Avalon Sudbury

PREPARED FOR

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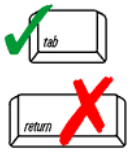
Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

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.

[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

Karen F. Staffier 5/23/2016
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): _____

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. **(As presented in the Preliminary Master Drainage Study revised April 2016)**

Standard 3: Recharge

☒ Soil Analysis provided.
(As presented in the Preliminary Master Drainage Study revised April 2016)

☒ Required Recharge Volume calculation provided.
(As presented in the Preliminary Master Drainage Study revised April 2016)

☐ 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.

[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.

Stormwater Report Narrative

This Stormwater Management Report is prepared to support the multi-family housing portion of the multi-phase, mixed-use redevelopment project proposed at 526 & 528 Boston Post Road, Sudbury, MA. The multi-family housing portion includes the construction of approximately 250 housing units with associated drive aisles, parking, and landscaped areas.

Due to the nature of the phased development on the Site, VHB developed a Preliminary Stormwater Management Master Plan for the full-build project to evaluate the existing and anticipated proposed full-build hydrologic conditions on the site. The Preliminary Master Plan demonstrates that the overall project will not increase pre-construction peak rates or volumes of stormwater discharging from the site in the 1-inch, 2-year, 10-year, 25-year and 100-year design storms.

As detailed herein, this Stormwater Management Report:

- Demonstrates compliance with the Massachusetts Department of Environmental Protection (DEP) Stormwater Management Standards;
- Confirms that the design included herein for Avalon Sudbury is consistent with the overall Preliminary Stormwater Management Master Plan developed for the Project;
- Details construction-phase erosion and sedimentation controls, inspection requirements and maintenance requirements to protect downstream receiving waters; and,
- Presents a detailed long term operation and maintenance plan for the stormwater management system and the site.

Project Description

The Applicant, Sudbury Avalon, Inc., is proposing to construct the multi-family housing portion of the Full Build Redevelopment at 526 & 528 Boston Post Road, Sudbury, MA (the Site). Avalon Sudbury (The Project) involves the construction of approximately 250 housing units, an associated club house, maintenance/trash buildings, parking, access roadways, landscape, utilities, and wastewater treatment plant improvements required to support the Project. Stormwater management BMPs and conveyances are proposed to support the Project's construction.

The Project Area of the Site is generally represented by Subcatchments S-1C, S-1E and a very small portion of S-1A in the hydrologic modeling presented in Preliminary Stormwater Management Master Plan. The existing and proposed conditions of Subcatchments S-1C, S-1E, and S-1A are depicted herein as Figure 1: Master Plan Existing Drainage Conditions and Figure 2: Master Plan Proposed Drainage Conditions.

Existing Drainage Conditions

The existing conditions in the Project area of the Site is predominately of a large impervious parking area and several existing buildings. Topography is relatively flat and slopes southeasterly. In the existing conditions, runoff from the Project area is collected by catch basins and piped in a through a closed drainage system. Runoff of from the majority of the Project Area discharges directly to the manmade stormwater retention pond and series of wetlands located at the centroid of the Site. The remaining runoff from the area along the western property line flows through a wetland/swale area before being piped to the central stormwater retention pond. Outflows from the retention pond discharge via closed drainage system towards the southeastern corner of the Site, which ultimately discharges to a wetland on the southern side of Boston Post Road, east of the Sudbury Plaza.

The existing Site contains a stormwater management system that was constructed prior to the current DEP Stormwater Management Standards and as such is a "grandfathered" existing condition. Raytheon recently undertook a significant maintenance effort, with approval of the Sudbury Conservation Commission, to re-establish and enhance the functional characteristics of the on-Site stormwater management system. While the system is compliant as an existing condition, the water quality treatment is not consistent with current state stormwater management standards.

For a more detailed discussion of the existing hydrologic conditions at the Site, refer to the Preliminary Stormwater Management Master Plan revised April 2016, prepared by VHB, which is provided under separate cover.

Proposed Drainage Conditions

The Project provides an opportunity to enhance the existing on-Site stormwater management system by (1) implementing a series of stormwater water quality and infiltrative BMPs at the Site and (2) reducing the amount of impervious cover at the Site. These site improvements will help to restore elements of a natural hydrologic

cycle in the Project Area which will benefit the underlying aquifer by increasing both the amount and quality of runoff that is infiltrated.

The stormwater treatment methods proposed for the Project are shown in Figure 3. Several different treatment trains are proposed for stormwater runoff from paved areas, including:

- Runoff discharges via overland flow to surface bio-retention areas;
- Runoff is collected by deep-sump, hooded catch basins, directed through an isolator row, and then infiltrated via a subsurface system; or,
- Runoff is collected by deep-sump, hooded catch basins and then directed through a water quality unit (when other options proved impractical/infeasible).

All stormwater treatment BMPs (bio-retention areas, subsurface infiltration systems, and water quality units) are sized to treat the 1" water quality volume, or its equivalent flow rate. Additionally, stornwater runoff from all proposed buildings will be discharged to underground, perforated pipes, to maximize recharge to the underlying aquifer. Storage capacity will be provided using stone below the perforated pipes to infiltration the first 1" of runoff from rooftops. All stormwater treatment BMPs and the perforated pipes will overflow into the closed drainage system and discharge to existing stormwater outfalls.

The Site is in the watershed of Hop Brook, which is classified as an impaired waterway requiring a TMDL for impairments including dissolved oxygen saturation, excess algal growth, dissolved oxygen, and total phosphorous. Because a TMDL has not been determined for Hop Brook, there are no required performance standards for discharges in the watershed. The proposed suite of BMPs, as discussed in the next paragraph, and the reduction of impervious area on the Site will provide improvements to these impairments relative to the no-build conditions. Recharge is generally considered the best way to remove phosphorous from stormwater and has a beneficial impact on stormwater temperatures.

VHB considered a wide range of stormwater BMPs during the preliminary design of the Project. The topography on the site and the relatively shallow depth to groundwater are significant factors in the design, limiting the use of recharge BMPs. VHB is proposing the use of one subsurface infiltration basin as part of Avalon Sudbury to provide water quality treatment, and also to maximize recharge into the underlying aquifer. Additionally, the use of overland flow and bio-retention areas is deliberate to provide some vegetated stormwater features while also maximizing separation from groundwater. Because groundwater is generally shallow across the Site, further geotechnical explorations are required to confirm that the required 2' of separation between infiltrating BMPs and groundwater is provided in the design. Should the additional data indicate that the minimum separation is not available, infiltrative BMPs will be removed from the design and runoff from the tributary impervious areas will be treated by water quality units (sizing for this alternative design is included herein). Furthermore, VHB explored the use of sand and

proprietary filters, but given the Project's reuse of existing drainage infrastructure and outfalls, the elevation drop required for filters was not attainable.

Fortunately, both in the interim and the full build conditions, impervious cover will be reduced on-Site, which in addition to the proposed stormwater management system, will provide an improvement to water quality and will increase groundwater recharge on the Site, benefitting the underlying aquifer. As previously described, stormwater runoff from buildings proposed by Avalon Sudbury will discharge to underground perforated pipes to maximize recharge to the underlying aquifer.

The comprehensive stormwater management system has been developed in accordance with the Massachusetts Stormwater Handbook. Low Impact Development (LID) techniques and stormwater BMPs implemented into the Project design include reduction of impervious area, deep-sump and hooded catch basins, bio-retention areas, water quality units, and subsurface infiltration equipped with isolator rows where feasible. The stormwater management system provides a minimum of 80% removal of Total Suspended Solids (TSS) for the one inch Water Quality Volume (or equivalent flow rate) and provides a minimum of 44% TSS pretreatment prior to infiltration.

A detailed discussion of the proposed Full Build Redevelopment hydrologic conditions are summarized in the Preliminary Stormwater Management Master Plan. Avalon Sudbury comprises a portion of the redevelopment, and in the interim condition will reflect significantly less impervious cover than is proposed at full build, as summarized in the table below. As such, there will be no increase in peak rates or volumes of runoff from the Site for the design storms.

Table 1 below summarizes the composition of the drainage areas containing the Avalon Sudbury and illustrates consistency with the Preliminary Stormwater Management Master Plan.

Table 1
Proposed Conditions Impervious Cover Comparison

Drainage Area	*Discharge Location*	*Design Point*	*Preliminary Master Plan Existing Impervious Area (acres)*	*Preliminary Master Plan Proposed Impervious Area (acres)*	*Currently Proposed Impervious Area* (acres)*
S-1A	48" RCP Across Boston Post Road	DP-1	7.1	5.3	4.6
S-1C	Ex Pond at Center of Property	DP-1	11.3	10.8	10.8
S-1E	Ex Pond at Center of Property	DP-1	3.4	2.3	1.7

*Currently Proposed Impervious Area includes all proposed work associated with the "Grocery Store at Meadow Walk" project as previously approved by the Town of Sudbury, all work described herein proposed as part of the "Avalon Sudbury" project, and all other existing impervious areas to remain.

The proposed stormwater management system incorporates low impact development (LID) techniques and Best Management Practices (BMPs) including a reduction of impervious area, minimized disturbance to existing trees and vegetation, overland flow to surface bio-retention areas, and roof runoff infiltration via perforated pipes. The LID techniques incorporated in the stormwater system for Avalon Sudbury are described below.

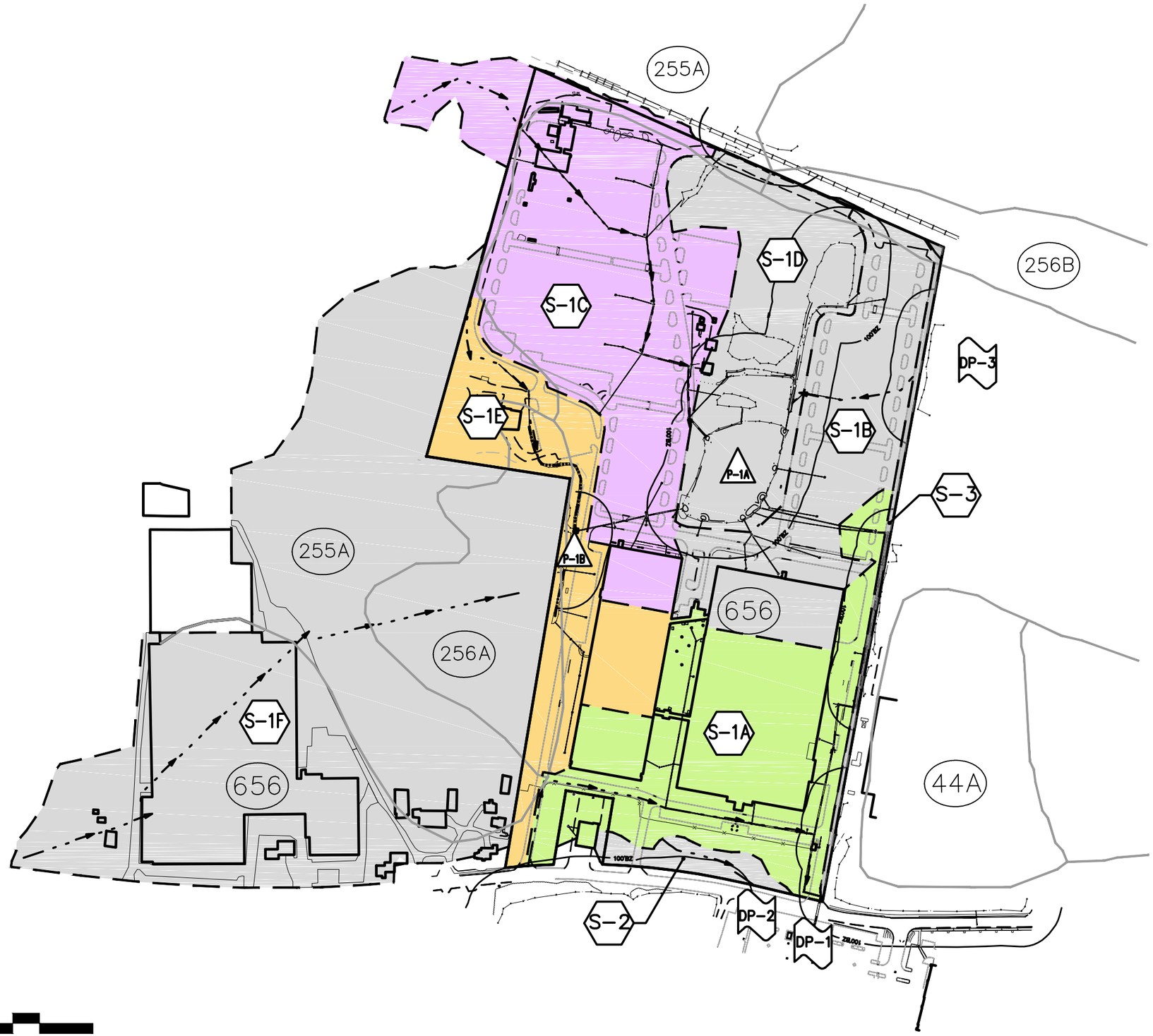
Bio-Retention Basin
Runoff from portions of the site is directed to Bio-retention Basins via sheet flow. The bio-retention basins use soils, plants, and microbes to treat stormwater before it is discharged. The bio-retention cells are shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with vegetation.

Deep Sump Hooded Catch Basins
Catch basins at the Site are to be constructed with sumps (minimum 4-feet) and oil/debris traps to prevent the discharge of sediments and floating contaminants.

Subsurface Infiltration Basin
The subsurface infiltration system consists of underground Stormtech Chambers. The system has an "Isolator Row", which is the entrance row wrapped in geosynthetic material which collects sediment and can be easily cleaned through the manhole structures located at each end. The design of the chambers includes a permeable bottom that allows for maximum exfiltration of runoff from the system to the groundwater.

Water Quality Units
The proposed hydrodynamic water quality units proposed on Site separate and trap trash, debris, sediment and hydrocarbons from stormwater runoff.

Rooftop Recharge Systems
All roof runoff from Avalon Sudbury will discharge to perforated pipes set in stone to recharge the uncontaminated runoff to the underlying aquifer.



LEGEND

- P-1 — POND
- DP-1 — DESIGN POINT
- S-1 — DRAINAGE AREA DESIGNATION
- DRAINAGE AREA BOUNDARY
- TIME OF CONCENTRATION FLOW LINE
- SOIL TYPEBOUNDARY

SCS SOIL CLASSIFICATIONS

- 656 — UDORTHENTS – URBAN LAND HSG – UNKNOWN
- 44A — BIRDSALL MUCKY SILT LOAM HSG – C/D
- 255A — WINDSOR LOAMY SAND HSG – A
- 256A — DEERFIELD LOAMY SAND 3% HSG – B
- 256B — DEERFIELD LOAMY SAND 8% HSG – B

0 150 300 Feet

Figure #1
Master Plan Existing Drainage Conditions
Avalon Sudbury
Sudbury, MA
May 2016

LEGEND

- P-1 — POND
- DP-1 — DESIGN POINT
- S-1 — DRAINAGE AREA DESIGNATION
- DRAINAGE AREA BOUNDARY
- TIME OF CONCENTRATION FLOW LINE

0 150 300 Feet

Figure #2
Master Plan Proposed Drainage Conditions
Avalon Sudbury May 2016
Sudbury, MA

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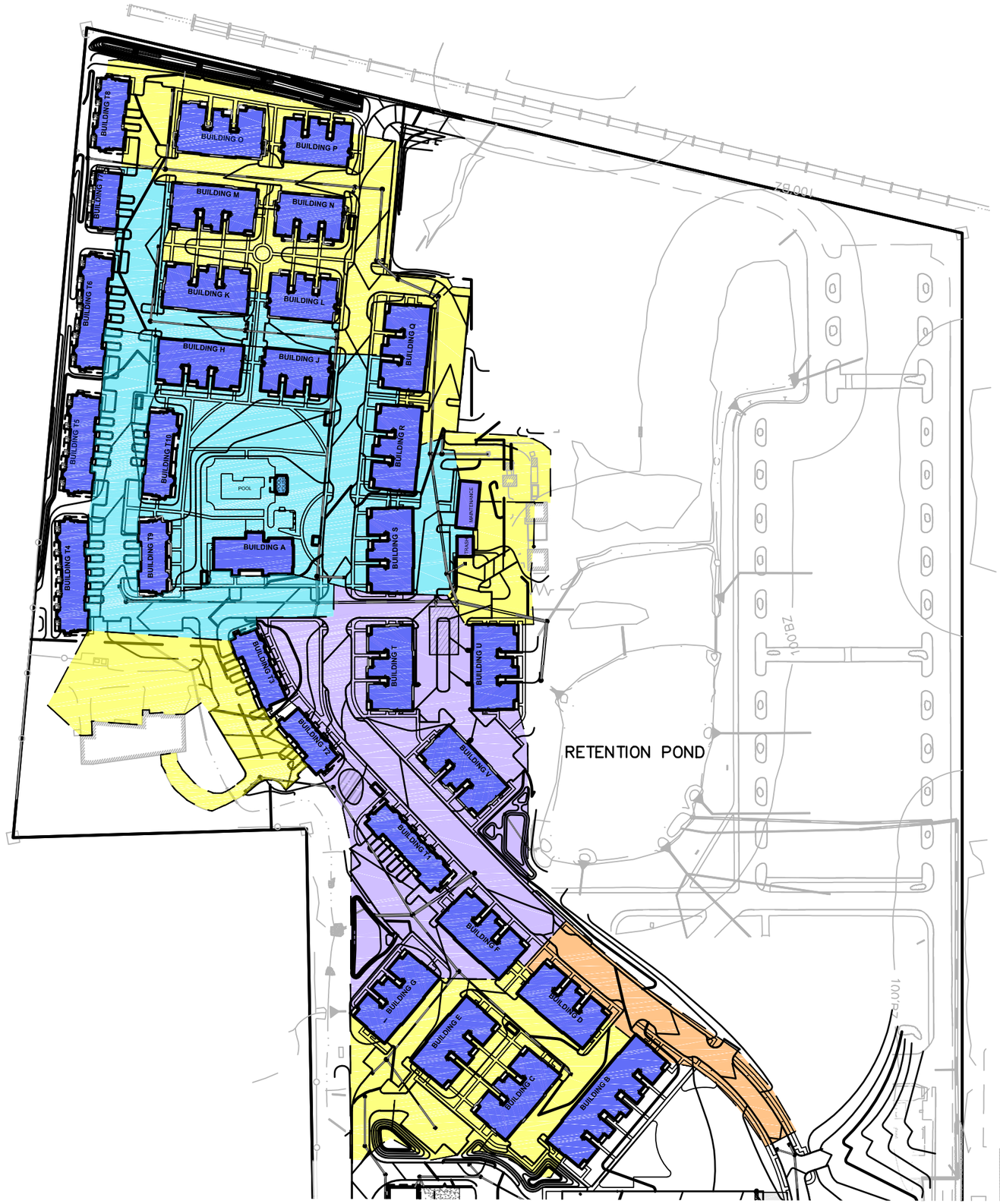


Subcatchment Treatment Legend

- ROOFTOP INFILTRATION
- S1–C TREATED BY INFILTRATION
- S1–C TREATED BY BIO–RETENTION
- S1–C TREATED BY WQU
- S1–A TREATED BY WQU

0 80 160 Feet

Figure #3
Avalon Sudbury Stormwater Treatment
Avalon Sudbury May 2016
Sudbury, MA

Regulatory Compliance

Massachusetts Department of Environmental Protection (DEP) - Stormwater Management Standards

Standard 1: No New Untreated Discharges or Erosion to Wetlands

The Project has been designed to comply with Standard 1.

The Best Management Practices (BMPs) included in the proposed stormwater management system have been designed in accordance with the Massachusetts Stormwater Handbook. Supporting information and computations demonstrating that no new untreated discharges will result from the Project are presented through compliance with Standards 4 through 6.

The Project proposes to discharge all stormwater to existing closed drainage systems and does not propose any new outfalls to wetlands.

Standard 2: Peak Rate Attenuation

The Project has been designed to comply with Standard 2.

As noted herein, Avalon Sudbury is consistent with the Preliminary Master Hydrologic Analysis for the Project, and will not increase peak rates or total volume of runoff from the site for the design storms.

Standard 3: Stormwater Recharge

The Project has been designed to comply with Standard 3.

As noted herein the Project will result in a decrease in impervious coverage on the site, both in the interim condition and in the full-build condition, and will consequently result in an increase in recharge on the property.

Additionally, the Project proposes to maximize recharge to the underlying aquifer through the use of a subsurface infiltration system and rooftop runoff perforated piping systems.

Standard 4: Water Quality

The Project has been designed to comply with Standard 4.

The proposed stormwater management system implements treatment trains of BMPs that have been designed to provide 80% TSS removal of stormwater runoff from all proposed impervious surfaces as well as 44% pretreatment prior to infiltration BMPs.

Computations and supporting information are included in Appendix B.

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

The Project is not considered a LUHPPL.

Standard 6: Critical Areas

The Project will discharge treated storm water to a critical area and therefore has been designed with BMPs sized to treat the one inch Water Quality Volume. Proposed source controls and pollution prevention measures have been identified in the Operation and Maintenance Plan included in Appendix C.

For computations and supporting information regarding the sizing of BMPs suitable for treatment of runoff near or to critical areas, see Appendix B.

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the Maximum Extent Practicable

The Project is a redevelopment. The Project has been designed to fully comply with the Stormwater Management Standards as noted above and below for a majority of the Project. As permitted for a redevelopment, the BMP selection criteria associated with standards 4 and 6 are met to the maximum extent practical only because of the selection of water quality units for treatment, where other treatment options have proven infeasible given practical limitations associated with groundwater elevations, reuse of existing infrastructure, and topographic constraints.

