support preparation of Construction Documents. In the event of changes in the design or building, the conclusions and recommendations contained in this report should not be considered valid unless they are reviewed and modified or verified in writing by Haley & Aldrich.

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TABLES

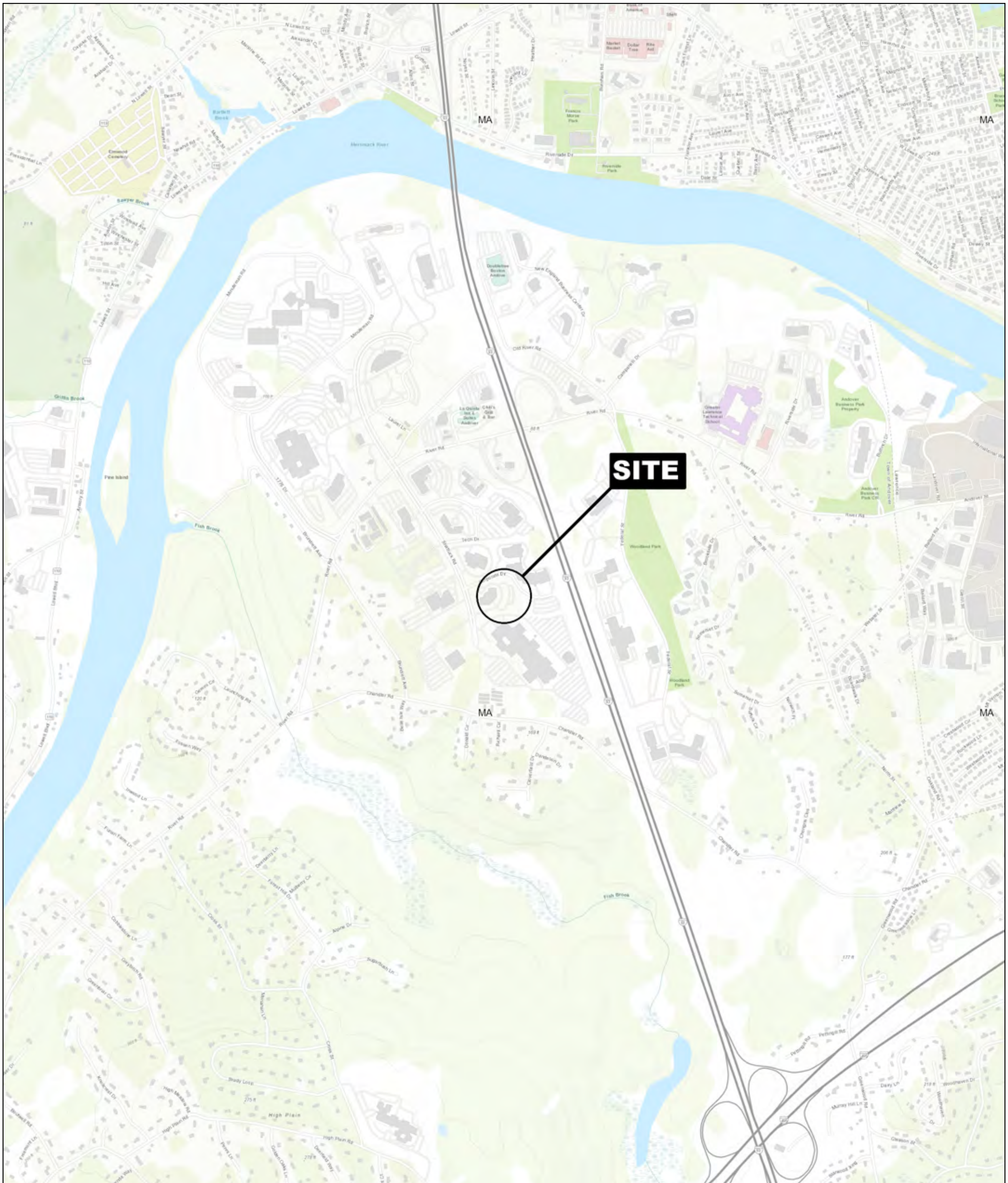
TABLE I
SUMMARY OF RECENT TEST PIT EXPLORATIONS
1 CORPORATE DRIVE
ANDOVER, MASSACHUSETTS
FILE NO. 0203691-000

EXPLORATION DESIGNATION	DEPTH OF EXPLORATION (FT)	GROUND SURFACE EL. (NGVD) (NOTES 1,2)	FILL	GLACIAL TILL DEPOSITS		
			THICKNESS (FT)	DEPTH TO TOP (FT)	EL. OF TOP (FT, NGVD)	THICKNESS (FT)
RECENT TEST PIT EXPLORATIONS						
HA21-TP1	8.8	157.9	7.5	7.5	150.4	> 1.3
HA21-TP2	10.0	152.3	3.8	3.8	148.5	> 6.2
HA21-TP3	5.5	153.1	2.9	2.9	150.2	> 2.6
HA21-TP4	10.5	154.3	2.5	2.5	151.8	> 8
HA21-TP5	11.6	152.4	5.0	5.0	147.4	> 6.6
HA21-TP6	10.0	153.0	4.0	4.0	149.0	> 6
HA21-TP7	11.5	153.8	2.2	2.2	151.6	> 9.3
HA21-TP8	9.0	141.5	2.4	2.4	139.1	> 6.6
HA21-TP10	11.0	158.0	2.8	2.8	155.2	> 8.2
HA21-TP11	9.8	161.7	2.5	2.5	159.2	> 7.3
HA21-TP12	10.5	158.3	1.5	1.5	156.8	> 9
HA21-TP13	11.5	154.5	5.5	5.5	149.0	> 6
HA21-TP14	6.0	157.9	> 6	-	-	-
HA21-TP15	8.0	157.9	6.3	6.3	151.6	> 1.7

NOTES:
1. ESTIMATED GROUND SURFACE ELEVATIONS ARE IN FEET, REFERENCE THE NATIONAL GEODETIC VERTICAL DATUM (NGVD) AND CORRESPOND TO THE GROUND SURFACE ELEVATION AT THE TIME OF THE EXPLORATIONS.
2. ELEVATIONS WERE NOT SURVEYED AND ARE THEREFORE CONSIDERED APPROXIMATE.

ABBREVIATIONS:
">" : INDICATES TOTAL THICKNESS NOT DETERMINED; EXPLORATION TERMINATED AT DEPTH INDICATED WITHIN MATERIAL/DEPOSIT
"-" : INDICATES NOT DETERMINED; DEPOSIT NOT SAMPLED OR EXPLORATION TERMINATED BEFORE PRESENCE OF DEPOSIT VERIFIED

FIGURES



SITE COORDINATES: 42°41'03"N, 71°12'25"W

MAP SOURCE: USGS

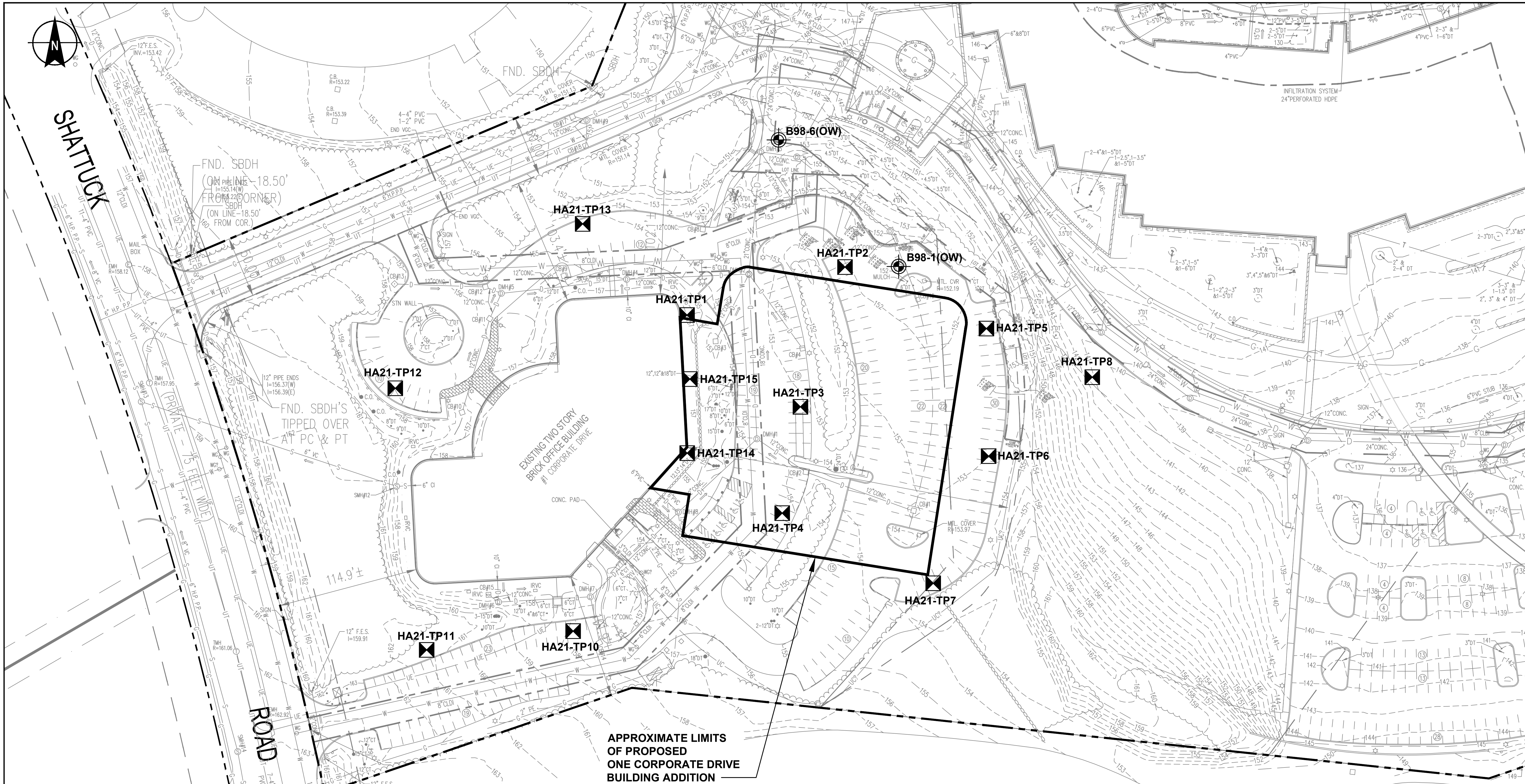
ONE CORPORATE DRIVE
ANDOVER, MASSACHUSETTS

PROJECT LOCUS

APPROXIMATE SCALE: 1 INCH = 2,000 FEET
JANUARY 2022

FIGURE 1

0203692_000_LOCUS HALEYALDRICH\DABATE



LEGEND

HA21-TP1 — DESIGNATION AND APPROXIMATE LOCATION OF TEST PIT EXCAVATED BY EARTHWORK INDUSTRIES, INC. BETWEEN 10 AND 16 NOVEMBER 2021 AND OBSERVED BY HALEY & ALDRICH, INC.

B98-1(OW) — DESIGNATION AND APPROXIMATE LOCATION OF TEST BORING DRILLED BY NEW HAMPSHIRE BORING, INC. IN MAY 1998 AND OBSERVED BY HALEY & ALDRICH, INC.

(OW) — INDICATES GROUNDWATER OBSERVATION WELL INSTALLED IN COMPLETED BOREHOLE

NOTES

1. BASE PLAN OBTAINED FROM DRAWING TITLED "SV-1 SITE SURVEY", PREPARED BY LINDEN ENGINEERING PARTNERS LLC AND DATED 1 OCTOBER 2021.
2. APPROXIMATE LIMITS OF PROPOSED BUILDING ADDITION OBTAINED FROM DRAWING TITLED "C-1 SITE LAYOUT AND MATERIALS PLAN", PREPARED BY LINDEN ENGINEERING AND DATED 1 OCTOBER 2021.
3. ELEVATIONS ARE IN FEET AND REFERENCE THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29).
4. TECHNICAL MONITORING OF THE TEST PITS AND TEST BORINGS WAS PERFORMED BY HALEY & ALDRICH, INC.; THE LOCATIONS OF THE EXPLORATIONS IN 2021 WERE ESTIMATED BY TAPING TO EXISTING SITE FEATURES IN THE FIELD AND SHOULD BE CONSIDERED APPROXIMATE.
5. FOR ADDITIONAL INFORMATION ON CONDITIONS ENCOUNTERED IN TEST PITS, REFER TO ANNOTATED PHOTOS INCLUDED IN APPENDIX C.

0 80 160
SCALE IN FEET

HALEY ALDRICH
ONE CORPORATE DRIVE
ANDOVER, MASSACHUSETTS

SITE AND SUBSURFACE
EXPLORATION LOCATION PLAN

SCALE: AS SHOWN
JANUARY 2022

FIGURE 2

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APPENDIX A

Previous Test Boring Logs

NEW HAMPSHIRE BORING INC.
P.O. BOX 165
DERRY NH 03038
TEL:-603-437-1610

Boring #:B98-1 (OW) Project:CORPORATE DRIVE Project # : 12263-000

Project Address: City:ANDOVER State:MA Zip:

Date Start:05/06/98 Date End:05/06/98 Location:See Plan

	Casing	Sampler		Casing	Sampler
TYPE	:H-S-A	S/S	SIZE:	4 1/4 in. I.D.	1 3/8 in. I.D.
HAMMER:		140 lbs.	FALL:		30 in.

