Preliminary Design Report

Lawrence Brook Watershed Outfall and Upstream BMP/Storage

Peabody, Massachusetts

Prepared for:

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February 2019

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1.0 INTRODUCTION

The Lawrence Brook watershed is tributary to the North River on the northern side, just downstream of Peabody Square and upstream of the Salem border (Figure 1). Between 2017 and 2018, the watershed was evaluated to assess alternatives for mitigating flooding in the lower reaches of the watershed in the vicinity of 45 Walnut Street (Century Tire). This assessment identified a preferred alternative of installing a new stormwater outfall to the North River, upstream storage, and green Low Impact Development (LID) features including bioretention basins, porous pavement, and tree filters (Figure 1). This Preliminary Design Report (PDR) describes design elements for the new outfall and associated new drain pipe, as well as preliminary considerations regarding design of the upstream storage and green LID components.

2.0 FIELD INVESTIGATIONS AND DATA COLLECTION

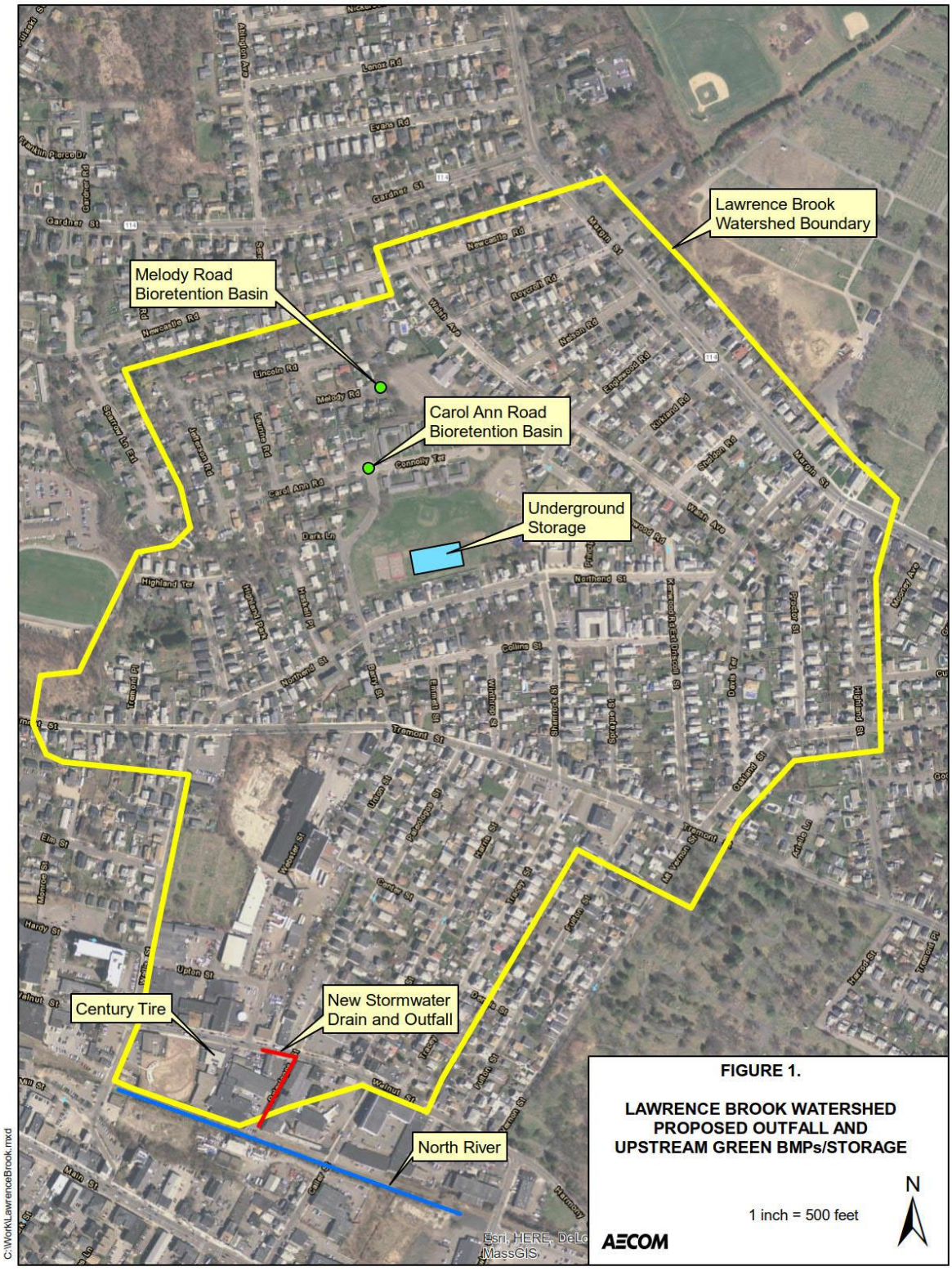
Investigations performed for this project consist of physical survey, collection of geotechnical data and review of available records. These efforts are described in the text below. Prior to performing the physical survey and geotechnical data collection work, a notice was provided to all abutters to alert residents of upcoming field work.

2.1 Physical Survey

Physical survey work was performed by Hancock Associates, Inc. under subcontract to AECOM, in November, 2018. Topographic and utility surveys were performed for the project areas including along Walnut Street, Paleologos Street, Connolly Park, Connolly Terrace and Melody Road. Existing conditions plans were generated by Hancock Associates and incorporated into the preliminary design plans included in this report.

2.2 Geotechnical Data

A subsurface investigation program was performed to collect data necessary to support the project design. Geotechnical data collection was performed by Terracon Consultants, Inc. under subcontract to AECOM in November, 2018. Nine test borings were drilled ranging in depth from 9 to 22 feet; an AECOM geotechnical engineer observed Terracon's conduct of the borings. In some locations, in-situ permeability testing was performed to observe the hydraulic response in upper soils, and laboratory testing of soil samples was performed to obtain the engineering properties of the soils. A summary of the subsurface investigation program is provided in the Geotechnical Design Memorandum presented in Attachment A, including boring logs, falling head permeability test data and soil sample laboratory testing results.


Lawrence Brook Watershed Boundary
Melody Road Bioretention Basin
Carol Ann Road Bioretention Basin
Underground Storage
Century Tire
New Stormwater Drain and Outfall
North River
Esri, HERE, DeLo
MassGIS
C:\Work\LawrenceBrook.mxd
FIGURE 1.
LAWRENCE BROOK WATERSHED
PROPOSED OUTFALL AND
UPSTREAM GREEN BMPs/STORAGE
1 inch = 500 feet
N
AECOM

2.3 Review of Available Records

Data collected and reviewed includes the following:

- South Essex Sewerage District (SESD) record drawings for Contract 71-3 of the SESD interceptor (sewer) showing information for the 78-inch diameter Class V reinforced concrete sewer. The record drawings were prepared by Metcalf and Eddy and are dated April 7, 1975.

- Shop drawings showing cross-sectional details of the 78-inch SESD sewer.

- Various utility as-built drawings provided by the City.

- Record drawings for North River Canal – North Wall Rehabilitation Project, prepared by Weston & Sampson Engineers, Inc., dated June 2008.

In addition, the City Department of Community Development reviewed City records regarding ownership of the parcels between Walnut Street and the North River, where new storm drain pipe is proposed.

2.4 Parcel Ownership South of Walnut Street

The City confirmed the ownership of the area between Walnut Street and the North River where new storm drain pipe is proposed. This segment of the proposed alignment is not a City street, but is instead comprised of privately owned parcels. The City would need to get the assents of the four abutters to the thirty (30) foot wide ROW to install the new storm drain pipe.

2.5 Railroad Tracks

The railroad tracks that parallel to the North River along the northerly side are active, and they are owned by the Massachusetts Bay Transportation Authority (MBTA). Pan-Am Railways operates and maintains the tracks.

Multiple communications and a site visit occurred with representatives from Pan-Am to identify their requirements related to work near and under the tracks. The following information was provided by Pan-Am:

- Pan-Am recommends the tracks in the area of the proposed culvert construction be temporarily taken out of service, removed and then replaced with new materials after culvert construction is completed. This will allow the culvert crossing of the tracks to be performed by open cut. All work related to track

removal and replacement would be performed by Pan-Am and paid for under this project. Pan-Am provided a cost estimate for this work which totals approximately $90,000.

- It is anticipated that construction of the culvert crossing in the vicinity of the railroad tracks and the SESD sewer would require multiple weeks. Removing the track from service to its customer, Rousselot, for this period of time will require that alternative accommodations be made to provide delivery services. The cost of the alternative delivery would be the City's responsibility. An allotment has been included in the cost estimate in Attachment C for the alternative delivery, although consultation with Rousselot during the next phase of design is needed to confirm the cost that would be incurred.

- A minimum of 1-foot below the tracks is required for ballast.

- The culvert crossing under the tracks must be capable of withstanding Cooper E-80 loading.

- The City will need to obtain a License Agreement from MBTA for work on railroad property

- Based on the City's review of parcel records, the existing utility easement along "Paleologos Street" south of Walnut Street ends at the Railroad property line. Therefore, the City would need to obtain a License Agreement from MBTA for work on railroad property.

- The construction contractor must carry railroad liability insurance.

- Materials to build the new railroad tracks have a typical lead time of 3 to 4 months from time of order to delivery.

2.6 SESD Sewer

A 78-inch diameter Class V reinforced concrete sewer exists on the north side of the railroad tracks and runs parallel to the tracks and the North River. SESD representatives were consulted to identify their requirements for work near the sewer. The following information was obtained:

- The sewer is owned and maintained by the SESD, and SESD has a right-of-way for the District's exclusive use. Any work within the right-of-way must be reviewed and approved by SESD's legal representative.

- The culverts must be designed so that no loads are transferred to the SESD sewer.

- If any work is to be performed on the SESD sewer, SESD must perform the work.

3.0 OUTFALL DESIGN

3.1 General Description

Drainage from the Lawrence Brook watershed is currently conveyed primarily through two 30-inch diameter drains which cross Walnut Street at Upton Street and extend to a 4-foot high by 5-foot wide box culvert that discharges into the North River approximately 250 feet upstream of Paleologos Street. This project will provide a secondary path for drainage to reach the North River through a series of new drainage pipes and culverts that will extend east along Walnut Street to Paleologos Street, and then south along Paleologos Street to a new discharge outfall into the North River (see Figure 1). A plan and profile showing the preliminary design elements of the proposed drainage system are provided on SK-1 and SK-2, respectively, presented in Attachment B.

A transition structure (DMH Sta. 0+00) will be constructed on top of the two 30-inch drains in Walnut Street. Four, 12-inch diameter drains will be connected to the east side of DMH Sta. 0+00. When the flow elevation in DMH Sta. 0+00 reaches approximately 1.2 feet above the invert of the 30-inch pipes, drainage will begin to flow into the four 12-inch pipes which will extend approximately 130 feet east along Walnut Street to another transition structure (DMH Sta. 1+32). A 2-foot high by 4-foot wide culvert will exit DMH Sta. 1+32 and extend approximately 55 feet to DMH Sta. 1+85 at the intersection of Walnut Street and Paleologos Street. The 2-foot high by 4-foot wide culvert will then extend approximately 340 feet from DMH Sta. 1+85 along Paleologos Street to its discharge point at the North River. The most downstream section of the culvert will cross over an existing 78-inch SESD sewer and then cross under existing railroad tracks prior to discharge at the North River. The depth of the culvert at the downstream end is limited by the elevation of both of these crossings.

Presented below is a discussion of key design elements incorporated into the preliminary design of the new drainage system.

3.2 Box Culvert

The 2-foot high by 4-foot wide culvert will be constructed of precast sections installed to depths ranging from approximately 5.5 feet to 7 feet below the ground surface. In most locations, the culvert will be constructed on 12 inches of screened gravel bedding. The reinforced concrete design thickness will vary depending on loadings. The typical thickness will be 8 inches on all sides for standard H-20 loading. For the railroad crossing where Cooper E-80loading is required, the thickness will be 8 inches on the sides and 10 inches on the top and floor slab. A typical cross section of the precast box culvert is shown on SK-3 in Attachment B.

The 1-foot spacing between the edge of culvert and side of trench will be backfilled with controlled density fill (concrete) to the top of the culvert. This will eliminate the need for compaction in areas of limited space below the top of the culvert.

Except where noted below, paved areas above the culvert will comply with City requirements for pavement in City roads, which consists of 5 inches of pavement in two courses underlain with 12 inches gravel base course on top of select borrow extending to the top of the culvert. In unpaved areas, a minimum of 6 inches loam and seed underlain with bank run gravel to the top of the culvert is recommended.

Because of limited available cover, a short stretch of approximately 15 feet of culvert in Walnut Street may not have the full 12 inches of gravel base.

3.3 12-Inch Diameter Drains

Due to limited cover at the upstream end of the work, drainage will be conveyed by four 12-inch polyvinylchloride (PVC) diameter pipes for approximately 130 linear feet. The pipes will be constructed in the same trench with an approximately 8-inch separation between pipes. The pipes will also be constructed at the same elevations and grade.

3.4 Drain Manholes

The drain manholes will generally consist of 8-foot by 8-foot precast vaults. Inverts and benches will be formed with concrete or brick and will be curved where required to provide smooth transition of flow from inlet to outlet pipes or culvert. Existing drains along Walnut Street that are to remain in service will be connected to the new drain manholes.

3.5 Utilities

Relocation of utilities will be required, including water, gas and sewer pipelines. Presented below are known utilities that will need to be relocated or replaced to accommodate the proposed drainage facilities.

- Approximately 185 linear feet of 15-inch drain in Walnut Street will be replaced by the new 12-inch drains and 2-foot high by 4-foot wide culvert.
- Approximately 160 linear feet of 12-inch sewer in Paleologos Street will be relocated.
- Approximately 175 linear feet of gas line will be relocated in Walnut Street.
- A gas pipe will be relocated where it crosses over the culvert in Paleologos Street.

- A water main will be relocated where it crosses over the culvert in Walnut Street near Paleologos Street.

3.6 SESD Pipe Crossing

The culvert must cross over the 78-inch diameter SESD pipe without transferring any loads to the SESD pipe. To accomplish this, a span of culvert approximately 12-feet long will be supported by micropiles located on each side of the SESD pipe. The micropiles will be 10.75-inch diameter cement grout with reinforced steel casing and drilled to an approximate depth of 50 feet. Each pile will have a factored resistance of 40 tons. The top of each pile will be tied into a cast-in-place reinforced concrete pile cap which will provide a platform to support the culvert where it crosses over the SESD pipe. The design allows an approximately 3-inch clearance between the bottom of the culvert and the top of the SESD pipe. An estimated maximum settlement of 0.5 inches is expected. Although no more than 0.5 inches of settlement of the pile supported culvert is expected at this location, the 3-inch space will be filled with a compressible material to ensure no loads are transferred to the SESD pipe. Cross sections of the SESD pipe crossing, including estimated pile cap dimensions, are shown on Section A-A and Section B-B presented in Attachment B.

During the next phase of design, one 60-foot deep boring is recommended at the approximate location of the micropiles to confirm the subsurface ground conditions and allow for appropriate design of the piles. In addition, a vacuum excavation is recommended to confirm the elevation of the top of the SESD sewer at the proposed culvert crossing.

3.7 Crossing of Railroad Tracks, Steel Sheeting and Granite Block Wall

The culvert crossing underneath the railroad tracks must be designed for standard railroad loading, commonly referred to as “Coopers E-80” loading. AECOM communicated with a culvert manufacturer/supplier to confirm that their culverts can meet Cooper E-80 loading. For this application, the culvert must have a minimum of 18 inches of cover under the railroad tracks, and the culvert roof and floor slab must have a minimum 10-inch thickness, compared to an 8-inch thickness for standard H-20 highway loading. These features are incorporated into the preliminary design.

Approximately 2 feet south of the southerly railroad track, vertical steel sheeting is located parallel to the track. The sheeting extends a minimum of 25 feet below grade. A portion of the top of the steel sheeting, approximately 24 square feet, will be cut and removed to accommodate the culvert passing through.

A granite block wall exists a few feet south of the steel sheeting, and forms the northerly bank of the North River. The granite blocks will be removed to allow culvert construction and will be re-installed around the culvert perimeter.

The above referenced railroad track, steel sheeting and granite block culvert crossings are shown on Section A-A.

3.8 Scour Protection

Scour protection for the river at the culvert outlet will be investigated in the next phase of the design. The conveyance Best Management Practice (BMP) discussion Chapter 3 of the MassDEP Stormwater Handbook indicates that discharge velocities greater than 5 feet per second (ft/s) are those that will result in scour. Modelling results, discussed further below, indicate that the discharge velocity at the outfall is anticipated to be less than 5 ft/s for the smaller 1-year and 2-year storm events, but higher than 5 ft/s for the 10-year storm and higher. During final design, options to incorporate velocity dissipation devices within the discharge pipe will be investigated in order to avoid the need to place rip-rap in the North River.

4.0 UPSTREAM UNDERGROUND STORAGE

Upstream storage is proposed in the form of an underground storage system in Connolly Park in the upstream portion of the Lawrence Brook watershed. The storage would receive flow during storm events, and then discharge the flow back to the storm drain system after the peak of the flow. The tank is sized to hold approximately 50,000 cubic feet of water, which is equivalent to the stormwater flow predicted for the 2-year design storm. During the preliminary design, survey information was obtained and three borings were conducted in Connolly Park in order to further evaluate the feasibility of constructing an underground storage system in the park. AECOM used this new information as well as information provided by product vendors to develop a preliminary sketch of the proposed storage system, drawing SK-4 presented in Attachment B. The following sections describe AECOM's evaluation of Connolly Park based on survey and boring findings, as well as the proposed underground storage system.

4.1 Subsurface Investigation

The survey conducted by Hancock Associates shows that drainage from Connolly Terrace enters Connolly Park through a deep manhole located approximately 15 feet north of the retaining wall at the northern border of the park. The surveyor was unable to determine where this drain line connects downstream. AECOM is working under the assumption that the drain line continues across the park and connects to the drainage going into Northend Street to the south. The survey also shows that there is an existing sewer line that runs north and south through the middle of the park. The proposed storage system has been located to the west of the sewer line in order to avoid any conflicts. AECOM recommends that drain lines bordering and within the park be evaluated by use of closed circuit television (CCTV), to check the condition of the

existing pipes and to check the connectivity between the proposed underground storage system and the existing drainage system.

The borings in Connolly Park revealed that the park subgrade has low permeability soil, rock is present, and groundwater ranges from 1 foot to 4.25 feet deep. Due to these findings, AECOM believes that infiltration will not be practical as part of an underground storage system. Instead, it is recommended that the proposed system be detention only. Rock was found at a depth of 4.9 feet in Boring B-4 and at a depth of 10.5 feet in boring B-5. No rock was encountered in boring B-6 which ended at a depth of 16 feet. From this information it appears that ledge is present in the northern portions of Connolly Park, but not in the southern portions of the park. AECOM believes that the majority of rock can be avoided by locating the underground storage system along the southern limit of the park. AECOM recommends that additional borings be conducted during the next design phase to confirm the absence of rock at the proposed storage location.

4.2 ChamberMaxx Retention System

The preliminary design of the underground storage system is based around a product by Contech called ChamberMaxx. Additional information on the system is included in Appendix D. This system consists of corrugated plastic halfpipes that are buried inside a 42 inch tall envelope of porous crushed stone. The proposed system consists of 650 halfpipe chambers arranged in a 220-foot by 110-foot area providing a storage capacity of 50,000 cubic feet. Approximately 275 feet of new drain line will be installed to divert flow into the storage system, and then back into downstream drainage at the southern limit of the park. The sewer line in the park will need to be crossed at least once as part of the proposed drainage. The system can be arranged in many configurations, and the final dimensions will be determined during the 90% design. Due to the presence of a high groundwater table (water was encountered at a depth of 3 feet in Boring B-6). The system will require a liner to keep the groundwater out.

AECOM had originally recommended the ChamberMaxx system because it was believed the system would provide significant cost savings over other storage systems. However, with the additional information on the subsurface conditions in Connolly Park, and after advancing the preliminary design, it is our opinion that the ChamberMaxx system will be more expensive to construct than initially anticipated in the Conceptual Design Memorandum. Factors that contribute to the increased cost include additional earthwork required based on the survey of the park and the storage system location, installing additional features such as a bottom liner associated with the presence of high groundwater, as well as costs for disposal of excess material offsite. AECOM recently learned that Connolly Park used to be the site of a landfill, which raises concerns about the potential for contaminated materials in the park substrate. AECOM recommends that environmental borings be performed during the next design phase to help inform what the costs of hauling material offsite will be.

4.3 Alternative Storage Systems

AECOM has also investigated alternative underground storage systems including installing a system comprised of a series of concrete storage vaults. Like the ChamberMaxx system, the concrete vaults would require a pond liner in order to keep groundwater out. The concrete alternative would also require a concrete floor slab underneath the vaults, to counteract buoyancy issues, which would prove difficult to construct considering the high groundwater. Overall the concrete alternative poses additional design challenges as well as higher construction costs. For the above listed reasons, AECOM does not recommend using a concrete vault style underground storage system. Additional alternative underground storage products will continue to be investigated during the next phase of design.

5.0 UPSTREAM GREEN LID BMPs

Upstream Green Low Impact Development features are proposed in the upstream portion of the Lawrence Brook watershed to aid in mitigating flooding as well as enhance water quality. Two bioretention basins are planned; one is proposed at the existing cul-de-sac on Melody Road, and one is proposed along Connelly Terrace in an area that was previously occupied by a cul-de-sac. In both locations, the basin design would accommodate continued access to adjacent private properties; the exact configuration of the basin and associated accommodations for private access will be determined during the next phase of design. In addition, porous pavement and tree box filters area proposed on the sidewalks along Connolly Terrace. The locations of these BMPs are shown on SK-5 presented in Attachment B.

As part of the field data collection effort, survey data was collected and geotechnical borings and infiltration testing was conducted at the proposed Green LID BMP locations. Borings B-1, B-2, and B-3 were located in the vicinity of the proposed BMPs (see boring locations on SK-5 in Attachment B).

As noted in the Geotechnical Design Memorandum in Attachment A, based on the shallow bedrock conditions encountered, the moderate to low permeability of the underlying soils, and (most notably) the relatively shallow groundwater table (between 3.0 and 5.0 feet below ground surface), the proposed locations are not suitable for groundwater recharge BMPs. It is important to note that these water depth measurements do not represent spring high water levels (which the permit criteria for infiltration BMPs require), which might be higher. In any event, the groundwater levels documented are sufficiently high that infiltration at these locations is not feasible. Although originally envisioned as infiltration BMPs, the proposed BMPs can be modified to provide only water quality treatment and some minor retention. The two bioretention basins would be designed to function solely as organic filters. A filtering bioretention basin includes an impermeable liner and underdrain system that conveys treated stormwater to a discharge outlet, another downstream BMP, or the municipal storm drain. The proposed tree boxes could be designed in a similar fashion. Stormwater runoff would enter the BMP through a curb-inlet opening or pipe and flow through a filter

(treatment) media and then into an underdrain system before discharging to the storm drain.

Design of these BMPs is proceeding under a separate task, and the design will be provided for review when complete.

6.0 MODELING UPDATE

During the Conceptual Design completed in 2018, several stormwater outfall alignments were explored. Optimization 2a included a 2-foot by 4-foot box culvert with a flap valve along Walnut Street, and a 3-foot by 5-foot box culvert along Paleologos Street from Walnut Street to a new outfall at the North River. Based on discussions with the City, it was agreed that Optimization 2a offered the maximum flood mitigation benefit of the alternatives evaluated, and was selected for additional model runs with BMPs, storage, and the full North River watershed-wide SWMM model.

As previously described in this memo, additional survey was performed throughout the project area in 2018. During this survey, the actual rim and invert elevations for the existing drainage network were obtained. After processing the survey data, the design for the outfall was modified. The outlet invert elevation was lowered, the slopes were decreased, the culvert on Paleologos Street was changed to a 2-foot by 4-foot culvert, and the invert elevations throughout the culvert network were modified based on the new slopes. Infiltration testing and geotechnical borings were conducted at the BMP locations in the fall of 2018. Bedrock and low infiltration rates were found in the area of the proposed green infrastructure systems, (see Attachment A), which removes the possibility of infiltration for these systems.

Due to these changes in the design, additional model simulations were performed to better represent the existing conditions. Infiltration was removed from the green infrastructure systems, and the box culvert sizes and slopes were updated to reflect the change in design. During the conceptual design modelling, the Huff rainfall distribution was used because it is built into the SWMM model software and allows for different rainfall durations. For the modelling conducted as part of this preliminary design report, the rainfall distribution was changed from the Huff distribution to the Atlas 14 rainfall distribution for the northeast United States. Atlas 14 has become more widely accepted and is believed to be the best information available for simulating rainfall distribution under current conditions in the northeast United States. One additional change was made to the modelling approach for the PDR, which involved using the1st quartile rainfall distribution rather than the 2nd quartile distribution .Based on Atlas 14 documentation for the Pennsylvania - New Jersey area, storms with durations of less than 6-hours are slightly more likely to occur in the 1st quartile. In addition, the 1st quartile has a higher intensity rainfall than the 2nd quartile.

Table 1 is a summary of the updated model results and Figures 2 through 5 illustrate the extent of flooding under existing and proposed conditions.

Table 1. Existing and Future Flooding Conditions

Scenario	Design Storm	Estimated Peak Flood Depth (Feet)[1,2,3]	Estimated Total Area Flooded (acres)
Existing Conditions	1-year, 60-minutes	1.3	0.81
	2-year, 60-minutes	1.7	1.69
New Outfall with Upstream Green BMPs and Storage	1-year, 60-minutes	0.4	0.13
	2-year, 60-minutes	1.1	0.82

1. Peak Depth at 45 Walnut Street/ Century Tire
2. Note that results are the same for typical low and high tides
3. These are results from the full SWMM model covering the entire North River watershed

The design storms modelled with conclusions reported in Table 1 are Atlas 14 design storms predicted under current conditions. However, under a separate task, future storm events estimated to occur under climate change conditions will be evaluated.

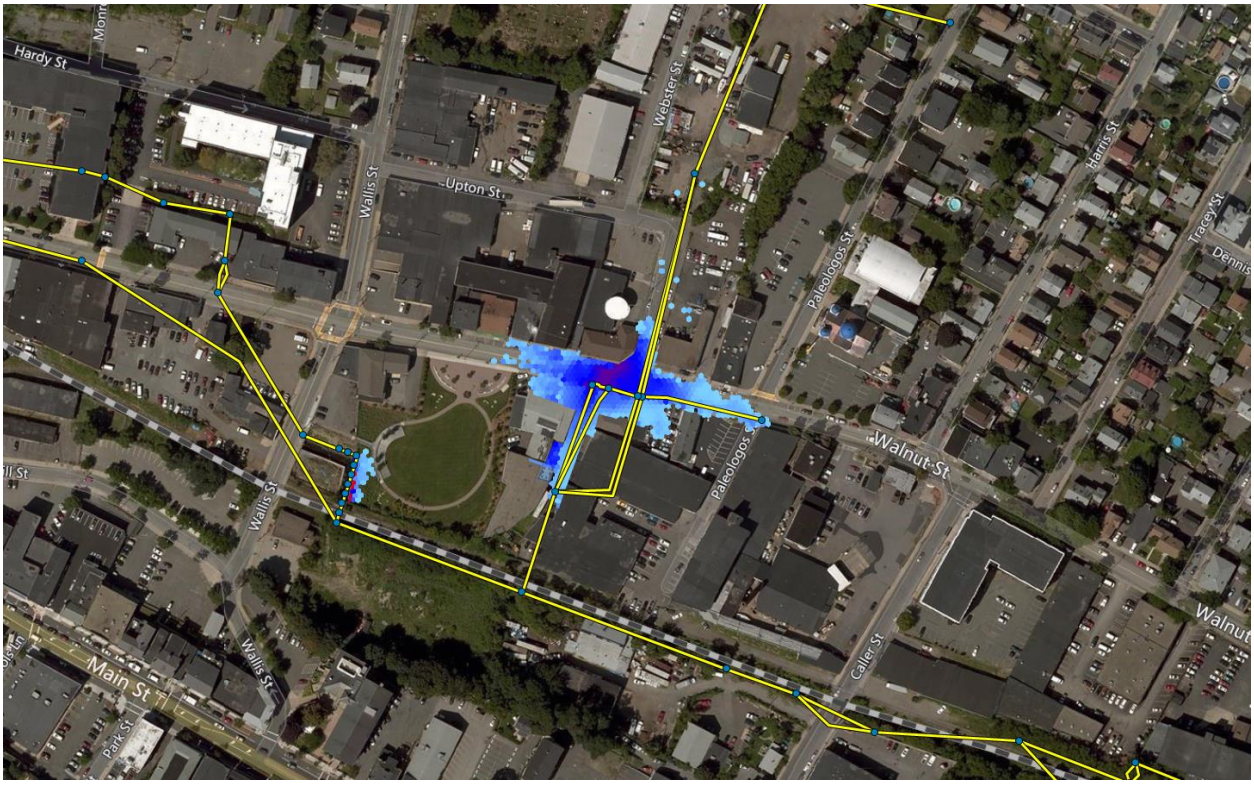


Figure 2 – Existing Conditions 1-Year, 60-Minute Storm

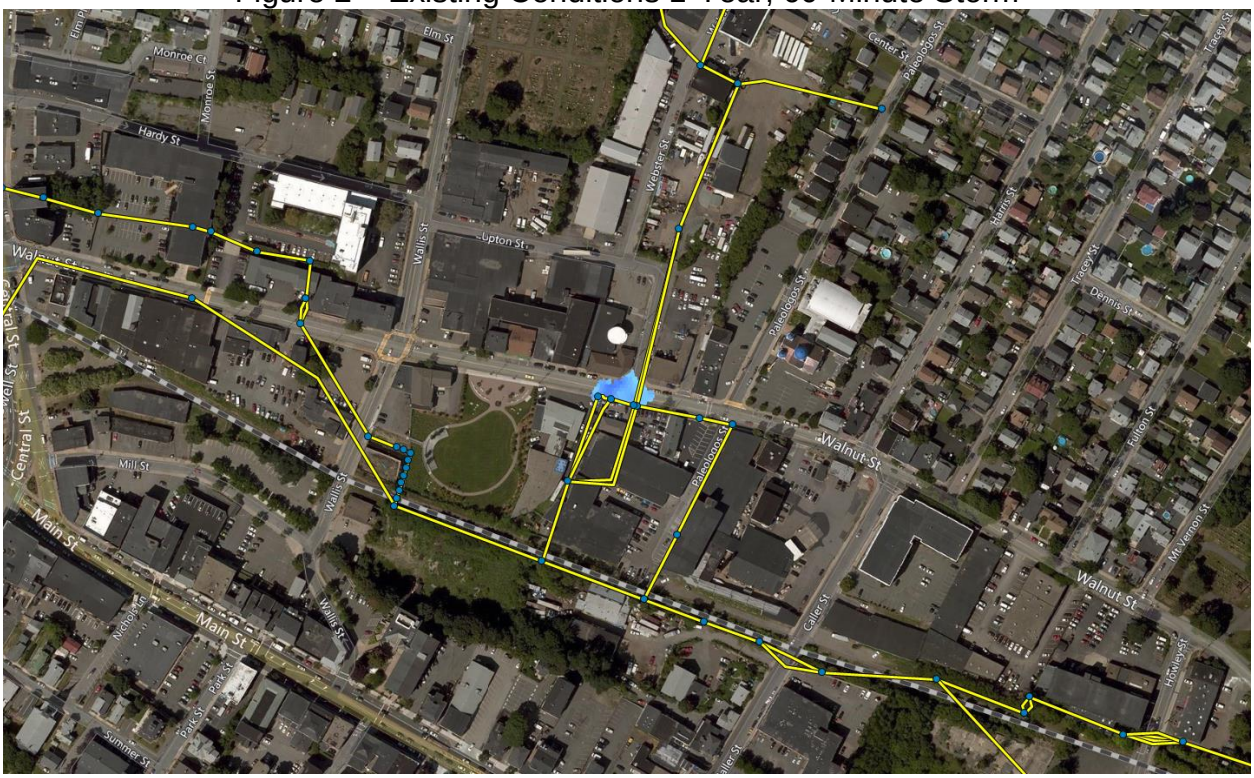


Figure 3– Future Conditions 1-Year, 60-Minute Storm

Figure 4 – Existing Conditions 2-Year, 60-Minute Storm

Figure 5 – Future Conditions 2-Year, 60-Minute Storm

7.0 COST ESTIMATE

Our opinion of the probable construction cost estimate for the proposed drainage facilities along Walnut Street and Paleologos Street is approximately $1,200,000. A detailed breakdown of the estimated construction cost by major item is presented in Attachment C. The construction cost estimate is escalated to the probable mid-point of construction of August 2020, and includes 22 percent contractor's overhead and profit plus 25 percent contingency.