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

The Project will disturb more than 1 acre of land and is therefore required to obtain coverage under the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Construction General Permit. As required under this permit, a Stormwater Pollution Prevention Plan (SWPPP) will be developed and submitted before land disturbance begins. Recommended construction period pollution prevention and erosion and sedimentation controls to be finalized in the SWPPP are included in the Stormwater Operations & Maintenance Manual included in Appendix C.

Standard 9: Operation and Maintenance Plan

In compliance with Standard 9, a Post Construction Stormwater Operation and Maintenance (O&M) Plan has been developed for the Project. The O&M Plan is included in Appendix C.

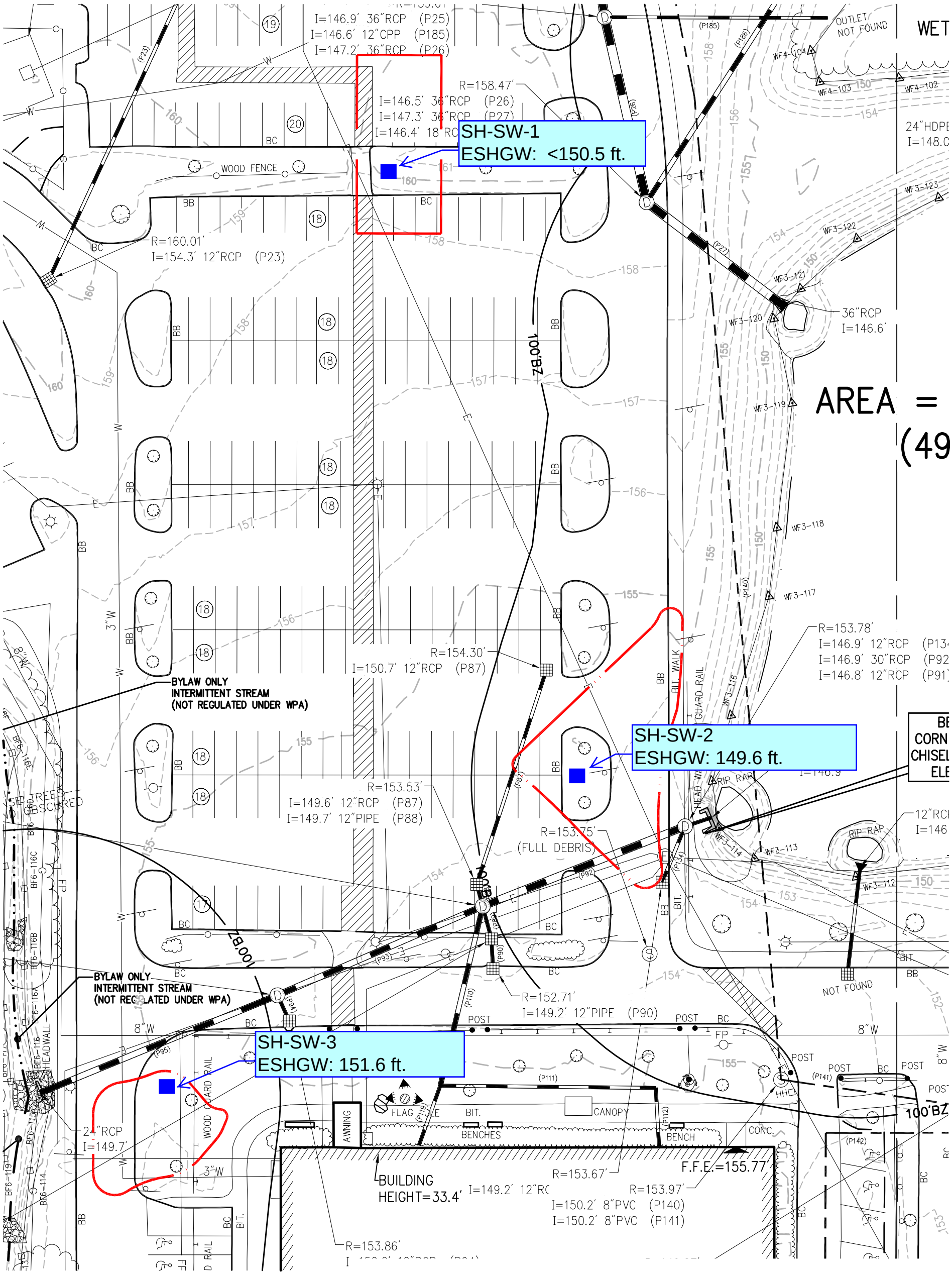
Standard 10: Prohibition of Illicit Discharges

Sanitary sewer and storm drainage structures remaining from the previous development, which are part of the redevelopment area, will be removed or will be incorporated into updated sanitary sewer and separate stormwater sewer systems. The design plans submitted with this report have been designed so that the components included therein are in full compliance with current standards. No statement is made with regard to the drainage system in portions of the site not included in the redevelopment project area.

Appendix A
Standard 3 Computations and Supporting Information

- Exploration Location Plan
- Test Pit Logs
- Groundwater Contour Plan

Exploration Location Plan



EXPLORATION LOCATION PLAN
STORMWATER TEST PITS COMPLETED ON MAY 12, 2016

SANBORN, HEAD & ASSOCIATES, INC
MAY 17, 2016

Test Pit Logs

Test Pit Logs

Site Location:	Sudbury, MA	Project Name: Meadow Walk Sudbury	Date: 5/12/2016
Site Address:	528 Boston Post Road		Time: 7:00
Project No.:	3888.03		
Ground Surface Elev. (ft):	±160		Weather : Clear, 60°F

Deep Hole Number: SH-SW-1 Location (Identify on site Plan): Median between upper and lower parking lots

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			
0-13	A	2.5Y 3/3	--	--	--	Sandy Loam	5	--	Weak Subangular	Friable	
13-26	FILL	2.5Y 6/4	--	--	--	Loamy Sand	5	--	Structureless	Loose	
26-30	A_b	2.5Y 3/3	--	--	--	Sandy Loam	5	--	Weak Subangular	Friable	
30-78	C_1	2.5Y 6/4	--	--	--	Loamy Sand	--	--	Single Grain	Loose	
78-114	C_2	2.5Y 5/6	--	--	--	Sandy Loam	--	--	Single Grain	Very Friable	1

Additional Notes:
1. Isolated pocket of organic material observed on east sidewall, at approximately 80-83 inches.

Groundwater Observed: No If Yes; Depth Weeping from Pit Face: N/A Standing Water in the Hole: N/A

Estimated Depth to Seasonal High Ground Water: >114"

Test Pit Logs

Site Location:	Sudbury, MA	Project Name: Meadow Walk Sudbury	Date: 5/12/2016
Site Address:	528 Boston Post Road		Time: 7:30
Project No.:	3888.03		
Ground Surface Elev. (ft):	±154		Weather : Clear, 60°F

Deep Hole Number: SH-SW-2 Location (Identify on site Plan):

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	A	2.5Y 5/4	--	--	--	Loamy Sand	5	--	Structureless	Friable	1
12-26	FILL	2.5Y 6/3	--	--	--	Loamy Sand	10	--	Structureless	Friable	
26-40	FILL	2.5Y 5/3	--	--	--	Gravelly Loamy Sand	15	--	Structureless	Friable	
40-53	FILL	2.5Y 5/4	53"	7.5YR 5/8 10YR 6/3	--	Loamy Sand	--	--	Structureless	Friable	2
53-59	C_1	2.5Y 3/2	--	--	--	Fine to Medium Sand	--	--	Single Grained	Loose	3
59-102	C_2	Gley 1 7/10Y	--	--	--	Fine to Medium Sand	--	--	Single Grained	Loose	

Additional Notes:
1. A-horizon contained numerous 1-inch tree roots.
2. Redoximorphic features observes just above the Fill/C_1 interface.
3. C_1 layer contains significant organic material mixed throughout.

Groundwater Observed: Yes If Yes; Depth Weeping from Pit Face: 82" Standing Water in the Hole: Yes

Estimated Depth to Seasonal High Ground Water: 53"

Test Pit Logs

Site Location:	Sudbury, MA	Project Name: Meadow Walk Sudbury	Date: 5/12/2016
Site Address:	528 Boston Post Road		Time: 8:00
Project No.:	3888.03		
Ground Surface Elev. (ft):	±155		Weather : Clear, 60°F

Deep Hole Number: SH-SW-3 Location (Identify on site Plan):

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	A	2.5Y 3/3	--	--	--	Fine to Coarse Sand	5	5	Single Grained	Loose	
12-18	B_w	2.5Y 5/4	--	--	--	Fine to Coarse Sand	5	5	Single Grained	Loose	
18-41	C_1	2.5Y 5/2	41"	10YR 5/8	--	Fine to Coarse Sand	5	5	Single Grained	Loose	
41-78	C_2	2.5Y 4/2	--	--	--	Fine to Coarse Sand	5	5	Single Grained	Loose	

Additional Notes:

Groundwater Observed: Yes If Yes; Depth Weeping from Pit Face: 53" Standing Water in the Hole: Yes

Estimated Depth to Seasonal High Ground Water: 41"

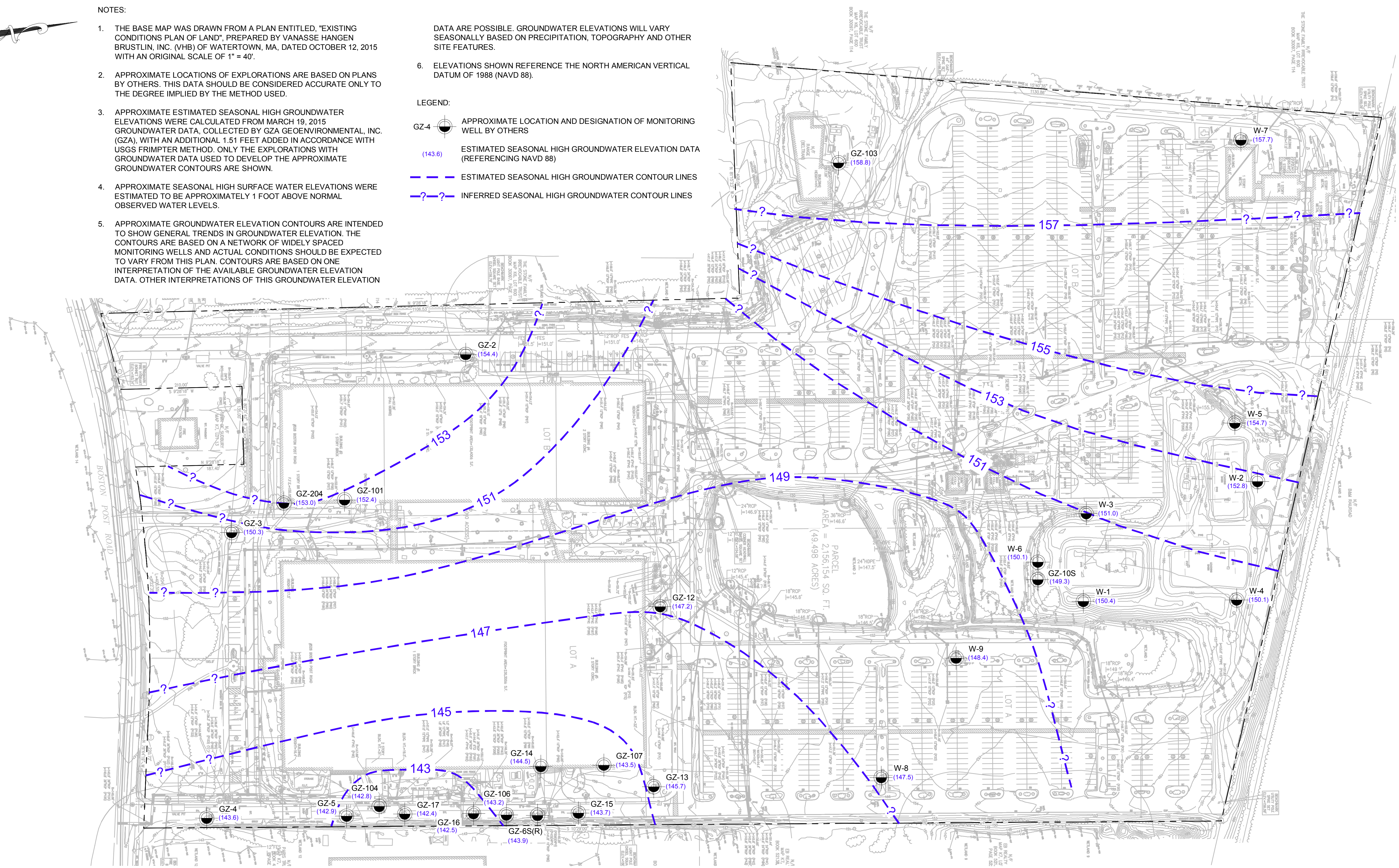
Groundwater Contour Plan

NOTES:

1. THE BASE MAP WAS DRAWN FROM A PLAN ENTITLED, "EXISTING CONDITIONS PLAN OF LAND", PREPARED BY VANASSE HANGEN BRUSTLIN, INC. (VHB) OF WATERTOWN, MA, DATED OCTOBER 12, 2015 WITH AN ORIGINAL SCALE OF 1" = 40'.
2. APPROXIMATE LOCATIONS OF EXPLORATIONS ARE BASED ON PLANS BY OTHERS. THIS DATA SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
3. APPROXIMATE ESTIMATED SEASONAL HIGH GROUNDWATER ELEVATIONS WERE CALCULATED FROM MARCH 19, 2015 GROUNDWATER DATA, COLLECTED BY GZA GEOENVIRONMENTAL, INC. (GZA), WITH AN ADDITIONAL 1.51 FEET ADDED IN ACCORDANCE WITH USGS FRIMPTER METHOD. ONLY THE EXPLORATIONS WITH GROUNDWATER DATA USED TO DEVELOP THE APPROXIMATE GROUNDWATER CONTOURS ARE SHOWN.
4. APPROXIMATE SEASONAL HIGH SURFACE WATER ELEVATIONS WERE ESTIMATED TO BE APPROXIMATELY 1 FOOT ABOVE NORMAL OBSERVED WATER LEVELS.
5. APPROXIMATE GROUNDWATER ELEVATION CONTOURS ARE INTENDED TO SHOW GENERAL TRENDS IN GROUNDWATER ELEVATION. THE CONTOURS ARE BASED ON A NETWORK OF WIDELY SPACED MONITORING WELLS AND ACTUAL CONDITIONS SHOULD BE EXPECTED TO VARY FROM THIS PLAN. CONTOURS ARE BASED ON ONE INTERPRETATION OF THE AVAILABLE GROUNDWATER ELEVATION DATA. OTHER INTERPRETATIONS OF THIS GROUNDWATER ELEVATION DATA ARE POSSIBLE. GROUNDWATER ELEVATIONS WILL VARY SEASONALLY BASED ON PRECIPITATION, TOPOGRAPHY AND OTHER SITE FEATURES.
6. ELEVATIONS SHOWN REFERENCE THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

LEGEND:

GZ-4	APPROXIMATE LOCATION AND DESIGNATION OF MONITORING WELL BY OTHERS
(143.6)	ESTIMATED SEASONAL HIGH GROUNDWATER ELEVATION DATA (REFERENCING NAVD 88)
— — —	ESTIMATED SEASONAL HIGH GROUNDWATER CONTOUR LINES
—?—?—	INFERRED SEASONAL HIGH GROUNDWATER CONTOUR LINES



SANBORN HEAD

GRAPHICAL SCALE
80' 40' 0' 80' 160'

NO.	DATE	DESCRIPTION	BY

DRAWN BY: C.GREEN
DESIGNED BY: T.ORSZULAK/D.VOLPE
REVIEWED BY: M.HEIL
PROJECT MGR: L.NORTON
PIC: K.STETSON
DATE: NOVEMBER 2015

GEOTECHNICAL CONSULTING SERVICES
528 BOSTON POST ROAD
SUDBURY, MASSACHUSETTS

GROUNDWATER CONTOUR PLAN
(BASED ON GROUNDWATER DATA COLLECTED 3/19/15)

PROJECT NUMBER: 3888.02

SHEET NUMBER: 1

Appendix B
Standard 4 Computations and Supporting Information

- TSS Removal Worksheets
- Bio-retention Basin Sizing Calculations
  - Water Quality Volume Calculations
  - Hydrologic Sizing
- Subsurface Infiltration Basin Sizing Calculations
- Roof Runoff Water Quality Volume Calculations
- WQU Sizing Calculations
- MASTEP CDS Report and Details

TSS Removal Worksheets

TSS Removal Calculation Worksheet

101 Walnut Street
Post Office Box 9151
Watertown, MA 02471
P 617.924.1770

Project Name:	**Avalon Sudbury**	Sheet:	**1 of 3**
Project Number:	**13125.00**	Date:	**5/11/2016**
Location:	**Sudbury, MA**	Computed by:	**BMG**
Discharge Point:	**DP1**	Checked by:	
Drainage Area(s):	**S-1C - Portion**		

1. Pre-Treatment prior to Infiltration

BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (C*D)	Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**25%**	**100%**	**25%**	**75%**
Isolator Row	**25%**	**75%**	**19%**	**56%**
	0%	**56%**	**0%**	**56%**
			Pre-Treatment TSS Removal =	**44%**

2. Total TSS Removal including Pretreatment 1.

BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (C*D)	Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**25%**	**100%**	**25%**	**75%**
Subsurface Infiltration Structure	**80%**	**75%**	**60%**	**15%**
	0%	**15%**	**0%**	**15%**
	0%	**15%**	**0%**	**15%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
** Equals remaining load from previous BMP (E)

Treatment Train TSS Removal = **85%**

TSS Removal Calculation Worksheet

VHB, Inc..
101 Walnut Street
Post Office Box 9151
Watertown, MA 02471
P 617.924.1770

Project Name:	**Avalon Sudbury**	Sheet:	**2 of 3**
Project Number:	**13125.00**	Date:	**5/11/2016**
Location:	**Sudbury, MA**	Computed by:	**BMG**
Discharge Point:	**DP1**	Checked by:	
Drainage Area(s):	**S-1C - Portion**		

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (C*D)	Remaining Load (D E)
Bioretention Area	**90%**	**1.00**	**0.90**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1. Removal rates for proprietary devices are from approved studies and/or manufacturer data.
** Equals remaining load from previous BMP (E)

Treatment Train TSS Removal = **90%**

TSS Removal Calculation Worksheet

VHB, Inc..
101 Walnut Street
Post Office Box 9151
Watertown, MA 02471
P 617.924.1770

Project Name:	**Avalon Sudbury**	Sheet:	**3 of 3**
Project Number:	**13125.00**	Date:	**5/11/2016**
Location:	**Sudbury, MA**	Computed by:	**BMG**
Discharge Point:	**DP1**	Checked by:	
Drainage Area(s):	**S-1C & S-1E - Portion**		

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (C*D)	Remaining Load (D E)
Deep Sump and Hooded Catch Basin	**25%**	**1.00**	**0.25**	**0.75**
Water Quality Unit	**74%**	**0.75**	**0.55**	**0.20**
	0%	**0.20**	**0.00**	**0.20**
	0%	**0.20**	**0.00**	**0.20**
	0%	**0.20**	**0.00**	**0.20**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1. Removal rates for proprietary devices are from approved studies and/or manufacturer data.

