DRAINAGE REPORT

For

Rte 85 Realty Corp.

PROPOSED

Retail Development

190, 194 & 198 Hartford Avenue
Bellingham, Massachusetts
Norfolk County

Prepared by:

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TABLE OF CONTENTS

LIST OF TABLES

APPENDICES

I. EXECUTIVE SUMMARY

This report examines the changes in drainage that can be expected as the result of the development of a proposed two-story retail development located on the northeast corner of the intersection of Hartford Avenue and Cedar Hill Road in the Town of Bellingham, Massachusetts. The site, which contains approximately 1.23 acres of land, contains three (3) existing residences. The remaining portion of the site is undeveloped consisting of grass and landscaped areas.

The proposed project includes the construction of a new two-story, 5,000 sf (10,000 sf total) freestanding retail building along with new paved parking areas, landscaping, storm water management components and associated utilities. This report addresses a comparative analysis of the pre- and post-development site runoff conditions. Additionally, this report provides calculations documenting the design of the proposed stormwater conveyance/management system as illustrated within the accompanying Site Development Plans prepared by Bohler. The project will also provide erosion and sedimentation controls during the demolition and construction periods, as well as long term stabilization of the site.

For the purposes of this analysis the pre- and post-development drainage conditions were analyzed at one (1) "design point" where stormwater runoff currently drains to under existing conditions. This design point is described in further detail in **Section II** below. A summary of the existing and proposed conditions peak runoff rates for the 2-, 10-, 25-, and 100-year storms can be found in **Table 1.1** below. In addition, the project has been designed to meet or exceed the Stormwater Management Standards as detailed herein.

Table 1.1: Design Point Peak Runoff Rate Summary

Point of Analysis	2-Year Storm			10-Year Storm			25-Year Storm			100-Year Storm		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
DP1	0.14	0.03	**-0.11**	1.15	0.90	**-0.25**	2.38	1.87	**-0.51**	4.81	4.56	**-0.25**

**Flows are represented in cubic feet per second (cfs)*

II. EXISTING SITE CONDITIONS

Existing Site Description

The site consists of approximately 1.22 acres of land located at the northeast corner of the intersection of Hartford Avenue and Cedar Hill Avenue in the Town of Bellingham, Massachusetts. The southern portion of the site contains three (3) existing residences. The remaining portion of the site is undeveloped consisting of grass and landscaped areas.

On-Site Soil Information

Soils within the analyzed area consist of the following as classified by the Natural Resource Conservation Service (NRCS):

Table 2.1: Existing Soil Information

Soil Unit Symbol	Soil Name / Description	Hydrologic Soil Group (HSG)
103B	Charlton-Hollis-Rock outcrop complex	A
254A	Merrimac fine sandy loam	A
300C	Montauk fine sandy loam	C

Onsite soil testing was performed by Sanborn, Head & Associates, Inc. on April 24th, 2025. Refer to **Appendix C** for additional information.

Existing Collection and Conveyance

The site drains to the south and into the Hartford Avenue municipal drainage system. Slopes on the site range from 1%-50% with on-site elevations ranging from 277 along the northern property boundary to 270 at the southwest property corner adjacent to Hartford Avenue.

Existing Watersheds and Design Point Information

For the purposes of this analysis, the pre- and post-development drainage conditions were analyzed at one (1) “design point” as described below where stormwater runoff currently drains to under existing conditions. The existing site was subdivided into one (1) separate sub catchments, as described below, to analyze existing and proposed flow rates at each design point. The minimum time of concentration for all proposed areas is calculated as 5 minutes.

Design Point #1 (DP1) is the Hartford Avenue right-of-way. Under existing conditions, this design point receives stormwater flows from approximately 1.22 acres of land, designated as watershed "ED1.1". Refer to Table 2.1 below for additional detail.

Table 2.2: Existing Sub-Catchment Summary

Sub-catchment Name	Total Area (acres)	Cover Description	Curve Number (CN)	Time of Concentration (Tc, minutes)
ED1.1	1.22±	Rooftops, paved parking, grass, gravel	51	12.2

Refer to **Table 1.1 and 6.1** for the existing conditions peak rates of runoff. Refer to **Appendix D** and the Drainage Area Maps in the appendices of this report for a graphical representation of the existing drainage areas.

III. PROPOSED SITE CONDITIONS

Proposed Development Description

The proposed project consists of the construction of a new two-story, 5,000 sf (10,000 sf total) freestanding retail building including paved parking areas, landscaping, associated utilities, and a new stormwater management system. The site, including the proposed parking areas, has been designed to drain to deep-sump, hooded catch basins. The catch basins will capture and convey stormwater runoff, via an underground pipe system, to a proposed underground infiltration system. Pretreatment of stormwater runoff will be provided by a combination of the deep-sump, hooded catch basins and an Isolator Row of chambers prior to discharge to the proposed underground infiltration system. Rooftop runoff has been designed to flow to the underground system as well.

Proposed Development Collection and Conveyance

Deep-sump, hooded catch basins are proposed to collect and route runoff from the paved parking areas to the proposed underground infiltration system. Pipes have been designed for the 25-year storm using the Rational Method.

The best management practices (BMPs) incorporated into the proposed stormwater management system have been designed to meets, or exceeds, the standards set forth in the Massachusetts Department of Environmental Protection Stormwater Handbook standards. Refer to **Section V** for additional information.

Proposed Watersheds and Design Point Information

The project has been designed to maintain existing drainage watersheds to the greatest extent possible, with the same design points described in **Section II** above. The site was subdivided into two (2) separate sub catchments for the proposed conditions as described below. The minimum time of concentration for all proposed areas is calculated as 5 minutes.

Under proposed conditions DP1 receives stormwater flows from approximately 1.22 acres of land, designated as watersheds “P1.1” and “P1.2”. Refer to Table 3.1 below for additional detail.

Table 3.1: Proposed Sub-catchment Summary

Sub-catchment Name	Total Area (acres)	Cover Description	Curve Number (CN)	Time of Concentration (Tc, minutes)	Hydrologic Routing
P1.1	0.85±	Rooftops, paved parking, grass	90	5.0	UGS1 / DP1
P1.2	0.37±	Paved parking, grass	52	5.0	DP1

Refer to **Table 1.1 and 6.1** for the calculated proposed conditions peak rates of runoff. For additional hydrologic information, refer to **Appendix D** and the Drainage Area Maps in the appendices of this report for a graphical representation of the proposed drainage areas.

IV. METHODOLOGY

Peak Flow Calculations

Methodology utilized to design the proposed stormwater management system includes compliance with the guidelines set forth in the latest edition of the Massachusetts DEP Stormwater Handbook. The pre- and post-development runoff rates being discharged from the site were computed using the HydroCAD computer program. The drainage area and outlet information were entered into the program, which routes storm flows based on NRCS TR-20 and TR-55 methods. The other components of the model were determined following standard NRCS procedures for Curve Numbers (CNs) and times of concentrations documented in the appendices of this report. The rainfall data utilized and listed below in table 4.1 below for stormwater calculations is based on NOAA. Refer to **Appendix F** for more information.

Table 4.1: NOAA Rainfall Intensities

Frequency	2 year	10 year	25 year	100 year
Rainfall* (inches)	4.18	6.55	8.42	11.5

*Values derived from NOAA ATLAS 90% Intervals on 02/03/2025

The proposed stormwater management as designed will provide a decrease in peak rates of runoff from the proposed facility for the 2-, 10-, 25- and 100-year design storm events. Additionally, the proposed project meets, or exceeds, the MADEP Stormwater Management standards. Compliance with these standards is described further below.

V. STORMWATER MANAGEMENT STANDARDS

Standard #1: No New Untreated Discharges

The project has been designed so that proposed impervious areas (including the building roof and paved parking/driveway areas) shall be collected and passed through the proposed drainage system for treatment prior to discharge.

Standard #2: Peak Rate Attenuation

As outlined in **Table 1.1** and **Table 6.1**, the development of the site and the proposed stormwater management system have been designed so that post-development peak runoff rates are below pre-development conditions for the 2-, 10-, 25- and 100-year storm events at all design points.

Standard #3: Recharge

The stormwater runoff from the project will be collected and diverted to a proposed underground infiltration system. The project as proposed will involve the creation of 24,054 square feet of new impervious area and is required to infiltrate 1,274 cubic feet of stormwater as defined in Stormwater Standard 3. The proposed infiltration basin will provide 4,356 cubic feet of volume below the lowest outlet for groundwater recharge. Refer to **Appendix F** of this report for calculations documenting required and provided recharge volumes.

The DEP Stormwater Standards require that the infiltration BMP drains completely within 72 hours of the end of the storm event. Calculations showing that the proposed underground infiltration system will drain within 4.3 hours are included in **Appendix F** of this report.

A groundwater mounding analysis has been provided in **Appendix F** of this report. The analysis shows that the groundwater mound will have no effect on the proposed system.

Standard #4: Water Quality

Water quality treatment is provided via deep-sump, hooded catch basins, an Isolator Row of chambers, and an underground infiltration system. TSS removal calculations are included in **Appendix F** of this report. The project as proposed will involve the creation of 33,002 square feet of total impervious area and is required to treat 2,750 cubic feet of water quality volume as defined in Stormwater Standard 4. The proposed infiltration basin provides 4,356 cubic feet of water quality volume below the lowest outlet for water quality treatment. Refer to **Appendix F** of this report for calculations documenting required and provided water quality volumes.

Standard #5: Land Use with Higher Potential Pollutant Loads

Not Applicable for this project.

Standard #6: Critical Areas

Not Applicable for this project.

Standard #7: Redevelopment

Not Applicable for this project.

Standard #8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

The proposed project will provide construction period erosion and sedimentation controls as indicated within the site plan set provided for this project. This includes a proposed construction exit, protection for stormwater inlets, protection around temporary material stock piles and various other techniques as outlined on the erosion and sediment control sheets. Additionally, the project is required to file a Notice of Intent with the US EPA and implement a Stormwater Pollution Prevention Plan (SWPPP) during the construction period. The SWPPP will be prepared prior to the start of construction and will be implemented by the site contractor under the guidance and responsibility of the project's proponent. Refer to **Appendix H**.

Standard #9: Operation and Maintenance Plan (O&M Plan)

An Operation and Maintenance (O&M) Plan for this site has been prepared and is included in **Appendix G** of this report. The O&M Plan outlines procedures and time tables for the long term operation and maintenance of the proposed site stormwater management system, including initial inspections upon completion of construction, and periodic monitoring of the system components, in accordance with established practices and the manufacturer's recommendations. The O&M Plan includes a list of responsible parties and an estimated budget for inspections and maintenance.

Standard #10: Prohibition of Illicit Discharges

The proposed stormwater system will only convey allowable non-stormwater discharges (firefighting waters, irrigation, air conditioning condensates, etc.) and will not contain any illicit discharges from prohibited sources. An Illicit Discharge Statement is included in **Appendix G** of this report.

VI. SUMMARY

In summary, the proposed stormwater management system illustrated on the drawings prepared by Bohler results in a reduction in peak rates of runoff from the subject site when compared to pre-development conditions for the 2-, 10-, 25- and 100-year storm frequencies. In addition, the proposed best management practices will result in an effective removal of total suspended solids from the post-development runoff. The pre-development versus post-development stormwater discharge comparisons are contained in **Table 6.1** below:

Table 6.1: Design Point Peak Runoff Rate Summary

Point of Analysis	2-Year Storm			10-Year Storm			25-Year Storm			100-Year Storm		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
DP1	0.14	0.03	**-0.11**	1.15	0.90	**-0.25**	2.38	1.87	**-0.51**	4.81	4.56	**-0.25**

**Flows are represented in cubic feet per second (cfs)*

As outlined in the table above, the proposed stormwater management system as designed will provide a decrease in peak rates of runoff from the proposed facility for the 2-, 10-, 25- and 100-year storm events. Additionally, the project meets or exceeds the MADEP Stormwater Management Standards as described further herein.

APPENDIX A: MASSACHUSETTS STORMWATER MANAGEMENT CHECKLIST

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

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[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

09/25/2025

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☒ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☐ Reduced Impervious Area (Redevelopment Only)

☒ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

- ☐ Credit 1
- ☐ Credit 2
- ☐ Credit 3

☐ Use of "country drainage" versus curb and gutter conveyance and pipe

☐ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☐ Grass Channel

☐ Green Roof

☒ Other (describe): Underground Infiltration System

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☐ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☒ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

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[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

- ☐ is within the Zone II or Interim Wellhead Protection Area
- ☐ is near or to other critical areas
- ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
- ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

☒ The BMP is sized (and calculations provided) based on:

- ☐ The ½" or 1" Water Quality Volume or
- ☒ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☒ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☐ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☐ Description and delineation of public safety features;
- ☒ Estimated operation and maintenance budget; and
- ☒ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

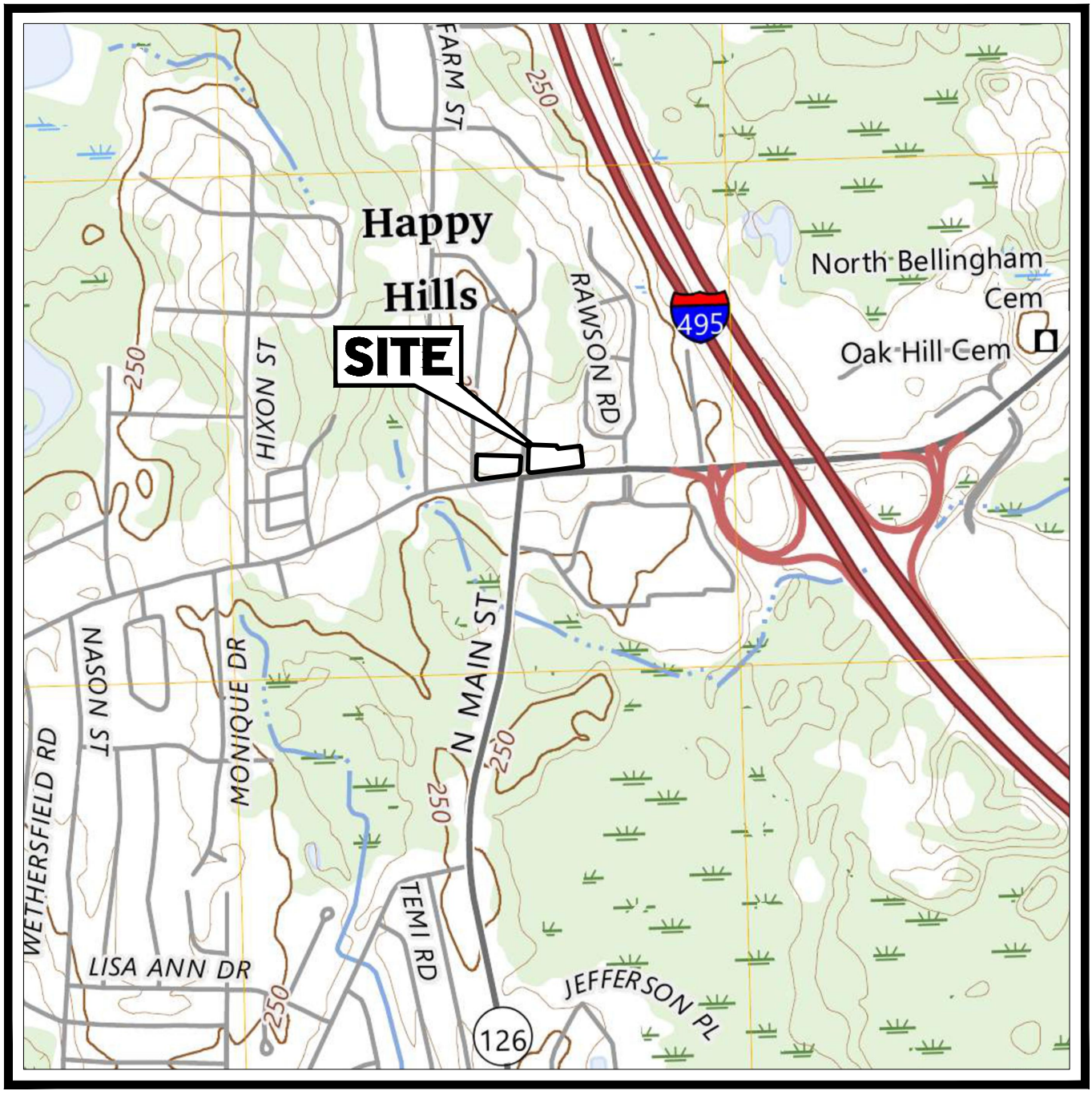
☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

APPENDIX B: PROJECT LOCATION MAPS

- *USGS MAP*
- *FEMA FIRMETTE*



TAX MAP

SCALE: 1" = 1,000'
SOURCE: USGS FRANKLIN, MA,
RI QUADRANGLE, 2024

National Flood Hazard Layer FIRMette

FEMA

71°28'38"W 42°7'5"N

71°28'1"W 42°6'38"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

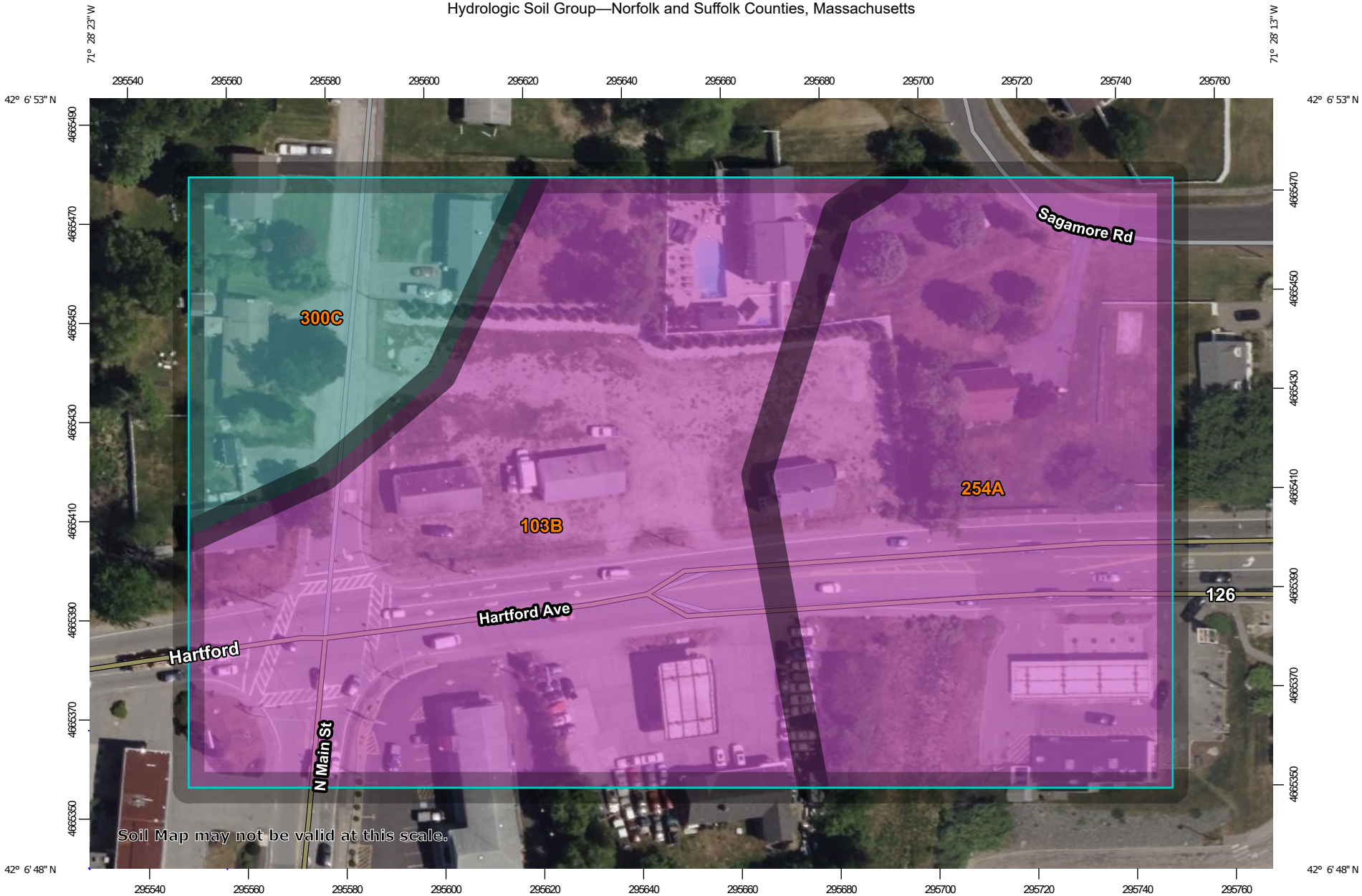
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 2/5/2025 at 10:35 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

APPENDIX C: SOIL AND WETLAND INFORMATION

- *NCRS CUSTOM SOIL RESOURCE REPORT*
- *SUBSURFACE EVALUATION FOR STORMWATER INFILTRATION*



Map Scale: 1:1,090 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 15 30 60 90

Feet: 0 50 100 200 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Norfolk and Suffolk Counties, Massachusetts
Survey Area Data: Version 20, Aug 27, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 22, 2022—Jun 5, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
103B	Charlton-Hollis-Rock outcrop complex, 3 to 8 percent slopes	A	2.9	47.9%
254A	Merrimac fine sandy loam, 0 to 3 percent slopes	A	2.3	38.4%
300C	Montauk fine sandy loam, 8 to 15 percent slopes	C	0.8	13.7%
Totals for Area of Interest			**6.1**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

SANBORN HEAD

98 North Washington Street, Suite 101
Boston, Massachusetts 02114

Mr. Tariq Fayyad
The Meehan Group
32 Hastings Street
P.O. Box 444
Mendon, Massachusetts 01756

July 2, 2025
File No. 6649.000

Re: Subsurface Evaluation for Stormwater Infiltration
Proposed Commercial Development – Retail Site
190, 194, and 198 Hartford Avenue
Bellingham, Massachusetts

Dear Mr. Fayyad:

Sanborn, Head & Associates, Inc. (Sanborn Head) is pleased to provide this subsurface evaluation for stormwater to The Meehan Group (Client) to summarize subsurface hydrogeologic data for the proposed retail development located at 190, 194, and 198 Hartford Avenue in Bellingham, Massachusetts (Site).

Our understanding of the existing conditions and proposed development is based on plans provided electronically entitled "MAA240490.00_C-401 GRDR" by Bohler Engineering (Bohler) of Southborough, Massachusetts dated July 1, 2025, and our evaluation of the subsurface conditions encountered in the subsurface explorations observed by Sanborn Head. This letter is subject to the Limitations provided in Attachment A.

EXISTING CONDITIONS AND PROJECT UNDERSTANDING

The Site is comprised of three parcels located at 190, 194, and 198 Hartford Avenue in Bellingham, MA. The Site is currently improved by three residential homes, one on each parcel. The site is bound by residential homes to the north and east, Hartford Ave and commercial spaces to the south, and Cedar Hill Road to the west. Based on our review of available historic aerial photographs, the Site was used for agricultural purposes prior to approximately 1961, when the property was redeveloped for residential use. Topography at the Site slopes from a high point along the eastern property border at approximate Elevation El. 274 feet, towards low points along the southwestern portion of the site at the intersection of Cedar Hill Road and Hartford Avenue at approximate El. 270 feet.

Based on the information provided, the proposed concept consists of an approximately 5,000 square-foot, two-story retail building with associated stormwater management and septic features (i.e., infiltration basin and underground sanitary field), landscaped areas, and parking areas and access drives. The proposed retail building in the western portion of the site has a proposed finish floor elevation of El. 276 feet. A stormwater infiltration basin is proposed in the eastern portion of the site and a proposed soil absorption system (leach field) is located in the northern portion of the Site. Elevations provided in this report reference the North American

Vertical Datum of 1988 (NAVD 88). The proposed Site development and proposed locations of the stormwater and leach field management areas are shown on Figure 1.

SUBSURFACE EXPLORATIONS

The following table summarizes the subsurface explorations by Sanborn Head.

Dates	Firm	Type of Exploration	Designations	Depth (ft)
April 24, 2025	The Meehan Group, Mendon, MA	Test Pits	SH-TP-101 through SH-TP-105	8.1 to 9.7 bgs[1]
June 4, 2025	Barrow Contracting Inc., Upton, MA	Test Pits	SH-TP-106 and SH-TP-107	8.2 to 8.8 bgs[1]

Notes:
1. bgs = below ground surface

Subsurface explorations were observed and logged by Sanborn Head personnel on a full-time basis. Test pits were field classified using the United States Department of Agriculture (USDA) Textural Classification System. The locations of the explorations performed by Sanborn Head are shown on Figure 1; logs of the test pits are provided in Attachment B.

SOIL LABORATORY TESTING

Geotechnical laboratory tests were performed by GeoTesting Express, Inc. of Acton, MA to evaluate the engineering properties of the soils at the Site. Two (2) soil sample of the anticipated receiving soils collected from a test pit nearby the proposed stormwater infiltration and soil absorption system areas were submitted for grain size distribution (sieve) analysis in accordance with ASTM D6913, hydrometer analysis (ASTM D7928) and USDA Textural Classification in accordance with USDA guidelines. The laboratory test reports are provided in Attachment C.

SUBSURFACE CONDITIONS

Based on Sanborn Head's observations during our subsurface exploration programs, the subsurface conditions at the exploration locations generally consist of variable thicknesses of surficial materials (fill, topsoil, buried topsoil, and subsoil) overlying the natural sand and gravel and glacial till deposits.

A summary of our subsurface observations is provided below:

Soil Strata [1]	Locations Encountered	Depth to Top of Layer (feet)	Approximate Layer Thickness (feet)	Layer Composition
Fill	SH-TP-101 through SH-TP-107	0	1 to 3.8[3]	Loamy Sand to Gravelly Sand, with varying amounts of gravel, cobbles, and 12 to 24 inch-diameter boulders.
Topsoil and Buried Topsoil (A, Ab, and Afill horizons)[2]	SH-TP-103 through SH-TP-105	0 to 1.0	0.8 to 1.0[4]	Sandy Loam, with varying amounts of 12 to 24 inch-diameter boulders.

Subsoil (B and Bfill horizons)[2]	SH-TP-103 through SH-TP-105	0.8 to 2.5	0.8 to 1.8	Cobbely Sand, with varying amounts of 12 to 24 inch-diameter boulders.
Sand and Gravel (C-horizon)	SH-TP-101 through SH-TP-105	1.9 to 3.8	0.6 to >6.3	Gravelly to Cobbely Loamy Sand to Very Cobbely Sand, with varying amounts of 12 to 24 inch-diameter boulders.
Glacial Till (Cd- horizon)	SH-TP-101 through SH-TP-103, SH-TP-106, and SH-TP-107	2.5 to 8.2	>0.3 to >6.3	Loamy Sand, Sandy Loam, and Silt Loam, with varying amounts of gravel, cobbles, and 12 to greater than 24 inch-diameter boulders.

Notes:
1. See subsurface exploration logs by Sanborn Head for further observations made during excavation. The depths and thicknesses listed above reference the ground surface elevation at the time of the exploration.
2. The topsoil and subsoil strata at test pits SH-TP-104 and SH-TP-105 were observed to be anthropogenically placed (i.e., fill).
3. A pocket of fill extended down to approximately 4.2 feet bgs on the east side of test pit SH-TP-101. Due to the Site history and existing buildings, the depth and thickness of fill may vary across the Site.
4. Due to the agricultural history of the Site, the depth of topsoil, buried topsoil, and subsoil may vary across the Site.

Where encountered, the depth to groundwater was measured in the test pits 15 minutes following the excavation. Estimated seasonal high groundwater (ESGHW) was encountered in test pits SH-TP-101 through SH-TP-103, and SH-TP-106 between approximate elevations El. 267.8 feet and El. 263.6 feet. Visual evidence of ESHGW was not observed at test pits SH-TP-104, SH-TP-105, and SH-TP-107. As a conservative measure, ESHGW was taken at as the bottom of the test pit where it was not encountered. ESHGW at the exploration locations are shown on Figure 1.

RECOMMENDATIONS

Based on the subsurface conditions discussed above, the recommended Rawls Rates, and the elevation of ESHGW for the infiltration basin is below:

Stormwater System Location	USDA Textural Classification[1]	ESHGW El. (feet)[2,3]	Rawls Rate (in/hr)[4]
Infiltration Basin	Loamy Sand	263.4	2.41

Notes:
1. The USDA Soil Texture shown represents the anticipated receiving layer soil texture observed in the test pits.
2. In the absence of soil mottling and visual observations of groundwater, ESHGW elevations were interpreted as bottom of the test pit.
3. '<' denotes 'less than'
4. Based on Table 2.3.3. 1982 Rawls Rates from the Massachusetts Stormwater Handbook.

Depth and elevation of the natural receiving layer, depth and elevation of ESHGW, and recommended infiltration rate are also summarized on Figure 1.

Fill, topsoil, and organic subsoil should be excavated down to the natural inorganic subgrade to prepare the subgrade for the proposed stormwater basin; and, if necessary, replaced with suitably draining material that meets or exceeds the proposed infiltration rates for the respective basin.

Care should also be taken to limit disturbance to exposed stormwater system subgrades to avoid over-compaction and/or deposition of silty materials by erosion and surface runoff. In the

event exposed subgrades are not maintained, unsuitable subgrades should be identified, cleaned or scraped and, if necessary, unsuitable materials over-excavated and replaced with suitably draining material that meets or exceeds the proposed infiltration rates for the respective basin.

We trust this data report meets the current needs of the project. If you should have any questions, please call us at (978) 392-0900.

Very truly yours,
SANBORN, HEAD & ASSOCIATES, INC.