Our opinion of the probable construction cost estimate for the underground storage system is approximately $980,000. A detailed breakdown of the estimated construction cost by major item is presented in Attachment C. The construction cost estimate is escalated to the probable mid-point of construction of August 2020, and includes 22 percent contractor's overhead and profit plus 25 percent contingency.

The bioretention, porous pavement, and treebox filter design is still ongoing, and an opinion of the probable construction cost estimate for these items will be provided in spring 2019 under a separate task.

Note that the costs presented above do not include engineering services during construction and Owner's contingency.

8.0 NEXT STEPS

The next steps for the project are to proceed with the 90% design for the new drainage pipe/outfall and to proceed with the 100% design for the underground storage tank and upstream Green Low Impact Development (LID) BMPs, which include the two bioretention basins, porous pavement and tree box filters. The additional tasks to be completed during the next stage of design include the following:

- Complete additional 60-foot deep vacuum boring in area of SESD crossing
- Complete environmental and rock borings in area of Underground Storage
- Complete Closed Circuit TV inspection of the pipe discharging from the Connolly Terrace area into the Underground Storage vicinity
- Consult with MassDEP regarding permitting issues
- Conduct additional modeling to reflect future climate change conditions
- Conduct additional coordination with SESD, the Railroad, and MBTA to gain consensus on the design approach and identify any access approval required
- Coordinate with Rousselot to confirm alternative delivery approach and associated cost

Attachment A
Geotechnical Design Memorandum

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Memorandum

Date: December 13, 2018

To: Project Files

From: Todd Dwyer, Geotechnical Department, Chelmsford

Subject: Geotechnical Design Memorandum
Proposed Stormwater BMPs and Culvert
Peabody, Massachusetts

Distribution: John Risitano; Jennifer Doyle-Breen; Mark Meserve; Stephen Eisenlord

1.0 Introduction

1.1 Purpose of the Report

This geotechnical design memorandum provides a summary of the subsurface conditions at the site, estimates for hydraulic conductivity of the underlying soils in the vicinity of proposed storm water BMPs at Connolly Park and nearby streets based on the subsurface data and in-situ testing, and recommendations for the design of a proposed box culvert along Walnut and Paleologos Street in Peabody, Massachusetts.

1.2 Site Description and Proposed Construction

The City of Peabody is planning several new BMPs and a box culvert to aid in the management of storm water. The proposed BMPs are located within existing asphalt-surfaced city streets and the field at Connolly Park. This area is primarily developed as residential housing.

The following BMPs have been proposed:

- Bioretention basin at Melody Road cul-de-sac
- Bioretention basin at Former Carol Ann Road cul-de-sac
- Pervious pavement at Our Lady of Fatima Church parking lot
- Tree boxes and pervious pavement at the Peabody Housing Authority property
- Subsurface storage at Connolly Park

The City is also proposing a box culvert from the intersection of Upton Street and Walnut Street east along Walnut Street and then south along Paleologos Street. The proposed culvert will pass below the existing railroad tracks and empty into the North River. This area is a commercial/industrial area of Peabody.

The areas of the proposed BMPs and the box culvert are shown on Figure 1, Project Locus Map.

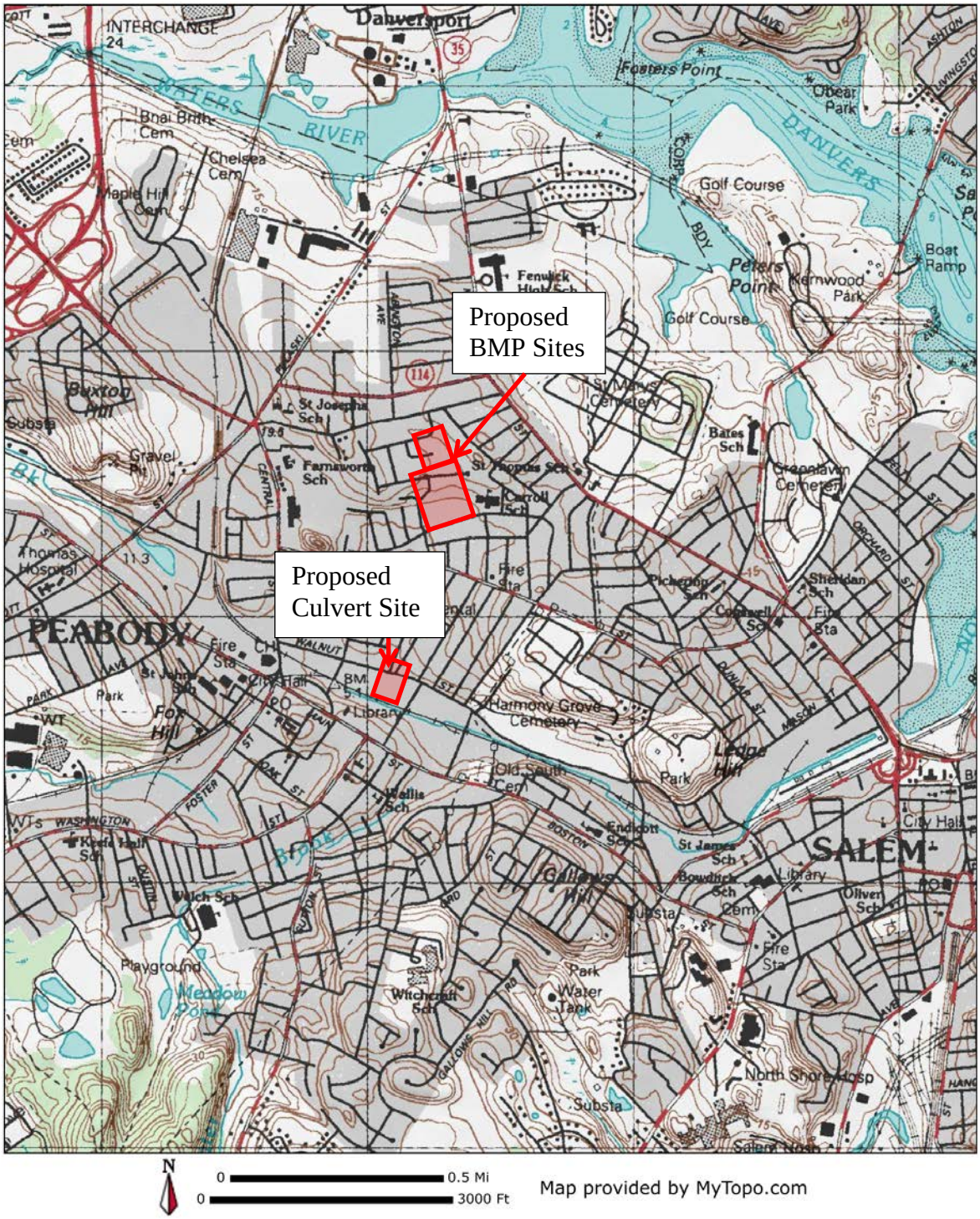

Figure 1: Project Locus Map

1.3 Site Datum

All elevations referred to in this report are in feet, and are based on the North American Vertical Datum of 1988 (NAVD 88), unless otherwise noted.

2.0 Subsurface Information

2.1 Regional Geology

Based on a Surficial Geology Map of the Salem Quadrangle published by USGS in 2006 as shown in Figure 2 below, surficial geology at the project site may consist of three major different units: Coarse deposits, Glaciomarine deposits, and Thin Till deposits.

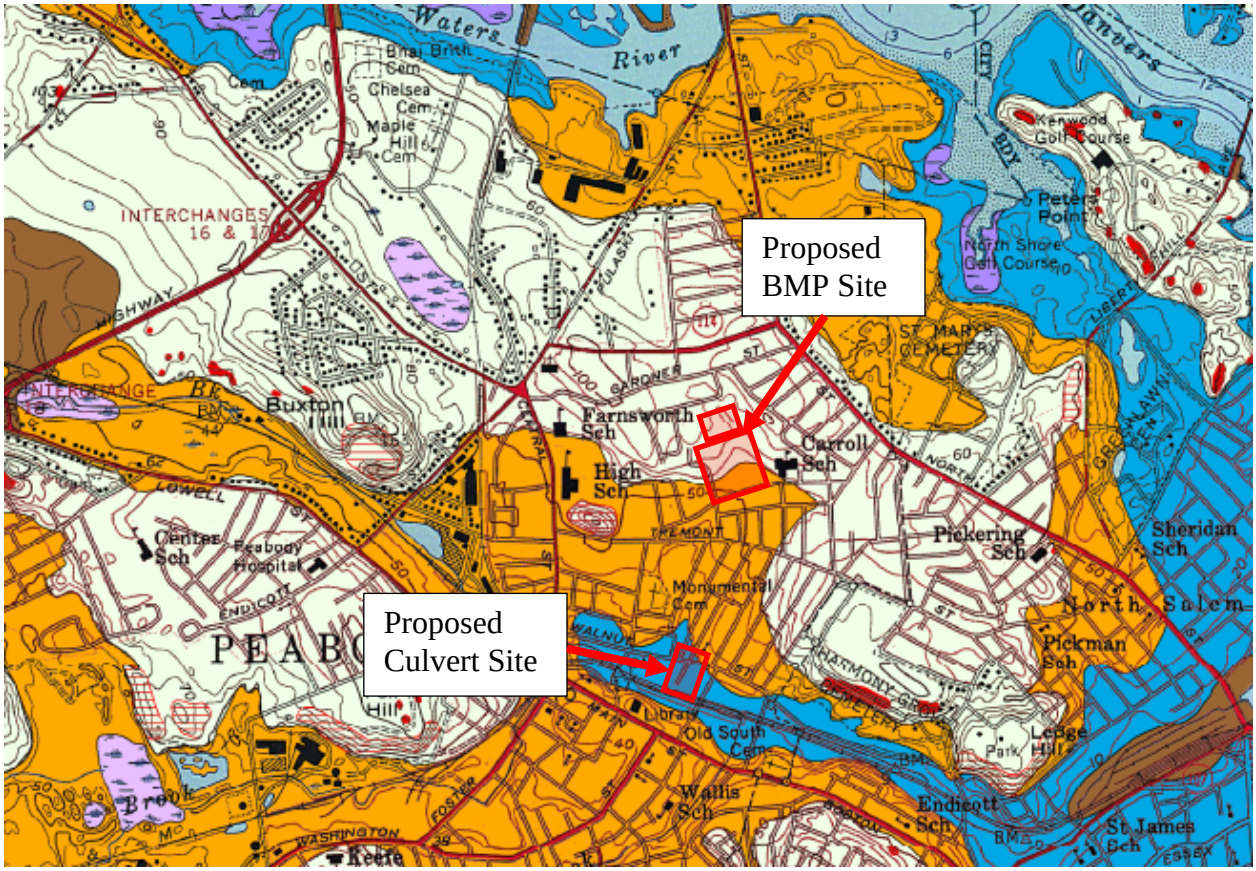

Figure 2 - Surficial Geology at the Project Site (from USGS Surficial Geologic Map of the Salem Quadrangle, 2006)

The units are described in the explanatory text of the Surficial Geologic Map of the Salem Depot, Newburyport, and East-Wilmington-Rockport 16 Quadrangle Area in Northeast Massachusetts as follows:

Coarse sand and gravel deposits (noted in orange in Figure 2): "composed of mixtures of gravel and sand within individual layers and as alternating layers. Sand and gravel layers generally range from 25 to 50 percent gravel particles and from 50 to 75 percent sand particles. Layers are well to poorly sorted; bedding may be distorted and faulted due to post depositional collapse."

Glaciomarine fine deposits (noted in blue in Figure 2): "include silty clay, fine sand, and some fine gravel deposited in a higher level sea in environments of low wave energy along the coast

and in river estuaries. Fine to very fine sand, massive and laminated, commonly is present at the surface and grades downward into interbedded very fine sand, silt, and silty clay. Lower silty clay and clay is massive and thinly laminated. Total thickness is generally a few feet to 75 feet."

Thin till deposits (noted in light green in Figure 2): "Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders; in areas where till is generally less than 10-15 feet thick and including areas of bedrock outcrop where till is absent."

2.2 Subsurface Investigation Program

A subsurface investigation program consisting of drilling nine (9) soil borings was performed by Terracon Consultants, Inc. of Manchester, New Hampshire on November 7, 8, and 14, 2018. The test borings ranged in depth from 9 to 22 feet. The boring logs and locations are included in the Geotechnical Data Report (GDR) dated December 13, 2018 and included in Appendix A.

The soils were classified in the field using the Unified Soil Classification System following ASTM D2488 – Description and Identification of Soils (Visual-Manual Procedure) and ASTM D 2487 – Standard Practice for Classification of Soils for Engineering Purposes.

Shallow bedrock (<10 ft.), when encountered, was cored using an N-size core barrel. Shallow bedrock was encountered in borings B-2 and B-4.

One and two stage falling head permeability tests were conducted in the BMP borings that did not encounter shallow bedrock (B-1, B-3, B-5 & B-6). The falling head tests were conducted at approximate 5-feet depths to observe the hydraulic response of the upper soils. The Stage 1 falling head tests were performed by seating the casing at the test interval (*i.e., flush with the bottom of the borehole)*, flushing and filling the casing with clean sediment-free water and recording the drop in head at regular intervals. Once the Stage 1 test was completed, a split spoon sample was driven and withdrawn and a Stage 2 falling head test was performed after topping the casing with clean water. The falling head test data are provided in Attachment 2 of the GDR.

2.3 Laboratory Testing Program

A laboratory testing program was performed to estimate the engineering properties of encountered site soils. Representative soil samples were selected and tested for physical characteristics (i.e. gradation, Atterberg limits and organic content). The soil samples were tested by GeoTesting Express in Acton, Massachusetts.

Summary tables of laboratory tests performed and laboratory testing results of the tests performed are included in GDR.

2.4 Subsurface Conditions

The subsurface materials, encountered during the subsurface exploration program for the proposed BMPs and culvert, are described in the following subsections:

2.4.1 *Proposed BMPs – Borings B-1 to B-6*

Artificial Fill

Artificial fill was encountered in all borings, except boring B-4, and observed thicknesses ranged from about 2.0 to 6.5 feet. The origin of the fill material is unknown. It is most often described as fine to coarse silty sand, less frequently as silt with sand and sand with silt. The fill had various amounts of cobbles, gravel, and fines. Boring B-6 encountered samples of ash and slag within the fill. Glass shards and glass were also noted occasionally. Standard penetration test (SPT) N-values ranged from 3 to 32

blows per foot (bpf), with most values (8 of 9) equal to 20 bpf or less, indicating the relative density of the fill is typically loose to medium dense, and occasionally dense.

Organics

An organic layer was encountered below the existing fill in boring B-3 from an approximate depth of 4 feet to 9 feet. The organic soils were comprised of silt with organics. SPT N-values ranged from 0 to 9 bpf indicating very soft to stiff soils.

Sand and Gravel

At the ground surface in boring B-4, and below the fill in the other borings, natural soils were encountered. The natural deposits were comprised of interbedded layers of silty sand, poorly graded sand with silt, silty gravel and well graded gravel. Occasional strata of silt, less than 2 feet thick, were also encountered in boring B-1 and B-5. SPT N-values ranged from 8 bpf to refusal, with most values (10 of 14) between 10 and 50 bpf indicating the relative density typically varies from medium dense to dense and occasionally loose or very dense.

The interbedded sand and gravel extended to the bottom of boring B-3, B-5 and B-6.

Bedrock

Bedrock was encountered below the sand and gravel in borings B-1, B-2, and B-4. In boring B-1, the roller bit was advanced 1.5 feet into weathered bedrock until refusal was encountered at 13.5 feet.

Upon encountering refusal in Borings B-2 and B-4, the borings were advanced using core drilling techniques. The core samples recovered consisted of dark gray, fine to medium grained, very hard, broken GRANODIORITE. The rock quality designation (RQD) of the core samples ranged from 0 to 31 percent, indicated very poor to poor quality rock.

Groundwater

Groundwater was observed during drilling in borings B-1 and B-3 to B-6. Boring B-2 did not encounter groundwater prior to rock coring, which introduces water into the borehole. The groundwater levels observed ranged from 1.0 to 5.0 feet below the ground surface (bgs). It should be noted that groundwater levels may fluctuate with precipitation, season, construction activities, run-off controls, and other factors. As a result, water levels during construction may vary from those observed during the subsurface investigation.

2.4.1 *Proposed Culvert – Borings B-7 to B-9*

Artificial Fill
Artificial fill thickness ranged from 3.5 to 9.0 feet. The origin of the fill material is unknown. It is generally described as fine to coarse silty sand with variable amounts of gravel. SPT N-values ranged from 10 to 28 bpf, which indicates the relative density of the fill as medium dense.

Organics

A thin organic layer was encountered below the existing fill in borings B-7 to B-9. The organic soils were comprised of silt with organics and the observed strata ranged in thickness from approximately 6 inches to 3 feet.

Sand and Silt

Below the fill and organics, silty sand and sandy silt, with occasional clayey seams were encountered. The soils were typically non-plastic with occasional strata with low to moderate plasticity. SPT N-values in the sand and silt ranged between 8 and 18 blows per foot, indicating the relative density of the soils as loose to medium dense. The sand and silt extended to the bottom of the borings.

Groundwater

Groundwater was observed during drilling in all three test borings. The groundwater level ranged from 3.5 to 9 feet below the ground surface at the time of drilling. It should be noted that groundwater levels may fluctuate with precipitation, season, construction activities, run-off controls, and other factors. As a result, water levels during construction may vary from those observed during the subsurface investigation.

3.0 Geotechnical Discussion and Recommendations

3.1 BMP Recommendations

Falling head tests were performed by AECOM during the recent investigation program. Falling head tests were performed in at the proposed locations of the proposed BMPs at depths of about 5 feet. The estimated hydraulic conductivity from these tests ranged from 1.3×10^{-3} cm/s to 8×10^{-6} cm/s. Falling head tests were not performed in boring B-2 and B-4 due to the shallow bedrock encountered. The falling head test data are provided in GDR.

Based on the shallow bedrock conditions encountered, the moderate to low permeability of the underlying soils, and the relatively shallow groundwater table that ranged between 1.0 and 5.0 feet bgs in the borings, the proposed site is not suitable for the installation of infiltrating BMPs.

3.2 Culvert Recommendations

3.2.1 Bearing Resistance and Settlement

We recommend supporting the proposed box culvert on a minimum of 12 inches of Gravel Borrow or crushed stone place directly on improved fill or the natural sand and silt layer described in Section 2.4.1. We recommend a factored bearing resistance of 4.0 kips per square foot for the box culvert. The factored bearing resistance includes a resistance factor (φ_b) of 0.45.

Long term settlement of the proposed box culvert should not be a concern because the culvert and overlying backfill will apply a similar or smaller load on the foundation soils than the weight of the excavated material. However, the static groundwater level may be higher than what was encountered during the geotechnical exploration. The box culvert may be submerged during its design life and therefore should be designed to resist buoyancy.

3.2.2 Lateral Earth Pressures

Below grade walls will be subject to soil lateral pressures from earth, line loads, traffic loads, and other loads, and hydrostatic pressures. The design lateral pressures should be calculated by adding earth and water pressures, and surcharge pressures from structures near the proposed culvert alignment. Box culvert walls are braced at the top such that lateral deflections are not permitted or restricted and should be designed for an at-rest earth pressure shown in Table 1.

Table 1: Lateral Earth Pressure Design Parameters – Horizontal Backfill

Material	Total Unit Weight (pcf)	Friction Angle (degrees)	Ko, At-Rest Earth Pressure Coefficient
Retained Fill	125	30	0.5

4.0 Construction Considerations

The purpose of this section is to discuss geotechnical related construction issues for the planned box culvert.

4.1 Subgrade Preparation

Loose or soft soils identified during the compaction of the subgrade should be excavated to a suitable bearing stratum as determined by the field representative of AECOM. Grades should be restored by backfilling with Gravel Borrow (MHD M1.03.0, Type b) or crushed stone as described in Section 3.

To reduce the potential of increasing lateral pressures on the culvert walls, fill placed within 2 feet of the walls should be compacted using a small plate compactor imparting a maximum dynamic effort of 4 kips. The fill within 2 feet of the culvert wall should be placed in maximum 8-inch loose lifts.

When crushed stone is required in the drawings or it is used for the convenience of the contractor, it should be wrapped in a geotextile fabric for separation except where introduction of the geotextile promotes sliding.

4.2 Subgrade Protection

The onsite soils are anticipated to be frost susceptible. If construction takes place during freezing weather, special measures such as heat blankets or other measures should be taken to prevent the subgrade from freezing. Excavations should be backfilled as soon as possible after construction. Soil used as backfill should be free of frozen material, as should be the ground on which it is placed. Fill placement should be halted during freezing weather.

4.3 Water Control

Groundwater control will be required within the excavations to construct the box culvert. We recommend filtered sump pumps installed in pits located at least 3 feet below the bottom of the excavation. Multiple sump pumps may be needed as the bottom of the culvert will be in sand fill and therefore is expected to be very permeable.

To reduce the potential for sinkholes developing over sump pump pits after the sump pumps are removed, the crushed stone placed in the sump pump pits should be wrapped in a geotextile fabric. Alternatively, the crushed stone should be entirely removed after the sump pump is no longer in use and the sump pump pit should be restored with suitable backfill. If sump pumps are not sufficient, the contractor should be prepared to use well points to maintain a dry excavation.

Groundwater levels should be maintained at a minimum of 2-foot below the bottom of excavations during construction. The contractor should be permitted to employ whatever commonly accepted means and practices to dewater.

The water collected from excavations should be filtered for fines in sedimentation basins before being discharged. At a minimum, the sedimentation basins could be constructed of hay bales wrapped in a geotextile fabric.

The contractor should discharge groundwater from the dewatering system in accordance with permits and local and state regulations. We recommend that a professional engineer registered in the Commonwealth of Massachusetts design and submit a plan to collect and remove groundwater prior to the start of the excavations.

4.4 Soil Excavations

The Contractor will be responsible for the excavation in accordance with the applicable federal and state laws and regulations, including OSHA.

The Contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of the excavation sides and bottom.

4.5 Protection of Existing Utilities and Rail

Existing utilities may be encountered in the vicinity of the work. In addition, the outfall for the proposed culvert will cross below an existing rail line. Proper planning and protection measures should be implemented to protect the existing utilities, railroad, and minimize impacts accordingly.

4.6 Construction Monitoring

It is recommended that AECOM be retained to provide resident representative services and consultation services during construction to observe compliance with design and construction recommendations and specifications. The field representative would undertake the following responsibilities:

- Monitor all excavation activities;
- Check foundation bearing of the subgrade;
- Monitor all dewatering operations;

Additionally, the field representative would be present to verify and provide timely responses to the project team in the event that the actual conditions encountered differ from those described herein.

5.0 Limitations

This memorandum has been prepared for specific application to the subject project in accordance with generally accepted geotechnical engineering practices. The interpretations and evaluations presented in this report are based, in part, on preliminary information on the proposed layout of the BMP's and box culvert made available prior to submission of the final design documents. In the event that any changes in the nature, elevations, design, or locations of the proposed facilities are implemented, the conclusions and recommendations presented herein may no longer be considered applicable. This geotechnical design memorandum is intended for the use of the designers and should not be included in the construction documents.

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APPENDIX A

GDR

GEOTECHNICAL DATA REPORT

Geotechnical Subsurface Investigation
For
The Lawrence Brook Watershed Stormwater Project
Peabody, Massachusetts

AECOM Project No.: 60547746

December 13, 2018

1.1 PURPOSE OF REPORT

The purpose of this Geotechnical Data Report (GDR) is to provide supporting data for the design and construction of proposed stormwater BMPs and a drainage box culvert and outfall. The data was collected during a subsurface investigation that involved the drilling of test borings, in-situ permeability testing and the laboratory testing of soil samples. The subsurface investigation was performed as part of stormwater mapping services that AECOM is providing to the City of Peabody in support of potential Green Infrastructure (GI) Retrofits. The proposed retrofits may include bioretention basins, pervious pavement, underground storage at Connolly Park and an outfall at the southern end of Paleologos Street

1.2 SUBSURFACE INVESTIGATION

The subsurface investigation was performed November 7, 8, and 14, 2018 and consisted of the drilling of nine test borings. The test borings ranged in depth from 9 to 22 feet and were drilled by Terracon Consultants, Inc. of Manchester, New Hampshire. The test boring locations are shown on Figure 1.

1.2.1 Drilling and Sampling

Utility locating efforts were implemented prior to the start of borehole drilling. These efforts included a *DigSafe* mark-out and hand clearing to 5-feet at boring locations of concern (borings B-7, B-8, and B-9).

Test borings were advanced using hollow stem augers (2.25” ID) and HW casing (4-in. ID). Standard penetration test (SPT) split-spoon soil samples were collected and logged by an AECOM geologist in accordance with ASTM D2488. The SPT soil samples in the BMP borings (B-1 to B-6) were taken near-continuously to a depth of 10-feet and then at 5-foot intervals thereafter. The SPT soil samples in the culvert test borings (B-7 to B-9) were collected at maximum 5-foot intervals.

Shallow bedrock (<10 ft.), when encountered, was cored using an N-size core barrel. Shallow bedrock was encountered in borings B-2 and B-4.

The boring locations are shown on Figure 1. The test boring logs from the subsurface investigation are provided in Attachment 1.

1.2.2 Groundwater Levels

Groundwater levels at each boring location were estimated during the drilling. The groundwater depths observed during the subsurface investigation ranged from ≤12-inches at Connolly Park (B-4) to 9-feet beneath the crown of Paleologos Street (B-8). Groundwater depths at the remaining seven borehole locations measured between 3 and 5-feet, including the two other borings drilled along the proposed Paleologos Street culvert alignment.

It should be noted that groundwater levels may fluctuate with changes in precipitation, season, construction activities, run-off controls, and other hydraulic factors.