** Equals remaining load from previous BMP (E)

Treatment Train TSS Removal = **80%**

Bio-retention Basin Sizing Calculations

Summary for Pond P-A: Bio-retention Basin

Inflow Area = 0.9 ac, 32.34% Impervious, Inflow Depth = 1.0" for WQV-DYN-A event
Inflow = 1.0 cfs @ 12.08 hrs, Volume= 0.1 af
Outflow = 0.5 cfs @ 12.26 hrs, Volume= 0.1 af, Atten= 51%, Lag= 10.6 min
Discarded = 0.5 cfs @ 12.26 hrs, Volume= 0.1 af
Primary = 0.0 cfs @ 0.00 hrs, Volume= 0.0 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 154.11' @ 12.26 hrs Surf.Area= 2,687 sf Storage= 277 cf
Flood Elev= 155.00' Surf.Area= 3,882 sf Storage= 3,214 cf

Plug-Flow detention time= 2.9 min calculated for 0.1 af (100% of inflow)
Center-of-Mass det. time= 2.8 min (858.7 - 855.9)

Volume	Invert	Avail.Storage	Storage Description
#1	154.00'	3,214 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
154.00	2,545	0	0
155.00	3,882	3,214	3,214

Device	Routing	Invert	Outlet Devices
#1	Primary	151.00'	**12.0" Round Culvert** L= 16.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 151.00' / 150.50' S= 0.0313 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	154.50'	**24.0" Horiz. Orifice/Grate X 2.00** C= 0.600 Limited to weir flow at low heads
#3	Discarded	154.00'	**8.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.5 cfs @ 12.26 hrs HW=154.11' (Free Discharge)
└**3=Exfiltration** (Exfiltration Controls 0.5 cfs)

Primary OutFlow Max=0.0 cfs @ 0.00 hrs HW=154.00' (Free Discharge)
└**1=Culvert** (Passes 0.0 cfs of 6.0 cfs potential flow)
└**2=Orifice/Grate** (Controls 0.0 cfs)

Summary for Pond P-A: Bio-retention Basin

Inflow Area = 0.9 ac, 32.34% Impervious, Inflow Depth = 3.6" for 25-Year event
Inflow = 3.9 cfs @ 12.07 hrs, Volume= 0.3 af
Outflow = 2.8 cfs @ 12.15 hrs, Volume= 0.3 af, Atten= 29%, Lag= 4.4 min
Discarded = 0.7 cfs @ 12.15 hrs, Volume= 0.2 af
Primary = 2.1 cfs @ 12.15 hrs, Volume= 0.0 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 154.64' @ 12.15 hrs Surf.Area= 3,399 sf Storage= 1,898 cf
Flood Elev= 155.00' Surf.Area= 3,882 sf Storage= 3,214 cf

Plug-Flow detention time= 12.8 min calculated for 0.3 af (100% of inflow)
Center-of-Mass det. time= 12.8 min (831.0 - 818.2)

Volume	Invert	Avail.Storage	Storage Description
#1	154.00'	3,214 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
154.00	2,545	0	0
155.00	3,882	3,214	3,214

Device	Routing	Invert	Outlet Devices
#1	Primary	151.00'	**12.0" Round Culvert** L= 16.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 151.00' / 150.50' S= 0.0313 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	154.50'	**24.0" Horiz. Orifice/Grate X 2.00** C= 0.600 Limited to weir flow at low heads
#3	Discarded	154.00'	**8.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.7 cfs @ 12.15 hrs HW=154.64' (Free Discharge)
└**3=Exfiltration** (Exfiltration Controls 0.7 cfs)

Primary OutFlow Max=2.1 cfs @ 12.15 hrs HW=154.64' (Free Discharge)
└**1=Culvert** (Passes 2.1 cfs of 6.7 cfs potential flow)
└**2=Orifice/Grate** (Weir Controls 2.1 cfs @ 1.22 fps)

Hydrograph for Pond P-A: Bio-retention Basin

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
8.00	0.0	1	154.00	0.0	0.0	0.0
8.50	0.0	1	154.00	0.0	0.0	0.0
9.00	0.0	2	154.00	0.0	0.0	0.0
9.50	0.1	3	154.00	0.1	0.1	0.0
10.00	0.1	4	154.00	0.1	0.1	0.0
10.50	0.1	6	154.00	0.1	0.1	0.0
11.00	0.2	9	154.00	0.2	0.2	0.0
11.50	0.3	16	154.01	0.3	0.3	0.0
12.00	**2.5**	**826**	**154.30**	**0.6**	**0.6**	**0.0**
12.50	**0.8**	**1,591**	**154.55**	**1.0**	**0.6**	**0.4**
13.00	0.4	1,241	154.44	0.6	0.6	0.0
13.50	0.3	761	154.28	0.6	0.6	0.0
14.00	0.2	262	154.10	0.5	0.5	0.0
14.50	0.2	11	154.00	0.2	0.2	0.0
15.00	0.2	9	154.00	0.2	0.2	0.0
15.50	0.2	8	154.00	0.2	0.2	0.0
16.00	0.1	7	154.00	0.1	0.1	0.0
16.50	0.1	6	154.00	0.1	0.1	0.0
17.00	0.1	5	154.00	0.1	0.1	0.0
17.50	0.1	5	154.00	0.1	0.1	0.0
18.00	0.1	4	154.00	0.1	0.1	0.0
18.50	0.1	4	154.00	0.1	0.1	0.0
19.00	0.1	4	154.00	0.1	0.1	0.0
19.50	0.1	3	154.00	0.1	0.1	0.0
20.00	0.1	3	154.00	0.1	0.1	0.0
20.50	0.1	3	154.00	0.1	0.1	0.0
21.00	0.1	3	154.00	0.1	0.1	0.0
21.50	0.1	3	154.00	0.1	0.1	0.0
22.00	0.1	3	154.00	0.1	0.1	0.0
22.50	0.0	3	154.00	0.0	0.0	0.0
23.00	0.0	2	154.00	0.0	0.0	0.0
23.50	0.0	2	154.00	0.0	0.0	0.0
24.00	0.0	2	154.00	0.0	0.0	0.0
24.50	0.0	0	154.00	0.0	0.0	0.0
25.00	0.0	0	154.00	0.0	0.0	0.0
25.50	0.0	0	154.00	0.0	0.0	0.0
26.00	0.0	0	154.00	0.0	0.0	0.0
26.50	0.0	0	154.00	0.0	0.0	0.0
27.00	0.0	0	154.00	0.0	0.0	0.0
27.50	0.0	0	154.00	0.0	0.0	0.0
28.00	0.0	0	154.00	0.0	0.0	0.0

Summary for Pond P-B: Bio-retention Basin

Inflow Area = 2.2 ac, 52.26% Impervious, Inflow Depth = 1.0" for WQV-DYN-B event
Inflow = 2.8 cfs @ 12.08 hrs, Volume= 0.2 af
Outflow = 0.5 cfs @ 12.55 hrs, Volume= 0.2 af, Atten= 82%, Lag= 28.3 min
Discarded = 0.5 cfs @ 12.55 hrs, Volume= 0.2 af
Primary = 0.0 cfs @ 0.00 hrs, Volume= 0.0 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 153.29' @ 12.55 hrs Surf.Area= 2,650 sf Storage= 2,553 cf
Flood Elev= 155.00' Surf.Area= 5,206 sf Storage= 6,908 cf

Plug-Flow detention time= 42.0 min calculated for 0.2 af (100% of inflow)
Center-of-Mass det. time= 42.0 min (884.7 - 842.7)

Volume	Invert	Avail.Storage	Storage Description
#1	152.00'	6,908 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
152.00	1,364	0	0
153.00	2,290	1,827	1,827
154.00	3,513	2,902	4,729
154.50	5,206	2,180	6,908

Device	Routing	Invert	Outlet Devices
#1	Primary	150.50'	**15.0" Round Culvert** L= 11.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 150.50' / 150.00' S= 0.0455 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf
#2	Device 1	154.00'	**24.0" Horiz. Orifice/Grate X 2.00** C= 0.600 Limited to weir flow at low heads
#3	Discarded	152.00'	**8.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.5 cfs @ 12.55 hrs HW=153.29' (Free Discharge)
└**3=Exfiltration** (Exfiltration Controls 0.5 cfs)

Primary OutFlow Max=0.0 cfs @ 0.00 hrs HW=152.00' (Free Discharge)
└**1=Culvert** (Passes 0.0 cfs of 5.5 cfs potential flow)
└**2=Orifice/Grate** (Controls 0.0 cfs)

Summary for Pond P-B: Bio-retention Basin

Inflow Area = 2.2 ac, 52.26% Impervious, Inflow Depth = 4.2" for 25-Year event
Inflow = 11.2 cfs @ 12.07 hrs, Volume= 0.8 af
Outflow = 10.2 cfs @ 12.11 hrs, Volume= 0.8 af, Atten= 9%, Lag= 2.1 min
Discarded = 0.9 cfs @ 12.11 hrs, Volume= 0.5 af
Primary = 9.2 cfs @ 12.11 hrs, Volume= 0.3 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 154.37' @ 12.11 hrs Surf.Area= 4,765 sf Storage= 6,741 cf
Flood Elev= 155.00' Surf.Area= 5,206 sf Storage= 7,390 cf

Plug-Flow detention time= 59.0 min calculated for 0.8 af (100% of inflow)
Center-of-Mass det. time= 59.0 min (861.5 - 802.6)

Volume	Invert	Avail.Storage	Storage Description
#1	151.60'	7,390 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
151.60	1,045	0	0
152.00	1,364	482	482
153.00	2,290	1,827	2,309
154.00	3,513	2,902	5,210
154.50	5,206	2,180	7,390

Device	Routing	Invert	Outlet Devices
#1	Primary	150.50'	**15.0" Round Culvert** L= 11.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 150.50' / 150.00' S= 0.0455 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf
#2	Device 1	154.00'	**24.0" Horiz. Orifice/Grate X 2.00** C= 0.600 Limited to weir flow at low heads
#3	Discarded	151.60'	**8.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.9 cfs @ 12.11 hrs HW=154.37' (Free Discharge)
└**3=Exfiltration** (Exfiltration Controls 0.9 cfs)

Primary OutFlow Max=9.2 cfs @ 12.11 hrs HW=154.37' (Free Discharge)
└**1=Culvert** (Passes 9.2 cfs of 10.6 cfs potential flow)
└**2=Orifice/Grate** (Weir Controls 9.2 cfs @ 1.99 fps)

Hydrograph for Pond P-B: Bio-retention Basin

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
8.00	0.1	15	151.61	0.1	0.1	0.0
8.50	0.1	21	151.62	0.1	0.1	0.0
9.00	0.2	30	151.63	0.2	0.2	0.0
9.50	0.2	52	151.65	0.2	0.2	0.0
10.00	0.3	161	151.75	0.2	0.2	0.0
10.50	0.4	394	151.93	0.3	0.3	0.0
11.00	0.6	798	152.22	0.3	0.3	0.0
11.50	1.0	1,562	152.65	0.4	0.4	0.0
12.00	**7.3**	**5,682**	**154.13**	**2.6**	**0.8**	**1.9**
12.50	**2.2**	**5,700**	**154.13**	**2.7**	**0.8**	**2.0**
13.00	1.0	5,359	154.04	1.1	0.7	0.4
13.50	0.8	5,274	154.02	0.8	0.7	0.1
14.00	0.6	5,211	154.00	0.7	0.7	0.0
14.50	0.5	5,053	153.95	0.7	0.7	0.0
15.00	0.5	4,796	153.88	0.6	0.6	0.0
15.50	0.4	4,450	153.77	0.6	0.6	0.0
16.00	0.3	4,029	153.64	0.6	0.6	0.0
16.50	0.3	3,567	153.49	0.6	0.6	0.0
17.00	0.3	3,116	153.32	0.5	0.5	0.0
17.50	0.2	2,679	153.16	0.5	0.5	0.0
18.00	0.2	2,259	152.98	0.4	0.4	0.0
18.50	0.2	1,862	152.80	0.4	0.4	0.0
19.00	0.2	1,504	152.62	0.4	0.4	0.0
19.50	0.2	1,186	152.45	0.3	0.3	0.0
20.00	0.2	905	152.28	0.3	0.3	0.0
20.50	0.2	660	152.13	0.3	0.3	0.0
21.00	0.2	451	151.98	0.3	0.3	0.0
21.50	0.1	272	151.84	0.2	0.2	0.0
22.00	0.1	117	151.71	0.2	0.2	0.0
22.50	0.1	23	151.62	0.1	0.1	0.0
23.00	0.1	22	151.62	0.1	0.1	0.0
23.50	0.1	20	151.62	0.1	0.1	0.0
24.00	0.1	19	151.62	0.1	0.1	0.0
24.50	0.0	0	151.60	0.0	0.0	0.0
25.00	0.0	0	151.60	0.0	0.0	0.0
25.50	0.0	0	151.60	0.0	0.0	0.0
26.00	0.0	0	151.60	0.0	0.0	0.0
26.50	0.0	0	151.60	0.0	0.0	0.0
27.00	0.0	0	151.60	0.0	0.0	0.0
27.50	0.0	0	151.60	0.0	0.0	0.0
28.00	0.0	0	151.60	0.0	0.0	0.0

Subsurface Infiltration Basin Sizing Calculations

Summary for Pond P-C: Subsurface Infiltration System

Inflow Area = 2.6 ac,100.00% Impervious, Inflow Depth = 1.0" for WQV-DYN event
Inflow = 2.9 cfs @ 12.07 hrs, Volume= 0.2 af
Outflow = 0.1 cfs @ 9.20 hrs, Volume= 0.2 af, Atten= 98%, Lag= 0.0 min
Discarded = 0.1 cfs @ 9.20 hrs, Volume= 0.2 af
Primary = 0.0 cfs @ 0.00 hrs, Volume= 0.0 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 155.49' @ 16.68 hrs Surf.Area= 2,921 sf Storage= 5,732 cf
Flood Elev= 155.50' Surf.Area= 2,921 sf Storage= 5,747 cf

Plug-Flow detention time= 760.2 min calculated for 0.2 af (100% of inflow)
Center-of-Mass det. time= 760.2 min (1,541.3 - 781.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	152.50'	2,593 cf	**39.50'W x 73.64'L x 3.50'H Field A** 10,180 cf Overall - 3,698 cf Embedded = 6,483 cf x 40.0% Voids
#2A	153.00'	3,698 cf	**ADS_StormTech SC-740** x 80 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 Row Length Adjustment= +0.44' x 6.45 sf x 8 rows
#3	152.50'	63 cf	**4.00'D x 5.00'H Vertical Cone/Cylinder**
		6,354 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	152.50'	**1.020 in/hr Exfiltration over Surface area**
#2	Device 3	155.50'	**4.0' long x 2.50' rise Sharp-Crested Rectangular Weir** 0 End Contraction(s) 3.5' Crest Height
#3	Primary	145.40'	**18.0" Round Culvert** L= 90.0' Ke= 0.500 Inlet / Outlet Invert= 145.40' / 144.90' S= 0.0056 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 1.77 sf

Discarded OutFlow Max=0.1 cfs @ 9.20 hrs HW=152.56' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.1 cfs)

Primary OutFlow Max=0.0 cfs @ 0.00 hrs HW=152.50' (Free Discharge)
↑—**3=Culvert** (Passes 0.0 cfs of 21.4 cfs potential flow)
↑—**2=Sharp-Crested Rectangular Weir** (Controls 0.0 cfs)

Pond P-C: Subsurface Infiltration System - Chamber Wizard Field A

Chamber Model = ADS_StormTechSC-740 (ADS StormTech® SC-740)
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
Row Length Adjustment= +0.44' x 6.45 sf x 8 rows

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

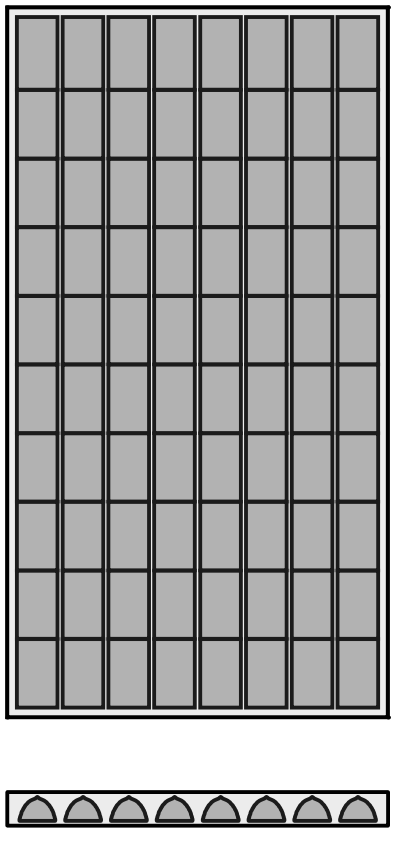
10 Chambers/Row x 7.12' Long +0.44' Row Adjustment = 71.64' Row Length +12.0" End Stone x 2 = 73.64' Base Length
8 Rows x 51.0" Wide + 6.0" Spacing x 7 + 12.0" Side Stone x 2 = 39.50' Base Width
6.0" Base + 30.0" Chamber Height + 6.0" Cover = 3.50' Field Height

80 Chambers x 45.9 cf +0.44' Row Adjustment x 6.45 sf x 8 Rows = 3,697.8 cf Chamber Storage

10,180.5 cf Field - 3,697.8 cf Chambers = 6,482.7 cf Stone x 40.0% Voids = 2,593.1 cf Stone Storage

Chamber Storage + Stone Storage = 6,290.9 cf = 0.1 af
Overall Storage Efficiency = 61.8%

80 Chambers
377.1 cy Field
240.1 cy Stone



Hydrograph for Pond P-C: Subsurface Infiltration System

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
0.00	0.0	0	152.50	0.0	0.0	**0.0**
2.00	0.0	0	152.50	0.0	0.0	0.0
4.00	0.0	2	152.50	0.0	0.0	0.0
6.00	0.0	13	152.51	0.0	0.0	0.0
8.00	0.0	36	152.53	**0.0**	**0.0**	0.0
10.00	0.1	132	152.61	**0.1**	**0.1**	0.0
12.00	**1.9**	1,946	153.56	0.1	0.1	0.0
14.00	**0.2**	5,388	155.22	0.1	0.1	0.0
16.00	0.1	**5,719**	**155.48**	0.1	0.1	0.0
18.00	0.0	**5,685**	**155.45**	0.1	0.1	0.0
20.00	0.0	5,505	155.31	0.1	0.1	0.0
22.00	0.0	5,268	155.15	0.1	0.1	0.0
24.00	0.0	4,982	154.98	0.1	0.1	0.0
26.00	0.0	4,493	154.72	0.1	0.1	0.0
28.00	0.0	3,996	154.47	0.1	0.1	0.0
30.00	0.0	3,500	154.24	0.1	0.1	0.0
32.00	0.0	3,003	154.02	0.1	0.1	0.0
34.00	0.0	2,506	153.80	0.1	0.1	0.0
36.00	0.0	2,010	153.59	0.1	0.1	0.0
38.00	0.0	1,513	153.38	0.1	0.1	0.0
40.00	0.0	1,017	153.17	0.1	0.1	0.0
42.00	0.0	520	152.94	0.1	0.1	0.0
44.00	0.0	34	152.53	0.0	0.0	0.0
46.00	0.0	0	152.50	0.0	0.0	0.0
48.00	0.0	0	152.50	0.0	0.0	0.0
50.00	0.0	0	152.50	0.0	0.0	0.0
52.00	0.0	0	152.50	0.0	0.0	0.0
54.00	0.0	0	152.50	0.0	0.0	0.0
56.00	0.0	0	152.50	0.0	0.0	0.0
58.00	0.0	0	152.50	0.0	0.0	0.0
60.00	0.0	0	152.50	0.0	0.0	0.0
62.00	0.0	0	152.50	0.0	0.0	0.0
64.00	0.0	0	152.50	0.0	0.0	0.0
66.00	0.0	0	152.50	0.0	0.0	0.0
68.00	0.0	0	152.50	0.0	0.0	0.0
70.00	0.0	0	152.50	0.0	0.0	0.0
72.00	0.0	0	152.50	0.0	0.0	0.0

Roof Runoff Water Quality Volume Calculations

Summary for Pond P-ROOF: Perforated Pipe System

Inflow Area = 4.7 ac,100.00% Impervious, Inflow Depth = 1.0" for WQV-DYN event
Inflow = 5.3 cfs @ 12.07 hrs, Volume= 0.4 af
Outflow = 0.8 cfs @ 11.69 hrs, Volume= 0.4 af, Atten= 85%, Lag= 0.0 min
Discarded = 0.8 cfs @ 11.69 hrs, Volume= 0.4 af
Primary = 0.0 cfs @ 0.00 hrs, Volume= 0.0 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 150.76' @ 12.55 hrs Surf.Area= 14,250 sf Storage= 4,891 cf
Flood Elev= 151.50' Surf.Area= 14,250 sf Storage= 9,669 cf

Plug-Flow detention time= 38.8 min calculated for 0.4 af (100% of inflow)
Center-of-Mass det. time= 38.8 min (819.9 - 781.1)

Volume	Invert	Avail.Storage	Storage Description
#1	150.50'	1,865 cf	**6.0" Round Pipe Storage** Inside #2 L= 9,500.0'
#2	150.00'	7,804 cf	**1.50'W x 9,500.00'L x 1.50'H Prismatoid** 21,375 cf Overall - 1,865 cf Embedded = 19,510 cf x 40.0% Voids
		9,669 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Discarded	150.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	151.49'	**4.0' long x 2.50' rise Sharp-Crested Rectangular Weir** 0 End Contraction(s) 3.5' Crest Height

Discarded OutFlow Max=0.8 cfs @ 11.69 hrs HW=150.04' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.8 cfs)

Primary OutFlow Max=0.0 cfs @ 0.00 hrs HW=150.00' (Free Discharge)
↑—**2=Sharp-Crested Rectangular Weir** (Controls 0.0 cfs)

Hydrograph for Pond P-ROOF: Perforated Pipe System

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
0.00	0.0	0	150.00	0.0	0.0	**0.0**
2.00	0.0	0	150.00	0.0	0.0	0.0
4.00	0.0	2	150.00	0.0	0.0	0.0
6.00	0.0	8	150.00	0.0	0.0	0.0
8.00	0.1	21	150.00	0.1	0.1	0.0
10.00	0.2	54	150.01	**0.2**	**0.2**	0.0
12.00	**3.5**	**1,408**	**150.25**	**0.8**	**0.8**	0.0
14.00	**0.3**	**2,877**	**150.50**	0.8	0.8	0.0
16.00	0.1	44	150.01	0.2	0.2	0.0
18.00	0.1	26	150.00	0.1	0.1	0.0
20.00	0.1	21	150.00	0.1	0.1	0.0
22.00	0.1	17	150.00	0.1	0.1	0.0
24.00	0.0	14	150.00	0.0	0.0	0.0
26.00	0.0	0	150.00	0.0	0.0	0.0
28.00	0.0	0	150.00	0.0	0.0	0.0
30.00	0.0	0	150.00	0.0	0.0	0.0
32.00	0.0	0	150.00	0.0	0.0	0.0
34.00	0.0	0	150.00	0.0	0.0	0.0
36.00	0.0	0	150.00	0.0	0.0	0.0
38.00	0.0	0	150.00	0.0	0.0	0.0
40.00	0.0	0	150.00	0.0	0.0	0.0
42.00	0.0	0	150.00	0.0	0.0	0.0
44.00	0.0	0	150.00	0.0	0.0	0.0
46.00	0.0	0	150.00	0.0	0.0	0.0
48.00	0.0	0	150.00	0.0	0.0	0.0
50.00	0.0	0	150.00	0.0	0.0	0.0
52.00	0.0	0	150.00	0.0	0.0	0.0
54.00	0.0	0	150.00	0.0	0.0	0.0
56.00	0.0	0	150.00	0.0	0.0	0.0
58.00	0.0	0	150.00	0.0	0.0	0.0
60.00	0.0	0	150.00	0.0	0.0	0.0
62.00	0.0	0	150.00	0.0	0.0	0.0
64.00	0.0	0	150.00	0.0	0.0	0.0
66.00	0.0	0	150.00	0.0	0.0	0.0
68.00	0.0	0	150.00	0.0	0.0	0.0
70.00	0.0	0	150.00	0.0	0.0	0.0
72.00	0.0	0	150.00	0.0	0.0	0.0