GROUNDWATER OBSERVATION

DATE	DEPTH	CASING	STABILIZATION PER.
05/06/98	3.98	OUT	Upon Completion

DP.	S./#	DEPTH	PEN	REC	BLOWS/6"	ST/CH	SAMPLE DESCRIPTION
-	S-1	0.5'-1.5'	12"	0"	22-22	0.2	-ASPHALT-
-	S-1A	1.5'-2.5'	12"	12"	32-21	1.5'	S-1:Dense brown medium SAND,little gravel, coarse sand, fine sand. -FILL- (offsite borrow)
-						3.5'	S-1A: Very dense, brown silty fine SAND, some gravel,little coarse to medium sand.-FILL- (onsite borrow)
-							NOTE: Boulder @3.5'
5'	S-2	5'-5.4'	5"	4"	48/5" 50/0"		S-2: Very dense, brown silty fine SAND, some gravel,little coarse to medium sand,moderately well bonded in-situ. -GLACIAL TILL-
-							NOTE: numerous boulders 5.4'-10'
10'	S-3	10'-10.4'	4"	4"	35/4" 100/0"		S-3: Very dense, brown silty fine SAND, little gravel, coarse to medium sand, very well bonded in-situ. - GLACIAL TILL-
-							NOTE: numerous boulders 10.4'-15'
15'	S-4	15'-16.5'	18"	18"	51-58-63		S-4: Very dense, brown silty fine SAND, little gravel, coarse to medium sand, very well bonded in-situ. - GLACIAL TILL-
20'	S-5	20'-21.5'	18"	15"	27-50-62		S-5: Very dense, gray-brown fine sandy SILT, some gravel, little coarse to medium sand, trace silt, extemely well bonded in-situ. -GLACIAL TILL-
25'	S-6	25'-27'	24"	18"	107-160 119-111		S-6: very dense, gray-brown silty fine SAND, some gravel, little coarse to medium sand, extemely well bonded in-situ. -GLACIAL TILL
30'							

DRILLER: K.SMITH HELPER:S.COOLEY INSPECTOR: C.OSGOOD

REMARKS: BOTTOM OF EPXLORATION AT 27'
INSTALLED OW AT 24.5'

S/#: SAMPLE # PEN: PENETRATION REC: RECOVERY ST/CH: STRATA CHANGE

HALEY & ALDRICH

OBSERVATION WELL INSTALLATION REPORT

Observation Well	**B98-1(OW)**
Test Boring	B98-1(OW)
Installation Date	6 May 1998
Location	See Plan
H&A File No.	12263-000
H&A Rep.	C.S. Osgood

Project	**CORPORATE DRIVE**
City/State	ANDOVER, MASSACHUSETTS
Client	EISAI GLOBAL RESEARCH COMMITTEE
Contractor	NEW HAMPSHIRE BORING
Foreman	K. SMITH

Ground El. 151.5±

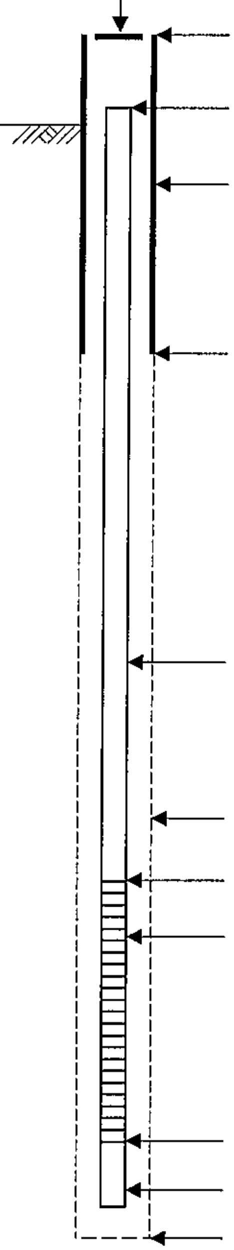
El. Datum

SOIL/ROCK CONDITIONS — BOREHOLE BACKFILL

(Numbers refer to depth from ground surface in feet)
(not to scale)

SOIL/ROCK CONDITIONS	Depth (ft)	BOREHOLE BACKFILL	Depth (ft)
FILL		CONCRETE	1.0
	3.5	FILTER SAND	11.0
GLACIAL TILL		BENTONITE	13.0
	27.0	FILTER SAND	27.0

Bottom of exploration



Type of protective cover/lock: Compression

Depth of top of roadway box below ground surface: 0.0 ft

Depth of top of riser pipe below ground surface: 0.5 ft

Type of protective casing: Roadway Box

- Length: 1.5 ft
- Inside diameter: 3.75 in

Depth of bottom of roadway box: 1.5 ft

Seals:

Type	Depth to top (ft)	Thickness (ft)
Concrete	0.0	1.0
Bentonite	11.0	2.0

Type of riser pipe: Schedule 40 PVC

- Inside diameter of riser pipe: 2.0 in
- Type of backfill around riser: Filter Sand

Diameter of borehole: 8.0 in

Depth of top of wellpoint: 15.0 ft

Type of point or manufacturer: Schedule 40 PVC

- Screen gauge or size of openings: 0.010 in
- Diameter of wellpoint: 2.0 in
- Type of backfill around point: Filter Sand

Depth of bottom of wellpoint: 24.5 ft

Silt trap: 0.5

Depth of bottom of borehole: 27.0 ft

(Depths refer to ground surface)

Remarks:

OWI06GOZ.FRP F:\12263\000\A06920WI.dbf 1 July 1998

HALEY & ALDRICH

OBSERVATION WELL MONITORING REPORT

Observation Well	**B98-1(OW)**
Test Boring	B98-1(OW)
Installation Date	6 May 1998
File No.	12263-000
Ground El.	151.5
El. Datum	

Project CORPORATE DRIVE

City/State ANDOVER, MASSACHUSETTS

Client EISAI GLOBAL RESEARCH COMMITTEE

Depths to water are measured from ground surface, which is at El. 151.5.

Date	Time	Elapsed Time (days)	Depth to Water (ft)	Elevation of Water	Remarks	Read By
6 May 98		0.0			Installation	CSO
7 May 98	12:00	1.0	4.0	147.5		CSO
13 May 98	03:50	7.0	3.9	147.6		MJA
22 May 98	03:05	16.0	4.1	147.4		MJA

NEW HAMPSHIRE BORING INC.
P.O. BOX 165
DERRY NH 03038
TEL:-603-437-1610

Boring #:B98-6 (OW) Project:CORPORATE DRIVE Project # : 12263-000

Project Address: City:ANDOVER State:MA Zip:

Date Start:05/06/98 Date End:05/06/98 Location:See Plan

	Casing	Sampler		Casing	Sampler
TYPE	:H-W	S/S	SIZE:	4 in. I.D.	1 3/8 in. I.D.
HAMMER:	300 LB	140 lbs.	FALL:	24 IN.	30 in.

GROUNDWATER OBSERVATION

DATE	DEPTH	CASING	STABILIZATION PER.
05/06/98	5.60	OUT	Upon Completion

DP.	S./#	DEPTH	PEN	REC	BLOWS/6"	ST/CH	SAMPLE DESCRIPTION
	S-1	0'-2'	24"	11"	2-5 10-10	1.0 2.5	S-1: Loose, dark brown organic silty fine SAND, little gravel, trace coarse to medium sand. -FILL- Medium dense brown-dark brown silty fine SAND, little coarse to medium sand, trace organics. -FILL-
5'	S-2	4'-6'	24"	16"	28-34 34-25		S-2: Very dense brown silty fine SAND, little gravel, coarse to medium sand. Moderately well bonded in-situ. -GLACIAL TILL-
10'	S-3	9'-11'	24"	12"	14-18 23-34		S-3: Dense, brown silty fine SAND, some gravel, little coarse to medium sand, well bonded in-situ. -GLACIAL TILL-
15'	S-4	14'-14.8'	9"	6"	41-100/3		S-4: Very dense, gray-brown fine sandy SILT, some gravel, little coarse to medium sand, extremely well bonded in-situ.
20'	S-5	19'-21'	24"	17"	35-33 29-40		S-5: Very dense brown silt fine SAND, little gravel, coarse to medium sand, moderately well bonded. -GLACIAL TILL-
25'	S-6	24'-25'	12"	10"	87-135		S-6: Very dense, gray-brown silty fine SAND, little gravel, coarse to medium sand, extremely well bonded in-situ. -GLACIAL TILL-
30'							Bottom of exploration at 25' Installed OW at 23'

DRILLER: K.SMITH HELPER:S.COOLEY INSPECTOR: C.OSGOOD

REMARKS:

S/#: SAMPLE # PEN: PENETRATION REC: RECOVERY ST/CH: STRATA CHANGE

OBSERVATION WELL INSTALLATION REPORT

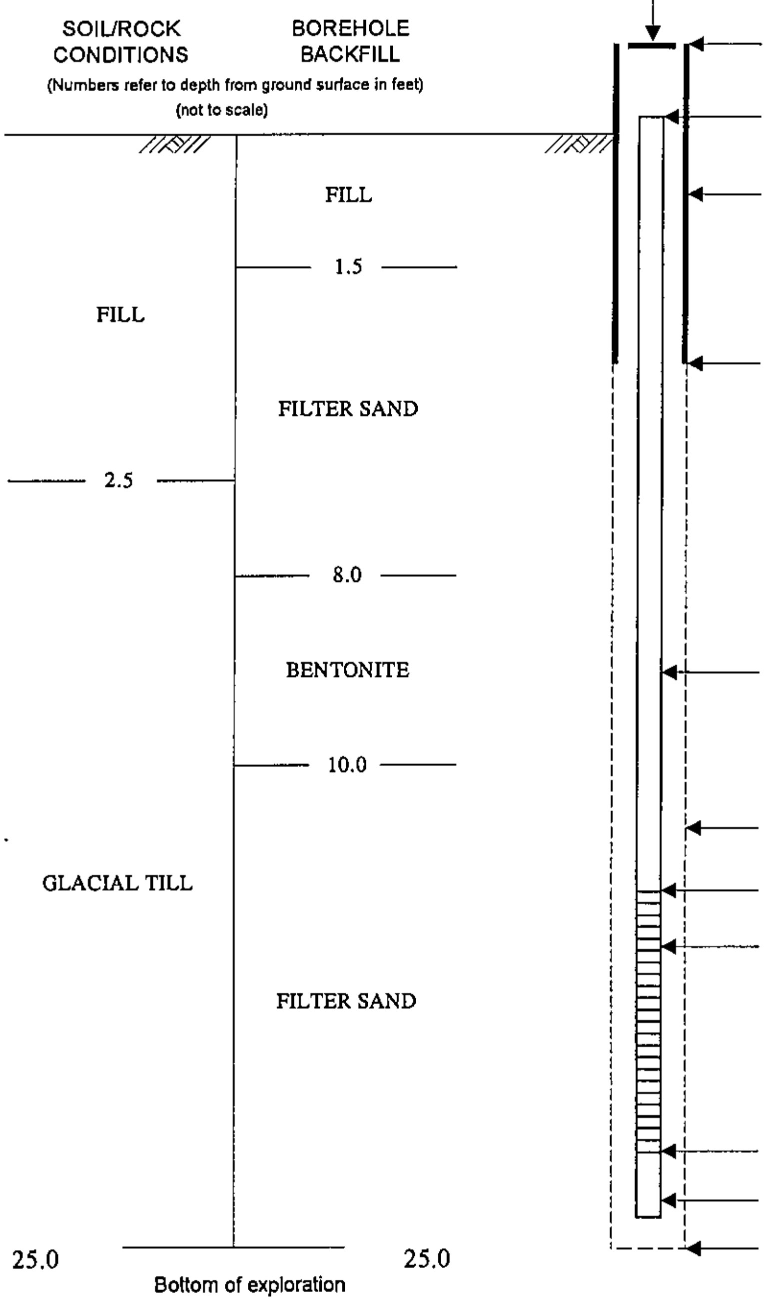
HALEY & ALDRICH

Project	**CORPORATE DRIVE**
City/State	ANDOVER, MASSACHUSETTS
Client	EISAI GLOBAL RESEARCH COMMITTEE
Contractor	NEW HAMPSHIRE BORING
Foreman	K. SMITH

Observation Well	**B98-6(OW)**
Test Boring	B98-6(OW)
Installation Date	6 May 1998
Location	See Plan
H&A File No.	12263-000
H&A Rep.	C.S. Osgood

Ground El. 151.0 ±

El. Datum



Type of protective cover/lock: Compression

Depth of top of roadway box below ground surface: 0.3 ft

Depth of top of riser pipe below ground surface: 0.0 ft

Type of protective casing: Roadway Box

- Length: 1.5 ft
- Inside diameter: 3.75 in

Depth of bottom of roadway box: 1.2 ft

Seals:

Type	Depth to top (ft)	Thickness (ft)
Concrete	0.0	1.0
Bentonite	8.0	2.0

Type of riser pipe: Schedule 40 PVC

- Inside diameter of riser pipe: 2.0 in
- Type of backfill around riser: Filter Sand

Diameter of borehole: 4.5 in

Depth of top of wellpoint: 13.5 ft

Type of point or manufacturer: Schedule 40 PVC

- Screen gauge or size of openings: 0.010 in
- Diameter of wellpoint: 2.0 in
- Type of backfill around point: Filter Sand

Depth of bottom of wellpoint: 23.0 ft

Silt trap 0.5

Depth of bottom of borehole: 25.0 ft

(Depths refer to ground surface)

Remarks:

HALEY & ALDRICH

OBSERVATION WELL MONITORING REPORT

Observation Well	B98-6(OW)
Test Boring	B98-6(OW)
Installation Date	6 May 1998
File No.	12263-000
Ground El.	151.0
El. Datum	

Project **CORPORATE DRIVE**

City/State ANDOVER, MASSACHUSETTS

Client EISAI GLOBAL RESEARCH COMMITTEE

Depths to water are measured from ground surface, which is at El. 151.0.