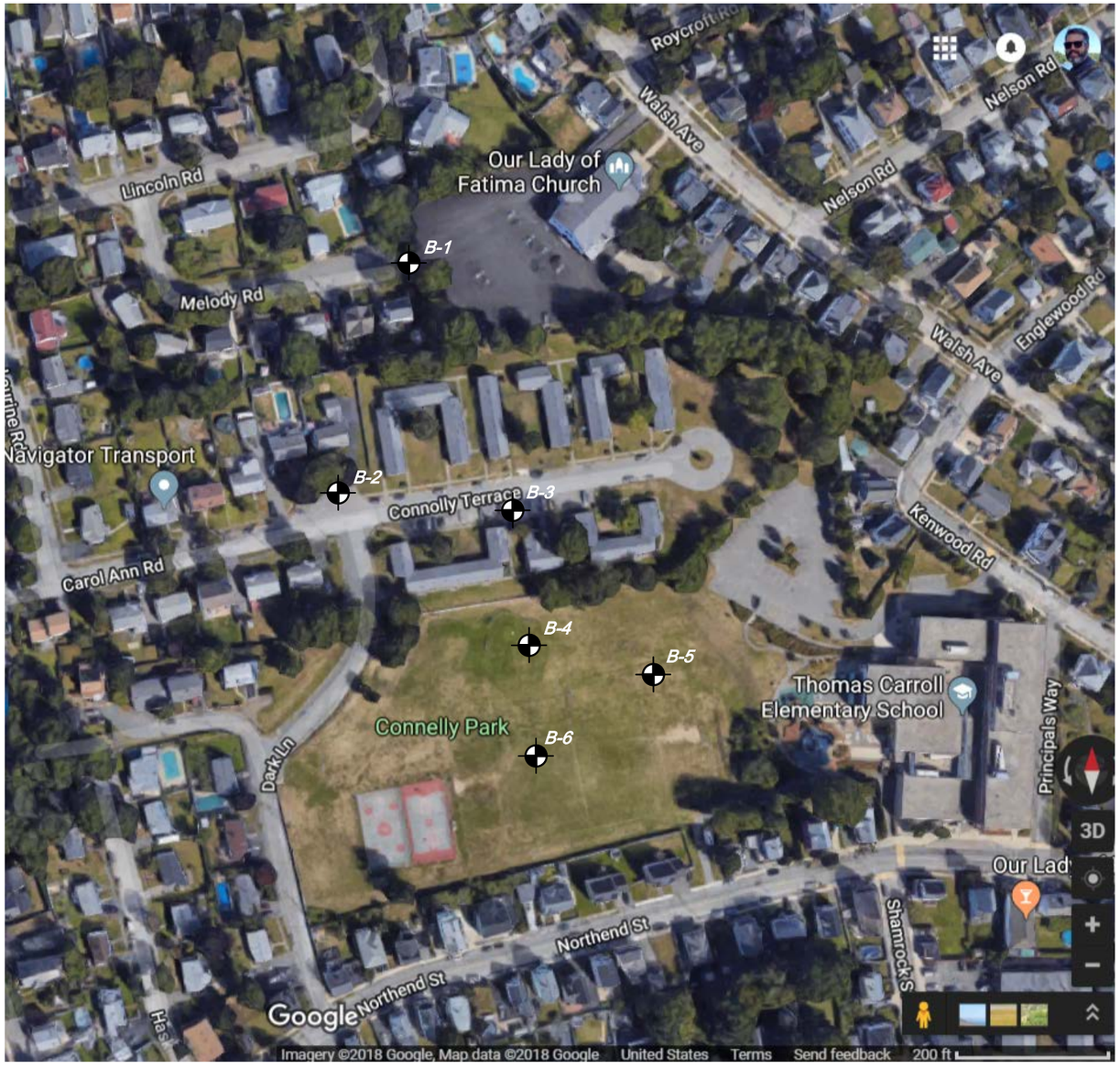
1.2.3 In-Situ Permeability Testing

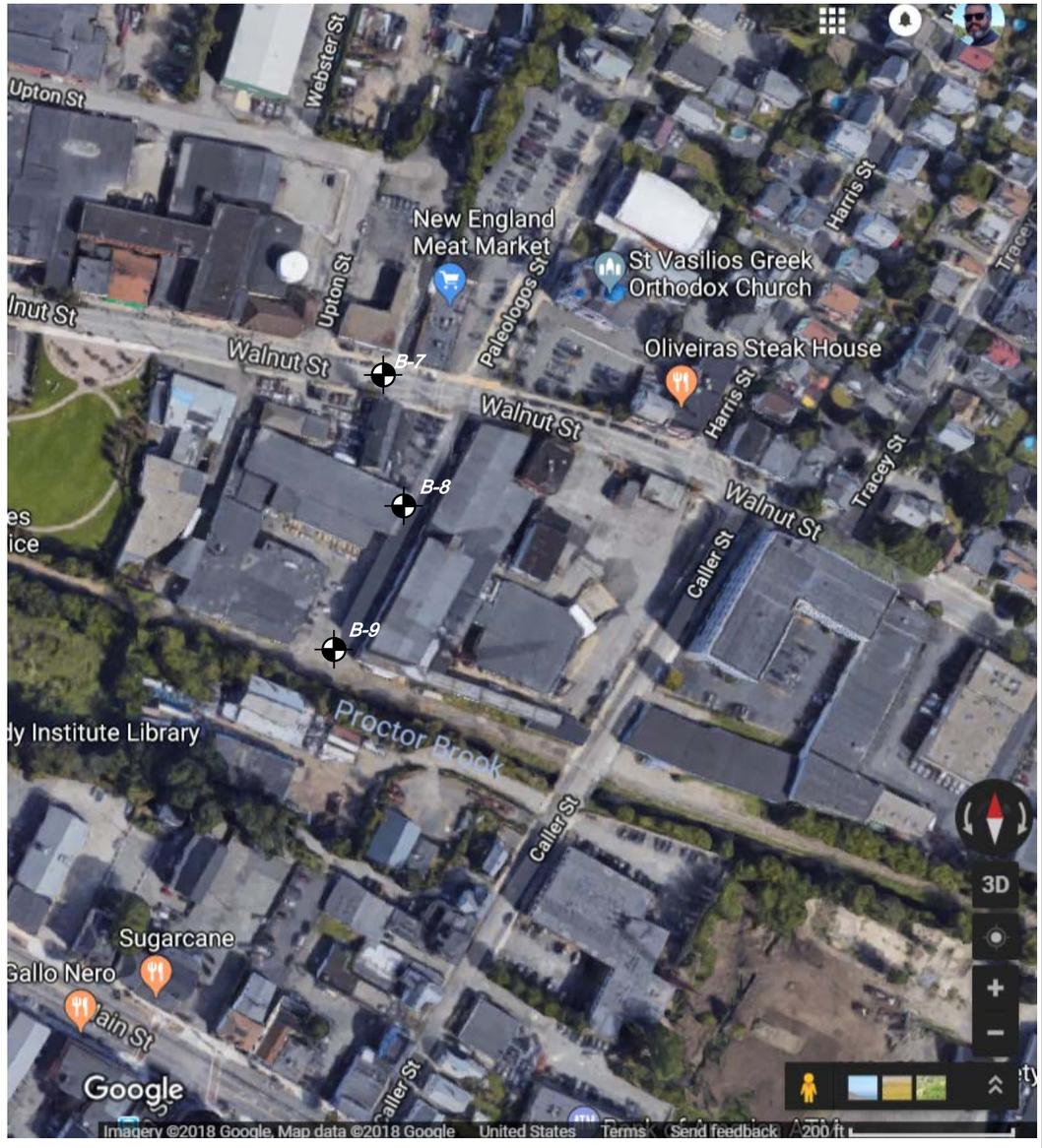
One and two stage falling head permeability tests were conducted in the BMP borings that did not encounter shallow bedrock (B-1, B-3, B-5 & B-6). The falling head tests were conducted at approximate 5-feet depths to observe the hydraulic response of the upper soils. The Stage 1 falling head tests were performed by seating the casing at the test interval (*i.e., flush with the bottom of the borehole)*, flushing and filling the casing with clean sediment-free water and recording the drop in head at regular intervals. Once the Stage 1 test was completed, a split spoon sample was driven and withdrawn and a Stage 2 falling head test was performed after topping the casing with clean water. The falling head test data are provided in Attachment 2.

1.2.4 Laboratory Testing

A laboratory testing program was performed to determine the engineering properties of encountered site soils. Representative soil samples were selected and tested for physical characteristics (*i.e. gradation and organic content)*. The soil samples were tested by GeoTesting Express in Acton, Massachusetts.

A summary of the soil laboratory testing is provided in Table 1. The laboratory test results are provided in Attachment 3.





Note – Figure based on aerial map obtained from the website: www.google.com/maps

Legend

⌖ Approximate locations of proposed borings observed by AECOM.

Client: City of Peabody	Project: Proposed Stormwater BMPs and Culvert	**Figure 1 – Boring Location Plan**
AECOM	Project Location: Peabody, Massachusetts	Date: October, 2018

ATTACHMENT 1

Test Boring Logs

Exploration Location

NORTHING: 3,020,145.93 **EASTING:** 812,376.55 **STATION:** _____ **OFFSET:** _____

HORIZONTAL DATUM: NAD 83 **INCLINATION FROM VERTICAL:** 0 degree

VERTICAL DATUM: NAVD88 **GROUND SURFACE ELEV. (FT):** _____

LOCATION: Melody Road **ESTIMATED/SURVEYED?:** Estimated

GEOLOGIC LOG

B-1

Drilling Information

DATE START / END: 11/8/2018 - 11/8/2018 **TOTAL DEPTH (FT):** 13.5

CONTRACTOR: Terracon Consultants Inc. **DRILLER:** P. Michaud **LOGGED BY:** Kevin Harten

EQUIPMENT: D-50 Track Rig **EXPLORATION TYPE/METHOD:** HW Casing (drive & wash)

AUGER ID/OD: N/A **CASING ID/OD:** 4-inch **CORE INFORMATION:** N/A

HAMMER TYPE: Automatic **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30

WATER LEVEL DEPTHS (ft): Groundwater level upon auger retrieval measured 3.0 ft.

GENERAL NOTES: Borehole backfilled w/ cuttings, granular material and an asphaltic patch

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; SS = Split-Spoon Sample
ST = Undisturbed Tube Sample; RC = Rock Core; FVS = Field Vane Shear; CBR = California Bearing Ratio
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; PID = Photoionization Detector
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Depth (ft)	Elev. (ft)	Casing Pen. (bpf) or Core Rate (mpf)	SAMPLE INFORMATION: Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field/ Laboratory Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
										Bituminous Concrete (~4")		
			S-1		1 to 3	24/10	4-7-9-17			Dry to moist, brown, Silty SAND with Gravel - fine to coarse sand, some fine to coarse gravel, little fines; piece of coarse gravel lodged in tip, possible FILL	▽	
			S-2		3 to 4	12/0	20-20			No Recovery - Possible Cobbles, Possible FILL		
5			S-3		5 to 7	24/8	4-4-4-4	Hydrometer		Wet, brown, Silty SAND (SM) - fine to coarse sand, some fines, trace fine gravel, occasional organic fibers		Conducted Falling Head Perm test @ 5 ft.
			S-4		7 to 9	24/7	14-7-5-19			Top: Wet, brown, Silty GRAVEL with Sand (GM/SM) - fine to coarse gravel, some fine to coarse sand, little fines; possible wash material Bottom: Wet, light gray, Gravelly SILT (ML) - non-plastic, fine to coarse gravel, few fine sand		
10			S-5		10 to 12	24/12	15-16-16-35	Sieve		COBBLE @ 9.5 ft. Wet, brown, Silty SAND with Gravel (SM) - fine to coarse sand, little fine to coarse gravel, few to little fines; poorly to well graded, siltier in some layers		
										- More dense @ 12 ft. : Possible Weathered/Decomposed Rock		Roller Bit Refusal @ 13.5 ft.
										End of Boring at 13.5 feet		
15												

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

LOGGED BY (Consultant): AECOM

PROJECT NAME: Lawrence Brook Stormwater Project

CITY/STATE: Peabody, MA

AECOM PROJECT NUMBER: 60547746

AECOM

MASSDOT I-90 REV. 2 LBWSP-PROJECT.GPJ 12/6/18

Exploration Location

NORTHING: 3,019,833.86 **EASTING:** 812,308.32 **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: NAD 83 **INCLINATION FROM VERTICAL:** 0 degree
VERTICAL DATUM: NAVD88 **GROUND SURFACE ELEV. (FT):** _____
LOCATION: Dark Lane cul-de-sac **ESTIMATED/SURVEYED?:** Estimated

GEOLOGIC LOG
B-2

Drilling Information

DATE START / END: 11/7/2018 - 11/8/2018 **TOTAL DEPTH (FT):** 9.0
CONTRACTOR: Terracon Consultants Inc. **DRILLER:** P. Michaud **LOGGED BY:** Kevin Harten
EQUIPMENT: D-50 Track Rig **EXPLORATION TYPE/METHOD:** Solid Stem Auger/HW Casing
AUGER ID/OD: 4-inch **CASING ID/OD:** 4-inch **CORE INFORMATION:** N-size
HAMMER TYPE: Automatic **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): Groundwater was not encountered above bedrock at time of drilling
GENERAL NOTES: Borehole backfilled w/ cuttings, granular material and an asphaltic patch

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; SS = Split-Spoon Sample
ST = Undisturbed Tube Sample; RC = Rock Core; FVS = Field Vane Shear; CBR = California Bearing Ratio
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; PID = Photoionization Detector
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Depth (ft)	Elev. (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field/ Laboratory Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
										Bituminous Concrete (~4")		
			S-1		1 to 3	24	6-5-4-4			Moist, brown, Silty SAND (SM) - fine to coarse sand, little to few fines, few fine gravel; possible FILL		
			S-2		3 to 3.67	8	3-50/2"	Hydrometer		Moist, dark brown, Silty SAND with Gravel (SM) - fine to coarse sand, little fine subrounded gravel; gravel coated with buff colored silt; sample does not look like weathered rock: the silt material looks organic		Auger refusal @ 4.5 ft
5		4 3 4	RC-1		5 to 8	36/28	RQD=0%			GRANODIORITE - dark gray, fine to medium grained, very broken, slightly weathered, lightly pitted w/ moderate angle jointing and some light green chloritic coating on fracture surfaces		
		6	RC-2		8 to 9	12/6	RQD=0%			GRANODIORITE, as above; fine to medium grained, very broken, only small pieces recovered		Core Barrel jammed
										End of Boring at 9 feet		
10												
15												

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

LOGGED BY (Consultant): AECOM
PROJECT NAME: Lawrence Brook Stormwater Project
CITY/STATE: Peabody, MA
AECOM PROJECT NUMBER: 60547746

AECOM

MASSDOT I-90 REV. 2 LBWSP-PROJECT.GPJ 12/6/18

Exploration Location

NORTHING: 3,019,803.77 **EASTING:** 812,546.23 **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: NAD 83 **INCLINATION FROM VERTICAL:** 0 degree
VERTICAL DATUM: NAVD88 **GROUND SURFACE ELEV. (FT):** _____
LOCATION: Connolly Terrace **ESTIMATED/SURVEYED?:** Estimated

GEOLOGIC LOG
B-3

Drilling Information

DATE START / END: 11/8/2018 - 11/8/2018 **TOTAL DEPTH (FT):** 13.0
CONTRACTOR: Terracon Consultants Inc. **DRILLER:** P. Michaud **LOGGED BY:** Kevin Harten
EQUIPMENT: D-50 Track Rig **EXPLORATION TYPE/METHOD:** HW Casing (drive & wash)
AUGER ID/OD: N/A **CASING ID/OD:** 4-inch **CORE INFORMATION:** N/A
HAMMER TYPE: Automatic **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): Groundwater depth estimated @ 5 ft. at time of drilling
GENERAL NOTES: Borehole backfilled w/ cuttings, granular material and an asphaltic patch

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; SS = Split-Spoon Sample
ST = Undisturbed Tube Sample; RC = Rock Core; FVS = Field Vane Shear; CBR = California Bearing Ratio
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; PID = Photoionization Detector
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Depth (ft)	Elev. (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field/ Laboratory Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
										Bituminous Concrete (~6")		
			S-1		1 to 3	24/4	18-19-13-6			Dry, brown, Silty SAND with Gravel (SM) - fine to coarse sand, some fine gravel; possible FILL		
			S-2		3 to 5	24/0	3-4-5-5			No Recovery		
5										Cuttings below 4-ft. contain very dark brown, SILT with Sand (ML/OL) - sand is fine to coarse	▽	
			S-3		5.8 to 7.8	24/0	1-1-1-1			No Recovery		Few fibers in wash from 5.8 ft to 10 ft; Conducted Falling Head Perm test @ 5.8 ft.
			S-4		7.8 to 9.8	24/4	Push	Organic Content		Wet, very dark brown, SILT with Organics (OL) - high plasticity, little organic matter, few fine to coarse sand; gravel, sand and porcelain fragments in spoon wash, possible FILL/Organic Silt mix		Stiffened at depth more than 9 ft during push
10			S-5		10 to 12	24/12	1-9-16-17			Top: Wet, dark brown, Silty SAND (SM) - fine to coarse sand, little to few fines, few to little fine gravel		
										Bottom: Gray Poorly Graded GRAVEL (GM) - angular fine to coarse gravel in a sandy silt binder, sand is fine to coarse, little fines; possible Decomposed Rock		
										End of Boring at 13 feet		
15												

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

LOGGED BY (Consultant): AECOM
PROJECT NAME: Lawrence Brook Stormwater Project
CITY/STATE: Peabody, MA
AECOM PROJECT NUMBER: 60547746

AECOM

MASSDOT I-90 REV. 2 LBWSP-PROJECT.GPJ 12/6/18

Exploration Location

NORTHING: 3,019,644.32 **EASTING:** 812,518.23 **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: NAD 83 **INCLINATION FROM VERTICAL:** 0 degree
VERTICAL DATUM: NAVD88 **GROUND SURFACE ELEV. (FT):** _____
LOCATION: Connolly Field **ESTIMATED/SURVEYED?:** Estimated

GEOLOGIC LOG
B-4

Drilling Information

DATE START / END: 11/14/2018 - 11/14/2018 **TOTAL DEPTH (FT):** 9.0
CONTRACTOR: Terracon Consultants Inc. **DRILLER:** P. Michaud **LOGGED BY:** Kevin Harten
EQUIPMENT: D-50 Track Rig **EXPLORATION TYPE/METHOD:** HW Casing (drive & wash)
AUGER ID/OD: N/A **CASING ID/OD:** 4-inch **CORE INFORMATION:** N/A
HAMMER TYPE: Automatic **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): Groundwater depth measured @ <12-inches at time of drilling
GENERAL NOTES: Borehole backfilled w/ cuttings and granular material

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; SS = Split-Spoon Sample
ST = Undisturbed Tube Sample; RC = Rock Core; FVS = Field Vane Shear; CBR = California Bearing Ratio
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; PID = Photoionization Detector
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Depth (ft)	Elev. (ft)	Casing Pen. (bpf) or Core Rate (mpf)	SAMPLE INFORMATION: Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field/ Laboratory Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
			S-1		0 to 2	24/18	2-3-6-10			Top 8": TOPSOIL, dry Bottom 10": Moist to wet, brown, Poorly Graded SAND with Silt (SP-SM) - fine to coarse sand, few to trace fines, trace fine gravel	▽	
			S-2		2 to 4	24/18	10-25-25-20	Sieve (Top); Hydrometer (Bottom)		Top 8": Wet, brown, Poorly Graded SAND with Silt, as above Bottom 10": Wet, brown, Silty SAND with Gravel (SM) - fine to coarse sand, angular to subangular fine to coarse gravel in a sandy silt binder, little to some fines; possible Decomposed Rock		
5		2 2 2 2	RC-1		5 to 9	48/36	RQD=31%			(Possible Weathered Rock) GRANITE - gray. fine to medium grained, slightly weathered, hard to very hard, broken w/ moderate to high angle jointing, few calcite stringer veins, FeOx stained fracture surfaces w/ light green chloritic coating; core barrel jammed 4-ft. into run		Auger refusal @ 4.9 ft
10										End of Boring at 9 feet		
15												

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

LOGGED BY (Consultant): AECOM
PROJECT NAME: Lawrence Brook Stormwater Project
CITY/STATE: Peabody, MA
AECOM PROJECT NUMBER: 60547746

AECOM

MASSDOT I-90 REV. 2 LBWSP-PROJECT.GPJ 12/6/18

Exploration Location

NORTHING: 3,019,603.21 **EASTING:** 812,743.58 **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: NAD 83 **INCLINATION FROM VERTICAL:** 0 degree
VERTICAL DATUM: NAVD88 **GROUND SURFACE ELEV. (FT):** _____
LOCATION: Connolly Field **ESTIMATED/SURVEYED?:** Estimated

GEOLOGIC LOG
B-5

Drilling Information

DATE START / END: 11/14/2018 - 11/14/2018 **TOTAL DEPTH (FT):** 10.5
CONTRACTOR: Terracon Consultants Inc. **DRILLER:** P. Michaud **LOGGED BY:** Kevin Harten
EQUIPMENT: D-50 Track Rig **EXPLORATION TYPE/METHOD:** HW Casing (drive & wash)
AUGER ID/OD: N/A **CASING ID/OD:** 4-inch **CORE INFORMATION:** N/A
HAMMER TYPE: Automatic **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): Groundwater depth measured ~4.25 ft. at time of drilling
GENERAL NOTES: Borehole backfilled w/ cuttings and granular material

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; SS = Split-Spoon Sample
ST = Undisturbed Tube Sample; RC = Rock Core; FVS = Field Vane Shear; CBR = California Bearing Ratio
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; PID = Photoionization Detector
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Depth (ft)	Elev. (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field/ Laboratory Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
			S-1		0 to 2	24/13	2-1-2-2			5" TOPSOIL Bottom 8": Dry, brown, SILT with Sand (ML), little fine to medium sand, few glass shards, occasional slag clasts; FILL		
			S-2		2 to 4	24/13	5-7-12-13			Dry to moist, mottled brown, SILT with Sand (ML) - little fine to medium sand, trace fine gravel	▽	
5			S-3		5 to 7	24/12	10-10-13-16	Sieve		Wet, brown, Silty SAND with Gravel (SM) - fine to medium sand, little fine to coarse gravel, some to little fines, few coarse sand		Conducted Falling Head Perm test @ 4.5 ft.
			S-4		7 to 9	24/8	10-10-17-16			Wet, brown, Silty SAND with Gravel (SM), as above		
10			S-5		10 to 10.08	1	50/1"			Wet, brown, Silty SAND with Gravel (SM), as above End of Boring at 10.5 feet		Auger refusal @ 10.5 ft
15												

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

LOGGED BY (Consultant): AECOM
PROJECT NAME: Lawrence Brook Stormwater Project
CITY/STATE: Peabody, MA
AECOM PROJECT NUMBER: 60547746

AECOM

MASSDOT I-90 REV. 2 LBWSP-PROJECT.GPJ 12/6/18

Exploration Location

NORTHING: 3,019,445.67 **EASTING:** 812,513.92 **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: NAD 83 **INCLINATION FROM VERTICAL:** 0 degree
VERTICAL DATUM: NAVD88 **GROUND SURFACE ELEV. (FT):** _____
LOCATION: Connolly Field **ESTIMATED/SURVEYED?:** Estimated

GEOLOGIC LOG
B-6

Drilling Information

DATE START / END: 11/14/2018 - 11/14/2018 **TOTAL DEPTH (FT):** 16.0
CONTRACTOR: Terracon Consultants Inc. **DRILLER:** P. Michaud **LOGGED BY:** Kevin Harten
EQUIPMENT: D-50 Track Rig **EXPLORATION TYPE/METHOD:** HW Casing (drive & wash)
AUGER ID/OD: N/A **CASING ID/OD:** 4-inch **CORE INFORMATION:** N/A
HAMMER TYPE: Automatic **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): Groundwater level upon auger retrieval measured 3.0 ft.
GENERAL NOTES: Borehole backfilled w/ cuttings and granular material

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; SS = Split-Spoon Sample
ST = Undisturbed Tube Sample; RC = Rock Core; FVS = Field Vane Shear; CBR = California Bearing Ratio
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; PID = Photoionization Detector
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Depth (ft)	Elev. (ft)	Casing Pen. (bpf) or Core Rate (mpf)	SAMPLE INFORMATION: Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field/ Laboratory Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
			S-1		0 to 2	24/7	3-4-5-6			Top 5": Moist, dark brown, Sandy SILT, little fine to medium sand; TOPSOIL, non-plastic Bottom 2": Moist, brown, Poorly Graded SAND with Silt (SP-SM) - fine to medium sand, few fines		
			S-2		2 to 4	24/14	2-1-2-1			Moist, white to buff colored ASH, few fine to coarse sand, few slag; FILL	▽	
5			S-3		4.7 to 6.7	24/12	3-3-8-8	Hydrometer (Bottom)		Top: Moist to wet, black, crushed SLAG, few fines, few ash; FILL Bottom: Wet, black to gray-brown, non-homogenous Silty SAND (SM) - fine to medium sand, some fines, few to trace fine gravel, few to trace coarse sand; possible FILL		Conducted Falling Head Perm test @ 4.7 ft.
			S-4		6.7 to 8.7	24/2	6-11-10-10			Wet, gray-brown, Silty GRAVEL with Sand (GM) - fine angular gravel, some fine to coarse sand, little to some fines		Poor recovery
10			S-5		9 to 11	24/14	10-15-23-20	Sieve (Top); Hydrometer (Bottom)		Top 5": Wet, gray, Well Graded GRAVEL with Sand (GW) - fine to coarse gravel of variable angularity, some fine to coarse sand, trace fines; similar to above Bottom 9": wet, rust to orange brown, Silty SAND (SM) - fine to coarse sand, little fines, little to few fine gravel		
15			S-6		14 to 16	24/14	11-30-30-30			Wet, rust to orange brown, Silty SAND (SM), as above, with layers of clean to slightly silty GRAVEL with Sand (GP/GM); piece of coarse gravel lodged in tip		
										End of Boring at 16 feet		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

LOGGED BY (Consultant): AECOM
PROJECT NAME: Lawrence Brook Stormwater Project
CITY/STATE: Peabody, MA
AECOM PROJECT NUMBER: 60547746

AECOM

MASSDOT I-90 REV. 2 LBWSP-PROJECT.GPJ 12/6/18

Exploration Location

NORTHING: 3,017,400.24 **EASTING:** 811,901.63 **STATION:** _____ **OFFSET:** _____

HORIZONTAL DATUM: NAD 83 **INCLINATION FROM VERTICAL:** 0 degree

VERTICAL DATUM: NAVD88 **GROUND SURFACE ELEV. (FT):** _____

LOCATION: 58 Walnut St. **ESTIMATED/SURVEYED?:** Estimated

GEOLOGIC LOG

B-7

Drilling Information

DATE START / END: 11/7/2018 - 11/7/2018 **TOTAL DEPTH (FT):** 21.0

CONTRACTOR: Terracon Consultants Inc. **DRILLER:** P. Michaud **LOGGED BY:** Kevin Harten

EQUIPMENT: D-50 Track Rig **EXPLORATION TYPE/METHOD:** Hollow Stem Auger

AUGER ID/OD: 2.25" **CASING ID/OD:** N/A **CORE INFORMATION:** N/A

HAMMER TYPE: Automatic **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30

WATER LEVEL DEPTHS (ft): Groundwater level estimated @ 3.5 ft. at time of drilling

GENERAL NOTES: Borehole backfilled w/ cuttings, granular material and an asphaltic patch

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; SS = Split-Spoon Sample
ST = Undisturbed Tube Sample; RC = Rock Core; FVS = Field Vane Shear; CBR = California Bearing Ratio
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; PID = Photoionization Detector
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Depth (ft)	Elev. (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field/ Laboratory Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
			Grab Sample		1 to 4	36				Bituminous Concrete (~4") Moist, brown to dark brown, Silty SAND with Gravel (SM) - fine to coarse sand, some fine to coarse gravel, little to few fines; FILL	▽	Hand clear to 5 ft
										ORGANICs mixed with FILL		
5			S-1		5 to 7	24/7	7-4-4-6			Top: Wet, gray brown, Silty SAND (SM) - fine sand, few medium to coarse sand, some to little fines, trace organics Bottom: Wet, brown, Well Graded SAND with Silt and Gravel (SW-SM) - fine to coarse sand, some fine gravel, few silt		
10			S-2		10 to 12	24/16	4-5-7-9	Hydrometer		Wet, gray, interbedded SILT and CLAY (ML/CL) - medium plastic to non-plastic, few to little fine sand; laminated fines @ top, more sandy at bottom		
15			S-3		15 to 17	24/14	4-6-6-10	Hydrometer		Wet, brown, interbedded Sandy SILT (ML) - non-plastic, fine sand, trace to few medium sand; several silty laminae		
20			S-4		19 to 21	24/14	4-6-6-10			Wet, brown, interbedded Sandy SILT (ML), as above		
										End of Boring at 21 feet		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

LOGGED BY (Consultant): AECOM

PROJECT NAME: Lawrence Brook Stormwater Project

CITY/STATE: Peabody, MA

AECOM PROJECT NUMBER: 60547746

AECOM

MASSDOT I-90 REV. 2 LBWSP-PROJECT.GPJ 12/6/18

Exploration Location

NORTHING: 3,017,234.08 **EASTING:** 811,960.17 **STATION:** _____ **OFFSET:** _____

HORIZONTAL DATUM: NAD 83 **INCLINATION FROM VERTICAL:** 0 degree

VERTICAL DATUM: NAVD88 **GROUND SURFACE ELEV. (FT):** _____

LOCATION: Paleologos Street **ESTIMATED/SURVEYED?:** Estimated

GEOLOGIC LOG

B-8

Drilling Information

DATE START / END: 11/7/2018 - 11/7/2018 **TOTAL DEPTH (FT):** 22.0

CONTRACTOR: Terracon Consultants Inc. **DRILLER:** P. Michaud **LOGGED BY:** Kevin Harten

EQUIPMENT: D-50 Track Rig **EXPLORATION TYPE/METHOD:** Hollow Stem Auger

AUGER ID/OD: 2.25" **CASING ID/OD:** N/A **CORE INFORMATION:** N/A

HAMMER TYPE: Automatic **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30

WATER LEVEL DEPTHS (ft): Groundwater level estimated @ 9.0 ft. at time of drilling

GENERAL NOTES: Borehole backfilled w/ cuttings, granular material and an asphaltic patch

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; SS = Split-Spoon Sample
ST = Undisturbed Tube Sample; RC = Rock Core; FVS = Field Vane Shear; CBR = California Bearing Ratio
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; PID = Photoionization Detector
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Depth (ft)	Elev. (ft)	Casing Pen. (bpf) or Core Rate (mpf)	SAMPLE INFORMATION: Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field/ Laboratory Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
										Bituminous Concrete (~4")		Hand clear to 5 ft (No SPTs)
										Cuttings consist of moist, very dark brown, Silty SAND with Gravel (SM) - fine to coarse sand, some fine to coarse gravel (mostly fine), little fines; FILL		
5			S-1		5 to 7	24/16	6-5-5-10			Moist, dark brown and light brown, Silty SAND (SM) - fine to coarse sand, little fines, little to few fine gravel; possible FILL		
			S-2		7 to 9	24/7	10-14-14-15	Sieve		Moist, brown, Silty SAND (SM) - fine to coarse sand, little to few fine to coarse gravel, little fines; possible FILL	▽	
10			S-3		10 to 12	24/20	10-10-8-5			Top: Moist, very dark brown to brown, SILT with Organics (ML/OL); highly plastic		
										Bottom: Wet, gray brown, Well Graded SAND with Silt and Gravel (SW-SM) - fine to coarse sand, some fine to coarse gravel, few fines		
										Spoon Tip: Wet, gray, Clayey SILT (ML/CL); medium plastic		
15			S-4		15 to 17	24/12	4-5-7-8	Organic Content (Top)		Top 7": Wet, dark brown, SILT with Organics (OL) - high plasticity, little organic matter, few fine to coarse sand, trace fine gravel		
										Bottom 5": Wet, gray brown, Silty SAND to Sandy SILT (SM/ML) - non-plastic, fine sand, some fines		
20			S-5		20 to 22	24/14	4-8-8-10	Hydrometer		Wet, orange brown to gray brown, interbedded SILT with Sand (ML) - fine sand		
										End of Boring at 22 feet		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

LOGGED BY (Consultant): AECOM

PROJECT NAME: Lawrence Brook Stormwater Project

CITY/STATE: Peabody, MA

AECOM PROJECT NUMBER: 60547746

AECOM

MASSDOT I-90 REV. 2 LBWSP-PROJECT.GPJ 12/6/18

Exploration Location

NORTHING: 3,017,054.08 **EASTING:** 811,857.87 **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: NAD 83 **INCLINATION FROM VERTICAL:** 0 degree
VERTICAL DATUM: NAVD88 **GROUND SURFACE ELEV. (FT):** _____
LOCATION: Paleologos Street **ESTIMATED/SURVEYED?:** Estimated

GEOLOGIC LOG
B-9

Drilling Information

DATE START / END: 11/7/2018 - 11/7/2018 **TOTAL DEPTH (FT):** 22.0
CONTRACTOR: Terracon Consultants Inc. **DRILLER:** P. Michaud **LOGGED BY:** Kevin Harten
EQUIPMENT: D-50 Track Rig **EXPLORATION TYPE/METHOD:** Hollow Stem Auger
AUGER ID/OD: 2.25" **CASING ID/OD:** N/A **CORE INFORMATION:** N/A
HAMMER TYPE: Automatic **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): Groundwater level estimated @ 4.0 ft. at time of drilling
GENERAL NOTES: Borehole backfilled w/ cuttings, granular material and an asphaltic patch

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; SS = Split-Spoon Sample
ST = Undisturbed Tube Sample; RC = Rock Core; FVS = Field Vane Shear; CBR = California Bearing Ratio
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; PID = Photoionization Detector
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Depth (ft)	Elev. (ft)	Casing Pen. (bpf) or Core Rate (mpf)	SAMPLE INFORMATION: Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field/ Laboratory Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
										Bituminous Concrete (~4")		No SPT Samples were collected above 5-feet
											▽	
5			S-1		5 to 7	24/12	9-10-10-9	Hydrometer		Moist to wet, brown and gray brown, Silty SAND with Gravel (SM) - fine to coarse sand, little fines, little fine gravel; non-homogenous FILL		
			S-2		7 to 9	24/13	5-6-6-7			Wet, brown, non-homogenous Silty SAND (SM) - fine to coarse sand, little to some fines, few fine gravel; possible FILL		
10			S-3		10 to 12	24/8	5-6-6-7			Top 5": Wet, dark brown, Organic SILT (ML/OL) - high plasticity, few fine to coarse sand		
										Bottom 3": Wet, brown, Silty SAND (SM) - fine to coarse sand, little fines		
15			S-4		15 to 17	24/10	3-4-5-6	Sieve		Wet, brown, Silty SAND (SM) - fine sand, little fines		
20			S-5		20 to 22	24/12	5-6-6-5			Wet, brown, Silty SAND to Sandy SILT (SM/ML) - non-plastic, fine sand, occasional silt laminae; some FeOx staining		
										End of Boring at 22 feet		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