WQU Sizing Calculations

CDS ESTIMATED NET ANNUAL TSS REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

CONTECH ENGINEERED SOLUTIONS

AVALON SUDBURY
SUDBURY, MA
for SYSTEM: WQU 103

Area	0.8	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	5	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	96.5	9.8
0.04	9.6%	19.8%	0.03	0.03	95.8	9.2
0.06	9.4%	29.3%	0.04	0.04	95.1	9.0
0.08	7.7%	37.0%	0.06	0.06	94.4	7.3
0.10	8.6%	45.6%	0.07	0.07	93.7	8.0
0.12	6.3%	51.9%	0.09	0.09	93.0	5.9
0.14	4.7%	56.5%	0.10	0.10	92.3	4.3
0.16	4.6%	61.2%	0.12	0.12	91.6	4.3
0.18	3.5%	64.7%	0.13	0.13	90.9	3.2
0.20	4.3%	69.1%	0.14	0.14	90.2	3.9
0.25	8.0%	77.1%	0.18	0.18	88.5	7.1
0.30	5.6%	82.7%	0.22	0.22	86.7	4.8
0.35	4.4%	87.0%	0.25	0.25	85.0	3.7
0.40	2.5%	89.5%	0.29	0.29	83.2	2.1
0.45	2.5%	92.1%	0.32	0.32	81.5	2.1
0.50	1.4%	93.5%	0.36	0.36	79.7	1.1
0.75	5.0%	98.5%	0.54	0.54	70.9	3.6
1.00	1.0%	99.5%	0.72	0.72	62.2	0.6
1.50	0.0%	99.5%	1.08	1.08	44.7	0.0
2.00	0.0%	99.5%	1.44	1.40	28.3	0.0
3.00	0.5%	100.0%	2.16	1.40	18.9	0.1
						90.1
					Removal Efficiency Adjustment[2] =	6.5%
					Predicted % Annual Rainfall Treated =	93.4%
					Predicted Net Annual Load Removal Efficiency =	**83.7%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

CONTECH ENGINEERED SOLUTIONS

AVALON SUDBURY
SUDBURY, MA
for SYSTEM: WQU 113

Area	0.6	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	5	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	96.7	9.8
0.04	9.6%	19.8%	0.02	0.02	96.2	9.3
0.06	9.4%	29.3%	0.03	0.03	95.6	9.0
0.08	7.7%	37.0%	0.04	0.04	95.1	7.4
0.10	8.6%	45.6%	0.05	0.05	94.6	8.1
0.12	6.3%	51.9%	0.06	0.06	94.1	5.9
0.14	4.7%	56.5%	0.08	0.08	93.5	4.4
0.16	4.6%	61.2%	0.09	0.09	93.0	4.3
0.18	3.5%	64.7%	0.10	0.10	92.5	3.3
0.20	4.3%	69.1%	0.11	0.11	92.0	4.0
0.25	8.0%	77.1%	0.14	0.14	90.6	7.2
0.30	5.6%	82.7%	0.16	0.16	89.3	5.0
0.35	4.4%	87.0%	0.19	0.19	88.0	3.8
0.40	2.5%	89.5%	0.22	0.22	86.7	2.2
0.45	2.5%	92.1%	0.24	0.24	85.4	2.2
0.50	1.4%	93.5%	0.27	0.27	84.1	1.2
0.75	5.0%	98.5%	0.41	0.41	77.5	3.9
1.00	1.0%	99.5%	0.54	0.54	70.9	0.7
1.50	0.0%	99.5%	0.81	0.81	57.8	0.0
2.00	0.0%	99.5%	1.08	1.08	44.7	0.0
3.00	0.5%	100.0%	1.62	1.40	25.1	0.1
						91.8

Removal Efficiency Adjustment[2] =	6.5%
Predicted % Annual Rainfall Treated =	93.5%
Predicted Net Annual Load Removal Efficiency =	**85.4%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

CONTECH ENGINEERED SOLUTIONS

AVALON SUDBURY
SUDBURY, MA
for SYSTEM: WQU 316

Area	0.2	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	5	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.00	0.00	97.0	9.9
0.04	9.6%	19.8%	0.01	0.01	96.9	9.3
0.06	9.4%	29.3%	0.01	0.01	96.7	9.1
0.08	7.7%	37.0%	0.01	0.01	96.5	7.5
0.10	8.6%	45.6%	0.02	0.02	96.3	8.3
0.12	6.3%	51.9%	0.02	0.02	96.2	6.1
0.14	4.7%	56.5%	0.03	0.03	96.0	4.5
0.16	4.6%	61.2%	0.03	0.03	95.8	4.4
0.18	3.5%	64.7%	0.03	0.03	95.6	3.4
0.20	4.3%	69.1%	0.04	0.04	95.5	4.1
0.25	8.0%	77.1%	0.05	0.05	95.0	7.6
0.30	5.6%	82.7%	0.05	0.05	94.6	5.3
0.35	4.4%	87.0%	0.06	0.06	94.2	4.1
0.40	2.5%	89.5%	0.07	0.07	93.7	2.4
0.45	2.5%	92.1%	0.08	0.08	93.3	2.4
0.50	1.4%	93.5%	0.09	0.09	92.8	1.3
0.75	5.0%	98.5%	0.14	0.14	90.6	4.6
1.00	1.0%	99.5%	0.18	0.18	88.5	0.9
1.50	0.0%	99.5%	0.27	0.27	84.1	0.0
2.00	0.0%	99.5%	0.36	0.36	79.7	0.0
3.00	0.5%	100.0%	0.54	0.54	70.9	0.3
						95.4
					Removal Efficiency Adjustment[2] =	6.5%
					Predicted % Annual Rainfall Treated =	93.5%
					Predicted Net Annual Load Removal Efficiency =	**89.0%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

CONTECH ENGINEERED SOLUTIONS

AVALON SUDBURY
SUDBURY, MA
for SYSTEM: WQU 318

Area	0.3	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	5	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	97.0	9.9
0.04	9.6%	19.8%	0.01	0.01	96.7	9.3
0.06	9.4%	29.3%	0.02	0.02	96.4	9.1
0.08	7.7%	37.0%	0.02	0.02	96.2	7.4
0.10	8.6%	45.6%	0.03	0.03	95.9	8.2
0.12	6.3%	51.9%	0.03	0.03	95.6	6.0
0.14	4.7%	56.5%	0.04	0.04	95.4	4.4
0.16	4.6%	61.2%	0.04	0.04	95.1	4.4
0.18	3.5%	64.7%	0.05	0.05	94.9	3.4
0.20	4.3%	69.1%	0.05	0.05	94.6	4.1
0.25	8.0%	77.1%	0.07	0.07	93.9	7.5
0.30	5.6%	82.7%	0.08	0.08	93.3	5.2
0.35	4.4%	87.0%	0.09	0.09	92.6	4.0
0.40	2.5%	89.5%	0.11	0.11	92.0	2.3
0.45	2.5%	92.1%	0.12	0.12	91.3	2.3
0.50	1.4%	93.5%	0.14	0.14	90.6	1.3
0.75	5.0%	98.5%	0.20	0.20	87.4	4.4
1.00	1.0%	99.5%	0.27	0.27	84.1	0.9
1.50	0.0%	99.5%	0.41	0.41	77.5	0.0
2.00	0.0%	99.5%	0.54	0.54	70.9	0.0
3.00	0.5%	100.0%	0.81	0.81	57.8	0.3
						94.5
					Removal Efficiency Adjustment[2] =	6.5%
					Predicted % Annual Rainfall Treated =	93.5%
					Predicted Net Annual Load Removal Efficiency =	**88.1%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

CONTECH ENGINEERED SOLUTIONS

AVALON SUDBURY
SUDBURY, MA
for SYSTEM: WQU 322

Area	0.9	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	5	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.02	0.02	96.4	9.8
0.04	9.6%	19.8%	0.03	0.03	95.6	9.2
0.06	9.4%	29.3%	0.05	0.05	94.9	9.0
0.08	7.7%	37.0%	0.06	0.06	94.1	7.3
0.10	8.6%	45.6%	0.08	0.08	93.3	8.0
0.12	6.3%	51.9%	0.10	0.10	92.5	5.8
0.14	4.7%	56.5%	0.11	0.11	91.7	4.3
0.16	4.6%	61.2%	0.13	0.13	90.9	4.2
0.18	3.5%	64.7%	0.15	0.15	90.1	3.2
0.20	4.3%	69.1%	0.16	0.16	89.3	3.9
0.25	8.0%	77.1%	0.20	0.20	87.4	7.0
0.30	5.6%	82.7%	0.24	0.24	85.4	4.8
0.35	4.4%	87.0%	0.28	0.28	83.4	3.6
0.40	2.5%	89.5%	0.32	0.32	81.5	2.1
0.45	2.5%	92.1%	0.36	0.36	79.5	2.0
0.50	1.4%	93.5%	0.41	0.41	77.5	1.1
0.75	5.0%	98.5%	0.61	0.61	67.7	3.4
1.00	1.0%	99.5%	0.81	0.81	57.8	0.6
1.50	0.0%	99.5%	1.22	1.22	38.1	0.0
2.00	0.0%	99.5%	1.62	1.40	25.1	0.0
3.00	0.5%	100.0%	2.43	1.40	16.8	0.1
						89.3
					Removal Efficiency Adjustment[2] =	6.5%
					Predicted % Annual Rainfall Treated =	93.3%
					Predicted Net Annual Load Removal Efficiency =	**82.8%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

CONTECH ENGINEERED SOLUTIONS

AVALON SUDBURY
SUDBURY, MA
for SYSTEM: WQU 3

Area	0.7	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	5	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	96.6	9.8
0.04	9.6%	19.8%	0.03	0.03	96.0	9.3
0.06	9.4%	29.3%	0.04	0.04	95.4	9.0
0.08	7.7%	37.0%	0.05	0.05	94.8	7.3
0.10	8.6%	45.6%	0.06	0.06	94.2	8.1
0.12	6.3%	51.9%	0.08	0.08	93.5	5.9
0.14	4.7%	56.5%	0.09	0.09	92.9	4.3
0.16	4.6%	61.2%	0.10	0.10	92.3	4.3
0.18	3.5%	64.7%	0.11	0.11	91.7	3.2
0.20	4.3%	69.1%	0.13	0.13	91.1	4.0
0.25	8.0%	77.1%	0.16	0.16	89.6	7.2
0.30	5.6%	82.7%	0.19	0.19	88.0	4.9
0.35	4.4%	87.0%	0.22	0.22	86.5	3.8
0.40	2.5%	89.5%	0.25	0.25	85.0	2.2
0.45	2.5%	92.1%	0.28	0.28	83.4	2.1
0.50	1.4%	93.5%	0.32	0.32	81.9	1.1
0.75	5.0%	98.5%	0.47	0.47	74.2	3.7
1.00	1.0%	99.5%	0.63	0.63	66.6	0.7
1.50	0.0%	99.5%	0.95	0.95	51.2	0.0
2.00	0.0%	99.5%	1.26	1.26	35.9	0.0
3.00	0.5%	100.0%	1.89	1.40	21.6	0.1
						91.0
					Removal Efficiency Adjustment[2] =	6.5%
					Predicted % Annual Rainfall Treated =	93.4%
					Predicted Net Annual Load Removal Efficiency =	**84.5%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

MASTEP CDS Report and Details

UNIVERSITY OF MASSACHUSETTS
AT AMHERST
Water Resources Research Center
Blaisdell House, UMass
310 Hicks Way
Amherst, MA 01003

Massachusetts Stormwater Evaluation Project

(413) 545-5532
(413) 545-2304 FAX
www.mastep.net

MASTEP Technology Review

Technology Name: CDS (Continuous Deflective Separator) - Contech Stormwater Solutions, Inc.

Studies Reviewed:

- NJCAT Technology Verification High Efficiency Continuous Deflective Separators CDS Technologies Inc. January 2010.
- Independent Review of CDS 2015 Product Evaluation, FB Environmental Associates, 2009.
- NJCAT Technology Verification Addendum Report High Efficiency Continuous Deflective Separators CDS Technologies Inc. December 2004
- Continuous Deflection Separation (CDS) Unit For Sediment Control In Brevard County, Florida January, 2000

Date: 5/13/2011
Reviewer: Jerry Schoen

Rating: 2

Brief rationale for rating: MASTEP rating is based primarily on NJCAT 2010 field study and FB Environmental 2009 laboratory study. Both studies generally followed TARP field or NJDEP-recommended laboratory test protocols, with some exceptions. The 2010 field study sampled storms totaling 37% of average annual rainfall (50% is required), and experienced excessively large influent particles. This is discussed further below and in the MASTEP study description. In the FB lab study, no evidence of a Quality Assurance Project Plan, little discussion of quality control, higher than recommended particle size distribution, limited range of influent sediment concentration, sediments analyzed by SSC method but not TSS.

The Florida field study monitored 5 storm events and encountered sampling/equipment problems in four of them. The NJCAT lab study was conducted on a unit that was specially modified for testing in New Jersey, and is now being sold in NJ and NY.

Other Comments:

FB Environmental Associates study:

- OK-110 sediment mix used. This is recommended by Maine DEP, but produces sediments somewhat larger than those recommended by New Jersey DEP.
- Sediment analysis conducted with whole sample; essentially SSC method. SSC is generally regarded as more accurate than TSS method, but comparisons with other studies or products that use TSS data are problematic.
- Full range of flows were tested.
- Only one target sediment concentration was tested; average influent SSC was 313 mg/l, slightly outside of recommended 100-300 mg/l range.
- Scour test was performed; system produced no scour at flows up to 137% of capacity.

NJCAT 2010 Study

- Mean influent particle size was 500-600 microns, well above the TARP criteria of < 100 microns. To address this problem, the testing agency separated samples into

filtered subsamples of several size ranges (> 2000 microns, < 2000, < 500 and < 50). Removal efficiencies were calculated for each of these ranges, with results ranging from 64% (for <50 micron particles) to 99% (for > 2000 microns).
- TSS and SSC efficiencies were calculated by Event Mean Concentration and by Sum Of Loads methods.
- Study was well document. Other than issues of particle size and % annual rainfall, study closely followed TARP guidelines.

NJCAT 2004 Study

- Expectations of sediment removal performance comparable to this study should be confined to units that contain the sediment weir and a 2400 micron screen.
- The study did not include a scour test.
- A particularly fine sediment mix (Sil-Col-Sil 106, pre-washed to remove all particles > 100 microns), which makes sediment removal more difficult. Higher removal efficiencies may be obtained if sediment particle size range is larger.
- A narrow range of influent sediment (164 – 203 mg/l, average 184), was tested but this is within the NJDEP-recommended 100-300 mg/l range.
- TSS analysis appears to have been performed by a non- standardized method.
- No discussion of quality control.

Brevard County FL study

- This study was performed before release of the TARP Tier II Protocols and does not conform to them.
- The study states that "testing under higher flow conditions would be desirable."
- TSS, BOD, COD, pH, total phosphorus, and turbidity were monitored.

Test Report Details

Back to Summary Page | Back to Profile

CDS Inline Unit :: A product from CONTECH STORMWATER SOLUTIONS, INC. ::

General Information:

This report describes a laboratory study that evaluated the performance of a CDS model PMSU20_20_6 with a special configuration, involving an enlarged pipe diameter and a sediment weir. This is an inverted oil baffle that extends several inches above the outlet invert. This reconfigured unit is sold in NJ and NY. Anyone considering this unit with expectations of sediment removal performance comparable to this study should ensure that a unit with the sediment weir, and with a 2400 micron screen is obtained. A 4700 screen is also available – solids removal would be adversely affected with the larger mesh screen. A particularly fine sediment mix (Sil-Col-Sil 106, pre-washed to remove all particles > 100 microns), which created rigorous testing conditions for sediment removal. It tested a rather narrow range of influent sediment concentration (164 – 203 mg/l, average 184), but this is within the NJDEP-recommended 100-300 mg/l range. For the most part, the study tested NJ-recommended operating rates; except that no tests at 125% operating rate were conducted. 0% credit for sediment removal at this rate was given when calculating the overall performance of 73.7% removal. The report states that this figure may be conservative because of the 0% credit at 125% operating rate. However, this assertion cannot be substantiated, because no scour tests were conducted. No discussion of quality control. MASTEP Rating 3: This study has some scientific merit. Significant caveats exist regarding use of the study information.

Report title	Author	Agency conducting study	Funding source for study
NJCAT Technology Verification Addendum Report High Efficiency Continuous Deflective Separators	-	Portland State U, for NJCAT	-

Report date	Date system installed	Study start date	Study end date
12/01/2004	-	-	-

Name, location of test site	Watershed where test site exists	% impervious surface in test watershed	Size of BMP drainage area (acres)
-	-	-	-

Performance claims statement used for this study:

A 500 GPM unit (Model PMSU20_20_5) with a 2400 micron screen opening and a reconfigured outlet for best sediment control, operating with an average influent TSS concentration of 184 mg/L and zero initial sediment loading, has been shown to have a total mass TSS removal efficiency of 73.7% (per NJDEP treatment efficiency calculation methodology) for silica sand particles < 100 microns (d50 particle size of 63 microns) in laboratory studies using simulated stormwater.

Rating /Verification given by agency conducting study:

Based on the evaluation of the results from the Portland State University sub-100 micron particle testing studies, sufficient data is available to support the CDS Technologies Claim: A 500 GPM unit (Model PMSU20_20_5) with a 2400 micron screen opening and a reconfigured outlet for best sediment control, operating with an average influent TSS concentration of 184mg/l and zero initial sediment loading, has been shown to have a total mass TSS removal efficiency of 73.7% (per NJDEP treatment efficiency calculation methodology) for silica sand particles <100 microns (d50 particle size of 63 microns) in laboratory studies using simulated stormwater.

Average annual number of storms in test watershed	Average annual rainfall at test site (inches)	Average monthly rainfall during test period (inches)
-	-	-

% of total annual rainfall monitored during study	Number of storms that occurred during study period	Number of storm events that were monitored during the study

-	-	-

Dates, precipitation amounts of storm events occurring during study	Dates of storm events that were monitored during study
-	-

Qualifying event minimum storm depth (inches)	Maximum event recurrence interval (years)	Was bypass monitored?
-	-	No

Type of samples collected	Parameters measured	Analytical methods used	Statistical methods used	Pollution removal efficiency calculation methods
-	-	-	-	9

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Appendix C
Stormwater Management System Operation and Maintenance Manual

Avalon Sudbury

Sudbury, Massachusetts

PREPARED FOR

Sudbury Avalon, Inc.
c/o AvalonBay Communities, Inc.
51 Sleeper Street
Suite 750
Boston, MA 02210

PREPARED BY

101 Walnut Street
PO Box 9151
Watertown, MA 02471
617.924.1770

Issued: May 2016

Table of Contents

Operations & Maintenance Manual Introduction

This Stormwater Management Operations and Maintenance Manual (O&M Manual) has been prepared to support the multi-family housing portion, referred to as Avalon Sudbury, of the multi-phase redevelopment proposed for 526-528 Boston Post Road, Sudbury, MA. This O&M Manual incorporates stormwater management features proposed only as part of the Avalon Sudbury phase of redevelopment. Refer to Stormwater O&M Manuals prepared by VHB under separate cover for required O&M of infrastructure proposed by other phases on-site as well as the required O&M of all existing stormwater management features which are to remain. Where applicable, this O&M Manual reflects the requirements incorporated for the site in the "Operations and Maintenance Plan" dated July 20, 2012 prepared by Paul Finger Associates, approved as part of the Order of Conditions MassDEP File #301-1083 issued on August 21, 2012.

Project Information

Site

Avalon Sudbury
Sudbury, Massachusetts

Developer

Sudbury Avalon, Inc.
c/o AvalonBay Communities, Inc.
51 Sleeper Street
Suite 750
Boston, MA 02210

Site Supervisor

TBD

Site Contact

Name: _____

Telephone: _____

Cell phone: _____

Email: _____

Section A - Source Control

A. Source Control

A comprehensive source control program will be implemented at the Site, which includes the following components:

- Regular pavement sweeping
- Catch basin cleaning
- Clearing litter from the pavement and landscape areas
- Enclosure and regular maintenance of all dumpsters
- Spill Prevention training

Section B - Spill Prevention

B. Spill Prevention

Spill prevention equipment and training will be provided by the property management company.

B.1 Initial Notification

In the event of a spill the facility and/or construction manager or supervisor will be notified immediately.

Facility Manager (name): _____

Facility Manager (phone): _____

Construction Manager (name): _____

Construction Manager (phone): _____

The supervisor will first contact the Fire Department and then notify the Police Department, the Public Health Commission and the Conservation Commission. The Fire Department is ultimately responsible for matters of public health and safety and should be notified immediately.

B.2 Further Notification

Based on the assessment from the Fire Chief, additional notification to a cleanup contractor may be made. The Massachusetts Department of Environmental Protection (DEP) and the EPA may be notified depending upon the nature and severity of the spill. The Fire Chief will be responsible for determining the level of cleanup and notification required. The attached list of emergency phone numbers shall be posted in the main construction/facility office and readily accessible to all employees. A hazardous waste spill report shall be completed as necessary using the attached form.