Date	Time	Elapsed Time (days)	Depth to Water (ft)	Elevation of Water	Remarks	Read By
6 May 98		0.0			Installation	CSO
7 May 98	12:05	1.0	5.6	145.4		CSO
13 May 98	04:00	7.0	5.6	145.4		MJA
22 May 98	03:00	16.0	6.7	144.3		MJA

APPENDIX B

Recent Test Pit Logs

TEST PIT LOG

HALEY ALDRICH

Test Pit No. HA21-TP1

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	12 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Rain, 50s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 157.9 (est.)
El. Datum: NGVD 29
Location: See Plan
Groundwater depths/entry rates (in./min.): Not Encountered

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0			ML	Dark brown sandy SILT (ML), no structure, no odor, moist, 15% of cobbles and roots, trace scrap building materials, trace oversized, mps 2 ft - LOAMY FILL -	5	5	5	10	25	50				
2		154.9 3.0												
4			SP	Yellow poorly-graded SAND (SP), no structure, no odor, moist - FILL -	5	5	10	50	25	5				
6		150.4 7.5												
8			SM	Gray-brown to tan silty SAND with gravel (SM), no structure, no odor, till becomes less gray-brown and more tan with depth, possible remnant topsoil at stratum change, cuttings indicate possible leaching coloration on upper foot of till from removed topsoil above - GLACIAL TILL -	10	10	5	15	35	25				
		149.1 8.8		BOTTOM OF EXPLORATION 8.8 FT										

Obstructions: Top of existing building footing encountered at 42 in. below ground surface.

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth NE ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 8.8

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH — TEST PIT LOG

Test Pit No. HA21-TP2

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	11 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Overcast, 30s to 50s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 152.3 (est.) **El. Datum:** NGVD 29 **Location:** See Plan **Groundwater depths/entry rates (in./min.):** 9.5 ft

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0				-ASPHALT-										
		151.9 / 0.4	SP	Yellow poorly-graded SAND (SP), no structure, no odor, moist - FILL -	5	5	15	35	35	5				
2		150.6 / 1.7	SM	Light-brown to brown silty SAND (SM), no structure, no odor, moist, 10% pockets of dark brown organic soil, Mix of remnant topsoil, subsoil and fill above - FILL - PID = 0.0 ppm	5	5	10	25	35	20				
4, 6, 8		148.5 / 3.8	SM	Light-brown to tan silty SAND with gravel (SM), bonded, no odor, moist to wet, 5% cobbles, no oversized, slightly to occasionally moderately bonded, becomes more tan and slightly more silty/bonded with depth - GLACIAL TILL - PID = 0.0 ppm	5	10	10	10	45	20				
10		142.3 / 10.0		BOTTOM OF EXPLORATION 10.0 FT										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth 9.7 ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 10.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

Test Pit No. HA21-TP3

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	11 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Overcast, 30s to 50s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 153.1 (est.) **El. Datum:** NGVD 29 | **Location:** See Plan | **Groundwater depths/entry rates (in./min.):** Not Encountered

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0				-ASPHALT-										
		152.8 0.3	SP	Yellow-brown poorly-graded SAND (SP), no structure, no odor, moist - FILL -	5	5	10	35	40	5				
1														
2		151.3 1.8	SM	Yellow-brown to brown silty SAND (SM), no structure, no odor, moist, trace oversized, mps 1.2 ft, appears to be remnant subsoil, trace topsoil in pockets, disturbed with fill above - FILL -	5	5	5	20	45	20				
3		150.2 2.9	SM	Tan to olive-brown silty SAND (SM), trace cobbles, no oversized - GLACIAL TILL -	5	5	15	25	30	20				
4														
5		147.6 5.5		BOTTOM OF EXPLORATION 5.5 FT										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth NE ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 5.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

Test Pit No. HA21-TP4

HALEY ALDRICH

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	10 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Overcast, 40s to 50s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 154.3 (est.)
El. Datum: NGVD 29
Location: See Plan
Groundwater depths/entry rates (in./min.): 10.2 ft

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0		153.9 / 0.4		-ASPHALT-										
		153.3 / 1.0	SP	Yellow-brown poorly-graded SAND with gravel (SP), no structure, no odor, moist, no oversized - FILL -	5	10	10	40	30	5				
		152.6 / 1.7	SM	Brown to gray-brown silty SAND (SM), no oversized, mps 3 in. - FILL -	5	5	5	20	45	20				
2		151.8 / 2.5	SM	Black to brown silty SAND (SM), Appears disturbed, remnant topsoil and subsoil, some subsoil may be undisturbed - FORMER TOPSOIL - PID = 0.0 ppm		5	5	10	40	40				
4–10		143.8 / 10.5	SM	Light-brown to tan silty SAND (SM), bonded, no odor, moist to moist, slight mottling below 5.5 ft, highest seepage 7.4 - GLACIAL TILL - PID = 0.0 ppm	5	5	15	15	40	20				
				BOTTOM OF EXPLORATION 10.5 FT										
				Note: Electrical line for parking lot light encountered within test pit excavation at 2.2 ft below ground surface; electrical line repaired prior to backfilling of test pit.										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth 10.2 ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 10.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

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TEST PIT LOG

Test Pit No. HA21-TP5

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	10 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.		
Equipment Used	RUBBER TIRED EXCAVATOR	**Weather**	Overcast, 40s to 50s F

Ground El.: 152.4 (est.) **Location:** See Plan **Groundwater depths/entry rates (in./min.):** 11.0 ft

El. Datum: NGVD 29

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0		152.1 / 0.3		-ASPHALT-										
			SP	Yellow poorly-graded SAND (SP), no structure, no odor, moist - FILL -	5	5	15	45	30					
2		149.5 / 2.9	OL/OH	Black sandy ORGANIC SOIL (OL/OH), no structure, organic odor, moist, 10% roots - FORMER TOPSOIL -			5	5	30	60				
4		148.4 / 4.0	SM	Brown silty SAND (SM), no structure, no odor, moist, fines slightly organic - SUBSOIL -				10	50	40				
6, 8, 10		147.4 / 5.0	SM	Silty SAND with gravel (SM), bonded, 5% oversized, very slightly bonded to unbonded, mottling, more silty below ~ 10.0 ft, possibly stratified or bedded - GLACIAL TILL -	5	10	5	20	45	15				
		141.1 / 11.3		BOTTOM OF EXPLORATION 11.6 FT										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth 11.4 ft

measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)

Pit Depth (ft) 11.6

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

Test Pit No. HA21-TP6

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	10 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Overcast, 40s to 50s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 153.0 (est.)
El. Datum: NGVD 29
Location: See Plan
Groundwater depths/entry rates (in./min.): 9.0 ft

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0				-ASPHALT-										
		152.7 0.3	SP	Yellow poorly-graded SAND (SP), no structure, no odor, no oversized - FILL -	5	5	10	45	30	5				
2				PID = 0.0 ppm										
		150.7 2.3	SM	Black to gray-brown silty SAND with gravel (SM), no structure, no odor, trace wood debris - FILL -	10	10	10	15	35	20				
		150.3 2.7	SM	Dark brown to red-yellow silty SAND (SM), no structure, no odor, disturbed, higher fines % and organic content towards top, variable thickness - FILL -	5	5	10	20	35	25				
4		149.0 4.0	SM	Tan to light-brown silty SAND (SM), bonded, no odor, moist to wet, 5% oversized, mps 2.5 ft, slight red-yellow oxidation below 7.5 ft, trace clayey pockets	10	5	5	20	40	20				
				PID = 0.0 ppm										
6				PID = 0.0 ppm										
				-GLACIAL TILL-										
8				PID = 0.0 ppm										
10		143.0 10.0		BOTTOM OF EXPLORATION 10.0 FT										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth 9.6 ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 10.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

Test Pit No. HA21-TP7

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	10 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Overcast, 40s to 50s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 153.8 (est.)
El. Datum: NGVD 29
Location: See Plan
Groundwater depths/entry rates (in./min.): 7.5 ft

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0		153.5 0.3		-ASPHALT-										
		152.3 1.5	SP	Yellow-brown to light-brown poorly-graded SAND (SP), layer, no odor, moist, no oversized -FILL-	5	5	10	45	30	5				
2		151.6 2.2	SM	Dark brown to brown silty SAND (SM), no structure, no odor, moist, former topsoil and subsoil, partially excavated, disturbed, fines moderately organic - FORMER TOPSOIL - PID = 0.0 ppm		5	5	10	50	30				
4, 6, 8		144.8 9.0	SM	Tan to light-brown silty SAND (SM), bonded, no odor, moist, 10% oversized, mps 3 ft, boulder remained in sidewall at 8 ft, slightly bonded to unbonded, moist to nearly wet below ~8 ft - GLACIAL TILL - PID = 0.0 ppm	5	5	15	15	40	20				
10		142.3 11.5	SM	Tan to olive-brown silty SAND with gravel (SM), no structure, no odor, moist to wet, trace oversized, mps 1.0 ft, lodgement till - GLACIAL TILL - PID = 0.0 ppm	5	10	5	10	35	35				
				BOTTOM OF EXPLORATION 11.5 FT										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth 9.0 ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 11.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

HALEY ALDRICH

Test Pit No. HA21-TP8

Project	**ONE CORPORATE DRIVE**	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	11 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Overcast, 30s to 50s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 141.5 (est.)
El. Datum: NGVD 29
Location: See Plan
Groundwater depths/entry rates (in./min.): 7.4 ft

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0			OL/OH	Black to dark brown sandy ORGANIC SOIL (OL/OH), no structure, no odor, moist, trace oversized - LOAMY FILL -	5		5	10	25	55				
		140.4 1.1	GP-GM	Tan to gray poorly-graded GRAVEL with silt and sand (GP-GM), no structure, no odor, moist, 25% cobbles, trace boulders, 10% oversized - FILL -	40	20	5	10	15	10				
2				PID = 0.0 ppm										
		139.1 2.4	SM	Tan silty SAND with gravel (SM), bonded, no odor, moist to wet, highest seepage 7.4 ft, little seepage - GLACIAL TILL -	10	10	10	10	20	40				
4				PID = 0.0 ppm										
6														
8														
		132.5 9.0		BOTTOM OF EXPLORATION 9.0 FT										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth NE ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 9.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH — TEST PIT LOG

Test Pit No. HA21-TP10

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	15 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Overcast, 30s to 40s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 158.0 (est.)
El. Datum: NGVD 29
Location: See Plan
Groundwater depths/entry rates (in./min.): 10.0 ft

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0		157.7 0.3		-ASPHALT-										
			SP	Yellow-brown to dark brown poorly-graded SAND (SP), layer, no odor, moist, no oversized, mps 6 in., remnant former topsoil in lenses, more prevalent - FILL - PID = 0.0 ppm	5	5	5	30	50	5				
2		155.2 2.8	SM	Tan to olive-gray silty SAND (SM), bonded, no odor, moist, 5% cobbles, mps 8 in. - GLACIAL TILL - PID = 0.0 ppm	5	5	5	15	40	30				
4														
6														
8		149.5 8.5	ML	Olive-brown to olive-gray sandy SILT (ML), bed, no odor, wet, bedded stratified horizontal but uneven and slightly folded				5	35	60				
10		147.0 11.0	SM	Olive-brown silty SAND with gravel (SM), bonded, no odor, wet - GLACIAL TILL - PID = 0.0 ppm	10	10	10	15	25	30				
				BOTTOM OF EXPLORATION 11.0 FT										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth NE ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 11.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

Test Pit No. HA21-TP11

HALEY ALDRICH

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	15 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Overcast, 30s to 40s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 161.7 (est.)
El. Datum: NGVD 29
Location: See Plan
Groundwater depths/entry rates (in./min.): 8.5 ft

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0		160.7 / 1.0	ML	SILT with sand (ML), no structure, organic odor, moist, fines moderately organic - LOAMY FILL -	5	5	5	5	20	60				
2		159.2 / 2.5	ML	Yellow-brown sandy SILT (ML), no structure, no odor, moist - SUBSOIL - PID = 0.0 ppm			5	5	40	50				
4, 6, 8		151.9 / 9.8	SM	Tan silty SAND with gravel (SM), bonded, no odor, moist to wet, trace oversized, mps 2.0 ft, wet below 8.5 ft PID = 0.0 ppm -GLACIAL TILL- PID = 0.0 ppm PID = 0.0 ppm	5	5	5	10	45	30				
				BOTTOM OF EXPLORATION 9.8 FT PID = 0.0 ppm										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth 9.3 ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 9.8

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

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HALEY ALDRICH

TEST PIT LOG

Test Pit No. HA21-TP12

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	15 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Overcast, 30s to 40s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 158.3 (est.) **Location:** See Plan **Groundwater depths/entry rates (in./min.):** 10.0 ft

El. Datum: NGVD 29

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0			SP	Yellow-brown poorly-graded SAND with gravel (SP), no structure, no odor, moist, no oversized, mps 8 in. - FILL -	5	5	5	30	50	5				
		156.8 / 1.5	SM	Tan silty SAND with gravel (SM), bonded PID = 0.0 ppm	10	5	10	15	35	25				
2														
4														
6														
8			SM	Yellow-brown to olive-brown silty SAND with gravel (SM), bonded, no odor, moist to wet, 10% cobbles, no oversized, moist to wet below highest seepage at 10.0 ft, lodgement till - GLACIAL TILL - PID = 0.0 ppm	15	10	10	10	20	35				
10		147.8 / 10.5		BOTTOM OF EXPLORATION 10.5 FT										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth 10.0 ft

measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)