LOGGED BY (Consultant): AECOM
PROJECT NAME: Lawrence Brook Stormwater Project
CITY/STATE: Peabody, MA
AECOM PROJECT NUMBER: 60547746

AECOM

MASSDOT I-90 REV. 2 LBWSP-PROJECT.GPJ 12/6/18

ATTACHMENT 2

Falling Head Permeability Test Data

IN SITU PERMEABILITY TEST FORM

Project:	Lawrence Brook Stormwater Project	Boring No.:	**B-1**
Project No.:	60547746 Task 6.1	Test Date:	November 8, 2018
Contractor:	Terracon	Test Type:	Falling Head Test
Inspector:	K. Harten	Driller:	P. Michaud

Test Interval*:	Depth (Z_1):	5.01	Length (L):	NA	Diam. (D):	NA
	Sample Recovery:	N/A	Sample Description:	N/A		
Casing*:	Type:	HW	Length (l):	6.5	ID (d):	0.33

Height of casing above groundwater table (Ho): 4.49

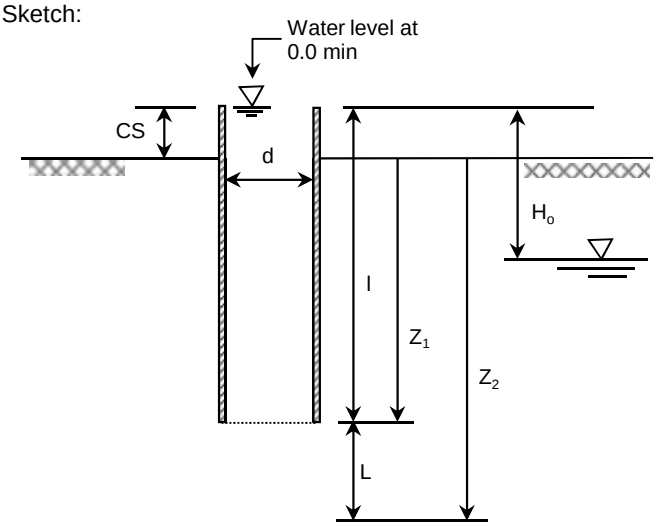
ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING* (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
0.0	0.00		
0.5	0.00		
1.0	0.00		
2.0	0.00		
3.0	0.00		
4.0	0.00		
5.0	0.00		
7.5			

Leave Blank

ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING* (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
10.0			
12.5			
15.0			
20.0			
25.0			
30.0			

Leave Blank

Sketch:



Notes:

*: Measurements were recorded in feet

1. The groundwater table measurement was determined after auger retrieval.

2. The falling head test was terminated @ 5 minutes after no measurable drop was observed.

AECOM

IN SITU PERMEABILITY TEST FORM

Project:	Lawrence Brook Stormwater Project	Boring No.:	**B-1**
Project No.:	60547746 Task 6.1	Test Date:	November 8, 2018
Contractor:	Terracon	Test Type:	Falling Head Test
Inspector:	K. Harten	Driller:	P. Michaud

Test Interval*:	Depth (Z_1):	5.01	Length (L):	2.00	Diam. (D):	0.167
	Sample Recovery:	0.70	Sample Description:	Refer to Boring Log		
Casing*:	Type:	HW	Length (l):	6.5	ID (d):	0.33

Height of casing above groundwater table (Ho): 4.49

ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
0.0	0.00		
0.5	0.005		
1.0	0.010		
2.0	0.015		
3.0	0.020		
4.0	0.025		
5.0	0.030		
7.5	0.055		

ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
10.0	0.080		
12.5	0.095		
15.0	0.105		
20.0	0.145		
27.0	0.180		
32.0	0.210		

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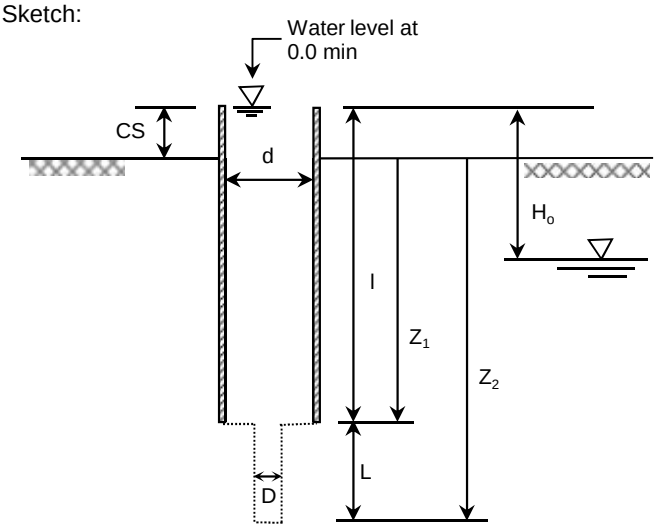
Sketch:



Notes:

*: Measurements were recorded in feet

1. The groundwater table measurement was determined after auger retrieval.

AECOM

IN SITU PERMEABILITY TEST FORM

Project:	Lawrence Brook Stormwater Project	Boring No.:	**B-3**
Project No.:	60547746 Task 6.1	Test Date:	November 8, 2018
Contractor:	Terracon	Test Type:	Falling Head Test
Inspector:	K. Harten	Driller:	P. Michaud

Test Interval*:	Depth (Z_1):	5.81	Length (L):	NA	Diam. (D):	NA
	Sample Recovery:	N/A	Sample Description:	N/A		
Casing*:	Type:	HW	Length (l):	6.5	ID (d):	0.33

Height of casing above groundwater table (Ho): 5.7 Estimated

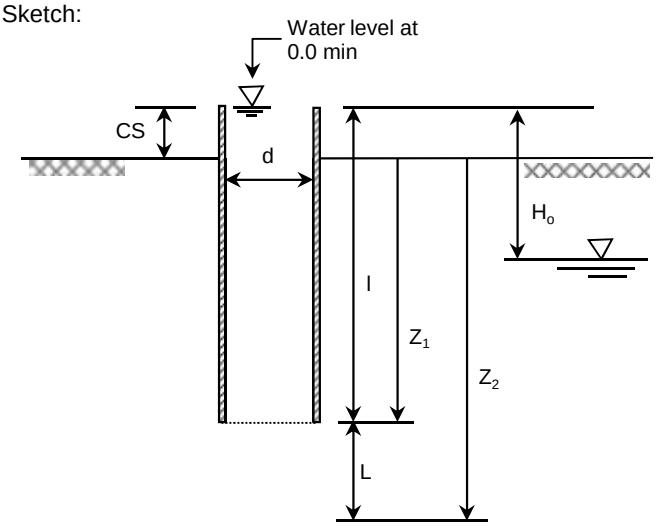
ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
0.0	0.00		
0.5	0.31		
1.0	0.60		
2.0	1.05		
3.0	1.45		
4.0	1.82		
5.0	2.20		
7.5	2.91		

Leave Blank

ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
10.0	3.52		
12.5	3.95		
15.0	4.29		
20.0	4.67		
25.0	4.86		
30.0	4.93		

Leave Blank

Sketch:



Notes:

*: Measurements were recorded in feet

1. Leakage was observed on outside of casing before start of test; casing was reset before beginning test.

AECOM

IN SITU PERMEABILITY TEST FORM

Project:	Lawrence Brook Stormwater Project	Boring No.:	**B-3**
Project No.:	60547746 Task 6.1	Test Date:	November 8, 2018
Contractor:	Terracon	Test Type:	Falling Head Test
Inspector:	K. Harten	Driller:	P. Michaud

Test Interval*:	Depth (Z_1):	5.81	Length (L):	4.00	Diam. (D):	0.167
	Sample Recovery:	0.33	Sample Description:	Refer to Boring Log		
Casing*:	Type:	HW	Length (I):	6.5	ID (d):	0.33

Height of casing above groundwater table (Ho): 5.7 Estimated

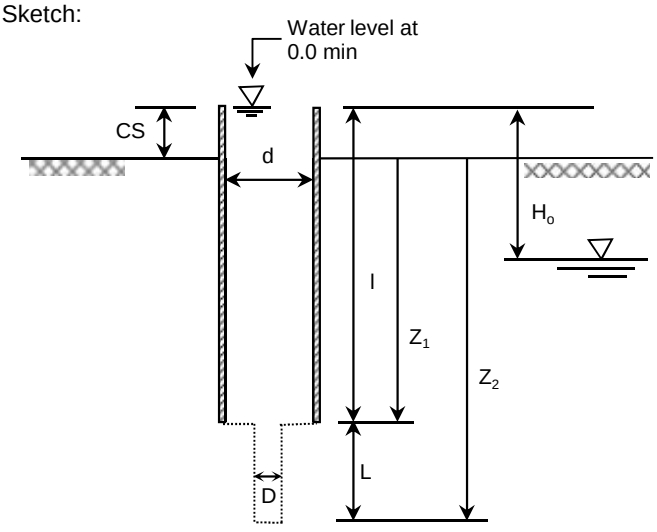
ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
0.0	See Note 1		
0.5			
1.0			
2.0			
3.0			
4.0			
5.0			
7.5			

Leave Blank

ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
10.0			
12.5			
15.0			
20.0			
25.0			
30.0			

Leave Blank

Sketch:



Notes:

*: Measurements were recorded in feet

1. Drillers (mistakenly) collected two consecutive spoons before start of test; the observed drop in water level during the test was too swift to accurately measure.

AECOM

IN SITU PERMEABILITY TEST FORM

Project:	Lawrence Brook Stormwater Project	Boring No.:	**B-5**
Project No.:	60547746 Task 6.1	Test Date:	November 14, 2018
Contractor:	Terracon	Test Type:	Falling Head Test
Inspector:	K. Harten	Driller:	P. Michaud

Test Interval*:	Depth (Z_1):	4.45	Length (L):	NA	Diam. (D):	NA
	Sample Recovery:	N/A	Sample Description:	N/A		
Casing*:	Type:	HW	Length (l):	5.5	ID (d):	0.33

Height of casing above groundwater table (Ho): 5.3

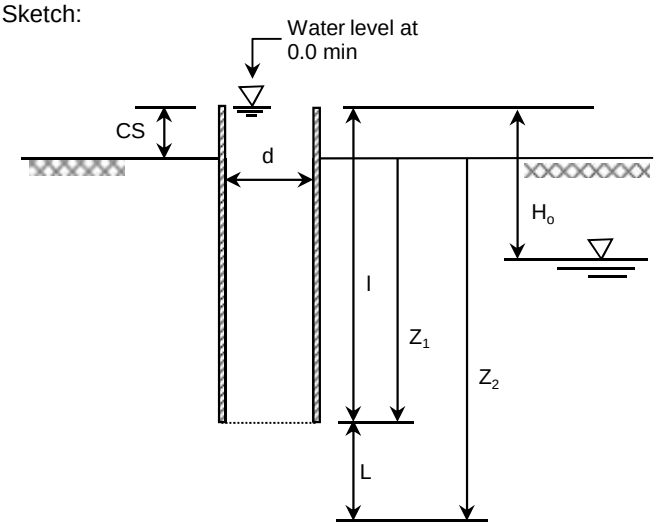
ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
0.0	0.00		
0.5	Negligible		
1.0	Negligible		
2.0	Negligible		
3.0	0.005		
4.0	0.005		
6.0	0.010		
7.5	0.013		

Leave Blank

ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
10.0	0.020		
13.0	0.020		
15.0	0.040		
22.0	0.070		
25.0			
30.0			

Leave Blank

Sketch:



Notes:

*: Measurements were recorded in feet

1. Borehole was drilled using solid stem augers; Terracon drilled and performed falling head test at an offset location using 4-inch HW casing.

2. Stiff winds may have contributed to initial water level drop (i.e., wind blew water over casing lip)

AECOM

IN SITU PERMEABILITY TEST FORM

Project:	Lawrence Brook Stormwater Project	Boring No.:	**B-5**
Project No.:	60547746 Task 6.1	Test Date:	
Contractor:	Terracon	Test Type:	Falling Head Test
Inspector:	K. Harten	Driller:	P. Michaud

Test Interval*:	Depth (Z_1):	4.45	Length (L):	2.0	Diam. (D):	0.167
	Sample Recovery:	1.10	Sample Description:	Refer to Boring Log		
Casing*:	Type:	HW	Length (l):	5.5	ID (d):	0.33

Height of casing above groundwater table (Ho): 5.3

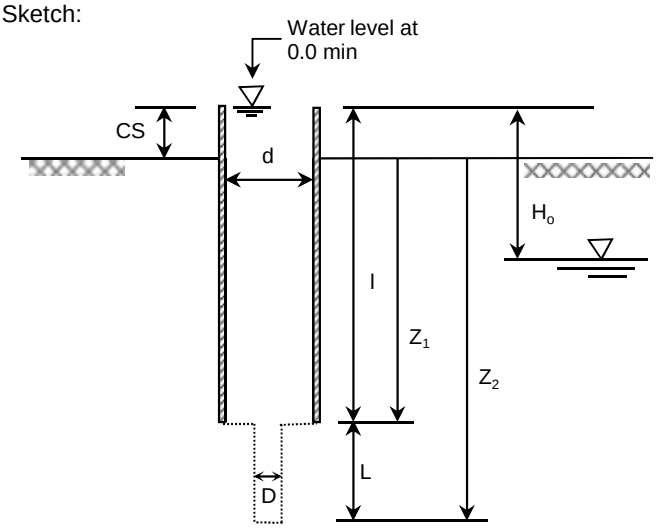
ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
0.0	0.00		
0.5	Negligible		
1.0	0.003		
2.0	0.005		
3.0	0.010		
4.0	0.015		
6.0	0.020		
8.0	0.035		

Leave Blank

ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
11.0	0.045		
16.0	0.070		
20.0	0.085		
26.0	0.100		

Leave Blank

Sketch:



Notes:

*: Measurements were recorded in feet

1. Borehole was drilled using solid stem augers; Terracon drilled and performed falling head test at an offset location using 4-inch HW casing.

2. The collected split-spoon sample @ 4.45 ft. contained rust brown sandy SILT, some fine to coarse sand (mostly fine grained) and few fine gravel; the sample was borderline non-cohesive (ML/SM)

3. The recorded sample blow counts were 10-10-11-13.

AECOM

IN SITU PERMEABILITY TEST FORM

Project:	Lawrence Brook Stormwater Project	Boring No.:	**B-6**
Project No.:	60547746 Task 6.1	Test Date:	November 14, 2018
Contractor:	Terracon	Test Type:	Falling Head Test
Inspector:	K. Harten	Driller:	P. Michaud

Test Interval*:	Depth (Z_1):	4.72	Length (L):	NA	Diam. (D):	NA
	Sample Recovery:	N/A	Sample Description:	N/A		
Casing*:	Type:	HW	Length (l):	6.5	ID (d):	0.33

Height of casing above groundwater table (Ho): 4.78

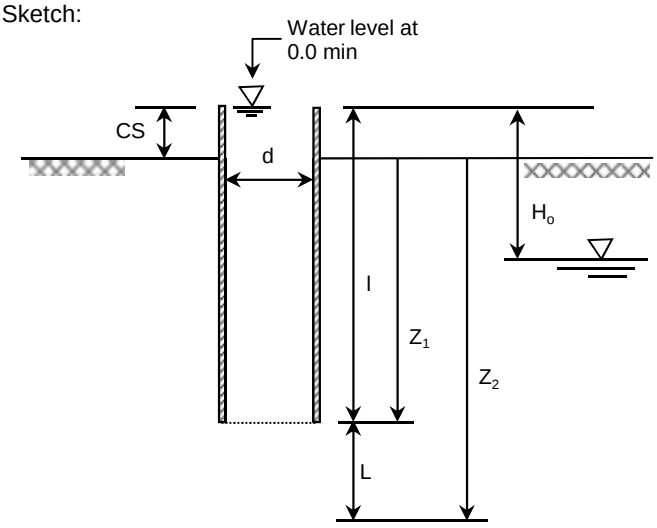
ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
0.0	0.00		
0.5	0.10		
1.0	0.20		
2.0	0.40		
3.0	0.59		
4.0	0.75		
5.0	0.91		
7.5	1.27		

Leave Blank

ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
10.0	1.60		
12.5	1.90		
15.0	2.16		
20.0	2.64		
25.0	3.03		
30.0	3.33		

Leave Blank

Sketch:



Notes:

*: Measurements were recorded in feet

AECOM

IN SITU PERMEABILITY TEST FORM

Project:	Lawrence Brook Stormwater Project	Boring No.:	**B-6**
Project No.:	60547746 Task 6.1	Test Date:	November 14, 2018
Contractor:	Terracon	Test Type:	Falling Head Test
Inspector:	K. Harten	Driller:	P. Michaud

Test Interval*:	Depth (Z_1):	4.72	Length (L):	2.0	Diam. (D):	0.167
	Sample Recovery:	1.00	Sample Description:	Refer to Boring Log		
Casing*:	Type:	HW	Length (l):	6.5	ID (d):	0.33

Height of casing above groundwater table (Ho): 4.78

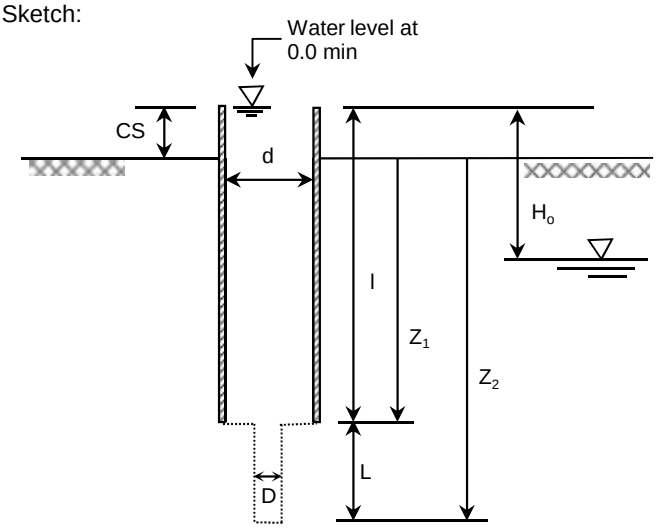
ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
0.0	0.00		
0.5	0.17		
1.0	0.34		
2.0	0.64		
3.0	0.86		
4.0	1.10		
5.0	1.29		
7.5	1.74		

Leave Blank

ELAPSED TIME (minutes)	DEPTH TO WATER FROM TOP OF CASING (feet)	HEAD (Ht)	HEAD RATIO (Ht/Ho)
10.0	2.11		
12.5	2.44		
15.0	2.71		
20.5	3.20		
25.75	3.59		
34.5	3.99		

Leave Blank

Sketch:



Notes:

*: Measurements were recorded in feet

1. The groundwater table measurement was determined after auger retrieval.

AECOM

ATTACHMENT 3

Geotechnical Laboratory Testing Results

TABLE 1: SUMMARY OF LABORATORY TESTING - SOILS

Boring ID	Sample ID	Depth	Sieve (ASTM D6913)	Hydrometer (ASTM D7928)	Organic Content (ASTM D2974)	Comments
B-1	SS-3	5 - 7		X		
B-1	SS-5	10 - 12	X			
B-2	SS-2	3 – 3’8”		X		
B-3	SS-4	7.8 – 9.8			X	
B-4	SS-2	2 – 4 Bottom		X		
B-4	SS-2	2 – 4 Top	X			
B-5	SS-3	5 - 7	X			
B-6	SS-3	4.7 – 6.7		X		
B-6	SS-5	9 – 11 Top	X			
B-6	SS-5	9 – 11 Bottom		X		
B-7	SS-2	10 – 12		X		
B-7	SS-3	15 – 17		X		
B-8	SS-2	7 - 9	X			
B-8	SS-4	15 – 17 Top			X	
B-8	SS-5	20 - 22		X		
B-9	SS-1	5 - 7		X		
B-9	SS-4	15 - 17	X			

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	---	Sample Type:	---	Tested By:	cam
Sample ID:	---	Test Date:	11/29/18	Checked By:	emm
Depth :	---	Test Id:	482591		

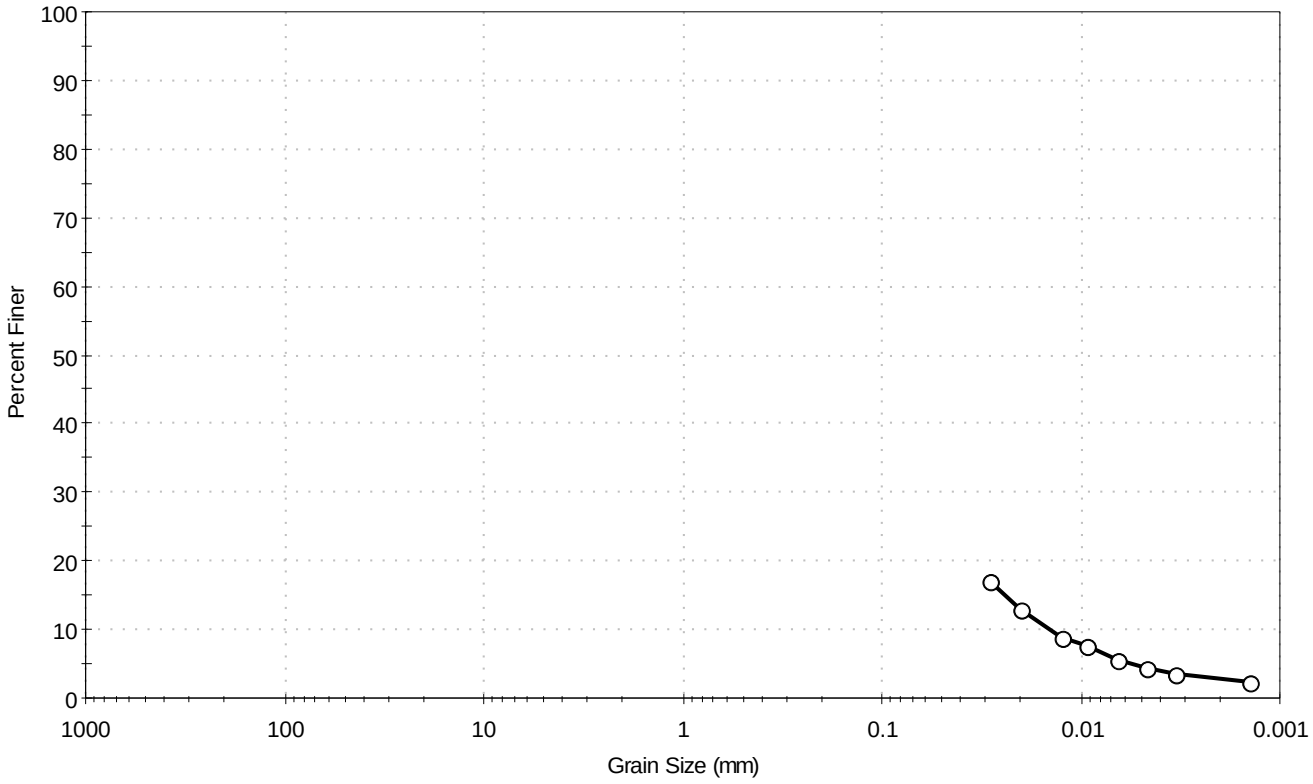
Moisture, Ash, and Organic Matter - ASTM D2974

Boring ID	Sample ID	Depth	Description	Moisture Content, %	Ash Content, %	Organic Matter, %
B-3	SS-4	7.8-9.8	Moist, very dark gray silt with organics	111	79.2	20.8
B-8	SS-4	15-17 top	Moist, very dark gray silt with organics	87	84.5	15.5

Notes: Moisture content determined by Method A and reported as a percentage of oven-dried mass;
dried to a constant mass at temperature of 105º C
Ash content and organic matter determined by Method C; dried to constant mass at temperature 440º C

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-1	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-3	Test Date:	12/02/18	Checked By:	emm
Depth :	5-7	Test Id:	482581		
Test Comment:	Hydrometer portion only per client request				
Visual Description:	Moist, very dark grayish brown silty sand				
Sample Comment:	Percent Passing No. 200 Sieve = 38%				

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	---	---	---

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0286	17		
---	0.0200	13		
---	0.0127	9		
---	0.0093	8		
---	0.0066	6		
---	0.0048	5		
---	0.0034	4		
---	0.0014	2		

Coefficients

D_{85} = N/A	D_{30} = N/A
D_{60} = N/A	D_{15} = 0.0238 mm
D_{50} = N/A	D_{10} = 0.0145 mm
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO ()

Sample / Test Description

Dispersion Device : Apparatus A - Mech Mixer

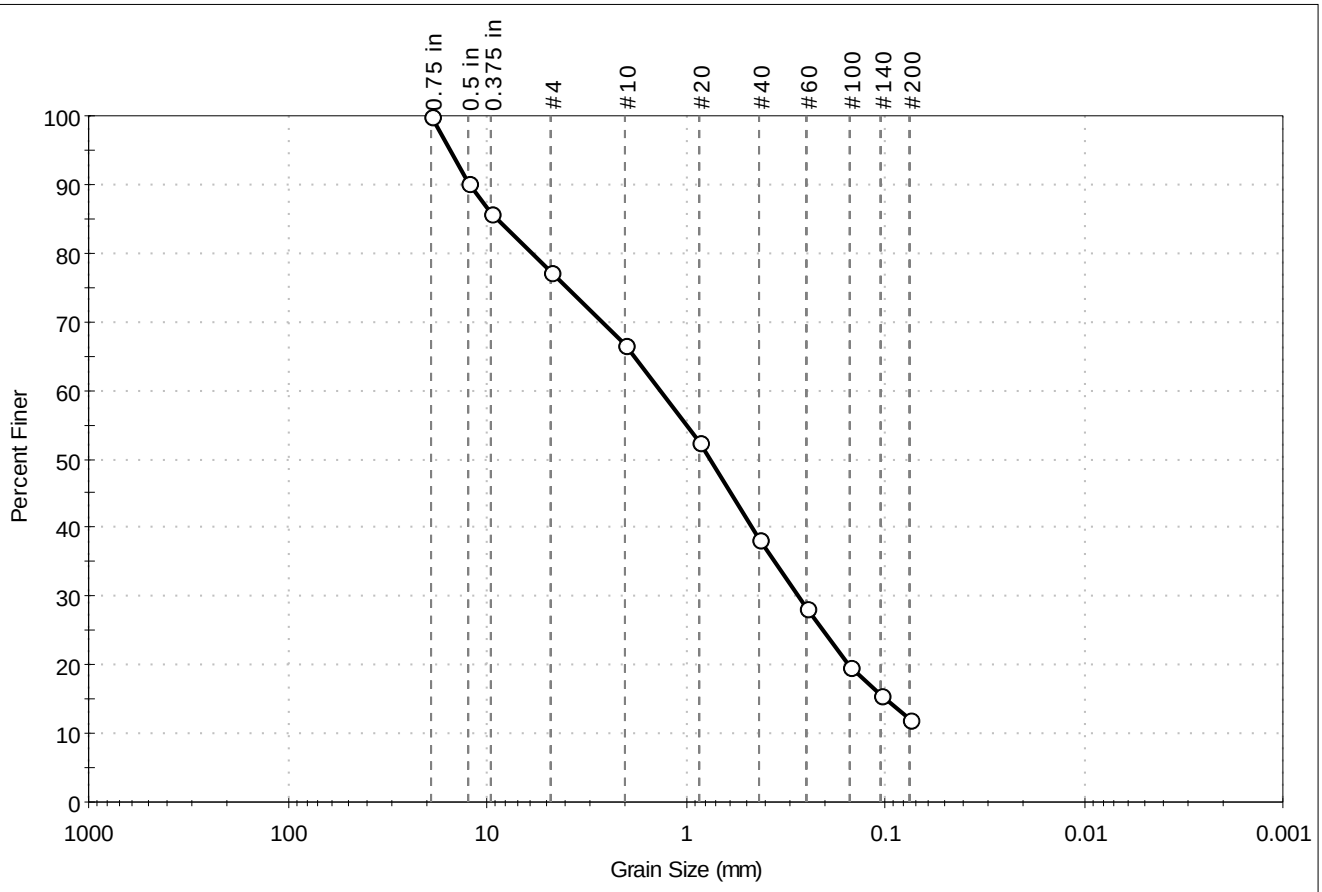
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-1	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-5	Test Date:	11/27/18	Checked By:	emm
Depth :	10-12	Test Id:	482575		
Test Comment:	---				
Visual Description:	Moist, dark yellowish brown silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	22.6	65.2	12.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	90		
0.375 in	9.50	86		
#4	4.75	77		
#10	2.00	67		
#20	0.85	52		
#40	0.42	38		
#60	0.25	28		
#100	0.15	20		
#140	0.11	16		
#200	0.075	12		

Coefficients

D_{85} = 8.8193 mm
D_{30} = 0.2729 mm
D_{60} = 1.3341 mm
D_{15} = 0.1005 mm
D_{50} = 0.7538 mm
D_{10} = N/A
C_u = N/A
C_c = N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

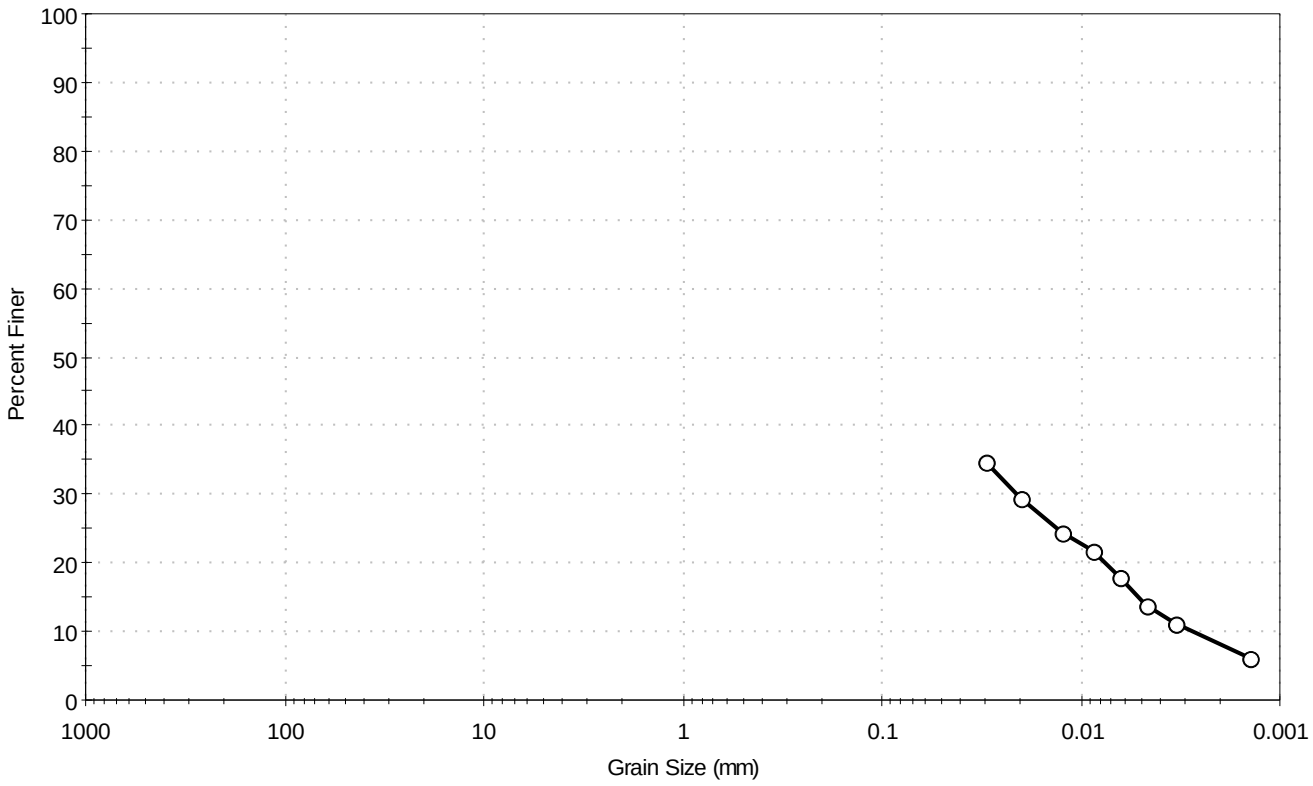
Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-2	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-2	Test Date:	12/04/18	Checked By:	emm
Depth :	3-3.67 ft	Test Id:	482582		
Test Comment:	Hydrometer portion only per client request				
Visual Description:	Moist, dark brown silty sand with gravel				
Sample Comment:	Percent Passing No. 200 Sieve = 50%				