Emergency Notification Phone Numbers

1.	FACILITY MANAGER NAME: _____ ALTERNATE CONTACT: NAME: _____	PHONE: _____ BEEPER/CELL: _____, _____ HOME PHONE: _____ PHONE: _____ BEEPER/CELL: _____, _____ HOME PHONE: _____
2.	FIRE & POLICE DEPARTMENT	EMERGENCY: **911**
3.	CLEANUP CONTRACTOR: _____ ADDRESS: _____ _____	PHONE: _____
4.	MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION (DEP)	EMERGENCY PHONE: **(888) 304-1133**
5.	NATIONAL RESPONSE CENTER ALTERNATE: U.S. ENVIRONMENTAL PROTECTION AGENCY	PHONE: (800) 424-8802 EMERGENCY: (800) 424-8802 BUSINESS: (888) 372-7341
6.	SUDBURY HEALTH DEPARTMENT	PHONE: (978) 440-5479
SUDBURY CONSERVATION COMMISSION:		PHONE: (978) 440-5471

Hazardous Waste / Oil Spill Report

Date: ____/____/_____ Time: _____ AM / PM

Exact location _____

Type of equipment:_____ Make:_____ Size:_____

License or S/N:_____ Weather Conditions:_____

On or near water · Yes If yes, name of body of water:_____

· No

Type of chemical / oil spilled: _____

Amount of chemical / oil spilled: _____

Cause of spill: _____

_____

Measures taken to contain or clean up spill: _____

_____

_____

Amount of chemical / oil recovered: _____ Method:_____

Material collected as a result of clean up

_____ drums containing: _____

_____ drums containing: _____

_____ drums containing: _____

Location and method of debris disposal:_____

Name and address of any person, firm, or corporation suffering damages:_____

_____

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

_____

Spill reported to General Office by:_____Time: _____AM / PM

Spill reported to DEP / National Response Center by:_____

DEP Date: ____/_____/_____ Time:_____AM / PM Inspector:_____

NRC Date: ____/_____/_____ Time:_____AM / PM Inspector: _____

Additional comments: _____

_____

B.3 Assessment - Initial Containment

The supervisor or manager will assess the incident and initiate containment control measures with the appropriate spill containment equipment included in the spill kit kept on-site. A list of recommended spill equipment to be kept on site is included on the following page.

Fire / Police Department:	**911**
Sudbury Health Department:	**(978) 440-5479**
Sudbury Conservation Commission:	**(978) 440-5471**

Emergency Response Equipment

The following equipment and materials shall be maintained at all times and stored in a secure area for long-term emergency response need.

Supplies		Recommended Suppliers
➢ SORBENT PILLOWS/"PIGS"	**2**	http://www.newpig.com
➢ SORBENT BOOM/SOCK	**25 FEET**	Item # KIT276 — mobile container with two pigs, 26
➢ SORBENT PADS	**50**	feet of sock, 50 pads, and five pounds of absorbent
➢ LITE-DRI® ABSORBENT	**5 POUNDS**	(or equivalent)
➢ SHOVEL	**1**	http://www.forestry-suppliers.com
➢ PRY BAR	**1**	Item # 43210 — Manhole cover pick (or equivalent)
➢ GOGGLES	**1 PAIR**	Item # 33934 — Shovel (or equivalent)
➢ GLOVES – HEAVY	**1 PAIR**	Item # 90926 — Gloves (or equivalent)
		Item # 23334 — Goggles (or equivalent)

Section C - Snow Management

C. Snow Management

Snow storage areas are shown on Figure B-1 included herein.

- Snow storage areas will be managed to prevent blockage of storm drain catch basins, stormwater drainage channels, and on-street parking. Snow combined with sand and debris may block a storm drainage system, diminishing the infiltration capacity of the system and causing localized flooding.
- Sand and debris deposited on vegetated or paved areas shall be cleared from the site and properly disposed of at the end of the snow season, no later than May 15.
- Snow shall not be dumped into any waterbody, pond, or wetland resource area.
- All sand shall be removed from the top of bank and on the banks of all wetlands immediately following spring snow melt each year.
- Only calcium or magnesium-based de-icing chemicals shall be used on surfaces where runoff/drainage will discharge into any wetland resources, or the 100' adjacent upland resource area.

Section D - Maintenance of Stormwater Management Systems

Maintenance of Stormwater Management Systems

D.1 Pavement Systems

D.1.1 Standard Asphalt Pavement

- Sweep or vacuum standard asphalt pavement areas with a rotary brush sweeper and properly dispose of removed material.
- Recommended sweeping schedule:
  - Oct/Nov
  - Apr/May
  - More frequent sweeping of paved surfaces will result in less accumulation in catch basins, less cleaning of subsurface structures, and less disposal costs.
- Check loading docks and dumpster areas frequently for spillage and/or pavement staining and clean as necessary.
- No coal-tar, petroleum-based, or other parking lot "sealants" are permitted to be used on-site. Normal maintenance activities intended to extend the life expectancy of the pavement surfaces including the use of bitumen asphalt to seal developing cracks, asphalt repair are not subject to this special condition.

D.2 Structural Stormwater Management Devices

D.2.1 Catch Basins & Landscape Drains

The proper removal of sediments and associated pollutants and trash occurs only when catch basin inlets and sumps are cleaned out regularly. The more frequent the cleaning, the less likely sediments will be re-suspended and subsequently discharged. In addition, frequent cleaning also results in more volume available for future deposition and enhances the overall performance. As noted in the pavement Operation and Maintenance (O&M) section, more frequent sweeping of paved surfaces will result in less accumulation in catch basins, less cleaning of subsurface structures, and less disposal costs.

Catch basins installed as part the redevelopment are constructed with sumps (minimum 4 feet) and hooded outlets to trap debris, sediments, and floating contaminants. Disposal of sediments from all catch basins must be in accordance with applicable local, state, and federal guidelines. Catch basin and landscape drain locations are shown on Figure A-1 included herein.

Inspections and Cleaning

- Catch basins with hoods shall be cleaned and inspected according to manufacturer recommendations.
- All catch basins shall be inspected at least four times per year and cleaned a minimum of at least once per year or when the depth of deposits is greater than one half of the depth from the bottom of the sump to the invert of the lowest connecting pipe.
- Sediment and/or floatable pollutants shall be pumped from the basin and disposed of at an approved offsite facility in accordance with all applicable regulations.
- Any structural damage or other indication of malfunction will be reported to the site manager and repaired as necessary
- During colder periods, the catch basin grates must be kept free of snow and ice.
- During warmer periods, the catch basin grates must be kept free of leaves, litter, sand, and debris.

D.2.2 Structural Water Quality Devices

The stormwater drainage system includes structural water quality devices. They are Contech CDS units, which efficiently remove sediment and hydrocarbons from stormwater runoff. The locations of the water quality devices are shown on Figure A-1 included herein.

- All water quality units are to be inspected at least twice per year and cleaned a minimum of at least once per year or when sediment reaches 75% of the sump depth, whichever occurs sooner.
- Remove oil and sediment through manhole access cover.
- Follow manufacturer instructions and contact manufacturer if system is malfunctioning. Manufacturer's inspection and maintenance instructions are included in Section F - Project Literature.

D.2.3 Subsurface Infiltration Basins

The subsurface infiltration/detention basins are used to detain and infiltrate roadway and rooftop runoff. The Project proposes to install Stormtech subsurface infiltration chambers. The subsurface basin has a water quality pre-treatment device in the form of a sediment removal row to protect the infiltration bed from clogging. The sediment removal row is an integral part of the underground infiltration system. The location of the subsurface infiltration system is shown on Figure A-1 included herein.

Inspections and Cleaning

- The subsurface infiltration system will be inspected at least once each year by removing the manhole/access port covers and determining the thickness of sediment that has accumulated in the sediment removal row.

- If sediment is more than six inches deep, it must be suspended via flushing with clean water and removed using a vactor truck.
- Manufacturer's specifications and instructions for cleaning the sediment removal row are provided in Section G – Project Literature.
- Emergency overflow pipes will be examined at least once each year and verified that no blockage has occurred.
- System will be observed after rainfalls to see if it is properly draining.

D.2.4 Stormwater Outfalls, Filter Berms and Sediment Forebays

The stormwater drainage system contains many outfall locations, where treated stormwater is discharged to surface wetlands or existing drainage pipes. Outfall locations are shown on Figure A-1 included herein.

- At a minimum, inspect outfalls annually.
- At a minimum, inspect sediment forebays quarterly and clean them out annually. When mowing grasses, keep the grass height no greater than 6-inches. Set mower blades no lower than 3 to 4 inches. Annual inspections should be supplemented after large storms, when washouts may occur.
- Maintain vegetation around outfalls to prevent blockages at the outfall.
- Maintain rip rap pad below each outfall and replace any washouts.
- Remove and dispose of any trash or debris at the outfall.
- Replace vegetation damaged during the clean-out by either reseeding or resodding. When reseeding, incorporate practices such as hydroseeding with a tackifier, blanket, or similar practice to ensure no scour occurs in the forebay, while the seeds germinate and develop roots

D.2.5 Roof Drain Leaders and Rooftop Recharge Systems

Roof runoff is directed to the rooftop recharge system via roof drain leaders. The rooftop recharge system uses perforated pipe to infiltrate clean runoff.

Inspections and Cleaning

- Perform routine roof drain leader and recharge system inspections and cleanings annually.
- Keep roofs clean and free of debris.
- Keep roof drainage systems clear.
- Keep roof access limited to authorized personnel.
- Clean inlets once per year.

D.3 Vegetated Stormwater Management Devices

D.3.1 Surface Basins

All surface stormwater basins shall be inspected annually. The maintenance of surface basins may affect the functioning of stormwater management practices. All sediment and debris shall be removed and disposed according to local, state, and federal regulations. All side slopes shall be maintained.

Initial Post-Construction Inspection

- Bio-retention basins should be inspected after every major storm for the first few months to ensure proper stabilization and function.

Long-Term Maintenance

- Inspect planted areas on a semi-annual basis and remove any litter.
- Regular maintenance includes mowing, keeping the grass no shorter than 3 to 4 inches and no larger than 6-inches.
- Grass clippings, organic matter, and accumulated trash and debris removed, at least twice during the growing season.
- Eroded or barren spots should be reseeded immediately after inspection to prevent additional erosion and accumulation of sediment.
- Deep tilling can be used to break up a clogged surface area.
- Sediment should be removed from the basin as necessary. Removal procedures should not take place until the floor of the basin is thoroughly dry.
- Vegetated drainage systems shall be inspected at regular intervals and record specific information:
    - Notable changes in general extent of standing water
    - Stability of embankments, channels, and outfall areas
    - Accumulation of sediment

D.3.2 Vegetated Areas Maintenance

Although not a structural component of the drainage system, the maintenance of vegetated areas may affect the functioning of the stormwater management system. This includes the health/density of vegetative cover and activities such as the application and disposal of lawn and garden care products, disposal of leaves and yard trimmings and proper aeration of soils.

- Inspect planted areas on a semi-annual basis and remove any litter.
- Maintain planted areas adjacent to pavement to prevent soil washout.
- Immediately clean any soil deposited on pavement.
- Re-seed bare areas; install appropriate erosion control measures when native soil is exposed or erosion channels are forming.

- Plant alternative mixture of grass species in the event of unsuccessful establishment.
- The grass vegetation should be cut to a height between three and four inches.
- Pesticide/Herbicide Usage – No pesticides are to be used unless a single spot treatment is required for a specific control application.
- No pesticides or herbicides are allowed within the 100' adjacent upland resource area property without prior approval of the Conservation Commission.
- Fertilizer usage should be avoided. If deemed necessary, fertilizer may only be of the low nitrogen and phosphorous variety. Fertilizer may be used to begin the establishment of vegetation in bare or damaged areas, but should not be applied on a regular basis unless necessary.
- Fertilizer applications shall be limited to the spring and early fall, and applied per the manufacturers' specifications. Nitrogen content shall not exceed 25% with ratios for Nitrogen, Phosphorus, and Potassium at 3-1-2 or 3-1-1. It is also recommended at least 30%-50% of total nitrogen be slow release.
- Annual application of compost amendments and aeration are recommended.

Section E - Operations and Maintenance Summary

Operations & Maintenance Plan Summary

This Operation and Maintenance Plan has been prepared in accordance with the Stormwater Management Policy developed by the DEP and local regulations. It specifies operational practices and drainage system maintenance requirements for Avalon Sudbury. Requirements should be adjusted by the site manager as necessary to ensure successful functioning of system components.

E.1 Routine Maintenance Checklists

Routine required maintenance is described in Sections A – D. The following checklists are to be used by the property manager to implement and document the required maintenance and inspection tasks.

E.2 Reporting and Documentation

The site supervisor shall be responsible for ensuring that the scheduled tasks as described in this plan are appropriately completed and recorded in the Maintenance Log. Accurate records of all inspections, routine maintenance and repairs shall be documented and these records shall be available for inspection by members of the Sudbury Conservation Commission, or their designated agent, upon request.

The Maintenance Log shall:

- Document the completion of required maintenance tasks.
- Identify the person responsible for the completion of tasks.
- Identify any outstanding problems, malfunctions or inconsistencies identified during the course of routine maintenance.
- Document specific repairs or replacements.

E.3a Construction Practices Maintenance/ Evaluation Checklist

Avalon Sudbury – Sudbury, Massachusetts

Best Management Practice	Inspection Frequency	Date Inspected	Inspector Initials	Minimum Maintenance and Key Items to Check	Cleaning or Repair Needed Yes/No (List Items)	Date of Cleaning or Repair	Performed by:
Hay Bales/Silt Fencing	Weekly or bi-weekly and after a ¼" rainfall event	/ /		Sediment build up, broken bales or stakes			
Gravel Construction Entrance	Weekly or bi-weekly and after a ¼" rainfall event	/ /		Filled voids, runoff/sediments into street			
Catch Basin Protection	Weekly or bi-weekly and after a ¼" rainfall event	/ /		Clogged or sediment build-up at surface or in basin			
Diversion Channels	Weekly or bi-weekly and after a ¼" rainfall event	/ /		Maintained, moved as necessary to correct locations, Check for erosion or breakout			
Temporary Sedimentation Basins	Weekly or bi-weekly and after a ¼" rainfall event	/ /		Cracking, erosion, breakout, sediment buildup, contaminants			

Date of Inspection: _____
Stormwater Control Manager: _____
Inspector (list title/qualifications):_____
Weather: _____ Weather since last inspection: _____
Comments:_____
_____
_____

E.3b Construction Stormwater Management System Evaluation Checklist

Avalon Sudbury – Sudbury, Massachusetts

Date:_____

Name:_____ Title/Qualifications:_____

Stormwater Management Component/Location Evaluated:_____

Notes (Please note any variations from approved construction specifications; compliance with construction plans; violations, etc):

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

E.3 Long Term Maintenance/ Evaluation Checklist

Avalon Sudbury– Sudbury, Massachusetts

These checklists are provided for the maintenance crew to photocopy and use when conducting inspections and cleaning activities to the stormwater management systems.

Date:_____Name of Inspector:_____

Catch Basins and Landscape Drains – Inspect 4 times per year, clean when sediment depth >1/2 depth of sump or at least once per year					
Structure	Inspected (Y/N)	Sediment Depth (inches)	Cleaning needed (Y/N)	Date Cleaned	Comments (Trash, Oil, Pet Waste, Lawn Debris, Damaged)
				/ /	
				/ /	
				/ /	
				/ /	
				/ /	
				/ /	
				/ /	
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				/ /	

Date: _____Name of Inspector: _____

Water Quality/Pretreatment Devices – Inspect 2 times per year, clean at least once per year or when sediment reaches a depth of 75% of the sump					
Device	Inspected (Y/N)	Sediment Depth (inches)	Cleaning needed (Y/N)	Date Cleaned	Comments
WQU-				/ /	
Manhole baffle intact?				/ /	
WQU-				/ /	
Manhole baffle intact?				/ /	
WQU-				/ /	
Manhole baffle intact?				/ /	
WQU-				/ /	
Manhole baffle intact?				/ /	
WQU-				/ /	
Manhole baffle intact?				/ /	
WQU-				/ /	
Manhole baffle intact?				/ /	

Date: _____Name of Inspector: _____

Roof Runoff Systems – Inspect once per year and remove all debris at least once per year					
Building Number	Inspected (Y/N)	Sediment Depth (inches)	Cleaning needed (Y/N)	Date Cleaned	Comments (Trash, Oil, Pet waste, Lawn Debris, Damage)
				/ /	
				/ /	
				/ /	
				/ /	
				/ /	
				/ /	
				/ /	
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Date: _____Name of Inspector: _____

Stormwater Outfalls – Inspect outfalls once per year, clean as needed.					
Outfall	Inspected (Y/N)	Sediment Depth (inches)	Cleaning needed (Y/N)	Date Cleaned	Comments (Trash, Oil, Pet waste, Lawn Debris, Damage)
				/ /	
				/ /	
				/ /	
				/ /	
				/ /	
				/ /	
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				/ /	
				/ /	
				/ /	

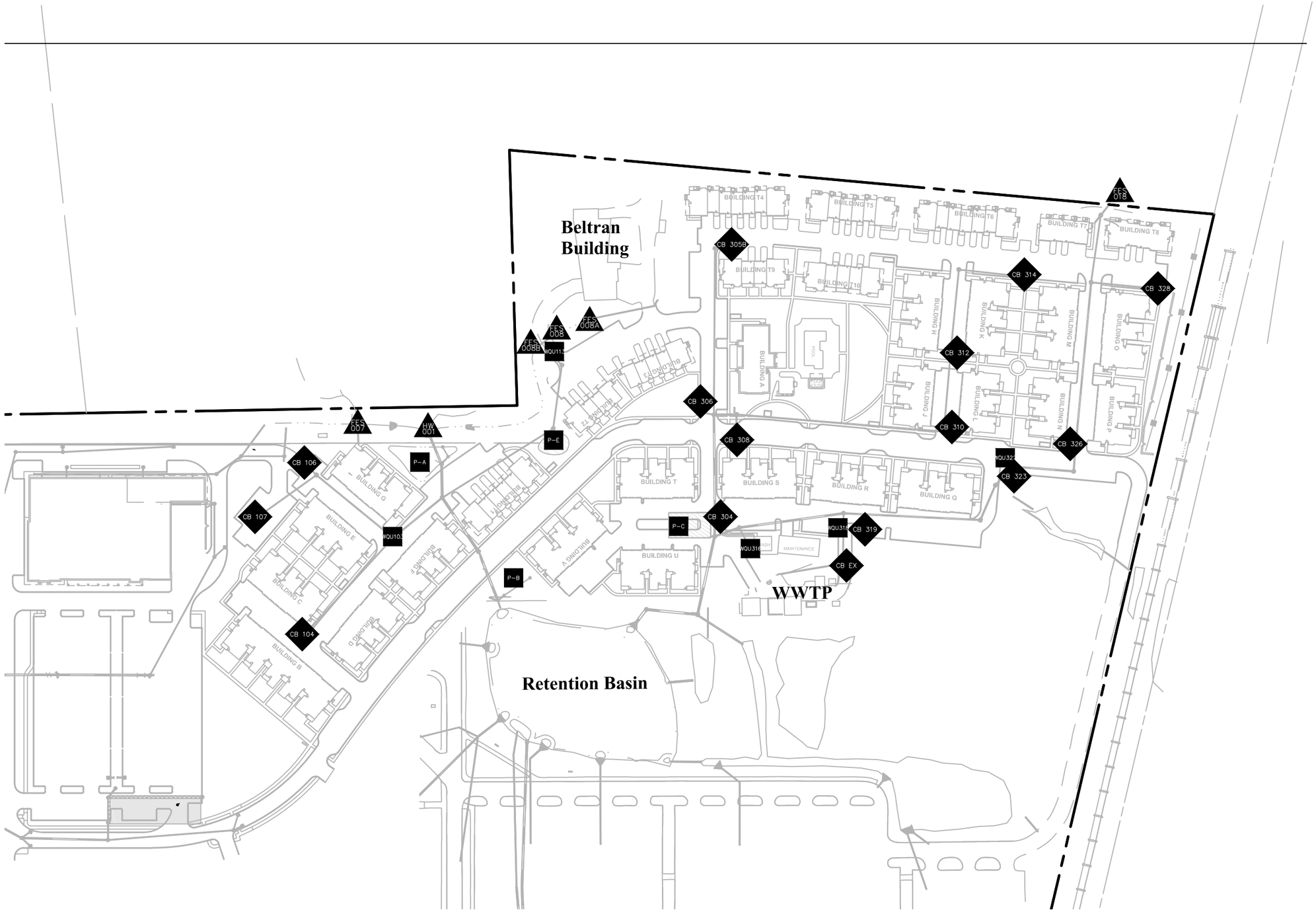
Date: _____Name of Inspector: _____

Subsurface Infiltration Systems – Inspect once per year					
System/Inspection Item	Inspected (Y/N)	Sediment Depth (inches)	Cleaning needed (Y/N)	Date Cleaned	Comments
P				/ /	
Proper drainage/ function				/ /	
Sediment carryover				/ /	
Major rainfall inspection				/ /	
Immediate oil/hazardous material removal				/ /	
Integrity/ function of structures				/ /	
Other maintenance as necessary				/ /	
P				/ /	
Proper drainage/ function				/ /	
Sediment carryover				/ /	
Major rainfall inspection				/ /	
Immediate oil/hazardous material removal				/ /	
Integrity/ function of structures				/ /	
Other maintenance as necessary				/ /	

Date: _____Name of Inspector: _____

Surface Infiltration/Bio-retention Basins – Inspect twice per year. If sediment build-up is found, core aeration or cultivating of unvegetated areas may be required to ensure adequate filtration.					
Surface Infiltration/Detention Basin	Inspected (Y/N)	Sediment Depth (inches)	Cleaning needed (Y/N)	Date Cleaned	Comments (Trash, Oil, Pet waste, Lawn Debris, Damage)
P				/ /	
Sediment buildup and erosion				/ /	
Monthly trash/debris removal				/ /	
Bi-annual pruning and vegetation maintenance				/ /	
Major rainfall inspection				/ /	
Immediate oil/hazardous material removal				/ /	
Integrity/function of structures				/ /	
Other maintenance as necessary				/ /	
P				/ /	
Sediment buildup and erosion				/ /	
Monthly trash/debris removal				/ /	
Bi-annual pruning and vegetation maintenance				/ /	
Major rainfall inspection				/ /	
Immediate oil/hazardous material removal				/ /	
Integrity/function of structures				/ /	
Other maintenance as necessary				/ /	