Nicholas C. Johnson, E.I.T.
Senior Project Professional

Quincy Pratt, P.E.
Project Director

NCJ/QP: mtd

Encl. Figure 1 – Depth to Receiving Layer and Groundwater Plan

Attachment A: Limitations
Attachment B: USDA Test Pit Logs
Attachment C: Laboratory Test Results
Attachment D: Photograph Log

P:\6600s\6649.000\Source Files\Storm Water Memos\Retail Space\20250612 Bellingham Retail Space - Subsurface Evaluation for Stormwater.docx

Figures

N

N/F
TIMOTHY M. &
SHARON M. NORTON
BOOK: 35441 PAGE: 441
7 CEDAR HILL RD

N/F
KIMBERLY A. LADOUCEUR
BOOK: 40692 PAGE:279
4 SAGAMORE RD

CEDAR HILL ROAD
PUBLIC

HARTFORD AVENUE (ROUTE 126)

1920 COUNTY LAYOUT

1972 TOWN LAYOUT

BIT. CONC. DRIVE

GARAGE

SHED

CONCRETE BLOCK RETAINING WALL

PROP 5,000 SF 2 STORY RETAIL (10,000 SF TOTAL)
FF 276.00

PROP 56 LF 6" HDPE @ 1.79%

PROP 10 LF 12" HDPE @ 0.00%

PROP 180 LF 12" HDPE @ 1.00%

PROP 65 LF 12" HDPE @ 0.50%

PROP 117 LF 12" HDPE @ 0.50%

PROP 9 LF 12" HDPE @ 3.05%

PROP 9 LF 12" HDPE @ 0.86%

PROP 40 LF 12" HDPE @ 0.79%

PROP 24 LF 12" HDPE @ 2.46%

PROP 5 LF 12" HDPE @ 0.00%

PROP 30 LF 12" HDPE @ 0.50%

PROP INSPECTION PORT (TYP OF 6)

RL-1
PROP ROOF DRAIN
INV OUT 270.00 (6") A-210

A-140
PROP CB
GRT 271.95
INV OUT 269.20 (12") A-130

A-130
PROP DMH
RIM 274.30
INV IN 268.71 (12") A-140
INV OUT 268.61 (12") A-120

A-20
PROP DMH
RIM 273.18
INV IN 265.50 (12") A-30
INV OUT 265.40 (12") A-10

A-10
INV IN 265.25

A-120
PROP DMH
RIM 274.19
INV IN 268.63 (12") A-125
INV IN 268.03 (12") A-130
INV OUT 267.93 (12") A-90

A-125
PROP CB
GRT 273.90
INV OUT 268.90 (12") A-120

A-90
PROP DMH
RIM 273.64
INV IN 266.79 (12") A-100
INV IN 267.60 (12") A-120
INV OUT 267.50 (12") B-30

A-100
PROP DMH
RIM 273.49
INV IN 267.98 (12") A-85
INV OUT 266.86 (12") A-90

A-85
PROP CB
GRT 272.10
INV OUT 268.30 (12") A-100

A-80
PROP CB
GRT 271.70
INV OUT 268.20 (12") A-50

A-50
PROP DMH
RIM 272.37
INV IN 267.60 (12") A-80
INV OUT 267.50 (12") B-20

B-10
INV OUT 267.40

B-20
INV IN 267.50

B-30

SH-TP-101
24" [270.0]
60" [267.0]
GRAVELLY LOAMY SAND
2.41 IN/HR

SH-TP-102
40" [268.2]
60" [266.5]
COBBELY LOAMY SAND
2.41 IN/HR

SH-TP-103
40" [268.7]
101" [263.6]
LOAMY SAND
2.41 IN/HR

SH-TP-104
29" [269.6]
N.E. [<263.3]
VERY COBBELY SAND
8.27 IN/HR

SH-TP-105
45" [267.8]
N.E. [<263.4]
VERY COBBELY SAND
2.41 IN/HR

SH-TP-106
30" [269.5]
50" [267.8]
SILT LOAM
0.27 IN/HR

SH-TP-107
36" [268.0]
N.E. [<262.8]
SANDY LOAM
1.02 IN/HR

TOP OF CHAMBER ELEV=269.80
TOP OF STONE ELEV=270.30

BENCHMARK TOP OF DRILLHOLE ELEVATION=269.00 (NAVD 88)

BENCHMARK TOP OF STONE BOUND ELEVATION=271.23 (NAVD 88)

N/F
BELLINGHAM N MAIN ST II LLC
BOOK:22912 PAGE:459
217 HARTFORD AV

N/F
193 HARTFORD AVE REALTY LLC
BOOK:41251 PAGE:74
193 HARTFORD AV

N/F
M A REALTY ACQUISITION LLC
BOOK:26834 PAGE:118
189 HARTFORD AV

NOTES:

1. THE BASE PLAN WAS TAKEN FROM A SITE PLAN TITLED "GRADING AND DRAINGAGE PLAN". PREPARED BY BOHLER ENGINEERING OF SOUTHBOROUGH, MA, DATED JULY 1, 2025.

2. TEST PITS DESIGNATED SH-TP-101 THROUGH SH-TP-105 WERE EXCAVATED BY THE MEEHAN GROUP OF MENDON, MA AND OBSERVED BY SANBORN HEAD ON APRIL 24, 2025.

3. TEST PITS DESIGNATED SH-TP-106 AND SH-TP-107 WERE EXCAVATED BY BARROWS CONTRACTING INC. OF UPTON, MA AND OBSERVED BY SANBORN HEAD ON JUNE 4, 2025.

4. APPROXIMATE LOCATIONS OF EXPLORATIONS ARE BASED ON TAPED MEASUREMENTS MADE IN THE FIELD RELATIVE TO PROMINENT SITE FEATURES. THIS DATA SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

5. GROUND SURFACE ELEVATIONS AT THE EXPLORATION LOCATIONS WERE ESTIMATED BY INTERPOLATION BETWEEN THE TOPOGRAPHIC CONTOURS SHOWN ON THE BASE PLAN. AS SUCH, THE GROUND ELEVATIONS AT THE EXPLORATIONS SHOULD BE CONSIDERED APPROXIMATE.

6. GROUNDWATER OBSERVATIONS BY SANBORN HEAD WERE MADE IN THE EXPLORATIONS AT THE TIME OF EXCAVATING.

LEGEND:

SH-TP-101	APPROXIMATE LOCATION AND DESIGNATION OF TEST PIT OBSERVED BY SANBORN HEAD (APRIL 2025)
SH-TP-106	APPROXIMATE LOCATION AND DESIGNATION OF TEST PIT OBSERVED BY SANBORN HEAD (JUNE 2025)
24" [270.0]	DEPTH (IN INCHES) AND ELEVATION (IN FEET) OF RECEIVING LAYER
60" [267.0]	DEPTH (IN INCHES) AND ELEVATION (IN FEET) OF ESTIMATED SEASONAL HIGH GROUNDWATER (ESHGW)
GRAVELLY LOAMY SAND	USDA TEXTURAL CLASSIFCATION OF RECEIVING LAYER
2.41 IN/HR	RECOMMENDED RAWL'S RATE, IN INCHES PER HOUR (IN/HR)
N.E.	NOT ENCOUNTERED
<	DENOTED "LESS THAN" ITEM WAS NOT ENCOUNTERED AND IS AT AN ELEVATION LESS THAN ELEVATION SHOWN

SANBORN HEAD

NOT TO SCALE

NO.	DATE	DESCRIPTION	BY

DRAWN BY: N. JOHNSON
DESIGNED BY: N. JOHNSON
REVIEWED BY: Q. PRATT
PROJECT MGR: N. JOHNSON
PIC: Q. PRATT
DATE: JULY 2025

SUBSURFACE EVALUATION FOR STORMWATER
190, 194 & 198 HARTFORD AVENUE
BELLINGHAM, MA

DEPTH TO RECEIVING LAYER AND GROUNDWATER PLAN

PROJECT NUMBER: 6649.000

FIGURE NUMBER: 1

File created in Bluebeam: S:\BOSDATA\Staff\QPRATT\Bluebeam Source Files\TITLE BLOCK TEMPLATE 11X17.pdf/

Attachment A

Limitations

ATTACHMENT A
LIMITATIONS

1. The analyses, recommendations, and designs submitted in this letter are based in part on the data obtained from subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to re-evaluate the recommendations of this letter.

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretation of widely spaced explorations and samples; actual soil transitions may be more or less gradual than indicated. For specific information, refer to the subsurface exploration logs.

3. Water level readings have been made in the explorations at the times and under the conditions stated on the test pit logs. These data have been reviewed and interpretations have been made in the text of this letter. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors differing from those occurring at the time measurements were made.

4. In the event that any changes in the nature, design, or location of the proposed building or stormwater management features are planned, the conclusions and recommendations contained in this letter shall not be considered valid unless the changes are reviewed, and conclusions of the letter modified or verified in writing by Sanborn Head.

5. It is recommended that this firm be retained to provide soil engineering services during the excavation and earthwork construction phases of the work. This is to observe compliance with the design concepts, specifications, or recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated prior to the start of construction.

6. This letter has been prepared for the exclusive use of The Meehan Group of Mendon, Massachusetts for the proposed retail development located at 190, 194, and 198 Hartford Avenue in Bellingham, Massachusetts, in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

7. This stormwater letter has been prepared for this project by Sanborn Head for design purposes only and is not sufficient to prepare an accurate bid. Contractors wishing a copy of this report may secure it with the understanding that its scope is limited to design considerations only.

Attachment B

USDA Test Pit Logs

Deep Observation Hole

Site Name:	190, 194 & 198 Hartford Avenue	Date:	4/24/2025
Site Address:	Bellingham, MA	Time:	10:25
Project No.:	6649.00		
Ground Surface Elev. (ft.):	272	Weather :	65, Clear

Test Pit Number: SH-TP-101

Logged by: A. Baker
Soil Evaluator #: --
Signature: --

Depth (inches)	Soil Horizon or Layer	Soil Matrix Color (Moist)	Redoximorphic Features			Soil Texture (NRCS)	Coarse Fragments (% by Volume)		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles			
0 - 24	Fill	5Y 4/3	-	-	-	Sandy Loam	10	-	Single Grain	Friable	1
24 - 59	C	2.5Y 4/1	-	-	-	Gravelly Loamy Sand	20	5	Weak Massive	Loose	2
59 - 107	Cd	2.5Y 5/2	60	7.5YR 5/9	30	Loamy Sand	10	5	Moderate Massive	Firm	3
-											
-											
-											
-											

Test Pit Termination Depth (in.): 107" **Reason for Termination:** Machine Reach

Groundwater Observations:				**In-Situ Testing:**			
Depth to water weeping from pit face (in.):	90"			Percolation Test:	Not performed	Depth (in.):	--
Depth to standing water in hole (in.):	100"	Stabilization Time:	15 minutes	Permeameter Test:	Not performed	Depth (in.):	--
Depth to estimated seasonal high groundwater [ESHGW] (in.):	60"	Basis for ESHGW:	Redoximorphic Features	Falling Head Test:	Not performed	Depth (in.):	--
				Other Test:	--	Depth (in.):	--

Additional Notes:

1) A pocket of fill extended down to 50 inches on the east test pit wall
2) 5 Boulders 12-24"
3) 4 boulders >24"

Deep Observation Hole

Site Name:	190, 194 & 198 Hartford Avenue	Date:	4/24/2025
Site Address:	Bellingham, MA	Time:	11:00
Project No.:	6649.00		
Ground Surface Elev. (ft.):	271.5	Weather :	65, Clear

Test Pit Number: SH-TP-102

Logged by: A. Baker
Soil Evaluator #: --
Signature: --

Depth (inches)	Soil Horizon or Layer	Soil Matrix Color (Moist)	Redoximorphic Features			Soil Texture (NRCS)	Coarse Fragments (% by Volume)		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles			
0 - 24	Fill1	2.5Y 4/2	-	-	-	Sandy Loam	10	-	Single Grain	Friable	
24 - 40	Fill2	10YR 4/4				Cobbely Loamy Sand	10	15	Weak Massive	Loose	1
40 - 68	C	10YR 4/4	60	7.5YR 5/8	20	Cobbely Loamy Sand	10	15	Subangualr Blocky	Loose	1
68 - 116	Cd	5Y 5/2	-	-	-	Loamy Sand	10	5	Moderate Massive	Firm	2, 3
-											
-											
-											

Test Pit Termination Depth (in.): 116" **Reason for Termination:** Machine Reach

Groundwater Observations:				**In-Situ Testing:**			
Depth to water weeping from pit face (in.):	71"			Percolation Test:	Not performed	Depth (in.):	--
Depth to standing water in hole (in.):	112"	Stabilization Time:	15 minutes	Permeameter Test:	Not performed	Depth (in.):	--
Depth to estimated seasonal high groundwater [ESHGW] (in.):	60"	Basis for ESHGW:	Redoximorphic Features	Falling Head Test:	Not performed	Depth (in.):	--
				Other Test:	--	Depth (in.):	--

Additional Notes:
1) Numerous boulders 12-24"
2) 2 boulders 12-18"
3) F-C sand, little silt, little gravel
4) Weeping near interface between C layer and Cd layer

Deep Observation Hole

Site Name:	190, 194 & 198 Hartford Avenue	Date:	4/24/2025
Site Address:	Bellingham, MA	Time:	--
Project No.:	6649.00		
Ground Surface Elev. (ft.):	272	Weather :	65, Clear

Test Pit Number: SH-TP-103

Logged by: A. Baker
Soil Evaluator #: --
Signature: --

Depth (inches)	Soil Horizon or Layer	Soil Matrix Color (Moist)	Redoximorphic Features			Soil Texture (NRCS)	Coarse Fragments (% by Volume)		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles			
0 - 18	Fill	10YR 5/2	-	-	-	Sandy Loam	10	-	Single Grain	Friable	
18 - 30	Ab	10YR 4/3	-	-	-	Sandy Loam	10	-	Single Grain	Friable	
30 - 40	B	10YR 3/4	-	-	-	Cobbely Sand	10	15	Single grain	Friable	1
40 - 98	C	2.5Y 5/2	-	-	-	Loamy Sand	-	5	Moderate massive	Firm	2
98 - 102	Cd	5Y 5/2	-	-	-	Loamy Sand	10	5	Moderate Massive	Firm	
-											
-											

Test Pit Termination Depth (in.): 102" **Reason for Termination:** Machine Reach

Groundwater Observations:				**In-Situ Testing:**			
Depth to water weeping from pit face (in.):	Not observed			Percolation Test:	Not performed	Depth (in.):	--
Depth to standing water in hole (in.):	101"	Stabilization Time:	15 minutes	Permeameter Test:	Not performed	Depth (in.):	--
Depth to estimated seasonal high groundwater [ESHGW] (in.):	101"	Basis for ESHGW:	Observed Water	Falling Head Test:	Not performed	Depth (in.):	--
				Other Test:	--	Depth (in.):	--

Additional Notes:
1) Numerous boulders 12-24"
2) F-C SAND, trace silt, little gravel

Deep Observation Hole

Site Name:	190, 194 & 198 Hartford Avenue	Date:	4/24/2025
Site Address:	Bellingham, MA	Time:	--
Project No.:	6649.00		
Ground Surface Elev. (ft.):	272	Weather :	65, Clear

SANBORN HEAD

Test Pit Number: SH-TP-104

Logged by: A. Baker
Soil Evaluator #: --
Signature: --

Depth (inches)	Soil Horizon or Layer	Soil Matrix Color (Moist)	Redoximorphic Features			Soil Texture (NRCS)	Coarse Fragments (% by Volume)		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles			
0 - 10	Afill	10YR 2/2	-	-	-	Sandy Loam	-	-	Single Grain	Friable	
10 - 29	Bfill	7.5 YR 4/4	-	-	-	Loam	5	5	Weak Massive	Loose	1
29 - 104	C	10YR 4/3	-	-	-	Very Cobbely Sand	10	35	Single grain	Friable	2
-											
-											
-											
-											

Test Pit Termination Depth (in.): 104" **Reason for Termination:** Machine Reach

Groundwater Observations:				**In-Situ Testing:**			
Depth to water weeping from pit face (in.):	Not observed			Percolation Test:	Not performed	Depth (in.):	--
Depth to standing water in hole (in.):	Not observed	Stabilization Time:	N/A	Permeameter Test:	Not performed	Depth (in.):	--
Depth to estimated seasonal high groundwater [ESHGW] (in.):	Not observed	Basis for ESHGW:	Not observed	Falling Head Test:	Not performed	Depth (in.):	--
				Other Test:	--	Depth (in.):	--

Additional Notes:
1) Numerous boulders 12-24"
2) F-C sand, some cobbles, some gravel, trace silt

Deep Observation Hole

Site Name:	190, 194 & 198 Hartford Avenue	Date:	4/24/2025
Site Address:	Bellingham, MA	Time:	--
Project No.:	6649.00		
Ground Surface Elev. (ft.):	271.5	Weather :	65, Clear

Logged by: A. Baker
Test Pit Number: SH-TP-105
Soil Evaluator #: --
Signature: --

Depth (inches)	Soil Horizon or Layer	Soil Matrix Color (Moist)	Redoximorphic Features			Soil Texture (NRCS)	Coarse Fragments (% by Volume)		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles			
0 - 12	Fill	2.5Y 4/2	-	-	-	Loamy Sand	10	-	Single Grain	Friable	
12 - 23	Afill	10YR 2/3	-	-	-	Loamy Sand	-	-	Single grain	Friable	
23 - 45	Bfill	10YR 3/2	-	-	-	Loamy Sand	10	10	Single grain	Friable	1
45 - 97	C	10YR 4/3	-	-	-	Very cobbely sand	15	35	Weak Massive	Loose	2
-											
-											
-											

Test Pit Termination Depth (in.): 97" **Reason for Termination:** Machine Reach

Groundwater Observations:				**In-Situ Testing:**			
Depth to water weeping from pit face (in.):	Not observed			Percolation Test:	Not performed	Depth (in.):	--
Depth to standing water in hole (in.):	Not observed	Stabilization Time:	N/A	Permeameter Test:	Not performed	Depth (in.):	--
Depth to estimated seasonal high groundwater [ESHGW] (in.):	Not observed	Basis for ESHGW:	Not observed	Falling Head Test:	Not performed	Depth (in.):	--
				Other Test:	--	Depth (in.):	--

Additional Notes:
1) 5 boulders 12-24"
2) F-C sand, some cobbles, some gravel, trace silt

Deep Observation Hole

Site Name:	190, 194 & 198 Hartford Avenue	Date:	6/4/2025
Site Address:	Bellingham, MA	Time:	--
Project No.:	6649.00		
Ground Surface Elev. (ft.):	272.0	Weather :	80, Clear

Test Pit Number: SH-TP-106

Logged by: A. Baker
Soil Evaluator #: --
Signature: --

Depth (inches)	Soil Horizon or Layer	Soil Matrix Color (Moist)	Redoximorphic Features			Soil Texture (NRCS)	Coarse Fragments (% by Volume)		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles			
0 - 23	Fill	5Y 4/3	-	-	-	Gravelly Sand	20	-	Single Grain	Friable	
23 - 30	C	2.5Y 5/2	-	-	-	Gravelly Loamy Sand	15	5	Weak Massive	Loose	1
30 - 106	Cd	5Y 6/1	-	-	-	Silt Loam	10	5	Weak Massive	Loose	2
-											
-											
-											
-											

Test Pit Termination Depth (in.): 106" **Reason for Termination:** Machine Reach

Groundwater Observations:				**In-Situ Testing:**			
Depth to water weeping from pit face (in.):	50"			Percolation Test:	Not performed	Depth (in.):	--
Depth to standing water in hole (in.):	105"	Stabilization Time:	15 minutes	Permeameter Test:	Not performed	Depth (in.):	--
Depth to estimated seasonal high groundwater [ESHGW] (in.):	50"	Basis for ESHGW:	Observed Water	Falling Head Test:	Not performed	Depth (in.):	--
				Other Test:	--	Depth (in.):	--

Additional Notes:
1) Two 12" boulders
2) Three 12" boulders

Deep Observation Hole

Site Name:	190, 194 & 198 Hartford Avenue	Date:	6/4/2025
Site Address:	Bellingham, MA	Time:	--
Project No.:	6649.00		
Ground Surface Elev. (ft.):	271.0	Weather :	80, clear

Test Pit Number: SH-TP-107

Logged by: A. Baker
Soil Evaluator #: --
Signature: --

Depth (inches)	Soil Horizon or Layer	Soil Matrix Color (Moist)	Redoximorphic Features			Soil Texture (NRCS)	Coarse Fragments (% by Volume)		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles			
0 - 17	Fill1	7.5Y 4/2	-	-	-	Loamy Sand	10	-	Weak Massive	Friable	
17 - 36	Fill2	7.5Y 4/4	-	-	-	Gravelly Loamy Sand	15	5	Weak Massive	Friable	
36 - 61	C	7.5Y 4/4	-	-	-	Gravelly Loamy Sand	15	5	Weak Massive	Friable	
61 - 98	Cd	10YR 5/1	-	-	-	Sandy Loam	10	5	Weak Massive	Friable	
-											
-											
-											

Test Pit Termination Depth (in.): 98" **Reason for Termination:** Machine Reach and large boulders

Groundwater Observations:				**In-Situ Testing:**			
Depth to water weeping from pit face (in.):	Not observed			Percolation Test:	Not performed	Depth (in.):	--
Depth to standing water in hole (in.):	Not observed	Stabilization Time:	N/A	Permeameter Test:	Not performed	Depth (in.):	--
Depth to estimated seasonal high groundwater [ESHGW] (in.):	Not observed	Basis for ESHGW:	Not observed	Falling Head Test:	Not performed	Depth (in.):	--
				Other Test:	--	Depth (in.):	--

Additional Notes:

Attachment C

Laboratory Test Results

Client:	Sanborn, Head & Associates, Inc.				
Project:	Hartford Ave				
Location:	Bellingham, MA			Project No:	GTX-321011
Boring ID:	SH-TP-104	Sample Type:	Bag	Tested By:	ajl
Sample ID:	S3	Test Date:	05/09/25	Checked By:	ank
Depth :	29"-104"	Test Id:	814916		
Test Comment:	---				
Visual Description:	Moist, grayish brown sand with gravel				
Sample Comment:	---				

USDA Textural Classification

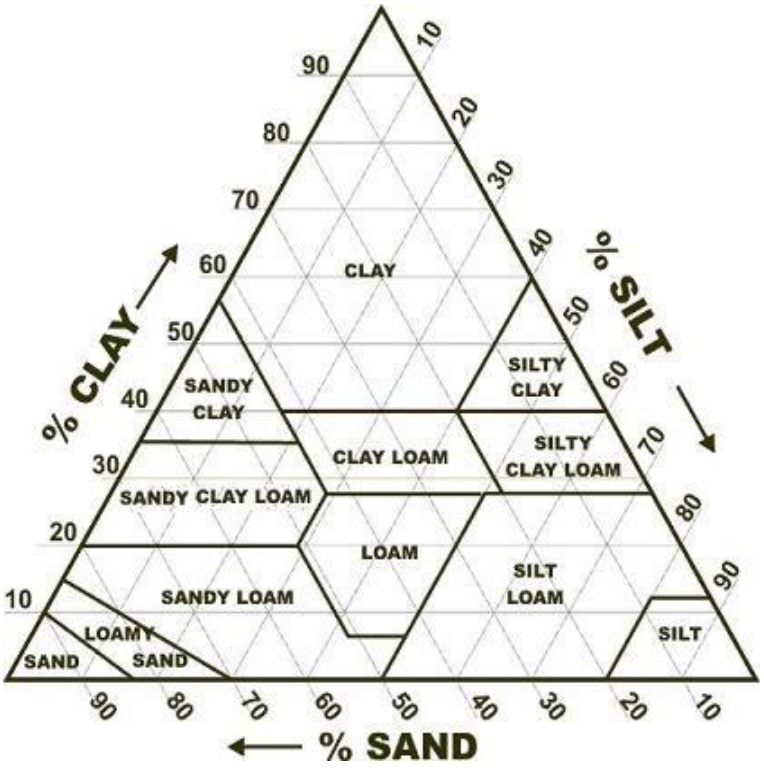
Boring ID	Sample ID	Depth	Sand, %	Silt, %	Clay, %	Classification
SH-TP-104	S3	29"-104"	94	6	0	Sand

Classifications based only on material passing the #10 sieve

Sand: material passing 2.0 mm and retained on 0.05 mm diameter

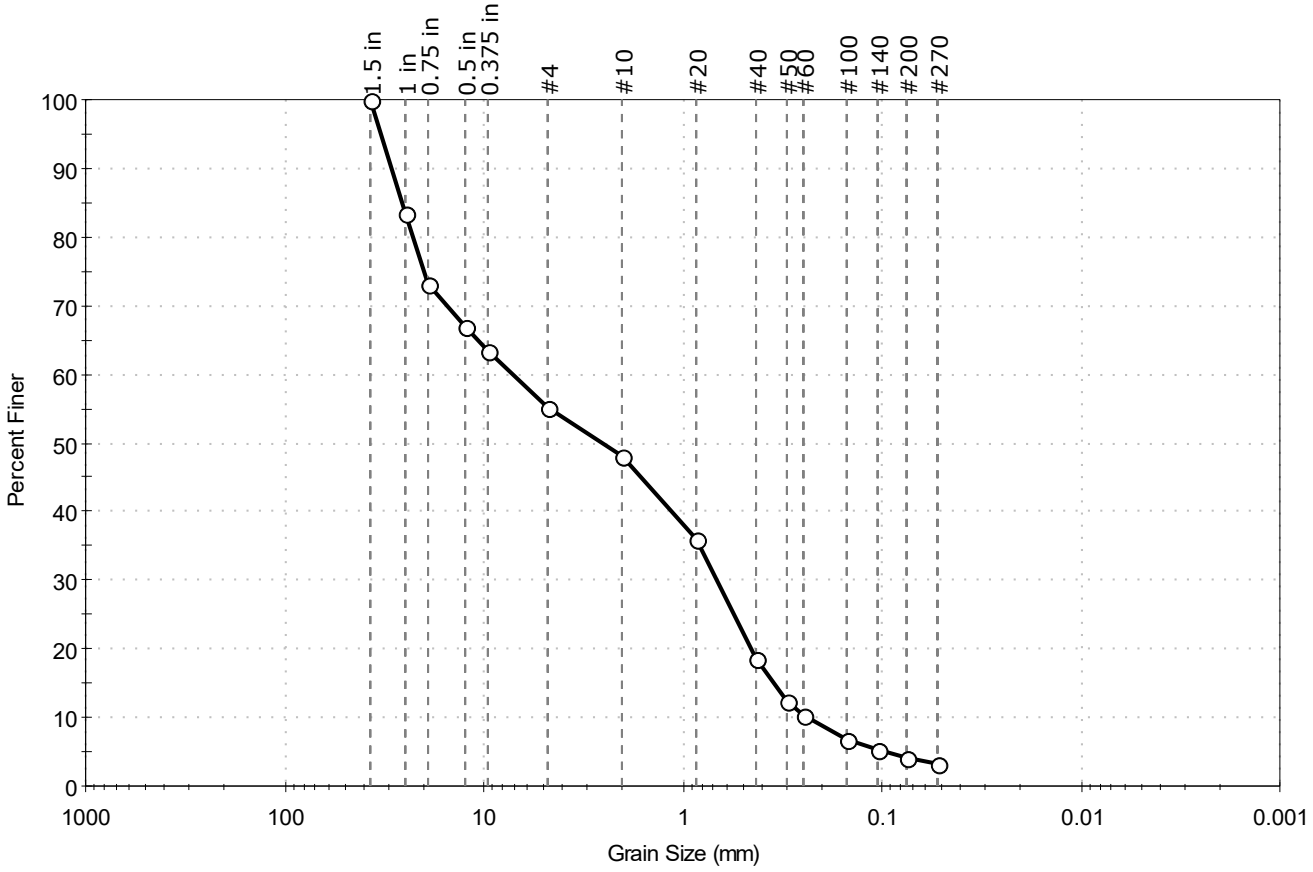
Silt: material passing 0.05 mm and retained on 0.002 mm diameter

Clay: material passing 0.002 mm diameter



Client:	Sanborn, Head & Associates, Inc.				
Project:	Hartford Ave				
Location:	Bellingham, MA			Project No:	GTX-321011
Boring ID:	SH-TP-104	Sample Type:	Bag	Tested By:	ajl
Sample ID:	S3	Test Date:	05/13/25	Checked By:	ank
Depth :	29"-104"	Test Id:	814915		
Test Comment:	Less than 5% fines, hydrometer not performed				
Visual Description:	Moist, grayish brown sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	45.0	50.8	4.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	83		
0.75 in	19.00	73		
0.5 in	12.50	67		
0.375 in	9.50	63		
#4	4.75	55		
#10	2.00	48		
#20	0.85	36		
#40	0.42	19		
#50	0.30	12		
#60	0.25	10		
#100	0.15	7		
#140	0.11	5		
#200	0.075	4.2		
#270	0.053	3		

Coefficients

D_{85} = 26.0322 mm	D_{30} = 0.6710 mm
D_{60} = 7.1643 mm	D_{15} = 0.3470 mm
D_{50} = 2.5419 mm	D_{10} = 0.2400 mm
C_u = 29.851	C_c = 0.262

Classification

ASTM — Poorly graded SAND with Gravel (SP)