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	---	---	---

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0306	35		
---	0.0200	30		
---	0.0124	24		
---	0.0088	22		
---	0.0065	18		
---	0.0047	14		
---	0.0034	11		
---	0.0014	6		

Coefficients

D_{85} = N/A	D_{30} = 0.0206 mm
D_{60} = N/A	D_{15} = 0.0052 mm
D_{50} = N/A	D_{10} = 0.0027 mm
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO ()

Sample / Test Description

Dispersion Device : Apparatus A - Mech Mixer

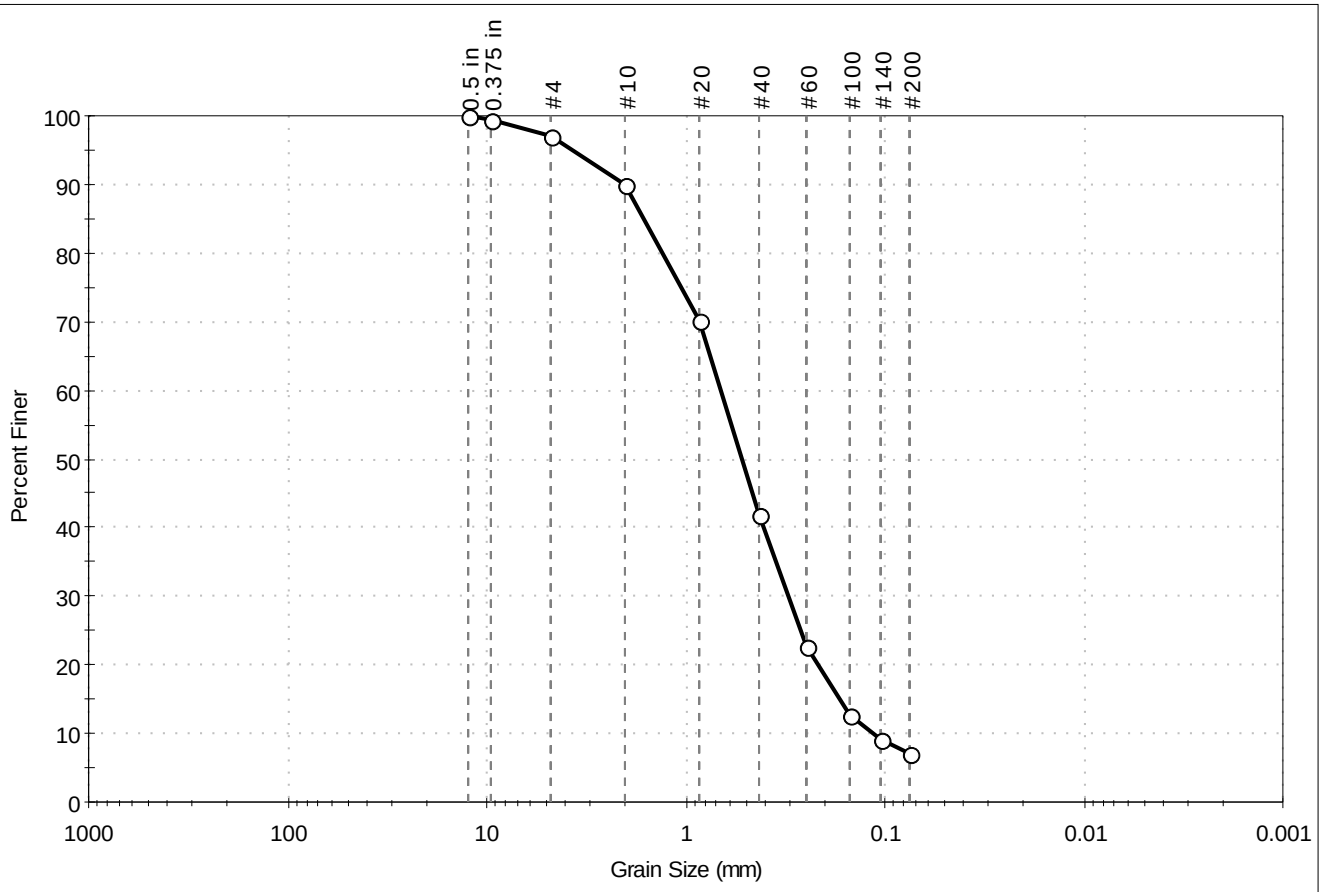
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-4	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-2	Test Date:	11/27/18	Checked By:	emm
Depth :	2-4 top	Test Id:	482576		
Test Comment:	---				
Visual Description:	Moist, dark yellowish brown sand with silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	2.9	90.2	6.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	99		
#4	4.75	97		
#10	2.00	90		
#20	0.85	70		
#40	0.42	42		
#60	0.25	23		
#100	0.15	13		
#140	0.11	9		
#200	0.075	6.9		

Coefficients

D_{85} = 1.6074 mm
D_{30} = 0.3060 mm
D_{60} = 0.6604 mm
D_{15} = 0.1689 mm
D_{50} = 0.5173 mm
D_{10} = 0.1162 mm
C_u = 5.683
C_c = 1.220

Classification

ASTM N/A

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

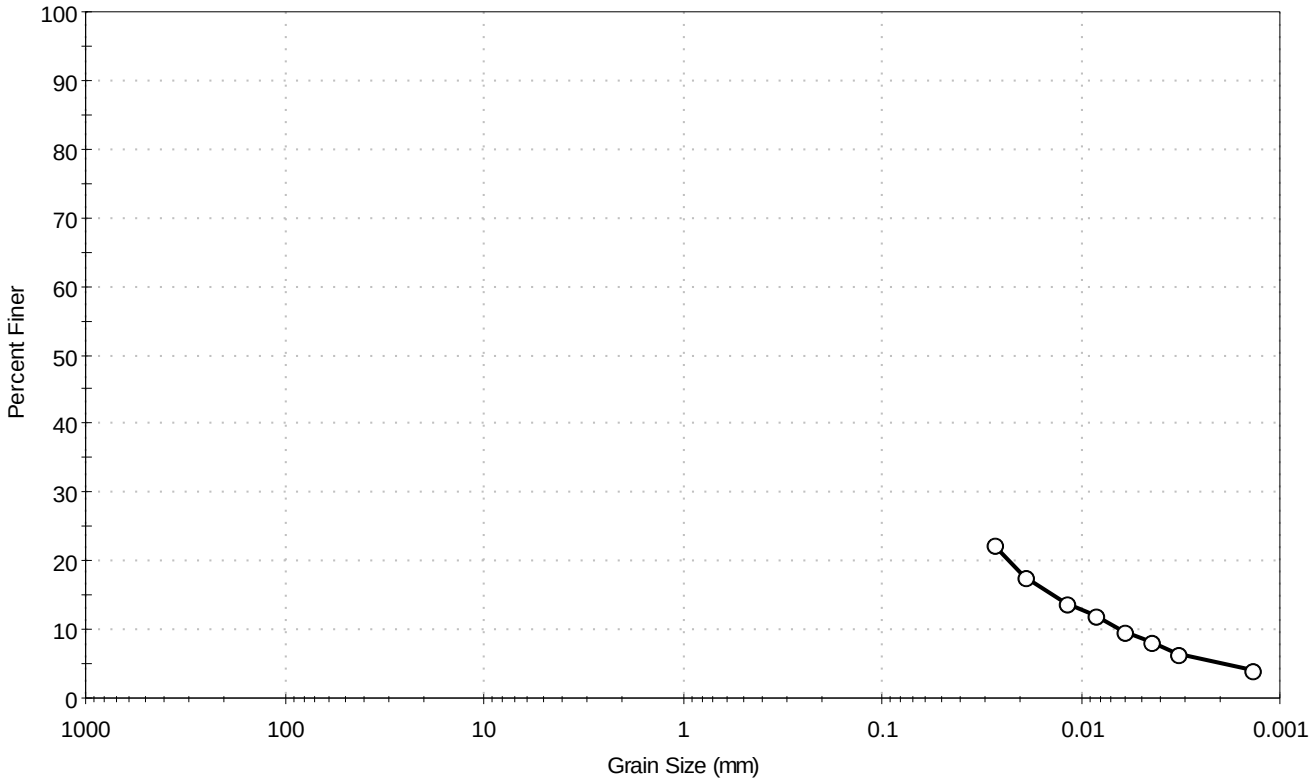
Sample / Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-4	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-2	Test Date:	12/02/18	Checked By:	emm
Depth :	2-4 bottom	Test Id:	482583		
Test Comment:	Hydrometer portion only per client request				
Visual Description:	Moist, dark yellowish brown silty sand with gravel				
Sample Comment:	Percent Passing No. 200 Sieve = 26%				

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	---	---	---

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0279	23		
---	0.0193	18		
---	0.0119	14		
---	0.0086	12		
---	0.0061	10		
---	0.0045	8		
---	0.0033	7		
---	0.0014	4		

Coefficients

D_{85} = N/A	D_{30} = N/A
D_{60} = N/A	D_{15} = 0.0138 mm
D_{50} = N/A	D_{10} = 0.0063 mm
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO ()

Sample / Test Description

Dispersion Device : Apparatus A - Mech Mixer

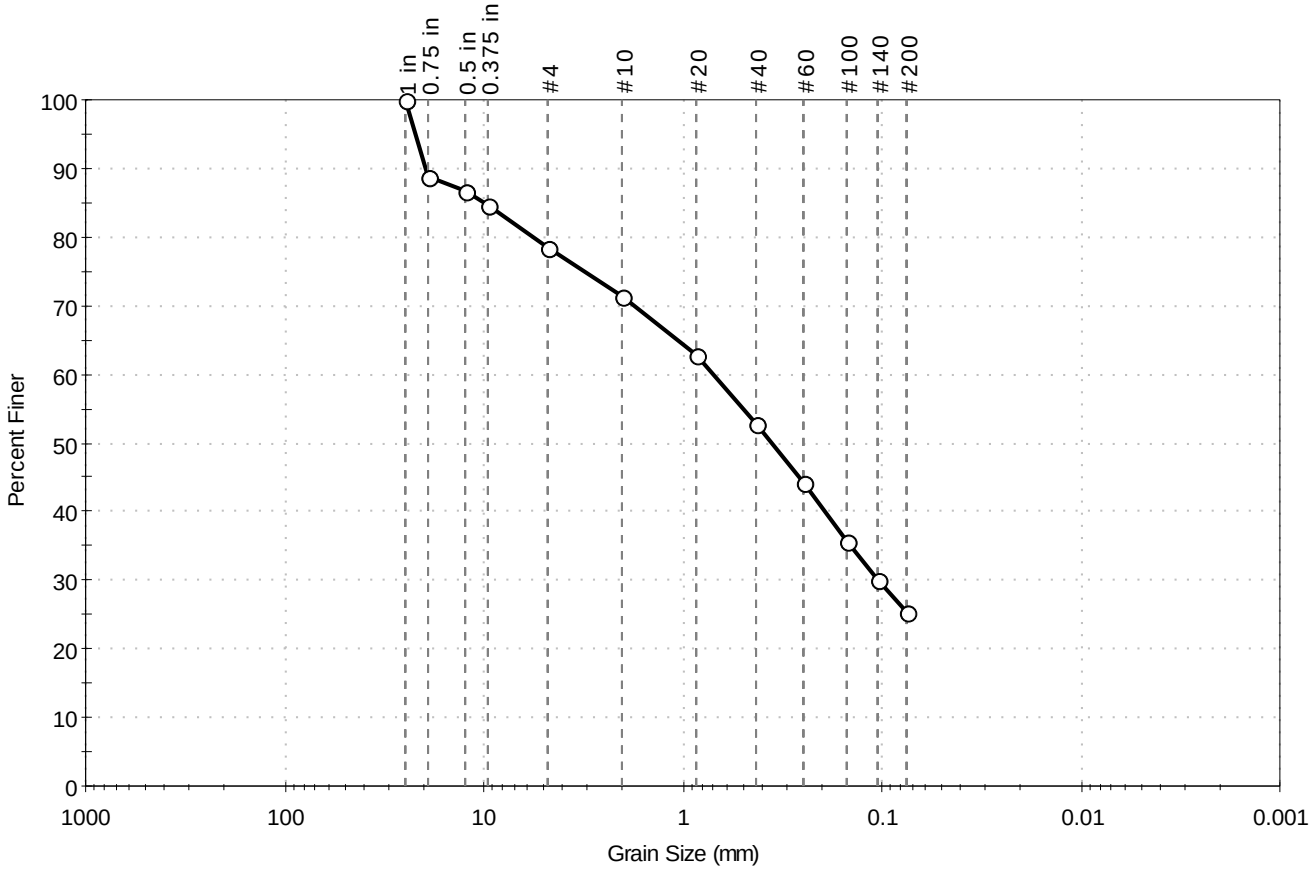
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-5	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-3	Test Date:	11/27/18	Checked By:	emm
Depth :	5-7	Test Id:	482577		
Test Comment:	---				
Visual Description:	Moist, yellowish brown silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	21.6	53.0	25.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	89		
0.5 in	12.50	87		
0.375 in	9.50	85		
#4	4.75	78		
#10	2.00	71		
#20	0.85	63		
#40	0.42	53		
#60	0.25	44		
#100	0.15	36		
#140	0.11	30		
#200	0.075	25		

Coefficients

D_{85} = 10.0253 mm D_{30} = 0.1054 mm

D_{60} = 0.6987 mm D_{15} = N/A

D_{50} = 0.3586 mm D_{10} = N/A

C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

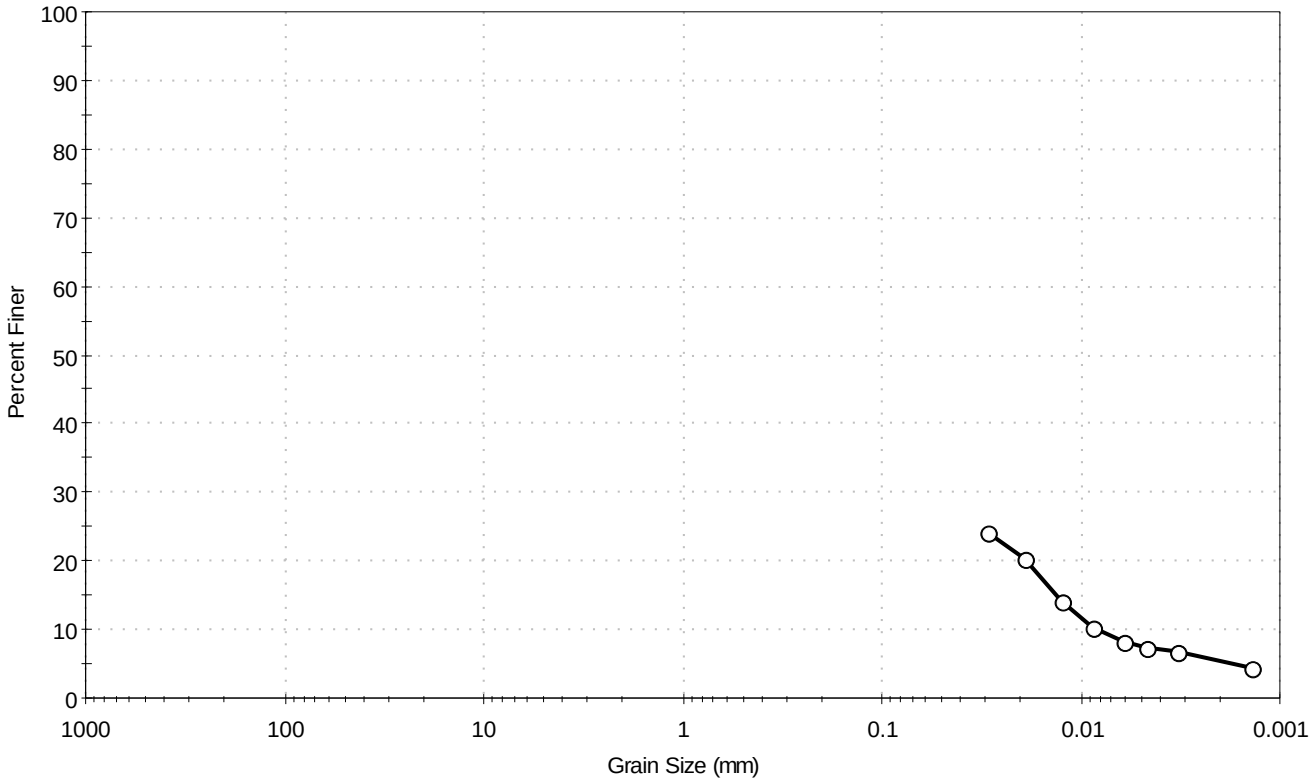
Sample / Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-6	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-3	Test Date:	12/02/18	Checked By:	emm
Depth :	4.7-6.7	Test Id:	482584		
Test Comment:	Hydrometer portion only per client request				
Visual Description:	Moist, very dark gray silty sand				
Sample Comment:	Percent Passing No. 200 Sieve = 32%				

Particle Size Analysis - ASTM D7928



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	---	---	---

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0293	24		
---	0.0194	20		
---	0.0125	14		
---	0.0088	10		
---	0.0062	8		
---	0.0047	7		
---	0.0033	7		
---	0.0014	4		

Coefficients

D_{85} = N/A	D_{30} = N/A
D_{60} = N/A	D_{15} = 0.0132 mm
D_{50} = N/A	D_{10} = 0.0083 mm
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO ()

Sample / Test Description

Dispersion Device : Apparatus A - Mech Mixer

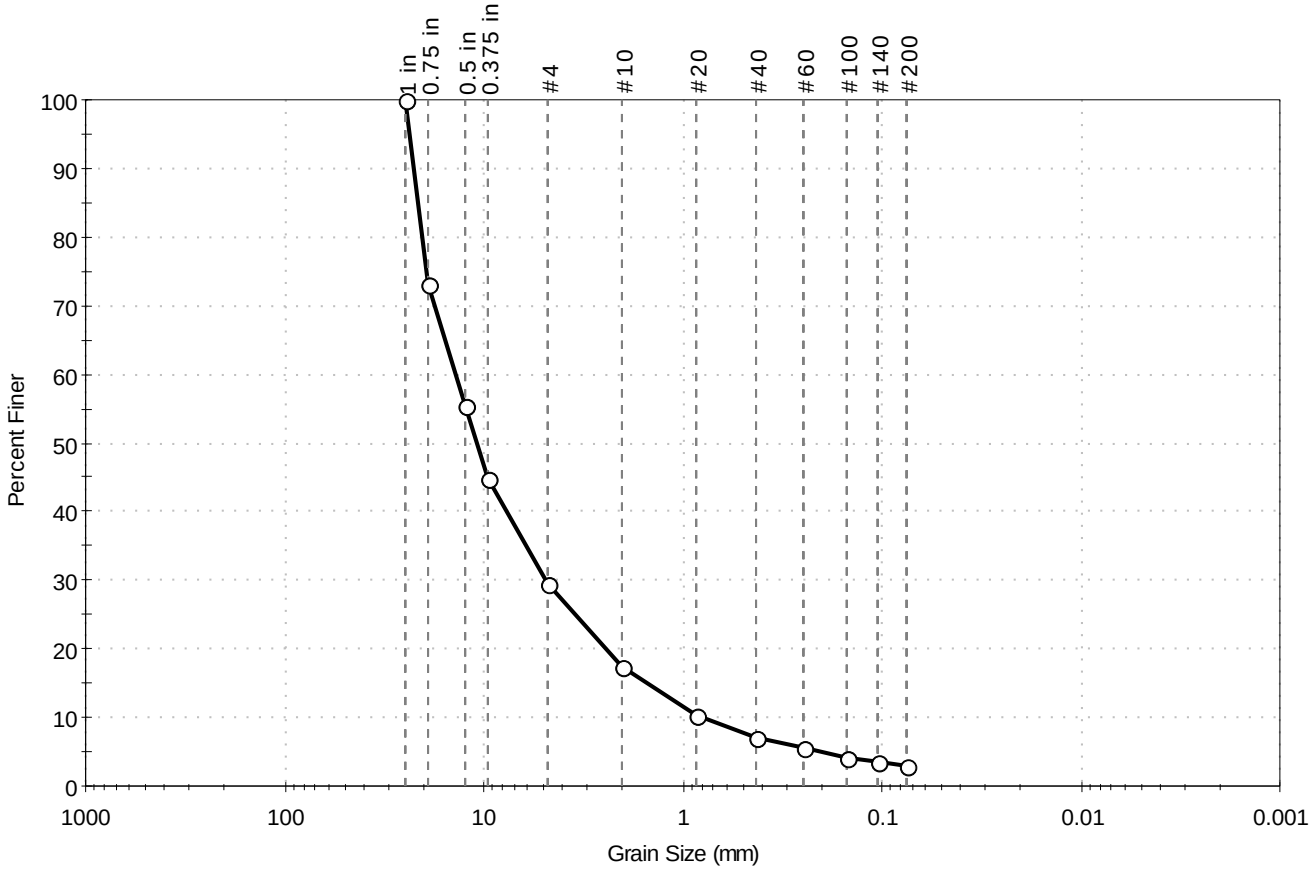
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-6	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-5	Test Date:	11/27/18	Checked By:	emm
Depth :	9-11 top	Test Id:	482578		
Test Comment:	---				
Visual Description:	Moist, dark olive brown gravel with sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	70.5	26.6	2.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	73		
0.5 in	12.50	55		
0.375 in	9.50	45		
#4	4.75	30		
#10	2.00	17		
#20	0.85	10		
#40	0.42	7		
#60	0.25	6		
#100	0.15	4		
#140	0.11	3		
#200	0.075	2.9		

Coefficients

D_{85} = 21.4364 mm	D_{30} = 4.8401 mm
D_{60} = 13.9182 mm	D_{15} = 1.5131 mm
D_{50} = 10.8479 mm	D_{10} = 0.7914 mm
C_u = 17.587	C_c = 2.127

Classification

ASTM — Well-graded GRAVEL with Sand (GW)

AASHTO — Stone Fragments, Gravel and Sand (A-1-a (1))

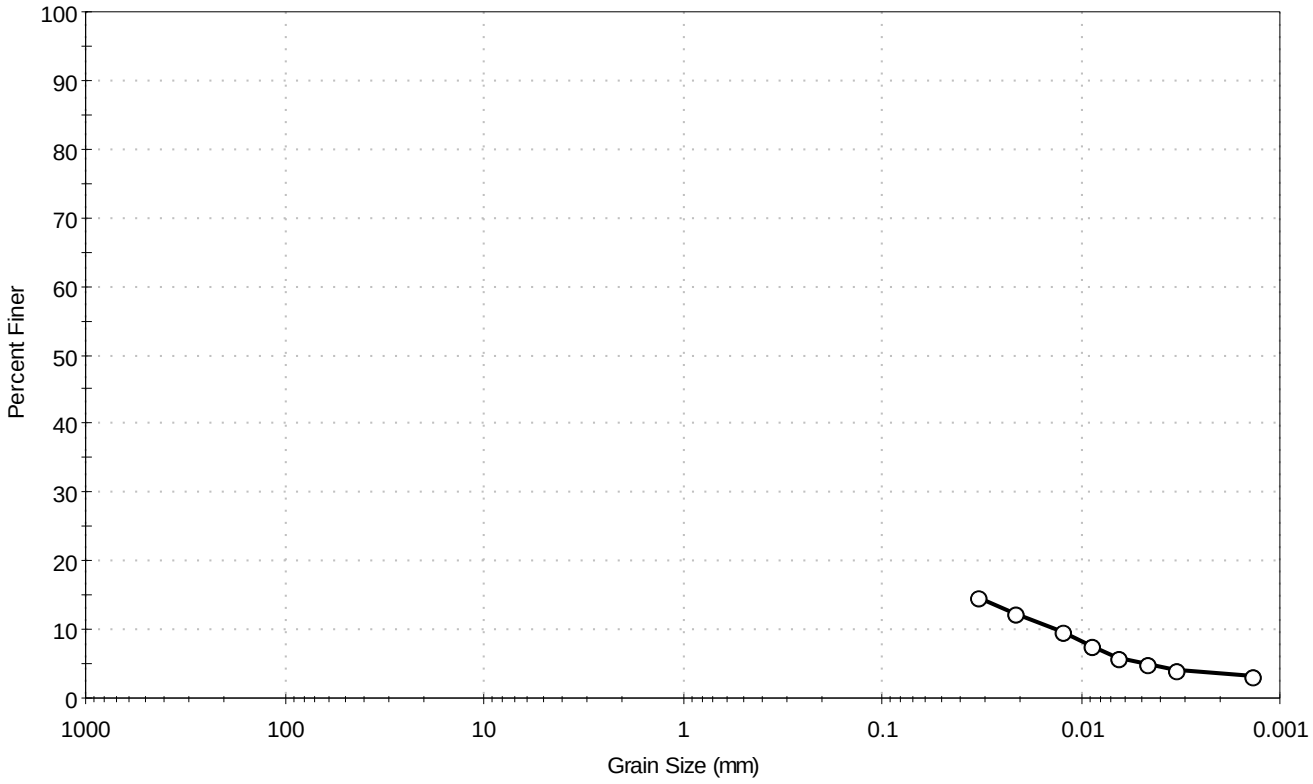
Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-6	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-5	Test Date:	11/30/18	Checked By:	emm
Depth :	9-11 bottom	Test Id:	482585		
Test Comment:	Hydrometer portion only per client request				
Visual Description:	Moist, dark brown silty sand				
Sample Comment:	Percent Passing No. 200 Sieve = 21%				

Particle Size Analysis - ASTM D7928



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	---	---	---

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0336	15		
---	0.0219	12		
---	0.0127	10		
---	0.0090	8		
---	0.0065	6		
---	0.0047	5		
---	0.0034	4		
---	0.0014	3		

Coefficients

D_{85} = N/A	D_{30} = N/A
D_{60} = N/A	D_{15} = N/A
D_{50} = N/A	D_{10} = 0.0137 mm
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO ()

Sample / Test Description

Dispersion Device : Apparatus A - Mech Mixer

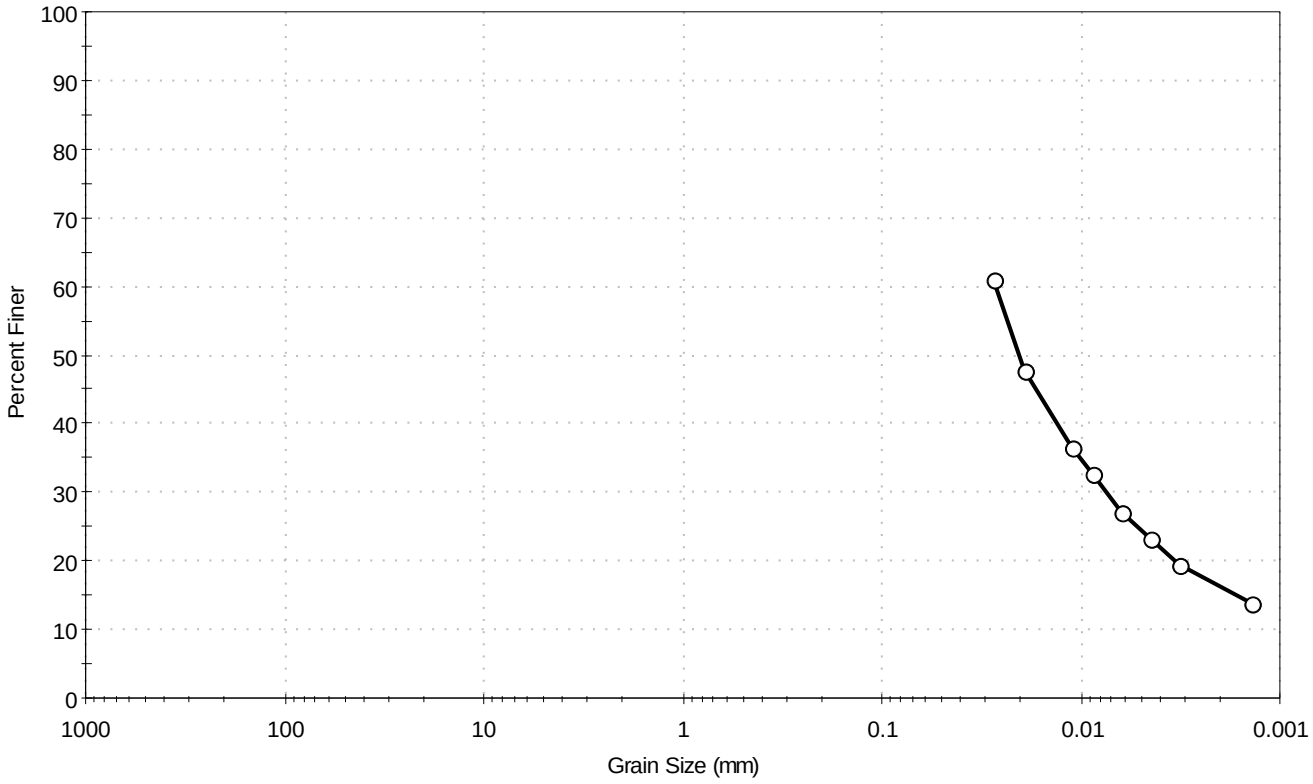
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-7	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-2	Test Date:	12/02/18	Checked By:	emm
Depth :	10-12	Test Id:	482586		
Test Comment:	Hydrometer portion only per client request				
Visual Description:	Moist, olive gray silt				
Sample Comment:	Percent Passing No. 200 Sieve = 87%				

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	---	---	---

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0278	61		
---	0.0192	48		
---	0.0111	36		
---	0.0088	33		
---	0.0063	27		
---	0.0045	23		
---	0.0032	19		
---	0.0014	14		

Coefficients

D_{85} = N/A	D_{30} = 0.0075 mm
D_{60} = 0.0270 mm	D_{15} = 0.0017 mm
D_{50} = 0.0205 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO ()