Figure A-1 – Device Location Map



LEGEND

- CB# — Catch Basin (CB), Double Catch Basin (DCB), Area Drain (AD), or Trench Drain (TD)
- WQU# — Water Quality Unit
- DW# — Drywell
- # — Stormwater Headwall/FES
- SW# — Vegetated Swale

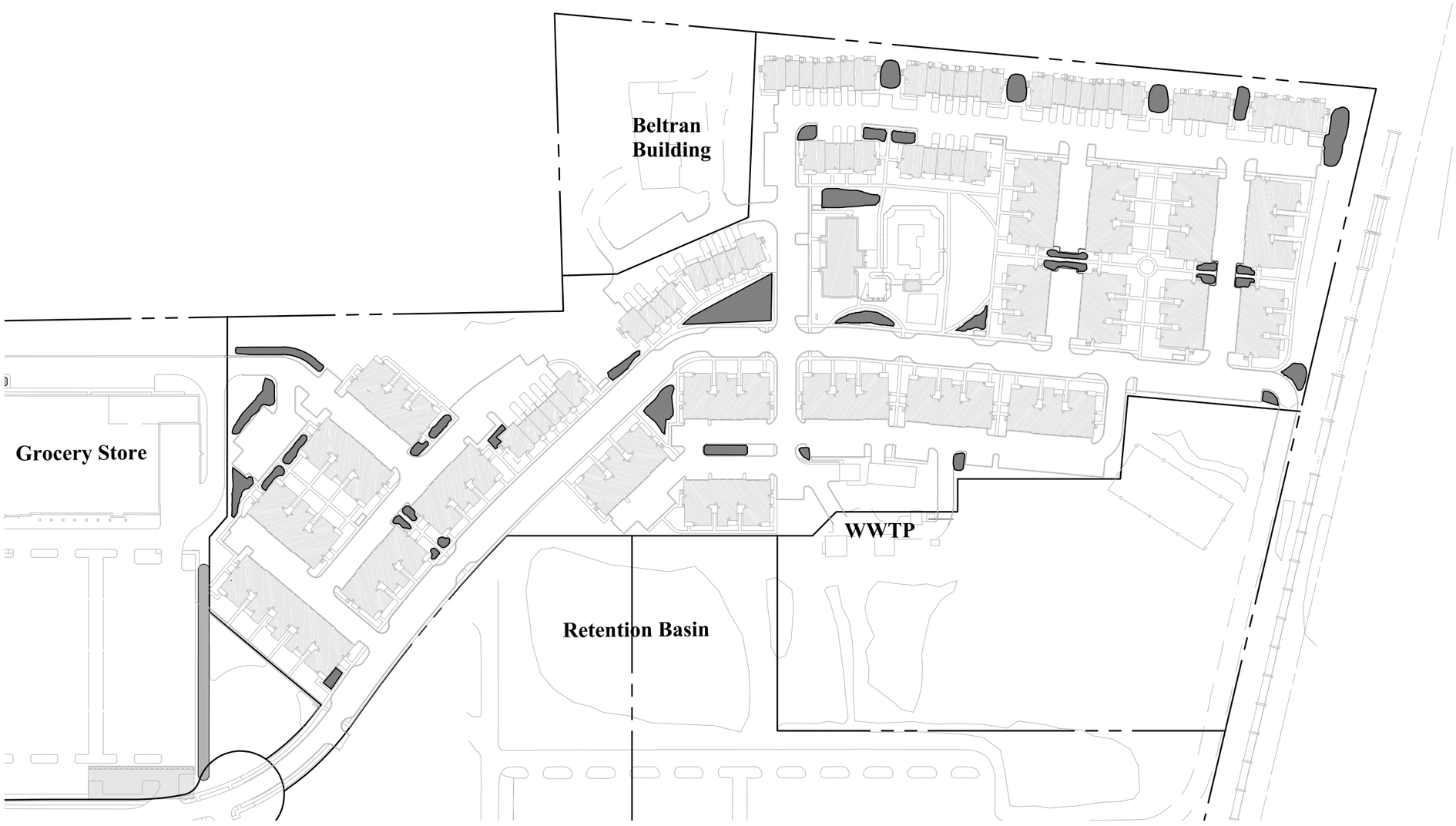
0 80 160 Feet

Drainage Device Location Map
AvalonBay
Sudbury, MA

Figure A-1

May, 2016

Figure B-1 – Snow Storage Plan



Legend

Approximate Snow Storage Area

Notes

1. The Avalon area has approximately 5.8 acres of paved vehicular area and 1.5 acres of sidewalk. The plan does not include snow storage for the roof or pervious areas.

2. The plan depicts approximately 32,000 SF of area available for snow storage within the Avalon area. This area is estimated to accommodate an approximate 1' snowfall, assuming 5:1 compaction and an average snow pile height of 2'. Additional snow storage required beyond this will be provided by using excess parking spaces or by trucking.

3. Under no circumstance shall snow be stored in any wetland resource area or proposed stormwater best management practice.

4. Snow storage will be implemented to avoid hydrants, fences, landscaping, and other permanent features.

0 80 160 Feet

Snow Storage Plan
Avalon Sudbury
Sudbury, MA

Figure B-1

May 2016

Section F – MA Stormwater Handbook BMP and Product Literature

CONTECH®
ENGINEERED SOLUTIONS

CDS® Inspection and Maintenance Guide

CDS TECHNOLOGIES

Maintenance

The CDS system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit. For example, unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping of paved surfaces will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant transport and deposition may vary from year to year and regular inspections will help ensure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (e.g. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment washdown areas. Installations should also be inspected more frequently where excessive amounts of trash are expected.

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions in the inlet and separation screen. The inspection should also quantify the accumulation of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If absorbent material is used for enhanced removal of hydrocarbons, the level of discoloration of the sorbent material should also be identified during inspection. It is useful and often required as part of an operating permit to keep a record of each inspection. A simple form for doing so is provided.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (cylinder and screen) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained outside the screen. For deep units, a single manhole access point would allows both sump cleanout and access outside the screen.

The CDS system should be cleaned when the level of sediment has reached 75% of capacity in the isolated sump or when an appreciable level of hydrocarbons and trash has accumulated. If absorbent material is used, it should be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Particles at the top of the pile typically offer less resistance to the end of the rod than consolidated particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine weather the height of the sediment pile off the bottom of the sump floor exceeds 75% of the total height of isolated sump.

Cleaning

Cleaning of a CDS systems should be done during dry weather conditions when no flow is entering the system. The use of a vacuum truck is generally the most effective and convenient method of removing pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be cleaned out if pollutant build-up exists in this area.

In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use absorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash and debris can be netted out to separate it from the other pollutants. The screen should be power washed to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure that proper safety precautions have been followed. Confined space entry procedures need to be followed if physical access is required. Disposal of all material removed from the CDS system should be done in accordance with local regulations. In many jurisdictions, disposal of the sediments may be handled in the same manner as the disposal of sediments removed from catch basins or deep sump manholes.

CDS Model	Diameter		Distance from Water Surface to Top of Sediment Pile		Sediment Storage Capacity	
	ft	m	ft	m	yd3	m3
CDS2015-4	4	1.2	3.0	0.9	0.9	0.7
CDS2015	5	1.5	3.0	0.9	1.3	1.0
CDS2020	5	1.5	3.5	1.1	1.3	1.0
CDS2025	5	1.5	4.0	1.2	1.3	1.0
CDS3020	6	1.8	4.0	1.2	2.1	1.6
CDS3030	6	1.8	4.6	1.4	2.1	1.6
CDS3035	6	1.8	5.0	1.5	2.1	1.6
CDS4030	8	2.4	4.6	1.4	5.6	4.3
CDS4040	8	2.4	5.7	1.7	5.6	4.3
CDS4045	8	2.4	6.2	1.9	5.6	4.3
CDS5640	10	3.0	6.3	1.9	8.7	6.7
CDS5653	10	3.0	7.7	2.3	8.7	6.7
CDS5668	10	3.0	9.3	2.8	8.7	6.7
CDS5678	10	3.0	10.3	3.1	8.7	6.7

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities

Support

- Drawings and specifications are available at www.contechstormwater.com.
- Site-specific design support is available from our engineers.

Contech Engineered Solutions LLC provides site solutions for the civil engineering industry. Contech's portfolio includes bridges, drainage, sanitary sewer, stormwater, earth stabilization and wastewater treament products. For information, visit www.ContechES.com or call 800.338.1122

CONTECH ENGINEERED SOLUTIONS
800.925.5240
www.ContechES.com

CDS Inspection & Maintenance Log

CDS Model: _____ Location: _____

Date	Water depth to sediment[1]	Floatable Layer Thickness[2]	Describe Maintenance Performed	Maintenance Personnel	Comments

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. If the difference between these measurements is less than the values listed in table 1 the system should be cleaned out. **Note: to avoid underestimating the volume of sediment in the chamber, the measuring device must be carefully lowered to the top of the sediment pile.**

2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of an oil spill, the system should be cleaned immediately.

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.

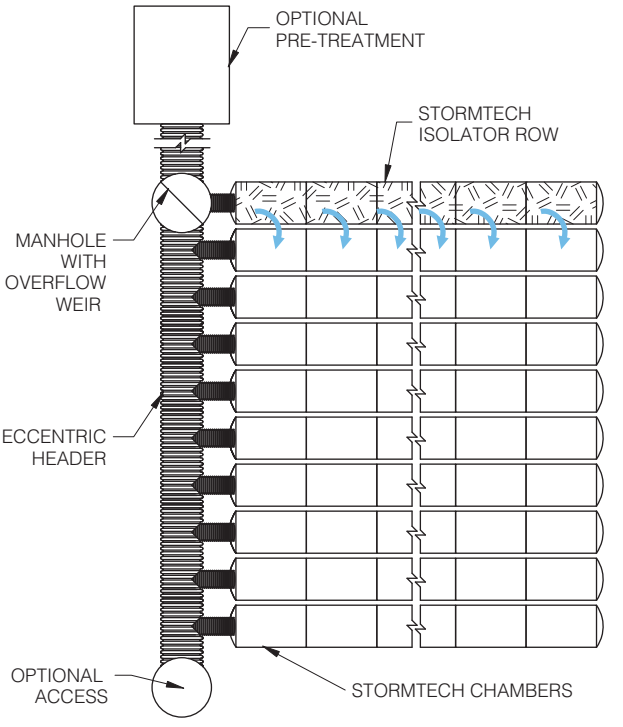
Two different fabrics are used for the Isolator Row. A woven geotextile fabric is placed between the stone and the Isolator Row chambers. The tough geotextile provides a media for storm water filtration and provides a durable surface for maintenance operations. It is also designed to prevent scour of 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.

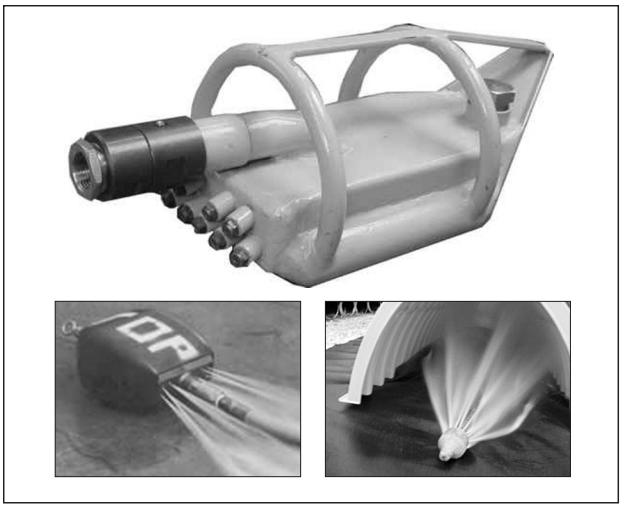
At a minimum, StormTech recommends annual inspections. Initially, the Isolator Row should be inspected every 6 months for the first year of operation. For subsequent years, the inspection should be adjusted based upon previous observation of sediment deposition.

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

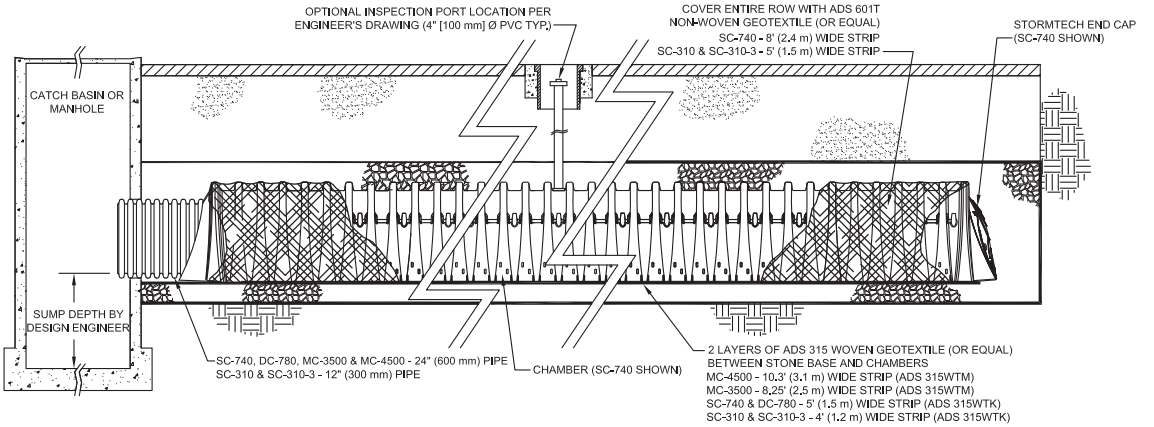
The Isolator Row was designed to reduce the cost of periodic maintenance. By "isolating" sediments to just one row, costs are dramatically reduced by eliminating the need to clean out each row of the entire storage bed. If inspection indicates the potential need for maintenance, access is provided via 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

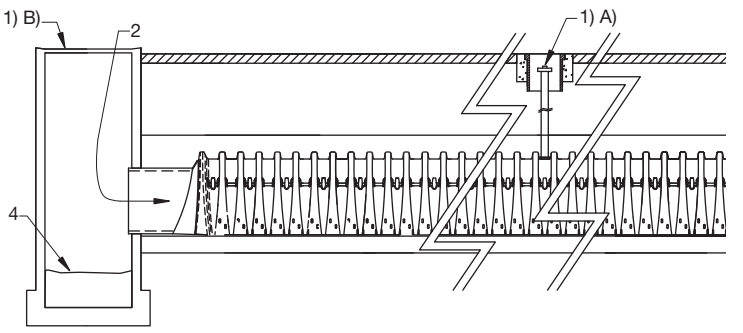
ii. Using a flashlight, inspect down Isolator Row through outlet pipe

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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Bioretention Areas & Rain Gardens

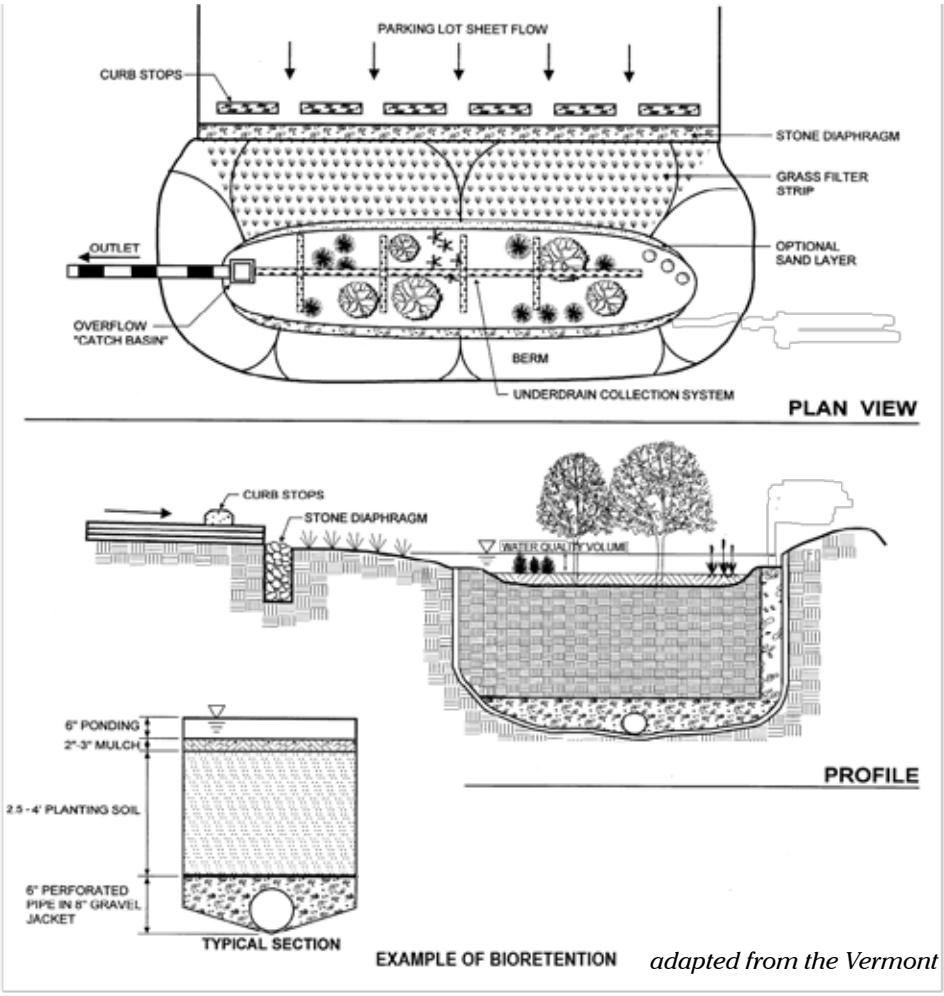
Description: Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with dense native vegetation. Stormwater runoff is directed into the cell via piped or sheet flow. The runoff percolates through the soil media that acts as a filter.
There are two types of bioretention cells: those that are designed solely as an organic filter filtering bioretention areas and those configured to recharge groundwater in addition to acting as a filter exfiltrating bioretention areas. A filtering bioretention area includes an impermeable liner and underdrain that intercepts the runoff before it reaches the water table so that it may be conveyed to a discharge outlet, other best management practices, or the municipal storm drain system. An exfiltrating bioretention area has an underdrain that is designed to enhance exfiltration of runoff into the groundwater.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	An exfiltrating bioretention area provides groundwater recharge.
4 - TSS Removal	90% TSS removal credit with adequate pretreatment
5 - Higher Pollutant Loading	Can be used for certain land uses with higher potential pollutant loads if lined and sealed until adequate pretreatment is provided. Adequate pretreatment must include 44% TSS removal prior to infiltration. For land uses that have the potential to generate runoff with high concentrations of oil and grease such as high intensity use parking lots and gas stations, adequate pretreatment may also include an oil grit separator, sand filter or equivalent. In lieu of an oil grit separator or sand filter, a filtering bioretention area also may be used as a pretreatment device for infiltration practices exfiltrating runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.
6 - Discharges near or to Critical Areas	Good option for discharges near cold-water fisheries. Should not be used near bathing beaches and shellfish growing areas.
7 - Redevelopment	Suitable with appropriate pretreatment

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) — 90% with vegetated filter strip or equivalent
- Total Nitrogen — 30% to 50% if soil media at least 30 inches
- Total Phosphorus — 30% to 90%
- Metals (copper, lead, zinc, cadmium) — 40% to 90%
- Pathogens (coliform, e coli) — Insufficient data



EXAMPLE OF BIORETENTION *adapted from the Vermont Stormwater Manual*

Special Features:

- Can be lined and sealed to prevent recharge where appropriate
- Adequate pretreatment is essential
- Not recommended in areas with steep slope
- Depth of soil media depends on type of vegetation that is proposed
- Soil media must be 30 inches deep to achieve removal of nitrogen

Advantages/Benefits:

- Can be designed to provide groundwater recharge and preserves the natural water balance of the site
- Can be designed to prevent recharge where appropriate
- Supplies shade, absorbs noise, and provides windbreaks
- Can remove other pollutants besides TSS including phosphorus, nitrogen and metals
- Can be used as a stormwater retrofit by modifying existing landscape or if a parking lot is being resurfaced
- Can be used on small lots with space constraints
- Small rain gardens are mosquito death traps
- Little or no hazard for amphibians or other small animals

Disadvantages/Limitations:

- Requires careful landscaping and maintenance
- Not suitable for large drainage areas

Maintenance

Activity	Frequency
Inspect and remove trash	Monthly
Mow	2 to 12 times per year
Mulch	Annually
Fertilize	Annually
Remove dead vegetation	Annually
Prune	Annually

Bioretention Areas & Rain Gardens

Not all bioretention cells are designed to exfiltrate. Only the infiltration requirements are applicable to bioretention cells intended to exfiltrate.

Applicability

Bioretention areas can provide excellent pollutant removal for the "first flush" of stormwater runoff. Properly designed and maintained cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as "rain gardens" and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper direction.

Bioretention systems can be applied to a wide range of commercial, residential, and industrial developments in many geologic conditions; they work well on small sites and on large sites divided into multiple small drainage areas. Bioretention systems are often well suited for ultra-urban settings where little pervious area exists. Although they require significant space (approximately 5% to 7% of the area that drains to them), they can be integrated into parking lots, parking lot islands, median strips, and traffic islands. Sites can be retrofitted with bioretention areas by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites, they are commonly used for rooftop and driveway runoff.

Effectiveness

Bioretention areas remove pollutants through filtration, microbe activity, and uptake by plants; contact with soil and roots provides water quality treatment better than conventional infiltration structures. Studies indicate that bioretention areas can remove from 80% to 90% of TSS. If properly designed and installed, bioretention areas remove phosphorus, nitrogen, metals, organics, and bacteria to varying degrees.