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

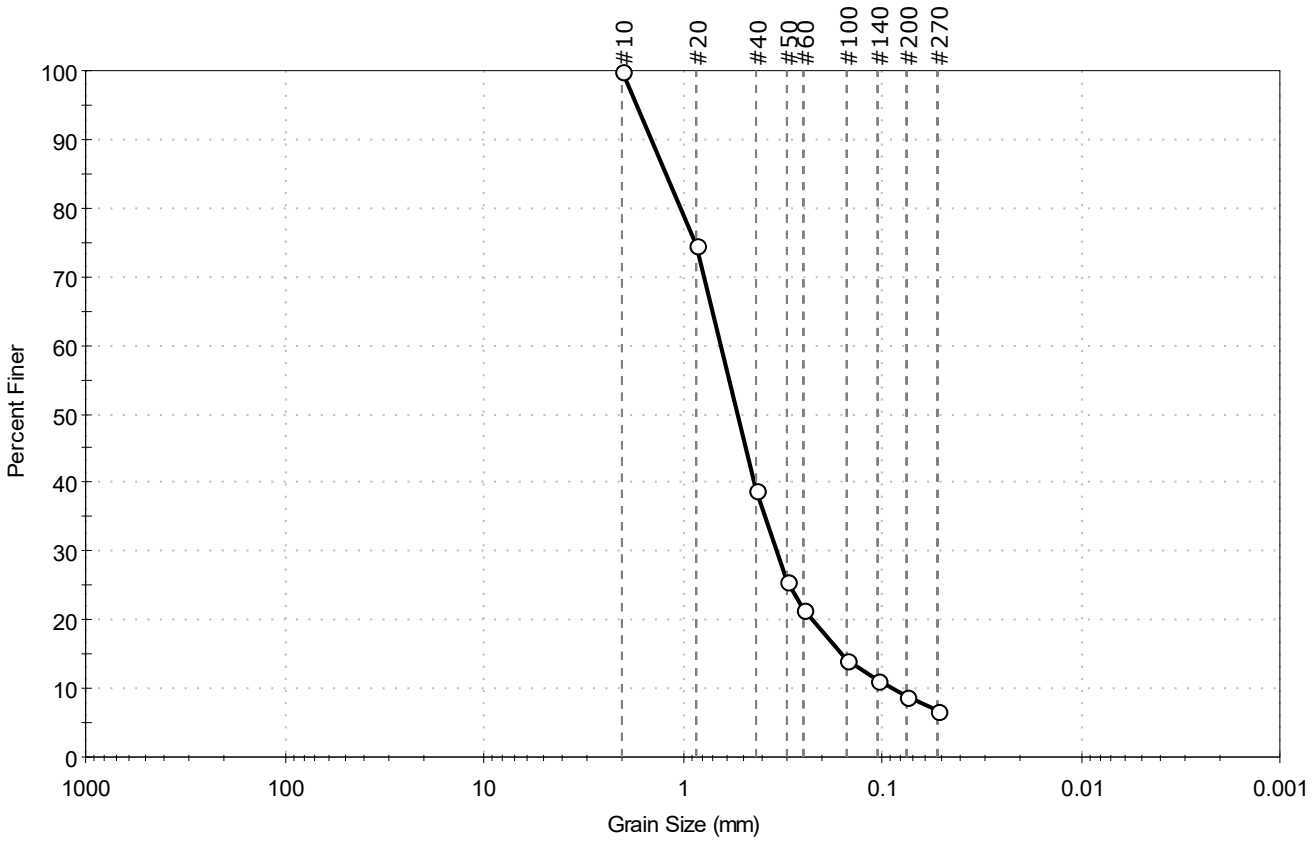
Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Sanborn, Head & Associates, Inc.				
Project:	Hartford Ave				
Location:	Bellingham, MA			Project No:	GTX-321011
Boring ID:	SH-TP-104	Sample Type:	Bag	Tested By:	ajl
Sample ID:	S3	Test Date:	05/13/25	Checked By:	ank
Depth :	29"-104"	Test Id:	814915		
Test Comment:	Less than 5% fines, hydrometer not performed				
Visual Description:	Moist, grayish brown sand with gravel				
Sample Comment:	Only minus No. 10 sieve for USDA classification				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	91.2	8.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#10	2.00	100		
#20	0.85	75		
#40	0.42	39		
#50	0.30	26		
#60	0.25	21		
#100	0.15	14		
#140	0.11	11		
#200	0.075	8.8		
#270	0.053	7		

Coefficients

D_{85} = 1.2063 mm
D_{30} = 0.3360 mm
D_{60} = 0.6404 mm
D_{15} = 0.1601 mm
D_{50} = 0.5275 mm
D_{10} = 0.0896 mm
C_u = 7.147
C_c = 1.968

Classification

ASTM N/A

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

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Sanborn, Head & Associates, Inc.				
Project:	Hartford Ave				
Location:	Bellingham, MA			Project No:	GTX-321011
Boring ID:	SH-TP-107	Sample Type:	Bag	Tested By:	ajl
Sample ID:	S3	Test Date:	06/16/25	Checked By:	ank
Depth :	61-98"	Test Id:	818990		
Test Comment:	---				
Visual Description:	Moist, light yellowish brown silty sand				
Sample Comment:	---				

USDA Textural Classification

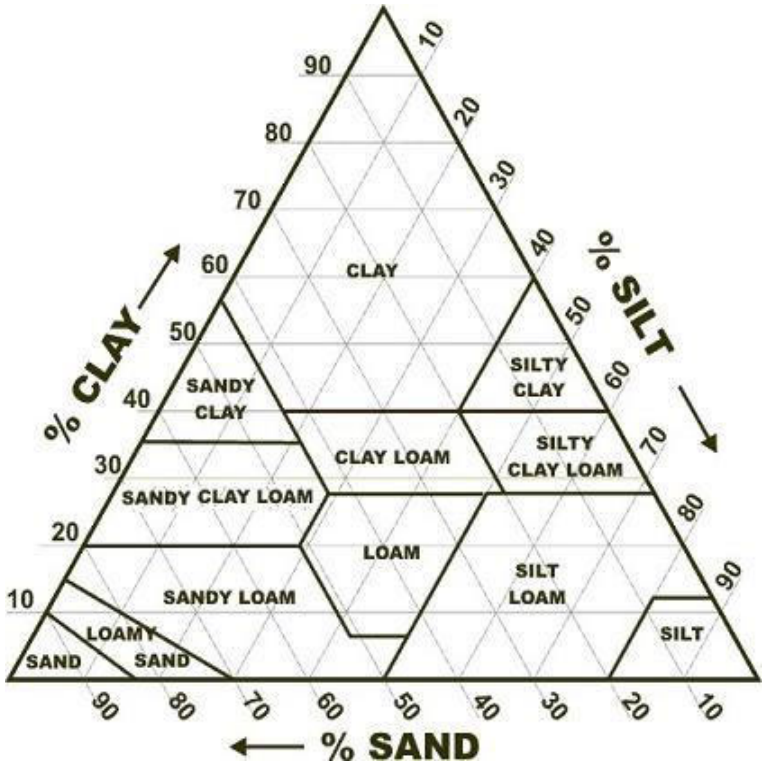
Boring ID	Sample ID	Depth	Sand, %	Silt, %	Clay, %	Classification
SH-TP-107	S3	61-98"	69	27	4	Sandy Loam

Classifications based only on material passing the #10 sieve

Sand: material passing 2.0 mm and retained on 0.05 mm diameter

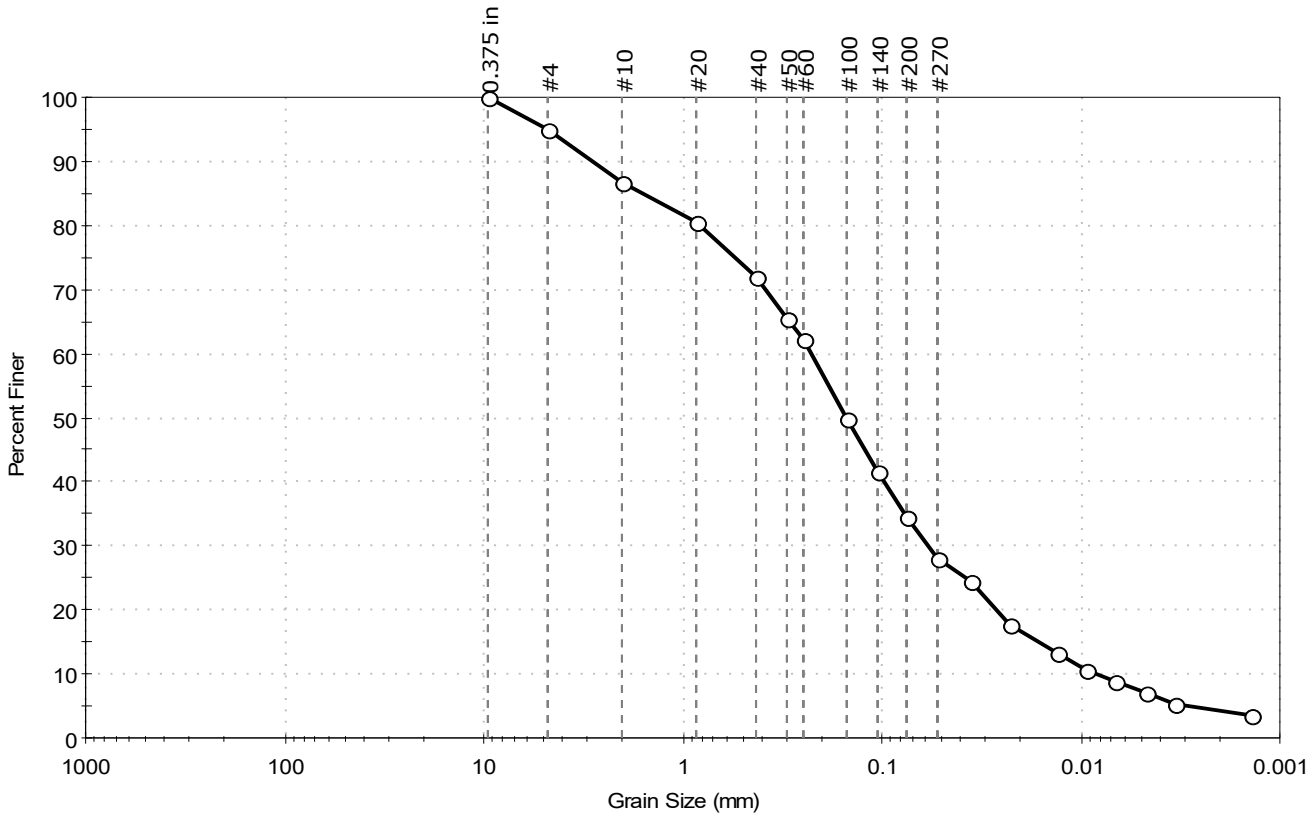
Silt: material passing 0.05 mm and retained on 0.002 mm diameter

Clay: material passing 0.002 mm diameter



Client:	Sanborn, Head & Associates, Inc.				
Project:	Hartford Ave				
Location:	Bellingham, MA			Project No:	GTX-321011
Boring ID:	SH-TP-107	Sample Type:	Bag	Tested By:	ajl
Sample ID:	S3	Test Date:	06/11/25	Checked By:	ank
Depth :	61-98"	Test Id:	818988		
Test Comment:	---				
Visual Description:	Moist, light yellowish brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	5.0	60.4	34.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	95		
#10	2.00	87		
#20	0.85	81		
#40	0.42	72		
#50	0.30	66		
#60	0.25	62		
#100	0.15	50		
#140	0.11	42		
#200	0.075	35		
#270	0.053	28		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0360	25		
---	0.0227	18		
---	0.0133	13		
---	0.0095	11		
---	0.0067	9		
---	0.0048	7		
---	0.0034	5		
---	0.0014	4		

Coefficients

D_{85} = 1.5796 mm D_{30} = 0.0587 mm

D_{60} = 0.2291 mm D_{15} = 0.0166 mm

D_{50} = 0.1515 mm D_{10} = 0.0085 mm

C_u = 26.953 C_c = 1.769

Classification

ASTM N/A

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

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

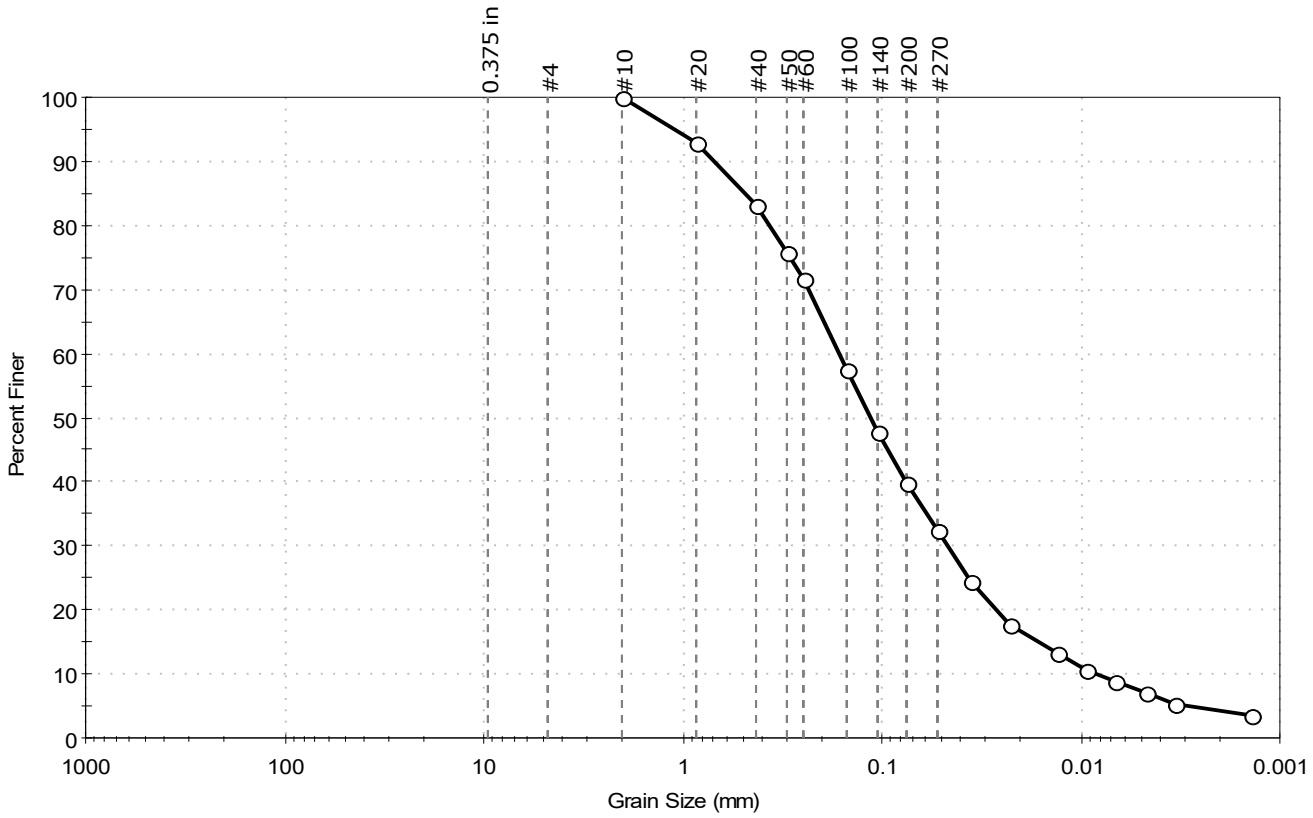
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #270 Sieve

Client:	Sanborn, Head & Associates, Inc.				
Project:	Hartford Ave				
Location:	Bellingham, MA			Project No:	GTX-321011
Boring ID:	SH-TP-107	Sample Type:	Bag	Tested By:	ajl
Sample ID:	S3	Test Date:	06/11/25	Checked By:	ank
Depth :	61-98"	Test Id:	818988		
Test Comment:	Only minus No. 10 sieve for USDA classification				
Visual Description:	Moist, light yellowish brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	0.0	60.1	39.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#10	2.00	100		
#20	0.85	93		
#40	0.42	83		
#50	0.30	76		
#60	0.25	72		
#100	0.15	57		
#140	0.11	48		
#200	0.075	40		
#270	0.053	32		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0360	25		
---	0.0227	18		
---	0.0133	13		
---	0.0095	11		
---	0.0067	9		
---	0.0048	7		
---	0.0034	5		
---	0.0014	4		

Coefficients

D_{85} =0.4867 mm	D_{30} =0.0470 mm
D_{60} =0.1646 mm	D_{15} =0.0166 mm
D_{50} =0.1145 mm	D_{10} =0.0085 mm
C_u =19.365	C_c =1.579

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #270 Sieve

Attachment D

Photograph Log

Attachment D
Photograph Log

Photograph 1: Test pit location SH-TP-101 sidewall.

Photograph 2: Test pit location SH-TP-101 spoils.

Photograph 3: Test pit location SH-TP-102 sidewall.

Photograph 4: Test pit location SH-TP-102 spoils.

Photograph 5: Test pit location SH-TP-103 sidewall.

Photograph 6: Test pit location SH-TP-103 spoils.

Photograph 7: Test pit location SH-TP-104 sidewall.

Photograph 8: Test pit location SH-TP-104 spoils.

Photograph 9: Test pit location SH-TP-105 sidewall.

Photograph 10: Test pit location SH-TP-105 spoils.

Photograph 11: Test pit location SH-TP-106 sidewall.

Photograph 12: Test pit location SH-TP-106 spoils.

Photograph 13: Test pit location SH-TP-107 sidewall.

Photograph 14: Test pit location SH-TP-107 spoils.

APPENDIX D: EXISTING CONDITIONS HYDROLOGIC ANALYSIS

- *EXISTING CONDITIONS DRAINAGE MAP*
- *EXISTING CONDITIONS HYDROCAD COMPUTATIONS*

LEGEND

EXISTING WATERSHED

DESIGN POINT	DP1 / DP1
SUBCATCHMENT ID	ED1.1 / ED1.1
SUBCATCHMENT BOUNDARY	
OVERALL BOUNDARY	
TIME OF CONCENTRATION PATH	
STORMWATER CONTROL MEASURE OR MODELED DRAINAGE STRUCTURE	P1.1 / P1.1
SURFACE OR CULVERT CONVEYANCE	R1.1 / R1.1
SOIL BOUNDARY WITH NRCS MAP UNIT AND HYDROLOGIC SOIL GROUP RATING	MapUnit A

LEGEND

EXISTING COVER TYPES

BUILDING	
PAVEMENT / CONCRETE / WALK / MISC IMPERVIOUS	
GRASS / SOD / LAWN	
GRAVEL	

P:\2024\MAA240490.00\CAD\DRAWINGS\PLAN SETS\DRAINAGE AREA MAPS\P-DMAP-HYDR-MAA240490.00-1A---->LAYOUT: PRED

BOHLER

352 TURNPIKE ROAD, 3rd FLOOR
SOUTHBOROUGH, MA 01772
Phone: (508) 480-9900

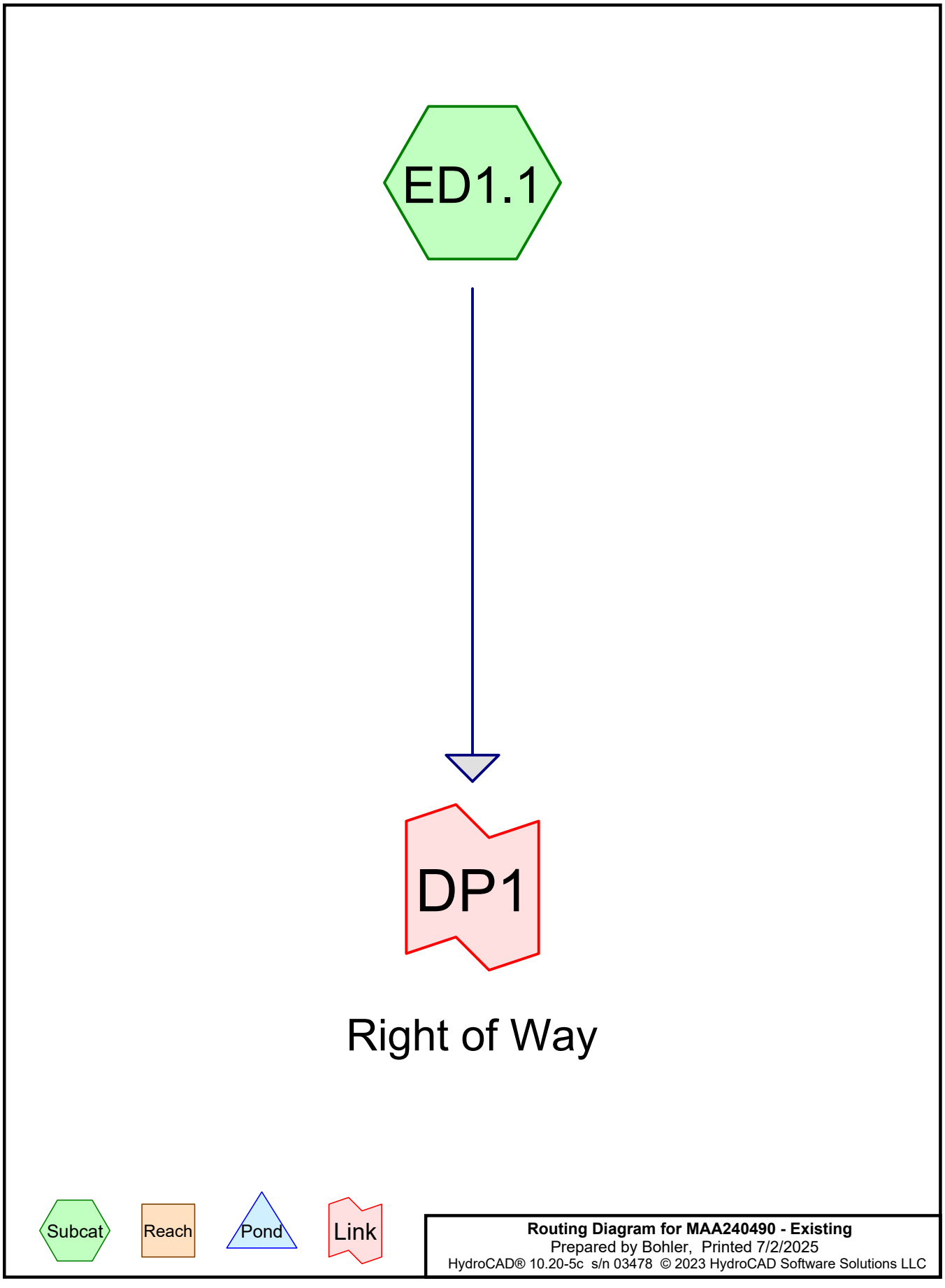
www.BohlerEngineering.com

PREDEVELOPMENT WATERSHED MAP

RTE 85
REALTY CORP
BELLINGHAM, MA 02019

07/01/2025 | CB | MAA240490.00 | REV 1a

60 30 15 0 60
SCALE: 1" = 60'



Routing Diagram for MAA240490 - Existing
Prepared by Bohler, Printed 7/2/2025

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.946	39	>75% Grass cover, Good, HSG A (ED1.1)
0.058	74	>75% Grass cover, Good, HSG C (ED1.1)
0.062	96	Gravel surface, HSG A (ED1.1)
0.003	96	Gravel surface, HSG C (ED1.1)
0.053	98	Unconnected pavement, HSG A (ED1.1)
0.008	98	Unconnected pavement, HSG C (ED1.1)
0.088	98	Unconnected roofs, HSG A (ED1.1)
1.218	**51**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
1.149	HSG A	ED1.1
0.000	HSG B	
0.070	HSG C	ED1.1
0.000	HSG D	
0.000	Other	
1.218		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.946	0.000	0.058	0.000	0.000	1.004	>75% Grass cover, Good	ED1.1
0.062	0.000	0.003	0.000	0.000	0.065	Gravel surface	ED1.1
0.053	0.000	0.008	0.000	0.000	0.061	Unconnected pavement	ED1.1
0.088	0.000	0.000	0.000	0.000	0.088	Unconnected roofs	ED1.1
1.149	**0.000**	**0.070**	**0.000**	**0.000**	**1.218**	**TOTAL AREA**	

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentED1.1: Runoff Area=53,072 sf 12.28% Impervious Runoff Depth=0.32"
Flow Length=305' Tc=12.2 min UI Adjusted CN=48 Runoff=0.14 cfs 0.032 af

Link DP1: Right of Way Inflow=0.14 cfs 0.032 af
Primary=0.14 cfs 0.032 af

Total Runoff Area = 1.218 ac Runoff Volume = 0.032 af Average Runoff Depth = 0.32"
87.72% Pervious = 1.069 ac 12.28% Impervious = 0.150 ac

Summary for Subcatchment ED1.1:

Runoff = 0.14 cfs @ 12.44 hrs, Volume= 0.032 af, Depth= 0.32"
Routed to Link DP1 : Right of Way

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=4.18"

Area (sf)	CN	Adj	Description
3,850	98		Unconnected roofs, HSG A
2,295	98		Unconnected pavement, HSG A
41,188	39		>75% Grass cover, Good, HSG A
2,699	96		Gravel surface, HSG A
370	98		Unconnected pavement, HSG C
2,537	74		>75% Grass cover, Good, HSG C
133	96		Gravel surface, HSG C
53,072	51	48	Weighted Average, UI Adjusted
46,557			87.72% Pervious Area
6,515			12.28% Impervious Area
6,515			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	50	0.0300	0.20		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 4.18"
7.1	211	0.0050	0.49		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.9	39	0.0100	0.70		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
0.0	5	0.0150	2.49		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
12.2	305	Total			

Summary for Link DP1: Right of Way

Inflow Area = 1.218 ac, 12.28% Impervious, Inflow Depth = 0.32" for 2-Year event
Inflow = 0.14 cfs @ 12.44 hrs, Volume= 0.032 af
Primary = 0.14 cfs @ 12.44 hrs, Volume= 0.032 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentED1.1: Runoff Area=53,072 sf 12.28% Impervious Runoff Depth=1.26"
Flow Length=305' Tc=12.2 min UI Adjusted CN=48 Runoff=1.15 cfs 0.128 af

Link DP1: Right of Way Inflow=1.15 cfs 0.128 af
Primary=1.15 cfs 0.128 af

Total Runoff Area = 1.218 ac Runoff Volume = 0.128 af Average Runoff Depth = 1.26"
87.72% Pervious = 1.069 ac 12.28% Impervious = 0.150 ac

Summary for Subcatchment ED1.1:

Runoff = 1.15 cfs @ 12.21 hrs, Volume= 0.128 af, Depth= 1.26"
Routed to Link DP1 : Right of Way

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=6.55"

Area (sf)	CN	Adj	Description
3,850	98		Unconnected roofs, HSG A
2,295	98		Unconnected pavement, HSG A
41,188	39		>75% Grass cover, Good, HSG A
2,699	96		Gravel surface, HSG A
370	98		Unconnected pavement, HSG C
2,537	74		>75% Grass cover, Good, HSG C
133	96		Gravel surface, HSG C
53,072	51	48	Weighted Average, UI Adjusted
46,557			87.72% Pervious Area
6,515			12.28% Impervious Area
6,515			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	50	0.0300	0.20		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 4.18"
7.1	211	0.0050	0.49		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.9	39	0.0100	0.70		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
0.0	5	0.0150	2.49		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
12.2	305	Total			

Summary for Link DP1: Right of Way

Inflow Area = 1.218 ac, 12.28% Impervious, Inflow Depth = 1.26" for 10-Year event
Inflow = 1.15 cfs @ 12.21 hrs, Volume= 0.128 af
Primary = 1.15 cfs @ 12.21 hrs, Volume= 0.128 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentED1.1: Runoff Area=53,072 sf 12.28% Impervious Runoff Depth=2.29"
Flow Length=305' Tc=12.2 min UI Adjusted CN=48 Runoff=2.38 cfs 0.232 af

Link DP1: Right of Way Inflow=2.38 cfs 0.232 af
Primary=2.38 cfs 0.232 af

Total Runoff Area = 1.218 ac Runoff Volume = 0.232 af Average Runoff Depth = 2.29"
87.72% Pervious = 1.069 ac 12.28% Impervious = 0.150 ac

Summary for Subcatchment ED1.1:

Runoff = 2.38 cfs @ 12.19 hrs, Volume= 0.232 af, Depth= 2.29"
Routed to Link DP1 : Right of Way

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=8.42"

Area (sf)	CN	Adj	Description
3,850	98		Unconnected roofs, HSG A
2,295	98		Unconnected pavement, HSG A
41,188	39		>75% Grass cover, Good, HSG A
2,699	96		Gravel surface, HSG A
370	98		Unconnected pavement, HSG C
2,537	74		>75% Grass cover, Good, HSG C
133	96		Gravel surface, HSG C
53,072	51	48	Weighted Average, UI Adjusted
46,557			87.72% Pervious Area
6,515			12.28% Impervious Area
6,515			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	50	0.0300	0.20		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 4.18"
7.1	211	0.0050	0.49		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.9	39	0.0100	0.70		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
0.0	5	0.0150	2.49		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
12.2	305	Total			

Summary for Link DP1: Right of Way

Inflow Area = 1.218 ac, 12.28% Impervious, Inflow Depth = 2.29" for 25-Year event
Inflow = 2.38 cfs @ 12.19 hrs, Volume= 0.232 af
Primary = 2.38 cfs @ 12.19 hrs, Volume= 0.232 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentED1.1: Runoff Area=53,072 sf 12.28% Impervious Runoff Depth=4.32"
Flow Length=305' Tc=12.2 min UI Adjusted CN=48 Runoff=4.81 cfs 0.439 af

Link DP1: Right of Way Inflow=4.81 cfs 0.439 af
Primary=4.81 cfs 0.439 af

Total Runoff Area = 1.218 ac Runoff Volume = 0.439 af Average Runoff Depth = 4.32"
87.72% Pervious = 1.069 ac 12.28% Impervious = 0.150 ac

Summary for Subcatchment ED1.1:

Runoff = 4.81 cfs @ 12.18 hrs, Volume= 0.439 af, Depth= 4.32"
Routed to Link DP1 : Right of Way

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=11.50"