Sample / Test Description

Dispersion Device : Apparatus A - Mech Mixer

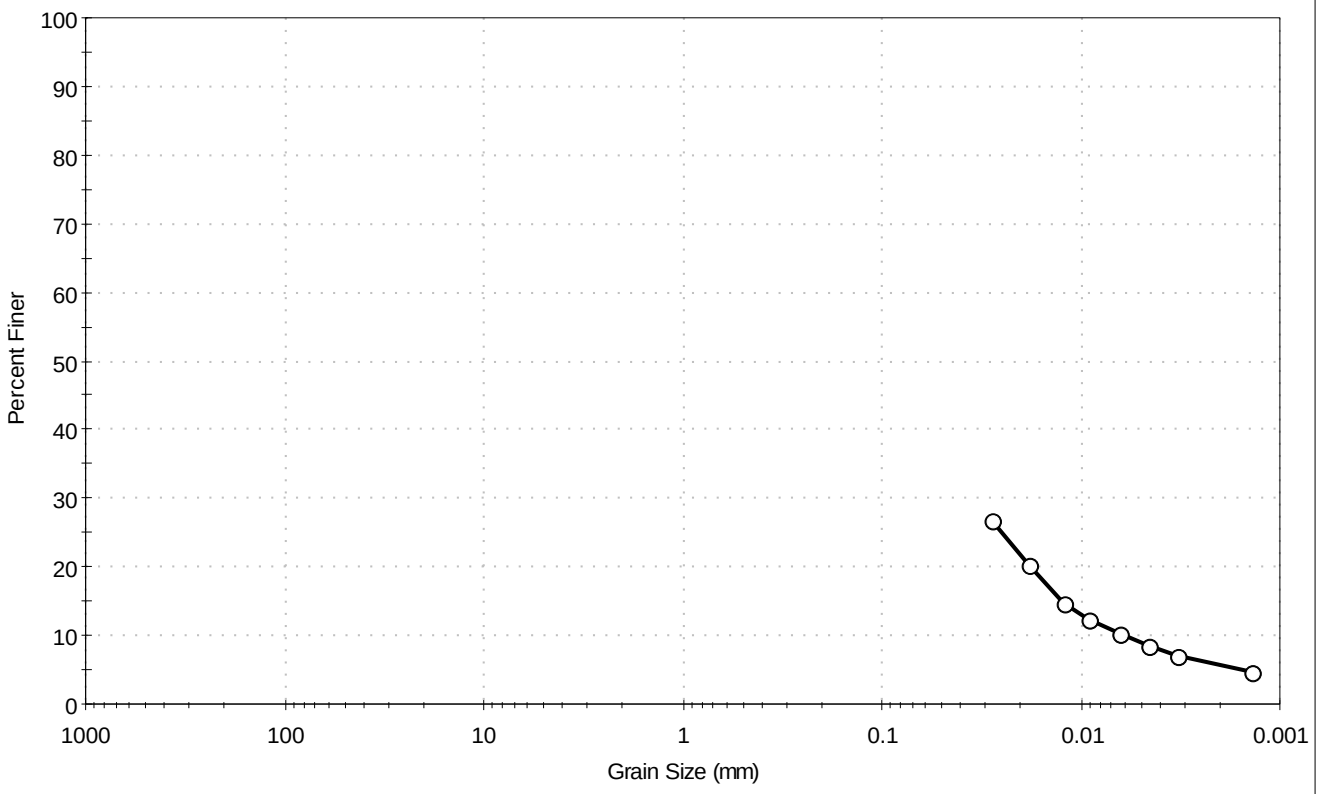
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-7	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-3	Test Date:	12/02/18	Checked By:	emm
Depth :	15-17	Test Id:	482587		
Test Comment:	Hydrometer portion only per client request				
Visual Description:	Moist, light yellowish brown sandy silt				
Sample Comment:	Percent Passing No. 200 Sieve = 60%				

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	---	---	---

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0279	27		
---	0.0185	20		
---	0.0124	15		
---	0.0091	13		
---	0.0064	10		
---	0.0046	9		
---	0.0033	7		
---	0.0014	5		

Coefficients

D_{85} = N/A	D_{30} = N/A
D_{60} = N/A	D_{15} = 0.0127 mm
D_{50} = N/A	D_{10} = 0.0060 mm
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO ()

Sample / Test Description

Dispersion Device : Apparatus A - Mech Mixer

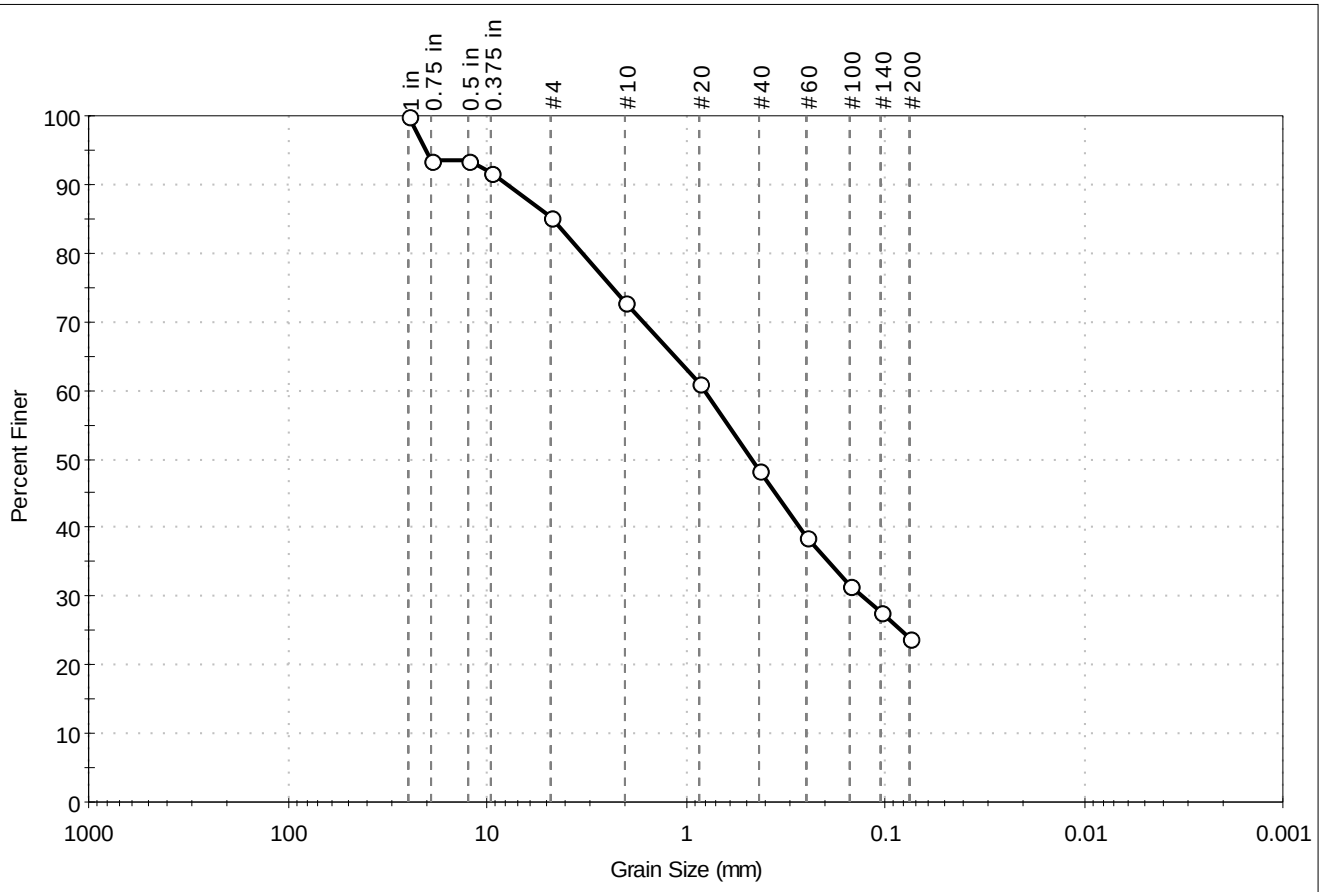
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-8	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-2	Test Date:	11/27/18	Checked By:	emm
Depth :	7-9	Test Id:	482579		
Test Comment:	---				
Visual Description:	Moist, very dark grayish brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	14.7	61.3	24.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	94		
0.5 in	12.50	94		
0.375 in	9.50	92		
#4	4.75	85		
#10	2.00	73		
#20	0.85	61		
#40	0.42	48		
#60	0.25	39		
#100	0.15	31		
#140	0.11	28		
#200	0.075	24		

Coefficients

D_{85} = 4.6628 mm	D_{30} = 0.1317 mm
D_{60} = 0.7987 mm	D_{15} = N/A
D_{50} = 0.4639 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

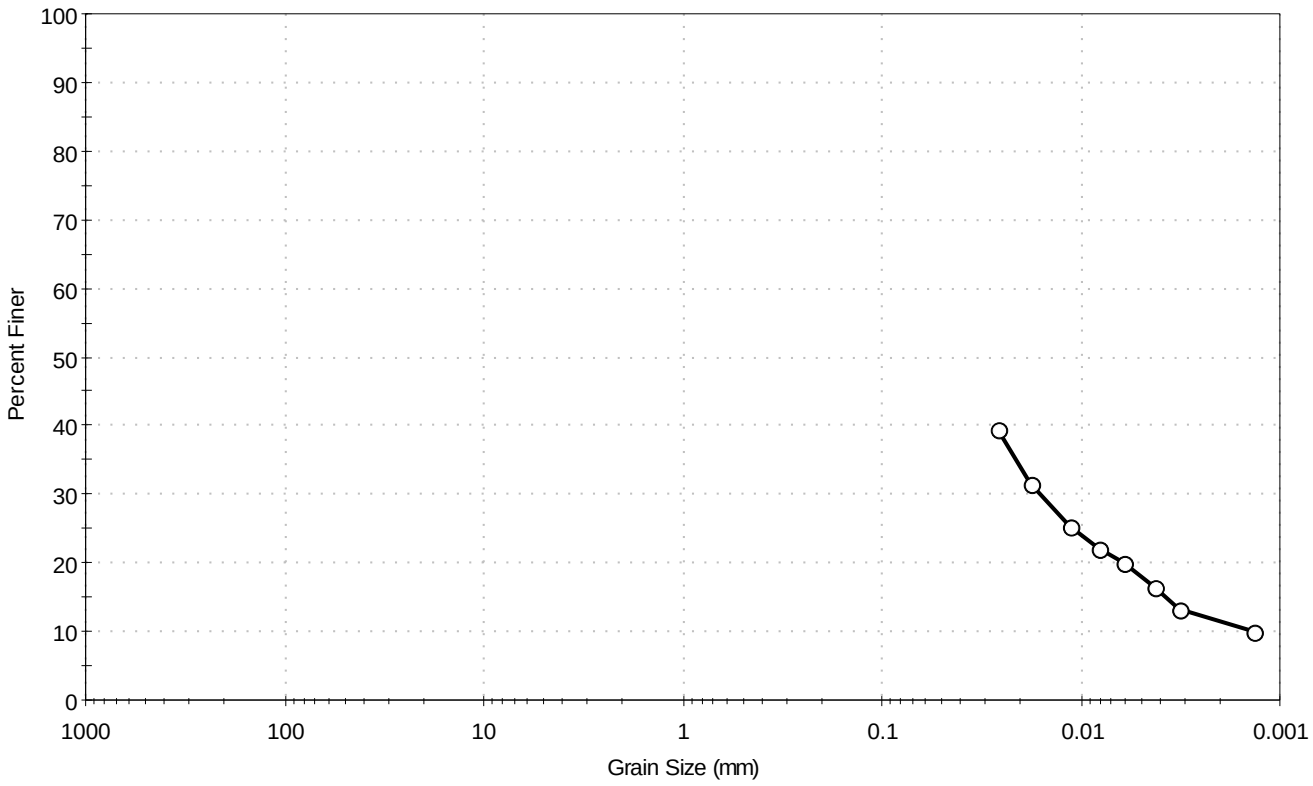
Sample / Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-8	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-5	Test Date:	12/02/18	Checked By:	emm
Depth :	20-22	Test Id:	482588		
Test Comment:	Hydrometer portion only per client request				
Visual Description:	Moist, light olive brown sandy silt				
Sample Comment:	Percent Passing No. 200 Sieve = 74%				

Particle Size Analysis - ASTM D7928



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	---	---	---

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0263	39		
---	0.0182	32		
---	0.0115	25		
---	0.0082	22		
---	0.0062	20		
---	0.0043	17		
---	0.0032	13		
---	0.0014	10		

Coefficients

D_{85} = N/A	D_{30} = 0.0162 mm
D_{60} = N/A	D_{15} = 0.0037 mm
D_{50} = N/A	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO ()

Sample / Test Description

Dispersion Device : Apparatus A - Mech Mixer

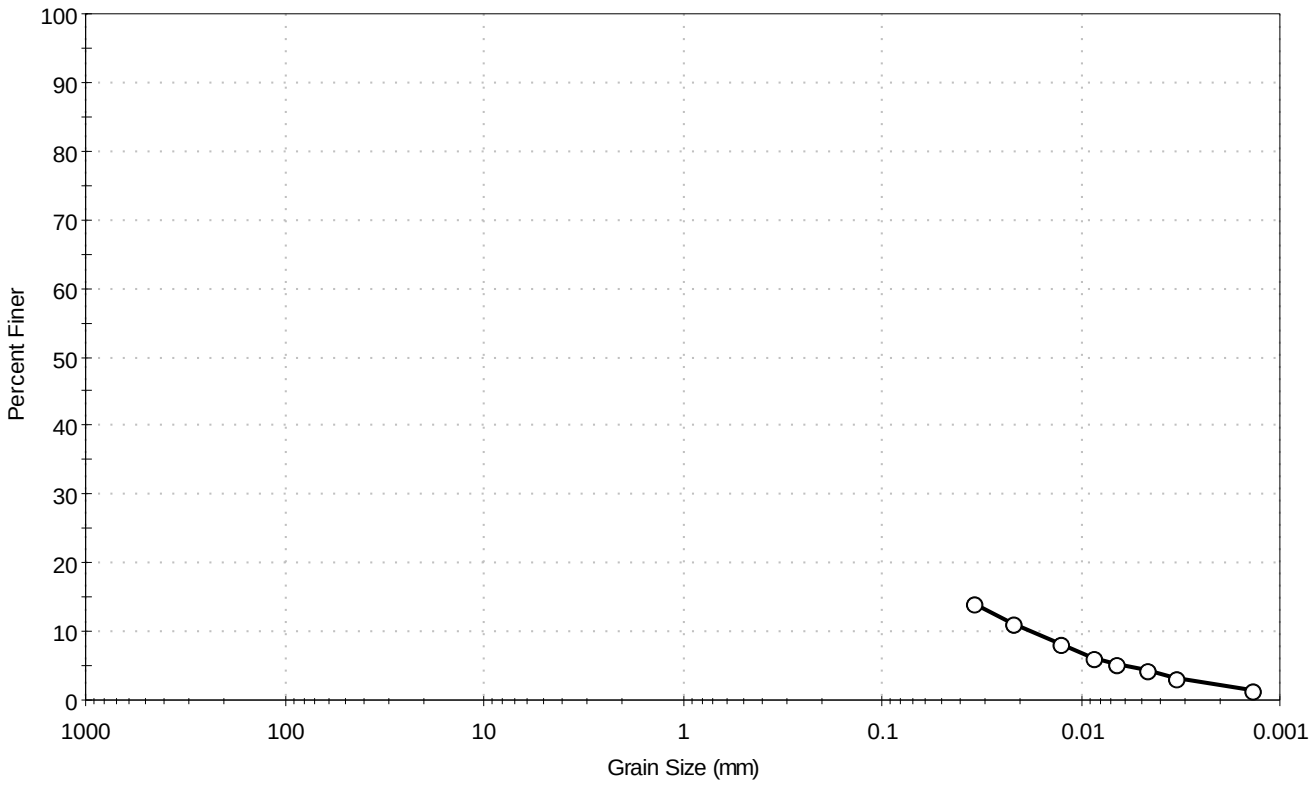
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-9	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-1	Test Date:	12/04/18	Checked By:	emm
Depth :	5-7	Test Id:	482589		
Test Comment:	Hydrometer portion only per client request				
Visual Description:	Moist, very dark gray silty sand with gravel				
Sample Comment:	Percent Passing No. 200 Sieve = 21%				

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	---	---	---

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0351	14		
---	0.0224	11		
---	0.0129	8		
---	0.0088	6		
---	0.0067	5		
---	0.0048	4		
---	0.0034	3		
---	0.0014	1		

Coefficients

D_{85} = N/A	D_{30} = N/A
D_{60} = N/A	D_{15} = N/A
D_{50} = N/A	D_{10} = 0.0176 mm
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO ()

Sample / Test Description

Dispersion Device : Apparatus A - Mech Mixer

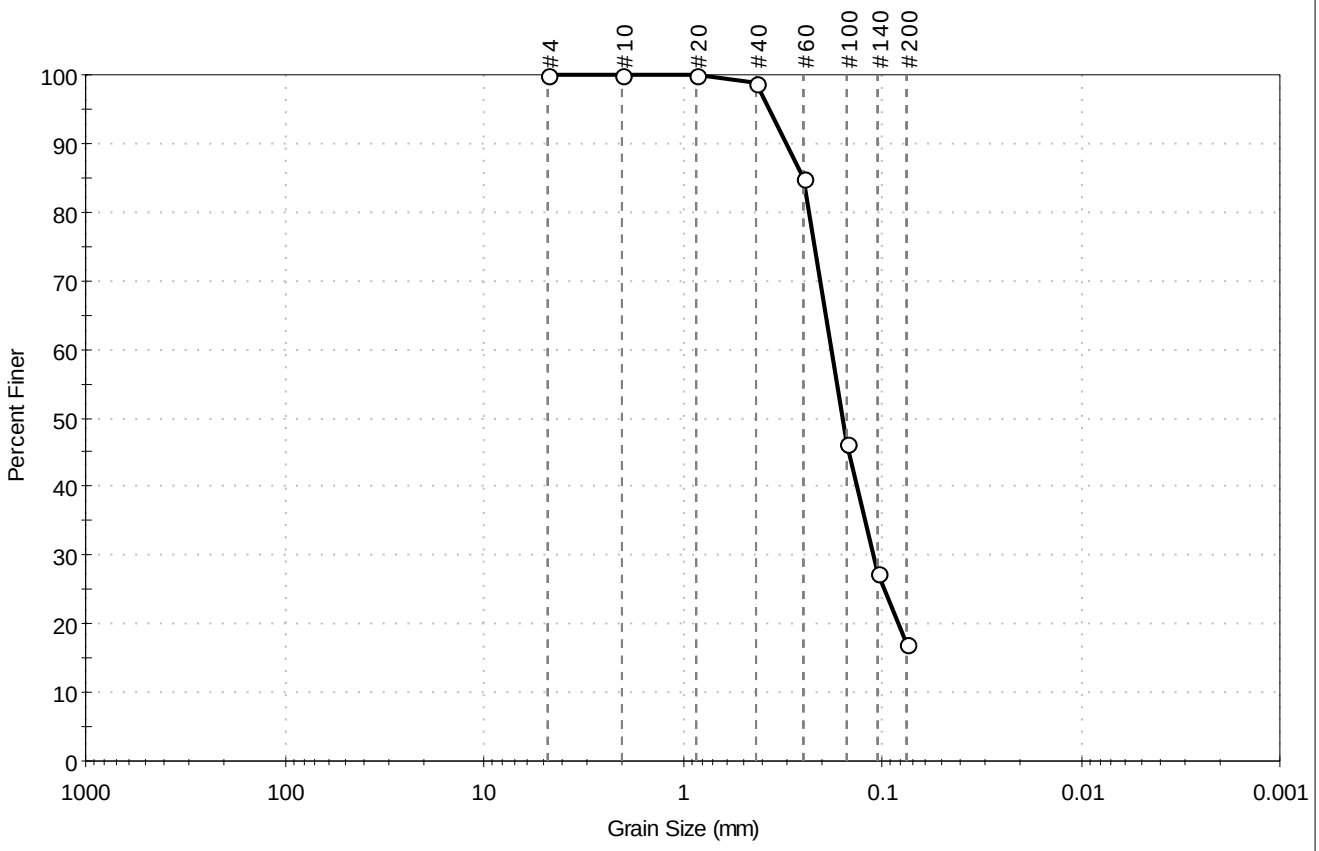
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	AECOM				
Project:	Lawrence Brook Watershed Stormwater				
Location:	Peabody, MA			Project No:	GTX-309158
Boring ID:	B-9	Sample Type:	jar	Tested By:	ckg
Sample ID:	SS-4	Test Date:	11/27/18	Checked By:	emm
Depth :	15-17	Test Id:	482580		
Test Comment:	---				
Visual Description:	Moist, light olive brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	0.0	82.8	17.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	99		
#60	0.25	85		
#100	0.15	46		
#140	0.11	27		
#200	0.075	17		

Coefficients

D_{85} = 0.2499 mm	D_{30} = 0.1114 mm
D_{60} = 0.1797 mm	D_{15} = N/A
D_{50} = 0.1575 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample / Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Attachment B
Drawings and Sections

- **SK-1 Walnut Street/Paleologos Street Drain Plan**
- **SK-2 Walnut Street/Paleologos Street Drain Profile**
- **SK-3 Typical Culvert Cross-Section**
- **SK-4 Connolly Park Underground Storage**
- **SK-5 Connolly Terrance Existing Conditions Plan**
- **Section A-A Railroad/SESD Pipe Crossing**
- **Section B-B Typical Pile Cap**

CONNECT EXIST. 12"D TO NEW DMH

DMH STA. 1+32 (8'x8' VAULT)

4 12" PVC DRAINS IN SAME TRENCH

2'x4' CULVERT

RELOCATE WATER AT CROSSING

18° BEND AT STA. 1+76

CONNECT 12"D TO NEW DMH

DMH STA. 0+00 (8'x8' VAULT)

DMH STA. 0+27

CONNECT EXIST. 12"D TO NEW DMH

DMH STA. 1+85 (8'x8' VAULT)

CONNECT 30"D TO NEW DMH (4 LOCATIONS)

RELOCATE 175 LF GAS MAIN

REPLACE 185 LF 15"D WITH NEW 12" DRAINS AND 2'H x 4'W CULVERT. MAINTAIN EXISTING DRAINAGE FLOW.

CONNECT EXIST. 15"D TO NEW DMH

2'x4' CULVERT

PROVIDE CONNECTION TO EXISTING SEWER

REMOVE 160 LF 12" SEWER AND REPLACE WITH NEW 12" PVC SEWER. MATCH EXISTING SLOPE OF PIPE. MAINTAIN EXISTING WASTEWATER FLOW.

RELOCATE 4" GAS AT CROSSING

REMOVE EXISTING SMH AND REPLACE WITH 4' DIAMETER SMH.

PROTECT 78" DIAMETER SESD SEWER DURING CONSTRUCTION. CONSTRUCT PILE SUPPORTED FOUNDATION AT CULVERT CROSSING. SEE SECTION A–A.

10° BEND AT STA. 5+29

OPEN CUT CROSSING OF RAILROAD TRACKS. REMOVAL OF TRACKS PRIOR TO THE WORK AND REINSTATEMENT OF TRACKS AFTER CONSTRUCTION TO BE PERFORMED BY OTHERS.

WALNUT REALTY TRUST
DEED BOOK 16668, PAGE 520
49 WALNUT STREET
MAP 85, LOT 39

PETRADELIS REALTY TRUST
DEED BOOK 10102, PAGE 19
55 WALNUT STREET
MAP 85, LOT 35

SCOURAS REALTY TRUST
DEED BOOK 35637, PAGE 58
59 WALNUT STREET
MAP 85, LOT 34

SCOURAS REALTY TRUST
DEED BOOK 35637, PAGE 59
61 WALNUT STREET
MAP 85, LOT 33

119 REAR FOSTER STREET LLC
DEED BOOK 16848, PAGE 22
65 WALNUT STREET
MAP 86, LOT 140X

ZION REALTY CORP
DEED BOOK 5327, PAGE 772
59R WALNUT STREET
MAP 85, LOT 39X

CLARK STEEL DRUM CO INC
DEED BOOK 6779, PAGE 577
24 CALLER STREET

7 PALEOLOGOS STREET
MAP 86, LOT 20X

WALNUT STREET

PALEOLOGOS STREET

NORTH RIVER CANAL

N/F BOSTON & MAINE RAILROAD

OLD RAILS

1 STORY CONC BLOCK

2 STORY BRICK/WOOD

1 STORY BRICK

3 STORY BRICK

BIT CONC PARKING

BIT CONC DRIVE

78"SESD CLASS V RCP SEWER

40"SESD BRICK SEWER

46"SESD BRICK SEWER

8"GAS

JZ 120 STEEL SHEETING

5'W x 4'H BOX CULVERT

BOX CULVERT 5.84

1+00

2+00

3+00

4+00

5+00

5+65

B-7

B-8

B-9

NOTES:

1) ELEVATIONS SHOWN HEREON REFER TO N.A.V.D. 1988 AND ARE BASED ON GPS OBSERVATIONS MADE ON NOVEMBER 5–7, 2018.

2) UNDERGROUND UTILITIES SHOWN HEREON ARE COMPILED FROM FIELD LOCATIONS OF STRUCTURES AND FROM AVAILABLE RECORD INFORMATION ON FILE AT THE CITY ENGINEERING OFFICES, CITY D.P.W., AND UTILITY COMPANIES. OTHER UNDERGROUND UTILITIES MAY EXIST. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY THE LOCATION, SIZE & ELEVATION OF ALL UTILITIES WITHIN THE AREA OF PROPOSED WORK AND TO CONTACT "DIG–SAFE" AT 811 AT LEAST 72 HOURS PRIOR TO ANY EXCAVATION, DEMOLITION OR CONSTRUCTION.

3) PROPERTY LINES SHOWN HEREON ARE FROM THE CITY OF PEABODY GIS INFO AND ARE APPROXIMATE ONLY.

LEGEND

EXISTING

- SURFACE CONTOUR
- EDGE OF PAVEMENT
- CHAIN LINK FENCE
- WOOD FENCE
- CURB WITH TOP AND BOTTOM CURB ELEVATION
- EDGE OF WOODED AREA
- SEWERLINE & MANHOLE
- DRAIN LINE WITH MANHOLE & ROUND CATCH BASIN
- WATER MANHOLE, WATER MAIN WITH SIZE, TEE, GATE VALVE & FIRE HYDRANT
- GAS MAIN WITH SIZE & GATE VALVE
- EXISTING UTILITY POLE WITH DESIGNATION OVERHEAD WIRES AND GUY POLE
- ELECTRIC MANHOLE & UNDERGROUND ELECTRIC LINES
- TELEPHONE MANHOLE & UNDERGROUND TELEPHONE LINES
- RETAINING WALL
- LIMIT OF 100–YEAR FLOOD PLAIN
- APPROXIMATE PROPERTY LINES
- B–7 BORING LOCATION

PROPOSED

- DRAIN AND FLOW DIRECTION
- 2+00 APPROX. LIMIT 2'H X 4'W CULVERT WITH 100' STATIONING
- PIPE TO BE REMOVED

EXISTING

- × 100.7 SPOT ELEVATION
- 93.7 PROMINENT DECIDUOUS TREE 12"M WITH ELEVATION, SIZE AND SPECIES
- 96.2 PROMINENT CONIFEROUS TREE 18"P WITH ELEVATION, SIZE AND SPECIES
- LIGHT POLE
- SESD SOUTH ESSEX SEWERAGE DISTRICT
- RCP REINFORCED CONCRETE PIPE
- CI CAST IRON
- CMP CORRUGATED METAL PIPE
- VC VITRIFIED CLAY
- PVC POLYVINYL CHLORIDE
- CPP CORRUGATED PLASTIC PIPE
- TOW TOP OF WEIR
- REC RECORD
- NFO NOT FIELD OBSERVED
- NPV NO PIPES VISIBLE
- CINV CENTER INVERT
- SMH (S) SEWER MANHOLE
- DMH (D) DRAIN MANHOLE
- CB CATCH BASIN
- RCB ROUND CATCH BASIN
- DOUBLE GRATE CATCHBASIN
- D GRATE CATCHBASIN
- GM GAS METER
- EM ELECTRIC METER
- CU CONNECTION UNKNOWN
- BOLLARD
- SIGN
- (V) MANHOLE (UNKNOWN UTILITY)
- VGC VERTICAL GRANITE CURB
- BB BITUMINOUS BERM
- BIT. CONC. BITUMINOUS CONCRETE
- CLF CHAIN LINK FENCE
- BOLLARD
- UTILITY HAND HOLE

20 0 20 40
SCALE: 1" = 20'

PATH/FILENAME: \\VSCHLTP001\DATA\PROJECTS\WAKEFIELD\DATA_2\OVERTONE\60547746 PEABODY LAWRENCE BROOK – CONCEPTUAL DESIGN\900 CAD\SK-1 (UPDATED).DWG
LAST UPDATE: Wednesday, January 30, 2019 2:13:22 PM
PLOT DATE: Wednesday, January 30, 2019 2:13:39 PM

AECOM

PROJECT

LAWRENCE BROOK WATERSHED ASSESSMENT

CLIENT

CITY OF PEABODY
CITY HALL, DEPARTMENT OF COMMUNITY DEVELOPMENT AND PLANNING
24 LOWELL STREET,
PEABODY, MA 01960

CONSULTANT

AECOM TECHNICAL SERVICES, INC.
250 APOLLO DRIVE
CHELMSFORD, MA 01824
PHONE: (978) 905-2100
www.aecom.com

REGISTRATION

ISSUE/REVISION

I/R	DATE	DESCRIPTION

PROJECT NUMBER

60547746

Designed By:	S. EISENLORD
Drawn By:	B. TEETSEL
Dept Check:	M. MESERVE
Proj Check:	J. DOYLE-BREEN
Date:	JANUARY 2019
Scale:	AS NOTED

DISCIPLINE

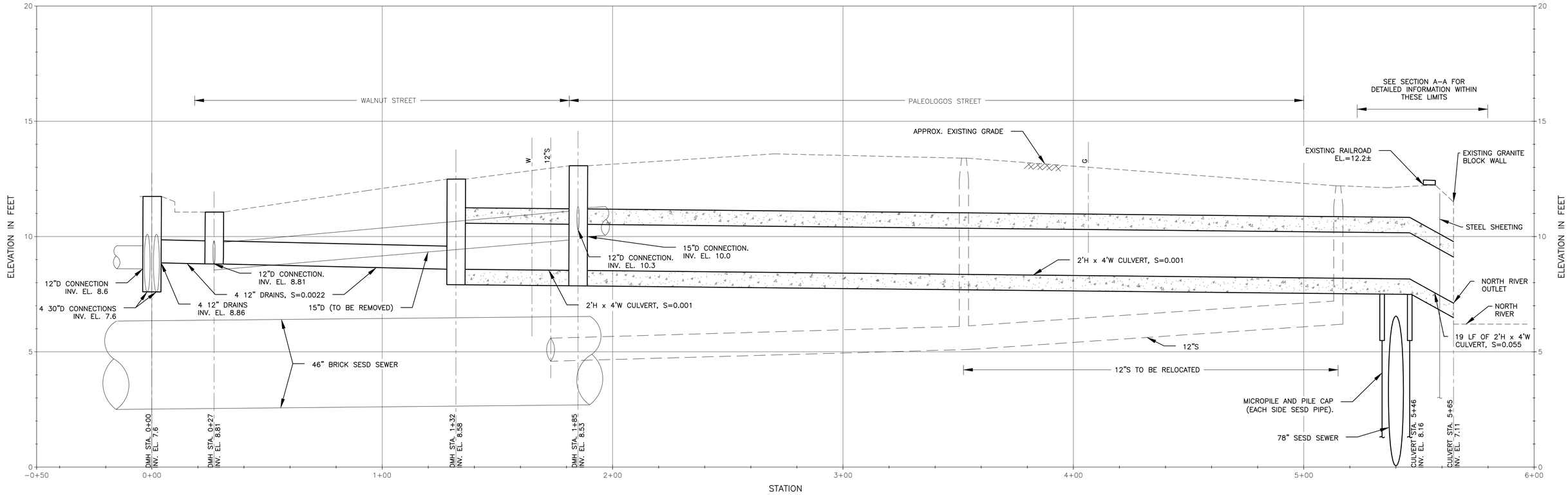
GENERAL

SHEET TITLE

WALNUT STREET/PALEOLOGOS STREET DRAIN PLAN

SHEET NUMBER

SK-1



DRAIN PROFILE

SCALE: 1"=20' (HORIZ.)
1"= 2' (VERT.)

