Stormwater Management Report

Definitive Subdivision Plan of Rocky Maple Lane

Off Carver Road
Wareham, Massachusetts

Prepared for:
Brett Meredith
PO Box 359
Carver, Massachusetts 02330

Prepared by:

BEALS + THOMAS

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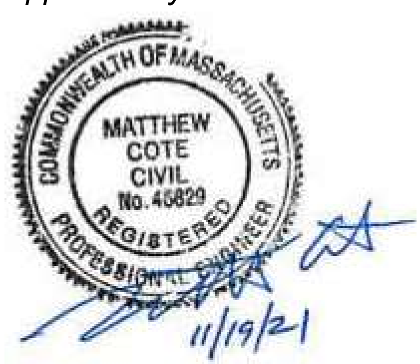
Calculated by: **Nathaniel Bautz, EIT**

Checked by: **Matthew Cote, PE**

Approved by:



Matthew Cote, PE

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LIST OF ATTACHMENTS

1.0 INTRODUCTION

The proposed project includes a stormwater management system designed to mitigate potential impacts the proposed project could have on the existing watershed. Stormwater controls have been proposed to control peak runoff rates, provide water quality, promote groundwater recharge and sediment removal. The proposed system has been designed to comply with:

- The 2008 Massachusetts Department of Environmental Protection (DEP) Stormwater Management Handbook,
- The Massachusetts Wetland Protection Act (310 CMR 10.00), and
- Town of Wareham Rules & Regulations Governing The Subdivision of Land

The pre- and post-development hydrologic conditions were modeled using HydroCAD™ version 10.10 to demonstrate that post-development stormwater runoff rates will be less than or equal to the pre-development rates. Watershed maps with soil types as well as detailed analysis of the model results are also included. The following table summarizes the peak runoff rates for the pre- and post-development conditions.

Table 1: Pre- & Post-development Peak Runoff Rate Comparison, units are in cubic feet per second (cfs).

Storm Event	2 Year		10 Year		25 Year		50 Year		100 Year	
	Pre	Post	*Pre*	Post	*Pre*	Post	*Pre*	Post	*Pre*	Post
Design Point 1	*0.51*	0.05	*3.06*	1.93	*7.07*	6.08	*9.30*	7.07	*13.62*	10.93

2.0 PRE-DEVELOPMENT CONDITIONS

2.1 Site Conditions

The Site is currently developed and contains actively farmed cranberry bogs, blueberry patches, and other previously disturbed areas located off the east side of North Carver Road in Wareham and Carver, Massachusetts. Runoff from the Site generally stays on site and infiltrates into the cranberry bogs; however, some stormwater drains to the south and east to the Weweantic River.

Wetland buffer zones surround the existing cranberry bogs. Portions of the Site to the North, South, and East contain 200' Riverfront Areas. The majority of the Site is within the 100-year FEMA floodplain and associated flood plain buffer zone.

The Site does not contain, nor is it tributary to any Critical Areas.

The Site is within the broader Buzzards Bay watershed which ultimately has a TMDL for Pathogens, however the Project will not generate any Pathogens.

2.2 Soil Description

The Natural Resources Conservation Service (NRCS) lists the on-site soils as Hinckley loamy sand (NRCS hydrologic class A) and Udipsamments (NRCS hydrologic class A/D).

2.3 Hydrologic Analysis

Sub-catchment areas were delineated based on existing runoff patterns and topographic information. This information is shown on the *Pre-Development Conditions Hydrologic Areas Map* included in Attachment 2. Summaries of each area with respect to Curve Number and Time of Concentration calculations can be found in the model results also in Attachment 2.

3.0 POST-DEVELOPMENT CONDITIONS

3.1 Design Strategy

During the design phase of the site layout, consideration was given to conserving environmentally sensitive features and minimizing impact on the existing hydrology. To achieve this, extensive grading was avoided, and the site was designed to match the existing terrain where feasible. Minimizing earthwork helps to maintain the existing drainage patterns to the maximum extent practicable under post-development conditions. On-site resource areas, such as the Bordering Vegetated Wetlands in the northwest corner of the site, were excluded from the development envelope and will not be altered by the proposed project. Through careful site planning the proposed impervious surfaces have been minimized, reducing the impact the project may have on the existing watershed. This minimization of impervious surfaces was achieved without compromising compliance to local bylaw requirements.

A stormwater management system has been designed to provide treatment for stormwater runoff associated with the proposed impervious surfaces on site. All stormwater BMPs were designed to treat a minimum of the first 1.0 inch of runoff generated by the on-site impervious areas. Proprietary stormwater treatment systems were designed to treat the runoff rate associated with the water quality volume in accordance with the requirements of the DEP Stormwater Handbook. Stormwater BMP sizing worksheets and water quality sizing calculations are included in Attachment 5 of this report.

To mitigate increased stormwater flow rates associated with the proposed impervious area, an infiltration basin has been proposed. The infiltration system will discharge to the wetland system which eventually outlets into the existing cranberry bogs, consistent with the existing hydrology of the site.

3.2 Hydrologic Analysis

The established design point used in the pre-development conditions analysis were used in the post-development analysis for direct comparison. The tributary areas and flow paths were modified to reflect post-development conditions. See Attachment 3 for the *Post- Development Conditions Hydrologic Areas Map*. Summaries of each area with respect to Curve Number and Time of Concentration calculations can be found in the model results in Attachment 3.

3.3 Hydraulic Calculations

In compliance with Town of Wareham requirements, the proposed storm drain system was analyzed based on the 50-year storm event using the Rational Formula. A watershed map and detailed hydraulic analysis are provided in Attachment 4.

3.4 Compliance with DEP Stormwater Management Standards

The proposed stormwater management system was designed in compliance with the ten (10) DEP Stormwater Management Standards. The following summary provides key information related to the proposed stormwater management system, its design elements, and mitigation measures for potential impacts.

STANDARD 1: **No new stormwater conveyance (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.**

There will be no direct discharge of untreated stormwater to nearby wetlands or waters of the Commonwealth. Runoff from all impervious areas of the site will be conveyed to stormwater management controls for infiltration, water quality treatment, and runoff rate attenuation prior to discharge to adjacent wetlands.

STANDARD 2: **Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates.**

The stormwater management design will control post-development peak discharge rates for the 2-, 10-, 25-, 50-, and 100-year, 24-hour storms so as to maintain pre-development peak discharge rates. Refer to Section 1.0 Introduction for a summary of the peak runoff rates.

STANDARD 3: **Loss of annual recharge to groundwater shall be eliminated or minimized through the use of environmentally sensitive site design, low impact development techniques, stormwater management practices and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil types. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.**

The stormwater management system includes an infiltration basin that will effectively recharge groundwater on-site. Infiltration BMPs were sized using the static method based on the required recharge volume for the post-development site. As a result, annual recharge from the post-development site will approximate the annual recharge from the site under pre-development conditions. See Attachment 5 for stormwater BMP design worksheets and Groundwater Recharge Calculation.

STANDARD 4: Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS).

The proposed project will meet the water quality requirements of Standard 4 using several on-site treatment trains that achieve 80% TSS removal. Refer to Attachment 5 for the TSS removal worksheets. Structural BMPs designed for water quality treatment, including the deep sump hooded catch basins, and Contech® water quality treatment systems, were sized to capture and treat the flow rate associated with the first 1.0-inch of runoff from proposed impervious surfaces. All proposed stormwater management BMPs will be operated and maintained to ensure continued water quality treatment of runoff. The Site Owner's Manual complies with the Long-Term Pollution Prevention Plan (Standard 4) and the Long-Term Operation and Maintenance Plan (Standard 9) requirements of the 2008 Massachusetts Department of Environmental Protection (MassDEP) Stormwater Management Standards. The Manual outlines source control and pollution prevention measures and maintenance requirements of stormwater best management practices (BMPs) associated with the proposed development.

STANDARD 5: For land uses with higher potential pollutant loads (LUHPPLs), source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable.

The proposed project is not associated with stormwater discharges from land uses with higher potential pollutant loads.

STANDARD 6: Stormwater discharges to critical areas must utilize certain stormwater management BMPs approved for critical areas. Critical areas are Outstanding Resource Waters, shellfish beds, swimming beaches, coldwater fisheries and recharge areas for public water supplies.

There are no stormwater discharges to critical areas associated with this project.

STANDARD 7: **Redevelopment of previously developed sites must meet the Stormwater Management Standards to the maximum extent practicable. However, if it is not practicable to meet all the Standards, new (retrofitted or expanded) stormwater management systems must be designed to improve existing conditions.**

The proposed project is new development, and therefore this standard does not apply.

STANDARD 8: **A plan to control construction-related impacts during erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.**

A Stormwater Pollution Prevention Plan (SWPPP) will be developed prior to construction to comply with Section 3 of the NPDES Construction General Permit for Stormwater Discharges; therefore, the requirements of Standard 8 are fulfilled.

STANDARD 9: **A Long-Term Operation and Maintenance (O&M) Plan shall be developed and implemented to ensure that stormwater management systems function as designed.**

The Site Owner's Manual complies with the Long-Term Pollution Prevention Plan (Standard 4) and the Long-Term Operation and Maintenance Plan (Standard 9) requirements of the 2008 Massachusetts Department of Environmental Protection (MassDEP) Stormwater Management Standards. The Manual outlines source control and pollution prevention measures and maintenance requirements of the stormwater best management practices (BMPs) associated with the proposed development.

STANDARD 10: **All illicit discharges to the stormwater management system are prohibited.**

There will be no illicit discharges to the proposed stormwater management system associated with the proposed project. An Illicit Discharge Compliance Statement is provided on the following page.

3.5 Illicit Discharge Compliance Statement

An illicit discharge is any discharge to a stormwater management system that is not comprised entirely of stormwater, discharges from fire-fighting activities, and certain non-designated non-stormwater discharges.

To the best of my knowledge, no detectable illicit discharge exists on site. The site plans included with this report detail the storm sewers that convey stormwater on the site and demonstrate that these systems do not include the entry of an illicit discharge. A Site Owner's Manual is also included, which contains the Long Term Pollution Plan that outlines measures to prevent future illicit discharges. As the Site Owner, I will ultimately be responsible for implementing the Long Term Pollution Prevention Plan.

Signature: ______________________

Owner's Name

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.

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

COMMONWEALTH OF MASSACHUSETTS
MATTHEW
COTE
CIVIL
No. 45829
REGISTERED
PROFESSIONAL ENGINEER
11/19/21

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 (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 (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

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

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

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 (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 (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 (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.