Pit Depth (ft) 10.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

HALEY ALDRICH

Test Pit No. HA21-TP13

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	11 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.		
Equipment Used	RUBBER TIRED EXCAVATOR	**Weather**	Overcast, 30s to 50s F

Ground El.: 154.5 (est.) **El. Datum:** NGVD 29 | **Location:** See Plan | **Groundwater depths/entry rates (in./min.):** 10.9 ft

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0		154.2 0.3		-ASPHALT-										
			SP	Yellow poorly-graded SAND with gravel (SP), no structure, no odor, wet, 5% cobbles, trace oversized mps 2.5 ft from bottom of fill - FILL - PID = 0.0 ppm	10	5	10	45	25	5				
2														
4		150.1 4.4	SM	Yellow-brown to brown silty SAND with gravel (SM), no structure, no odor, moist, mix of remnant topsoil, subsoil and fill from above -FILL-	10	10	10	30	25	15				
		149.0 5.5	SM	Light-brown to tan silty SAND with gravel (SM), bonded, no odor, moist to wet, becomes more tan/light gray with depth, mottling below est. 8.5 ft - GLACIAL TILL - PID = 0.0 ppm	10	5	10	20	30	25				
6														
8														
10														
		143.0 11.5		BOTTOM OF EXPLORATION 11.5 FT										

Obstructions:

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth 11.1 ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 11.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

Test Pit No. HA21-TP14

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	12 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	Rain, 50s F
Equipment Used	RUBBER TIRED EXCAVATOR		

Ground El.: 157.9 (est.)
El. Datum: NGVD 29
Location: See Plan
Groundwater depths/entry rates (in./min.): Not Encountered

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0				Dark brown sandy SILT (ML), no structure, organic odor, moist, 15% roots, trace scrap building materials - LOAMY FILL -	5	5	10	10	20	50				
1			ML											
2		155.9 2.0		Yellow poorly-graded SAND (SP), no structure, no odor, moist - FILL - PID = 0.0 ppm	5	5	5	50	30	5				
3														
4			SP	PID = 0.0 ppm										
5														
6		151.9 6.0		BOTTOM OF EXPLORATION 6.0 FT PID = 0.0 ppm										

Obstructions: Top of existing building footing encountered at 42 in. below ground surface.

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth NE ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 6.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

HALEY ALDRICH

Test Pit No. HA21-TP15

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-ONE CORPORATE LLC	**Date**	16 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.		
Equipment Used	RUBBER TIRED EXCAVATOR	**Weather**	Overcast, 30s to 40s F

Ground El.: 157.9 (est.)
El. Datum: NGVD 29
Location: See Plan
Groundwater depths/entry rates (in./min.): Not Encountered

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0			ML	Dark brown sandy SILT (ML), trace building material debris, no oversized, fines moderately organic - LOAMY FILL - PID = 0.0 ppm	5	5	5	10	25	50				
2		155.4 2.5	SP	Yellow-brown poorly-graded SAND (SP) - FILL - PID = 0.0 ppm	5	5	15	30	40	5				
4														
6		151.6 6.3	SM	Tan to light-brown silty SAND (SM), no structure, no odor, moist - GLACIAL TILL - PID = 0.0 ppm	5	5	5	15	40	30				
8		149.9 8.0		BOTTOM OF EXPLORATION 8.0 FT										

Obstructions: Top of existing building footing encountered at 43 in. below ground surface.

Remarks: Test pit backfilled with excavated material, placed in lifts and each lift tamped with bucket of excavator.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth NE ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 8.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

APPENDIX C

Photographic Summary of Recent Test Pits

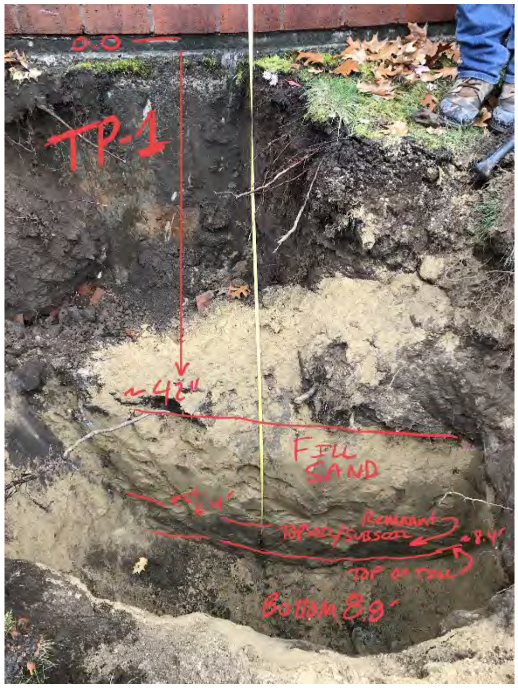


Photo 1: Sidewall at test pit HA21-TP1. Top of Glacial Till observed at approximately 8.4 ft below ground surface (bgs).

Photo 2: Photo of existing strip footing encountered at test pit HA21-TP1. Top of footing encountered 42 in. bgs. Footing was determined to be 10 to 12 in. thick. The footing protruded beyond the face of the foundation wall by 14 to 16 in.

Photo 3: Corner of existing footing foundation encountered in test pit HA21-TP1. Imported Fill (sand) was encountered below the bottom of the footing and above the naturally deposited glacial soils.

Photo 4: Test pit HA21-TP2. Former Topsoil layer observed in the Fill at the interface with the underlying Glacial soils. Water seepage observed at approximately 9.5 ft bgs.

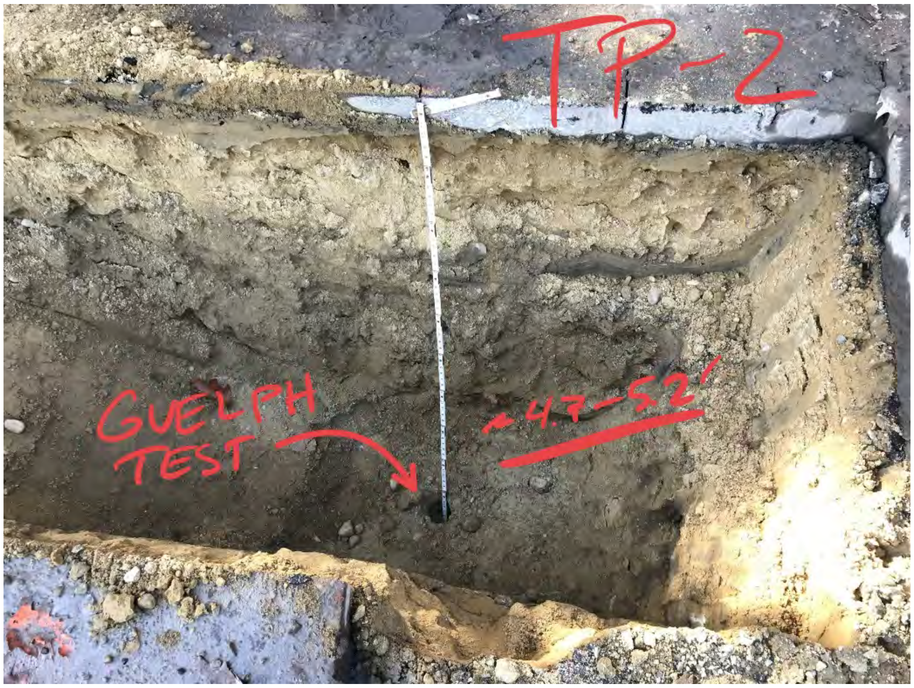


Photo 5: Guelph permeameter test performed in test pit HA21-TP2 from a depth of 4.7 ft to 5.2 ft bgs.

Photo 6: Stockpile of soil excavated from test pit HA21-TP3, consisting of light-brown Glacial Till to the left and medium-brown Fill to the right side of the of the stockpile. Cobbles and boulders are visible within the Glacial soils.

Photo 7: Completed excavation at test pit HA21-TP3. The top of the Glacial Till deposit is called out in the photo.

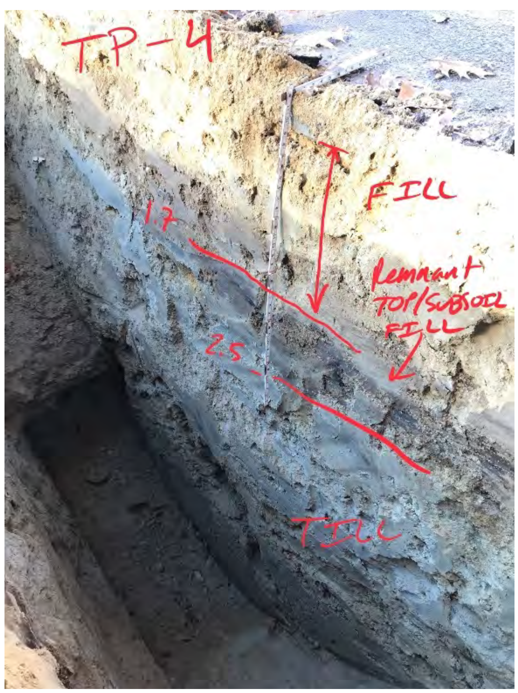


Photo 8: Photo showing the soil stratigraphy observed in the sidewall at test pit HA21-TP4. An approximately 8 in. thick layer of remnant Topsoil/Subsoil was encountered at the interface between the Fill soils and underlying Glacial Till deposit. The top of the Glacial Till deposit is noted at approximately 2.5 ft bgs.

Photo 9: Soil excavated from test pit HA21-TP4. Numerous cobbles and boulders are present in the excavated material.

Photo 10: Glacial Till encountered at approximately 5 ft below a 2.1 ft thick layer of former/remnant Topsoil/Subsoil in test pit HA21-TP5. Water seepage and cave-in observed at the bottom of excavation at about 11.4 ft bgs.

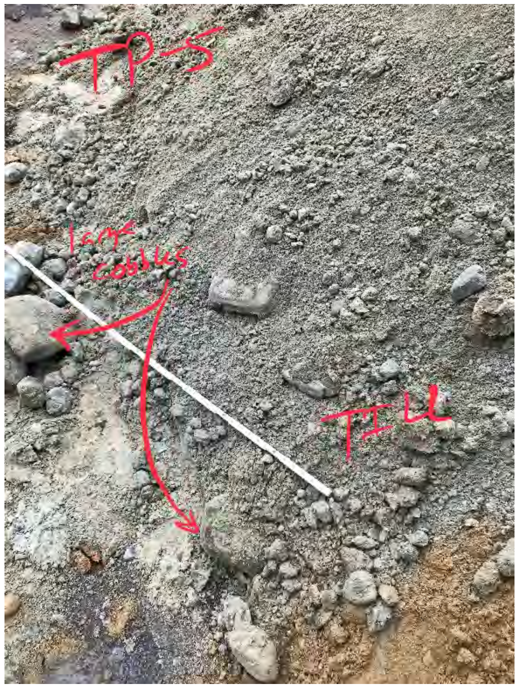


Photo 11: Large cobbles noted in the Glacial Till soils excavated from test pit HA21-TP5.

Photo 12: Stockpile of Glacial Till excavated from test pit HA21-TP6. Encountered a 1.5 ft long boulder in the Glacial Till.

Photo 13: Sidewall of test pit HA21-TP6 depicting soil stratigraphy. Top of Glacial Till is approximately 4 ft bgs and is underlying an approximately 1.7 ft thick layer of former/remnant Topsoil/Subsoil. Water is visible at the bottom of the excavation.

Photo 14: Test pit HA21-TP7. Water seepage noted at about 9 ft bgs. Sidewall of test pit collapsed at approximately 7.5 ft bgs. A 3 ft diameter boulder is noted within the Glacial Till layer.

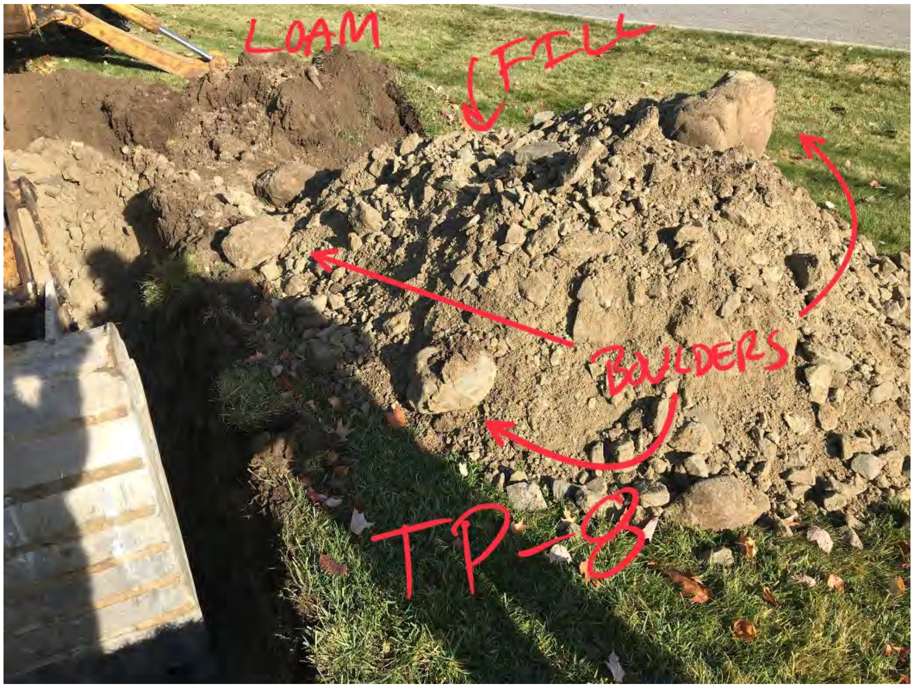


Photo 15: Stockpile of soil excavated from test pit HA21-TP8.