AECOM
AECOM TECHNICAL SERVICES, INC.
250 APOLLO DRIVE
CHELMSFORD, MA 01824
PHONE: (978) 905-2100

SHEET REFERENCE
00000000 1–28–19

PROJECT
LAWRENCE BROOK
WATERSHED ASSESSMENT

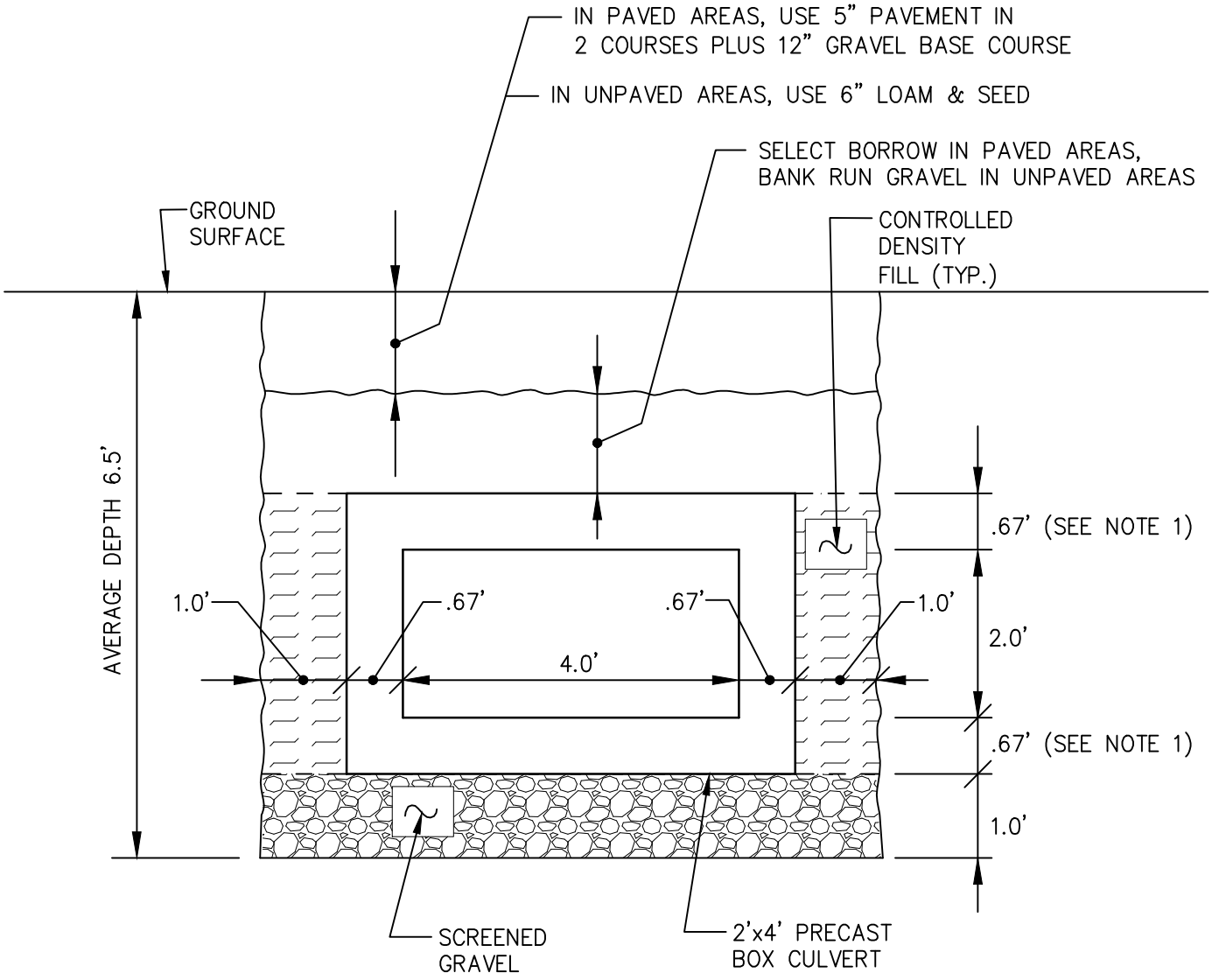
CLIENT
CITY OF PEABODY, MA

PROJECT NUMBER
60547746

DISCIPLINE

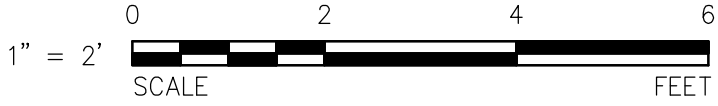
SHEET TITLE
WALNUT STREET/PALEOLOGOS STREET DRAIN PROFILE

SHEET NUMBER
SK–2



NOTE 1:

THICKNESSES SHOWN ARE FOR STANDARD H-20 LOADING, WHICH APPLIES IN ALL LOCATIONS EXCEPT UNDER THE RAILROAD TRACKS. APPROX. 20 L.F. OF CULVERT UNDER RAILROAD TRACKS TO BE DESIGNED FOR E80 COOPER LOADING. ROOF AND FLOOR SLAB UNDER RAILROAD TRACKS=.83' THICK.



AECOM

AECOM TECHNICAL SERVICES, INC.
250 APOLLO DRIVE
CHELMSFORD, MA 01824
PHONE: (978) 905-2100

SHEET REFERENCE
00000000 1-28-19

PROJECT
LAWRENCE BROOK
WATERSHED ASSESSMENT

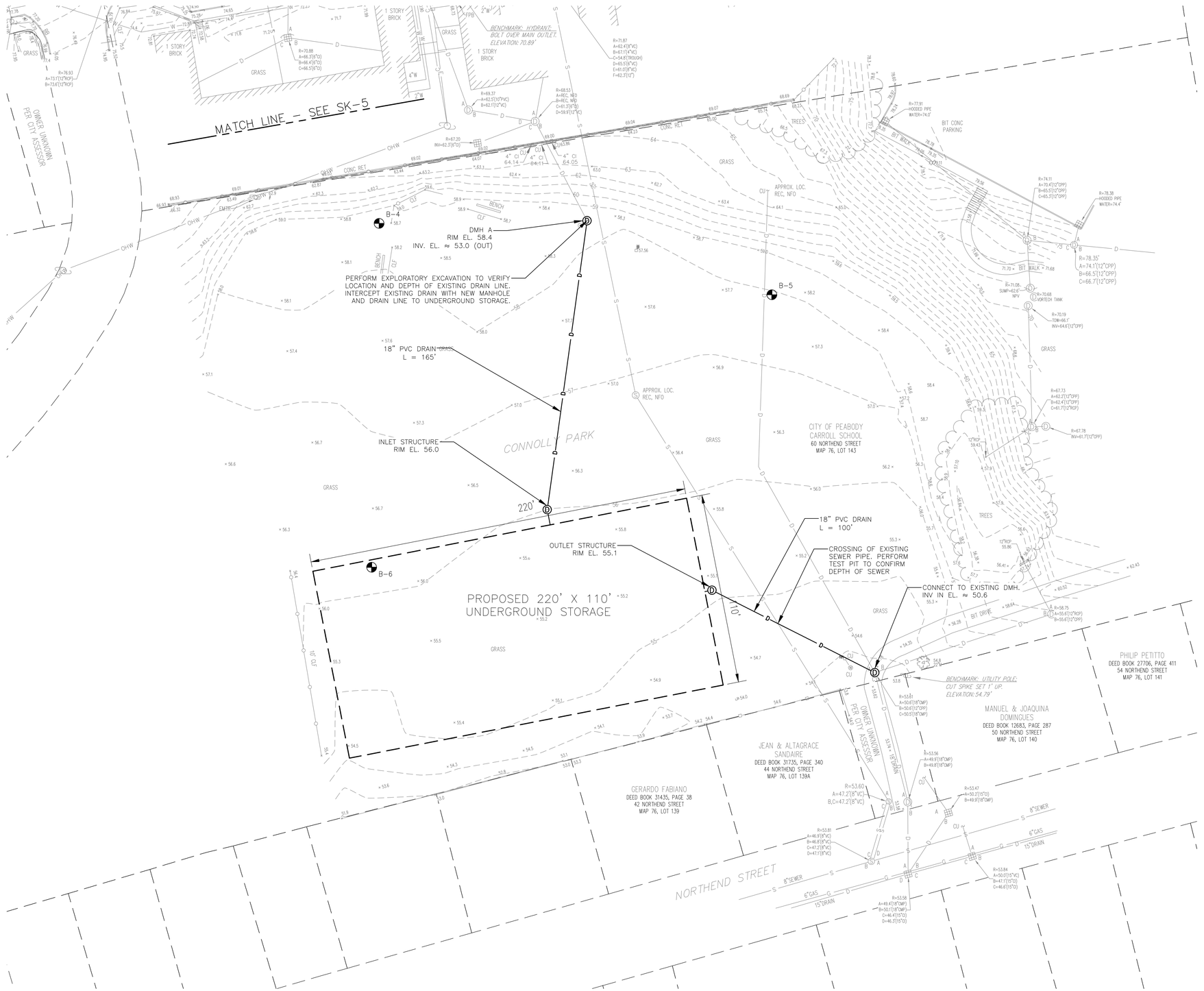
CLIENT
CITY OF PEABODY, MA

PROJECT NUMBER
60547746

DISCIPLINE

SHEET TITLE
TYPICAL CULVERT CROSS-SECTION

SHEET NUMBER
SK-3



CONNOLLY PARK UNDERGROUND STORAGE

SCALE: 1"=30'

PATH/FILNAME: x:\60547746 PEABODY LAWRENCE BROOK - CONCEPTUAL DESIGN\300 CAD\SK-4 UNDERGROUND STORAGE.DWG
LAST UPDATE: Friday, February 08, 2019 10:35:12 AM
PLOT DATE: Friday, February 08, 2019 10:36:21 AM

AECOM

PROJECT

LAWRENCE BROOK WATERSHED ASSESSMENT

CLIENT

CITY OF PEABODY

CITY HALL, DEPARTMENT OF COMMUNITY DEVELOPMENT AND PLANNING
24 LOWELL STREET,
PEABODY, MA 01960

CONSULTANT

AECOM TECHNICAL SERVICES, INC.
250 APOLLO DRIVE
CHELMSFORD, MA 01824
PHONE: (978) 905-2100
www.aecom.com

REGISTRATION

ISSUE/REVISION

I/R	DATE	DESCRIPTION

PROJECT NUMBER

60547746

Designed By:	S. EISENLORD
Drawn By:	S. EISENLORD
Dept Check:	M. MESERVE
Proj Check:	J. DOYLE-BREEN
Date:	FEBRUARY 2019
Scale:	AS NOTED

DISCIPLINE

GENERAL

SHEET TITLE

CONNOLLY PARK UNDERGROUND STORAGE

SHEET NUMBER

SK - 4

PROPOSED BIORETENTION BASIN LOCATION

PROPOSED BIORETENTION BASIN LOCATION

MEGAN HISHMAN
DEED BOOK 29660, PAGE 391
8 LINCOLN ROAD
MAP 65, LOT 35

8A LINCOLN ROAD TRUST
DEED BOOK 33214, PAGE 518
8A LINCOLN ROAD
MAP 65, LOT 36

OUR LADY OF FATIMA CHURCH
DEED BOOK 5503, PAGE 300
50 WALSH AVE
MAP 65, LOT 24-X

SERAFIN & HILDA MEDINA
DEED BOOK 6657, PAGE 657
10 LINCOLN ROAD
MAP 65, LOT 37

MELODY ROAD

ROBERT OSTROWSKI
DEED BOOK 15166, PAGE 214
11 MELODY ROAD
MAP 65, LOT 50

RONALD & MARY BETTANO
DEED BOOK 26672, PAGE 278
13 MELODY ROAD
MAP 65, LOT 49

DAVID & CHRISTINE FERRAR
DEED BOOK 18634, PAGE 551
15 MELODY ROAD
MAP 65, LOT 48

WAYNE & GALE EVERSON
DEED BOOK 15483, PAGE 152
14 CAROL ANN ROAD
MAP 65, LOT 45

FERNANDO AND MARIA BETTENCOURT
DEED BOOK 28384, PAGE 584
18 CAROL ANN ROAD
MAP 65, LOT 47

DONNA ROSATO & ANGELA PANEVINO
DEED BOOK 35696, PAGE 139
16 CAROL ANN ROAD
MAP 65, LOT 46

CARLOS & ARMINDA CORREIA
DEED BOOK 24771, PAGE 257
17 CAROL ANN ROAD
MAP 76, LOT 134

PEABODY HOUSING AUTHORITY
CONNOLLY TERRACE
0 CAROL ANN ROAD
MAP 65, LOT 40

CONNOLLY TERRACE

BENCHMARK: HYDRANT; BOLT OVER MAIN OUTLET. ELEVATION: 76.68'

BENCHMARK: HYDRANT; BOLT OVER MAIN OUTLET. ELEVATION: 70.89'

APPROXIMATE COMCAST

12"SEWER

8"SEWER

OWNER UNKN PER CITY ASS

MATCH LINE - SEE SK-4

B-1

B-2

B-3

BIT CONC PARKING LOT

BIT CONC PARKING

1 STORY BRICK

CONNOLLY TERRACE EXISTING CONDITIONS PLAN

SCALE: 1"=30'

30 0 30 60

SCALE: 1" = 30'

PATH/FILENAME: X:\60547746 PEABODY LAWRENCE BROOK - CONCEPTUAL DESIGN\90D CAD\SK-5 CONNOLLY TERRACE EXISTING CONDITIONS.DWG
LAST UPDATE: Monday, February 04, 2019 2:41 PM PLOT DATE: Friday, February 08, 2019 10:58:24 AM

AECOM

PROJECT

LAWRENCE BROOK WATERSHED ASSESSMENT

CLIENT

CITY OF PEABODY
CITY HALL, DEPARTMENT OF COMMUNITY DEVELOPMENT AND PLANNING
24 LOWELL STREET,
PEABODY, MA 01960

CONSULTANT

AECOM TECHNICAL SERVICES, INC.
250 APOLLO DRIVE
CHELMSFORD, MA 01824
PHONE: (978) 905-2100
www.aecom.com

REGISTRATION

ISSUE/REVISION

I/R	DATE	DESCRIPTION

PROJECT NUMBER

60547746

Designed By:	S. EISENLORD
Drawn By:	S. EISENLORD
Dept Check:	M. MESERVE
Proj Check:	J. DOYLE-BREEN
Date:	FEBRUARY 2019
Scale:	AS NOTED

DISCIPLINE

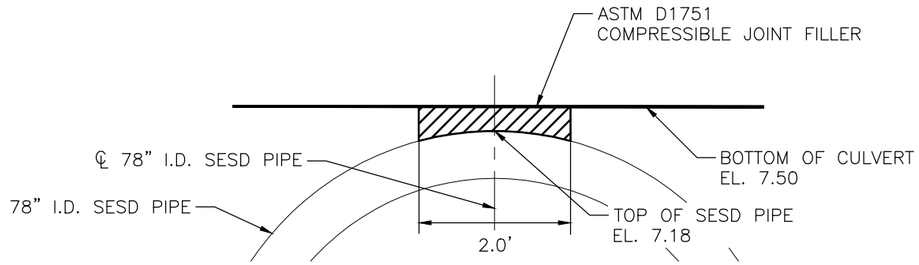
GENERAL

SHEET TITLE

CONNOLLY TERRACE EXISTING CONDITIONS PLAN

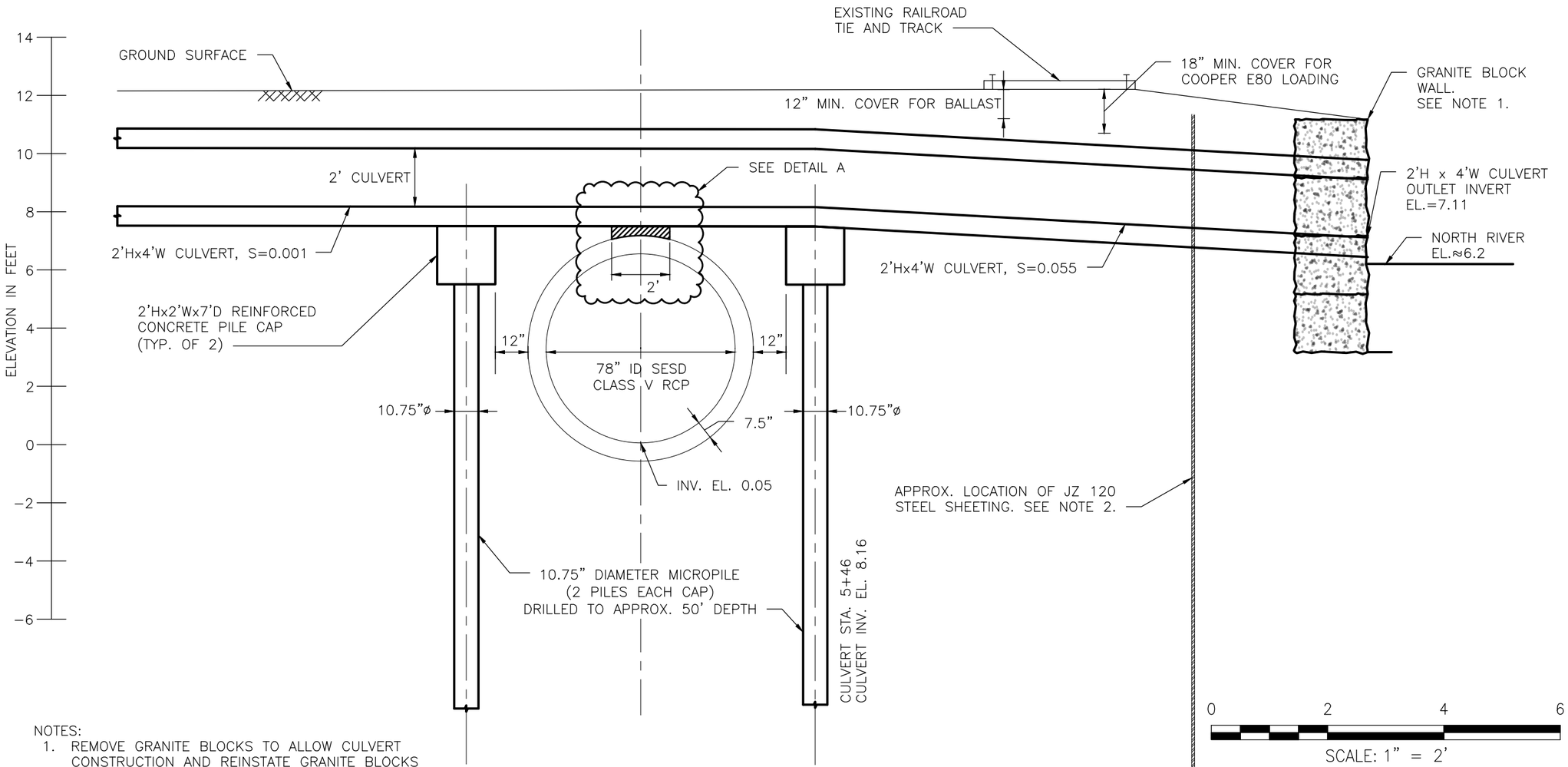
SHEET NUMBER

SK - 5



DETAIL A

SCALE: 1"=2'



NOTES:

1. REMOVE GRANITE BLOCKS TO ALLOW CULVERT CONSTRUCTION AND REINSTATE GRANITE BLOCKS AROUND CULVERT.
2. CUT HOLE IN STEEL SHEETING TO ALLOW CULVERT CONSTRUCTION.

SECTION A-A/SK-1

SCALE: 1"=4'

0 2 4 6

SCALE: 1" = 2'

0 4 8 12

SCALE: 1" = 4'

DISCIPLINE

SHEET TITLE
SECTION A–A AT RR/SESD
PIPE CROSSING

SHEET NUMBER

PROJECT
LAWRENCE BROOK
WATERSHED ASSESSMENT

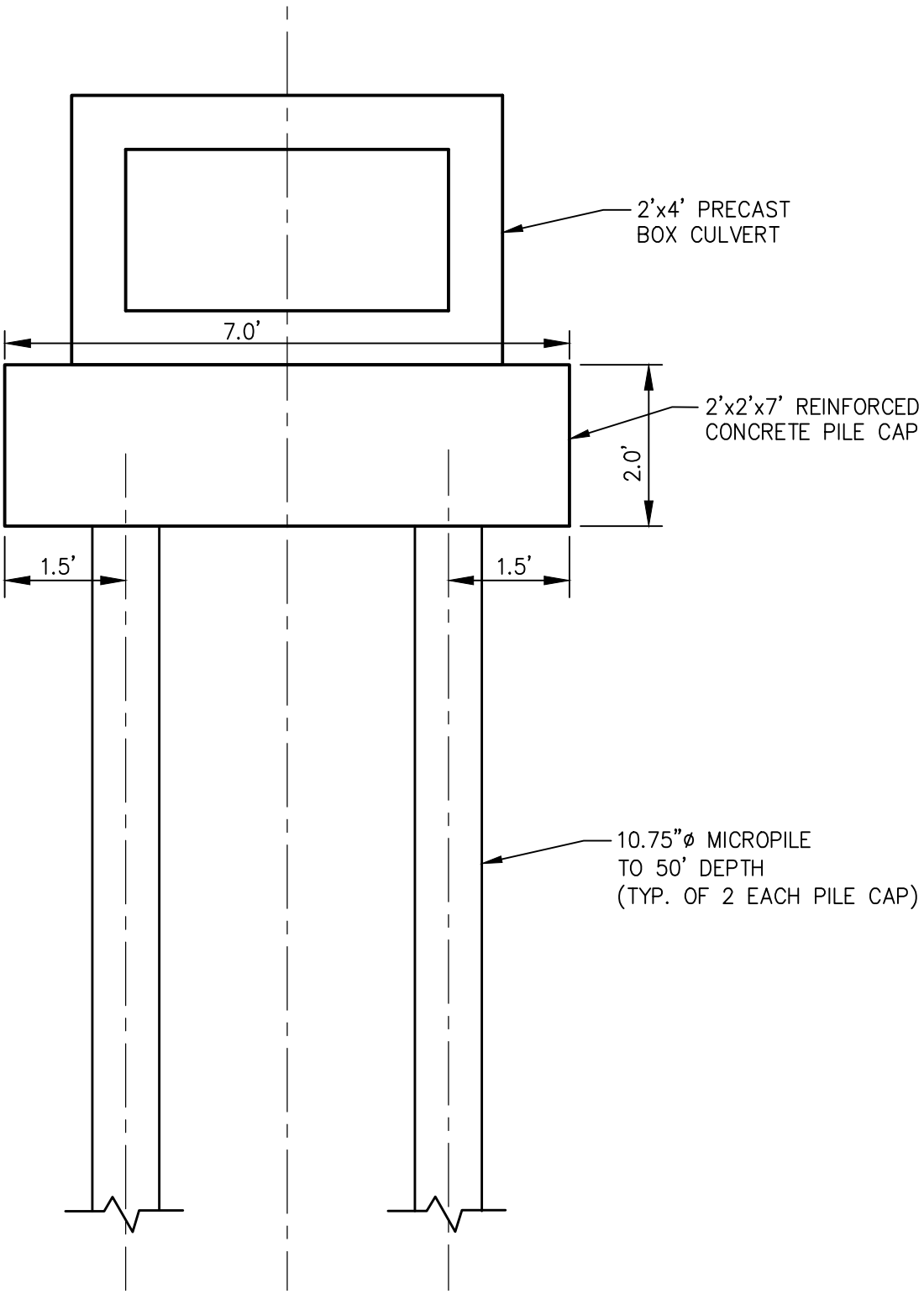
CLIENT
CITY OF PEABODY, MA

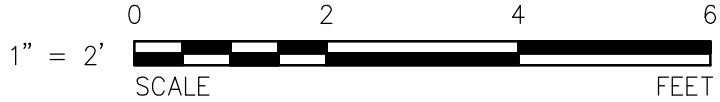
PROJECT NUMBER
60547746

AECOM
AECOM TECHNICAL SERVICES, INC.
250 APOLLO DRIVE
CHELMSFORD, MA 01824
PHONE: (978) 905-2100

SHEET REFERENCE
00000000

1–28–19





AECOM

AECOM TECHNICAL SERVICES, INC.
250 APOLLO DRIVE
CHELMSFORD, MA 01824
PHONE: (978) 905-2100

SHEET REFERENCE

00000000 1-28-19

PROJECT

LAWRENCE BROOK
WATERSHED ASSESSMENT

CLIENT

CITY OF PEABODY, MA

PROJECT NUMBER

60547746

DISCIPLINE

SHEET TITLE

SECTION B-B TYPICAL PILE CAP

SHEET NUMBER

REFER TO SK-1

Attachment C
Cost Estimate

AECOM - Water
Peabody, Massachusetts
Paleologos Street Outfall
Construction Cost Estimate

CLIENT : Peabody, MA
PROJECT : Watershed Assessment
ACCURACY ± 25 %
ENR. INDEX 11206

ACCOUNT NO.	DESCRIPTION	QUAN	UN	MANHOURS MHR/ UNIT	MANHOURS TOTAL MH	MATERIAL UNIT COST	MATERIAL TOTAL MATL	LABOR WAGE RATE	LABOR TOTAL LABOR	EQUIPMENT UNIT RATE	EQUIPMENT TOTAL EQUIP	TOTAL DIRECT COST
	Paleologos Street Outfall											
	Site Preparation/Restoration	1	AL	100.00	100		0	$ 96.14	9,614	2,000.00	2,000	$11,614
	Civil											
	Saw cut Street	1,500	LF	0.05	75	0.30	450	$ 96.14	7,211	1.00	1,500	$9,161
	Excavation (Culvert & 4-12" drains)	1,050	CY	0.20	210		0	$ 96.14	20,190	2.00	2,100	$22,290
	Bedding (Culvert & 4-12" Drains)	180	CY	0.20	36	14.00	2,520	$ 96.14	3,461	2.00	360	$6,341
	Backfill (Culvert & 4-12" Drains)	470	CY	0.20	94		0	$ 96.14	9,038	2.00	940	$9,978
	Control Density Fill	135	CY	0.33	45	75.00	10,125	$ 96.14	4,283	2.00	270	$14,678
	2' x 4' Box Culvert (HS20 Loading)	510	LF	0.45	230	320.00	163,200	$ 96.14	22,065	20.00	10,200	$195,465
	2' x 4' Box Culvert (Cooper E80 Loading)	20	LF	0.45	9	520.00	10,400	$ 96.14	865	20.00	400	$11,665
	8' x 8' Drain Vaults (pre cast)	4	EA	48.00	192	3,500.00	14,000	$ 96.14	18,460	500.00	2,000	$34,460
	12" PVC Pipe (4 in Same Trench)	120	LF	0.40	48	60.00	7,200	$ 96.14	4,615	4.00	480	$12,295
	Paving											
	Bituminous Pavement Removal & Disposal	750	SY	0.10	75		0	$ 96.14	7,211	3.00	2,250	$9,461
	Paving (12" Base Course)	750	SY	0.01	8	7.25	5,438	$ 96.14	721	0.60	450	$6,609
	Paving (3" Binder Course)	750	SY	0.02	15	11.00	8,250	$ 96.14	1,442	0.60	450	$10,142
	Paving (2" Wearing Course)	750	SY	0.02	15	8.00	6,000	$ 96.14	1,442	0.45	338	$7,780
	Police Detail	2	Mnths	176.00	352	0.00	0	$ 96.14	33,843	0.00	0	$33,843
	Portable Cofferdam for Flow Control											
	Install Porta Dam	1	EA	0.00	0	0.00	0	$ 96.14	0	14,000.00	14,000	$14,000
	Porta Dam Rental (First Month)	1	EA	0.00	0	0.00	0	$ 96.14	0	9,000.00	9,000	$9,000
	Porta Dam Rental (Second Month)	1	EA	0.00	0	0.00	0	$ 96.14	0	6,000.00	6,000	$6,000
	Remove Portadam	1	EA	0.00	0	0.00	0	$ 96.14	0	5,000.00	5,000	$5,000
	By-Pass Pumping	2	Mnths	160.00	320	500.00	1,000	$ 96.14	30,766	5,000.00	10,000	$41,766
	Utilities											
	Relocate Gas Line (6" Steel)	175	LF	1.20	210	40.00	7,000	$ 96.14	20,190	12.00	2,100	$29,290
	Remove 15" RCP (incidental)	185	LF	0.00	0		0	$ 96.14	0	0.00	0	$0
	Remove Drain MH's	4	EA	24.00	96		0	$ 96.14	9,230	500.00	2,000	$11,230
	Relocation of Water Line @ Culvert Crossing	1	AL	60.00	60		0	$ 96.14	5,769	2,000.00	2,000	$7,769
	Relocation of Gas Line @ Culvert Crossing	1	AL	60.00	60		0	$ 96.14	5,769	2,000.00	2,000	$7,769
	Miscellaneous Items											
	Connect 12" to New Structure	3	EA	14.00	42	300.00	900	$ 96.14	4,038	125.00	375	$5,313
	Connect 15" to New Structure	1	EA	16.00	16	500.00	500	$ 96.14	1,538	125.00	125	$2,163
	Connect 30" to New Structure	4	EA	24.00	96	750.00	3,000	$ 96.14	9,230	200.00	800	$13,030
	Control of Drainage Flow During Construction	1	AL	100.00	100		0	$ 96.14	9,614	10,000.00	10,000	$19,614
	Remove/Reinstate Granite Block Wall	20	SF	6.66	133	0.00	0	$ 96.14	12,806	100.00	2,000	$14,806
	Disposal of Excess Excavated Material (15 mi RT)	600	CY	0.10	60		0	$ 96.14	5,769	8.00	4,800	$10,569
	Sewer Relocation											
	Excavation (12" Sewer)	200	CY	0.20	40		0	$ 96.14	3,846	2.00	400	$4,246
	Bedding (12" Sewer)	15	CY	0.20	3	14.00	210	$ 96.14	288	2.00	30	$528
	Backfill (12" Sewer)	175	CY	0.20	35		0	$ 96.14	3,365	2.00	350	$3,715
	Relocate 12" PVC Sewer	160	LF	0.20	32	15.00	2,400	$ 96.14	3,077	2.00	320	$5,797
	Install 4' Dia SMH	1	EA	32.00	32	3,500.00	3,500	$ 96.14	3,077	200.00	200	$6,777
	Maintain Existing WW Flows	1	AL	120.00	120		0	$ 96.14	11,537	1,000.00	1,000	$12,537

12:32 PM
JOB #: 60547746.6.1
DATE: February 13, 2019
LOCATION: Peabody, Ma
PREPARED BY: R. Mastrogiacomo

AECOM - Water
Peabody, Massachusetts
Paleologos Street Outfall
Construction Cost Estimate

CLIENT : Peabody, MA
PROJECT : Watershed Assessment
ACCURACY ± 25 %
ENR. INDEX 11206

ACCOUNT NO.	DESCRIPTION	QUAN	UN	MANHOURS MHR/ UNIT	MANHOURS TOTAL MH	MATERIAL UNIT COST	MATERIAL TOTAL MATL	LABOR WAGE RATE	LABOR TOTAL LABOR	EQUIPMENT UNIT RATE	EQUIPMENT TOTAL EQUIP	TOTAL DIRECT COST
	12" Sewer Removal	1	AL	40.00	40		0	$ 96.14	3,846	1,000.00	1,000	$4,846
	Piles & Pile Caps											
	Pile Caps (2' w x 2' h x 7' Long)	2	EA	60.00	120	3,500.00	7,000	$ 96.14	11,537	500.00	1,000	$19,537
	Micro Piles (10.75" dia , 50' depth, 4 Piles) with: (Cement Grouted w/Reinforced Casing)	200	VLF	0.25	50	50.00	10,000	$ 96.14	4,807	15.00	3,000	$17,807
	Cut 6' x 4' Steel Sheeting	20	LF	1.25	25	5.00	100	$ 96.14	2,404	25.00	500	$3,004
	Remove/Replace Active RR Tracks 1	1	AL	0.00	0	0.00	0	$ 96.14	0	90,000.00	90,000	$90,000
	Delivery of Products to RR Consignees during Construction 1	1	AL	0.00	0	0.00	0	$ 96.14	0	30,000.00	30,000	$30,000
	SUBTOTAL DIRECT COSTS				3,193		263,193		306,965		221,738	$791,895
	GENERAL CONTRACTOR OVERHEAD&PROFIT	22.00%										$147,817
	SUBTOTAL GENERAL CONTRACTOR											$939,710
	CONTINGENCY	25.00%										$204,928
	UNESCALATED CONSTRUCTION COST											**$1,144,638**
ESCALATION TO MID-POINT OF CONSTRUCTION		3.3%						1.47	**4.8%**			$ 55,366
ASSUMED AT:	**August 1, 2020**	PER YEAR						YEARS	NON-COMPOUNDED RATE			
	TOTAL CONSTRUCTION COST											**$1,200,003**

NOTES:
1. Price Includes O&P and Contingency.