Attachment 1
Soil Data

Soil Map—Plymouth County, Massachusetts

Map Scale: 1:8,020 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 350 700 1400 2100

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

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

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

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

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

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

Soil Survey Area: Plymouth County, Massachusetts
Survey Area Data: Version 12, Sep 12, 2019

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

Date(s) aerial images were photographed: Dec 31, 2009—Jul 3, 2017

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Water	12.3	4.5%
7A	Rainberry coarse sand, 0 to 3 percent slopes, sanded surface	1.1	0.4%
23A	Tihonet coarse sand, 0 to 3 percent slopes	1.7	0.6%
52A	Freetown muck, 0 to 1 percent slopes	0.9	0.3%
53A	Freetown muck, ponded, 0 to 1 percent slopes	68.1	25.0%
55A	Freetown coarse sand, 0 to 3 percent slopes, sanded surface	33.2	12.2%
60A	Swansea coarse sand, 0 to 2 percent slopes	18.1	6.6%
221A	Eldridge fine sandy loam, 0 to 3 percent slopes	5.2	1.9%
252E	Carver coarse sand, 15 to 35 percent slopes	2.0	0.7%
253B	Hinckley loamy sand, 3 to 8 percent slopes	14.5	5.3%
253C	Hinckley loamy sand, 8 to 15 percent slopes	6.7	2.5%
253E	Hinckley loamy sand, 15 to 35 percent slopes	3.2	1.2%
255B	Windsor loamy sand, 3 to 8 percent slopes	2.4	0.9%
256A	Deerfield loamy fine sand, 0 to 3 percent slopes	2.6	0.9%
256B	Deerfield loamy fine sand, 3 to 8 percent slopes	2.1	0.8%
259B	Carver loamy coarse sand, 3 to 8 percent slopes	1.3	0.5%
259C	Carver loamy coarse sand, 8 to 15 percent slopes	4.3	1.6%
260A	Sudbury fine sandy loam, 0 to 3 percent slopes	33.2	12.2%
260B	Sudbury fine sandy loam, 3 to 8 percent slopes	1.5	0.6%
435B	Plymouth loamy coarse sand, 3 to 8 percent slopes	0.5	0.2%
435C	Plymouth loamy coarse sand, 8 to 15 percent slopes	4.0	1.5%
435E	Plymouth loamy coarse sand, 15 to 35 percent slopes	3.3	1.2%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
437C	Plymouth loamy coarse sand, 8 to 15 percent slopes, bouldery	18.4	6.8%
438E	Plymouth loamy coarse sand, 15 to 35 percent slopes, extremely bouldery	4.5	1.6%
654B	Udorthents, loamy, 0 to 8 percent slopes	0.7	0.3%
657A	Aquepts, 0 to 3 percent slopes	8.3	3.1%
658A	Endoaquents, 0 to 3 percent slopes, sanded surface	0.0	0.0%
659B	Udorthents, 0 to 8 percent slopes, gravelly	0.5	0.2%
700A	Udipsamments, wet substratum, 0 to 3 percent slopes	16.5	6.0%
701A	Rainberry coarse sand, 0 to 3 percent slope, sanded surface, inactive	1.4	0.5%
Totals for Area of Interest		**272.3**	**100.0%**

Attachment 2
Pre-Development Hydrologic Analysis

PRE-DEVELOPMENT CONDITIONS HYDROLOGY CALCULATION SUMMARY

OBJECTIVE

To determine the pre-development peak rates of runoff from the site for the 2, 10, 25, 50, & 100-year storm events at the design point.

CONCLUSION(S)

Peak Runoff Rates (CFS):

Storm Event	2-Year	10-Year	25-Year	50-Year	100-Year
Design Point-1	0.51	3.06	6.08	9.30	13.62

CALCULATION METHODS

1. Runoff curve numbers (CN), time-of-concentration (Tc), and runoff rates were calculated based on TR-55 methodology.
2. AutoCAD 2019 computer program was utilized for digitizing ground cover areas.
3. Peak runoff rates were computed using HydroCAD version 10.10.

ASSUMPTIONS

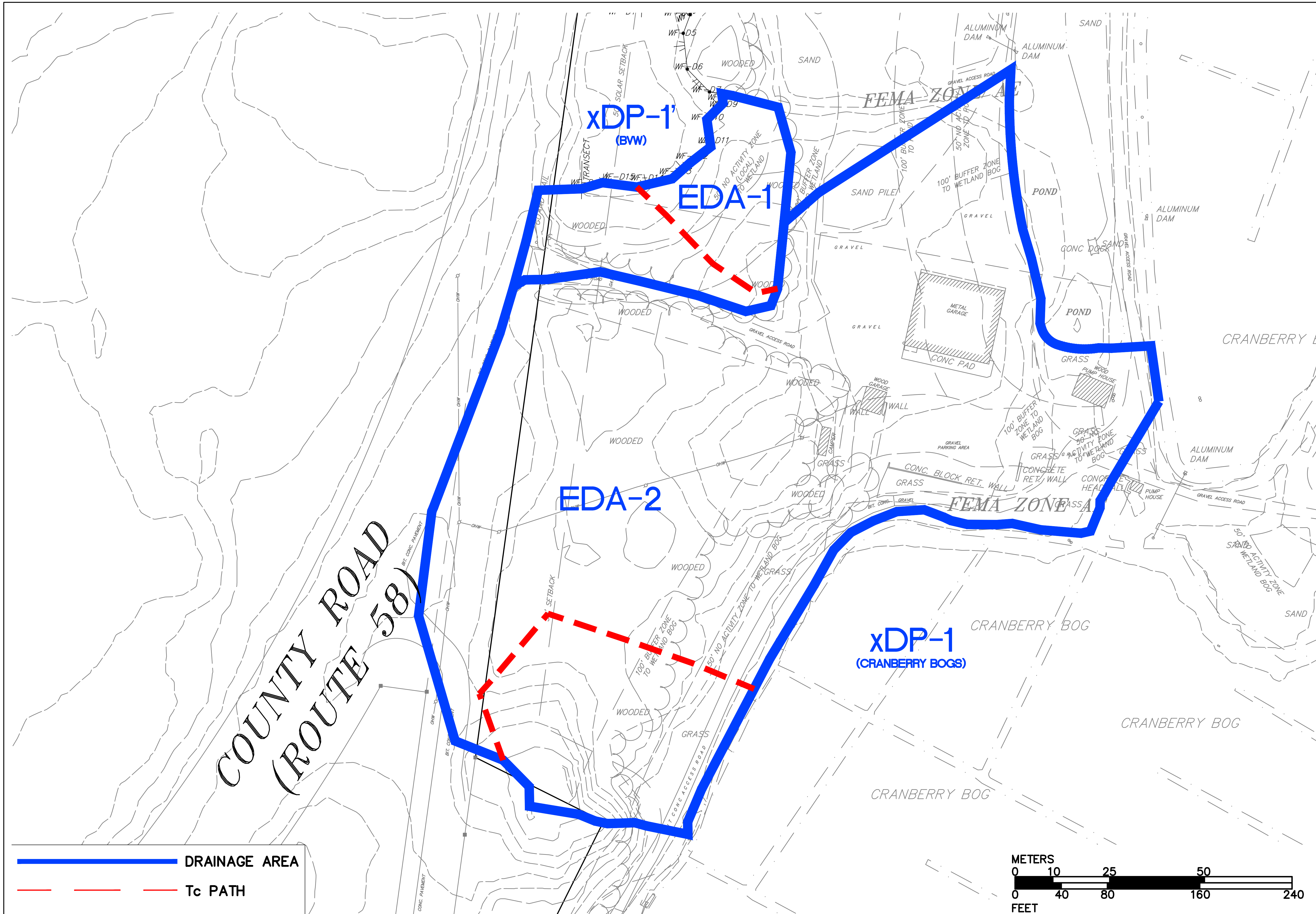
1. The ground cover types were determined using aerial imagery. Hydrologic soil groups based on United States Department of Agriculture, NRCS Soil Survey map information.
2. Stormwater runoff from offsite tributary areas was included in the calculations.
3. Wetlands were excluded for this calculation.

SOURCES OF DATA/ EQUATIONS

1. Pre-Development Conditions Hydrologic Areas Map prepared by Beals and Thomas, Inc. File No. 320302P011A-001.
2. NRCS Soil Survey for Plymouth County, hydrologic soil group report, downloaded from Web Soil Survey on 06/03/2020.
3. TR-55 Urban Hydrology for Small Watershed, SCS, 1986.
4. Massachusetts DEP Stormwater Management Handbook, February 2008.

REV	CALC. BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
0	NBB	11/16/2021	MC	11/17/2021	MC	11/17/2021

NBB/320302CS001A



Pre-Development Conditions Hydrologic Areas Map

Figure Number 001

Scale: 1" = 80'

Date: 11/16/2021

Plan No. 320302P011A-001

B+T Project No. 3203.02

Definitive Subdivision Plan of Rocky Maple Lane

Wareham, Massachusetts

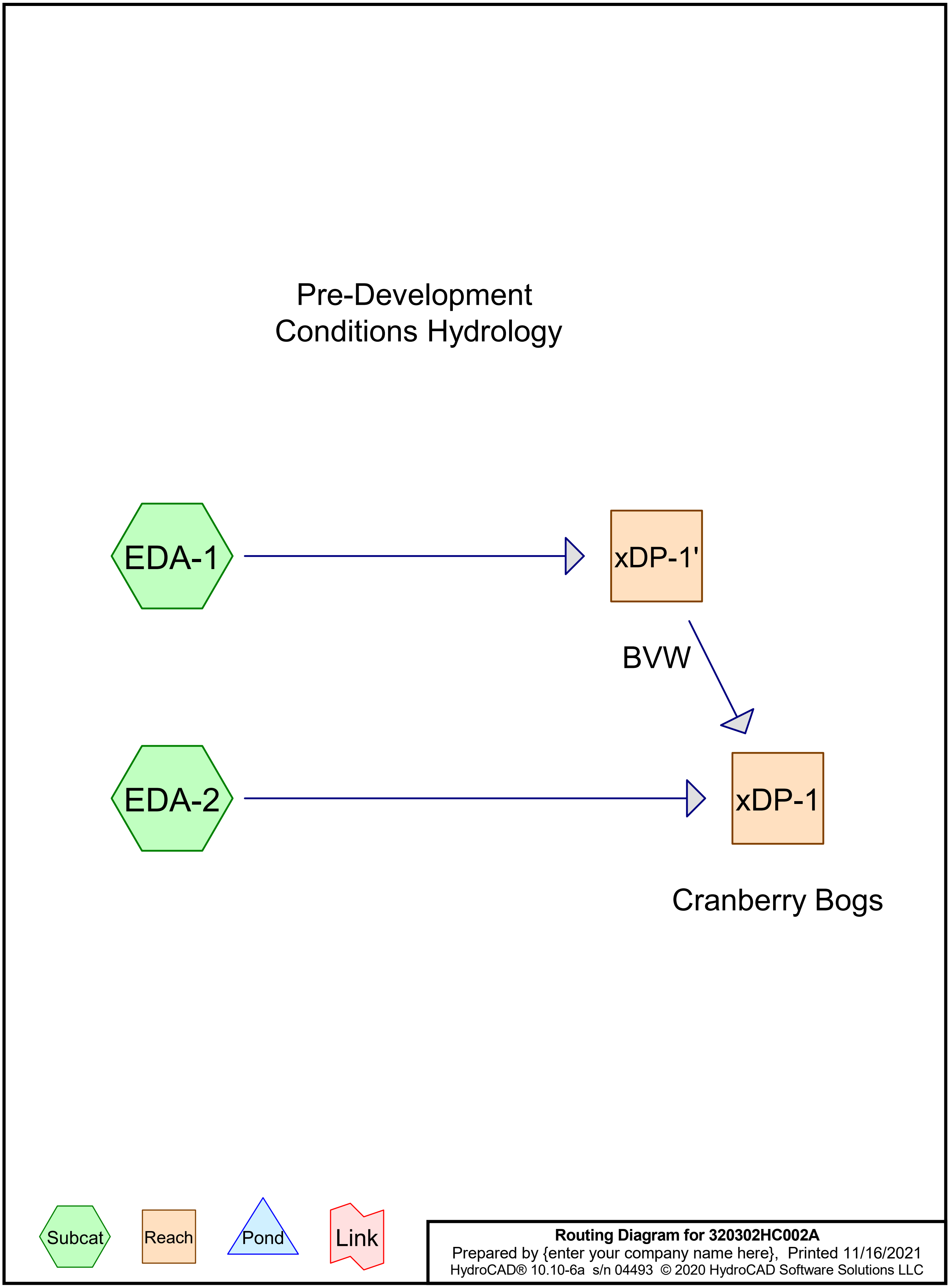
Brett Meredith

PO Box 359

Carver, Massachusetts

North Arrow

NORTH



Routing Diagram for 320302HC002A
Prepared by {enter your company name here}, Printed 11/16/2021

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	Plymouth-002yr	Type III 24-hr		Default	24.00	1	3.36	2
2	Plymouth-010yr	Type III 24-hr		Default	24.00	1	4.95	2
3	Plymouth-025yr	Type III 24-hr		Default	24.00	1	6.18	2
4	Plymouth-050yr	Type III 24-hr		Default	24.00	1	7.31	2
5	Plymouth-100yr	Type III 24-hr		Default	24.00	1	8.65	2