Photo 16: View of the sidewall at test pit HA21-TP8, showing soil stratigraphy. Top of Glacial Till was encountered at approximately 2.4 ft bgs and is underlying loam and cobble Fill layers.

Photo 17: Completed excavation for test pit HA21-TP10.

Photo 18: Test pit HA21-TP11. The top of the Glacial Till deposit was noted at 2.5 ft bgs. Water was noted at approximately 9.2 ft bgs.

Photo 19: Guelph permeameter test conducted at test pit HA21-TP11.

Photo 20: Fill overlying Glacial Till observed in the sidewall of test pit HA21-TP12.

Photo 21: Stockpile of Glacial Till excavated from the bottom of test pit HA21-TP12.

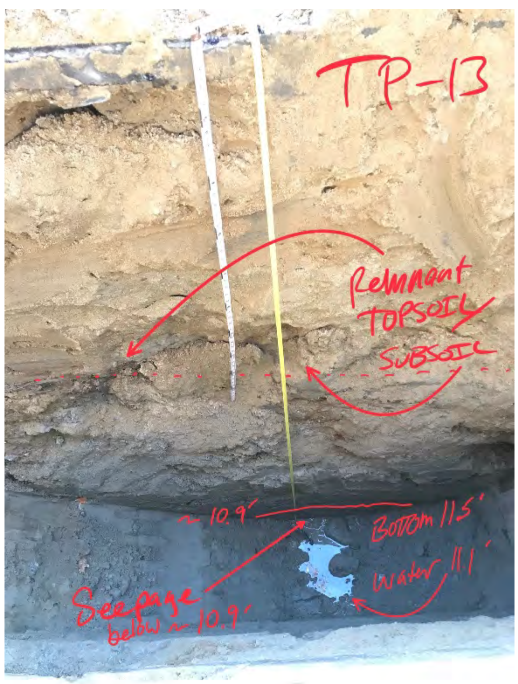


Photo 22: Sidewall of test pit HA21-TP13. Water seepage observed below 10.9 ft bgs and puddling at approximately 11.1 ft bgs.

Photo 23: Stockpile of soil excavated from test pit HA21-TP13. Encountered a 2.5 ft diameter boulder during the excavation.

Photo 24: Existing footing foundation encountered in test pit HA21-TP14. Top of footing encountered at 42 in. bgs. Footing was determined to protrude beyond the exterior face of the foundation wall by 28 in. where measured parallel to the wall. The depth of the footing was determined to be 18 in.

Photo 25: Irregular footing foundation encountered in test pit HA21-TP14 at the existing building corner. Dimensions as shown.

Photo 26: Close-up view of building foundation within test pit HA21-TP14.

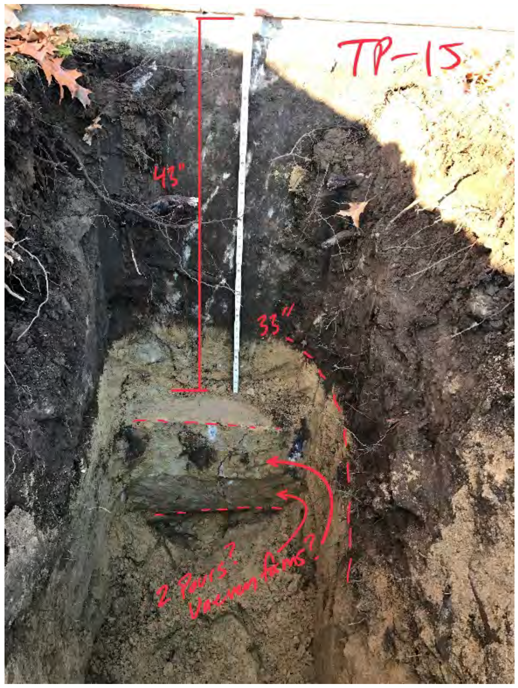


Photo 27: View of test pit HA21-TP15, exposing existing building foundation adjacent to the proposed Building Addition.

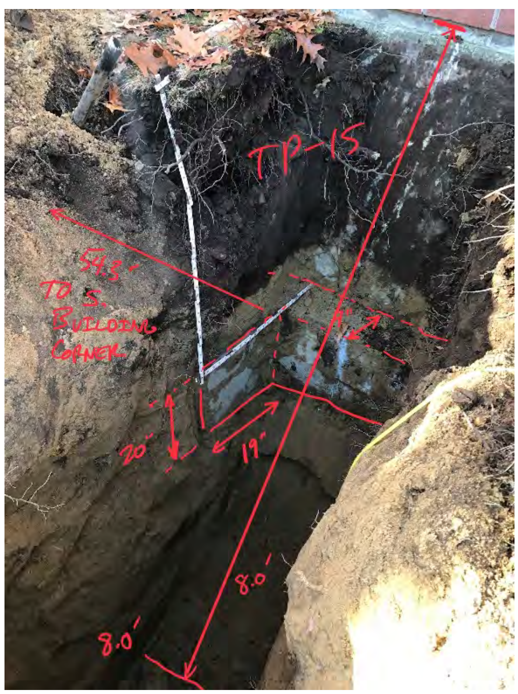


Photo 28: Another view of test pit HA21-TP15 at a different angle, showing exposed existing building foundation.

APPENDIX D

In-Situ Infiltration Testing Summary

HA21- TP2 11/11/2021

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: HA21-TP2 (Hole #) 11/11/2021 (Date) 1045 (Time) Sunny 40s (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use ______ (e.g., woodland, agricultural field, vacant lot, etc.) ______ Vegetation ______ Surface Stones (e.g., cobbles, stones, boulders, etc.) ______ Slope (%)

   Description of Location: ______

2. Soil Parent Material: Gl. Till TILL Plateau (Landform) ______ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ______ feet Drainage Way ______ feet Wetlands ______ feet

   Property Line ______ feet Drinking Water Well ______ feet Other ______ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No If yes: ______ Depth Weeping from Pit ______ Depth Standing Water in Hole

EL 152.5 HA21-TP2

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-5"	ASPHALT			—	—	—	—		-	—	
4"-1.7'	A/FILL	SAND	10YR 6/6 Brownish yellow							very friable	
1.7-3.8	B/FILL	Loam		—	—					friable	
3.8-10	C	Loamy SAND	Olive 5Y 5/3	8.5	Reddish Brn	10%				single Grain/friable	

Additional Notes: Seepage @ 9.5' BOE 10 ft. ESHWT 8.5 ft

HA21-TP5

11/10/2021
1 CORPORATE DRIVE

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: HA21-TP5 (Hole #) 11/10/2021 (Date) 1030 (Time) ____ (Weather) ____ (Latitude) ____ (Longitude:)

1. Land Use ____ (e.g., woodland, agricultural field, vacant lot, etc.) ____ Vegetation ____ Surface Stones (e.g., cobbles, stones, boulders, etc.) ____ Slope (%)

   Description of Location: ____

2. Soil Parent Material: Gl. Till / Outwash   'Edge of Till Slope (Landform)   ____ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ____ feet   Drainage Way ____ feet   Wetlands ____ feet
   Property Line ____ feet   Drinking Water Well ____ feet   Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No   If yes: ____ Depth Weeping from Pit   ____ Depth Standing Water in Hole

EL-152.4   HA21-TP5

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-4"	Asphalt			—	—	—	—		—	—	
4"-2.9	A/FILL	SAND	10 YR 6/6 Brownish Yellow	—	—	—	—		—	—	
2.9'-4.0	A_b (Buried)	LOAM	Dk Brown							V. friable	
4-5	B_1 (Buried)	Loamy SAND	10 YR 4/3 Brown	—					Granular/weak	friable	
5-11.0	C_1	Loamy SAND	Light Brownish Gray 2.5Y 6/2	10'	Yellowish Red 5YR 5/6	10%	5%	<10%	weak/Platy	friable	
11.0-11.6	C_2	SILT LOAM	Appears to be Interbedded w/ SILT LOAM @ 11.0 +/-			20%			—		

Additional Notes: Appears to be Gl. Till / OUTWASH - Ablation Till ; Total depth 11.6 11.4 standing water
Seepage @ 11.0   ESHWT @ 10'

11/10/2021

Commonwealth of Massachusetts
City/Town of

HA21 - TP6

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: HA21-TP6 (Hole #) 11/10/21 (Date) 0900 (Time) ______ (Weather) ______ (Latitude) ______ (Longitude)

1. Land Use: ______ (e.g., woodland, agricultural field, vacant lot, etc.) ______ Vegetation ______ Surface Stones (e.g., cobbles, stones, boulders, etc.) ______ Slope (%)

   Description of Location: ______

2. Soil Parent Material: Gl. Till ______ Landform ______ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ______ feet   Drainage Way ______ feet   Wetlands ______ feet
   Property Line ______ feet   Drinking Water Well ______ feet   Other ______ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No   If yes: ______ Depth Weeping from Pit ______ Depth Standing Water in Hole

HA21 - TP6   EL. 153.0

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features: Depth	Redoximorphic Features: Color	Redoximorphic Features: Percent	Coarse Fragments % by Volume: Gravel	Coarse Fragments % by Volume: Cobbles & Stones	Soil Structure	Soil Consistence (Moist)	Other
0-4	Asphalt		—	—							
4"-2.3'	A/FILL	SAND	10YR 6/6 Brownish Yellow	—					Single Grain		
2.3'-2.7'	A/FILL	LOAMY SAND	7.5YR 4/4 Brown						Weak	Friable	
2.7-3.2	A/B	SANDY LOAM	7.5YR 5/8 Strong Brn.						Weak	v. friable	
3.2-3.9'	B	LOAMY SAND	7.5YR 4/4 Brown						Weak	friable	
3.9-10'	C1	SILT LOAM AND LOAMY SAND	2.5Y 6/3 Light Yellowish Brn	7.5'	Yellowish Red 5YR 5/6	10%	15%	5%	massive	~~moist~~	
10-10.5	C2	SILT LOAM	2.5Y 5/3 Light olive Brn	10.0	5YR 5/6 and Light Gray 2.5Y 7.2	30%					

Additional Notes: Seepage @ 9'   Total Depth = 10.5'
ESHWT @ 7.5'

HA-21 - TP7
11/10/2021

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP7 (Hole #) ____ Date ____ Time ____ Weather ____ Latitude ____ Longitude:

1. Land Use ____ (e.g., woodland, agricultural field, vacant lot, etc.) ____ Vegetation ____ Surface Stones (e.g., cobbles, stones, boulders, etc.) ____ Slope (%)

   Description of Location: ____

2. Soil Parent Material: ____ Landform ____ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Wetlands ____ feet

   Property Line ____ feet Drinking Water Well ____ feet Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No If yes: ____ Depth Weeping from Pit ____ Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-4"	Parent										
4-1.5'	B/FILL	SAND	'						weak	v.friable	
1.5-2.2	B/FILL	LOAM/SANDY LOAM							weak	friable	
2.2-9	C1	LOAM	Olive 5Y 5/4	6.5	Reddish Brn 5YR 4/4	10%			massive	"	
9-10.5	Cd	SILT LOAM	Olive brn 2.5Y 5/3	7.5	Reddish Brn and Gray	20%			Massive	"	

Additional Notes: Seepage @ 7.5 ft ESHWT @ 6.5'

Test @ 3.5-4.0

HA21 - TP8 11/11/2021 0915 - 1015 0203691-000 One Corporate Drive, Andover, MA

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: HA21-TP8 (Hole #) 11/11 (Date) 10:00 (Time) Sunny (Weather) ____ (Latitude) ____ (Longitude:)

1. Land Use: Commercial Development (e.g., woodland, agricultural field, vacant lot, etc.) Field Edge (Vegetation) SOD (Surface Stones (e.g., cobbles, stones, boulders, etc.)) ~5% (Slope (%))

   Description of Location: Grass landscape edge of field slope

2. Soil Parent Material: GLACIAL TILL ____ (Landform) ____ (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Wetlands ____ feet
   Property Line ____ feet Drinking Water Well ____ feet Other 250 feet Catch Basin

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☑ Disturbed Soil ☑ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☑ Yes ☐ No If yes: 7.4 Depth Weeping from Pit — Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-1'	A/Fill	Loam	Dk Brn 7.5 YR 3/3						weak	V-friable	
1-2.5	B/Fill	Loam	2.5Y 6/3 Light Yellowish Brn	—	—		—	10%	weak	Friable	
2.5-3.2	C1	Silt Loam	5Y 5/3 Olive	4.5	Reddish Yellow 7.5YR 6/8	<5%	20%	10%	Blocky		
3.2-9'	Cd	Silt Loam	5Y 5/3 Olive	5.5	5Y 7/3 Pale Yellow	15%	20%	10%	Blocky	Firm	
					and 7.5YR 6/8 Reddish Yellow						

Additional Notes: Seepage @ 7.4' BOE 9.0 ft
ESHWT @ 5.5 ft.