Bioretention areas help reduce stress in watersheds that experience severe low flows due to excessive impervious cover. Low-tech, decentralized bioretention areas are also less costly to design, install, and maintain than conventional stormwater technologies that treat runoff at the end of the pipe. Decentralized bioretention cells can also reduce the size of storm drain pipes, a major component of stormwater treatment costs. Bioretention areas enhance the landscape in a variety of ways: they improve the appearance of developed sites, provide windbreaks, absorb noise, provide wildlife habitat, and reduce the urban heat island effect.

Planning Considerations

Filtering bioretention areas are designed with an impermeable liner and underdrain so that the stormwater may be transported to additional BMPs for treatment and/or discharge. Exfiltrating bioretention areas are designed so that following treatment by the bioretention area the stormwater may recharge the groundwater.

Both types of bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads. However, exfiltrating bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads, only if pretreatment has been provided to achieve TSS removal of at least 44%. If the land use has the potential to generate runoff with high concentrations of oil and grease, other types of pretreatment, i.e., a deep sump catch basin and oil grit separator or a sand filter, is required prior to discharge of runoff to an exfiltrating bioretention area. A filtering bioretention area may also be used as a pretreatment device for an exfiltrating bioretention area or other infiltration practice that exfiltrates runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.

To receive 90% TSS removal credit, adequate pretreatment must be provided. If the flow is piped to the bioretention area a deep sump catch catch basin and sediment forebay should be used to provide pretreatment. For sheet flow, there are a number or pretreatment options. These options include:

- A vegetated filter strip, grass channel or water quality swale designed in accordance with the specifications set forth in Chapter 2.
- A grass and gravel combination. This should consist of at least 8 inches of gravel followed by 3 to 5 feet of sod. (source: North Carolina Stormwater Manual, 2007, http://h2o.enr.state.nc.us/su/documents/Ch12-Bioretention_001.pdf)
- Pea diaphragm combined with a vegetated filter strip specially designed to provide pretreatment for a bioretention area as set forth in the following table. (source: Georgia Stormwater Manual and Claytor and Schuler 1996)

Dimensions for Filter Strip Designed Specially to Provide Pretreatment for Bioretention Area

Parameter	Impervious Area				Pervious Areas (lawns, etc.)			
Maximum inflow approach length (feet)	35		75		75		100	
Filter strip slope (max=6%)	<2%	>2%	<2%	>2%	<2%	>2%	<2%	>2%
Filter strip minimum length (feet)	10	15	20	25	10	12	15	18

Bioretention areas must not be located on slopes greater than 20%. When the bioretention area is designed to exfiltrate, the design must ensure vertical separation of at least 2 feet from the seasonal high groundwater table to the bottom of the bioretention cell.

For residential rain gardens, pick a low spot on the property, and route water from a downspout or sump pump into it. It is best to choose a location with full sun, but if that is not possible, make sure it gets at least a half-day of sunlight.

Do not excavate an extensive rain garden under large trees. Digging up shallow feeder roots can weaken or kill a tree. If the tree is not a species that prefers moisture, the additional groundwater could damage it. Size the bioretention area using the methodology set forth in Volume 3.

Design

Size the bioretention area to be 5% to 7% of the area draining to it. Determine the infiltrative capacity of the underlying native soil by performing a soil evaluation in accordance with Volume 3. Do not use a standard septic system (i.e., Title 5) percolation test to determine soil permeability.

The depth of the soil media must be between 2 and 4 feet. This range reflects the fact that most of the pollutant removal occurs within the first 2 feet of soil and that excavations deeper than 4 feet become expensive. The depth selected should accommodate the vegetation. If the minimum depth is used, only shallow rooted plants and grasses my be used. If there is a Total Maximum Daily Load that requires nitrogen to be removed from the stormwater dischrges, the bioretention area should have a soil media with a depth of at least 30 inches, because nitrogen removal takes place 30 inches below the ground surface. If trees and shrubs are to be planted, the soil media should be at least 3 feet.

Size the cells (based on void space and ponding area) at a minimum to capture and treat the required water quality volume (the first 0.5 inch or 1 inch of runoff) if intended to be used for water quality treatment (Stormwater Standard No. 4), the required recharge volume if used for recharge (Stormwater Standard No. 3), or the larger of the two volumes if used to achieve compliance with both Stormwater Standards 3 and 4.

Cover the bottom of the excavation with coarse gravel, over pea gravel, over sand. Earlier designs used filter fabric as a bottom blanket, but more recent experiences show that filter fabric is prone to clogging. Consequently, do not use fabric filters or sand curtains. Use the Engineered Soil Mix below.

Engineered Soil Mix for Bioretention Systems Designed to Exfiltrate

- The soil mix for bioretention areas should be a mixture of sand compost and soil.
  - o 40 % sand,
  - o 20-30% topsoil, and
  - o 30-40% compost.

- The soil mix must be uniform, free of stones, stumps, roots or similar objects larger than 2 inches. Clay content should not exceed 5%.
- Soil pH should generally be between 5.5-6.5, a range that is optimal for microbial activity and adsorption of nitrogen, phosphorus, and other pollutants.
- Use soils with 1.5% to 3% organic content and maximum 500-ppm soluble salts.
- The sand component should be gravelly sand that meets ASTM D 422.

Sieve Size	Percent Passing
2-inch	100
¾-inch	70-100
¼-inch	50-80
U.S. No. 40	15-40
U.S. No. 200	0-3

- The topsoil component shall be a sandy loam, loamy sand or loam texture.
- The compost component must be processed from yard waste in accordance with MassDEP Guidelines (see http://www.mass.gov/dep/recycle/reduce/leafguid.doc). The compost shall not contain biosolids.

On-site soil mixing or placement is not allowed if soil is saturated or subject to water within 48 hours. Cover and store soil to prevent wetting or saturation.

Test soil for fertility and micro-nutrients and, only if necessary, amend mixture to create optimum conditions for plant establishment and early growth.

Grade the area to allow a ponding depth of 6 to 8 inches; depending on site conditions, more or less ponding may be appropriate.

Cover the soil with 2 to 3 inches of fine-shredded hardwood mulch.

The planting plan shall include a mix of herbaceous perennials, shrubs, and (if conditions permit) understory trees that can tolerate intermittent ponding, occasional saline conditions due to road salt, and extended dry periods. A list of plants that are suitable for bioretention areas can be found at the end of this section. To avoid a monoculture, it is a good practice to include one tree or shrub per 50 square feet of bioretention area, and at least 3 species each of herbaceous perennials and shrubs. Invasive and exotic species are prohibited. The planting plan should also meet any applicable local landscaping requirements.

All exfiltrating bioretention areas must be designed to drain within 72 hours. However, rain gardens are typically designed to drain water within a day and are thus unlikely to breed mosquitoes.

Bioretention cells, including rain gardens, require pretreatment, such as a vegetated filter strip. A stone or pea gravel diaphragm or, even better, a concrete level spreader upstream of a filter strip will enhance sheet flow and sediment removal.
Bioretention cells can be dosed with sheet flow, a surface inlet, or pipe flow. When using a surface inlet, first direct the flow to a sediment forebay. Alternatively, piped flow may be introduced to the bioretention system via an underdrain.

For bioretention cells dosed via sheet flow or surface inlets, include a ponding area to allow water to pond and be stored temporarily while stormwater is exfiltrating through the cell. Where bioretention areas are adjacent to parking areas, allow three inches of freeboard above the ponding depth to prevent flooding.

Most bioretention cells have an overflow drain that allows ponded water above the selected ponding depth to be dosed to an underdrain. If the bioretention system is designed to exfiltrate, the underdrain is not connected to an outlet, but instead terminates in the bioretention cell. If the bioretention area is not designed to exfiltrate, the underdrain is connected to an outlet for discharge or conveyance to additional best management practices.

Construction

During construction, avoid excessively compacting soils around the bioretention areas and accumulating silt around the drain field. To minimize sediment loading in the treatment area, direct runoff to the bioretention area only from areas that are stabilized; always divert construction runoff elsewhere.

To avoid compaction of the parent material, work from the edge of the area proposed as the location of an exfiltrationg bioretention cell. Never direct runoff to the cell until the cell and the contributing drainage areas are fully stabilized.

Place planting soils in 1-foot to 2-foot lifts and compact them with minimal pressure until the desired elevation is reached. Some engineers suggest flooding the cell between each lift placement in lieu of compaction.

Maintenance

Premature failure of bioretention areas is a significant issue caused by lack of regular maintenance. Ensuring long-term maintenance involves sustained public education and deed restrictions or covenants for privately owned cells. Bioretention areas require careful attention while plants are being established

Bioretention Maintenance Schedule

Activity	*Time of Year*	*Frequency*
Inspect & remove trash	Year round	Monthly
Mulch	Spring	Annually
Remove dead vegetation	Fall or Spring	Annually
Replace dead vegetation	Spring	Annually
Prune	Spring or Fall	Annually
Replace entire media & all vegetation	Late Spring/early Summer	As needed*

** Paying careful attention to pretreatment and operation & maintenance can extend the life of the soil media*

and seasonal landscaping maintenance thereafter.

In many cases, a landscaping contractor working elsewhere on the site can complete maintenance tasks. Inspect pretreatment devices and bioretention cells regularly for sediment build-up, structural damage, and standing water.

Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove litter and debris monthly. Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall).

Proper selection of plant species and support during establishment of vegetation should minimize—if not eliminate—the need for fertilizers and pesticides. Remove invasive species as needed to prevent these species from spreading into the bioretention area. Replace mulch every two years, in the early spring. Upon failure, excavate bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch. A summary of maintenance activities can be found on the previous page.

Because the soil medium filters contaminants from runoff, the cation exchange capacity of the soil media will eventually be exhausted. When the cation exchange capacity of the soil media decreases, change the soil media to prevent contaminants from migrating to the groundwater, or from being discharged via an underdrain outlet. Using small shrubs and plants instead of larger trees will make it easier to replace the media with clean material when needed.

Plant maintenance is critical. Concentrated salts in roadway runoff may kill plants, necessitating removal of dead vegetation each spring and replanting. The operation and maintenance plan must include measures to make sure the plants are maintained. This is particularly true in residential subdivisions, where the operation and maintenance plan may assign each homeowner the legal responsibility to maintain a bioretention cell or rain garden on his or her property. Including the requirement in the property deed for new subdivisions may alert residential property owners to their legal responsibilities regarding the bioretention cells constructed on their lot.

Cold Climate Considerations

Never store snow in bioretention areas. The Operation and Maintenance plan must specify where on-site snow will be stored. All snow dumps must comply with MassDEP's guidance. When bioretention areas are located along roads, care must be taken during plowing operations to prevent snow from being plowed into the bioretention areas. If snow is plowed into the cells, runoff may bypass the cell and drain into downgradient wetlands without first receiving the required water quality treatment, and without recharging the groundwater.

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Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Agrostis alba redtop	FAC	Mesic-Xeric	1-2	H	–	H	H	Shade	Grass	2-3'	Fiberous Shallow	Yes	High	–
Andropogon gerardi bluejoint	FAC	Dry Mesic-Mesic	1-2	–	–	–	–	Sun	Grass	2-3'	Fiberous Shallow	Yes	High	–
Andropogon virginicus broomsedge	–	Wet meadow	1-2	L	–			Full sun	Grass	1-3'		Yes	High	Tolerant of fluctuating water levels and drought.
Carex vulpinoidea fox sedge	OBL	Freshwater marsh	2-4	L	–			Sun to partial sun	Grass	2-3.5'	Rhizome	Yes	High	–
Chelone glabra														
Deschampsia caespitosa tufted hairgrass	FACW	Mesic to wet Mesic	2-4	H	–	H	H	Sun	Grass	2-3'	Fiberous Shallow	Yes	High	May become invasive.
Glyceria striata fowl mannagrass, nerved mannagrass	OBL	Freshwater marsh, seeps	1-2	L	–			Partial shade to full shade	Grass	2-4'	Rhizome	Yes	High	–
Hedera helix English Ivy	FACU	Mesic	1-2	–	–	–	H	Sun	Evergreen ground cover	–	Fiberous Shallow	No	Low	–
Hibiscus palustris														
Iris kaempferi														

H High Tolerance
M Medium Tolerance
L Low Tolerance

FACU Facultative Upland - Usually occur in non-wetlands, however, occasionally found in wetlands.
FAC Facultative - Equally likely to occur in wetlands and non-wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Occur almost always in wetlands

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Lobelia siphilitica														
Lotus Corniculatus birdsfoot-trefoil	FAC	Mesic-Xeric	1-2	H	L	H	H	Sun	Grass	2-3'	Fiberous Shallow	Yes	High	Member of the legume family.
Onoclea sensibilis sensitive fern, beadfern	FACW							Shade		1-3.5'			H	
Pachysandra terminalis Japanese pachysandra	FACU	Mesic	1-2	–	–	–	M	Shade	Evergreen ground cover	–	Fiberous Shallow	No	Low	–
Panicum virgatum switch grass	FAC to FACU	Mesic	2-4	H	–	–	H	Sun or Shade	Grass	4-5'	Fiberous Shallow	Yes	High	Can spread fast and reach height of 6'
Vinca major large periwinkle	FACU	Mesic	1-2	–	–	–	H	Shade	Evergreen ground cover	–	Fiberous Shallow	No	Low	Sensitive to soil compaction and pH changes.
Vinca minor common periwinkle	FACU	Mesic	1-2	–	–	–	H	Shade	Evergreen ground cover	–	Fiberous Shallow	No	Low	–
Indian grass														
Little bluestem														
Deer tongue														
Green coneflower														

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Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Aronia arbutifolia (Pyrus arbutifolia) red chokeberry	FACW	Mesic	1-2	H	_	H	M	Sun to partial sun	Deciduous shrub	6-12'	_	Yes	High	Good bank stabilizer. Tolerates drought.
Clethra alnifolia sweet pepperbush	FAC	Mesic to wet Mesic	2-4	H	_	_	H	Sun to partial sun	Ovoid shrub	6-12'	Shallow	Yes	Med	Coastal plain species.
Cornus Stolonifera (Cornus sericea) red osier dogwood	FACW	Mesic-Hydric	2-4	H	H	H	M	Sun or shade	Arching, spreading shrub	8-10'	Shallow	Yes	High	Needs more consistent moisture levels.
Cornus amomum silky dogwood	FAC	Mesic	1-2	L	_	_	M	Sun to partial sun	Broad-leaved	6-12'	_	Yes	High	Good bank stabilizer
Euonymous europaeus spindle-tree	FAC	Mesic	1-2	M	M	M	M	Sun to partial sun	Upright dense oval shrub	10-12'	Shallow	No	No	_
Hamamelis virginiana witch hazel	FAC	Mesic	2-4	M	M	M	M	Sun or shade	Vase-like compact shrub	4-6'	Shallow	Yes	Low	_
Hypericum densiflorum common St. John's wort	FAC	Mesic	2-4	H	M	M	H	Sun	Ovoid shrub	3-6'	Shallow	Yes	Med	_
Ilex glabra inkberry	FACW	Mesic to wet Mesic	2-4	H	H	_	H	Sun to partial sun	Upright dense shrub	6-12'	Shallow	Yes	High	Coastal plain species.
Ilex verticillata winterberry	FACW	Mesic to wet Mesic	2-4	L	M	_	H	Sun to partial sun	Spreading shrub	6-12'	Shallow	Yes	High	_

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Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Itea virginica tassel-white, Virginia sweetspire	OBL	Mesic	1-2	M	–	–	M	Sun or shade	Broad-leaved, deciduous shrub	6-12'	–	Yes	Low	–
Juniperus communis "compressa" common juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Mounded shrub	3-6'	Deep taproot	No	High	Evergreen
Juniperus horizontalis "Bar Harbor" creeping juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Matted shrub	0-3'	Deep taproot	No	High	Evergreen
Lindera benzoin spicebush	FACW	Mesic to wet Mesic	2-4	H	–	–	H	Sun	Upright shrub	6-12'	Deep	Yes	High	–
Myrica pennsylvanica bayberry	FAC	Mesic	2-4	H	M	M	H	Sun to partial sun	Rounded, compact shrub	6-8'	Shallow	Yes	High	Coastal plain species.
Physocarpus opulifolius ninebark	FAC	Dry Mesic to wet Mesic	2-4	M	–	–	H	Sun	Upright shrub	6-12'	Shallow	Yes	Med	May be difficult to locate.
Viburnum cassinoides northern wild raisin	FACW	Mesic	2-4	H	H	H	H	Sun to partial sun	Rounded, compacted shrub	6-8'	Shallow	Yes	High	–
Viburnum dentatum arrow-wood	FAC	Mesic to wet	2-4	H	H	H	H	Sun to partial sun	Upright, multi-stemmed shrub	8-10'	Shallow	Yes	High	–
Viburnum lentago nannyberry	FAC	Mesic	2-4	H	H	H	H	Sun to partial sun	Upright, mlti-stemmed shrub	8-10'	Shallow	Yes	High	–

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Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Acer rubrum red maple	FAC	Mesic-Hydric	4-6	H	H	H	H	Partial sun	Single to multi-stem tree	50-70'	Shallow	Yes	High	-
Amelanchier canadensis shadbush	FAC	Mesic	2-4	H	M	-	H	Partial sun	Single to multi-stem tree	35-50'	Shallow	Yes	High	Not recommended for full sun.
Betula nigra river birch	FACW	Mesic-Hydric	4-6	-	M	M	H	Partial sun	Single to multi-stem tree	50-75'	Shallow	Yes	High	Not susceptible to bronze birch borer.
Betula populifolia gray birch	FAC	Xeric-Hydric	4-6	H	H	M	H	Partial sun	Single to multi-stem tree	35-50'	Shallow to deep	No	High	Native to New England area.
Fraxinus americana white ash	FAC	Mesic	2-4	M	H	H	H	Sun	Large tree	50-80'	Deep	Yes	Low	-
Fraxinus Pennsylvanica green ash	FACW	Mesic	4-6	M	H	H	H	Partial sun	Large tree	40-65'	Shallow to deep	Yes	Low	-
Ginko biloba Maidenhair tree	FAC	Mesic	2-4	H	H	H	H	Sun	Large tree	50-80'	Shallow to deep	No	Low	Avoid female species-offensive odor from fruit.
Gleditsia triacanthos honeylocust	FAC	Mesic	2-4	H	M	-	M	Sun	Small caopied large tree	50-75'	Shallow to deep variable taproot	Yes	Low	Select thornless variety.
Juniperus virginiana eastern red cedar	FACU	Mesic-Xeric	2-4	H	H	-	H	Sun	Dense single stem tree	50-75'	Taproot	Yes	Very high	Evergreen
Liquidambar styraciflua sweet gum	FAC	Mesic	4-6	H	H	H	M	Sun	Large tree	50-70'	Deep taproot	Yes	High	Edge and perimeter; fruit is a maintenance problem.
Nyssa sylvatica black gum	FACW	Mesic-Hydric	4-6	H	H	H	H	Sun	Large tree	40-70'	Shallow to deep taproot	Yes	High	-

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Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Platanus acerifolia London plane-tree	FACW	Mesic	2-4	H	–	–	M	Sun	Large tree	70-80'	Shallow	No	Low	Tree roots can heave sidewalks.
Platanus occidentalis sycamore	FACW	Mesic-Hydric	4-6	M	M	M	M	Sun	Large tree	70-80'	Shallow	Yes	Med	Edge and perimeter; fruit is a maintennance problem; tree is also prone to windthrow.
Populus deltoides eastern cottonnwood	FAC	Xeric-Mesic	4-6	H	H	H	L	Sun	Large tree with spreading branches	75-100'	Shallow	Yes	High	Short lived.
Quercus bicolor Swamp white oak	FACW	Mesic to wet Mesic	4-6	H	–	H	H	Sun to partial sun	Large tree	75-100'	Shallow	Yes	High	One of the faster growing oaks.
Quercus coccinea scarlet oak	FAC	Mesic	1-2	H	M	M	M	Sun	Large tree	50-75'	Shallow to deep	Yes	High	–
Quercus macrocarpa bur oak	FAC	Mesic to wet Mesic	2-4	H	H	H	M	Sun	Large spreading tree	75-100"	Taproot	No	High	Native to Midwest.
Quercus palustris pin oak	FACW	Mesic-Hydric	4-6	H	H	H	M	Sun	Large tree	60-80'	Shallow to deep taproot	Yes	High	–
Quercus phellos willow oak	FACW	Mesic to wet Mesic	4-6	H	–	–	H	Sun	Large tree	55-75'	Shallow	Yes	High	Fast growing oak.
Quercus rubra red oak	FAC	Mesic	2-4	M	H	M	M	Sun to partial sun	Large spreading tree	60-80'	Deep taproot	Yes	High	–
Quercus shumardii Shumard's red oak	FAC	Mesic	2-4	H	H	H	M	Sun to partial sun	Large spreading tree	60-80'	Deep taproot	No	High	Native to Southeast.

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Sophora japonica Japanese pagoda tree	FAC	Mesic	1-2	M	M	_	M	Sun	Shade tree	40-70'	Shallow	No	Low	Fruit stains sidewalk.
Taxodium distichum bald cypress	FACW	Mesic-Hydric	4-6	_	_	M	H	Sun to partial sun	Typically single stem tree	75-100'	Shallow	Yes	Low	Not well documented for planting in urban areas.
Thuja occidentalis arborvitae	FACW	Mesic to wet Mesic	2-4	M	M	M	H	Sun to partial sun	Dense single stem tree	50-75'	Shallow	No	Low	Evergreen
Zelkova serrata Japanese zelkova	FACU	Mesic	1-2	M	M	_	H	Sun	Dense shade tree	60-70'	Shallow	No	Low	Branches can split easily in storms.