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.919	39	>75% Grass cover, Good, HSG A (EDA-1, EDA-2)
0.365	80	>75% Grass cover, Good, HSG D (EDA-2)
0.461	96	Gravel surface, HSG A (EDA-1, EDA-2)
0.595	96	Gravel surface, HSG D (EDA-2)
0.121	98	Impervious Area, HSG A (EDA-1, EDA-2)
0.042	98	Impervious Area, HSG D (EDA-2)
0.004	98	Roofs, HSG A (EDA-2)
0.134	98	Roofs, HSG D (EDA-2)
2.694	30	Woods, Good, HSG A (EDA-1, EDA-2)
0.025	77	Woods, Good, HSG D (EDA-2)
5.360	**52**	**TOTAL AREA**

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EDA-1: Runoff Area=0.576 ac 1.04% Impervious Runoff Depth=0.00"
Flow Length=158' Tc=14.4 min CN=34 Runoff=0.00 cfs 0.000 af

Subcatchment EDA-2: Runoff Area=4.784 ac 6.17% Impervious Runoff Depth>0.27"
Flow Length=342' Tc=12.5 min CN=54 Runoff=0.51 cfs 0.107 af

Reach xDP-1: Cranberry Bogs Inflow=0.51 cfs 0.107 af
Outflow=0.51 cfs 0.107 af

Reach xDP-1': BVW Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Total Runoff Area = 5.360 ac Runoff Volume = 0.107 af Average Runoff Depth = 0.24"
94.38% Pervious = 5.059 ac 5.62% Impervious = 0.301 ac

Summary for Subcatchment EDA-1:

[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"
Routed to Reach xDP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-002yr Rainfall=3.36"

	Area (ac)	CN	Description
	0.505	30	Woods, Good, HSG A
	0.043	39	>75% Grass cover, Good, HSG A
	0.022	96	Gravel surface, HSG A
*	0.006	98	Impervious Area, HSG A
	0.576	34	Weighted Average
	0.570		98.96% Pervious Area
	0.006		1.04% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	50	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	108	0.0830	1.44		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
14.4	158	Total			

Summary for Subcatchment EDA-2:

Runoff = 0.51 cfs @ 12.43 hrs, Volume= 0.107 af, Depth> 0.27"
Routed to Reach xDP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-002yr Rainfall=3.36"

	Area (ac)	CN	Description
	2.189	30	Woods, Good, HSG A
	0.025	77	Woods, Good, HSG D
	0.876	39	>75% Grass cover, Good, HSG A
	0.365	80	>75% Grass cover, Good, HSG D
	0.439	96	Gravel surface, HSG A
	0.595	96	Gravel surface, HSG D
*	0.115	98	Impervious Area, HSG A
*	0.042	98	Impervious Area, HSG D
	0.004	98	Roofs, HSG A
	0.134	98	Roofs, HSG D
	4.784	54	Weighted Average
	4.489		93.83% Pervious Area
	0.295		6.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach xDP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 5.62% Impervious, Inflow Depth > 0.24" for Plymouth-002yr event
Inflow = 0.51 cfs @ 12.43 hrs, Volume= 0.107 af
Outflow = 0.51 cfs @ 12.43 hrs, Volume= 0.107 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach xDP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.576 ac, 1.04% Impervious, Inflow Depth = 0.00" for Plymouth-002yr event
Inflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
Routed to Reach xDP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EDA-1: Runoff Area=0.576 ac 1.04% Impervious Runoff Depth>0.05"
Flow Length=158' Tc=14.4 min CN=34 Runoff=0.00 cfs 0.003 af

Subcatchment EDA-2: Runoff Area=4.784 ac 6.17% Impervious Runoff Depth>0.89"
Flow Length=342' Tc=12.5 min CN=54 Runoff=3.06 cfs 0.356 af

Reach xDP-1: Cranberry Bogs Inflow=3.06 cfs 0.358 af
Outflow=3.06 cfs 0.358 af

Reach xDP-1': BVW Inflow=0.00 cfs 0.003 af
Outflow=0.00 cfs 0.003 af

Total Runoff Area = 5.360 ac Runoff Volume = 0.358 af Average Runoff Depth = 0.80"
94.38% Pervious = 5.059 ac 5.62% Impervious = 0.301 ac

Summary for Subcatchment EDA-1:

Runoff = 0.00 cfs @ 15.70 hrs, Volume= 0.003 af, Depth> 0.05"
Routed to Reach xDP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-010yr Rainfall=4.95"

	Area (ac)	CN	Description
	0.505	30	Woods, Good, HSG A
	0.043	39	>75% Grass cover, Good, HSG A
	0.022	96	Gravel surface, HSG A
*	0.006	98	Impervious Area, HSG A
	0.576	34	Weighted Average
	0.570		98.96% Pervious Area
	0.006		1.04% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	50	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	108	0.0830	1.44		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
14.4	158	Total			

Summary for Subcatchment EDA-2:

Runoff = 3.06 cfs @ 12.22 hrs, Volume= 0.356 af, Depth> 0.89"
Routed to Reach xDP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-010yr Rainfall=4.95"

	Area (ac)	CN	Description
	2.189	30	Woods, Good, HSG A
	0.025	77	Woods, Good, HSG D
	0.876	39	>75% Grass cover, Good, HSG A
	0.365	80	>75% Grass cover, Good, HSG D
	0.439	96	Gravel surface, HSG A
	0.595	96	Gravel surface, HSG D
*	0.115	98	Impervious Area, HSG A
*	0.042	98	Impervious Area, HSG D
	0.004	98	Roofs, HSG A
	0.134	98	Roofs, HSG D
	4.784	54	Weighted Average
	4.489		93.83% Pervious Area
	0.295		6.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach xDP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 5.62% Impervious, Inflow Depth > 0.80" for Plymouth-010yr event
Inflow = 3.06 cfs @ 12.22 hrs, Volume= 0.358 af
Outflow = 3.06 cfs @ 12.22 hrs, Volume= 0.358 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach xDP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.576 ac, 1.04% Impervious, Inflow Depth > 0.05" for Plymouth-010yr event
Inflow = 0.00 cfs @ 15.70 hrs, Volume= 0.003 af
Outflow = 0.00 cfs @ 15.70 hrs, Volume= 0.003 af, Atten= 0%, Lag= 0.0 min
Routed to Reach xDP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EDA-1: Runoff Area=0.576 ac 1.04% Impervious Runoff Depth>0.24"
Flow Length=158' Tc=14.4 min CN=34 Runoff=0.02 cfs 0.012 af

Subcatchment EDA-2: Runoff Area=4.784 ac 6.17% Impervious Runoff Depth>1.54"
Flow Length=342' Tc=12.5 min CN=54 Runoff=6.08 cfs 0.613 af

Reach xDP-1: Cranberry Bogs Inflow=6.08 cfs 0.624 af
Outflow=6.08 cfs 0.624 af

Reach xDP-1': BVW Inflow=0.02 cfs 0.012 af
Outflow=0.02 cfs 0.012 af

Total Runoff Area = 5.360 ac Runoff Volume = 0.624 af Average Runoff Depth = 1.40"
94.38% Pervious = 5.059 ac 5.62% Impervious = 0.301 ac

Summary for Subcatchment EDA-1:

Runoff = 0.02 cfs @ 12.63 hrs, Volume= 0.012 af, Depth> 0.24"
Routed to Reach xDP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-025yr Rainfall=6.18"

	Area (ac)	CN	Description
	0.505	30	Woods, Good, HSG A
	0.043	39	>75% Grass cover, Good, HSG A
	0.022	96	Gravel surface, HSG A
*	0.006	98	Impervious Area, HSG A
	0.576	34	Weighted Average
	0.570		98.96% Pervious Area
	0.006		1.04% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	50	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	108	0.0830	1.44		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
14.4	158	Total			

Summary for Subcatchment EDA-2:

Runoff = 6.08 cfs @ 12.20 hrs, Volume= 0.613 af, Depth> 1.54"
Routed to Reach xDP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-025yr Rainfall=6.18"

	Area (ac)	CN	Description
	2.189	30	Woods, Good, HSG A
	0.025	77	Woods, Good, HSG D
	0.876	39	>75% Grass cover, Good, HSG A
	0.365	80	>75% Grass cover, Good, HSG D
	0.439	96	Gravel surface, HSG A
	0.595	96	Gravel surface, HSG D
*	0.115	98	Impervious Area, HSG A
*	0.042	98	Impervious Area, HSG D
	0.004	98	Roofs, HSG A
	0.134	98	Roofs, HSG D
	4.784	54	Weighted Average
	4.489		93.83% Pervious Area
	0.295		6.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach xDP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 5.62% Impervious, Inflow Depth > 1.40" for Plymouth-025yr event
Inflow = 6.08 cfs @ 12.20 hrs, Volume= 0.624 af
Outflow = 6.08 cfs @ 12.20 hrs, Volume= 0.624 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach xDP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.576 ac, 1.04% Impervious, Inflow Depth > 0.24" for Plymouth-025yr event
Inflow = 0.02 cfs @ 12.63 hrs, Volume= 0.012 af
Outflow = 0.02 cfs @ 12.63 hrs, Volume= 0.012 af, Atten= 0%, Lag= 0.0 min
Routed to Reach xDP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EDA-1: Runoff Area=0.576 ac 1.04% Impervious Runoff Depth>0.51"
Flow Length=158' Tc=14.4 min CN=34 Runoff=0.10 cfs 0.025 af

Subcatchment EDA-2: Runoff Area=4.784 ac 6.17% Impervious Runoff Depth>2.22"
Flow Length=342' Tc=12.5 min CN=54 Runoff=9.28 cfs 0.884 af

Reach xDP-1: Cranberry Bogs Inflow=9.30 cfs 0.909 af
Outflow=9.30 cfs 0.909 af

Reach xDP-1': BVW Inflow=0.10 cfs 0.025 af
Outflow=0.10 cfs 0.025 af

Total Runoff Area = 5.360 ac Runoff Volume = 0.909 af Average Runoff Depth = 2.03"
94.38% Pervious = 5.059 ac 5.62% Impervious = 0.301 ac

Summary for Subcatchment EDA-1:

Runoff = 0.10 cfs @ 12.49 hrs, Volume= 0.025 af, Depth> 0.51"
Routed to Reach xDP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-050yr Rainfall=7.31"

	Area (ac)	CN	Description
	0.505	30	Woods, Good, HSG A
	0.043	39	>75% Grass cover, Good, HSG A
	0.022	96	Gravel surface, HSG A
*	0.006	98	Impervious Area, HSG A
	0.576	34	Weighted Average
	0.570		98.96% Pervious Area
	0.006		1.04% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	50	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	108	0.0830	1.44		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
14.4	158	Total			

Summary for Subcatchment EDA-2:

Runoff = 9.28 cfs @ 12.19 hrs, Volume= 0.884 af, Depth> 2.22"
Routed to Reach xDP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-050yr Rainfall=7.31"

	Area (ac)	CN	Description
	2.189	30	Woods, Good, HSG A
	0.025	77	Woods, Good, HSG D
	0.876	39	>75% Grass cover, Good, HSG A
	0.365	80	>75% Grass cover, Good, HSG D
	0.439	96	Gravel surface, HSG A
	0.595	96	Gravel surface, HSG D
*	0.115	98	Impervious Area, HSG A
*	0.042	98	Impervious Area, HSG D
	0.004	98	Roofs, HSG A
	0.134	98	Roofs, HSG D
	4.784	54	Weighted Average
	4.489		93.83% Pervious Area
	0.295		6.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach xDP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 5.62% Impervious, Inflow Depth > 2.03" for Plymouth-050yr event
Inflow = 9.30 cfs @ 12.19 hrs, Volume= 0.909 af
Outflow = 9.30 cfs @ 12.19 hrs, Volume= 0.909 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach xDP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.576 ac, 1.04% Impervious, Inflow Depth > 0.51" for Plymouth-050yr event
Inflow = 0.10 cfs @ 12.49 hrs, Volume= 0.025 af
Outflow = 0.10 cfs @ 12.49 hrs, Volume= 0.025 af, Atten= 0%, Lag= 0.0 min
Routed to Reach xDP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EDA-1: Runoff Area=0.576 ac 1.04% Impervious Runoff Depth>0.93"
Flow Length=158' Tc=14.4 min CN=34 Runoff=0.26 cfs 0.045 af