Area (sf)	CN	Adj	Description
3,850	98		Unconnected roofs, HSG A
2,295	98		Unconnected pavement, HSG A
41,188	39		>75% Grass cover, Good, HSG A
2,699	96		Gravel surface, HSG A
370	98		Unconnected pavement, HSG C
2,537	74		>75% Grass cover, Good, HSG C
133	96		Gravel surface, HSG C
53,072	51	48	Weighted Average, UI Adjusted
46,557			87.72% Pervious Area
6,515			12.28% Impervious Area
6,515			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	50	0.0300	0.20		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 4.18"
7.1	211	0.0050	0.49		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.9	39	0.0100	0.70		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
0.0	5	0.0150	2.49		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
12.2	305	Total			

Summary for Link DP1: Right of Way

Inflow Area = 1.218 ac, 12.28% Impervious, Inflow Depth = 4.32" for 100-Year event
Inflow = 4.81 cfs @ 12.18 hrs, Volume= 0.439 af
Primary = 4.81 cfs @ 12.18 hrs, Volume= 0.439 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

APPENDIX E: PROPOSED CONDITIONS HYDROLOGIC ANALYSIS

- *PROPOSED CONDITIONS DRAINAGE MAP*
- *PROPOSED CONDITIONS HYDROCAD CALCULATIONS*

LEGEND

PROPOSED WATERSHED

DESIGN POINT	DP1 / DP1
SUBCATCHMENT ID	PD1.1 PD1.1
SUBCATCHMENT BOUNDARY	
OVERALL BOUNDARY	
TIME OF CONCENTRATION PATH	
STORMWATER CONTROL MEASURE OR MODELED DRAINAGE STRUCTURE	P1.1 P1.1
SURFACE OR CULVERT CONVEYANCE	R1.1 R1.1
SOIL BOUNDARY WITH NRCS MAP UNIT AND HYDROLOGIC SOIL GROUP RATING	MapUnit A

LEGEND

PROPOSED COVER TYPES

BUILDING	
PAVEMENT / CONCRETE / WALK / MISC IMPERVIOUS	
GRASS / SOD / LAWN	

P:\2024\MAA240490.00\CAD\DRAWINGS\PLAN SETS\DRAINAGE AREA MAPS\P-DMAP-HYDR-MAA240490.00-1A----->LAYOUT: PSTD

BOHLER //

352 TURNPIKE ROAD, 3rd FLOOR
SOUTHBOROUGH, MA 01772
Phone: (508) 480-9900

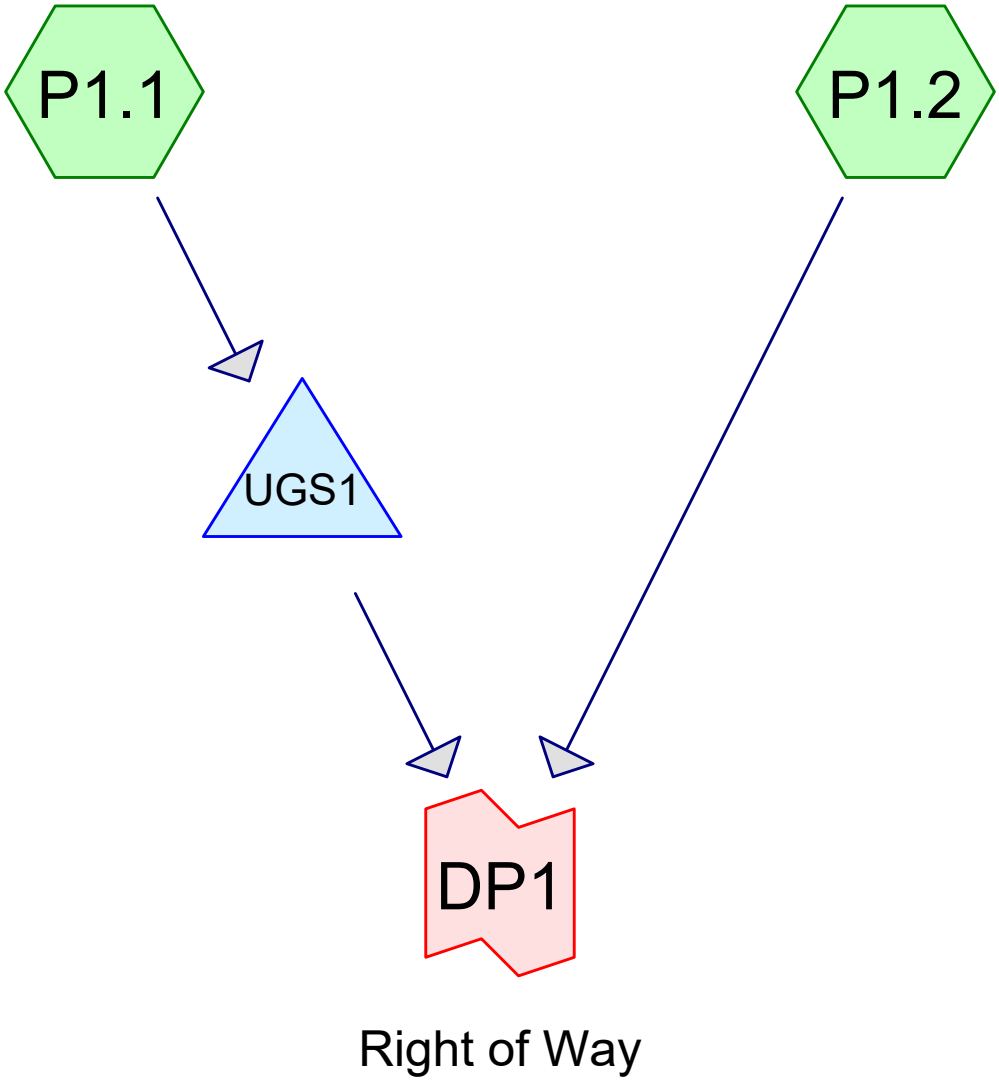
www.BohlerEngineering.com

POST-DEVELOPMENT WATERSHED MAP

RTE 85
REALTY CORP.
BELLINGHAM, MA 02019

07/01/2025 | CB | MAA240490.00 | REV 1a

60 30 15 0 60
SCALE: 1" = 60'



Right of Way

Subcat Reach Pond Link

Routing Diagram for MAA240490 - Proposed
Prepared by Bohler Engineering, PC, Printed 9/25/2025

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.432	39	>75% Grass cover, Good, HSG A (P1.1, P1.2)
0.029	74	>75% Grass cover, Good, HSG C (P1.1, P1.2)
0.602	98	Unconnected pavement, HSG A (P1.1, P1.2)
0.041	98	Unconnected pavement, HSG C (P1.1, P1.2)
0.115	98	Unconnected roofs, HSG A (P1.1)
1.218	**77**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
1.149	HSG A	P1.1, P1.2
0.000	HSG B	
0.070	HSG C	P1.1, P1.2
0.000	HSG D	
0.000	Other	
1.218		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.432	0.000	0.029	0.000	0.000	0.461	>75% Grass cover, Good	P1.1, P1.2
0.602	0.000	0.041	0.000	0.000	0.643	Unconnected pavement	P1.1, P1.2
0.115	0.000	0.000	0.000	0.000	0.115	Unconnected roofs	P1.1
1.149	**0.000**	**0.070**	**0.000**	**0.000**	**1.218**	**TOTAL AREA**	

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentP1.1: Runoff Area=37,152 sf 81.08% Impervious Runoff Depth=0.22"
Tc=6.0 min CN=87 Runoff=0.19 cfs 0.016 af

SubcatchmentP1.2: Runoff Area=15,920 sf 18.08% Impervious Runoff Depth=0.00"
Tc=6.0 min UI Adjusted CN=46 Runoff=0.00 cfs 0.000 af

Pond UGS1: Peak Elev=266.80' Storage=0.000 af Inflow=0.19 cfs 0.016 af
Discarded=0.19 cfs 0.016 af Primary=0.00 cfs 0.000 af Outflow=0.19 cfs 0.016 af

Link DP1: Right of Way Inflow=0.00 cfs 0.000 af
Primary=0.00 cfs 0.000 af

Total Runoff Area = 1.218 ac Runoff Volume = 0.016 af Average Runoff Depth = 0.16"
37.82% Pervious = 0.461 ac 62.18% Impervious = 0.758 ac

Summary for Subcatchment P1.1:

Runoff = 0.19 cfs @ 12.11 hrs, Volume= 0.016 af, Depth= 0.22"
Routed to Pond UGS1 :

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 1-inch Rainfall=1.00"

Area (sf)	CN	Description
5,000	98	Unconnected roofs, HSG A
23,824	98	Unconnected pavement, HSG A
6,525	39	>75% Grass cover, Good, HSG A
1,300	98	Unconnected pavement, HSG C
503	74	>75% Grass cover, Good, HSG C
37,152	87	Weighted Average
7,028		18.92% Pervious Area
30,124		81.08% Impervious Area
30,124		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment P1.2:

Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"
Routed to Link DP1 : Right of Way

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 1-inch Rainfall=1.00"

Area (sf)	CN	Adj	Description
2,383	98		Unconnected pavement, HSG A
12,300	39		>75% Grass cover, Good, HSG A
495	98		Unconnected pavement, HSG C
742	74		>75% Grass cover, Good, HSG C
15,920	51	46	Weighted Average, UI Adjusted
13,042			81.92% Pervious Area
2,878			18.08% Impervious Area
2,878			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Pond UGS1:

Inflow Area = 0.853 ac, 81.08% Impervious, Inflow Depth = 0.22" for 1-inch event
Inflow = 0.19 cfs @ 12.11 hrs, Volume= 0.016 af
Outflow = 0.19 cfs @ 12.11 hrs, Volume= 0.016 af, Atten= 0%, Lag= 0.0 min
Discarded = 0.19 cfs @ 12.11 hrs, Volume= 0.016 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Link DP1 : Right of Way

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 266.80' @ 12.10 hrs Surf.Area= 0.116 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (884.5 - 884.5)

Volume	Invert	Avail.Storage	Storage Description
#1A	266.80'	0.103 af	**49.00'W x 103.30'L x 3.50'H Field A** 0.407 af Overall - 0.149 af Embedded = 0.258 af x 40.0% Voids
#2A	267.30'	0.149 af	**ADS_StormTech SC-740 b +Cap** x 140 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 140 Chambers in 10 Rows Cap Storage= 2.7 cf x 2 x 10 rows = 53.1 cf
		0.252 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	266.80'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	267.30'	**12.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 267.30' / 266.80' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#3	Device 2	269.50'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Device 2	268.10'	**15.0" W x 4.0" H Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.28 cfs @ 12.11 hrs HW=266.80' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.28 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=266.80' TW=0.00' (Dynamic Tailwater)
└**2=Culvert** (Controls 0.00 cfs)
  ├**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)
  └**4=Orifice/Grate** (Controls 0.00 cfs)

Summary for Link DP1: Right of Way

Inflow Area = 1.218 ac, 62.18% Impervious, Inflow Depth = 0.00" for 1-inch event
Inflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentP1.1: Runoff Area=37,152 sf 81.08% Impervious Runoff Depth=2.80"
Tc=6.0 min CN=87 Runoff=2.72 cfs 0.199 af

SubcatchmentP1.2: Runoff Area=15,920 sf 18.08% Impervious Runoff Depth=0.25"
Tc=6.0 min UI Adjusted CN=46 Runoff=0.03 cfs 0.008 af

Pond UGS1: Peak Elev=267.79' Storage=0.071 af Inflow=2.72 cfs 0.199 af
Discarded=0.28 cfs 0.199 af Primary=0.00 cfs 0.000 af Outflow=0.28 cfs 0.199 af

Link DP1: Right of Way Inflow=0.03 cfs 0.008 af
Primary=0.03 cfs 0.008 af

Total Runoff Area = 1.218 ac Runoff Volume = 0.207 af Average Runoff Depth = 2.04"
37.82% Pervious = 0.461 ac 62.18% Impervious = 0.758 ac

Summary for Subcatchment P1.1:

Runoff = 2.72 cfs @ 12.09 hrs, Volume= 0.199 af, Depth= 2.80"
Routed to Pond UGS1 :

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=4.18"

Area (sf)	CN	Description
5,000	98	Unconnected roofs, HSG A
23,824	98	Unconnected pavement, HSG A
6,525	39	>75% Grass cover, Good, HSG A
1,300	98	Unconnected pavement, HSG C
503	74	>75% Grass cover, Good, HSG C
37,152	87	Weighted Average
7,028		18.92% Pervious Area
30,124		81.08% Impervious Area
30,124		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment P1.2:

Runoff = 0.03 cfs @ 12.39 hrs, Volume= 0.008 af, Depth= 0.25"
Routed to Link DP1 : Right of Way

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=4.18"

Area (sf)	CN	Adj	Description
2,383	98		Unconnected pavement, HSG A
12,300	39		>75% Grass cover, Good, HSG A
495	98		Unconnected pavement, HSG C
742	74		>75% Grass cover, Good, HSG C
15,920	51	46	Weighted Average, UI Adjusted
13,042			81.92% Pervious Area
2,878			18.08% Impervious Area
2,878			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Pond UGS1:

Inflow Area = 0.853 ac, 81.08% Impervious, Inflow Depth = 2.80" for 2-Year event
Inflow = 2.72 cfs @ 12.09 hrs, Volume= 0.199 af
Outflow = 0.28 cfs @ 11.75 hrs, Volume= 0.199 af, Atten= 90%, Lag= 0.0 min
Discarded = 0.28 cfs @ 11.75 hrs, Volume= 0.199 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Link DP1 : Right of Way

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 267.79' @ 12.91 hrs Surf.Area= 0.116 ac Storage= 0.071 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 84.2 min (892.3 - 808.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	266.80'	0.103 af	**49.00'W x 103.30'L x 3.50'H Field A** 0.407 af Overall - 0.149 af Embedded = 0.258 af x 40.0% Voids
#2A	267.30'	0.149 af	**ADS_StormTech SC-740 b +Cap** x 140 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 140 Chambers in 10 Rows Cap Storage= 2.7 cf x 2 x 10 rows = 53.1 cf
		0.252 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	266.80'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	267.30'	**12.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 267.30' / 266.80' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#3	Device 2	269.50'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Device 2	268.10'	**15.0" W x 4.0" H Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.28 cfs @ 11.75 hrs HW=266.85' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.28 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=266.80' TW=0.00' (Dynamic Tailwater)
└**2=Culvert** (Controls 0.00 cfs)
  ├**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)
  └**4=Orifice/Grate** (Controls 0.00 cfs)

Summary for Link DP1: Right of Way

Inflow Area = 1.218 ac, 62.18% Impervious, Inflow Depth = 0.07" for 2-Year event
Inflow = 0.03 cfs @ 12.39 hrs, Volume= 0.008 af
Primary = 0.03 cfs @ 12.39 hrs, Volume= 0.008 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentP1.1: Runoff Area=37,152 sf 81.08% Impervious Runoff Depth=5.05"
Tc=6.0 min CN=87 Runoff=4.77 cfs 0.359 af

SubcatchmentP1.2: Runoff Area=15,920 sf 18.08% Impervious Runoff Depth=1.11"
Tc=6.0 min UI Adjusted CN=46 Runoff=0.34 cfs 0.034 af

Pond UGS1: Peak Elev=268.43' Storage=0.130 af Inflow=4.77 cfs 0.359 af
Discarded=0.28 cfs 0.303 af Primary=0.76 cfs 0.056 af Outflow=1.04 cfs 0.359 af

Link DP1: Right of Way Inflow=0.90 cfs 0.089 af
Primary=0.90 cfs 0.089 af

Total Runoff Area = 1.218 ac Runoff Volume = 0.392 af Average Runoff Depth = 3.86"
37.82% Pervious = 0.461 ac 62.18% Impervious = 0.758 ac

Summary for Subcatchment P1.1:

Runoff = 4.77 cfs @ 12.09 hrs, Volume= 0.359 af, Depth= 5.05"
Routed to Pond UGS1 :

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=6.55"

Area (sf)	CN	Description
5,000	98	Unconnected roofs, HSG A
23,824	98	Unconnected pavement, HSG A
6,525	39	>75% Grass cover, Good, HSG A
1,300	98	Unconnected pavement, HSG C
503	74	>75% Grass cover, Good, HSG C
37,152	87	Weighted Average
7,028		18.92% Pervious Area
30,124		81.08% Impervious Area
30,124		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment P1.2:

Runoff = 0.34 cfs @ 12.12 hrs, Volume= 0.034 af, Depth= 1.11"
Routed to Link DP1 : Right of Way

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=6.55"

Area (sf)	CN	Adj	Description
2,383	98		Unconnected pavement, HSG A
12,300	39		>75% Grass cover, Good, HSG A
495	98		Unconnected pavement, HSG C
742	74		>75% Grass cover, Good, HSG C
15,920	51	46	Weighted Average, UI Adjusted
13,042			81.92% Pervious Area
2,878			18.08% Impervious Area
2,878			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Pond UGS1:

Inflow Area = 0.853 ac, 81.08% Impervious, Inflow Depth = 5.05" for 10-Year event
Inflow = 4.77 cfs @ 12.09 hrs, Volume= 0.359 af
Outflow = 1.04 cfs @ 12.51 hrs, Volume= 0.359 af, Atten= 78%, Lag= 25.0 min
Discarded = 0.28 cfs @ 11.40 hrs, Volume= 0.303 af
Primary = 0.76 cfs @ 12.51 hrs, Volume= 0.056 af
Routed to Link DP1 : Right of Way

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 268.43' @ 12.51 hrs Surf.Area= 0.116 ac Storage= 0.130 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 119.8 min (911.4 - 791.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	266.80'	0.103 af	**49.00'W x 103.30'L x 3.50'H Field A** 0.407 af Overall - 0.149 af Embedded = 0.258 af x 40.0% Voids
#2A	267.30'	0.149 af	**ADS_StormTech SC-740 b +Cap** x 140 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 140 Chambers in 10 Rows Cap Storage= 2.7 cf x 2 x 10 rows = 53.1 cf
		0.252 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	266.80'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	267.30'	**12.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 267.30' / 266.80' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#3	Device 2	269.50'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Device 2	268.10'	**15.0" W x 4.0" H Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.28 cfs @ 11.40 hrs HW=266.85' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.28 cfs)

Primary OutFlow Max=0.75 cfs @ 12.51 hrs HW=268.43' TW=0.00' (Dynamic Tailwater)
└**2=Culvert** (Passes 0.75 cfs of 2.37 cfs potential flow)
  ├**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)
  └**4=Orifice/Grate** (Orifice Controls 0.75 cfs @ 1.84 fps)

Summary for Link DP1: Right of Way

Inflow Area = 1.218 ac, 62.18% Impervious, Inflow Depth = 0.88" for 10-Year event
Inflow = 0.90 cfs @ 12.47 hrs, Volume= 0.089 af
Primary = 0.90 cfs @ 12.47 hrs, Volume= 0.089 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentP1.1: Runoff Area=37,152 sf 81.08% Impervious Runoff Depth=6.86"
Tc=6.0 min CN=87 Runoff=6.37 cfs 0.488 af

SubcatchmentP1.2: Runoff Area=15,920 sf 18.08% Impervious Runoff Depth=2.07"
Tc=6.0 min UI Adjusted CN=46 Runoff=0.77 cfs 0.063 af

Pond UGS1: Peak Elev=268.84' Storage=0.165 af Inflow=6.37 cfs 0.488 af
Discarded=0.28 cfs 0.347 af Primary=1.52 cfs 0.140 af Outflow=1.80 cfs 0.488 af

Link DP1: Right of Way Inflow=1.87 cfs 0.203 af
Primary=1.87 cfs 0.203 af

Total Runoff Area = 1.218 ac Runoff Volume = 0.551 af Average Runoff Depth = 5.42"
37.82% Pervious = 0.461 ac 62.18% Impervious = 0.758 ac

Summary for Subcatchment P1.1:

Runoff = 6.37 cfs @ 12.09 hrs, Volume= 0.488 af, Depth= 6.86"
Routed to Pond UGS1 :

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=8.42"

Area (sf)	CN	Description
5,000	98	Unconnected roofs, HSG A
23,824	98	Unconnected pavement, HSG A
6,525	39	>75% Grass cover, Good, HSG A
1,300	98	Unconnected pavement, HSG C
503	74	>75% Grass cover, Good, HSG C
37,152	87	Weighted Average
7,028		18.92% Pervious Area
30,124		81.08% Impervious Area
30,124		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment P1.2:

Runoff = 0.77 cfs @ 12.11 hrs, Volume= 0.063 af, Depth= 2.07"
Routed to Link DP1 : Right of Way

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=8.42"

Area (sf)	CN	Adj	Description
2,383	98		Unconnected pavement, HSG A
12,300	39		>75% Grass cover, Good, HSG A
495	98		Unconnected pavement, HSG C
742	74		>75% Grass cover, Good, HSG C
15,920	51	46	Weighted Average, UI Adjusted
13,042			81.92% Pervious Area
2,878			18.08% Impervious Area
2,878			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Pond UGS1:

Inflow Area = 0.853 ac, 81.08% Impervious, Inflow Depth = 6.86" for 25-Year event
Inflow = 6.37 cfs @ 12.09 hrs, Volume= 0.488 af
Outflow = 1.80 cfs @ 12.43 hrs, Volume= 0.488 af, Atten= 72%, Lag= 20.6 min
Discarded = 0.28 cfs @ 10.80 hrs, Volume= 0.347 af
Primary = 1.52 cfs @ 12.43 hrs, Volume= 0.140 af
Routed to Link DP1 : Right of Way

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 268.84' @ 12.43 hrs Surf.Area= 0.116 ac Storage= 0.165 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 107.3 min (890.6 - 783.3)

Volume	Invert	Avail.Storage	Storage Description
#1A	266.80'	0.103 af	**49.00'W x 103.30'L x 3.50'H Field A** 0.407 af Overall - 0.149 af Embedded = 0.258 af x 40.0% Voids
#2A	267.30'	0.149 af	**ADS_StormTech SC-740 b +Cap** x 140 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 140 Chambers in 10 Rows Cap Storage= 2.7 cf x 2 x 10 rows = 53.1 cf
		0.252 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	266.80'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	267.30'	**12.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 267.30' / 266.80' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#3	Device 2	269.50'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Device 2	268.10'	**15.0" W x 4.0" H Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.28 cfs @ 10.80 hrs HW=266.84' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.28 cfs)

Primary OutFlow Max=1.52 cfs @ 12.43 hrs HW=268.84' TW=0.00' (Dynamic Tailwater)
└**2=Culvert** (Passes 1.52 cfs of 3.05 cfs potential flow)
  ├**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)
  └**4=Orifice/Grate** (Orifice Controls 1.52 cfs @ 3.64 fps)

Summary for Link DP1: Right of Way

Inflow Area = 1.218 ac, 62.18% Impervious, Inflow Depth = 2.00" for 25-Year event
Inflow = 1.87 cfs @ 12.34 hrs, Volume= 0.203 af
Primary = 1.87 cfs @ 12.34 hrs, Volume= 0.203 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentP1.1: Runoff Area=37,152 sf 81.08% Impervious Runoff Depth=9.88"
Tc=6.0 min CN=87 Runoff=8.99 cfs 0.702 af

SubcatchmentP1.2: Runoff Area=15,920 sf 18.08% Impervious Runoff Depth=4.01"
Tc=6.0 min UI Adjusted CN=46 Runoff=1.62 cfs 0.122 af

Pond UGS1: Peak Elev=269.71' Storage=0.224 af Inflow=8.99 cfs 0.702 af
Discarded=0.28 cfs 0.406 af Primary=3.65 cfs 0.297 af Outflow=3.94 cfs 0.703 af

Link DP1: Right of Way Inflow=4.56 cfs 0.419 af
Primary=4.56 cfs 0.419 af

Total Runoff Area = 1.218 ac Runoff Volume = 0.825 af Average Runoff Depth = 8.12"
37.82% Pervious = 0.461 ac 62.18% Impervious = 0.758 ac

Summary for Subcatchment P1.1:

Runoff = 8.99 cfs @ 12.09 hrs, Volume= 0.702 af, Depth= 9.88"
Routed to Pond UGS1 :

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=11.50"

Area (sf)	CN	Description
5,000	98	Unconnected roofs, HSG A
23,824	98	Unconnected pavement, HSG A
6,525	39	>75% Grass cover, Good, HSG A
1,300	98	Unconnected pavement, HSG C
503	74	>75% Grass cover, Good, HSG C
37,152	87	Weighted Average
7,028		18.92% Pervious Area
30,124		81.08% Impervious Area
30,124		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment P1.2:

Runoff = 1.62 cfs @ 12.10 hrs, Volume= 0.122 af, Depth= 4.01"
Routed to Link DP1 : Right of Way

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=11.50"

Area (sf)	CN	Adj	Description
2,383	98		Unconnected pavement, HSG A
12,300	39		>75% Grass cover, Good, HSG A
495	98		Unconnected pavement, HSG C
742	74		>75% Grass cover, Good, HSG C
15,920	51	46	Weighted Average, UI Adjusted
13,042			81.92% Pervious Area
2,878			18.08% Impervious Area
2,878			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5-minute minimum**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Pond UGS1:

Inflow Area = 0.853 ac, 81.08% Impervious, Inflow Depth = 9.88" for 100-Year event
Inflow = 8.99 cfs @ 12.09 hrs, Volume= 0.702 af
Outflow = 3.94 cfs @ 12.28 hrs, Volume= 0.703 af, Atten= 56%, Lag= 11.8 min
Discarded = 0.28 cfs @ 9.80 hrs, Volume= 0.406 af
Primary = 3.65 cfs @ 12.28 hrs, Volume= 0.297 af
Routed to Link DP1 : Right of Way

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 269.71' @ 12.28 hrs Surf.Area= 0.116 ac Storage= 0.224 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 97.9 min (871.9 - 774.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	266.80'	0.103 af	**49.00'W x 103.30'L x 3.50'H Field A** 0.407 af Overall - 0.149 af Embedded = 0.258 af x 40.0% Voids
#2A	267.30'	0.149 af	**ADS_StormTech SC-740 b +Cap** x 140 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 140 Chambers in 10 Rows Cap Storage= 2.7 cf x 2 x 10 rows = 53.1 cf
		0.252 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	266.80'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	267.30'	**12.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 267.30' / 266.80' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#3	Device 2	269.50'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Device 2	268.10'	**15.0" W x 4.0" H Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.28 cfs @ 9.80 hrs HW=266.84' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.28 cfs)

Primary OutFlow Max=3.62 cfs @ 12.28 hrs HW=269.71' TW=0.00' (Dynamic Tailwater)
└**2=Culvert** (Passes 3.62 cfs of 4.12 cfs potential flow)
  ├**3=Sharp-Crested Rectangular Weir** (Weir Controls 1.21 cfs @ 1.48 fps)
  └**4=Orifice/Grate** (Orifice Controls 2.41 cfs @ 5.77 fps)

Summary for Link DP1: Right of Way

Inflow Area = 1.218 ac, 62.18% Impervious, Inflow Depth = 4.13" for 100-Year event
Inflow = 4.56 cfs @ 12.27 hrs, Volume= 0.419 af
Primary = 4.56 cfs @ 12.27 hrs, Volume= 0.419 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

APPENDIX F: STORMWATER CALCULATIONS

- *MA STANDARD #3 – RECHARGE AND DRAWDOWN TIME*
- *MA STANDARD #4 – WATER QUALITY AND TSS REMOVAL*
- *NOAA RAINFALL DATA*

Proposed Retail Development
190, 194 & 198 Hartford Avenue
Bellingham, MA
Bohler Job Number: MAA240490.00
July 1, 2025

MA DEP Standard 3: Recharge Volume Calculations

Required Recharge Volume - A Soils (0.60 in.)	
Existing Site Impervious Area (ac)	0.196
Proposed Site Impervious Area (ac)	0.716
Proposed Increase in Site Impervious Area (ac)	0.521
Recharge Volume Required (cf)	**1,134**

Required Recharge Volume - C Soils (0.25 in.)	
Existing Site Impervious Area (ac)	0.010
Proposed Site Impervious Area (ac)	0.041
Proposed Increase in Site Impervious Area (ac)	0.032
Recharge Volume Required (cf)	**29**

Total Recharge Volume Required (cf)	**1,163**

Recharge Volume Adjustment Factor	
Impervious Area Directed to Infiltration BMP (ac)	**0.692**
%Impervious Directed to Infiltration BMP	91%
Adjustment Factor	1.10
Adjusted Total Recharge Volume Required (cf)	**1,274**

Provided Recharge Volume*	
UGS1	4,356
Total Recharge Volume Provided (cf)	**4,356**

Provided greater than or Equal to Required

*Volume provided below lowest outlet in cubic feet (cf)

Prepared By:
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MA DEP Standard 3: Drawdown Time Calculations

Drawdown Time - UGS1	
Volume below outlet pipe (Rv) (cf)	4,356
Soil Type	Loamy Sand - A
Infiltration rate (K)*	2.41
Bottom Area (sf)	5,062
Drawdown time (Hours)*	**4.3**

*Infiltration Rates taken from Rawls Table
**Drawdown time = Rv / (K) x (bottom area)

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MA DEP Standard 4: Water Quality Volume Calculations

Water Quality Volume Required	
Water Quality Volume runoff (in.)*	1.0
Total Post Development Impervious Area (sf)	33,002
Required Water Quality Volume (cf)	**2,750**
*Water Quality volume runoff is equal to 1.0 inches of runoff times the total impervious area of the post development project site.	