11/15/2021
HA21-TP11

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP11 (Hole #) 11/15/2021 (Date) ____ Time ____ Weather ____ Latitude ____ Longitude:

1. Land Use ____ (e.g., woodland, agricultural field, vacant lot, etc.) ____ Vegetation ____ Surface Stones (e.g., cobbles, stones, boulders, etc.) ____ Slope (%)

   Description of Location: ____

2. Soil Parent Material: ____ Landform ____ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Wetlands ____ feet

   Property Line ____ feet Drinking Water Well ____ feet Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No If yes: ____ Depth Weeping from Pit ____ Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0 - 1 ft	A/Fill	Loam	Brown 10YR 4/3						weak	V friable	Root mat/Forest mat landscaped Area
1-3.0	B/Fill	Sandy Loam	Brownish Yellow 10YR 6/6						weak	v. friable	
3.0-6.0	C_1	Loam	Light Yellowish Brown 2.5Y 6/3			<5%	5%		Platy	friable	
6.0-9.5	Cd	Loam/Loamy Sand	Light Yellowish Gray 2.5Y 6/2	6.8'	Reddish Brn and Gray 5YR 4/4 / 5YR 6/1	15%			Firm/massive	friable	

Additional Notes: Seepage @ 8.5 ESHWT @ 6.8' Test 4.3 - 4.8 w/ Guelph
Standing Water 9.3

Commonwealth of Massachusetts
City/Town of

11/15/2021
HA21-TP12

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-12 (Hole #) ______ Date ______ Time ______ Weather ______ Latitude ______ Longitude:

1. Land Use ______ (e.g., woodland, agricultural field, vacant lot, etc.) ______ Vegetation ______ Surface Stones (e.g., cobbles, stones, boulders, etc.) ______ Slope (%)

   Description of Location: ______

2. Soil Parent Material: ______ ______ Landform ______ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ______ feet   Drainage Way ______ feet   Wetlands ______ feet
   Property Line ______ feet   Drinking Water Well ______ feet   Other ______ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No   If yes: ______ Depth Weeping from Pit ______ Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-5"	Asphalt								—	—	
5"-1.5	B/Fill	Sand	Yellowish Brn. 10YR 6/8						weak	v. friable	
1.5-8'	C_1	Loam	Light Yellowish Brn. 2.5Y 6/4						Platy	friable	
8-10.5	C_d	Silt Loam	Olive 5Y 5/3	9.5	Reddish Brn 5YR 4/4	10%			massive	friable	

Additional Notes: BOE 10.5'   Seepage @ 10.0   ESHWT 9.5

Guelph Permeameter Calculations

SOILMOISTURE®

Input (green)
Result (yellow)

Single Head Method (1)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 5
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 12.0000

Res Type	2.16
H	5
a	3
H/a	1.667
a*	0.12
C0.01	0.809
C0.04	0.842
C0.12	0.803
C0.36	0.803
C	0.803
R	#####
Q	0.432
pi	3.142

α^* = 0.12 cm^{-1}

C = 0.803154
Q = 0.432

K_{fs} = 7.86E-04 cm/sec
4.71E-02 cm/min
7.86E-06 m/sec
1.86E-02 inch/min
3.09E-04 inch/sec

Φ_m = 6.55E-03 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 24.0000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.12
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.28754
R	24.000
Q	0.864
pi	3.1415

α^* = 0.12 cm^{-1}

C = 1.287543
Q = 0.864

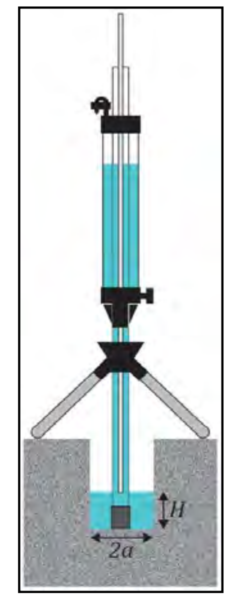
K_{fs} = 9.36E-04 cm/sec
5.62E-02 cm/min
9.36E-06 m/ses
2.21E-02 inch/min
3.69E-04 inch/sec

Φ_m = 7.80E-03 cm^2/min

Average

K_{fs} = 8.61E-04 cm/sec
5.17E-02 cm/min
8.61E-06 m/s
2.03E-02 inch/min
3.39E-04 inch/sec

Φ_m = 7.17E-03 cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = 0.12 cm^{-1}

α = 0.4292

Steady State Rate of Water Level Change ("R1" in cm/min): 12.0000
Steady State Rate of Water Level Change ("R2" in cm/min): 24.0000

Q_1 = 0.432
Q_2 = 0.864

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543
G-Denominator:	1525.687

C_1 = 0.803154257
C_2 = 1.287542759
G_1 = 0.005264214
G_2 = 0.004219551
G_3 = 0.055692198
G_4 = 0.024147811

K_{fs} = 1.37E-03 cm/sec
8.23E-02 cm/min
1.37E-05 m/sec
3.24E-02 inch/min
5.40E-04 inch/sec

Φ_m = 3.20E-03 cm^2/min

Θ_{fs} = 0.65 cm^3/cm^3
Θ_i = 0.4 cm^-/cm^-

Sorptivity = 0.0400 ($cm\ min^{-½}$)
Single Head Average Sorptivity = 0.0599 ($cm\ min^{-½}$)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm), H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	$\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	$G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$

Guelph Permeameter Calculations

Input

Result

Single Head Method (1)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16

Enter water Head Height ("H" in cm): 5

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 3.0000

Res Type	2.16
H	5
a	3
H/a	1.667
a*	0.12
C0.01	0.809
C0.04	0.842
C0.12	0.803
C0.36	0.803
C	0.803
R	3.000
Q	0.108
pi	3.142

α^* = 0.12 cm^{-1}

C = 0.803154

Q = 0.108

K_{fs} = 1.96E-04 cm/sec; 1.18E-02 cm/min; 1.96E-06 m/sec; 4.64E-03 inch/min; 7.73E-05 inch/sec

Φ_m = 1.64E-03 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16

Enter water Head Height ("H" in cm): 15

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 9.0000

Res Type	2.16
H	15
a	3
H/a	5
a*	0.12
C0.01	1.51827
C0.04	1.62914
C0.12	1.66689
C0.36	1.66689
C	1.66689
R	9.000
Q	0.324
pi	3.1415

α^* = 0.12 cm^{-1}

C = 1.666893

Q = 0.324

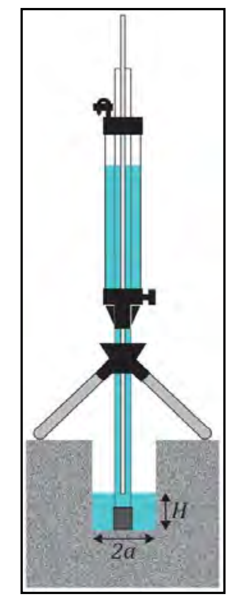
K_{fs} = 2.40E-04 cm/sec; 1.44E-02 cm/min; 2.40E-06 m/ses; 5.68E-03 inch/min; 9.47E-05 inch/sec

Φ_m = 2.00E-03 cm^2/min

Average

K_{fs} = 2.18E-04 cm/sec; 1.31E-02 cm/min; 2.18E-06 m/s; 5.16E-03 inch/min; 8.60E-05 inch/sec

Φ_m = 1.82E-03 cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16

Enter the first water Head Height ("H1" in cm): 5

Enter the second water Head Height ("H2" in cm): 15

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = 0.12 cm^{-1}

α = 0.2969

Steady State Rate of Water Level Change ("R1" in cm/min): 3.0000

Steady State Rate of Water Level Change ("R2" in cm/min): 9.0000

Q_1 = 0.108

Q_2 = 0.324

Res Type:	2.16
H1/a:	1.666667
H2/a:	5
C1-0.01:	0.809485
C2-0.01:	1.518269
C1-0.04:	0.842059
C2-0.04:	1.629144
C1-0.12:	0.803154
C2-0.12:	1.666893
C1-0.36:	0.803154
C2-0.36:	1.666893
G-Denominator:	4607.275

C_1 = 0.803154257

C_2 = 1.666892939

G_1 = 0.002614846

G_2 = 0.001808979

G_3 = 0.04053029

G_4 = 0.010352497

K_{fs} = 3.04E-04 cm/sec; 1.82E-02 cm/min; 3.04E-06 m/sec; 7.17E-03 inch/min; 1.20E-04 inch/sec

Φ_m = 1.02E-03 cm^2/min

Θ_{fs} = 0.65 cm^3/cm^3

Θ_i = 0.4 cm^3/cm^3

Sorptivity = 0.0226 $(cm\ min^{-½})$

Single Head Average Sorptivity = 0.0302 $(cm\ min^{-½})$

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	α^*(cm^{-1})	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1=\left(\frac{H_2/a}{2.081+0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1=\left(\frac{H_1/a}{1.992+0.091(H_1/a)}\right)^{0.683}$ $C_2=\left(\frac{H_2/a}{1.992+0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1=\left(\frac{H_1/a}{2.074+0.093(H_1/a)}\right)^{0.754}$ $C_2=\left(\frac{H_2/a}{2.074+0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1=\left(\frac{H_1/a}{2.074+0.093(H_1/a)}\right)^{0.754}$ $C_2=\left(\frac{H_2/a}{2.074+0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm), H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1=\bar{R}_1\times 35.22$	$K_{fs}=\frac{C_1\times Q_1}{2\pi H_1^2+\pi a^2 C_1+2\pi\left(\frac{H_1}{\alpha^*}\right)}$
One Head, Inner Reservoir	$Q_1=\bar{R}_1\times 2.16$	$\Phi_m=\frac{C_1\times Q_1}{(2\pi H_1^2+\pi a^2 C_1)\alpha^*+2\pi H_1}$
Two Head, Combined Reservoir	$Q_1=\bar{R}_1\times 35.22$ $Q_2=\bar{R}_2\times 35.22$	$G_1=\frac{H_2 C_1}{\pi(2H_1H_2(H_2-H_1)+a^2(H_1C_2-H_2C_1))}$ $G_2=\frac{H_1 C_2}{\pi(2H_1H_2(H_2-H_1)+a^2(H_1C_2-H_2C_1))}$ $K_{fs}=G_2Q_2-G_1Q_1$
Two Head, Inner Reservoir	$Q_1=\bar{R}_1\times 2.16$ $Q_2=\bar{R}_2\times 2.16$	$G_3=\frac{(2H_2^2+a^2C_2)C_1}{2\pi(2H_1H_2(H_2-H_1)+a^2(H_1C_2-H_2C_1))}$ $G_4=\frac{(2H_1^2+a^2C_1)C_2}{2\pi(2H_1H_2(H_2-H_1)+a^2(H_1C_2-H_2C_1))}$ $\Phi_m=G_3Q_1-G_4Q_2$

Guelph Permeameter Calculations

Input (green) — Result (yellow)

Single Head Method (1)

Reservoir Cross-sectional area in cm²
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 5
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 8.0000

Res Type	2.16
H	5
a	3
H/a	1.667
a*	0.12
C0.01	0.809
C0.04	0.842
C0.12	0.803
C0.36	0.803
C	0.803
R	8.000
Q	0.288
pi	3.142

α*= 0.12 cm^{-1}

C = 0.803154
Q = 0.288

K_{fs} = 5.24E-04 cm/sec
3.14E-02 cm/min
5.24E-06 m/sec
1.24E-02 inch/min
2.06E-04 inch/sec

Φ_m = 4.37E-03 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm²
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 15.0000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.12
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.28754
R	15.000
Q	0.54
pi	3.1415

α*= 0.12 cm^{-1}

C = 1.287543
Q = 0.54

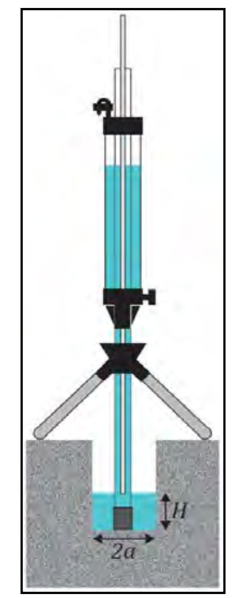
K_{fs} = 5.85E-04 cm/sec
3.51E-02 cm/min
5.85E-06 m/ses
1.38E-02 inch/min
2.30E-04 inch/sec

Φ_m = 4.88E-03 cm^2/min

Average

K_{fs} = 5.54E-04 cm/sec
3.33E-02 cm/min
5.54E-06 m/s
1.31E-02 inch/min
2.18E-04 inch/sec

Φ_m = 4.62E-03 cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm²
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α*= 0.12 cm^{-1}

α= 0.2542

Steady State Rate of Water Level Change ("R1" in cm/min): 8.0000
Steady State Rate of Water Level Change ("R2" in cm/min): 15.0000

Q_1 = 0.288

Q_2 = 0.54

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543
G-Denominator:	1525.687

C_1 = 0.803154257

C_2 = 1.287542759

G_1 = 0.005264214

G_2 = 0.004219551

G_3 = 0.055692198

G_4 = 0.024147811

K_{fs} = 7.62E-04 cm/sec
4.57E-02 cm/min
7.62E-06 m/sec
1.80E-02 inch/min
3.00E-04 inch/sec

Φ_m = 3.00E-03 cm^2/min

Θ_{fs} = 0.65 cm^3/cm^3
Θ_i = 0.4 cm^-/cm^-

Sorptivity = 0.0387 ($cm\ min^{-½}$)
Single Head Average Sorptivity = 0.0481 ($cm\ min^{-½}$)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm), H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