Subcatchment EDA-2: Runoff Area=4.784 ac 6.17% Impervious Runoff Depth>3.11"
Flow Length=342' Tc=12.5 min CN=54 Runoff=13.46 cfs 1.240 af

Reach xDP-1: Cranberry Bogs Inflow=13.62 cfs 1.285 af
Outflow=13.62 cfs 1.285 af

Reach xDP-1': BVW Inflow=0.26 cfs 0.045 af
Outflow=0.26 cfs 0.045 af

Total Runoff Area = 5.360 ac Runoff Volume = 1.285 af Average Runoff Depth = 2.88"
94.38% Pervious = 5.059 ac 5.62% Impervious = 0.301 ac

Summary for Subcatchment EDA-1:

Runoff = 0.26 cfs @ 12.38 hrs, Volume= 0.045 af, Depth> 0.93"
Routed to Reach xDP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-100yr Rainfall=8.65"

	Area (ac)	CN	Description
	0.505	30	Woods, Good, HSG A
	0.043	39	>75% Grass cover, Good, HSG A
	0.022	96	Gravel surface, HSG A
*	0.006	98	Impervious Area, HSG A
	0.576	34	Weighted Average
	0.570		98.96% Pervious Area
	0.006		1.04% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	50	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	108	0.0830	1.44		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
14.4	158	Total			

Summary for Subcatchment EDA-2:

Runoff = 13.46 cfs @ 12.19 hrs, Volume= 1.240 af, Depth> 3.11"
Routed to Reach xDP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-100yr Rainfall=8.65"

	Area (ac)	CN	Description
	2.189	30	Woods, Good, HSG A
	0.025	77	Woods, Good, HSG D
	0.876	39	>75% Grass cover, Good, HSG A
	0.365	80	>75% Grass cover, Good, HSG D
	0.439	96	Gravel surface, HSG A
	0.595	96	Gravel surface, HSG D
*	0.115	98	Impervious Area, HSG A
*	0.042	98	Impervious Area, HSG D
	0.004	98	Roofs, HSG A
	0.134	98	Roofs, HSG D
	4.784	54	Weighted Average
	4.489		93.83% Pervious Area
	0.295		6.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach xDP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 5.62% Impervious, Inflow Depth > 2.88" for Plymouth-100yr event
Inflow = 13.62 cfs @ 12.19 hrs, Volume= 1.285 af
Outflow = 13.62 cfs @ 12.19 hrs, Volume= 1.285 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach xDP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.576 ac, 1.04% Impervious, Inflow Depth > 0.93" for Plymouth-100yr event
Inflow = 0.26 cfs @ 12.38 hrs, Volume= 0.045 af
Outflow = 0.26 cfs @ 12.38 hrs, Volume= 0.045 af, Atten= 0%, Lag= 0.0 min
Routed to Reach xDP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Attachment 3
Post-Development Hydrologic Analysis

POST-DEVELOPMENT CONDITIONS HYDROLOGY CALCULATION SUMMARY

OBJECTIVE

To determine the post-development peak rates of runoff from the site for the 2, 10, 25, 50, & 100-year storm events at the design point.

CONCLUSION(S)

Peak Runoff Rates (CFS):

Storm Event	2-Year	10-Year	25-Year	50-Year	100-Year
Design Point-1	0.05	1.93	4.30	7.07	10.93

CALCULATION METHODS

1. Runoff curve numbers (CN), time-of-concentration (Tc), and runoff rates were calculated based on TR-55 methodology.
2. AutoCAD 2019 computer program was utilized for digitizing ground cover areas.
3. Peak runoff rates were computed using HydroCAD version 10.10.

ASSUMPTIONS

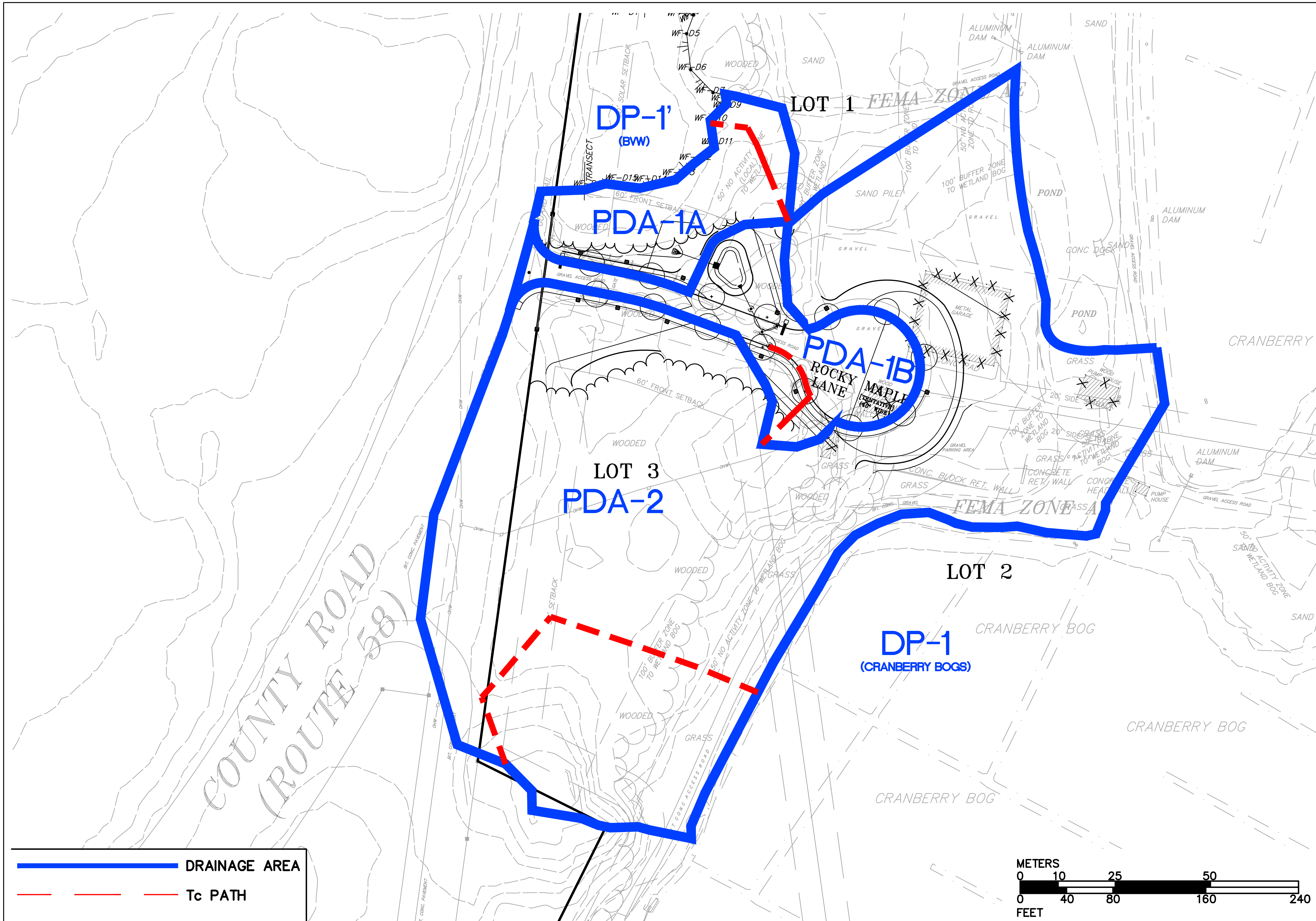
1. The ground cover types were determined using aerial imagery. Hydrologic soil groups based on United States Department of Agriculture, NRCS Soil Survey map information.
2. Stormwater runoff from offsite tributary areas was included in the calculations.
3. Wetlands were excluded for this calculation.

SOURCES OF DATA/ EQUATIONS

1. Post-Development Conditions Hydrologic Areas Map prepared by Beals and Thomas, Inc. File No. 320302P011A-002.
2. NRCS Soil Survey for Plymouth County, hydrologic soil group report, downloaded from Web Soil Survey on 06/03/2020.
3. TR-55 Urban Hydrology for Small Watershed, SCS, 1986.
4. Massachusetts DEP Stormwater Management Handbook, February 2008.

REV	CALC. BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
0	NBB	11/16/2021	MC	11/17/2021	MC	11/17/2021

NBB/320302CS002A



Post-Development Conditions Hydrologic Areas Map
Figure Number 002

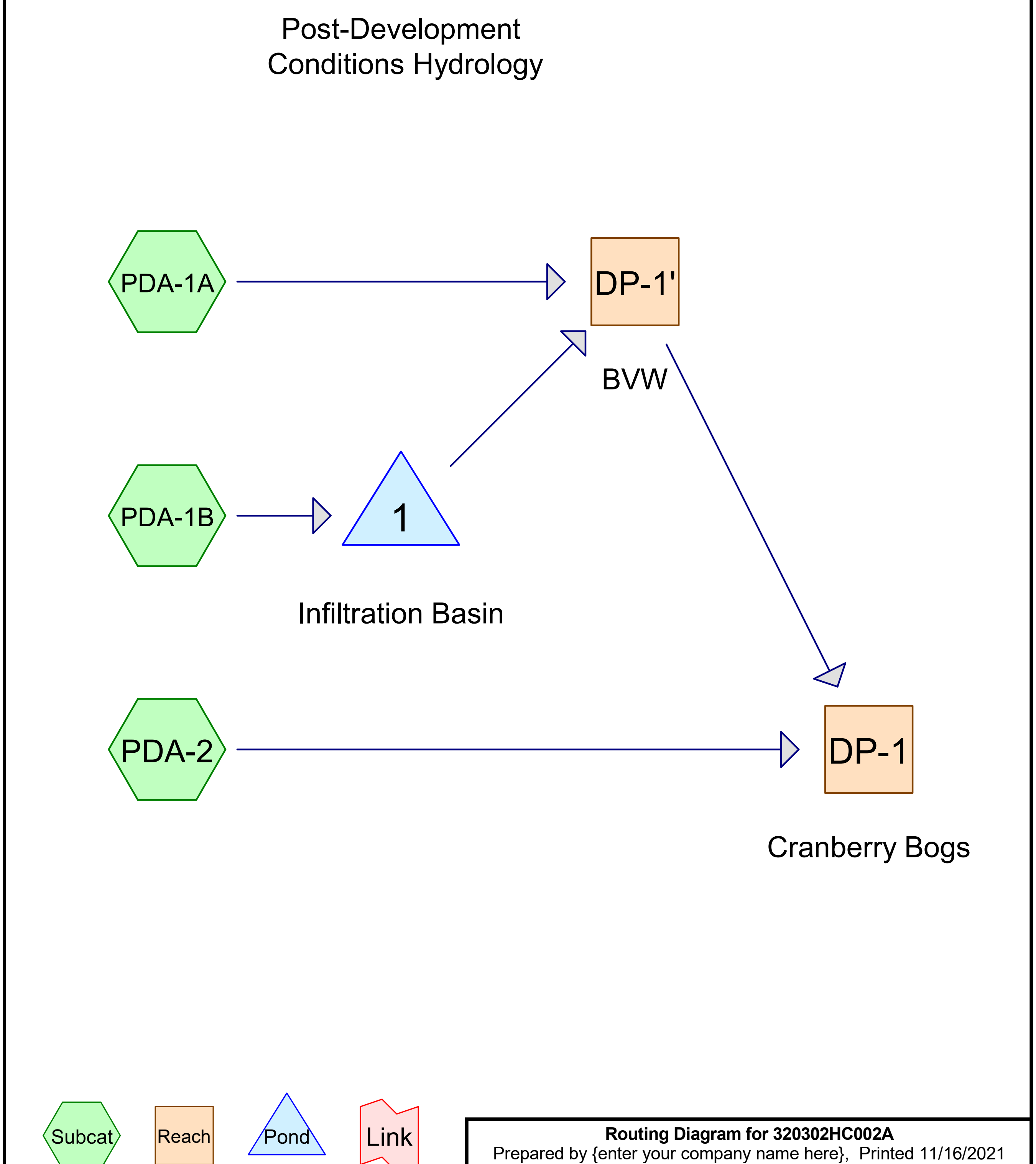
Scale: 1" = 80'
Date: 11/16/2021
Plan No. 320302P011A-002
B+T Project No. 3203.02