Water Quality Volume Provided*	
UGS1	4,356
Total Provided Water Quality Volume (cf)	**4,356**

Required Water Quality Volume Provided

*Volume provided below lowest outlet pipe in cubic feet (cf)

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July 1, 2025
1" Water Quality Volume to Flow Rate Calculation Sheet

Compute Water Quality Flow with the following Equation

WQF = (qu)(A)(WQV)

Site Plan Callout		qu (from 1" - qu Table)	Impervious Area (SF)	Ai (sq/mi)	WQV (inches)		WQF (cfs)
UGS1 Isolator Row	=	774	30124	0.001081	1	=	**0.84**

Water Quality Flow Rate =	WQF
Water Quality Volume =	WQV*
Unit peak discharge (csm/in) =	qu**
Impervious Area in watershed (square miles) =	Ai

*WQV is expressed in watershed inches (you must use 1.0-inches in all cases with this method and not 0.5-inches)
** calculate the qu based on the time of concentration (see 1" - qu Table)

Infiltration Basin #1 Isolator row sizing

Maximum treatment flow rate - SC-740 Chamber*	0.256 cfs
Number of chambers in Isolator Row	14
WQF provided by isolator row =	3.58 cfs

*Per NJCAT Technology Verifaction, Isolator Row Plus, StormTech, LLC, July 2020

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July 1, 2025

MA DEP Standard 4: TSS Removal Calculation Worksheet

BMP Treatment Train: CB to UGS1

A BMP	B TSS Removal Rate	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep-Sump, Hooded Catch Basins	**0.25**	**1.00**	**0.25**	**0.75**
Underground Infiltration System with Isolator Row	**0.80**	**0.75**	**0.60**	**0.15**
		Total TSS Removal =	**85%**	

*Equals remaining load from previous BMP (E) which enters BMP

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Stage-Area-Storage for Pond UGS1:

Elevation (feet)	Surface (acres)	Storage (acre-feet)	Elevation (feet)	Surface (acres)	Storage (acre-feet)
266.80	**0.116**	0.000	269.40	0.116	0.207
266.85	0.116	0.002	269.45	0.116	0.210
266.90	0.116	0.005	269.50	0.116	0.213
266.95	0.116	0.007	269.55	0.116	0.216
267.00	0.116	0.009	269.60	0.116	0.219
267.05	0.116	0.012	269.65	0.116	0.221
267.10	0.116	0.014	269.70	0.116	0.224
267.15	0.116	0.016	269.75	0.116	0.226
267.20	0.116	0.019	269.80	0.116	0.229
267.25	0.116	0.021	269.85	0.116	0.231
267.30	0.116	0.023	269.90	0.116	0.233
267.35	0.116	0.028	269.95	0.116	0.236
267.40	0.116	0.033	270.00	0.116	0.238
267.45	0.116	0.038	270.05	0.116	0.240
267.50	0.116	0.043	270.10	0.116	0.243
267.55	0.116	0.048	270.15	0.116	0.245
267.60	0.116	0.052	270.20	0.116	0.247
267.65	0.116	0.057	270.25	0.116	0.250
267.70	0.116	0.062	270.30	0.116	**0.252**
267.75	0.116	0.067			
267.80	0.116	0.072			
267.85	0.116	0.076			
267.90	0.116	0.081			
267.95	0.116	0.086			
268.00	0.116	0.091			
268.05	0.116	0.095			
268.10	0.116	0.100			
268.15	0.116	0.104			
268.20	0.116	0.109			
268.25	0.116	0.114			
268.30	0.116	0.118			
268.35	0.116	0.123			
268.40	0.116	0.127			
268.45	0.116	0.132			
268.50	0.116	0.136			
268.55	0.116	0.140			
268.60	0.116	0.145			
268.65	0.116	0.149			
268.70	0.116	0.153			
268.75	0.116	0.157			
268.80	0.116	0.161			
268.85	0.116	0.166			
268.90	0.116	0.170			
268.95	0.116	0.174			
269.00	0.116	0.178			
269.05	0.116	0.181			
269.10	0.116	0.185			
269.15	0.116	0.189			
269.20	0.116	0.193			
269.25	0.116	0.196			
269.30	0.116	0.200			
269.35	0.116	0.203			

Storage at 268.10 = 0.100 ac-ft = ±4,356 cf

NOAA Atlas 14, Volume 10, Version 3
Location name: Bellingham, Massachusetts, USA*
Latitude: 42.1142°, Longitude: -71.4724°
Elevation: 272 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.331** (0.257-0.421)	**0.399** (0.310-0.508)	**0.510** (0.394-0.652)	**0.601** (0.463-0.773)	**0.727** (0.542-0.978)	**0.823** (0.601-1.13)	**0.922** (0.654-1.31)	**1.03** (0.695-1.51)	**1.19** (0.770-1.80)	**1.31** (0.831-2.03)
10-min	**0.469** (0.365-0.597)	**0.565** (0.439-0.720)	**0.722** (0.559-0.924)	**0.852** (0.655-1.10)	**1.03** (0.768-1.39)	**1.17** (0.851-1.60)	**1.31** (0.926-1.86)	**1.46** (0.985-2.14)	**1.68** (1.09-2.55)	**1.86** (1.18-2.88)
15-min	**0.552** (0.429-0.702)	**0.664** (0.516-0.847)	**0.848** (0.656-1.08)	**1.00** (0.770-1.29)	**1.21** (0.903-1.63)	**1.37** (1.00-1.88)	**1.54** (1.09-2.19)	**1.72** (1.16-2.52)	**1.98** (1.28-3.00)	**2.19** (1.39-3.39)
30-min	**0.752** (0.585-0.957)	**0.907** (0.705-1.16)	**1.16** (0.898-1.48)	**1.37** (1.06-1.76)	**1.66** (1.24-2.24)	**1.88** (1.37-2.59)	**2.11** (1.50-3.01)	**2.36** (1.59-3.45)	**2.72** (1.76-4.12)	**3.01** (1.90-4.65)
60-min	**0.952** (0.741-1.21)	**1.15** (0.894-1.47)	**1.48** (1.14-1.89)	**1.74** (1.34-2.24)	**2.11** (1.58-2.84)	**2.39** (1.75-3.29)	**2.68** (1.90-3.82)	**3.00** (2.02-4.39)	**3.46** (2.24-5.24)	**3.82** (2.42-5.91)
2-hr	**1.22** (0.952-1.54)	**1.48** (1.16-1.88)	**1.92** (1.49-2.44)	**2.28** (1.76-2.91)	**2.78** (2.08-3.72)	**3.15** (2.31-4.31)	**3.54** (2.53-5.04)	**3.99** (2.70-5.80)	**4.65** (3.02-7.00)	**5.19** (3.30-7.98)
3-hr	**1.41** (1.10-1.77)	**1.72** (1.35-2.17)	**2.23** (1.74-2.82)	**2.65** (2.06-3.38)	**3.23** (2.44-4.32)	**3.67** (2.71-5.01)	**4.13** (2.97-5.88)	**4.67** (3.16-6.76)	**5.47** (3.56-8.20)	**6.14** (3.90-9.39)
6-hr	**1.81** (1.43-2.26)	**2.21** (1.74-2.77)	**2.86** (2.25-3.60)	**3.40** (2.66-4.30)	**4.15** (3.14-5.51)	**4.70** (3.49-6.39)	**5.30** (3.83-7.50)	**6.00** (4.08-8.63)	**7.07** (4.62-10.5)	**7.97** (5.09-12.1)
12-hr	**2.30** (1.82-2.86)	**2.80** (2.22-3.48)	**3.61** (2.86-4.51)	**4.29** (3.37-5.39)	**5.22** (3.98-6.89)	**5.91** (4.42-7.99)	**6.66** (4.85-9.39)	**7.56** (5.15-10.8)	**8.92** (5.85-13.2)	**10.1** (6.46-15.2)
24-hr	**2.76** (2.20-3.41)	**3.38** (2.70-4.18)	**4.40** (3.50-5.46)	**5.25** (4.15-6.55)	**6.41** (4.92-8.42)	**7.27** (5.47-9.79)	**8.20** (6.02-11.5)	**9.36** (6.40-13.3)	**11.2** (7.33-16.4)	**12.7** (8.15-19.0)
2-day	**3.13** (2.52-3.84)	**3.90** (3.13-4.79)	**5.15** (4.12-6.35)	**6.19** (4.92-7.67)	**7.62** (5.88-9.96)	**8.66** (6.57-11.6)	**9.82** (7.27-13.8)	**11.3** (7.74-15.9)	**13.6** (8.97-19.9)	**15.6** (10.1-23.3)
3-day	**3.42** (2.75-4.17)	**4.24** (3.42-5.19)	**5.59** (4.49-6.86)	**6.71** (5.35-8.28)	**8.25** (6.39-10.7)	**9.38** (7.13-12.5)	**10.6** (7.89-14.9)	**12.2** (8.39-17.1)	**14.7** (9.71-21.4)	**16.9** (10.9-25.0)
4-day	**3.68** (2.98-4.49)	**4.54** (3.66-5.54)	**5.94** (4.78-7.27)	**7.10** (5.68-8.74)	**8.70** (6.75-11.3)	**9.87** (7.52-13.1)	**11.2** (8.30-15.5)	**12.8** (8.82-17.9)	**15.4** (10.2-22.2)	**17.6** (11.4-26.0)
7-day	**4.42** (3.59-5.36)	**5.33** (4.33-6.47)	**6.82** (5.51-8.31)	**8.06** (6.47-9.86)	**9.75** (7.59-12.5)	**11.0** (8.39-14.5)	**12.4** (9.18-17.0)	**14.0** (9.71-19.5)	**16.6** (11.0-23.9)	**18.8** (12.2-27.5)
10-day	**5.13** (4.18-6.20)	**6.07** (4.94-7.34)	**7.61** (6.17-9.23)	**8.88** (7.16-10.8)	**10.6** (8.29-13.6)	**11.9** (9.11-15.6)	**13.3** (9.88-18.2)	**15.0** (10.4-20.8)	**17.5** (11.6-25.1)	**19.6** (12.7-28.6)
20-day	**7.23** (5.93-8.68)	**8.23** (6.74-9.89)	**9.86** (8.05-11.9)	**11.2** (9.10-13.6)	**13.1** (10.2-16.5)	**14.5** (11.1-18.7)	**16.0** (11.8-21.3)	**17.6** (12.3-24.1)	**19.8** (13.3-28.2)	**21.7** (14.1-31.4)
30-day	**8.98** (7.39-10.7)	**10.0** (8.23-12.0)	**11.7** (9.58-14.0)	**13.1** (10.7-15.8)	**15.0** (11.8-18.8)	**16.5** (12.6-21.1)	**18.0** (13.3-23.8)	**19.6** (13.7-26.7)	**21.6** (14.5-30.6)	**23.2** (15.1-33.6)
45-day	**11.1** (9.20-13.3)	**12.2** (10.1-14.6)	**14.0** (11.5-16.7)	**15.4** (12.6-18.6)	**17.5** (13.7-21.7)	**19.0** (14.6-24.1)	**20.6** (15.1-26.8)	**22.0** (15.5-29.9)	**23.8** (16.0-33.5)	**25.2** (16.4-36.2)
60-day	**12.9** (10.7-15.4)	**14.1** (11.6-16.7)	**15.9** (13.1-18.9)	**17.4** (14.2-20.8)	**19.5** (15.3-24.1)	**21.1** (16.2-26.6)	**22.7** (16.6-29.3)	**24.0** (16.9-32.5)	**25.7** (17.3-35.9)	**26.7** (17.5-38.3)

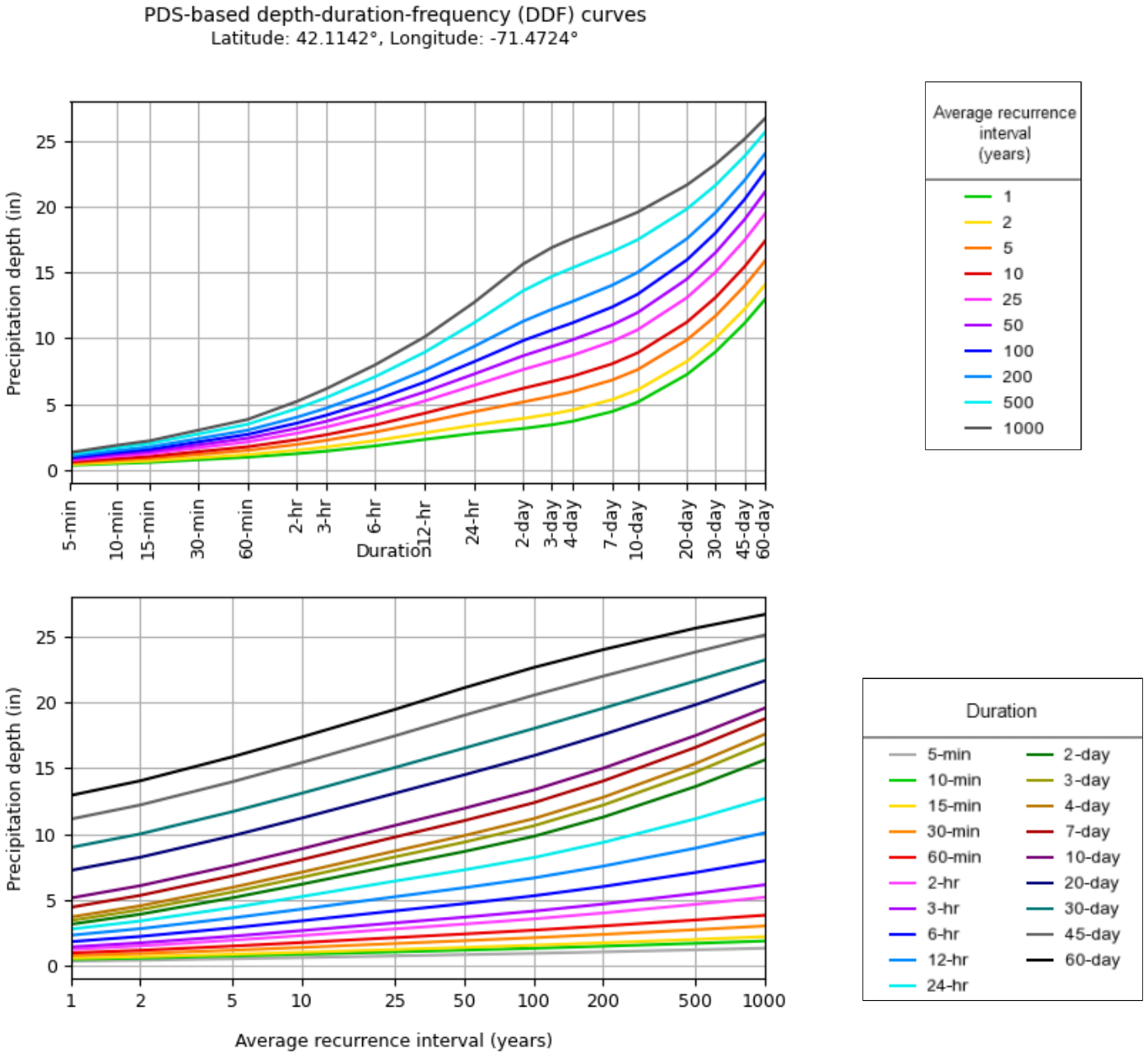
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical



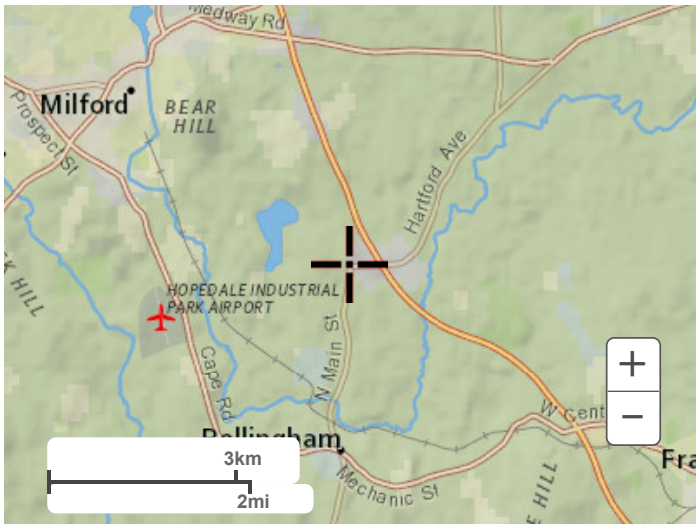
NOAA Atlas 14, Volume 10, Version 3

Created (GMT): Mon Feb 3 23:32:28 2025

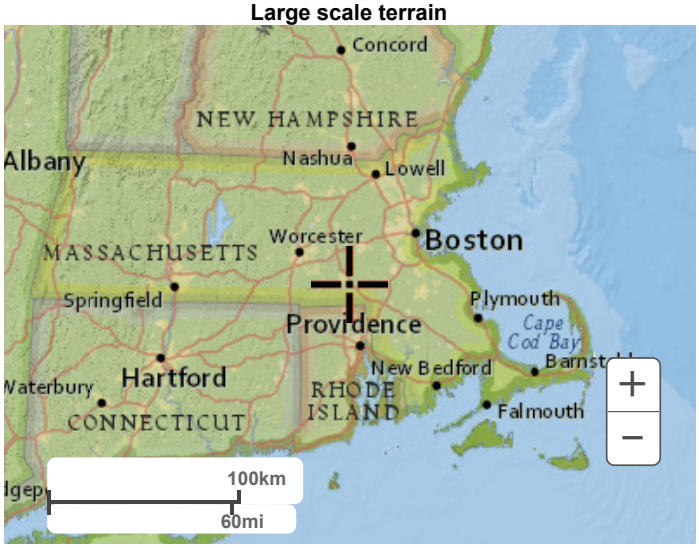
Back to Top

Maps & aerials

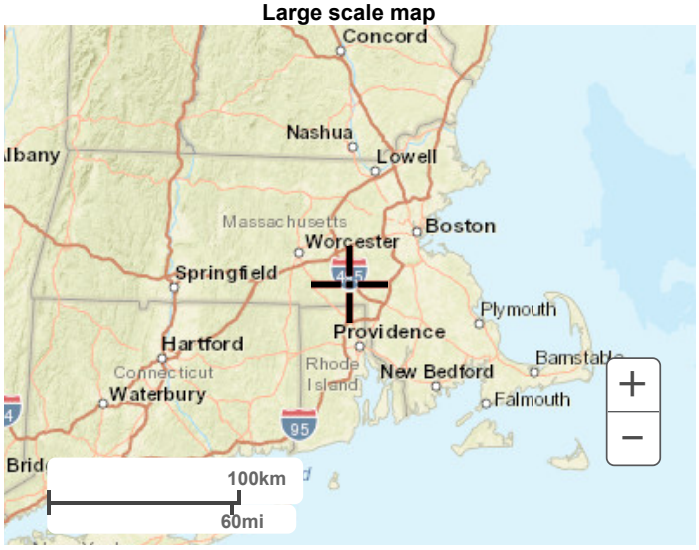
Small scale terrain



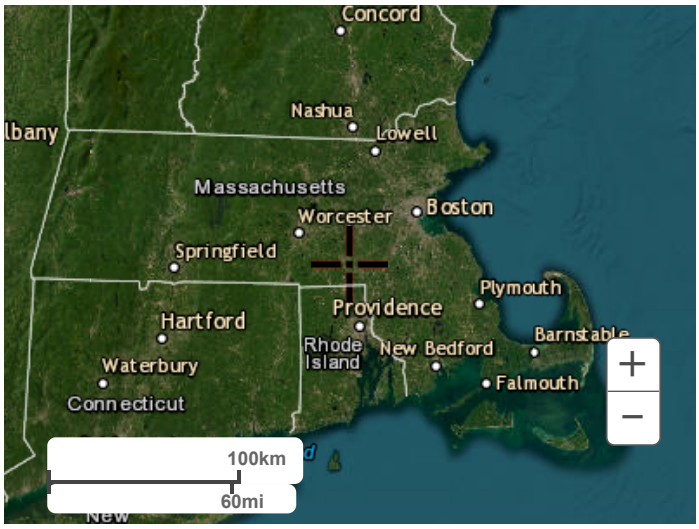
Large scale terrain



Large scale map



Large scale aerial



Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

GROUNDWATER MOUNDING CALCULATIONS

Proposed Storage Development
362 Turnpike Street, Canton, MA
BE Project No.: MAA220151.00

Methodology

UGS1 for this project is designed with less than 4 feet of groundwater separation. It is also designed to attenuate the 10-year storm event or larger. Therefore, groundwater mounding calculations are required according to MA DEP Stormwater Management Guidelines. The purpose of the calculations is to ensure that the mound will not prevent the full draining of the basin. The mounding analysis must show that the recharge volume will exfiltrate within seventy-two (72) hours. Additionally, it should be verified that the mounding effect will not cause stormwater to surge above the lowest discharge point out of a basin (during the 72-hour period) or raise the water elevation in a nearby resource area.

The groundwater mounding analysis was performed by a proprietary program using the Hantush Method with Glover's Solution. Input parameters are site specific and determined based on existing and proposed conditions. The required input parameters are the following: application rate; duration of application; fillable porosity; hydraulic conductivity; initial saturated thickness; length of application area; width of application area; and distance to closest resource area (constant head boundary).

Calculations using the Hantush Method are considered conservative due to the fact that the unsaturated soil zone is not incorporated. In practice, this zone will have a significant positive effect on reducing the groundwater mounding under an infiltration basin by allowing horizontal migration. A minimum of a 2-foot unsaturated zone has been provided in the basin and the mounding in the basin (Δh) falls below the lowest outlet in the basin ensuring that stormwater will not bypass the basin floor and discharge though the outlet device. Please refer to the table below:

Stormwater Basin	Unsaturated Zone (FT)	Depth Below Lowest Outlet (FT)	Mounding Storage Provided (FT)	Groundwater Mounding - Δh (FT)
UGS1	**3.5**	**1.3**	**4.8**	**2.1**

Additionally, given that the Groundwater Mounding (Δh) does not exceed the stone base of the proposed basin, it is assumed that the basin can still exfiltrate within 72 hours.

The application rate used is converted from the Rawls value selected for an exfiltration rate in HydroCAD. The duration of application used for the analysis is the 24-hour based duration of the storm event. The fillable porosity, hydraulic conductivity, and initial saturated thickness used for the analysis are based on the existing soil conditions.

Results

Based on the criteria mentioned above, the analysis (see attached) indicates the mound in the stormwater basin falls below the mounding storage provided. Additionally, the mounding effect at the end of Day 3 does not exceed the stone base of the proposed basin. Given these results, we assume that the basin recharges the stormwater volume within 72 hours as required.

This spreadsheet will calculate the height of a groundwater mound beneath a stormwater infiltration basin. More information can be found in the U.S. Geological Survey Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins".

The user must specify infiltration rate (R), specific yield (Sy), horizontal hydraulic conductivity (Kh), basin dimensions (x, y), duration of infiltration period (t), and the initial thickness of the saturated zone (hi(0), height of the water table if the bottom of the aquifer is the datum). For a square basin the half width equals the half length (x = y). For a rectangular basin, if the user wants the water-table changes perpendicular to the long side, specify x as the short dimension and y as the long dimension. Conversely, if the user wants the values perpendicular to the short side, specify y as the short dimension, x as the long dimension. All distances are from the center of the basin. Users can change the distances from the center of the basin at which water-table aquifer thickness are calculated.
Cells highlighted in yellow are values that can be changed by the user. Cells highlighted in red are output values based on user-specified inputs. The user MUST click the blue "Re-Calculate Now" button each time ANY of the user-specified inputs are changed otherwise necessary iterations to converge on the correct solution will not be done and values shown will be incorrect. Use consistent units for all input values (for example, feet and days)

use consistent units (e.g. feet & days **or** inches & hours)

Input Values		
4.8200	***R***	**Recharge (infiltration) rate (feet/day)**
0.280	**Sy**	**Specific yield, Sy (dimensionless, between 0 and 1)**
164.00	**K**	**Horizontal hydraulic conductivity, Kh (feet/day)***
48.200	**x**	**1/2 length of basin (x direction, in feet)**
24.500	**y**	**1/2 width of basin (y direction, in feet)**
0.179	**t**	**duration of infiltration period (days)**
5.000	**hi(0)**	**initial thickness of saturated zone (feet)**

Conversion Table

inch/hour	**feet/day**
0.67	1.33
2.00	4.00

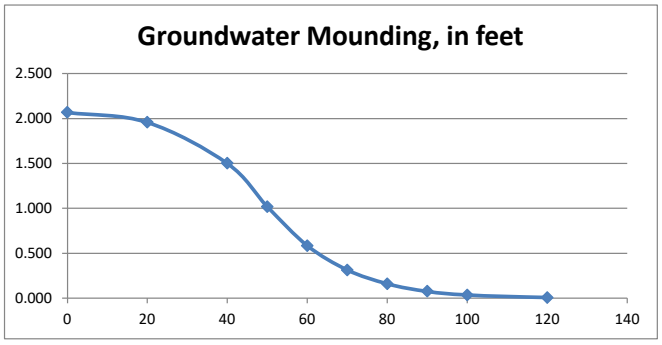
hours	**days**
36	1.50

In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).

7.068	**h(max)**	**maximum thickness of saturated zone (beneath center of basin at end of infiltration period)**
2.068	**Δh(max)**	**maximum groundwater mounding (beneath center of basin at end of infiltration period)**

Ground-water Mounding, in feet	**Distance from center of basin in x direction, in feet**
2.068	**0**
1.957	**20**
1.501	**40**
1.019	**50**
0.584	**60**
0.314	**70**
0.159	**80**
0.076	**90**
0.035	**100**
0.007	**120**

Re-Calculate Now



Disclaimer

This spreadsheet solving the Hantush (1967) equation for ground-water mounding beneath an infiltration basin is made available to the general public as a convenience for those wishing to replicate values documented in the USGS Scientific Investigations Report 2010-5102 "Groundwater mounding beneath hypothetical stormwater infiltration basins" or to calculate values based on user-specified site conditions. Any changes made to the spreadsheet (other than values identified as user-specified) after transmission from the USGS could have unintended, undesirable consequences. These consequences could include, but may not be limited to: erroneous output, numerical instabilities, and violations of underlying assumptions that are inherent in results presented in the accompanying USGS published report. The USGS assumes no responsibility for the consequences of any changes made to the spreadsheet. If changes are made to the spreadsheet, the user is responsible for documenting the changes and justifying the results and conclusions.

Sensitivity Analysis

- Determine most sensitive parameters in Hantush method and Modflow
- Hydraulic conductivity, and specific yield

Rock Type	Grain size (mm)	Hydraulic Conductivity K (m/d)
Clay	0.0005-0.002	10^{-8}-10^{-2}
Silt	0.002-0.06	10^{-2} - 1
Fine Sand	0.06 -0.25	1 - 5
Medium Sand	0.25-0.50	5 - 20
Coarse Sand	0.50-2	20 - 100
Gravel	2-64	100 - 1000
Shale	small	$5x10^{-8}$ - $5x10^{-6}$
Sandstone	medium	10^{-3} - 1
Limestone	variable	10^{-5} - 1
Basalt	small	0.0003 - 3
Granite	large	0.0003 - 0.03
Slate	small	10^{-8} - 10^{-5}
Schist	medium	10^{-7} - 10^{-4}

16.40-65.62 (ft/day)

Source: Brassington, 1988

Material	Specific Yield (%)
Gravel, coarse	23
Gravel, medium	24
Gravel, fine	25
Sand, coarse	27
Sand, medium	28
Sand, fine	23
Silt	8
Clay	3
Sandstone, fine-grained	21
Sandstone, medium-grained	27
Limestone	14
Dune sand	38
Loess	18
Peat	44
Schist	26
Siltstone	12
Till, predomintly silt	6
Till, predominantly sand	16
Till, predominantly gravel	16
Tuff	21

Source: Johnson, 1967

Proposed Retail Development
190, 194 & 198 Hartford Avenue
Bellingham, MA
Bohler Job Number: MAA240490.00
September 25, 2025

Rational Pipe Sizing Calculations

Design Period Storm:		25	Year	Design Period Intensity*			8.42	in/hr									
LOCATION		IMPERVIOUS			OTHER			SUM	Tc	I	Q	D	S	Material	n	Q Full	V Full
FROM	TO	A	C	CA	A	C	CA	CA	(min)	(in/hr)	(cfs)	(in)	(ft/ft)			(cfs)	(fps)
A-140	A-130	0.10	0.95	0.10	0.12	0.30	0.04	0.13	5	8.42	1.10	12	0.006	HDPE	0.012	2.89	3.68
A-130	A-120	0.10	0.95	0.10	0.12	0.30	0.04	0.13	5	8.42	1.10	12	0.005	HDPE	0.012	2.73	3.47
A-125	A-120	0.14	0.95	0.13	0.00	0.30	0.00	0.13	5	8.42	1.11	12	0.031	HDPE	0.012	6.74	8.58
A-120	A-90	0.24	0.95	0.23	0.12	0.30	0.04	0.26	5	8.42	2.22	12	0.005	HDPE	0.012	2.73	3.47
A-85	A-100	0.29	0.95	0.27	0.06	0.30	0.02	0.29	5	8.42	2.45	12	0.008	HDPE	0.012	3.43	4.37
A-100	A-90	0.29	0.95	0.28	0.06	0.30	0.02	0.29	5	8.42	2.47	12	0.017	HDPE	0.012	5.06	6.45
A-80	A-50	0.05	0.95	0.05	0.00	0.30	0.00	0.05	5	8.42	0.38	12	0.017	HDPE	0.012	5.06	6.45
A-30	A-20	N/A	0.95	N/A	N/A	0.30	N/A	N/A	5	8.42	1.52	12	0.010	HDPE	0.012	3.86	4.91
A-20	A-10	N/A	0.95	N/A	N/A	0.30	N/A	N/A	5	8.42	1.52	12	0.010	HDPE	0.012	3.86	4.91

*Rainfall intensity provided by NOAA Atlas 14, Volume 10, Version 2 on 02/03/2025

Prepared By:
BOHLER
352 Turnpike Road
Southborough, MA 01772
(508) 480-9900

NJCAT TECHNOLOGY VERIFICATION

Isolator® Row PLUS

StormTech, LLC

July 2020

Table of Contents

List of Figures

List of Tables

1. Description of Technology

The Isolator® Row PLUS (**shown in Figures 1 and 2**) is the first row of StormTech chambers that is surrounded with filter fabric and connected to a closely located manhole for easy access. The Isolator Row PLUS provides for settling and filtration of sediment as stormwater rises in the chamber and ultimately passes through the filter fabric. The open-bottom chambers allow stormwater to flow out of the chambers, while sediment is captured in the Isolator Row PLUS.