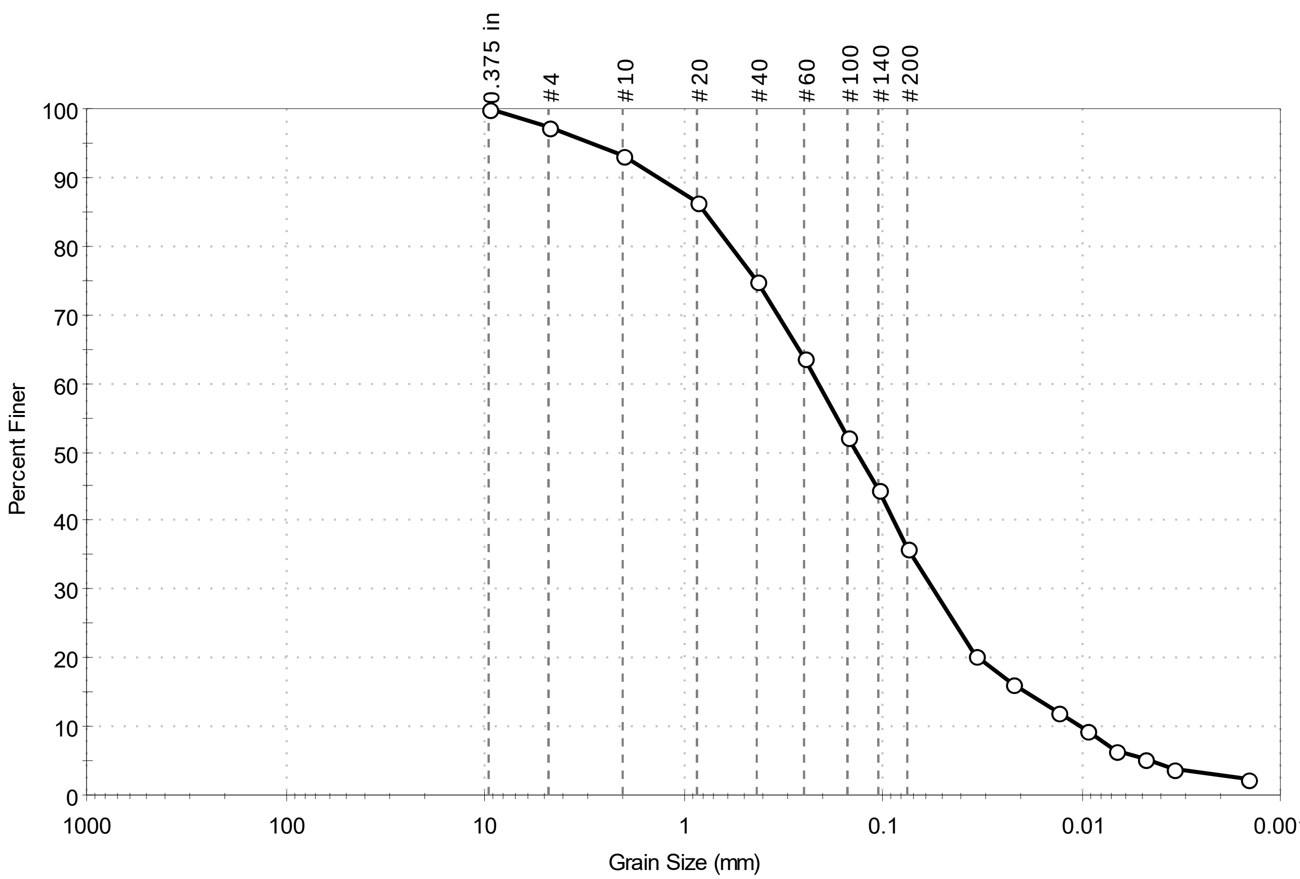
One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	$\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	$G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$

APPENDIX E

Geotechnical Laboratory Testing Results

Client:	Haley & Aldrich, Inc.		
Project:	One Corporate Drive		
Location:	Andover, MA	Project No:	GTX-314743
Boring ID:	HA21-TP2	Sample Type: bag	Tested By: ckg
Sample ID:	HA21-TP2	Test Date: 01/06/22	Checked By: jdt
Depth :	4.7 - 5.2 ft	Test Id: 644856	
Test Comment:	---		
Visual Description:	Moist, light brown silty sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	2.8	61.3	35.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	97		
#10	2.00	93		
#20	0.85	86		
#40	0.42	75		
#60	0.25	64		
#100	0.15	52		
#140	0.11	45		
#200	0.075	36		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0341	20		
---	0.0223	16		
---	0.0132	12		
---	0.0094	9		
---	0.0068	7		
---	0.0048	5		
---	0.0034	4		
---	0.0014	2		

Coefficients

D_{85} = 0.7843 mm | D_{30} = 0.0556 mm

D_{60} = 0.2116 mm | D_{15} = 0.0191 mm

D_{50} = 0.1358 mm | D_{10} = 0.0102 mm

C_u = 20.745 | C_c = 1.432

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

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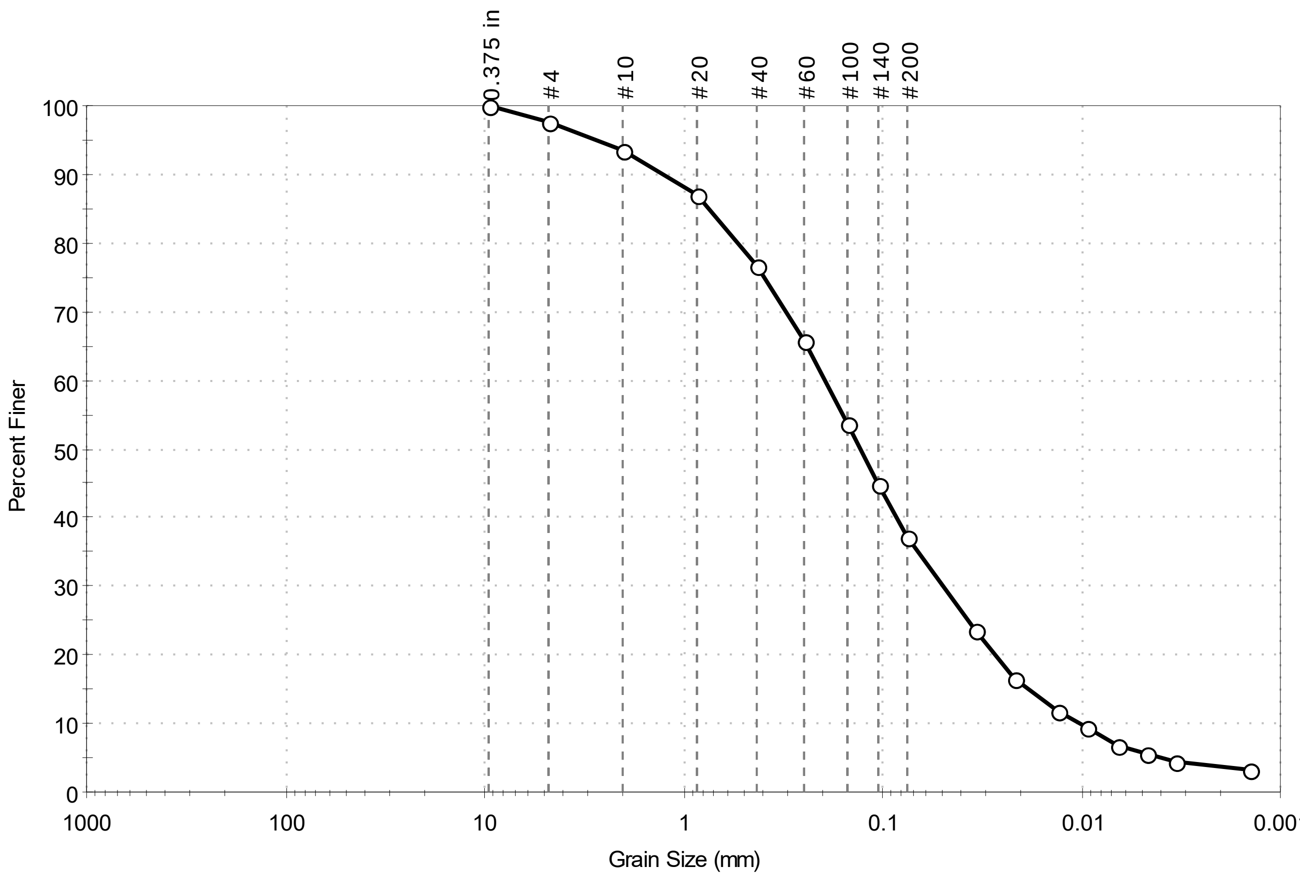
Client:	Haley & Aldrich, Inc.				
Project:	One Corporate Drive				
Location:	Andover, MA			Project No:	GTX-314743
Boring ID:	HA21-TP7	Sample Type:	bag	Tested By:	ckg
Sample ID:	HA21-TP7	Test Date:	01/06/22	Checked By:	jdt
Depth :	2.3 - 6 ft	Test Id:	644857		
Test Comment:	---				
Visual Description:	Moist, light brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	2.3	60.4	37.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	98		
#10	2.00	94		
#20	0.85	87		
#40	0.42	77		
#60	0.25	66		
#100	0.15	54		
#140	0.11	45		
#200	0.075	37		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0338	24		
---	0.0219	16		
---	0.0131	12		
---	0.0094	9		
---	0.0066	7		
---	0.0048	6		
---	0.0034	5		
---	0.0014	3		

Coefficients

D_{85} = 0.7429 mm
D_{30} = 0.0491 mm
D_{60} = 0.1958 mm
D_{15} = 0.0187 mm
D_{50} = 0.1298 mm
D_{10} = 0.0103 mm
C_u = 19.010
C_c = 1.195

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

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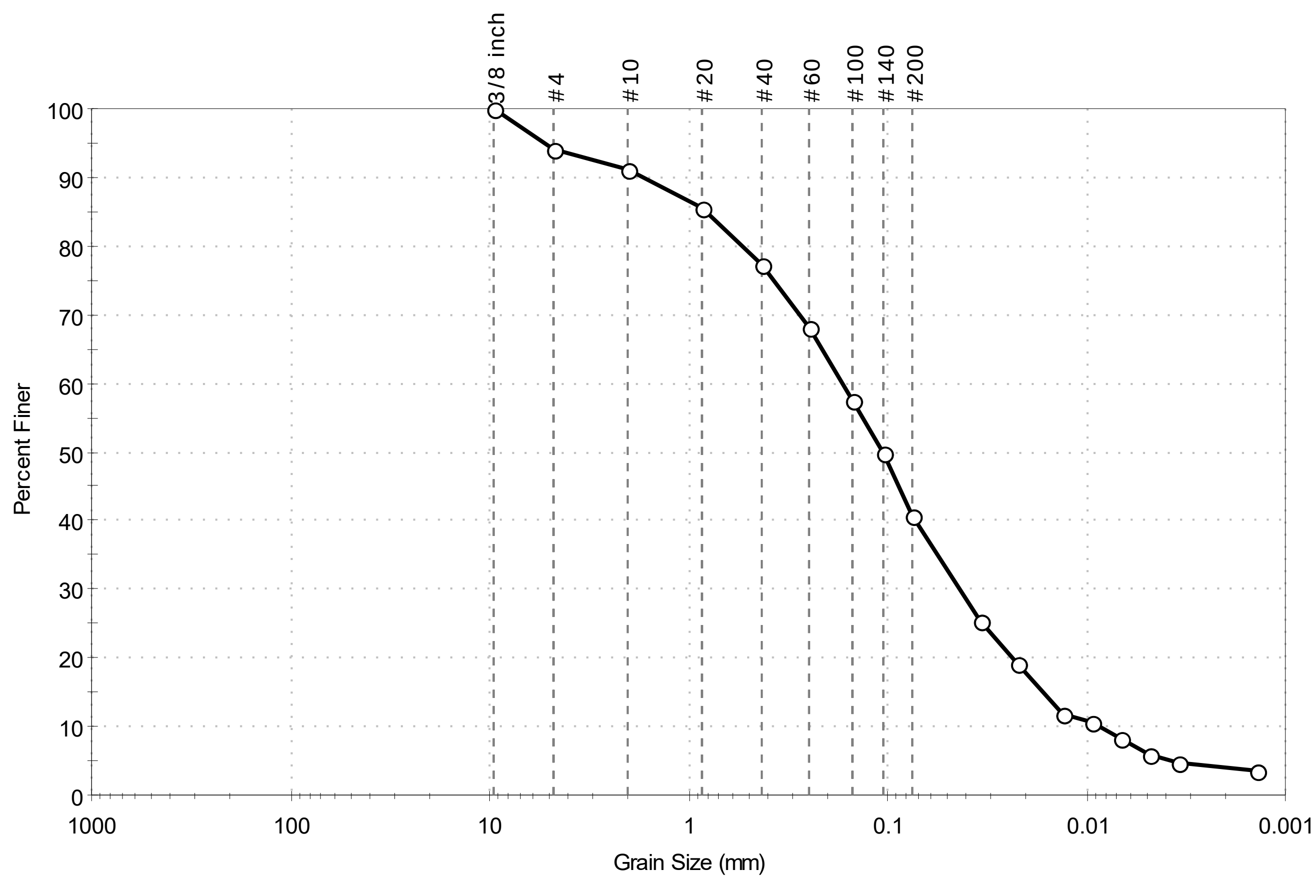
Client:	Haley & Aldrich, Inc.				
Project:	One Corporate Drive				
Location:	Andover, MA			Project No:	GTX-314743
Boring ID:	HA21-TP11	Sample Type:	bag	Tested By:	ckg
Sample ID:	HA21-TP11	Test Date:	01/06/22	Checked By:	jdt
Depth :	4 - 5 ft	Test Id:	644858		
Test Comment:	---				
Visual Description:	Moist, light brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	5.9	53.3	40.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/8 inch	9.50	100		
#4	4.75	94		
#10	2.00	91		
#20	0.85	86		
#40	0.42	77		
#60	0.25	68		
#100	0.15	57		
#140	0.11	50		
#200	0.075	41		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0338	25		
---	0.0221	19		
---	0.0132	12		
---	0.0094	11		
---	0.0067	8		
---	0.0048	6		
---	0.0034	5		
---	0.0014	3		