Definitive Subdivision Plan of Rocky Maple Lane
Wareham, Massachusetts

Brett Meredith
PO Box 359
Carver, Massachusetts

North Arrow
NORTH

BEALS+THOMAS



Routing Diagram for 320302HC002A
Prepared by {enter your company name here}, Printed 11/16/2021
HydroCAD® 10.10-6a s/n 04493 © 2020 HydroCAD Software Solutions LLC

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	Plymouth-002yr	Type III 24-hr		Default	24.00	1	3.36	2
2	Plymouth-010yr	Type III 24-hr		Default	24.00	1	4.95	2
3	Plymouth-025yr	Type III 24-hr		Default	24.00	1	6.18	2
4	Plymouth-050yr	Type III 24-hr		Default	24.00	1	7.31	2
5	Plymouth-100yr	Type III 24-hr		Default	24.00	1	8.65	2

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.686	39	>75% Grass cover, Good, HSG A (PDA-1A, PDA-1B, PDA-2)
1.021	80	>75% Grass cover, Good, HSG D (PDA-2)
0.049	98	Existing Impervious Area, HSG A (PDA-2)
0.240	98	Impervious Area, HSG A (PDA-1B, PDA-2)
0.128	98	Impervious Area, HSG D (PDA-1B, PDA-2)
2.222	30	Woods, Good, HSG A (PDA-1A, PDA-1B, PDA-2)
0.014	77	Woods, Good, HSG D (PDA-2)
5.360	**48**	**TOTAL AREA**

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PDA-1A: Runoff Area=0.429 ac 0.00% Impervious Runoff Depth=0.00"
Flow Length=120' Tc=9.5 min CN=32 Runoff=0.00 cfs 0.000 af

Subcatchment PDA-1B: Runoff Area=0.529 ac 63.14% Impervious Runoff Depth>1.26"
Flow Length=117' Tc=10.4 min CN=76 Runoff=0.65 cfs 0.056 af

Subcatchment PDA-2: Runoff Area=4.402 ac 1.89% Impervious Runoff Depth>0.08"
Flow Length=342' Tc=12.5 min CN=46 Runoff=0.05 cfs 0.029 af

Reach DP-1: Cranberry Bogs Inflow=0.05 cfs 0.029 af
Outflow=0.05 cfs 0.029 af

Reach DP-1': BVW Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Pond 1: Infiltration Basin Peak Elev=68.75' Storage=1,144 cf Inflow=0.65 cfs 0.056 af
Discarded=0.05 cfs 0.047 af Primary=0.00 cfs 0.000 af Outflow=0.06 cfs 0.047 af

Total Runoff Area = 5.360 ac Runoff Volume = 0.085 af Average Runoff Depth = 0.19"
92.22% Pervious = 4.943 ac 7.78% Impervious = 0.417 ac

Summary for Subcatchment PDA-1A:

[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"
Routed to Reach DP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-002yr Rainfall=3.36"

Area (ac)	CN	Description
0.352	30	Woods, Good, HSG A
0.077	39	>75% Grass cover, Good, HSG A
0.429	32	Weighted Average
0.429		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	50	0.0600	0.10		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.0	70	0.0570	1.19		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
9.5	120	Total			

Summary for Subcatchment PDA-1B:

Runoff = 0.65 cfs @ 12.16 hrs, Volume= 0.056 af, Depth> 1.26"
Routed to Pond 1 : Infiltration Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-002yr Rainfall=3.36"

	Area (ac)	CN	Description
	0.023	30	Woods, Good, HSG A
	0.172	39	>75% Grass cover, Good, HSG A
*	0.216	98	Impervious Area, HSG A
*	0.118	98	Impervious Area, HSG D
	0.529	76	Weighted Average
	0.195		36.86% Pervious Area
	0.334		63.14% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	30	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	20	0.2000	0.29		**Sheet Flow, Tc-2** Grass: Short n= 0.150 P2= 2.80"
0.0	5	0.0200	2.87		**Shallow Concentrated Flow, Tc-3** Paved Kv= 20.3 fps
0.1	3	0.0200	0.99		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.3	59	0.0200	2.87		**Shallow Concentrated Flow, Tc-5** Paved Kv= 20.3 fps
10.4	117	Total			

Summary for Subcatchment PDA-2:

Runoff = 0.05 cfs @ 14.84 hrs, Volume= 0.029 af, Depth> 0.08"
Routed to Reach DP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-002yr Rainfall=3.36"

	Area (ac)	CN	Description
	1.847	30	Woods, Good, HSG A
	0.014	77	Woods, Good, HSG D
	1.437	39	>75% Grass cover, Good, HSG A
	1.021	80	>75% Grass cover, Good, HSG D
*	0.024	98	Impervious Area, HSG A
*	0.049	98	Existing Impervious Area, HSG A
*	0.010	98	Impervious Area, HSG D
	4.402	46	Weighted Average
	4.319		98.11% Pervious Area
	0.083		1.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach DP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 7.78% Impervious, Inflow Depth > 0.07" for Plymouth-002yr event
Inflow = 0.05 cfs @ 14.18 hrs, Volume= 0.029 af
Outflow = 0.05 cfs @ 14.18 hrs, Volume= 0.029 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach DP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.958 ac, 34.86% Impervious, Inflow Depth = 0.00" for Plymouth-002yr event
Inflow = 0.00 cfs @ 14.17 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 14.17 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
Routed to Reach DP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Pond 1: Infiltration Basin

Inflow Area = 0.529 ac, 63.14% Impervious, Inflow Depth > 1.26" for Plymouth-002yr event
Inflow = 0.65 cfs @ 12.16 hrs, Volume= 0.056 af
Outflow = 0.06 cfs @ 14.17 hrs, Volume= 0.047 af, Atten= 91%, Lag= 121.0 min
Discarded = 0.05 cfs @ 14.17 hrs, Volume= 0.047 af
Primary = 0.00 cfs @ 14.17 hrs, Volume= 0.000 af
Routed to Reach DP-1' : BVW

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 68.75' @ 14.17 hrs Surf.Area= 935 sf Storage= 1,144 cf

Plug-Flow detention time= 255.9 min calculated for 0.047 af (84% of inflow)
Center-of-Mass det. time= 187.8 min (1,043.3 - 855.5)

Volume	Invert	Avail.Storage	Storage Description
#1	67.00'	2,584 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
67.00	409	0	0
68.00	673	541	541
70.00	1,370	2,043	2,584

Device	Routing	Invert	Outlet Devices
#1	Discarded	67.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	67.00'	**12.0" Round Culvert** L= 33.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 67.00' / 66.70' S= 0.0091 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf

#3	Device 2	68.75'	**48.0" x 48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.05 cfs @ 14.17 hrs HW=68.75' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=0.00 cfs @ 14.17 hrs HW=68.75' (Free Discharge)
└─**2=Culvert** (Passes 0.00 cfs of 3.34 cfs potential flow)
  └─**3=Orifice/Grate** (Weir Controls 0.00 cfs @ 0.08 fps)

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PDA-1A: Runoff Area=0.429 ac 0.00% Impervious Runoff Depth>0.02"
Flow Length=120' Tc=9.5 min CN=32 Runoff=0.00 cfs 0.001 af

Subcatchment PDA-1B: Runoff Area=0.529 ac 63.14% Impervious Runoff Depth>2.49"
Flow Length=117' Tc=10.4 min CN=76 Runoff=1.32 cfs 0.110 af

Subcatchment PDA-2: Runoff Area=4.402 ac 1.89% Impervious Runoff Depth>0.47"
Flow Length=342' Tc=12.5 min CN=46 Runoff=0.92 cfs 0.172 af

Reach DP-1: Cranberry Bogs Inflow=1.93 cfs 0.214 af
Outflow=1.93 cfs 0.214 af

Reach DP-1': BVW Inflow=1.13 cfs 0.042 af
Outflow=1.13 cfs 0.042 af

Pond 1: Infiltration Basin Peak Elev=68.83' Storage=1,217 cf Inflow=1.32 cfs 0.110 af
Discarded=0.05 cfs 0.054 af Primary=1.13 cfs 0.041 af Outflow=1.18 cfs 0.095 af

Total Runoff Area = 5.360 ac Runoff Volume = 0.283 af Average Runoff Depth = 0.63"
92.22% Pervious = 4.943 ac 7.78% Impervious = 0.417 ac

Summary for Subcatchment PDA-1A:

Runoff = 0.00 cfs @ 21.40 hrs, Volume= 0.001 af, Depth> 0.02"
Routed to Reach DP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-010yr Rainfall=4.95"

Area (ac)	CN	Description
0.352	30	Woods, Good, HSG A
0.077	39	>75% Grass cover, Good, HSG A
0.429	32	Weighted Average
0.429		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	50	0.0600	0.10		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.0	70	0.0570	1.19		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
9.5	120	Total			

Summary for Subcatchment PDA-1B:

Runoff = 1.32 cfs @ 12.15 hrs, Volume= 0.110 af, Depth> 2.49"
Routed to Pond 1 : Infiltration Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-010yr Rainfall=4.95"

	Area (ac)	CN	Description
	0.023	30	Woods, Good, HSG A
	0.172	39	>75% Grass cover, Good, HSG A
*	0.216	98	Impervious Area, HSG A
*	0.118	98	Impervious Area, HSG D
	0.529	76	Weighted Average
	0.195		36.86% Pervious Area
	0.334		63.14% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	30	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	20	0.2000	0.29		**Sheet Flow, Tc-2** Grass: Short n= 0.150 P2= 2.80"
0.0	5	0.0200	2.87		**Shallow Concentrated Flow, Tc-3** Paved Kv= 20.3 fps
0.1	3	0.0200	0.99		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.3	59	0.0200	2.87		**Shallow Concentrated Flow, Tc-5** Paved Kv= 20.3 fps
10.4	117	Total			

Summary for Subcatchment PDA-2:

Runoff = 0.92 cfs @ 12.39 hrs, Volume= 0.172 af, Depth> 0.47"
Routed to Reach DP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-010yr Rainfall=4.95"

	Area (ac)	CN	Description
	1.847	30	Woods, Good, HSG A
	0.014	77	Woods, Good, HSG D
	1.437	39	>75% Grass cover, Good, HSG A
	1.021	80	>75% Grass cover, Good, HSG D
*	0.024	98	Impervious Area, HSG A
*	0.049	98	Existing Impervious Area, HSG A
*	0.010	98	Impervious Area, HSG D
	4.402	46	Weighted Average
	4.319		98.11% Pervious Area
	0.083		1.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach DP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 7.78% Impervious, Inflow Depth > 0.48" for Plymouth-010yr event
Inflow = 1.93 cfs @ 12.26 hrs, Volume= 0.214 af
Outflow = 1.93 cfs @ 12.26 hrs, Volume= 0.214 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach DP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.958 ac, 34.86% Impervious, Inflow Depth > 0.52" for Plymouth-010yr event
Inflow = 1.13 cfs @ 12.25 hrs, Volume= 0.042 af
Outflow = 1.13 cfs @ 12.25 hrs, Volume= 0.042 af, Atten= 0%, Lag= 0.0 min
Routed to Reach DP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Pond 1: Infiltration Basin

Inflow Area = 0.529 ac, 63.14% Impervious, Inflow Depth > 2.49" for Plymouth-010yr event
Inflow = 1.32 cfs @ 12.15 hrs, Volume= 0.110 af
Outflow = 1.18 cfs @ 12.25 hrs, Volume= 0.095 af, Atten= 11%, Lag= 5.9 min
Discarded = 0.05 cfs @ 12.25 hrs, Volume= 0.054 af
Primary = 1.13 cfs @ 12.25 hrs, Volume= 0.041 af
Routed to Reach DP-1' : BVW

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 68.83' @ 12.25 hrs Surf.Area= 961 sf Storage= 1,217 cf