A single layer of proprietary Advanced Drainage Systems (ADS) PLUS fabric is placed between the angular base stone and the Isolator Row PLUS chamber. The geotextile provides the means for stormwater filtration and provides a durable surface for maintenance operations. A non-woven fabric is placed over the chambers. See link to O&M Manual (pg. 23) for installation pictures.

The Isolator Row PLUS is designed to capture the "first flush" runoff and offers the versatility to be sized on a volume basis or a flow basis. An upstream manhole not only provides access to the Isolator Row PLUS but includes a high/low concept such that stormwater flow rates or volumes that exceed the capacity of the Isolator Row PLUS bypass through a manifold to the other chambers. This is achieved with either an elevated bypass manifold or a high-flow weir. This creates a differential between the Isolator Row PLUS row of chambers and the manifold to the rest of the system, thus allowing for settlement time in the Isolator Row PLUS. After Stormwater flows through the Isolator Row PLUS and into the rest of the StormTech chamber system it is either infiltrated into the soils below or passed at a controlled rate through an outlet manifold and outlet control structure. **Since this technology fits under the infiltration basin BMP in the New Jersey Stormwater BMP Manual, it is not eligible for NJDEP MTD certification.**

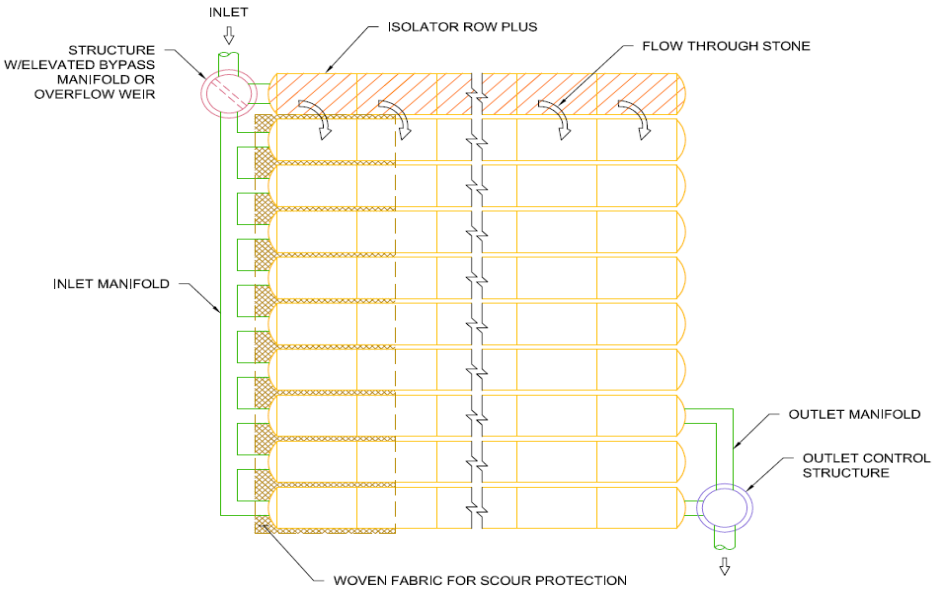


Figure 1 Schematic of the StormTech Isolator Row PLUS System

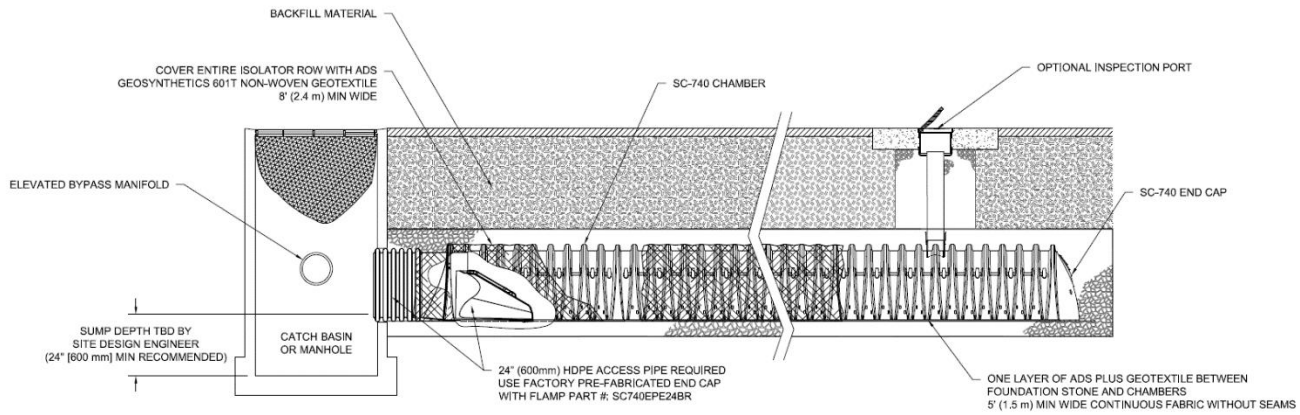


Figure 2 Isolator Row PLUS Detail

2. Laboratory Testing

Beginning in January 2020, two overlapping StormTech SC-740 Isolator Row PLUS commercial size chambers were installed at the BaySaver Laboratory in Mount Airy, Maryland, to evaluate the performance of Isolator Row PLUS on Total Suspended Solid (TSS) removal. Boggs Environmental Consultants (BEC) provided third-party review and oversight of all testing and data collection procedures, in accordance with the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device (January 2013)*. All sediment concentration samples were analyzed by Fredericktowne Labs (FTL) using ASTM D3977-97 (2019). All sediment PSD analysis was performed by Environmental Consulting Services (ECS), using the methodology of ASTM D422-63 (2007). Prior to the start of testing, a Quality Assurance Project Plan (QAPP), revision dated January 9, 2020, was submitted to, and approved by the New Jersey Corporation for Advanced Technology (NJCAT).

2.1 Test Setup

The testing system, shown in **Figure 3**, consisted of a source tank, feed pump, flow control valve, flow meter, background sample port, screw-auger sediment feeder (doser), and an Isolator Row PLUS test system. This verification report only addresses the performance of the Isolator Row PLUS and not the entire StormTech system, since this is the row designed to remove sediment until the system goes into bypass.

Testing Procedure

The water source was potable water from the Town of Mount Airy Water & Sewer Department, obtained from an onsite tap, which served as the raw water supply for the testing system. Municipal tap water was used to fill the source tank, and then pumped to the system. Flow rate was controlled to the target of 225 gpm by a flow control valve. An inline flow meter (FloCat MFE electromagnetic flow meter) was used to measure the flow, and a SeaMetrics DL76 data logger (pictured in **Figure 4**) recorded the flow at one-minute intervals. The test sediment was

introduced to the inlet stream via a 12 -inch dosing port teed with a 12-inch influent line (pictured in **Figure 5**) located approximately 4 feet upstream of the system inlet. The dosing rate was controlled by a screw-auger Velodyne Barracuda 1000A volumetric feeder with a ½ HP variable speed motor. The dosing rate was set to deliver an amount of sediment that, when mixed with the water from the source tank, would produce influent water with a target test sediment concentration of 200 mg/L.

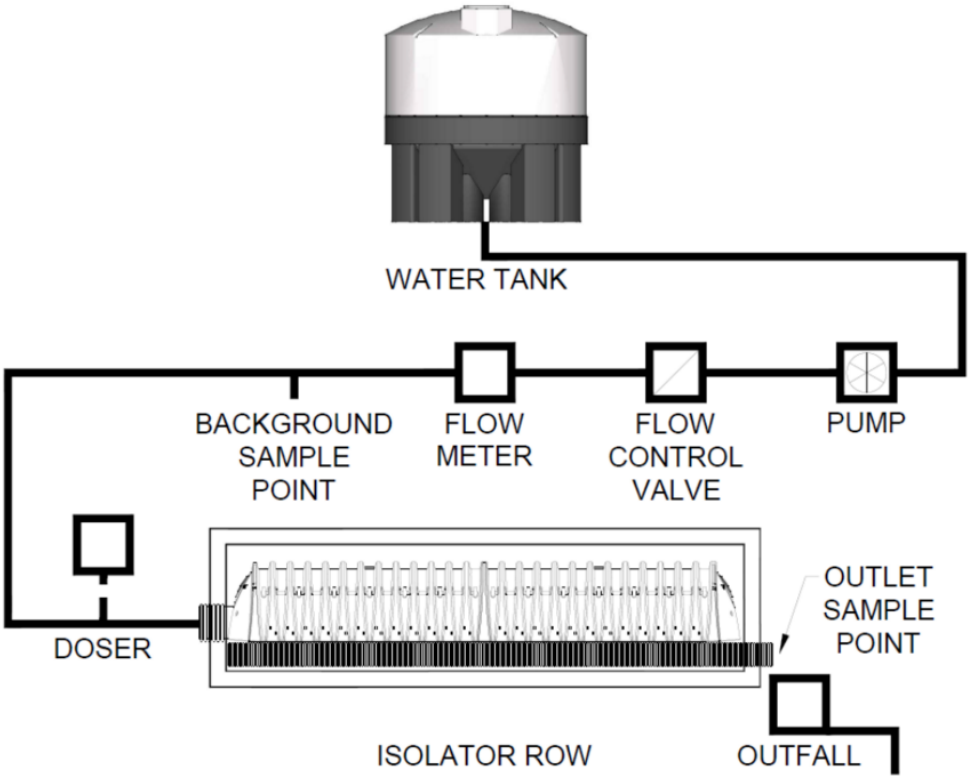


Figure 3 Schematic of the Isolator Row PLUS Test Configuration

The Isolator Row PLUS was installed inside a watertight 16'L x 6'W x 4'H test box (pictured in **Figures 6 and 7**). The Isolator Row PLUS is an arch-shaped stormwater detention/retention sediment collection and filtering device, sealed with end caps, with a 12"-inch inlet pipe welded into the upstream end cap. A ramp apparatus (patent pending) was attached to the inside of the chamber end cap to provide a smooth transition from pipe invert to fabric bottom. It is configured to improve chamber function performance over time by distributing sediment and debris that would otherwise collect at the inlet. It also serves to improve the fluid and solid flow back into the inlet pipe during maintenance and cleaning, and to guide cleaning and inspection equipment back into the inlet pipe when complete.

The chambers were installed on a 10-inch base of washed, angular, crushed stone, (#57, ¾ inch blue stone) containing an 8-inch perforated underdrain pipe running the length of the test box, penetrating the wall of the downstream end of the test box to the discharge collection point. An ADS non-woven geotextile fabric was placed over the top of the chamber row. The chambers were then backfilled with the washed crushed stone up to the top of the chamber elevation.

Additionally, an opening was cut into the top of one chamber to allow for visual monitoring and head measurement. No bypass or weir was installed upstream of the test box.

The test flow entered the chamber via the influent pipe and flowed across the filter fabric, filling the row. The water then flowed through the filter fabric, driven by hydrostatic head. The treated water exited the test box via the underdrain.

Figures 4 and 5 Photographs of Flow Meter and Sediment Delivery Port

Figure 6 Side View Photograph of Isolator Row PLUS Test Box

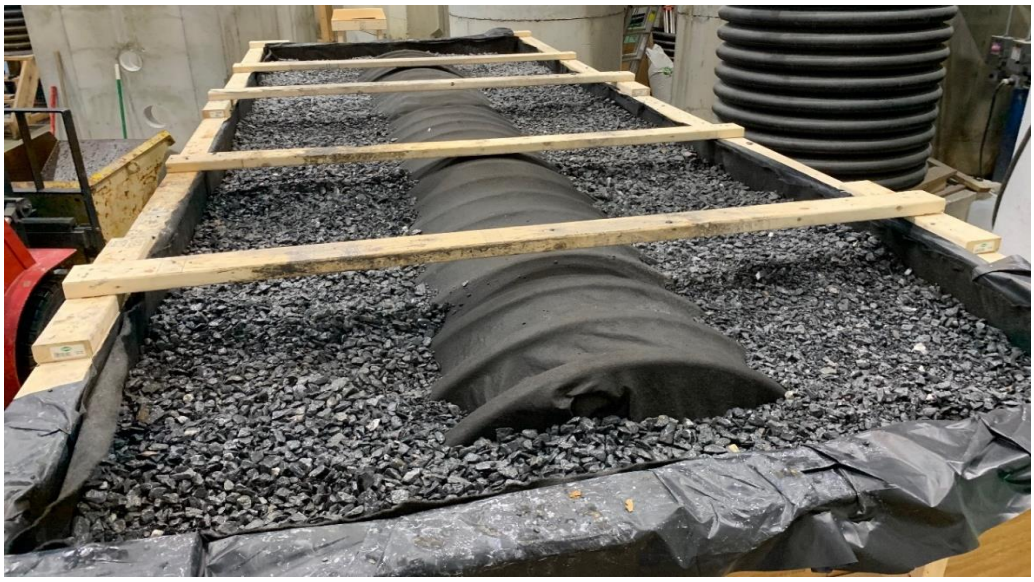


Figure 7 Top View Photograph of Isolator Row PLUS Test Box

Test Unit and Scaling Explanation

The Isolator Row PLUS used in this test was constructed from two (2) overlapping polypropylene open-bottom StormTech SC-740 chambers (one shortened by 5-in. to enable fitting into the test box), two (2) SC-740 end caps, a ramp apparatus and one layer of ADS PLUS geotextile fabric. The chamber floor filtration area (effective filtration treatment area, EFTA) was approximately 54.5 ft^2. (calculated using an average contact width inside the chamber of 45 in). The target test flow was 225 gpm. The calculated hydraulic loading rate, flow rate/EFTA is 4.13 gpm/ft^2 and the ratio of effective sedimentation treatment area to EFTA is 1.0. Given these data, one can effectively scale the test results for all commercial systems.

Sample Collection

The grab sampling method was used for all sample collection by sweeping a wide-mouth 1-L plastic bottle through the free-discharge effluent stream, to ensure the full cross section of the flow was sampled. The start time for each run was recorded.

The sampling schedule is provided in **Table 1**. The detention time for the Isolator Row PLUS unit operating at 20 inches hydrostatic head (maximum head tested) is 2.1 minutes. To comply with the NJDEP Filter Protocol, after initiating and stabilizing the flow rate at the MTFR and beginning sediment feed, effluent sampling did not begin until the filtration MTD has been in operation for a minimum of three detention times.

Background water samples were collected upstream of the doser (shown in **Figures 3 and 8**) in correspondence with the odd-numbered effluent samples (i.e., Samples E1, E3, E5 at t = 9, 20, 31 minutes).

Table 1 Sampling Schedule for the Isolator Row PLUS Tests

Time (min)	Sample(s)	Time (min)	Sample(s)
0	S1	22	S3
9	E1, BG1	31	E5, BG3
10	E2	32	E6
11	S2	33	Stop Flow
20	E3, BG2	N/A	DDA
21	E4	N/A	DDB

NOTE: S = sediment rate; E = effluent; BG = background; DD = drawdown

Figure 8 Photograph of Background Sampling Port

Two evenly-volume-spaced drawdown samples, DDA and DDB, were taken after the flow and sediment feed to the unit had been stopped.

Sediment injection rates were measured using a stopwatch and the mass collected measured on a calibrated scale once at the very beginning of the run and twice more during the run. A fourth sediment rate sample was taken after the run was finished as an internal check but was not included in the calculations for the report. The duration of each run was 33 minutes.

A Chain of Custody (COC) form was used for each test run to record sampling date and time for externally analyzed samples. Copies of these forms were maintained by BaySaver Laboratory and FTL. Sample bottles were labeled to identify the test run number and sample type (e.g., background, effluent), corresponding to the sample identification on the COC form. BEC was present during each test run and witnessed labeling, completion of COC forms, and packaging of

samples for delivery to the external laboratory (FTL). Each person taking or relinquishing possession of the samples was required to sign a COC form before samples changed hands.

Other Instrumentation and Measurement

Water temperature was recorded every minute by a HOBO data logger placed in the source water tank of the test system. The water level in the Isolator Row PLUS was recorded every 5 minutes by visual observation of a yardstick mounted through the observation port on top of the first chamber. Run and sampling times were measured using a digital timer and a stopwatch, respectively.

2.2 Test Sediment

The test sediment had the particle size distribution (PSD) presented in **Figure 9**. The test sediment was custom-blended using various commercially available silica sands. The resulting blended sediment met the specification for the NJDEP Filter Protocol. The test sediment was batched, labeled, and stored in covered bins for the duration of this project. Under the supervision of BEC, twenty-one subsamples, taken from various locations within the test sediment containers, were composited. From the composite, three random samples were taken for PSD and moisture content analyses, which were performed by ECS, using the methodology of ASTM method D422-63 (2007).

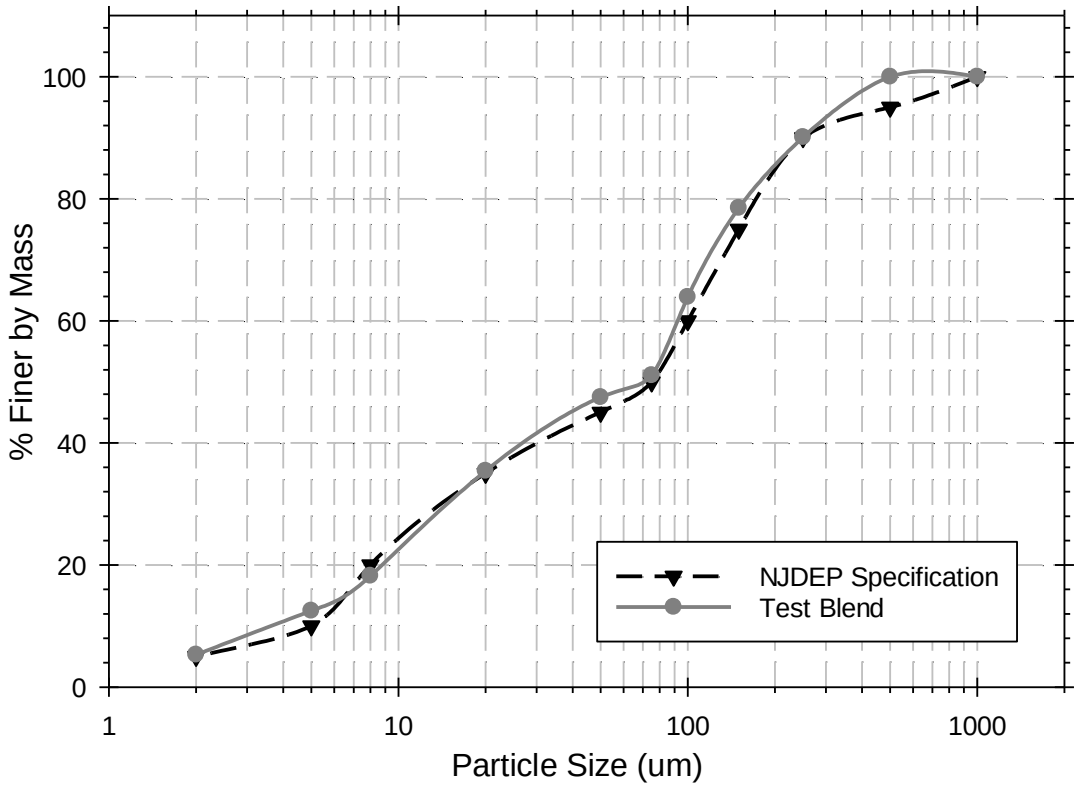


Figure 9 Average Particle Size Distribution of Test Sediment Verified by ECS

The PSD test analysis results are summarized in **Table 2**. ECS results showed that 17-19% of the particles were less than 8 µm and 89-90% of the particles were less than 250 µm. The d_{50} values (approximately 72 µm) also indicated that there was no significant difference between the NJDEP target gradation and the ECS-verified gradation of the test sediment. Thus, the blended test sediment was found to meet the NJDEP particle size specification and was acceptable for use. ECS also analyzed the sediment samples for moisture. The average moisture content was 0.1%.

Table 2 Particle Size Distribution of Test Sediment as Analyzed by ECS

Particle Size (µm)	Test Blend % Finer by Mass Analyzed by ECS				
	NJ Blend A	NJ Blend B	NJ Blend C	Average	NJDEP Specification (minimum % finer)
1000	100.0	100.0	100.0	100.0	98
500	100.0	100.0	100.0	100.0	93
250	90.3	89.8	90.2	90.1	88
150	79.3	78.1	78.1	78.5	73
100	66.0	63.2	62.7	63.9	58
75	52.0	50.9	50.3	51.1	50
50	47.5	47.7	47.4	47.5	43
20	35.9	36.0	34.3	35.4	33
8	18.6	18.7	17.4	18.2	18
5	13.0	13.0	11.6	12.5	8
2	5.5	5.4	5.1	5.3	3
d_{50}	69 µm	72 µm	74 µm	72 µm	75 µm

2.3 Sediment Removal Efficiency Testing

Sediment removal efficiency testing adhered to the guidelines set forth in Section 5 of the NJDEP Laboratory Protocol for Filtration MTDs. The target flow through the system was 225 gpm, with a target sediment concentration of 200 mg/L. All samples were collected in clean, 1-L wide-mouth bottles. Three background samples were taken at 9, 20 and 31 minutes after the test began to ensure the supply water met the sediment concentration requirement. According to the NJDEP Filter Protocol, these background concentrations cannot exceed a TSS concentration of 20 mg/L.

The test sediment screw-auger feeder introduced the test sediment into the influent stream to achieve the target influent TSS concentration of 200 mg/L. According to the NJDEP Filter Protocol, this influent concentration must stay within 10% of target, allowing for a 180 mg/L to 220 mg/L influent concentration. The feeder was calibrated prior to each run. In order to confirm sediment feed rates during the test, in accordance with the NJDEP Filter Protocol, three samples of the test sediment were collected from the injection point (**Figure 3**, "Doser") into a clean one-liter container for verification of sediment feed rate, over an interval timed to the nearest second, with a minimum volume of 0.1 liter or a collection interval not exceeding one minute (whichever came first). The time was measured with a stopwatch. The samples were weighed to the nearest

milligram in the BaySaver Laboratory under the observation of BEC. The sediment feed rate coefficient of variance (COV) for the test sediment samples did not exceed 0.10. The mass from the sediment feed rate measurement samples was subtracted from the total mass introduced to the system when removal efficiency was calculated.

Effluent sampling was performed by the grab sampling method during each run, according to the schedule in **Table 1**. When the test sediment feed was interrupted for test sediment measurements, the next effluent samples were collected after at least three detention times had elapsed. During the drawdown period, two evenly volume-spaced samples were collected after flow and sediment feed had stopped. All sediment concentration samples were analyzed by Fredericktowne Labs (FTL) using ASTM D3977-97 (2019) "Standard Test Methods for Determining Sediment Concentrations in Water Samples."

2.4 Sediment Mass Loading Capacity

The sediment mass loading capacity testing occurred as a continuation of removal efficiency testing, with the target for influent concentration remaining at 200 mg/L, and all aspects of testing procedures kept the same to ensure consistency throughout. The sediment mass loading capacity of the Isolator Row PLUS is defined per the protocol as the point at which the cumulative mass removal drops below 80.0%. For this testing program, the sediment mass loading testing was stopped prior to that point (after Run 16), because it was incorrectly assumed this criterion was reached. Thus, the mass loading is defined as mass loaded into the unit through the end of Run 16.

3. Supporting Documentation

The Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from NJCAT states that copies of the laboratory test reports, all data from performance evaluation test runs, original data, pertinent calculations, and documentation of any maintenance activities that occur during the testing process are to be included in this section. All of this information has been provided to NJCAT and is available upon request. It is not practical to include it in this report.

4. Testing Results

A total of 16 removal efficiency testing runs were completed in accordance with the NJDEP filter protocol. The target flow and influent sediment concentration were 225 gpm and 200 mg/L, respectively. The results from all 16 runs were used to calculate the overall cumulative removal efficiency of the Isolator Row PLUS.

4.1 Flow Rate

Flow was monitored by an inline flow meter (FloCat MFE electromagnetic flow meter) and recorded by a SeaMetrics DL76 data logger every minute during each run. For each run, the flow was maintained within 10% of the target (202.5 – 247.5 gpm). The average flow for all 16 runs was 226.1 gpm. The flow data with coefficient of variance (COV) values for all 16 runs are summarized in **Table 3**.

4.2 Water Temperature

Temperatures were recorded every minute by a HOBO water level logger (U20L-04). On average for all runs, the water temperature during testing was 45.7 degrees Fahrenheit, with a maximum of 52.2 degrees Fahrenheit, meeting the NJDEP Filter Protocol requirement to be below 80 degrees Fahrenheit. Data are summarized in **Table 3**.

Table 3 Flow Rate and Temperature Summary for All Runs

Run	Max Flow (gpm)	Min Flow (gpm)	Average Flow (gpm)	Flow COV	Flow Compliance (COV< 0.1)	Maximum Temperature (Fahrenheit)	NJDEP Temperature Compliance (< 80 F)
1	232.8	223.9	226.3	0.0078	Y	48.2	Y
2	228.9	218.6	220.8	0.0104	Y	51.5	Y
3	229.4	220.0	227.2	0.0094	Y	44.7	Y
4	230.2	218.7	223.2	0.0138	Y	40.5	Y
5	228.7	216.9	222.2	0.0103	Y	44.7	Y
6	227.6	217.0	224.2	0.0115	Y	46.7	Y
7	229.7	221.9	226.4	0.0092	Y	44.6	Y
8	230.3	222.2	226.8	0.0089	Y	43.5	Y
9	233.2	218.4	225.6	0.0136	Y	45.5	Y
10	232.2	219.7	228.4	0.0126	Y	44.7	Y
11	226.9	219.2	224.1	0.0088	Y	52.4	Y
12	232.2	222.1	226.9	0.0107	Y	48.5	Y
13	234.7	221.2	226.1	0.0109	Y	48.5	Y
14	231.9	223.4	228.7	0.0103	Y	45.6	Y
15	236.8	224.1	231.4	0.0131	Y	52.2	Y
16	232.5	221.3	229.0	0.0137	Y	47.8	Y
Average			226.1			45.7	
Max						52.2	

4.3 Head

The head level in the Isolator Row PLUS was recorded to the nearest 1/8 inch every five minutes, through visual observation of a yard stick mounted through the observation port of the first chamber. With each run, after the first several measurements, the head during the run remained the same or increased slightly over that of the previous run. The maximum head reached during all 16 runs was 18.75 inches. Maximum head for each run is summarized in **Table 4**.

Table 4 Maximum Head (inches) for All Runs

Run	Maximum Head (inches)	Run	Maximum Head (inches)
1	9.00	9	17.50
2	12.00	10	18.00
3	14.00	11	17.25
4	15.25	12	18.00
5	15.75	13	18.25
6	16.25	14	18.50
7	17.50	15	18.75
8	17.25	16	18.75

4.4 Sediment Concentration and Removal Efficiency

Background TSS

Municipal tap water was used as the water source during testing. The background TSS concentration for all runs was well below the 20 mg/L NJDEP Protocol limit. Background TSS concentrations for each run are provided in **Table 5**. The average background TSS concentration for each run was subtracted from the effluent and drawdown concentrations to provide adjusted figures, per the protocol.

Sediment Dosing Rate and Influent TSS

Influent TSS concentration was calculated by dividing the total mass of sediment added during a given run by the total volume of water flowing through the MTD during the addition of test sediment during that run. The volume of water flowing through the device during the run was calculated by multiplying the average measured flow by the time of sediment addition only. The average influent TSS was 204.2 mg/L, with individual run averages ranging from 195.9 to 216.7 mg/L. All values are within the target range of 200 ± 20 mg/L. **Tables 6 and 7** provide the measured sediment rates for each run, and the resulting calculated influent TSS concentration. In these tables, NJDEP Protocol compliance is defined as a TSS concentration in the range 180 – 220 mg/L and sediment feed rate COV < 0.1.

Table 5 Background TSS Concentrations

Run	BG TSS 9 min (mg/L)	BG TSS 20 min (mg/L)	BG TSS 31 min (mg/L)	Average (mg/L)	MDL (mg/L)
1	0.5	4	2	2.2	1.0
2	1	1	0.5	0.8	1.0
3	1	0.5	0.5	0.7	1.0
4	0.5	0.5	0.5	0.5	1.0
5	0.5	0.5	0.5	0.5	1.0
6	0.5	0.5	0.5	0.5	1.0
7	0.5	0.5	0.5	0.5	1.0
8	0.5	0.5	0.5	0.5	1.0
9	0.5	0.5	0.5	0.5	1.0
10	0.5	0.5	0.5	0.5	1.0
11	0.5	0.5	0.5	0.5	1.0
12	0.5	0.5	0.5	0.5	1.0
13	0.5	0.5	0.5	0.5	1.0
14	0.5	0.5	0.5	0.5	1.0
15	0.5	0.5	0.5	0.5	1.0
16	0.5	0.5	0.5	0.5	1.0

Note: In cases where the measured background TSS concentration was below the Minimum Detection Level (MDL) of 1.0 mg/L, half the MDL was reported for the background concentration.