12:32 PM
JOB #: 60547746.6.1
DATE: February 13, 2019
LOCATION: Peabody, Ma
PREPARED BY: R. Mastrogiacomo

AECOM - Water
Upstream Underground Storage
ChamberMaxx
Construction Cost Estimate

CLIENT : Peabody, MA
PROJECT : Watershed Assessment
ACCURACY ± 25 %
ENR. INDEX 11206

ACCOUNT NO.	DESCRIPTION	QUAN	UN	MANHOURS MHR/ UNIT	MANHOURS TOTAL MH	MATERIAL UNIT COST	MATERIAL TOTAL MATL	LABOR WAGE RATE	LABOR TOTAL LABOR	EQUIPMENT UNIT RATE	EQUIPMENT TOTAL EQUIP	TOTAL DIRECT COST
	Upstream Underground Storage											
	ChamberMaxx											
	Civil											
	18" PVC Drain pipe	275	LF	0.20	55	16.00	4,400	$ 96.14	5,288	1.00	275	$9,963
	Drain Manhole	4	EA	42.00	168	3,000.00	12,000	$ 96.14	16,152	500.00	2,000	$30,152
	Chamber Maxx Underground tank											
	Excavation	5,602	CY	0.20	1,120		0	$ 96.14	107,720	2.00	11,204	$118,924
	Pond Liner	26,000	SF	0.008	208	1.00	26,000	$ 96.14	19,998		0	$45,998
	3/4" stone	1,685	CY	0.20	337	14.00	23,590	$ 96.14	32,401	2.00	3,370	$59,361
	Chamber maxx units	650	EA	0.50	325	225.00	146,250	$ 96.14	31,247	15.50	10,075	$187,572
	Backfill	2,017	CY	0.20	403		0	$ 96.14	38,785	2.00	4,034	$42,819
	Disposal of Excess Excavated Material (15 mi RT)	3,585	CY	0.10	359		0	$ 96.14	34,468	8.00	28,680	$63,148
	Loam for Soccer Field	448	CY	0.05	22	28.00	12,544	$ 96.14	2,154	4.00	1,792	$16,490
	Hydro Seeding	2,900	SY	0.01	29	2.00	5,800	$ 96.14	2,788	0.10	290	$8,878
	Rock Excavation	295	CY	0.50	148		0	$ 96.14	14,199	25.00	7,384	$21,584
	Dewatering	1	MN	0.00	0		0	$ 96.14	0	20,000.00	20,000	$20,000
	SUBTOTAL DIRECT COSTS				3,174		230,584		305,200		89,104	$624,888
	GENERAL CONTRACTOR OVERHEAD&PROFIT	22.00%										$137,475
	SUBTOTAL GENERAL CONTRACTOR											$762,360
	CONTINGENCY	25.00%										$190,590
	UNESCALATED CONSTRUCTION COST											**$952,950**
ESCALATION TO MID-POINT OF CONSTRUCTION		3.3%						1.47	**4.8%**			$ 46,094
ASSUMED AT:	**August 1, 2020**	PER YEAR						YEARS	NON-COMPOUNDED RATE			
	TOTAL CONSTRUCTION COST											**$999,044**

12:32 PM

JOB #: 60547746.6.1
DATE: February 13, 2019
LOCATION: Peabody, Ma
PREPARED BY: R. Mastrogiacomo

AECOM - Water
Upstream Underground Storage
Concrete Storage Vaults
Construction Cost Estimate

CLIENT : Peabody, MA
PROJECT : Watershed Assessment
ACCURACY ± 25 %
ENR. INDEX 11206

ACCOUNT NO.	DESCRIPTION	QUAN	UN	MANHOURS MHR/ UNIT	MANHOURS TOTAL MH	MATERIAL UNIT COST	MATERIAL TOTAL MATL	LABOR WAGE RATE	LABOR TOTAL LABOR	EQUIPMENT UNIT RATE	EQUIPMENT TOTAL EQUIP	TOTAL DIRECT COST
	Upstream Underground Storage											
	Concrete Storage Vaults											
	Civil											
	18" PVC Drain pipe	275	LF	0.20	55	16.00	4,400	$ 96.14	5,288	1.00	275	$9,963
	Drain Manhole	4	EA	42.00	168	3,000.00	12,000	$ 96.14	16,152	500.00	2,000	$30,152
	Arrow Concrete Vaults Option											
	Excavation	4,877	CY	0.20	975		0	$ 96.14	93,779	2.00	9,754	$103,533
	Pond Liner	22,000	SF	0.008	176	1.00	22,000	$ 96.14	16,921		0	$38,921
	Concrete Floor Slab (10")	472	CY	2.00	944	150.00	70,800	$ 96.14	90,760	20.00	9,440	$171,000
	Concrete Vaults	299	EA	0.75	224	1,186.00	354,614	$ 96.14	21,560	5.00	1,495	$377,669
	Backfill	354	CY	0.20	71		0	$ 96.14	6,807	2.00	708	$7,515
	Crushed Stone Base (12")	566	CY	0.20	113	14.00	7,930	$ 96.14	10,891	2.50	1,416	$20,237
	Disposal of Excess Excavated Material (15 mi RT)	4,023	CY	0.10	402		0	$ 96.14	38,679	8.00	32,184	$70,863
	Loam for Soccer Field	359	CY	0.05	18	28.00	10,052	$ 96.14	1,726	4.00	1,436	$13,214
	Hydro Seeding	2,900	SY	0.01	29	2.00	5,800	$ 96.14	2,788	0.10	290	$8,878
	Rock Excavation	231	CY	0.50	116		0	$ 96.14	11,105	25.00	5,775	$16,880
	Dewatering	1.0	MN	0.00	0		0	$ 96.14	0	20,000.00	20,000	$20,000
	SUBTOTAL DIRECT COSTS				3,291		487,596		316,458		84,773	$888,826
	GENERAL CONTRACTOR OVERHEAD&PROFIT	22.00%										$195,542
	SUBTOTAL GENERAL CONTRACTOR											$1,084,370
	CONTINGENCY	25.00%										$271,093
	UNESCALATED CONSTRUCTION COST											**$1,355,463**
ESCALATION TO MID-POINT OF CONSTRUCTION		3.3%						1.47	**4.8%**			$ 65,564
ASSUMED AT:	**August 1, 2020**	PER YEAR						YEARS	NON-COMPOUNDED RATE			
	TOTAL CONSTRUCTION COST											**$1,421,026**

Attachment D

Chambermaxx Retention Installation Guide

CONTECH®
ENGINEERED SOLUTIONS

ChamberMaxx® Retention Installation Guide

CHAMBERMaxx®

ChamberMaxx Retention Installation Guide

The ChamberMaxx system requires adherence to the following installation procedure for the structural integrity of the system to be maintained.

All illustrations and photographs are examples of typical situations. Each individual site will vary, so it is important to follow the engineering project drawings as designed and sealed by a registered Professional Engineer.

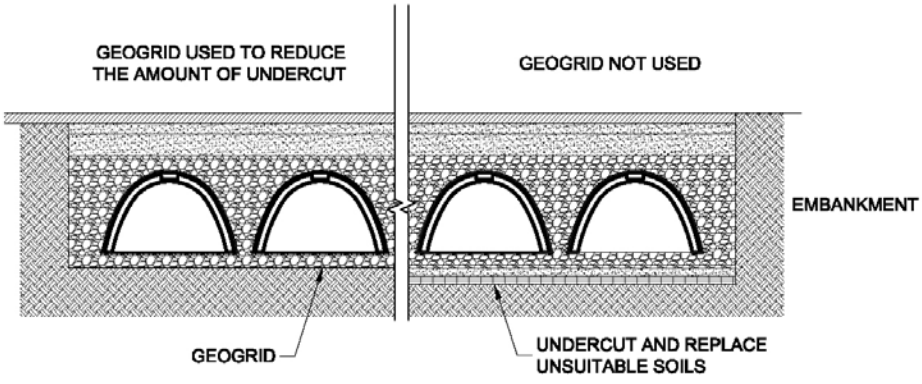
Prior to installation of the ChamberMaxx system a pre-construction meeting shall be conducted. Those required to attend are the supplier of the system, the general contractor, sub-contractors and the project Engineer of record.

Foundation

Construct a foundation that can support the design loading applied by the chambers and adjacent backfill weight as well as maintain its integrity during construction. A minimum of an extra foot of perimeter excavation is required for proper fit and adequate compaction. Excavation must be free of standing water. Dewater if present.

If soft or unsuitable soils are encountered, remove unsuitable material and bring back to grade with fill material as approved by the Engineer of record. See Detail A. The structural fill material gradation should not allow the migration of fines, which can cause settlement of the chamber system and possibly the above pavement, and occlusion of the void space in the bedding. If the structural fill material is not compatible with the underlying soils a Contech C-40, non-woven 4 oz separation geotextile, should be used as a separator.

Grade the foundation subgrade to a uniform and stable grade. If the subgrade is clay or relatively non-porous and the construction sequence will last for an extended period of time, it is best to slope the grade to one end of the system. This will allow excess water to drain quickly, preventing saturation of the subgrade.



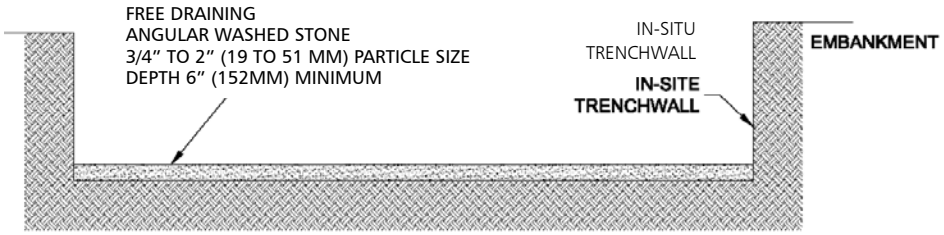
SECTION

DETAIL A

Bedding

A 6-inch (152 mm) minimum thickness, well-graded, free-draining angular washed stone 3/4 to 2-inch (19 to 51 mm) particle size is the required chamber bedding. Refer to project engineering plans for subgrade soil preparation and required stone foundation thickness. If the construction equipment will operate for an extended period of time on the bedding, use an engineering fabric or a geogrid to ensure the base material maintains its integrity. Bedding material is to be compacted to 90% AASHTO T99 standard proctor density. Do not use heavy equipment on bedding material to avoid excessive soil compaction. See Detail B.

Grade the base to a smooth, uniform grade to allow for the proper placement of chambers.



SECTION

DETAIL B

In-Situ Trench Wall

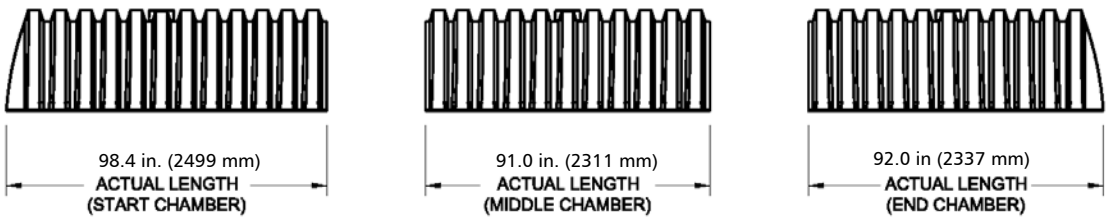
The trench wall must be capable of supporting the load that the chamber sheds as the system is loaded. If soils are not capable of supporting these loads, the integrity of the system can be compromised. Perform a simple soil pressure check using the applied loads to determine the limits of excavation beyond the edge of the outer most row of chambers. Wrap the walls with Contech C-40 non-woven geotextile to help prevent soil migration.

In most cases the requirements for a safe work environment and proper backfill placement and compaction take care of this concern.

ChamberMaxx Units

All systems are comprised of the Start, Mid and End chambers. The Start and End chambers are marked accordingly with a label on each end.

The maximum weight of a single chamber is 83 lbs. (37.65 kg) which allows the chamber to be hand carried. See Detail C.



ELEVATION VIEW

DETAIL C

Layout of the Manifold System

Temporarily layout the manifold system per the project engineering plans. Place the Start chamber of each row in your system. Standard spacing between rows is 5.6", with a minimum of 5" required between each row.. Use a reciprocating saw to cut the inlet pipe diameter hole out from the Start chamber at the correct inlet height. Insert the inlet pipe from the assembled manifold system into each Start chamber. Cover any open void spaces greater than 3/4-inch (19 mm) on the chambers with a non-woven geotextile to prevent infiltration of backfill material.

Layout of the Optional Containment Row

For ease of access during a maintenance operation, ChamberMaxx retention systems may have an optional Containment Row to allow for containment and settlement of sediments and associated pollutants during the initial flows of storm events. This row of chambers is set on top of a 2 layers of AASHTO M288 Class 1 woven geotextile a minimum of 53" wide with no overlaps.

1. Install diversion manhole per site plan.
2. Rollout the 12.5 ft (150 inch) wide woven geotextile and cut to the required length of the containment row while leaving 3-ft (.19m) overlap at each end of the chamber row. Fold the geotextile lengthwise creating 2 layers of 75" wide woven geotextile. Center the 2 layers of geotextile on the location of the containment row. The 75" wide geotextile layers will overlap approximately 1 ft of width on each side of the containment row. It may be necessary to temporarily weigh down the edges of the geotextile material to prevent displacement from wind.
3. Lay chambers for the Containment Row on the 2 layers of woven geotextile per the plans starting at the Start chamber, see Setting Units for installation instructions. It may be necessary to mark position of chambers on geotextile to ensure proper location during placement of chambers.
4. Install inlet connector pipe in Start chamber wall from the diversion manhole per plans.
5. Confirms the width of woven geotextile leaves a minimum of 6" around chamber along the sides. See Detail D.
6. Wrap the sides of the woven geotextile around the sides of the containment row and pin it to ensure that it does not unwrap during backfill
7. Fold overlapping ends of woven geotextile at the ends of the containment row so that they are flat against the end walls and fully wrapped around the inlet pipe of the containment row. Attach with construction tape as needed to keep the geotextile from moving during backfill.
8. Layout remaining chambers of retention system and header manifold per plans. See page 6.

Laying Out Scour Protection Netting

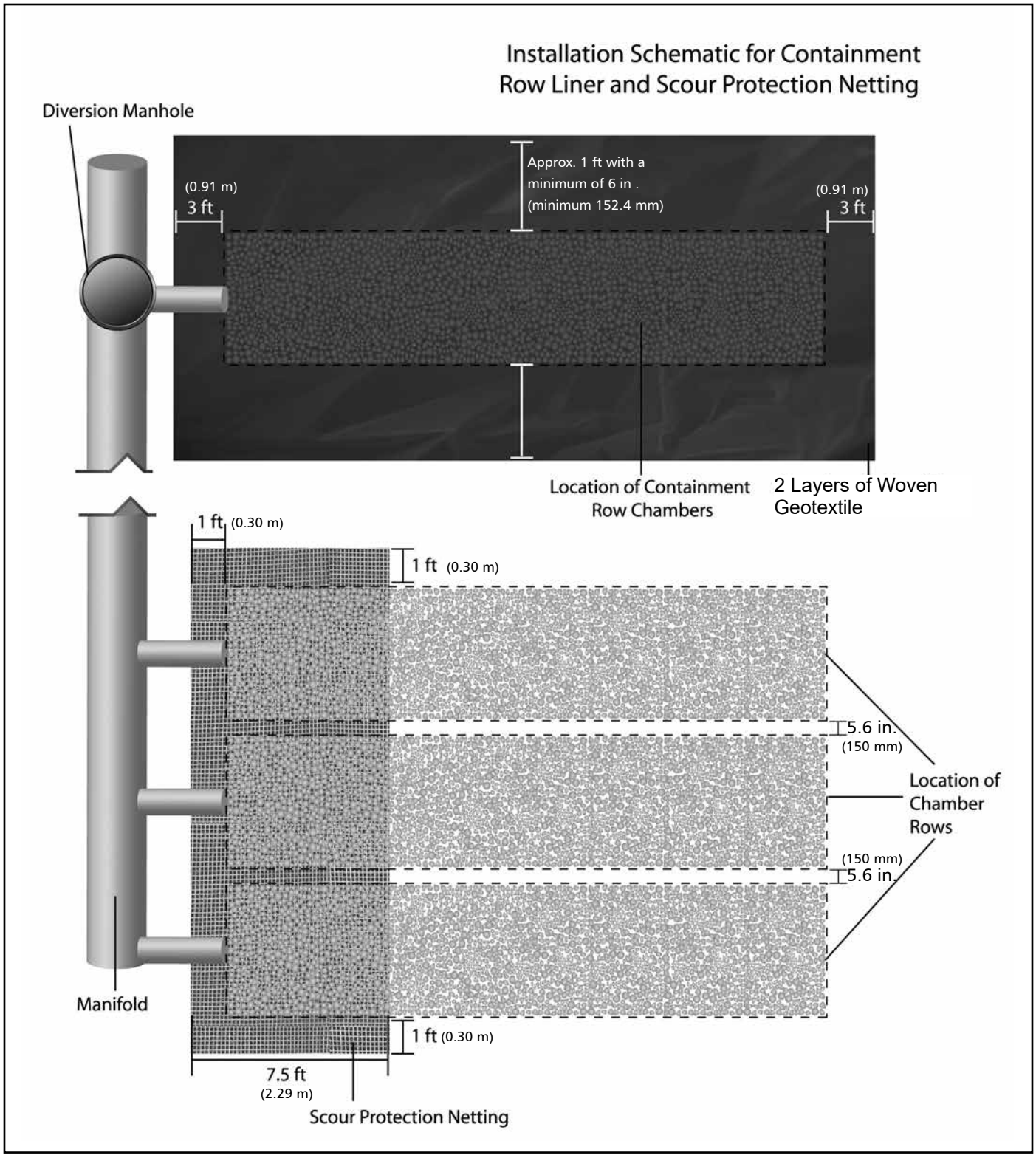
To insure the bedding is not disrupted as flows enter the system, rollout the Scour Protection Netting material perpendicular to the inlet chambers. In the area of the inlet chambers, lay the material with a one foot overlap towards the manifold system and footprint area. Tension material as needed to provide intimate contact with the bedding stone. When the inlet chamber is installed, this will "pin" the netting material in place. Inspect to insure netting is flat with no wrinkles and has intimate contact with the bedding stone. See Detail D.

Setting Units

Overlap the Mid chamber corrugation over the end of the Start chamber. Standard spacing between rows is 5.6", with a minimum of 5" required between each row. Always refer to the engineering plans for chamber arrangement. The End chamber will be the final chamber in each row.

Inspection Viewports

Where identified on the engineering project plans cut a 4-inch (102 mm) diameter hole in the reinforced circular port on the top of the chamber. Build an inspection port from PVC Schedule 40 pipe. Cut pipe to an oversized length, screw three small angle irons approximately 1-inch (25 mm) from the end of pipe. Anchor the riser in place on the chamber to keep secured during the backfill process. Install ring and cover on top of the riser pipe. After backfill, place an access casting in a concrete collar. To avoid crushing the inspection port riser, be sure concrete does not attach to riser pipe.


Installation Schematic for Containment
Row Liner and Scour Protection Netting
Diversion Manhole
(0.91 m)
3 ft
Approx. 1 ft with a
minimum of 6 in .
(minimum 152.4 mm)
(0.91 m)
3 ft
Location of Containment
Row Chambers
2 Layers of Woven
Geotextile
1 ft (0.30 m)
1 ft (0.30 m)
5.6 in.
(150 mm)
Location of
Chamber
Rows
(150 mm)
5.6 in.
Manifold
1 ft (0.30 m)
7.5 ft
(2.29 m)
Scour Protection Netting

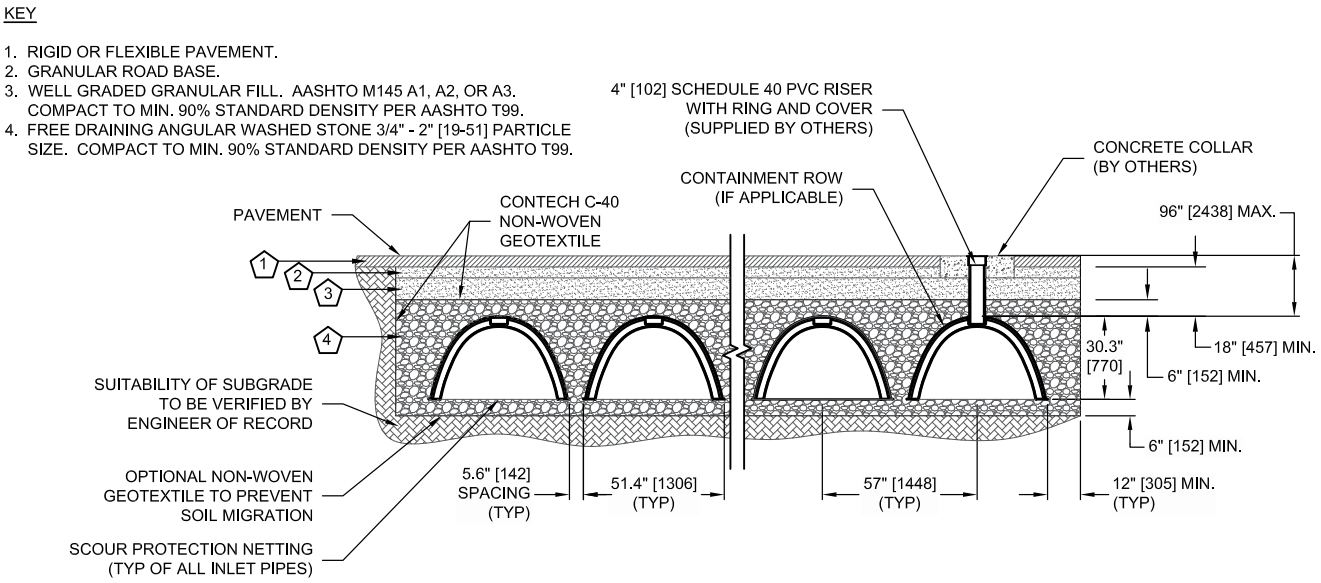
DETAIL D

Backfill Material

The chamber System incorporates two types of backfill material.

Free draining angular washed stone 3/4 to 2-inch (19 to 152 mm) particle size compacted to 90% AASHTO T99 is used around the chambers. This material is used around the chambers and within a minimum of 6-inches (152 mm) below and 6-inches (152 mm) above the chambers. The remaining space should be filled with an angular, well-graded granular fill meeting the requirements of AASHTO M145 A1, A2 or A3, compacted to 90% AASHTO T99.

Contech C-40 Non-Woven Geotextile should be used between the two layers of backfill material. See Detail E.



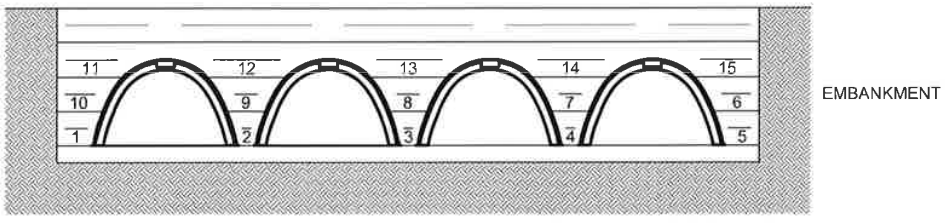
DETAIL E

Backfill Placement

Place backfill material in 6 to 8-inch (152 to 203 mm) loose lifts and compact to 90% AASHTO T99. Use mechanical hand tampers or approved compacting equipment to compact all backfill and embankment immediately adjacent to each side of the installation and over top of the installation to a minimum depth of 18-inches (457 mm). Place backfill so there is no more than a two lift differential between any of the chambers at anytime during the backfilling process. Advance the backfill along the length of the chamber system at the same rate to avoid differential loading on the chambers. Backfilling at differential heights from one side of the chamber to the other in excess of 16-inches (407 mm) can cause chamber distortion or potential collapse. Advance balanced lifts across the width of the system evenly along the length of the chambers as you backfill. See Detail F.

Use only lightweight tracked dozers (D-4 dozer or smaller) not exceeding 1,100 lbs/sf (0.54 kg/cm^2) ground pressure to spread backfill lifts over top of the chamber system. Maintain a minimum of 6-inch (152 mm) cover on top of chambers for the initial lifts.

For large systems use conveyor systems, backhoes with long reaches or draglines with stone buckets may be used to place backfill. Once minimum cover for construction loading across the entire width of the system is reached, advance the equipment to the end of the recently placed fill, and begin the sequence again until the system is completely backfilled. This type of construction sequence provides room for stockpiled backfill directly behind the backhoe, as well as the movement of construction traffic. Material stockpiles on top of the backfilled chamber system should be limited to six feet in total high above the structure and must provide balanced loading across all chambers. To determine the proper cover over the chambers to allow the movement of construction equipment, contact your local Contech Representative.



DETAIL F - TYPICAL BACKFILL SEQUENCE

Construction Loading

Typically, the minimum cover specified for a project assumes HS-20 or HS-25 live load. Because construction loads often exceed design live loads, increased temporary minimum cover requirements are necessary. Since construction equipment varies from job to job, it is best to address equipment specification and minimum cover requirements with our local Contech representative during the pre-construction meeting.

Equipment Restriction	
BACKFILL LEVEL*	ALLOWABLE CONSTRUCTION EQUIPMENT**
4 – Bedding	*No restrictions.*
4 – Back to Top of Chambers	*No equipment js permitted on or nearby the chambers. conveyors or excavators located such that their loads do not influence the chambers should be used to place the backfill stone. Stone should be worked between the chambers by hand.*
4 – Backfill Over the Top of the Chambers	*no wheel loads should be applied over the system. once 6" of stone has been placed over the crown of the chambers, lightweight tracked dozers with a maximum ground pressure of 1,100 psf are permitted over the structure. dozers must spread stone working in a direction parallel with the chamber rows; not working across the chamber rows. also, only small, walk behind compaction equipment can be used over the chambers until a minimum of 12" of cover is over the chambers.*
2 or 3 Select Fill Over the Chambers	*once 18" of compacted material is over the chambers, highway vehicles with axle loads of 32,000 pounds or less can be operated over the structures. front end loaders can be operated over the structures as long as the maximum wheel load does not exceed 16,000 pounds. compaction equipment can be operated over the structures as long as the dynamic force from the drum does not exceed 20,000 pounds and the gross vehicle weight does not exceed 12,000 pounds.*

** Please reference Detail E on page 7.*
*** Contact your local Contech Representative for questions on the use of specific pieces of construction equipment.*

Contractor Tool Checklist

- Wire cutters
- Stone bucket
- Transit or laser level
- Forklift or other type of equipment to unload chambers
- Reciprocating saw or router (to custom cut the end walls and inspection ports)
- Approved compaction equipment
- Excavator to dig trench and place stone and soil backfill
- Stone conveyor/light weight tracked dozer not exceeding 1,100 lbs/sf (0.54 kg/cm^2) to grade backfill

Material Checklist

Start, Mid and End ChamberMaxx chambers	Supplied by Contech
Manifold System	Supplied by Contech
Scour Protection Netting	Supplied by Contech
Contech C-40 Non-woven geotextile	Supplied by Contech
Containment Row Diversion Manhole if required)	Supplied by Contech
Containment Row AASHTO M288 Class 1 Woven Geotextile	Supplied by Contech
Free draining angular washed stone 3/4"-2" (.019 to .05 m) backfill material	Supplied by Contractor
Well graded granular backfill material	Supplied by Contractor
Construction Tape / Adhesive	Supplied by Contractor
Inspection port materials	Supplied by Contractor

ChamberMaxx Pre-Construction Checklist

Contech Field Contact and Phone: _____

Contech Plant Contact and Phone: _____

Contractor Contact and Phone: _____

Project Name: _____

Site Address: _____

Precon Attendees: _____

Topics to Review:

- ☐ Truck access and chamber storage availability/expectation
- ☐ Chamber unloading and handling safety, equipment and procedures
- ☐ System layout and fabrication drawing review
- ☐ Shipping schedule and installation sequence
- ☐ Scour protection netting layout
- ☐ Configuration and assembly
- ☐ Backfill material selection and placement procedure
- ☐ Backfill sequence, lift thickness and balanced loading
- ☐ Compaction requirement (90%) and equipment
- ☐ Additional Containment Row™ construction/liner material layout
- ☐ Inspection port installation

Notes: _____

_____

_____

_____

CHAMBERMaxx™

CONTECH ENGINEERED SOLUTIONS

Support

- Drawings and specifications are available at ContechES.com.
- Site-specific design support is available from Contech Engineered Solutions.

800.338.1122
www.ContechES.com