Coefficients

D_{85} =0.8059 mm D_{30} =0.0431 mm
D_{60} =0.1693 mm D_{15} =0.0165 mm
D_{50} =0.1072 mm D_{10} =0.0086 mm
C_u =19.686 C_c =1.276

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

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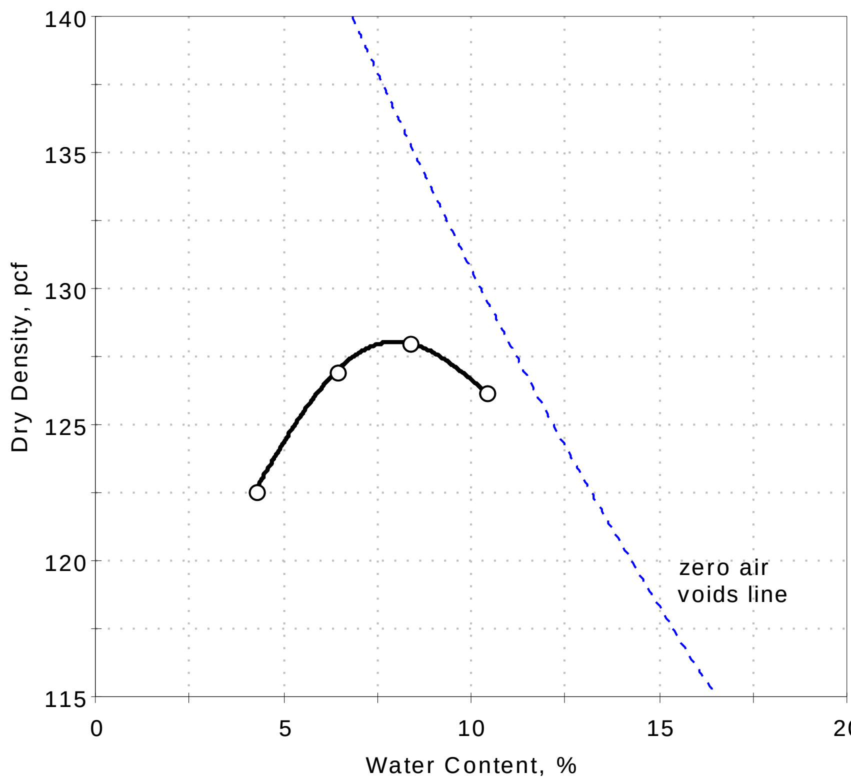
Client:	Haley & Aldrich, Inc.				
Project:	One Corporate Drive				
Location:	Andover, MA			Project No:	GTX-314743
Boring ID:	HA21-TP15	Sample Type:	bag	Tested By:	cwd
Sample ID:	HA21-TP15	Test Date:	12/29/21	Checked By:	jdt
Depth :	6 - 8 ft	Test Id:	644855		
Test Comment:	---				
Visual Description:	Moist, yellowish brown silty sand				
Sample Comment:	---				

Compaction Report - ASTM D1557



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	122.6	126.9	128.0	126.2
Moisture Content, %	4.3	6.4	8.3	10.4

Method : C

Preparation : DRY

As received Moisture :10 %

Rammer : Mechanical

Zero voids line based on assumed specific gravity of 2.65

Maximum Dry Density= 128.1 pcf

Optimum Moisture= 8.0 %

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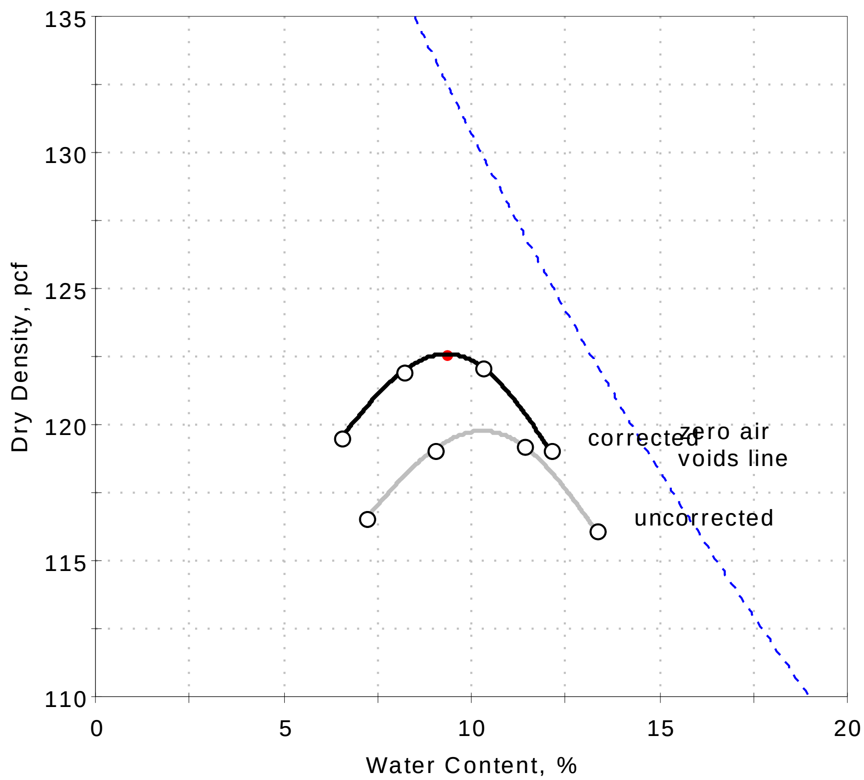
Client:	Haley & Aldrich, Inc.				
Project:	One Corporate Drive				
Location:	Andover, MA			Project No:	GTX-314743
Boring ID:	HA21-TP5	Sample Type:	bag	Tested By:	cwd
Sample ID:	HA21-TP5	Test Date:	12/30/21	Checked By:	jdt
Depth :	0.4 - 3 ft	Test Id:	644854		
Test Comment:	---				
Visual Description:	Moist, yellowish brown silty sand with gravel				
Sample Comment:	---				

Compaction Report - ASTM D1557



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	116.6	119.1	119.3	116.1
Moisture Content, %	7.2	9.0	11.4	13.3

Method : C

Preparation : DRY

As received Moisture :10 %

Rammer : Mechanical

Zero voids line based on assumed specific gravity of 2.55

Maximum Dry Density= 119.8 pcf
Optimum Moisture= 10.3 %

<u>Oversize Correction (9% > 3/4 inch Sieve)</u>

Corrected Maximum Dry Density= 122.6 pcf
Corrected Optimum Moisture= 9.3 %
Assumed Average Bulk Specific Gravity = 2.55

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HALEY & ALDRICH, INC.
465 Medford St.
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Boston, MA 02129
617.886.7400

MEMORANDUM

2 February 2022
File No. 0203691-000

TO: IQHQ – 1 Corporate Drive
Adrienne McGuire, Bryan Gubbins, Matt Formicola

C: Ellenzweig
James Blount

FROM: Haley & Aldrich, Inc.
Jessica L. Lefkowitz, P.E. (MA), Senior Technical Specialist
Mark X. Haley, P.E. (MA), Principal

SUBJECT: Addendum #1 – Geotechnical Design Recommendations
1 Corporate Drive
Andover, Massachusetts

The purpose of this Addendum is to provide an update to the recommendations made in the Haley & Aldrich, Inc. (Haley & Aldrich) report titled Subsurface Investigations and Geotechnical Design Recommendations Report dated 14 January 2022 (Geotechnical Report). These changes came about as the result of conversations with the project team on 27 January 2022, including the Construction Manager, Erland Construction (Erland), whom we understand is currently developing pricing for the project. We understand that Erland had conducted a preliminary evaluation of project costs based on the recommendations included in our Geotechnical Report which required over-excavation of all unsuitable fill soils within the building footprint, both below the building foundations and below the lowest level floor slab and found the quantity of over-excavation of Fill soils to be prohibitively expensive. Accordingly, we indicated that the project could consider limiting over-excavation and replacement of the fill soils below the building lowest level floor slab by excavating and replacing only the first 24 in. of fill soils encountered below the bottom of the slab and leaving any remaining underlying fill soils in place, understanding that in doing so, there is an increased risk for settlement of the ground floor building slab. The recommendations outlined herein include requirements specific to over-excavation and replacement of 24 in. of miscellaneous Fill soils below the ground floor slab-on-grade. The recommendations provided herein are specific to design and construction of the lowest level floor slab; all other recommendations provided in the Geotechnical Report remain unchanged.

GENERAL

Building foundations should be designed and constructed in accordance with the Massachusetts State Building Code (Building Code). Recommendations provided herein are intended to be consistent with the 9th Edition of the Building Code.

Recommendations presented herein are based on the proposed building layout, site development plan as understood at this time, and discussions held between the project team. As further information is developed by the architect and/or structural engineer concerning these items, the design criteria should be reviewed by Haley & Aldrich for continued applicability.

FOUNDATIONS

Foundation Recommendations

The requirements provided in our Geotechnical Report for design and construction of footing foundations remain unchanged; they are provided herein for clarity and convenience.

The existing Fill soils at the site, including any Subsoil/Topsoil, are not considered a suitable bearing strata to support the building foundations. The proposed building foundations should bear in the naturally deposited inorganic Glacial Till soils at the site (the bearing stratum). We recommend that the proposed building be supported on conventional reinforced concrete footing foundations bearing in the Glacial Till deposit. Concrete footing foundations may bear at "normal" depths on undisturbed, naturally deposited Glacial Till soils or on lean concrete or Structural Fill placed following removal of unsuitable soils. Specific recommended design criteria for concrete footing foundations are as follows:

- Design footings using a maximum allowable bearing pressure of 6 kips per sq ft (ksf).
- Design footings to have a least lateral dimension of 24-in.
- Locate bottoms of footings at least 48-in. below lowest adjacent ground surface exposed to freezing, and a minimum 18-in. below the top of the adjacent ground floor slab at heated interior locations. For construction during winter months, footings and floor slabs will require protection from freezing temperatures at the bearing surfaces until the building is enclosed and heated.
- New foundations to be constructed adjacent to the existing 1 Corporate Drive building should be designed to bear at the same elevation as the existing foundations. New foundations can bear on the existing imported structural Fill soils identified below the existing footing foundations in the recent test pit excavations. Unsuitable Fill soils should be removed from within the Zone of Influence (ZOI) of the new foundations as outlined herein.

Unsuitable materials must be removed from within the ZOI beneath foundations. The ZOI is defined as the zone beneath the footing and beneath imaginary lines extending 2 ft laterally beyond the footing outer bottom edges and down and out on a one horizontal to one vertical (1H:1V) slope, to the bearing stratum.

- Following removal of unsuitable materials from within the ZOI, compacted structural fill could be used to raise the grade, where practical, beneath footings. Alternatively, where it is desirable to limit the excavation required to replace material within the ZOI below a footing, lean concrete (1,500 psi minimum compressive strength) may be used in place of compacted granular fill. The advantage of lean concrete fill is that where the compacted granular fill must occupy the conventional ZOI as defined above, the plan area of lean concrete need only be slightly larger than the footing dimensions (extending 1 ft laterally beyond the outer footing edge on all sides) and can extend nearly vertical downward to the top of the Glacial Till deposit. In addition, systematic placement and compaction of lean concrete is not required.
- Design footings to bear below a reference line drawn upward and outward on a 1.5 horizontal to 1 vertical (1.5H:1V) slope from the bottom of any adjacent utilities or other underground structures. Where possible, footing elevations should be coordinated with utility elevations to allow utilities to pass through the foundation wall (rather than through or beneath the footing). Footings should also be positioned such that a reference line drawn downward and outward on a 2H:1V slope from points 5 ft laterally beyond the footing bottom edges will not "daylight" above ground surface or onto the adjacent slopes. Footing bearing may need to be lowered or stepped locally to meet these criteria.
- Tops of footings should be positioned a minimum of 4-in. beneath the underside of the overlying floor slab.

Ground Floor Slabs

We understand the proposed ground floor slab is planned to be constructed as a soil-supported concrete slab-on-grade and is generally planned to be finished at about elevation (El.) 156, corresponding to 1 to 4 ft above existing site grades. The top of the Glacial Till Deposit was encountered in the recent test pit excavations within and around the perimeter of the proposed building addition footprint at elevations varying from about El. 147 to about El. 152, corresponding to about 2 to 8 ft below existing site grades and about 4 to 9 ft below the elevation of the proposed finished floor slab.

As noted above, unsuitable Fill soils, including original Topsoil and Subsoil, are expected to be present below the proposed ground floor slab elevation. If larger magnitude total settlement of the lowest level slab can be accommodated (estimated to be in the range of 1.0 inches, then a portion of the existing Fill soils can be left in place below the ground floor slab (Fill soils must be removed completely below footing foundations as discussed above). Following over-excavation of a minimum of 24 in. below the bottom of the slab, the resulting subgrade should be proof-compacted with a minimum of four passes of a heavy vibratory roller imparting at least 25,000 lbs. of dynamic force. Compacted Granular Fill (Structural Fill) can then be used to raise the subgrade up to the desired finished floor design elevation.

The potential to use excavated on-site granular soils as backfill beneath the ground floor slab is also an option, that would need to be confirmed as construction progresses.

OTHER CONSIDERATIONS

We understand based on our discussions with the team that the final building use will be sensitive to vibrations. Although we cannot comment on performance of the building, soils observed at the site within the previous test pits are not anticipated to be sensitive to normal levels of vibrations.

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