Table 6 Sediment Rate Measurements for Runs 1-10

Run	Run Time (min)	Sediment Weight (g)	Duration (s)	Sediment Feed Rate (g/min)	Influent Water Flow Rate (gpm)	Influent TSS Conc. (mg/L)	NJDEP Compliance
1	0	117.767	39.78	177.6	226.3	202.9	Y
	11	110.674	40.16	165.4			
	22	118.819	40.00	178.2			
	COV			0.0418			
2	0	114.921	39.91	172.8	220.8	198.5	Y
	11	106.158	39.96	159.4			
	22	110.429	40.10	165.2			
	COV			0.0404			
3	0	117.364	39.85	176.7	227.2	206.8	Y
	11	116.700	39.90	175.5			
	22	120.156	39.72	181.5			
	COV			0.0179			
4	0	121.043	39.79	182.5	223.2	216.7	Y
	11	125.058	39.88	188.2			
	22	118.657	39.85	178.7			
	COV			0.0261			
5	0	111.624	40.03	167.3	222.2	215.0	Y
	11	117.883	40.00	176.8			
	22	132.393	39.88	199.2			
	COV			0.0904			
6	0	114.723	39.94	172.3	224.2	206.6	Y
	11	119.043	40.03	178.4			
	22	117.644	40.28	175.2			
	COV			0.0174			
7	0	115.351	40.00	173.0	226.4	198.1	Y
	11	110.196	40.25	164.3			
	22	114.603	40.00	171.9			
	COV			0.0281			
8	0	115.664	39.72	174.7	226.8	201.5	Y
	11	117.915	39.93	177.2			
	22	110.840	39.82	167.0			
	COV			0.0307			
9	0	116.845	39.87	175.8	225.6	205.2	Y
	11	114.135	39.81	172.0			
	22	117.894	39.75	178.0			
	COV			0.0172			
10	0	111.306	39.57	168.8	228.4	203.0	Y
	11	119.680	39.81	180.4			
	22	118.275	39.90	177.9			
	COV			0.0347			

Table 7 Sediment Rate Measurements for Runs 11-16

Run #	Run Time (min)	Sediment Weight (g)	Duration (s)	Sediment Feed Rate (g/min)	Influent Water Flow Rate (gpm)	Influent TSS Conc. (mg/L)	NJDEP Compliance
11	0	114.505	39.90	172.2	224.1	207.8	Y
	11	119.160	39.94	179.0			
	22	118.629	40.03	177.8			
	COV			0.0207			
12	0	115.516	39.78	174.2	226.9	208.8	Y
	11	118.805	39.87	178.8			
	22	124.236	40.22	185.3			
	COV			0.0311			
13	0	114.776	39.78	173.1	226.1	198.0	Y
	11	106.924	39.85	161.0			
	22	115.083	39.69	174.0			
	COV			0.0429			
14	0	112.871	39.72	170.5	228.7	199.9	Y
	11	116.869	39.84	176.0			
	22	114.529	39.81	172.6			
	COV			0.0161			
15	0	112.091	39.72	169.3	231.4	195.9	Y
	11	112.200	39.81	169.1			
	22	117.588	39.94	176.6			
	COV			0.0250			
16	0	118.503	39.59	179.6	229.0	202.3	Y
	11	116.834	39.78	176.2			
	22	112.971	39.84	170.1			
	COV			0.0273			

Effluent TSS

During each run, grab samples were taken of the effluent according to the schedule in **Table 1**, and all TSS analyses were conducted by Fredericktowne Labs. For each run, the average effluent concentration was adjusted by subtracting the average background TSS concentration. The average adjusted effluent TSS concentration during testing was 39 mg/L, with individual run averages ranging from 32.0 to 45.5 mg/L. Effluent and adjusted effluent TSS concentrations for each run are given in **Table 8**.

Table 8 Effluent Sample TSS Concentrations

Run	EFF TSS 9 min	EFF TSS 10 min	EFF TSS 20 min	EFF TSS 21 min	EFF TSS 31 min	EFF TSS 32 min	Mean	MDL	Adjusted Effluent TSS
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
1	48	48	47	47	48	48	47.7	1.0	45.5
2	32	32	33	32	35	33	32.8	1.0	32.0
3	33	37	37	40	38	38	37.2	1.0	36.5
4	28	31	34	38	32	38	33.5	1.0	33.0
5	40	41	39	33	42	42	39.5	1.0	39.0
6	38	41	39	37	41	44	40.0	1.0	39.5
7	37	40	37	36	37	38	37.5	1.0	37.0
8	38	41	38	40	32	38	37.8	1.0	37.3
9	35	41	36	36	42	41	38.5	1.0	38.0
10	39	44	34	38	37	41	38.8	1.0	38.3
11	35	41	38	38	38	43	38.8	1.0	38.3
12	36	43	36	41	46	47	41.5	1.0	41.0
13	41	46	37	37	42	45	41.3	1.0	40.8
14	44	49	39	42	42	45	43.5	1.0	43.0
15	40	43	41	39	40	45	41.3	1.0	40.8
16	43	45	41	44	45	46	44.0	1.0	43.5

Note: Adjusted effluent TSS concentration is the average effluent TSS concentration minus the average background TSS concentration (Table 5).

Drawdown TSS

According to the NJDEP Filter Protocol, the amount of sediment that leaves the filter during the drawdown period must be accounted for and documented. During each run, two evenly volume-spaced grab samples were taken of the drawdown, and all TSS analyses were conducted by Fredericktowne Labs. For each run, the average drawdown concentration was adjusted by subtracting the average background TSS concentration (**Table 9)**.

Table 9 Drawdown Sample TSS Concentrations

Run	DDA	DDB	Average	MDL	Adjusted Drawdown TSS
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
1	62	11	36.5	1.0	34.3
2	39	16	27.5	1.0	26.7
3	42	14	28.0	1.0	27.3
4	41	18	29.5	1.0	29.0
5	42	16	29.0	1.0	28.5
6	45	17	31.0	1.0	30.5
7	44	16	30.0	1.0	29.5
8	48	17	32.5	1.0	32.0
9	42	18	30.0	1.0	29.5
10	45	17	31.0	1.0	30.5
11	43	17	30.0	1.0	29.5
12	44	16	30.0	1.0	29.5
13	46	18	32.0	1.0	31.5
14	50	18	34.0	1.0	33.5
15	47	17	32.0	1.0	31.5
16	48	15	31.5	1.0	31.0

Note: Adjusted drawdown TSS concentration is the average drawdown TSS concentration minus the average background TSS concentration (Table 5).

In order to estimate the volume of water during drawdown, under observation by BEC, the unit was filled prior to all testing with clean water and the drawdown volume as a function of time was calculated from the height of the flow stream in the effluent pipe as a function of time. Total drawdown volume was estimated at 268.6 gal at an operating head of 2.5 inches. This volume was used to determine the volume of the void space of the gravel bed, which was then used, along with the dimensions of the Isolator Row PLUS chambers, to calculate the drawdown volume for incremental head levels above 2.5 inches. Adjusted average drawdown TSS concentrations and drawdown losses are given in **Table 10**.

Table 10 Drawdown Losses

Run	Head Level at End of Run (in)	Drawdown Volume (gal)	Average Adjusted Drawdown TSS Conc. (mg/L)	Total Sediment Lost During Drawdown (g)
1	9.00	285.2	34.3	37.1
2	12.00	354.2	26.7	35.7
3	14.00	403.3	27.3	41.7
4	15.25	432.8	29.0	47.5
5	15.75	443.9	28.5	47.9
6	16.25	454.2	30.5	52.4
7	17.50	476.0	29.5	53.2
8	17.00	468.2	32.0	56.7
9	17.25	472.3	29.5	52.7
10	17.75	476.0	30.5	55.0
11	17.25	472.3	29.5	52.7
12	17.5	476.0	29.5	53.2
13	18.00	482.4	31.5	57.5
14	18.25	484.9	33.5	61.5
15	18.50	486.8	31.5	58.1
16	18.25	484.9	31.0	56.9

Removal Efficiency Calculation

Removal efficiency was calculated using the following equation from the NJDEP Filter Protocol:

$$\text{Removal Efficiency (\%)} = \frac{\left(\begin{array}{c}\text{Average Influent}\\ \text{TSS Concentration x}\\ \text{Total Volume}\\ \text{of Test Water}\end{array}\right) - \left(\begin{array}{c}\text{Adjusted Effluent}\\ \text{TSS Concentration x}\\ \text{Total Volume}\\ \text{of Effluent Water}\end{array}\right) - \left(\begin{array}{c}\text{Average}\\ \text{Drawdown Flow}\\ \text{TSS Concentration x}\\ \text{Total Volume}\\ \text{of Drawdown Water}\end{array}\right)}{\text{Average Influent TSS Concentration x Total Volume of Test Water}} \text{ x } 100$$

For each run, sediment concentrations of background, influent, effluent, and drawdown, as well as the calculated removal efficiency, are summarized in **Table 11**. As shown in this summary table, the Isolator Row PLUS demonstrated a cumulative sediment removal efficiency of 81.2% over the course of 16 test runs.

Table 11 Removal Efficiency Results

Run	Average Influent TSS (mg/L)	Influent Water Volume (gal)	Adjusted Average Effluent TSS (mg/L)	Effluent Water Volume (gal)	Adjusted Average Drain Down TSS (mg/L)	Drain Down Water Volume (gal)	Single Run Removal Efficiency (%)	Mass of Captured Sediment (g)	Cumulative Removal Efficiency (%)
1	203	7166	46	6881	34	285	77.8	4282	77.8
2	199	6993	32	6639	27	354	84.0	4415	80.8
3	207	7197	37	6793	27	403	82.6	4654	81.4
4	217	7068	33	6635	29	433	84.9	4923	82.3
5	215	7037	39	6593	29	444	82.2	4705	82.3
6	207	7097	40	6643	31	454	81.2	4504	82.1
7	198	7169	37	6693	30	476	81.6	4386	82.0
8	201	7184	37	6716	32	468	81.6	4473	82.0
9	205	7147	38	6675	30	472	81.8	4539	82.0
10	203	7235	38	6759	31	476	81.4	4523	81.9
11	208	7096	38	6624	30	472	81.8	4567	81.9
12	209	7185	41	6709	30	476	80.7	4584	81.8
13	198	7162	41	6680	32	482	79.7	4277	81.6
14	200	7242	43	6757	34	485	78.8	4318	81.4
15	196	7329	41	6842	32	487	79.5	4320	81.3
16	202	7254	44	6769	31	485	78.9	4384	81.2
Ave.	204.2	7160	39	6713	31	447	81.2	4491	N/A
Cumulative Mass Removed (g)							71854		
Cumulative Mass Removed (lb)							158.4		
Total Mass Loaded (lb)							195.2		
Cumulative Removal Efficiency (%)							81.2		

4.5 Sediment Mass Loading

Sediment mass loading for each run was approximately 12.2 lbs on average. These data are summarized in **Table 12**.

Sediment mass loading was calculated from the summation of the total sediment mass added during dosing in each run.

Table 12 Sediment Mass Loading Summary

Run	Sediment Loading (lbs)	Cumulative Sediment Loading (lbs)	Run	Sediment Loading (lbs)	Cumulative Sediment Loading (lbs)
1	12.1	12.1	9	12.2	110.0
2	11.6	23.7	10	12.3	122.2
3	12.4	36.1	11	12.3	134.5
4	12.8	48.9	12	12.5	147.0
5	12.6	61.5	13	11.8	158.9
6	12.2	73.8	14	12.1	170.9
7	11.9	85.6	15	12.0	182.9
8	12.1	97.7	16	12.2	195.2

Overall, a total of 195.2 lbs of sediment was loaded into the Isolator Row PLUS over the course of the 16 runs. Total captured mass over the 16 runs was 158.4 lbs (**Table 11**).

The relationship between removal efficiency and sediment mass loading is shown in **Figure 10**. The relationship between driving head and sediment mass loading is shown in **Figure 11**.

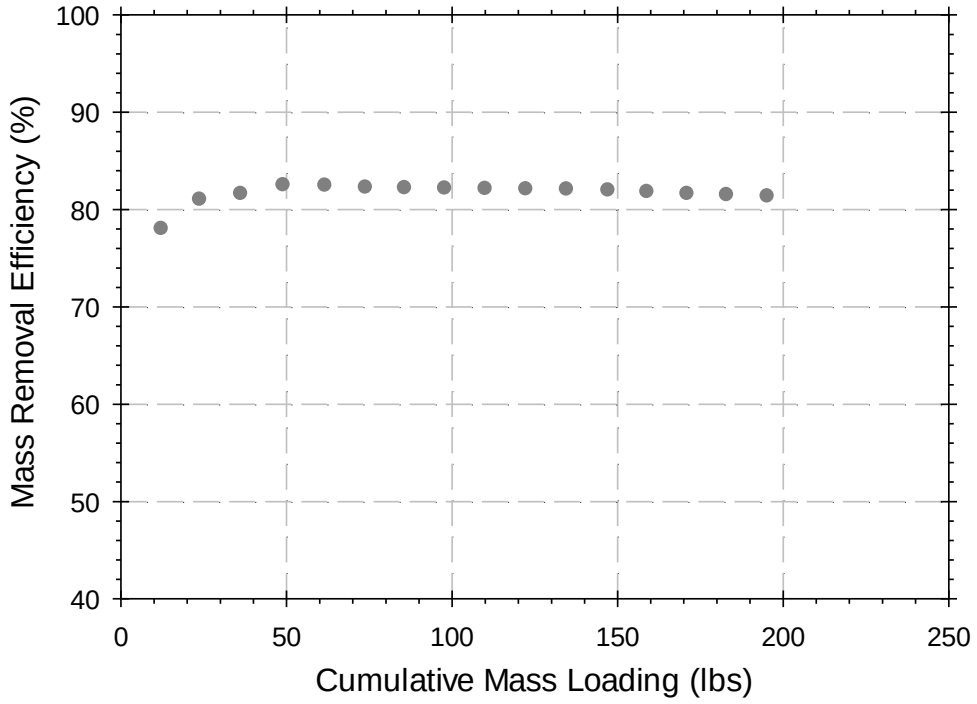


Figure 10 Removal Efficiency vs. Sediment Mass Loading

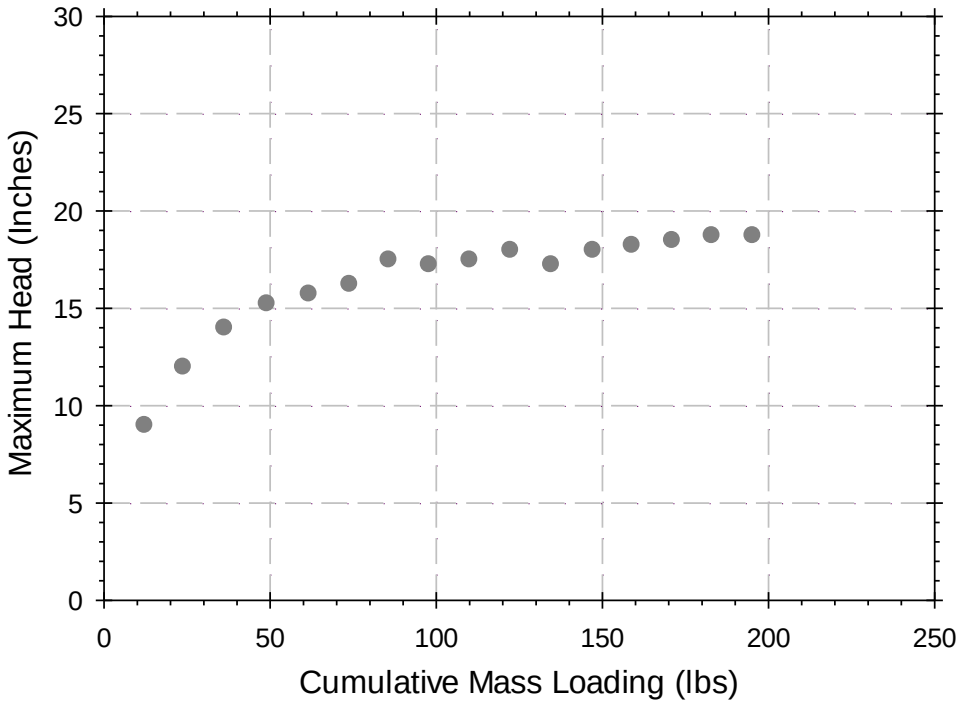


Figure 11 Driving Head vs. Sediment Mass Loading

5. Performance Verification

The Isolator Row PLUS used in this test, constructed from two (2) overlapping StormTech SC-740 chambers and one layer of ADS PLUS fabric, demonstrated a cumulative mass TSS removal efficiency of 81.2% and a sediment mass loading capacity of 3.58 lb./ft^2 (mass capture capacity of 2.91 lb./ft^2) of geotextile fabric filtration area when operated with a driving head < 20 inches at a hydraulic loading rate of 4.13 gpm/ft^2 of geotextile fabric filtration area. The MTFR's and maximum allowable drainage area for other StormTech Isolator Row PLUS models are shown in **Table 13**.

Table 13 Isolator Row PLUS System Model Sizes and New Jersey Treatment Capacities

Model	Surface Loading Rate (gpm/ft^2) Single Chamber	Effective Filtration Treatment Area (ft^2) Single Chamber	MTFR (cfs)[1] Single Chamber	Mass Loading Capacity (lbs) Single Chamber	Mass Capture Capacity (lbs) Single Chamber	Drainage Area (acres) Single Chamber
StormTech SC-160	4.13	11.45	0.105	41.0	33.4	0.06
StormTech SC-310	4.13	17.7	0.163	63.4	51.6	0.09
StormTech SC-740	4.13	27.8	0.256	99.6	81.0	0.14
StormTech DC-780	4.13	27.8	0.256	99.6	81.0	0.14
StormTech MC-3500	4.13	42.9	0.395	153.7	125.0	0.21
StormTech MC-4500	4.13	30.1	0.277	107.8	87.7	0.15

1. Based on 4.13 gpm/ft^2 of effective filtration treatment area.
2. Drainage Area is based on the equation in the NJDEP Filter Protocol wherein drainage area is calculated by dividing the pounds of mass captured by 600 lb/acre.

6. Design Limitations

Maximum Flow Rate

The StormTech Isolator Row PLUS unit has an MTFR of 0.501 cfs (225 gpm) and an effective filtration treatment area (EFTA) of 54.5 ft^2 (loading rate 4.13 gpm/ft^2).

Slope

The StormTech Isolator Row PLUS is recommended for installation with little to no slope to ensure proper, consistent operation. Steep slopes should be reviewed by ADS/StormTech Engineering support.

Allowable Head Loss

There is an operational head loss associated with the StormTech Isolator Row PLUS. The head loss will increase over time due to the sediment loading to the system. Site-specific treatment flow rates, peak flow rates, pipe diameter, and pipe slopes should be evaluated to ensure there is appropriate head for the system to function properly.

Sediment Load Capacity

Based on laboratory testing results, the StormTech Isolator Row PLUS unit has a mass loading capacity of 195.2 lbs. while operating at a sediment removal efficiency of 81.2%; the total sediment load captured by the tested Isolator Row PLUS is 158.4 lbs.

Pre-treatment Requirements

The StormTech Isolator Row PLUS unit does not require additional pre-treatment.

Configurations

The StormTech Isolator Row PLUS is available in multiple configurations. The length and size can be adjusted to meet project specific design volumes or flow rates.

Structure Load Limitations

The StormTech Isolator Row PLUS, as part of the overall chamber system, is designed to meet the full scope of design requirements of the American Society of Testing Materials (ASTM) International specification F2787 "Standard Practice for Structural Design of Thermoplastic Corrugated Wall Stormwater Collection Chambers" and produced to the requirements of the ASTM F2418 "Standard Specification for Polypropylene (PP) Corrugated Stormwater Collection Chambers". The StormTech chambers provide the full AASHTO safety factors for live loads and permanent earth loads. The ASTM F 2787 standard provides specific guidance on how to design thermoplastic chambers in accordance with AASHTO Section 12.12. of the AASHTO LRFD Bridge Design Specifications. ASTM F 2787 requires that the safety factors included in the AASHTO guidance are achieved as a prerequisite to meeting ASTM F 2418. The three standards provide both the assurance of product quality and safe structural design.

7. Maintenance Plan

The frequency of Inspection and Maintenance varies by location. A routine inspection schedule needs to be established for each individual location, based upon site-specific variables. The type of land use (i.e. industrial, commercial, public, residential), anticipated pollutant load, percent imperviousness, climate, rainfall data, etc., all play a critical role in determining the actual frequency of inspection and maintenance practices.

The Isolator Row PLUS may also be part of a treatment train. By treating stormwater prior to entry into the chamber system, the service life can be extended and pollutants such as hydrocarbons can be captured.

At a minimum, StormTech recommends annual inspections. Initially, the Isolator Row PLUS chamber should be inspected every 6 months for the first year of operation. For subsequent years, the inspection schedule should be adjusted based upon previous observation of sediment deposition.

The Isolator Row PLUS incorporates a combination of standard manhole(s) and strategically located inspection ports (as needed). The inspection ports allow for easy access to the Isolator Row PLUS from the surface, eliminating the need to perform a confined space entry for inspection purposes.

If, upon visual inspection, it is found that sediment has accumulated, a stadia rod should be inserted to determine the depth of sediment. When the average depth of sediment exceeds 3 inches throughout the length of the Isolator Row PLUS, clean-out should be performed.

The Isolator Row PLUS was designed to reduce the cost of periodic maintenance. By "isolating" sediment to just one row of the StormTech system, costs are dramatically reduced by eliminating the need to clean out each row of the entire storage bed. If inspection indicates the potential need for maintenance, access is provided via a manhole(s) located on the end(s) of the row for cleanout.

Maintenance is accomplished with the JetVac process. The JetVac process utilizes a high-pressure water nozzle to propel itself down the Isolator Row PLUS while scouring and suspending sediment. As the nozzle is retrieved, the captured pollutants are flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Selection of an appropriate JetVac nozzle will improve maintenance efficiency.

Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear-facing jets with an effective spread of at least 45" are best. Most JetVac reels have 400 feet of hose, allowing maintenance of an Isolator Row PLUS up to 50 chambers long. The JetVac process should only be performed on StormTech Isolator Rows PLUS that have AASHTO class 1 woven geotextile (as specified by StormTech) over their angular base stone.

Complete details of the design, operation, and maintenance of the Isolator Row PLUS can be found in the StormTech O&M Manual, available online at:
https://www.stormtech.com/download_files/pdf/11081-stormtech-isolator-row-plus-manual-07-20.pdf

8. Statements

The attached pages include signed statements from the manufacturer (Advanced Drainage Systems, Inc.), the third-party environmental consulting firm (Boggs Environmental Consultants, Inc.), and NJCAT. These statements are included as a requirement for the verification process.

June 26th, 2020

Dr. Richard S. Magee, Sc.D., P.E., BCEE
NJCAT
Center for Environmental Systems
Steven Institute of Technology
Castle Point on Hudson
Hoboken, NJ 07030-0000

Dr. Magee,

Advanced Drainage Systems is pleased to provide this letter as our statement certifying that the protocol, "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a filtration Manufactured Treatment Device" (NJDEP Filter Protocol, January 25, 2013), was strictly followed while testing our StormTech Isolator® Row PLUS. The testing was performed at BaySaver Laboratories, located in Mount Airy, MD. All data pertaining to the StormTech Isolator Row PLUS NJDEP Protocol test is included in the Verification Report.

Respectfully,

Greg Spires, PE
General Manager - StormTech
Advanced Drainage Systems
614.325.0032
greg.spires@ads-pipe.com

BOGGS ENVIRONMENTAL CONSULTANTS

Middletown, MD & Morgantown, WV

Administrative Office:
200 W Main Street
Middletown, Maryland 21769
Office (301) 694-5687
Fax (301) 694-9799

June 25, 2020

StormTech
Advanced Drainage Systems, Inc.
520 Cromwell Avenue
Rocky Hill, CT 06067
gregory.spires@ads-pipe.com

ATTENTION Greg Spires, PE
General Manager, StormTech
Advanced Drainage Systems, Inc.

REFERENCE: Third Party Review of Testing Procedures of the Isolator® Row PLUS at the
BaySaver Laboratory
1207 Park Ridge Drive
Mount Airy, MD 21771

BOGGS ENVIRONMENTAL CONSULTANTS, INC. (BEC) provided Third Party Review services for the testing of the Isolator® Row PLUS to evaluate if the required testing meets certification standards established by the New Jersey Department of Environmental Protection (NJDEP).

LABORATORY TESTING PROCEDURES & METHODOLOGIES

The following two procedures and testing requirements were followed during the testing process of the Isolator® Row PLUS:

- *New Jersey Department of Environmental Protection, Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device, dated January 25, 2013.*
- *QAPP for Isolator® Row PLUS, New Jersey Department of Environmental Protection Testing,* prepared by StormTech (a subsidiary of Advanced Drainage Systems, Inc.), Revision dated January 9, 2020.

ONSITE THIRD-PARTY OBSERVATION OF TESTING PROCEDURES

BEC was present at the BaySaver Laboratory, at 1207 Park Ridge Drive, in Mount Airy, MD 21771, to observe the following testing of the Isolator® Row PLUS:

- The mixing and establishment of a sediment blend that included manufactured sands that when delivered to the feed water would result in influent Total Suspended Solids (TSS) concentrations within the established range of approximately 200 mg/L and a particle size distribution specified and approved by NJDEP;
- BEC assisted in the establishment of a Procedure Checklist to be used on each run to verify and document the following: Verify that pumps and measurement devices are turned on and functioning; Verification that the correct measurements of dry sediments are added to the doser and feed stream; Document that, background effluent, and duplicate samples are collected at established intervals during the run; and, Recording of periodic flow rates and head measurements during each run;
- Observation of Runs 1 through 16 from January 14, 2020 to February 12, 2020 and verified that that sediment, background, effluent samples were collected during each 33-minute run, and that drawdown samples were collected after the end of each run.
- After sampling was completed for each run, BEC was present for the downloading of flow data as well as sediment feed rates to verify that calculated sediment feed rates met NJDEP protocols for testing. BEC also verified that that sample containers were properly labeled and chain of custodies were filled and were boxed and sealed for delivery to Fredericktowne Labs for analysis of Total Suspended Solids (TSS).

THIRD-PARTY VERIFICATION & OPINIONS

Based on observations during the runs and the reported TSS analytical results, BEC verified the following:

- That the testing of the Isolator® Row PLUS at the BaySaver Laboratory was conducted in accordance with the *New Jersey Department of Environmental Protection, Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device, dated January 25, 2013* and procedures established in Advanced Drainage Systems, Inc.'s *QAPP for Isolator® Row PLUS, New Jersey Department of Environmental Protection Testing,* prepared by StormTech (a subsidiary of Advanced Drainage Systems), Revision dated January 9, 2020.
- The report titled *NJCAT Technology Verification, of Isolator® Row PLUS,* prepared by StormTech, dated June 2020, used applicable NJCAT protocol and accurately reflects the testing observed by BEC.

BEC has no financial conflict of interest, as defined in the *Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation of Advanced Technology* (NJEP 2013).

Should you have any questions, contact our office at your earliest convenience.

Sincerely,
BOGGS ENVIRONMENTAL CONSULTANTS, INC.

William R. Warfel
Principal Environmental Scientist

Center for Environmental Systems
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030-0000

May 1, 2020

George F. Ives III, P.E.
StormTech, LLC
520 Cromwell Ave
Rocky Hill, CT 06067

Dear Mr. Ives,

Based on my review, evaluation and assessment of the testing conducted on the StormTech , LLC Isolator Row PLUS at the BaySaver Laboratory (Storm Tech, LLC and BaySaver Technologies, LLC are subsidiaries of Advanced Drainage Systems, Inc.), under the independent third-party oversight of Boggs Environmental Consultants (BEC), Inc., the test protocol requirements contained in the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" (NJDEP Filter Protocol, January 2013) were met or exceeded. Specifically:

Test Sediment Feed

The test blend was custom-blended using various commercially available silica sands under the oversight of BEC. The particle size distribution was independently analyzed by Environmental Consulting Services (ECS), using the methodology of ASTM method D422-63. The blended silica met the specification within tolerance as described in Section 5B of the NJDEP filter protocol and was acceptable for use.

Removal Efficiency Testing

Sixteen (16) removal efficiency testing runs were completed in accordance with the NJDEP filter protocol. The target flow rate was 225 gpm and the influent sediment concentration was 200 mg/L. The average flow rate for all 16 runs was 226.1, with a coefficient of variation (COV) below the flow compliance (COV) < 0.1 for all the runs. Likewise, for all runs the sediment feed rate COV was below the < 0.03 protocol limit. The Isolator Row PLUS demonstrated a cumulative sediment removal efficiency of 81.2% over the course of the 16 test runs.

Sediment Mass Loading Capacity

Mass loading capacity testing was conducted concurrently with removal efficiency testing. The Isolator Row PLUS has a mass loading capture capacity of 158.4 lbs (2.91 lbs/ft^2 of filtration area).

No maintenance was performed on the test system during the entire testing program.

Scour Testing

No scour testing was performed. Hence the Isolator Row PLUS is verified for off-line installation only.

Sincerely,

Richard S. Magee, Sc.D., P.E., BCEE

Specifications

Introduction

- Manufacturer – StormTech, LLC, 520 Cromwell Ave, Rocky Hill, CT 06067
- Website: http://www.StormTech.com. Phone: 888-892-2694
- MTD – StormTech Isolator Row PLUS verified models are shown in **Table 13**
- TSS Removal Rate – 81.2%
- Off-line installation

Detailed Specification

• NJDEP sizing tables and physical dimensions of StormTech Isolator Row PLUS verified models are shown in **Table 13**. These sizing tables are valid for NJ following NJDEP Water Quality Design Storm Event of 1.25" in 2 hours (NJAC 7:8-5.5(a)).

• Maximum inflow drainage area

  ◦ The maximum inflow drainage area is governed by the maximum treatment flow rate of each model as presented in **Table 13**.