Plug-Flow detention time= 143.7 min calculated for 0.094 af (86% of inflow)
Center-of-Mass det. time= 83.2 min (918.9 - 835.7)

Volume	Invert	Avail.Storage	Storage Description
#1	67.00'	2,584 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
67.00	409	0	0
68.00	673	541	541
70.00	1,370	2,043	2,584

Device	Routing	Invert	Outlet Devices
#1	Discarded	67.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	67.00'	**12.0" Round Culvert** L= 33.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 67.00' / 66.70' S= 0.0091 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf

#3	Device 2	68.75'	**48.0" x 48.0" Horiz. Orifice/Grate** Limited to weir flow at low heads	C= 0.600

Discarded OutFlow Max=0.05 cfs @ 12.25 hrs HW=68.83' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=1.12 cfs @ 12.25 hrs HW=68.83' (Free Discharge)
└─**2=Culvert** (Passes 1.12 cfs of 3.44 cfs potential flow)
  └─**3=Orifice/Grate** (Weir Controls 1.12 cfs @ 0.91 fps)

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PDA-1A: Runoff Area=0.429 ac 0.00% Impervious Runoff Depth>0.16"
Flow Length=120' Tc=9.5 min CN=32 Runoff=0.01 cfs 0.006 af

Subcatchment PDA-1B: Runoff Area=0.529 ac 63.14% Impervious Runoff Depth>3.53"
Flow Length=117' Tc=10.4 min CN=76 Runoff=1.87 cfs 0.156 af

Subcatchment PDA-2: Runoff Area=4.402 ac 1.89% Impervious Runoff Depth>0.94"
Flow Length=342' Tc=12.5 min CN=46 Runoff=2.62 cfs 0.345 af

Reach DP-1: Cranberry Bogs Inflow=4.30 cfs 0.429 af
Outflow=4.30 cfs 0.429 af

Reach DP-1': BVW Inflow=1.76 cfs 0.085 af
Outflow=1.76 cfs 0.085 af

Pond 1: Infiltration Basin Peak Elev=68.85' Storage=1,243 cf Inflow=1.87 cfs 0.156 af
Discarded=0.05 cfs 0.058 af Primary=1.76 cfs 0.079 af Outflow=1.81 cfs 0.137 af

Total Runoff Area = 5.360 ac Runoff Volume = 0.506 af Average Runoff Depth = 1.13"
92.22% Pervious = 4.943 ac 7.78% Impervious = 0.417 ac

Summary for Subcatchment PDA-1A:

Runoff = 0.01 cfs @ 14.70 hrs, Volume= 0.006 af, Depth> 0.16"
Routed to Reach DP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-025yr Rainfall=6.18"

Area (ac)	CN	Description
0.352	30	Woods, Good, HSG A
0.077	39	>75% Grass cover, Good, HSG A
0.429	32	Weighted Average
0.429		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	50	0.0600	0.10		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.0	70	0.0570	1.19		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
9.5	120	Total			

Summary for Subcatchment PDA-1B:

Runoff = 1.87 cfs @ 12.15 hrs, Volume= 0.156 af, Depth> 3.53"
Routed to Pond 1 : Infiltration Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-025yr Rainfall=6.18"

	Area (ac)	CN	Description
	0.023	30	Woods, Good, HSG A
	0.172	39	>75% Grass cover, Good, HSG A
*	0.216	98	Impervious Area, HSG A
*	0.118	98	Impervious Area, HSG D
	0.529	76	Weighted Average
	0.195		36.86% Pervious Area
	0.334		63.14% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	30	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	20	0.2000	0.29		**Sheet Flow, Tc-2** Grass: Short n= 0.150 P2= 2.80"
0.0	5	0.0200	2.87		**Shallow Concentrated Flow, Tc-3** Paved Kv= 20.3 fps
0.1	3	0.0200	0.99		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.3	59	0.0200	2.87		**Shallow Concentrated Flow, Tc-5** Paved Kv= 20.3 fps
10.4	117	Total			

Summary for Subcatchment PDA-2:

Runoff = 2.62 cfs @ 12.24 hrs, Volume= 0.345 af, Depth> 0.94"
Routed to Reach DP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-025yr Rainfall=6.18"

	Area (ac)	CN	Description
	1.847	30	Woods, Good, HSG A
	0.014	77	Woods, Good, HSG D
	1.437	39	>75% Grass cover, Good, HSG A
	1.021	80	>75% Grass cover, Good, HSG D
*	0.024	98	Impervious Area, HSG A
*	0.049	98	Existing Impervious Area, HSG A
*	0.010	98	Impervious Area, HSG D
	4.402	46	Weighted Average
	4.319		98.11% Pervious Area
	0.083		1.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach DP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 7.78% Impervious, Inflow Depth > 0.96" for Plymouth-025yr event
Inflow = 4.30 cfs @ 12.20 hrs, Volume= 0.429 af
Outflow = 4.30 cfs @ 12.20 hrs, Volume= 0.429 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach DP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.958 ac, 34.86% Impervious, Inflow Depth > 1.06" for Plymouth-025yr event
Inflow = 1.76 cfs @ 12.16 hrs, Volume= 0.085 af
Outflow = 1.76 cfs @ 12.16 hrs, Volume= 0.085 af, Atten= 0%, Lag= 0.0 min
Routed to Reach DP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Pond 1: Infiltration Basin

Inflow Area = 0.529 ac, 63.14% Impervious, Inflow Depth > 3.53" for Plymouth-025yr event
Inflow = 1.87 cfs @ 12.15 hrs, Volume= 0.156 af
Outflow = 1.81 cfs @ 12.16 hrs, Volume= 0.137 af, Atten= 3%, Lag= 0.5 min
Discarded = 0.05 cfs @ 12.16 hrs, Volume= 0.058 af
Primary = 1.76 cfs @ 12.16 hrs, Volume= 0.079 af
Routed to Reach DP-1' : BVW

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 68.85' @ 12.16 hrs Surf.Area= 971 sf Storage= 1,243 cf

Plug-Flow detention time= 105.5 min calculated for 0.136 af (88% of inflow)
Center-of-Mass det. time= 50.4 min (876.1 - 825.7)

Volume	Invert	Avail.Storage	Storage Description
#1	67.00'	2,584 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
67.00	409	0	0
68.00	673	541	541
70.00	1,370	2,043	2,584

Device	Routing	Invert	Outlet Devices
#1	Discarded	67.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	67.00'	**12.0" Round Culvert** L= 33.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 67.00' / 66.70' S= 0.0091 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf

#3	Device 2	68.75'	**48.0" x 48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.05 cfs @ 12.16 hrs HW=68.85' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=1.74 cfs @ 12.16 hrs HW=68.85' (Free Discharge)
└─**2=Culvert** (Passes 1.74 cfs of 3.47 cfs potential flow)
  └─**3=Orifice/Grate** (Weir Controls 1.74 cfs @ 1.05 fps)

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PDA-1A: Runoff Area=0.429 ac 0.00% Impervious Runoff Depth>0.38"
Flow Length=120' Tc=9.5 min CN=32 Runoff=0.05 cfs 0.014 af

Subcatchment PDA-1B: Runoff Area=0.529 ac 63.14% Impervious Runoff Depth>4.53"
Flow Length=117' Tc=10.4 min CN=76 Runoff=2.40 cfs 0.200 af

Subcatchment PDA-2: Runoff Area=4.402 ac 1.89% Impervious Runoff Depth>1.47"
Flow Length=342' Tc=12.5 min CN=46 Runoff=4.91 cfs 0.539 af

Reach DP-1: Cranberry Bogs Inflow=7.07 cfs 0.670 af
Outflow=7.07 cfs 0.670 af

Reach DP-1': BVW Inflow=2.34 cfs 0.131 af
Outflow=2.34 cfs 0.131 af

Pond 1: Infiltration Basin Peak Elev=68.88' Storage=1,264 cf Inflow=2.40 cfs 0.200 af
Discarded=0.05 cfs 0.061 af Primary=2.34 cfs 0.117 af Outflow=2.39 cfs 0.178 af

Total Runoff Area = 5.360 ac Runoff Volume = 0.752 af Average Runoff Depth = 1.68"
92.22% Pervious = 4.943 ac 7.78% Impervious = 0.417 ac

Summary for Subcatchment PDA-1A:

Runoff = 0.05 cfs @ 12.47 hrs, Volume= 0.014 af, Depth> 0.38"
Routed to Reach DP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-050yr Rainfall=7.31"

Area (ac)	CN	Description
0.352	30	Woods, Good, HSG A
0.077	39	>75% Grass cover, Good, HSG A
0.429	32	Weighted Average
0.429		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	50	0.0600	0.10		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.0	70	0.0570	1.19		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
9.5	120	Total			

Summary for Subcatchment PDA-1B:

Runoff = 2.40 cfs @ 12.15 hrs, Volume= 0.200 af, Depth> 4.53"
Routed to Pond 1 : Infiltration Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-050yr Rainfall=7.31"

	Area (ac)	CN	Description
	0.023	30	Woods, Good, HSG A
	0.172	39	>75% Grass cover, Good, HSG A
*	0.216	98	Impervious Area, HSG A
*	0.118	98	Impervious Area, HSG D
	0.529	76	Weighted Average
	0.195		36.86% Pervious Area
	0.334		63.14% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	30	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	20	0.2000	0.29		**Sheet Flow, Tc-2** Grass: Short n= 0.150 P2= 2.80"
0.0	5	0.0200	2.87		**Shallow Concentrated Flow, Tc-3** Paved Kv= 20.3 fps
0.1	3	0.0200	0.99		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.3	59	0.0200	2.87		**Shallow Concentrated Flow, Tc-5** Paved Kv= 20.3 fps
10.4	117	Total			

Summary for Subcatchment PDA-2:

Runoff = 4.91 cfs @ 12.21 hrs, Volume= 0.539 af, Depth> 1.47"
Routed to Reach DP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-050yr Rainfall=7.31"

	Area (ac)	CN	Description
	1.847	30	Woods, Good, HSG A
	0.014	77	Woods, Good, HSG D
	1.437	39	>75% Grass cover, Good, HSG A
	1.021	80	>75% Grass cover, Good, HSG D
*	0.024	98	Impervious Area, HSG A
*	0.049	98	Existing Impervious Area, HSG A
*	0.010	98	Impervious Area, HSG D
	4.402	46	Weighted Average
	4.319		98.11% Pervious Area
	0.083		1.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach DP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 7.78% Impervious, Inflow Depth > 1.50" for Plymouth-050yr event
Inflow = 7.07 cfs @ 12.19 hrs, Volume= 0.670 af
Outflow = 7.07 cfs @ 12.19 hrs, Volume= 0.670 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach DP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.958 ac, 34.86% Impervious, Inflow Depth > 1.64" for Plymouth-050yr event
Inflow = 2.34 cfs @ 12.16 hrs, Volume= 0.131 af
Outflow = 2.34 cfs @ 12.16 hrs, Volume= 0.131 af, Atten= 0%, Lag= 0.0 min
Routed to Reach DP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Pond 1: Infiltration Basin

Inflow Area = 0.529 ac, 63.14% Impervious, Inflow Depth > 4.53" for Plymouth-050yr event
Inflow = 2.40 cfs @ 12.15 hrs, Volume= 0.200 af
Outflow = 2.39 cfs @ 12.16 hrs, Volume= 0.178 af, Atten= 0%, Lag= 0.6 min
Discarded = 0.05 cfs @ 12.16 hrs, Volume= 0.061 af
Primary = 2.34 cfs @ 12.16 hrs, Volume= 0.117 af
Routed to Reach DP-1' : BVW

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 68.88' @ 12.16 hrs Surf.Area= 978 sf Storage= 1,264 cf

Plug-Flow detention time= 85.3 min calculated for 0.177 af (89% of inflow)
Center-of-Mass det. time= 34.4 min (853.0 - 818.6)

Volume	Invert	Avail.Storage	Storage Description
#1	67.00'	2,584 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
67.00	409	0	0
68.00	673	541	541
70.00	1,370	2,043	2,584