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Deep Sump Catch Basin

Description: Deep sump catch basins, also known as oil and grease or hooded catch basins, are underground retention systems designed to remove trash, debris, and coarse sediment from stormwater runoff, and serve as temporary spill containment devices for floatables such as oils and greases.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	25% TSS removal credit when used for pretreatment. Because of their limited effectiveness and storage capacity, deep sump catch basins receive credit for removing TSS only if they are used for pretreatment and designed as off-line systems.
5 - Higher Pollutant Loading	Recommended as pretreatment BMP. Although provides some spill control capability, a deep sump catch basin may not be used in place of an oil grit separator or sand filter for land uses that have the potential to generate runoff with high concentrations of oil and grease such as: high-intensity-use parking lots, gas stations, fleet storage areas, vehicle and/or equipment maintenance and service areas.
6 - Discharges near or to Critical Areas	May be used as pretreatment BMP. not an adequate spill control device for discharges near or to critical areas.
7 - Redevelopment	Highly suitable.

Advantages/Benefits:

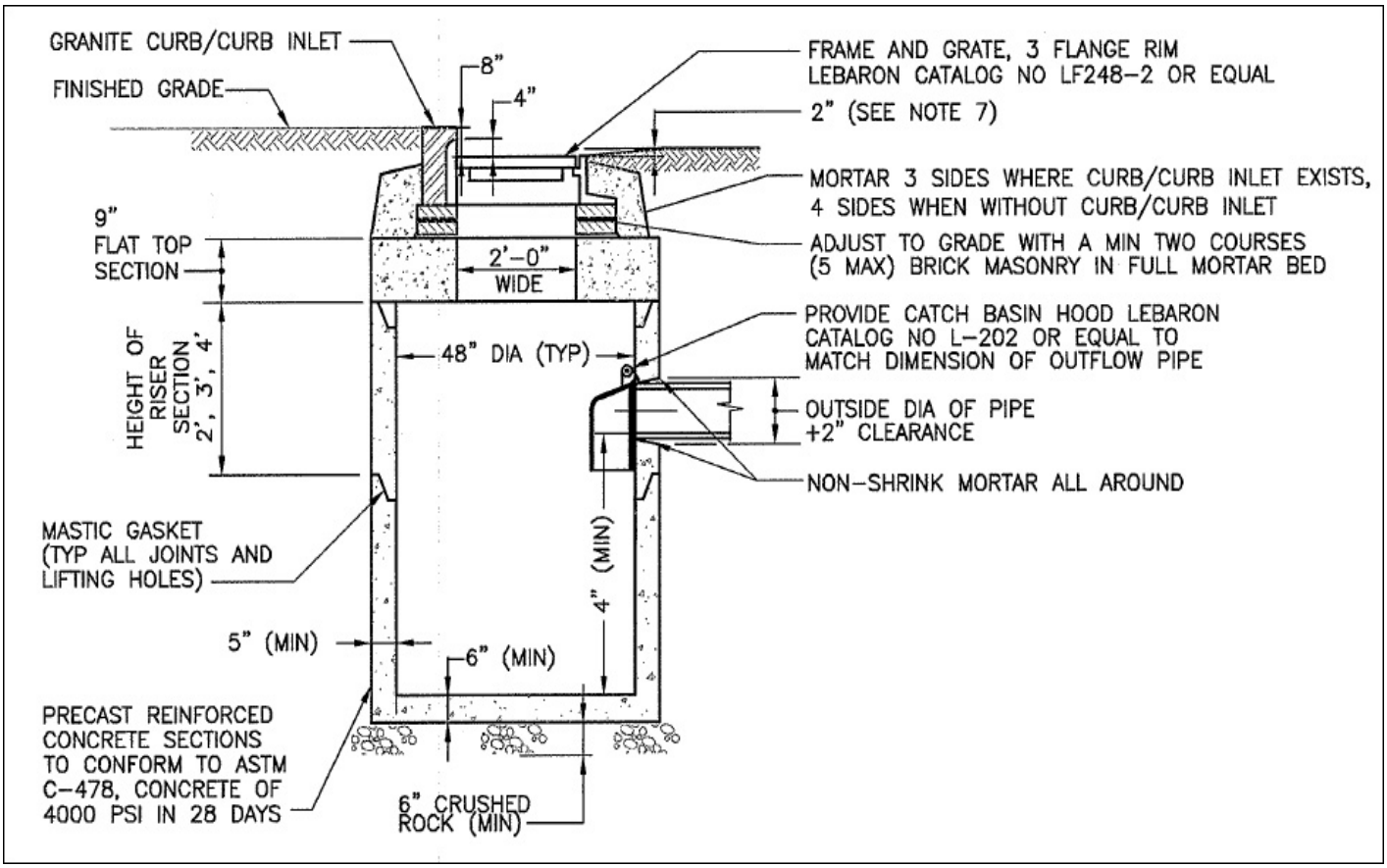
- Located underground, so limited lot size is not a deterrent.
- Compatible with subsurface storm drain systems.
- Can be used for retrofitting small urban lots where larger BMPs are not feasible.
- Provide pretreatment of runoff before it is delivered to other BMPs.
- Easily accessed for maintenance.
- Longevity is high with proper maintenance.

Disadvantages/Limitations:

- Limited pollutant removal.
- Expensive to install and maintain, resulting in high cost per unit area treated.
- No ability to control volume of stormwater
- Frequent maintenance is essential
- Requires proper disposal of trapped sediment and oil and grease
- Entrapment hazard for amphibians and other small animals

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) - 25% (for regulatory purposes)
- Nutrients (Nitrogen, phosphorus) - Insufficient data
- Metals (copper, lead, zinc, cadmium) - Insufficient data
- Pathogens (coliform, e coli) - Insufficient data



adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Inspect units	Four times per year
Clean units	Four 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 basin.

Special Features

All deep sump catch basins must include hoods. For MassHighway projects, consult the Stormwater Handbook for Highways and Bridges for hood requirements.

LID Alternative

Reduce Impervious Surface
Disconnect rooftop and non-rooftop runoff
Vegetated Filter Strip

Deep Sump Catch Basin

Suitable Applications

- Pretreatment
- Residential subdivisions
- Office
- Retail

Design Considerations

- The contributing drainage area to any deep sump catch basin should not exceed ¼ acre of impervious cover.
- Design and construct deep sump catch basins as off-line systems.
- Size the drainage area so that the flow rate does not exceed the capacity of the inlet grate.
- Divert excess flows to another BMP intended to meet the water quantity requirements (peak rate attenuation) or to a storm drain system. An off-line design enhances pollutant removal efficiency, because it prevents the resuspension of sediments in large storms.

Make the sump depth (distance from the bottom of the outlet pipe to the bottom of the basin) at least four feet times the diameter of the outlet pipe and more if the contributing drainage area has a high sediment load. The minimum sump depth is 4 feet. Double catch basins, those with 2 inlet grates, may require deeper sumps. Install the invert of the outlet pipe at least 4 feet from the bottom of the catch basin grate.

The inlet grate serves to prevent larger debris from entering the sump. To be effective, the grate must have a separation between the grates of one square inch or less. The inlet openings must not allow flows greater than 3 cfs to enter the deep sump catch basin. If the inlet grate is designed with a curb cut, the grate must reach the back of the curb cut to prevent bypassing. The inlet grate must be constructed of a durable material and fit tightly into the frame so it won't be dislodged by automobile traffic. The inlet grate must not be welded to the frame so that sediments may be easily removed. To facilitate maintenance, the inlet grate must be placed along the road shoulder or curb line rather than a traffic lane.

Note that within parking garages, the State Plumbing Code regulates inlet grates and other stormwater management controls. Inlet grates inside parking garages are currently required to have much smaller openings than those described herein.

To receive the 25% removal credit, hoods must be used in deep sump catch basins. Hoods also help contain oil spills. MassHighway may install catch basins without hoods provided they are designed, constructed, operated, and maintained in accordance with the Mass Highway Stormwater Handbook.

Install the weep hole above the outlet pipe. Never install the weep hole in the bottom of the catch basin barrel.

Site Constraints

A proponent may not be able to install a deep sump catch basin because of:

- Depth to bedrock;
- High groundwater;
- Presence of utilities; or
- Other site conditions that limit depth of excavation because of stability.

Maintenance

Regular maintenance is essential. Deep sump catch basins remain effective at removing pollutants only if they are cleaned out frequently. One study found that once 50% of the sump volume is filled, the catch basin is not able to retain additional sediments.

Inspect or clean deep sump basins at least four times per year and at the end of the foliage and snow-removal seasons. Sediments must also be removed four 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 basin. If handling runoff from land uses with higher potential pollutant loads or discharging runoff near or to a critical area, more frequent cleaning may be necessary.

Clamshell buckets are typically used to remove sediment in Massachusetts. However, vacuum trucks are preferable, because they remove more trapped sediment and supernatant than clamshells. Vacuuming is also a speedier process and is less likely to snap the cast iron hood within the deep sump catch basin.

Always consider the safety of the staff cleaning deep sump catch basins. Cleaning a deep sump catch basin within a road with active traffic or even within a parking lot is dangerous, and a police detail may be necessary to safeguard workers.

Although catch basin debris often contains concentrations of oil and hazardous materials such as petroleum hydrocarbons and metals, MassDEP classifies them as solid waste. Unless there is evidence that they have been contaminated by a spill or other means, MassDEP does not routinely require catch basin cleanings to be tested before disposal. Contaminated catch basin cleanings must be evaluated in accordance with the Hazardous Waste Regulations, 310 CMR 30.000, and handled as hazardous waste.

In the absence of evidence of contamination, catch basin cleanings may be taken to a landfill or other facility permitted by MassDEP to accept solid waste, without any prior approval by MassDEP. However, some landfills require catch basin cleanings to be tested before they are accepted.

With prior MassDEP approval, catch basin cleanings may be used as grading and shaping materials at landfills undergoing closure (see Revised Guidelines for Determining Closure Activities at Inactive Unlined Landfill Sites) or as daily cover at active landfills. MassDEP also encourages the beneficial reuse of catch basin cleanings whenever possible. A Beneficial Reuse Determination is required for such use.

MassDEP regulations prohibit landfills from accepting materials that contain free-draining liquids. One way to remove liquids is to use a hydraulic lift truck during cleaning operations so that the material can be decanted at the site. After loading material from several catch basins into a truck, elevate the truck so that any free-draining liquid can flow back into the structure. If there is no free water in the truck, the material may be deemed to be sufficiently dry. Otherwise the catch basin cleanings must undergo a Paint Filter Liquids Test. Go to www. Mass.gov/dep/recycle/laws/cafacts.doc for information on all of the MassDEP requirements pertaining to the disposal of catch basin cleanings.

Appendix D
Hydraulic Analysis

- 25-year Hydraulic Storm Drain Calculations

25-Year Hydraulic Storm Drain Calculations

Project: Avalon Sudbury | Project #: 13125.00
Location: Sudbury, MA | Sheet: 1 of 1
Calculated By: BMG | Date: 5/23/2016
Title: 25-Year Hydraulic Calculations per StormCAD using NRCC IDF Curve

Start Node	Stop Node	Upstream Invert (ft)	Downstream Invert (ft)	Slope (ft/ft)	Manning's n	Diameter (in)	Length (ft)	System Intensity (in/hr)	Upstream Inlet Area (sf)	Upstream Inlet C (acres)	Flow (cfs)	Capacity (cfs)	Average Velocity (ft/s)	Elevation Ground Start (ft)	Cover Start (ft)	Elevation Ground Stop (ft)	Cover Stop (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
CB-328	DMH-327	161	160	0.009	0.013	12	109	6.83	10,837	0.618	1.06	3.41	3.54	164	2	164.9	3.9	161.43	160.38
CB-314	DMH 313	160.8	160.2	0.006	0.013	12	104	6.83	15,482	0.785	1.92	2.71	3.86	163.8	2	164.9	3.7	161.42	160.79
DMH-329	DMH-327	162.4	160.0	0.022	0.013	12	109.0	6.83	80,000	0.30	3.8	5.3	6.4	165.5	2.1	164.9	3.9	163.2	160.6
OCS-302	DMH-301	148.7	147.8	0.007	0.013	30	125	5.481	(N/A)	(N/A)	36.57	34.8	8.27	157.8	6.6	156	5.7	150.88	149.85
DMH-327	DMH-325	159.5	158.0	0.006	0.013	18	266.0	6.553	(N/A)	(N/A)	4.7	7.9	4.5	164.9	3.9	162.1	2.6	160.3	158.9
CB-326	DMH-325	159.1	159	0.014	0.013	12	7	6.83	21,683	0.649	2.22	4.26	4.62	162.1	2	162.1	2.1	159.74	159.55
CB-323	WQU-322	156.8	156.4	0.044	0.013	12	9.0	6.83	37,631	0.61	3.6	7.5	5.0	160.3	2.5	160.4	3.0	157.6	157.4
CB-310	DMH-309	159.1	159	0.009	0.013	12	11	6.83	6,111	0.736	0.71	3.4	3.14	162.1	2	162.2	2.2	159.45	159.31
CB-312	DMH-311	160.4	160.3	0.011	0.013	12	9	6.83	5,937	0.808	0.8	3.8	3.3	163.4	2.0	163.5	2.2	160.8	160.6
CB-319	WQU-318	156.9	155.7	0.048	0.013	12	25.0	6.83	11,548	0.82	1.5	7.8	5.5	159.9	2.0	159.8	3.1	157.4	156.0
CB-308	DMH-307	156.4	156.0	0.011	0.013	18	37.0	6.83	74,696	0.68	8.0	10.9	6.2	158.9	1.0	159.8	2.3	157.5	157.0
CB-306	DMH-305	155.9	155.8	0.005	0.013	12	20.0	6.83	16,983	0.77	2.1	2.5	2.7	158.4	1.5	159.5	2.7	156.8	156.8
CB-304	DMH 303	155.0	154.6	0.017	0.013	12	24.0	6.83	12,565	0.79	1.6	4.6	3.5	158.0	2.0	158.8	3.2	155.5	155.2
WQU 316	DMH-315	152.4	152	0.009	0.013	12	47	6.83	16,295	0.588	1.5	3.3	3.9	155.4	2.0	158.3	5.3	152.9	152.5
CB-106	DMH-105	152	151.5	0.019	0.013	12	27	6.83	25,875	0.557	2.3	4.9	4.1	154.5	1.5	154.8	2.3	152.7	152.2
CB-107	DMH-105	152.3	151.5	0.007	0.013	12	116	6.83	13,434	0.632	1.34	2.96	2.89	154.8	1.5	154.8	2.3	152.79	152.21
CB-104	WQU-103	151.9	150.6	0.006	0.013	12	211	6.83	24,975	0.699	2.76	2.8	4.33	154.4	1.5	156.1	4.5	152.71	151.31
LD-109	DMH-108	151.0	150.5	0.031	0.013	12	16.0	6.83	(N/A)	(N/A)	3.9	6.3	6.6	154.0	2.0	155.5	4.0	151.8	151.1
DMH-325	DMH 321	157.9	157.5	0.011	0.013	18	38	6.097	(N/A)	(N/A)	6.31	10.78	5.74	162.1	2.7	161.5	2.5	158.87	158.33
WQU-322	DMH-324	156.2	155.8	0.010	0.013	18	40.0	5.928	(N/A)	(N/A)	9.3	10.5	6.5	160.4	2.7	161.3	4.0	157.4	156.9
DMH-320	DMH-317	152.9	150	0.013	0.013	18	219	5.85	(N/A)	(N/A)	11.86	12.09	6.71	161.9	7.5	160.2	8.7	154.44	151.65
DMH-309	DMH-307	158.1	156.2	0.006	0.013	15	332	6.052	(N/A)	(N/A)	3	4.89	4.23	162.2	2.85	159.8	2.35	158.81	156.9
DMH-317	DMH-315	149.9	149.2	0.004	0.013	24	173	5.692	(N/A)	(N/A)	13.69	14.39	4.55	160.2	8.3	158.3	7.1	151.65	151.14
WQU-318	DMH-317	155.5	155	0.031	0.013	12	16	6.643	(N/A)	(N/A)	2.43	6.3	5.56	159.8	3.3	160.2	4.2	156.17	155.47
DMH-307	DMH-305	155.7	155.4	0.008	0.013	24	36	5.633	(N/A)	(N/A)	9.43	20.65	4.74	159.8	2.1	159.5	2.1	156.8	156.76
DMH-305	DMH 303	155.3	154.5	0.005	0.013	24	165	5.6	(N/A)	(N/A)	13.9	15.8	5.9	159.5	2.2	158.8	2.3	156.8	155.8
DMH-315	OCS-302	149.1	148.8	0.005	0.013	24	61	5.533	(N/A)	(N/A)	14.6	15.9	4.7	158.3	7.2	157.8	7.0	151.1	150.9
DMH-301	DMH 300	147.7	147.1	0.007	0.013	30	82.0	5.426	(N/A)	(N/A)	36.3	35.1	8.3	156.0	5.8	157.0	7.4	149.8	149.1
DMH-108	DMH-102	149.1	148.6	0.009	0.013	30	54	6.83	(N/A)	(N/A)	30	39.47	7.24	155.5	3.9	155.2	4.1	150.97	150.69
DMH-102	DMH-101	148.5	147.6	0.009	0.013	30	104	6.029	(N/A)	(N/A)	39.84	38.15	8.57	155.2	4.2	155.7	5.6	150.69	149.91
WQU-103	DMH-102	150.1	149.5	0.006	0.013	18	102.0	6.18	(N/A)	(N/A)	5.8	8.1	4.4	156.1	4.5	155.2	4.2	151.0	150.7
DMH-105	WQU-103	151.4	150.6	0.005	0.013	15	158.0	6.469	(N/A)	(N/A)	3.4	4.6	4.3	154.8	2.2	156.1	4.3	152.2	151.4
CB-EX	WQU-318	156.1	155.7	0.006	0.013	12	62.0	6.83	11,475	0.55	1.0	2.9	3.0	159.2	2.1	159.8	3.1	156.5	156.2
DMH-324	DMH-320	153.9	153.0	0.015	0.013	18	60.0	5.891	(N/A)	(N/A)	11.9	12.9	7.1	161.3	5.9	161.9	7.4	155.2	154.4
DMH-101	EX-OF	147.5	146.9	0.007	0.013	30	84.0	5.95	(N/A)	(N/A)	39.7	34.7	8.6	155.7	5.7	153.8	4.4	149.9	149.0
EX-WET-1	DMH-108	149.7	149.2	0.01	0.013	24	49	6.83	(N/A)	(N/A)	26.1	22.85	8.56	155	3.3	155.5	4.3	151.71	150.99
WQU-113	DMH-112	153.9	153.6	0.011	0.012	15	27	6.83	47,000	0.642	4.77	7.38	5.66	156.9	1.75	157.2	2.35	154.79	154.35
DMH 300	EX-FES2	147.0	146.6	0.011	0.013	36	36.0	5.39	(N/A)	(N/A)	36.1	70.3	8.3	157.0	7.0	155.0	5.4	149.0	148.2
DMH 313	DMH-311	160.1	159.4	0.005	0.013	12	133	6.587	(N/A)	(N/A)	1.85	2.58	3.46	164.9	3.8	163.5	3.1	160.73	160.06
DMH-311	DMH-309	159.3	158.6	0.005	0.013	12	128	6.255	(N/A)	(N/A)	2.45	2.63	4.1	163.5	3.2	162.2	2.6	160.06	159.27
DMH 321	WQU-322	157.4	156.4	0.01	0.013	18	100	6.054	(N/A)	(N/A)	6.27	10.5	5.17	161.5	2.6	160.4	2.5	158.37	157.38

Project: Avalon Sudbury | Project #: 13125.00
Location: Sudbury, MA | Sheet: 1 of 1
Calculated By: BMG | Date: 5/23/2016
Title: 25-Year Hydraulic Calculations per StormCAD using NRCC IDF Curve

Start Node	Stop Node	Upstream Invert (ft)	Downstream Invert (ft)	Slope (ft/ft)	Manning's n	Diameter (in)	Length (ft)	System Intensity (in/hr)	Upstream Inlet Area (sf)	Upstream Inlet C (acres)	Flow (cfs)	Capacity (cfs)	Average Velocity (ft/s)	Elevation Ground Start (ft)	Cover Start (ft)	Elevation Ground Stop (ft)	Cover Stop (ft)	Hydraulic Grade Line In (ft)	Hydraulic Grade Line Out (ft)
CB-328	DMH-327	161	160	0.009	0.013	12	109	6.83	10,837	0.618	1.06	3.41	3.54	164	2	164.9	3.9	161.43	160.38
LD-100	EX-OF	150	149.5	0.042	0.013	15	12	6.83	(N/A)	(N/A)	9	13.19	8.52	153.5	2.25	153.8	3.05	151.16	150.41
DMH 303	OCS-302	153.8	153.5	0.01	0.013	24	31	5.498	(N/A)	(N/A)	14.92	22.25	6.88	158.8	3	157.8	2.3	155.19	154.73
DMH-112	DMH-111	153.5	152.4	0.011	0.012	15	103	6.787	(N/A)	(N/A)	4.74	7.23	5.7	157.2	2.45	157.5	3.85	154.38	153.14
DMH-111	DMH-102	152.3	150.0	0.011	0.012	15	208.0	6.624	(N/A)	(N/A)	4.6	7.4	5.7	157.5	4.0	155.2	4.0	153.2	150.7
CB-305B	DMH-305A	158.7	158.5	0.008	0.012	12	24	6.83	34,996	0.627	3.47	3.52	5.14	161.7	2	161.4	1.9	159.51	159.3
DMH-305A	DMH-305	158.4	156.3	0.008	0.012	15	266	6.788	(N/A)	(N/A)	3.45	6.22	4.84	161.4	1.75	159.5	1.95	159.15	156.96