• Driving head will vary for a given Isolator Row PLUS model based on the site-specific configuration. The maximum head without bypass is 36”, but the minimum head varies depending on the flow rate through the unit. Design support is given by StormTech for each project, and site-specific drawings (cut sheets) will be provided that show pipe inverts, finish surface elevation, and peak treatment and maximum flow rates through the unit.

• The drawdown flow exits via the underdrain. A clean filter draws down in approximately 20 minutes.

APPENDIX G: OPERATION AND MAINTENANCE

- *STORMWATER OPERATION AND MAINTENANCE PLAN*
- *INSPECTION REPORT*
- *INSPECTION AND MAINTENANCE LOG FORM*
- *LONG-TERM POLLUTION PREVENTION PLAN*
- *ILLICIT DISCHARGE STATEMENT*
- *SPILL PREVENTION*
- *PROPOSED OPERATION AND MAINTENANCE MAP*
- *MANUFACTURER'S INSPECTION AND MAINTENANCE MANUALS*

STORMWATER OPERATION AND MAINTENANCE PLAN

Proposed Retail Development
190, 194 & 198 Hartford Avenue
Bellingham, MA

RESPONSIBLE PARTY DURING CONSTRUCTION:

Rte. 85 Realty Corp.
32 Hastings Street, P.O. Box 444
Mendon, MA

RESPONSIBLE PARTY POST CONSTRUCTION:

Rte. 85 Realty Corp.
32 Hastings Street, P.O. Box 444
Mendon, MA

Construction Phase

During the construction phase, all erosion control devices and measures shall be maintained in accordance with the final record plans, local/state approvals and conditions, the EPA Construction General Permit and the Stormwater Pollution Prevention Plan (SWPPP) if applicable. Additionally, the maintenance of all erosion / siltation control measures during construction shall be the responsibility of the general contractor. Contact information of the OWNER and CONTRACTOR shall be listed in the SWPPP for this site. The SWPPP also includes information regarding construction period allowable and illicit discharges, housekeeping and emergency response procedures. Upon proper notice to the property owner, the Town/City or its authorized designee shall be allowed to enter the property at a reasonable time and in a reasonable manner for the purposes of inspection.

Post Development Controls

Once construction is completed, the post development stormwater controls are to be operated and maintained in compliance with the following permanent procedures (note that the continued implementation of these procedures shall be the responsibility of the Owner or its assignee):

1. Parking lots: Sweep at least four (4) times per year and on a more frequent basis depending on sanding operations. Swept areas shall include all parking, drive aisles, and access aisles. All resulting sweepings shall be collected and properly disposed of offsite in accordance with MADEP and other applicable requirements.

   Approximate Maintenance Budget: $1,000/year

2. Catch basins, manholes and piping: Inspect four (4) times per year and at the end of foliage and snow-removal seasons. These features shall be cleaned four (4) times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the catch basin or underground system. Accumulated sediment and hydrocarbons present must be removed and properly disposed of off-site in accordance with MADEP and other applicable requirements.

   Approximate Maintenance Budget: $500/year per structure.

3. Underground Infiltration Basins: Preventative maintenance after every major storm event during the first three (3) months of operation and at least twice per year thereafter. Inspect structure and pretreatment BMP to ensure proper operation after every major storm event (generally equal or greater to 3.0 inches in 24 hours) for the first three months. The outlet of the basin, if any, shall be inspected for erosion and sedimentation, and riprap shall be promptly repaired in the case of erosion. Sediment collecting in the bottom of the basin shall be inspected twice annually, and removal shall commence any time the sediment reaches a depth of six inches anywhere in the basin. Any sediment removed shall be disposed of in accordance with MADEP and other applicable requirements.

   Approximate Maintenance Budget: Cleaning - $1,000/year, Inspection - $200/year

All components of the stormwater system will be accessible by the owner or their assignee.

Per the Town of Bellingham Procedural Rules, revised June 2024, the Stormwater Management System Manager must notify the Planning Board of changes in ownership or assignment of financial responsibility. The maintenance schedule in the Maintenance Agreement may be amended to achieve the purposes of these regulations by mutual agreement of the Board and the Responsible Parties. Amendments must be in writing and signed by all Responsible Parties. Responsible Parties shall include owner(s), persons with financial responsibility, and Stormwater Management System Manager.

Owner Signature: _____ Date: _____

Owner Name: _____

Owner Title: _____

Company Name: _____

Address: _____

Phone Number: _____

Email Address: _____

STORMWATER MANAGEMENT SYSTEM

POST-CONSTRUCTION INSPECTION REPORT

LOCATION:

Proposed Retail Development
190, 194 & 198 Hartford Avenue
Bellingham, MA

RESPONSIBLE PARTY:

Rte. 85 Realty Corp.
32 Hastings Street, P.O. Box 444
Mendon, MA

NAME OF INSPECTOR:	INSPECTION DATE:
Note Condition of the Following (sediment depth, debris, standing water, damage, etc.):	
Catch Basins / Manholes / Piping:	
Underground Infiltration Basin:	
Isolator Row:	
Other:	

Note Recommended Actions to be taken on the Following (sediment and/or debris removal, repairs, etc.):
Catch Basins / Manholes / Piping:
Underground Infiltration Basin:
Isolator Row:
Other:
Comments:

STORMWATER INSPECTION AND MAINTENANCE LOG FORM			
Proposed Retail Development ***190, 194 & 198 Hartford Avenue - Bellingham, MA***			
Stormwater Management Practice	Responsible Party	Date	Maintenance Activity Performed

LONG-TERM POLLUTION PREVENTION PLAN

Proposed Retail Development
190, 194 & 198 Hartford Avenue
Bellingham, MA

RESPONSIBLE PARTY DURING CONSTRUCTION:

Rte. 85 Realty Corp.
32 Hastings Street, P.O. Box 444
Mendon, MA

RESPONSIBLE PARTY POST CONSTRUCTION:

Rte. 85 Realty Corp.
32 Hastings Street, P.O. Box 444
Mendon, MA

For this site, the Long-Term Pollution Prevention Plan will consist of the following:

- The property owner shall be responsible for "good housekeeping" including proper periodic maintenance of building and pavement areas, curbing, landscaping, etc.
- Proper storage and removal of solid waste (dumpsters).
- Sweeping of parking lots, drive aisles and access aisles a minimum of four times per year with a commercial cleaning unit. Any sediment removed shall be disposed of in accordance with applicable local and state requirements.
- Regular inspections and maintenance of Stormwater Management System as noted in the "O&M Plan".
- Snow removal shall be the responsibility of the property owner. Snow shall not be plowed, dumped and/or placed in forebays, infiltration basins or similar stormwater controls. Salting and/or sanding of pavement / walkway areas during winter conditions shall only be done in accordance with all state/local requirements and approvals.
- No outdoor maintenance or washing of vehicles allowed.
- Trash and other debris shall be removed from all areas of the site at least twice yearly.
- Reseed any bare areas as soon as they occur. Erosion control measures shall be installed in these areas to prevent deposits of sediment from entering the drainage system.

- Grass shall be maintained at a minimum blade height of two to three inches and only 1/3 of the plant height shall be removed at a time. Clippings shall not be disposed of within stormwater management areas or adjacent resource areas.

- Plants shall be pruned as necessary.

- Snow piles shall be located adjacent to or on pervious surfaces in upland areas. This will allow snow melt water to filter into the soil, leaving behind sand and debris which can be removed in the springtime.

- In no case shall snow be disposed of or stored in resource areas (wetlands, floodplain, streams, or other water bodies).

- In no case shall snow be disposed of or stored in the detention basins, infiltration basins or bioretention areas.

- If necessary, stockpiled snow will be removed from the Site and disposed of at an off-site location in accordance with all local, state and federal regulations.

- The amount of sand and deicing chemicals shall be kept at the minimum amount required to provide safe pedestrian and vehicle travel.

- Deicing chemicals are recommended as a pretreatment to storm events to minimize the amount of applied sand.

- Sand and deicing chemicals should be stockpiled under covered storage facilities that prevent precipitation and adjacent runoff from coming in contact with the deicing materials. Stockpile areas shall be located outside resource areas.

- The primary agents used for deicing at parking lots, sidewalks and the access roads shall consist of salt alternatives such as calcium carbonate (CaCO3) or potassium chloride (KCl) or sodium chloride.

- Deliveries shall be monitored by owner or owner's representative to ensure proper delivery and, in the event that a spillage occurs, it shall be contained and cleaned up immediately in accordance with the spill prevention program for the project.

- Recycle materials whenever possible. Provide separate containers for recycle materials. Recycling products will be removed by a certified waste hauler.

OPERATON AND MAINTENANCE TRAINING PROGRAM

The Owner will coordinate an annual in-house training session to discuss the Operations and Maintenance Plan, the Long-Term Pollution Prevention Plan, and the Spill Prevention Plan and response procedures. Annual training will include the following:

Discuss the Operations and Maintenance Plan:

- Explain the general operations of the stormwater management system and its BMPs
- Identify potential sources of stormwater pollution and measures / methods of reducing or eliminating that pollution
- Emphasize good housekeeping measures

Discuss the Spill Prevention and Response Procedures:

- Explain the process in the event of a spill
- Identify potential sources of spills and procedures for cleanup and /or reporting and notification
- Complete a yearly inventory or Materials Safety Data sheets of all tenants and confirm that no potentially harmful chemicals are in use.

ILLICIT DISCHARGE STATEMENT

Certain types of non-stormwater discharges are allowed under the U.S. Environmental Protection Agency Construction General Permit. These types of discharges will be allowed under the conditions that no pollutants will be allowed to come in contact with the water prior to or after its discharge. The control measures which have been outlined previously in this LTPPP will be strictly followed to ensure that no contamination of these non-storm water discharges takes place. Any existing illicit discharges, if discovered during the course of the work, will be reported to MassDEP and the local DPW, as applicable, to be addressed in accordance with their respective policies. No illicit discharges will be allowed in conjunction with the proposed improvements.

Duly Acknowledged:

_____

Name & Title Date

SPILL PREVENTION AND RESPONSE PROCEDURES (POST CONSTRUCTION)

In order to prevent or minimize the potential for a spill of Hazardous Substances or Oil or come into contact with stormwater, the following steps will be implemented:

1. All Hazardous Substances or Oil (such as pesticides, petroleum products, fertilizers, detergents, acids, paints, paint solvents, cleaning solvents, etc.) will be stored in a secure location, with their lids on, preferably under cover, when not in use.

2. The minimum practical quantity of all such materials will be kept on site.

3. A spill control and containment kit (containing, for example, absorbent materials, acid neutralizing powder, brooms, dust pans, mops, rags, gloves, goggles, plastic and metal trash containers, etc.) will be provided on site.

4. Manufacturer's recommended methods for spill cleanup will be clearly posted and site personnel will be trained regarding these procedures and the location of the information and cleanup supplies.

5. It is the OWNER's responsibility to ensure that all Hazardous Waste on site is disposed of properly by a licensed hazardous material disposal company. The OWNER is responsible for not exceeding Hazardous Waste storage requirements mandated by the EPA or state and local authorities.

In the event of a spill of Hazardous Substances or Oil, the following procedures should be followed:

1. All measures should be taken to contain and abate the spill and to prevent the discharge of the Hazardous Substance or Oil to stormwater or off-site. (The spill area should be kept well ventilated and personnel should wear appropriate protective clothing to prevent injury from contact with the Hazardous Substances.)

2. For spills of less than five (5) gallons of material, proceed with source control and containment, clean-up with absorbent materials or other applicable means unless an imminent hazard or other circumstances dictate that the spill should be treated by a professional emergency response contractor.

3. For spills greater than five (5) gallons of material immediately contact the MADEP at the toll-free 24-hour statewide emergency number: **1-888-304-1133**, the local fire department (**9-1-1**) and an approved emergency response contractor. Provide information on the type of material spilled, the location of the spill, the quantity spilled, and the time of the spill to the emergency response contractor or coordinator, and proceed with prevention, containment and/or clean-up if so desired. (Use the form provided, or similar).

4. If there is a Reportable Quantity (RQ) release, then the National Response Center should be notified immediately at (800) 424-8802; within 14 days a report should be submitted to the EPA regional office describing the release, the date and circumstances of the release and the steps taken to prevent another release. This Pollution Prevention Plan should be updated to reflect any such steps or actions taken and measures to prevent the same from reoccurring.

SPILL PREVENTION CONTROL AND COUNTERMEASURE FORM

Proposed Retail Development
190, 194 & 198 Hartford Avenue
Bellingham, MA

Where a release containing a hazardous substance occurs, the following steps shall be taken by the facility manager and/or supervisor:

1. Immediately notify The Bellingham Fire Department (at **9-1-1**)

2. All measures must be taken to contain and abate the spill and to prevent the discharge of the pollutant(s) to off-site locations, receiving waters, wetlands and/or resource areas.

3. Notify the Bellingham Board of Health at (508) 966-5820 and the Bellingham Conservation Commission at (508) 657-2858.

4. Provide documentation from licensed contractor showing disposal and cleanup procedures were completed as well as details on chemicals that were spilled to the Bellingham Board of Health and Conservation Commission.

Date of spill:_____ Time:_____ Reported By:_____

Weather Conditions:_____

Material Spilled	**Location of Spill**	**Approximate Quantity of Spill (in gallons)**	**Agency(s) Notified**	**Date of Notification**

Cause of Spill: _____

_____

Measures Taken to Clean up Spill: _____

_____

Type of equipment: _____ Make: _____ Size: _____

License or S/N: _____

Location and Method of Disposal _____

_____

Procedures, method, and precautions instituted to prevent a similar occurrence from recurring: _____

_____

_____

Additional Contact Numbers:

- DEPARTMENT OF ENVIRONMENTAL PROTECTION (DEP) EMERGENCY PHONE: 1-888-304-1133
- NATIONAL RESPONSE CENTER PHONE: (800) 424-8802
- U.S. ENVIRONMENTAL PROTECTION AGENCY PHONE: (888) 372-7341

StormTech®

Detention • Retention • Water Quality

A division of ADS

Save Valuable Land and Protect Water Resources

Isolator® Row O&M Manual

StormTech® Chamber System for Stormwater Management

1.0 The Isolator® Row

1.1 INTRODUCTION

An important component of any Stormwater Pollution Prevention Plan is inspection and maintenance. The StormTech Isolator Row is a patented technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance.

Looking down the Isolator Row from the manhole opening, woven geotextile is shown between the chamber and stone base.

1.2 THE ISOLATOR ROW

The Isolator Row is a row of StormTech chambers, either SC-310, SC-310-3, SC-740, DC-780, MC-3500 or MC-4500 models, that is surrounded with filter fabric and connected to a closely located manhole for easy access. The fabric-wrapped chambers provide for settling and filtration of sediment as storm water rises in the Isolator Row and ultimately passes through the filter fabric. The open bottom chambers and perforated sidewalls (SC-310, SC-310-3 and SC-740 models) allow storm water to flow both vertically and horizontally out of the chambers. Sediments are captured in the Isolator Row protecting the storage areas of the adjacent stone and chambers from sediment accumulation.

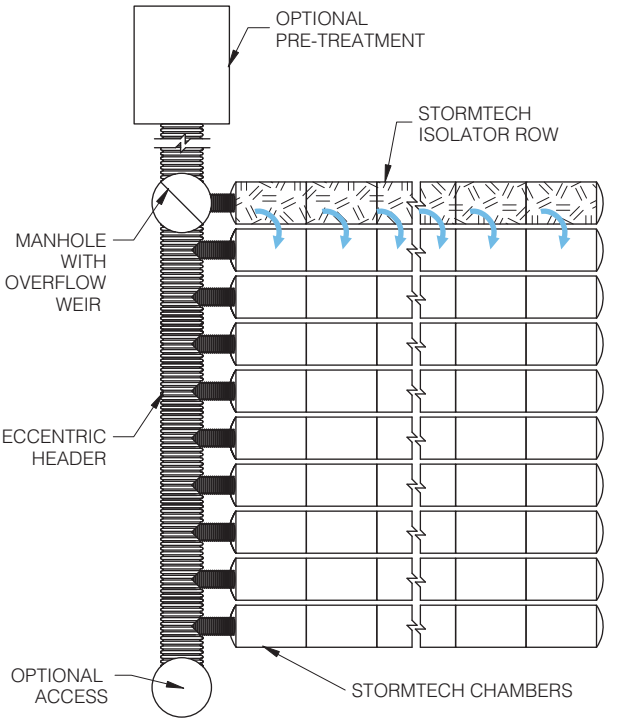
Two different fabrics are used for the Isolator Row. A woven geotextile fabric is placed between the stone and the Isolator Row chambers. The tough geotextile provides a media for storm water filtration and provides a durable surface for maintenance operations. It is also designed to prevent scour of the underlying stone and remain intact during high pressure jetting. A non-woven fabric is placed over the chambers to provide a filter media for flows passing through the perforations in the sidewall of the chamber. The non-woven fabric is not required over the DC-780, MC-3500 or MC-4500 models as these chambers do not have perforated side walls.

The Isolator Row is typically designed to capture the "first flush" and offers the versatility to be sized on a volume basis or flow rate basis. An upstream manhole not only provides access to the Isolator Row but typically includes a high flow weir such that storm water flowrates or volumes that exceed the capacity of the Isolator Row overtop the over flow weir and discharge through a manifold to the other chambers.

The Isolator Row may also be part of a treatment train. By treating storm water prior to entry into the chamber system, the service life can be extended and pollutants such as hydrocarbons can be captured. Pre-treatment best management practices can be as simple as deep sump catch basins, oil-water separators or can be innovative storm water treatment devices. The design of the treatment train and selection of pretreatment devices by the design engineer is often driven by regulatory requirements. Whether pretreatment is used or not, the Isolator Row is recommended by StormTech as an effective means to minimize maintenance requirements and maintenance costs.

Note: See the StormTech Design Manual for detailed information on designing inlets for a StormTech system, including the Isolator Row.

StormTech Isolator Row with Overflow Spillway
(not to scale)



2.0 Isolator Row Inspection/Maintenance

2.1 INSPECTION

The frequency of Inspection and Maintenance varies by location. A routine inspection schedule needs to be established for each individual location based upon site specific variables. The type of land use (i.e. industrial, commercial, residential), anticipated pollutant load, percent imperviousness, climate, etc. all play a critical role in determining the actual frequency of inspection and maintenance practices.

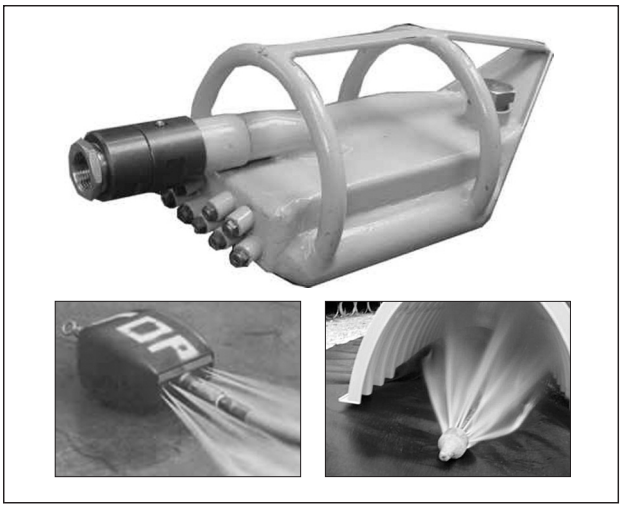
At a minimum, StormTech recommends annual inspections. Initially, the Isolator Row should be inspected every 6 months for the first year of operation. For subsequent years, the inspection should be adjusted based upon previous observation of sediment deposition.

The Isolator Row incorporates a combination of standard manhole(s) and strategically located inspection ports (as needed). The inspection ports allow for easy access to the system from the surface, eliminating the need to perform a confined space entry for inspection purposes.

If upon visual inspection it is found that sediment has accumulated, a stadia rod should be inserted to determine the depth of sediment. When the average depth of sediment exceeds 3 inches throughout the length of the Isolator Row, clean-out should be performed.

2.2 MAINTENANCE

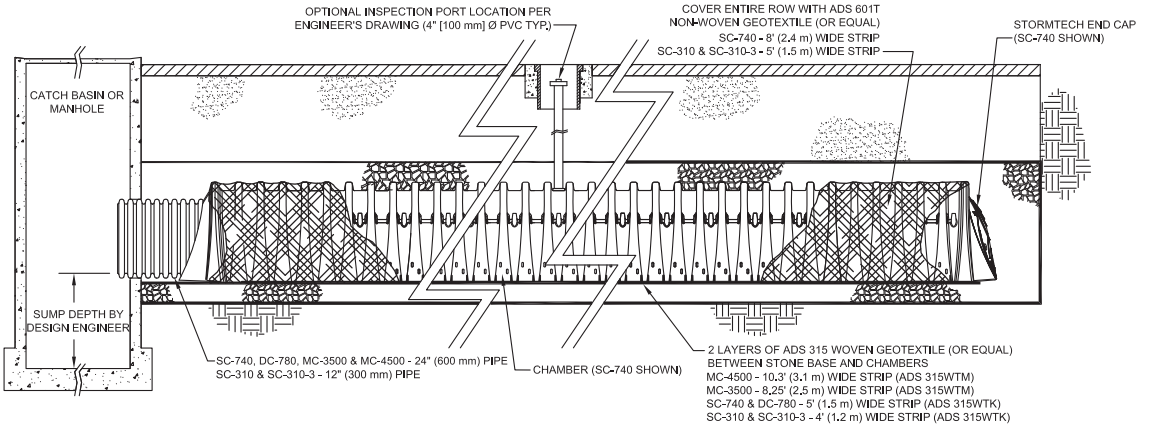
The Isolator Row was designed to reduce the cost of periodic maintenance. By "isolating" sediments to just one row, costs are dramatically reduced by eliminating the need to clean out each row of the entire storage bed. If inspection indicates the potential need for maintenance, access is provided via a manhole(s) located on the end(s) of the row for cleanout. If entry into the manhole is required, please follow local and OSHA rules for a confined space entries.



Examples of culvert cleaning nozzles appropriate for Isolator Row maintenance. (These are not StormTech products.)

Maintenance is accomplished with the JetVac process. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, the captured pollutants are flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Selection of an appropriate JetVac nozzle will improve maintenance efficiency. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45" are best. Most JetVac reels have 400 feet of hose allowing maintenance of an Isolator Row up to 50 chambers long. **The JetVac process shall only be performed on StormTech Isolator Rows that have AASHTO class 1 woven geotextile (as specified by StormTech) over their angular base stone.**

StormTech Isolator Row (not to scale)



NOTE: NON-WOVEN FABRIC IS ONLY REQUIRED OVER THE INLET PIPE CONNECTION INTO THE END CAP FOR DC-780, MC-3500 AND MC-4500 CHAMBER MODELS AND IS NOT REQUIRED OVER THE ENTIRE ISOLATOR ROW.

3.0 Isolator Row Step By Step Maintenance Procedures

Step 1) Inspect Isolator Row for sediment

A) Inspection ports (if present)

i. Remove lid from floor box frame

ii. Remove cap from inspection riser

iii. Using a flashlight and stadia rod, measure depth of sediment and record results on maintenance log.

iv. If sediment is at, or above, 3 inch depth proceed to Step 2. If not proceed to step 3.

B) All Isolator Rows

i. Remove cover from manhole at upstream end of Isolator Row

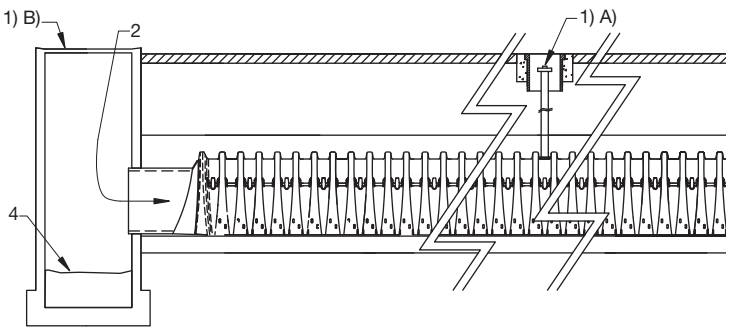
ii. Using a flashlight, inspect down Isolator Row through outlet pipe

1. Mirrors on poles or cameras may be used to avoid a confined space entry

2. Follow OSHA regulations for confined space entry if entering manhole

iii. If sediment is at or above the lower row of sidewall holes (approximately 3 inches) proceed to Step 2. If not proceed to Step 3.

StormTech Isolator Row (not to scale)



Step 2) Clean out Isolator Row using the JetVac process

A) A fixed culvert cleaning nozzle with rear facing nozzle spread of 45 inches or more is preferable

B) Apply multiple passes of JetVac until backflush water is clean

C) Vacuum manhole sump as required

Step 3) Replace all caps, lids and covers, record observations and actions

Step 4) Inspect & clean catch basins and manholes upstream of the StormTech system

Sample Maintenance Log

Date	Stadia Rod Readings		Sediment Depth (1) - (2)	Observations/Actions	Inspector
	Fixed point to chamber bottom (1)	Fixed point to top of sediment (2)			
3/15/01	6.3 ft.	none		New installation. Fixed point is CI frame at grade	djm
9/24/01		6.2	0.1 ft.	Some grit felt	sm
6/20/03		5.8	0.5 ft.	Mucky feel, debris visible in manhole and in Isolator row, maintenance due	rv
7/7/03	6.3 ft.		0	System jetted and vacuumed	djm

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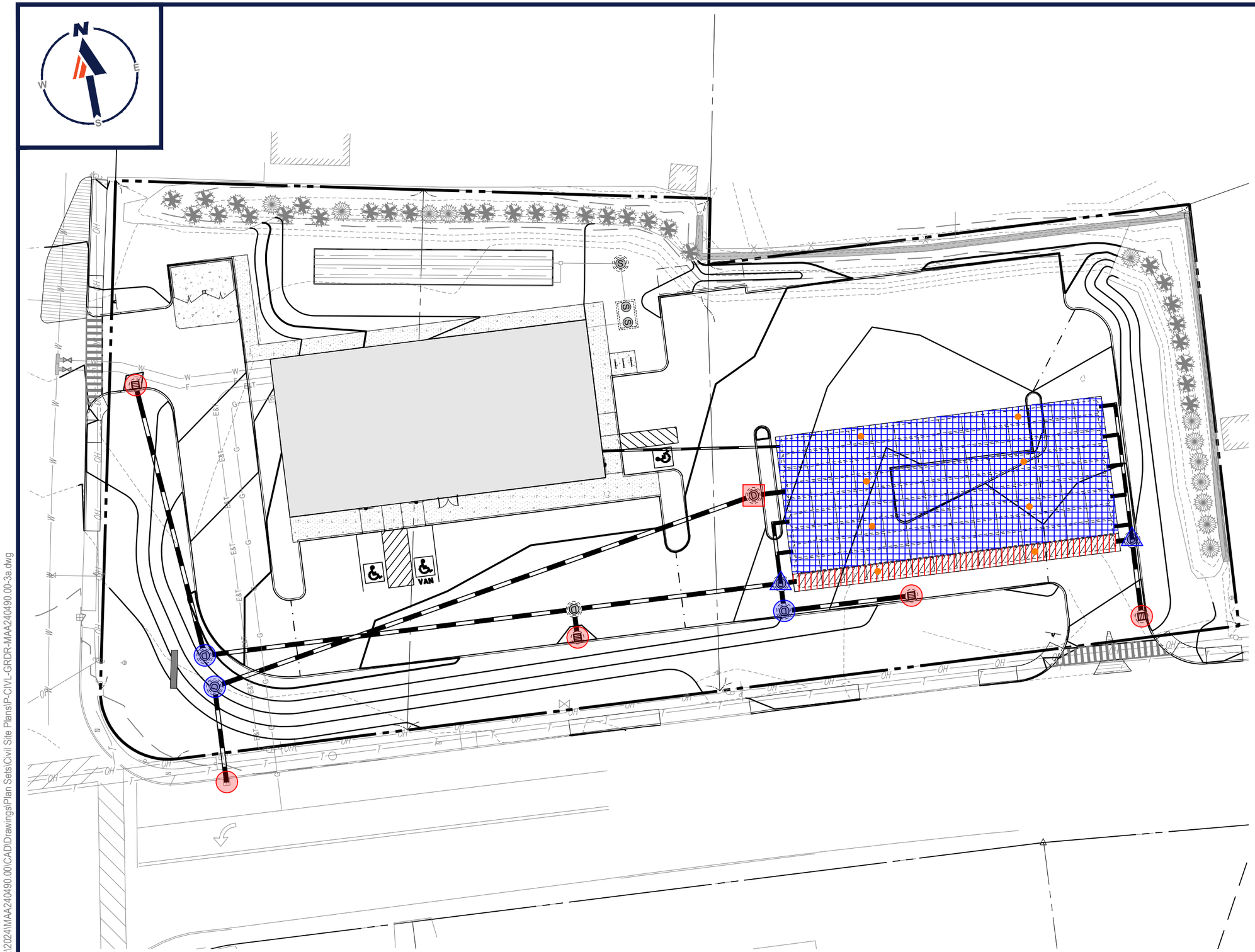

LEGEND

- CATCH BASIN ("PROP. CB") (SINGLE AND DOUBLE)
- OUTLET CONTROL STRUCTURE ("PROP. OCS")
- MANHOLE ("PROP. DMH")
- INLET CONTROL STRUCTURE ("PROP. ICS")
- INSPECTION PORT
- UNDERGROUND INFILTRATION BASIN AND ISOLATOR ROW ("UGS-1")
- ISOLATOR ROW OF CHAMBERS

OPERATION AND MAINTENANCE LOCATION MAP

190-198 HARTFORD AVENUE
BELLINGHAM, MASSACHUSETTS

PREPARED BY

BOHLER

SCALE:1"=30' DATE: 09/25/2025

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