Device	Routing	Invert	Outlet Devices
#1	Discarded	67.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	67.00'	**12.0" Round Culvert** L= 33.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 67.00' / 66.70' S= 0.0091 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf

#3	Device 2	68.75'	**48.0" x 48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.05 cfs @ 12.16 hrs HW=68.87' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=2.29 cfs @ 12.16 hrs HW=68.87' (Free Discharge)
└─**2=Culvert** (Passes 2.29 cfs of 3.50 cfs potential flow)
  └─**3=Orifice/Grate** (Weir Controls 2.29 cfs @ 1.15 fps)

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PDA-1A: Runoff Area=0.429 ac 0.00% Impervious Runoff Depth>0.75"
Flow Length=120' Tc=9.5 min CN=32 Runoff=0.14 cfs 0.027 af

Subcatchment PDA-1B: Runoff Area=0.529 ac 63.14% Impervious Runoff Depth>5.74"
Flow Length=117' Tc=10.4 min CN=76 Runoff=3.02 cfs 0.253 af

Subcatchment PDA-2: Runoff Area=4.402 ac 1.89% Impervious Runoff Depth>2.19"
Flow Length=342' Tc=12.5 min CN=46 Runoff=8.04 cfs 0.805 af

Reach DP-1: Cranberry Bogs Inflow=10.93 cfs 0.997 af
Outflow=10.93 cfs 0.997 af

Reach DP-1': BVW Inflow=3.04 cfs 0.192 af
Outflow=3.04 cfs 0.192 af

Pond 1: Infiltration Basin Peak Elev=68.90' Storage=1,286 cf Inflow=3.02 cfs 0.253 af
Discarded=0.06 cfs 0.063 af Primary=2.96 cfs 0.165 af Outflow=3.02 cfs 0.229 af

Total Runoff Area = 5.360 ac Runoff Volume = 1.085 af Average Runoff Depth = 2.43"
92.22% Pervious = 4.943 ac 7.78% Impervious = 0.417 ac

Summary for Subcatchment PDA-1A:

Runoff = 0.14 cfs @ 12.36 hrs, Volume= 0.027 af, Depth> 0.75"
Routed to Reach DP-1' : BVW

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-100yr Rainfall=8.65"

Area (ac)	CN	Description
0.352	30	Woods, Good, HSG A
0.077	39	>75% Grass cover, Good, HSG A
0.429	32	Weighted Average
0.429		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	50	0.0600	0.10		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.0	70	0.0570	1.19		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
9.5	120	Total			

Summary for Subcatchment PDA-1B:

Runoff = 3.02 cfs @ 12.15 hrs, Volume= 0.253 af, Depth> 5.74"
Routed to Pond 1 : Infiltration Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-100yr Rainfall=8.65"

	Area (ac)	CN	Description
	0.023	30	Woods, Good, HSG A
	0.172	39	>75% Grass cover, Good, HSG A
*	0.216	98	Impervious Area, HSG A
*	0.118	98	Impervious Area, HSG D
	0.529	76	Weighted Average
	0.195		36.86% Pervious Area
	0.334		63.14% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	30	0.0200	0.06		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
1.2	20	0.2000	0.29		**Sheet Flow, Tc-2** Grass: Short n= 0.150 P2= 2.80"
0.0	5	0.0200	2.87		**Shallow Concentrated Flow, Tc-3** Paved Kv= 20.3 fps
0.1	3	0.0200	0.99		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.3	59	0.0200	2.87		**Shallow Concentrated Flow, Tc-5** Paved Kv= 20.3 fps
10.4	117	Total			

Summary for Subcatchment PDA-2:

Runoff = 8.04 cfs @ 12.20 hrs, Volume= 0.805 af, Depth> 2.19"
Routed to Reach DP-1 : Cranberry Bogs

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr Plymouth-100yr Rainfall=8.65"

	Area (ac)	CN	Description
	1.847	30	Woods, Good, HSG A
	0.014	77	Woods, Good, HSG D
	1.437	39	>75% Grass cover, Good, HSG A
	1.021	80	>75% Grass cover, Good, HSG D
*	0.024	98	Impervious Area, HSG A
*	0.049	98	Existing Impervious Area, HSG A
*	0.010	98	Impervious Area, HSG D
	4.402	46	Weighted Average
	4.319		98.11% Pervious Area
	0.083		1.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.1000	0.12		**Sheet Flow, Tc-1** Woods: Light underbrush n= 0.400 P2= 2.80"
0.3	32	0.0940	1.53		**Shallow Concentrated Flow, Tc-2** Woodland Kv= 5.0 fps
4.6	180	0.0170	0.65		**Shallow Concentrated Flow, Tc-3** Woodland Kv= 5.0 fps
0.5	56	0.0710	1.87		**Shallow Concentrated Flow, Tc-4** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0200	2.28		**Shallow Concentrated Flow, Tc-5** Unpaved Kv= 16.1 fps
0.1	14	0.1430	2.65		**Shallow Concentrated Flow, Tc-6** Short Grass Pasture Kv= 7.0 fps
12.5	342	Total			

Summary for Reach DP-1: Cranberry Bogs

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.360 ac, 7.78% Impervious, Inflow Depth > 2.23" for Plymouth-100yr event
Inflow = 10.93 cfs @ 12.19 hrs, Volume= 0.997 af
Outflow = 10.93 cfs @ 12.19 hrs, Volume= 0.997 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Reach DP-1': BVW

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.958 ac, 34.86% Impervious, Inflow Depth > 2.41" for Plymouth-100yr event
Inflow = 3.04 cfs @ 12.16 hrs, Volume= 0.192 af
Outflow = 3.04 cfs @ 12.16 hrs, Volume= 0.192 af, Atten= 0%, Lag= 0.0 min
Routed to Reach DP-1 : Cranberry Bogs

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Pond 1: Infiltration Basin

Inflow Area = 0.529 ac, 63.14% Impervious, Inflow Depth > 5.74" for Plymouth-100yr event
Inflow = 3.02 cfs @ 12.15 hrs, Volume= 0.253 af
Outflow = 3.02 cfs @ 12.16 hrs, Volume= 0.229 af, Atten= 0%, Lag= 0.6 min
Discarded = 0.06 cfs @ 12.16 hrs, Volume= 0.063 af
Primary = 2.96 cfs @ 12.16 hrs, Volume= 0.165 af
Routed to Reach DP-1' : BVW

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 68.90' @ 12.16 hrs Surf.Area= 986 sf Storage= 1,286 cf

Plug-Flow detention time= 70.2 min calculated for 0.228 af (90% of inflow)
Center-of-Mass det. time= 24.1 min (836.0 - 811.9)

Volume	Invert	Avail.Storage	Storage Description
#1	67.00'	2,584 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
67.00	409	0	0
68.00	673	541	541
70.00	1,370	2,043	2,584

Device	Routing	Invert	Outlet Devices
#1	Discarded	67.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	67.00'	**12.0" Round Culvert** L= 33.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 67.00' / 66.70' S= 0.0091 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf

#3	Device 2	68.75'	**48.0" x 48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.05 cfs @ 12.16 hrs HW=68.90' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=2.95 cfs @ 12.16 hrs HW=68.90' (Free Discharge)
└─**2=Culvert** (Passes 2.95 cfs of 3.53 cfs potential flow)
  └─**3=Orifice/Grate** (Weir Controls 2.95 cfs @ 1.25 fps)

Attachment 4
Hydraulic Calculations

HYDRAULIC CALCULATIONS

OBJECTIVE

To size pipes to adequately convey flows from the proposed project and to meet the design standards of the Massachusetts DEP Stormwater Handbook for inlet capacity, pipe flow, and scour.

CONCLUSION

- The proposed pipes will adequately convey the 50-year storm event runoff rates.
- The proposed stormwater management design has been reviewed for compliance with the stormwater management standards described in the Massachusetts DEP Stormwater Management Handbook.

CALCULATION METHODS

- The pipes are designed using the Rational Formula, based on a 50-year storm event for the Town of Barnstable (see attached IDF curve).

ASSUMPTIONS

- Runoff coefficient C=0.3 for pervious areas and C=0.9 for impervious areas.
- Manning's n=0.012 for HDPE pipe.
- The times of concentration (T_C) for contributing subcatchments are approximately 5 minutes for flows to CB-1 and 9 minutes for flows to CB-2.
- The minimum full-flow (scour) velocity is 2 feet per second.
- The maximum full-flow (scour) velocity is 10 feet per second.

SOURCES OF DATA/ EQUATIONS

1. Rational Method (Q=CiA) was used to calculate peak runoff rates tributary to CB-1 and CB-2.
2. Manning's Equation was used to determine pipe capacities.
3. 50-year storm intensity obtained from the Intensity/Duration rainfall curve for Barnstable, MA in S.C.S Technical Report No. 40.
4. Massachusetts DEP Stormwater Management Handbook, February 2008.

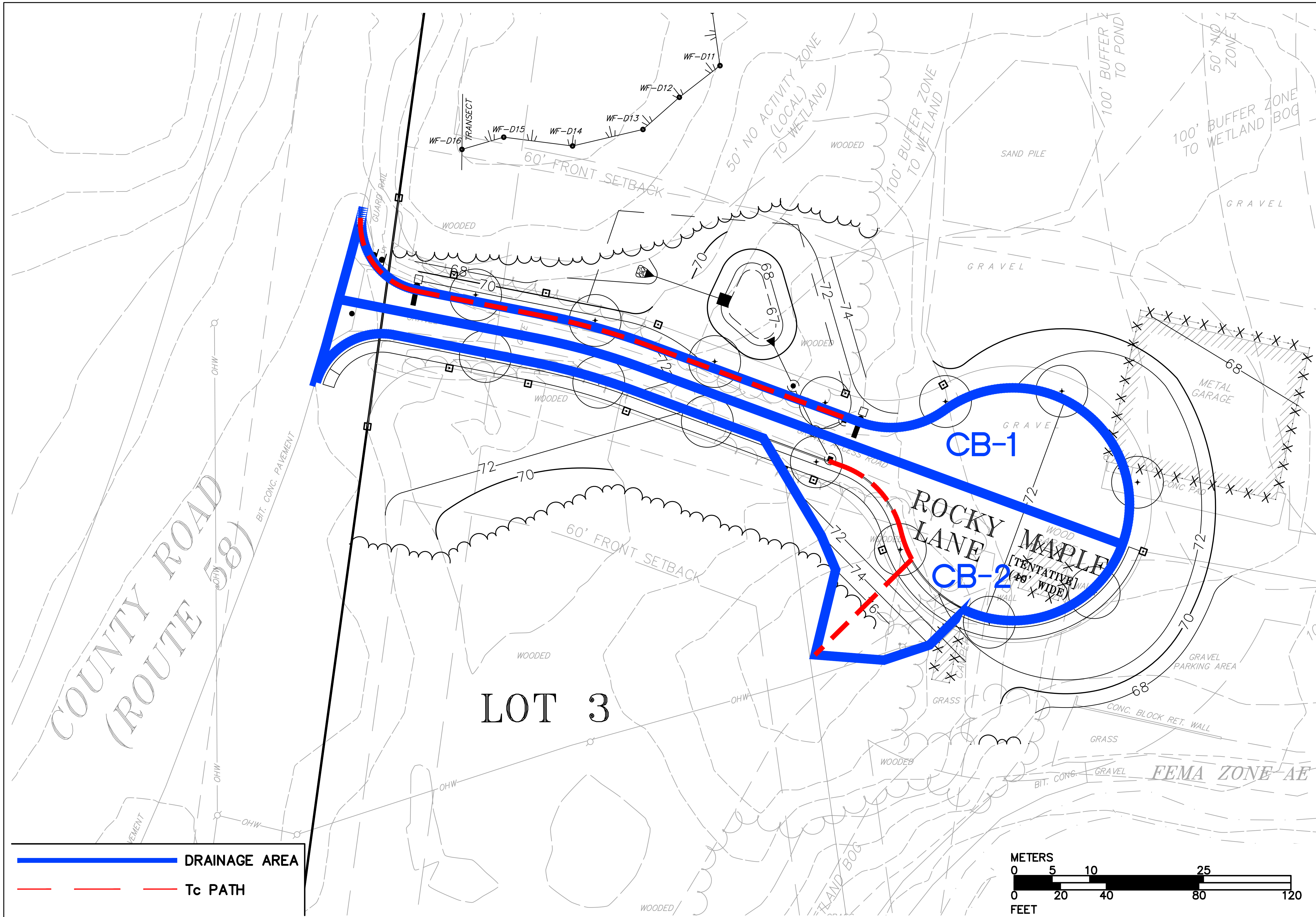
REV	CALC. BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
0	NBB	11/16/2021	MC	11/17/2021	MC	11/17/2021

NBB/320302CS003A

Corporate Office
144 Turnpike Road
Southborough, MA 01772

T 508.366.0560 | www.bealsandthomas.com | F 508.366.4391

Regional Office
32 Court Street
Plymouth, MA 02360



Proposed Hydraulic Areas Map

Figure Number 003

Scale: 1" = 40'

Date: 11/16/2021

Plan No. 320302P011A-003

B+T Project No. 3203.02

Definitive Subdivision Plan of Rocky Maple Lane

Wareham, Massachusetts

Brett Meredith

PO Box 359

Carver, Massachusetts

North Arrow

NORTH

DA- CB-1

	AREA	C
PAVED	0.161	0.9
GRASSED	0	0.3

Tc=	6	MIN
TOTAL AREA=	0.161	ACRES
WEIGHTED C=	0.90	

DA- CB-2

	AREA	C
PAVED	0.172	0.9
GRASSED	0.069	0.3

Tc=	9	MIN
TOTAL AREA=	0.241	ACRES
WEIGHTED C=	0.73	

DA- DMH-1

	AREA	C
PAVED	0.333	0.9
GRASSED	0.069	0.3

Tc=	9	MIN
TOTAL AREA=	0.402	ACRES
WEIGHTED C=	0.80	

JOB NO.	3203.02	COMPUTED BY	NBB	CHECKED BY	MC
FILE	Rocky Maple Lane	DATE	11/16/2021	DATE	11/17/2021

BEALS + THOMAS

Hydraulic Drainage Areas & Corresponding Rational Method Flows

Using the Rational Method:

$$Q = CIA$$

Where:

Q = flow (cfs)
C = Runoff Coefficient
I = Rainfall Intensity, 50-year storm (in/hr) (from Barnstable, MA IDF curve, see attached
A = Contributing Area (acres)

Assumptions: - Coefficient of runoff for Gravel Surfaces = 0.9
- Coefficient of runoff for Pervious Surfaces = 0.3

Inlet	Contributing Area (Acres)	Weighted Average Rational Coefficients	Rainfall Intensity for Worcester (in/hr)	Contributing Flow (cfs)
CB-1	0.161	0.90	6.80	0.99
CB-2	0.241	0.73	5.90	1.04
DMH-1	0.403	0.80	6.80	2.19

JOB NO. 3203.02 COMPUTED BY NBB CHECKED BY MC
FILE Rocky Maple Lane DATE 11/16/2021 DATE 11/17/2021

BEALS + THOMAS

Hydraulic Pipe Sizing Calculations

Using the Manning Equation to Verify Pipe Capacities Versus Pipe Flows:

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where:

Q = flow (cfs)
n = Manning's roughness coefficient
A = Cross Sectional Area (sf)
R = Hydraulic Radius (ft)
S = Pipe Slope

Assumptions: n = 0.012 for HDPE pipe
Pipe velocity shall be between 2.0 ft/sec and 10 ft/sec

Pipe Connection	Contributing Flow-50 Year Storm(cfs)	Proposed Pipe Size and Material	Proposed Pipe Slope (rise/run)	Full-Flow Capacity of Pipe from Manning Equation (cfs)	Adequate	Full Flow Velocity (ft/sec)
CB-1 to DMH-1	0.99	12" HDPE	0.010	3.87	OK	4.9
CB-2 to DMH-1	1.04	12" HDPE	0.010	3.87	OK	4.9
DMH-1 to WQS-1	2.19	12" HDPE	0.010	3.87	OK	4.9

JOB NO. 3203.02 COMPUTED BY NBB CHECKED BY MC

FILE Rocky Maple Lane DATE 11/16/2021 DATE 11/17/2021

BEALS + THOMAS

Catchbasin Grate Sizing

CB #	50-YEAR STORM DESIGN FLOW (CFS)	HEAD (ft) Lebaron LF248-2 (Single grate) A= 1.5625 SF	HEAD (ft) Lebaron LV2448-2 (Double grate) A= 3.125 SF	RECOMMENDED GRATE
CB-1	0.99	0.017315776	0.0043289	Single
CB-2	1.04	0.019109013	0.0047773	Single

Note: Capacity based on Orifice Flow (ponded condition).

JOB NO. 3203.02 COMPUTED BY: NBB CHECKED BY: MC

FILE: Rocky Maple Lane DATE: 11/16/21 DATE: 11/17/2021

Storm Data Detailed Report: Barnstable Rainfall

Element Details

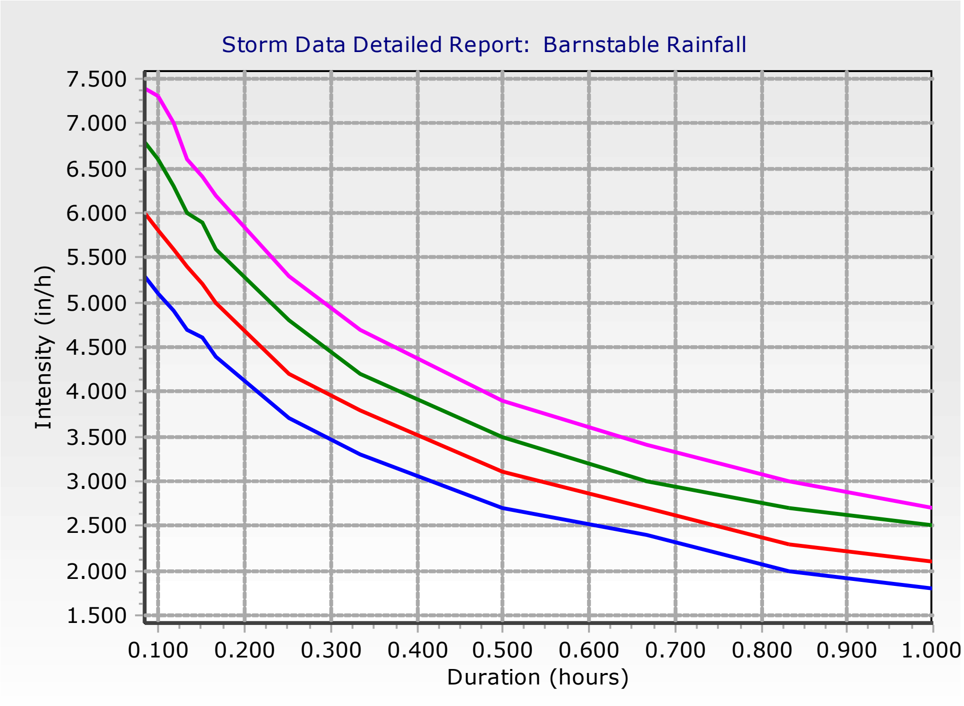
ID	30	Notes	
Label	Barnstable Rainfall		

Duration (hours)	10 Year (in/h)	25 Year (in/h)	50 Year (in/h)	100 Year (in/h)
0.083	5.300	6.000	6.800	7.400
0.100	5.100	5.800	6.600	7.300
0.117	4.900	5.600	6.300	7.000
0.133	4.700	5.400	6.000	6.600
0.150	4.600	5.200	5.900	6.400
0.167	4.400	5.000	5.600	6.200
0.250	3.700	4.200	4.800	5.300
0.333	3.300	3.800	4.200	4.700
0.500	2.700	3.100	3.500	3.900
0.667	2.400	2.700	3.000	3.400
0.833	2.000	2.300	2.700	3.000
1.000	1.800	2.100	2.500	2.700

Library Status Summary

	Synchronization Details
ID	30
Label	Barnstable Rainfall
Modified Date	6/25/2019 9:03:03 AM
Library Source	G:\Corp-Data\Qags\StormCAD\8 XM\Rainfall .xml
Library Modified Date	10/16/2008 3:19:18 PM
Synchronization Status	Synchronize to Library
Engineering Reference Guid	686ed606-a18a-4e03-9cab-f4a1ec6f02ac

Storm Data Detailed Report: Barnstable Rainfall



Attachment 5
Groundwater Recharge, Drawdown, Water Quality Volume, Proprietary Water Quality Inlet Sizing, Rip-Rap Apron Sizing, and Groundwater Mounding Calculations

B E A L S + T H O M A S

Standard 3: Groundwater Recharge

Groundwater Recharge Volume Required:

Rv = F x Impervious Area, where:

Rv = Required Recharge Volume [Ac-ft]

F = Target Depth Factor associated with each Hydrologic Soil Group (HSG) [in]

Impervious Area = Total Pavement and Rooftop Area under Post-development Conditions [Ac]

			Increased Impervious Area [Acres]	Required Recharge Volume [Ac-ft]	
HSG "A", use F =	0.6	in	0.240	0.012	
HSG "B", use F =	0.35	in	0.000	0.000	
HSG "C", use F =	0.25	in	0.000	0.000	
HSG "D", use F =	0.1	in	0.128	0.001	
Total Required Recharge Volume (Rv) =				**0.013**	**Ac-ft**

Capture Area Adjustment: (Ref: DEP Handbook V.3 Ch.1 P.27-28)

Total Increased Site Impervious Area (Total)= 0.368 Acres

Impervious Area Draining to Infiltrative BMPs (infil) = 0.334 Acres (PDA-02A Impervious Area)

Capture Area Adjustment Factor = (Total)/(Infil) = Ca = 1.10

Adjusted Required Recharge Volume = Ca x Rv **0.014 Ac-ft**

Groundwater Recharge Volume Provided :

BMP	Provided Recharge Volume [Ac-ft]	
Infiltration Basin	0.026	
Total Provided Recharge Volume =	**0.026**	**Ac-ft**

PROVIDED GROUNDWATER RECHARGE VOLUME IS GREATER THAN OR EQUAL TO THE REQUIRED RECHARGE VOLUME, THEREFORE PROPOSED STORMWATER MANAGEMENT DESIGN IS IN COMPLIANCE WITH STANDARD 3.

JOB NO.	3203.02	COMPUTED BY:	NBB	CHECKED BY:	MC
JOB:	Rocky Maple Lane	DATE:	11/16/21	DATE:	11/17/2021

BEALS + THOMAS

Standard 3: Drawdown

$$\text{Drawdown Time} = \frac{Rv}{(K)\ (\text{Bottom Area})}$$

where:

Rv = Storage Volume Below Outlet [Ac-ft]

K= Infiltration Rate [in/hr]

Bottom Area= Bottom Area of Recharge System [Ac]

Infiltration Basin

Rv =	0.026	Ac-ft	
K =	2.410	in/hr	
Bottom Area =	0.009	Acres	
Drawdown Time =	**14.385**	**Hours**	*< 72 Hours, Design is in compliance with the standard.*

Note:

1. The infiltration BMPs have been designed to fully drain within 72 hours, therefore the proposed stormwater management design is in compliance with Standard 3 .

2. Infiltration Rate based on Volume 3, Chapter 1, Table 2.3.3 *Rawls Rates* from the 2008 MA DEP Stormwater Management Handbook.

JOB NO.	3203.02	COMPUTED BY:	NBB	CHECKED BY:	MC
JOB:	Rocky Maple Lane	DATE:	11/16/21	DATE:	11/17/2021

Stage-Area-Storage for Pond 1: Infiltration Basin

Elevation (feet)	Surface (acres)	Storage (acre-feet)	Elevation (feet)	Surface (acres)	Storage (acre-feet)
67.00	0.009	0.000	67.52	0.013	0.006
67.01	0.009	0.000	67.53	0.013	0.006
67.02	0.010	0.000	67.54	0.013	0.006
67.03	0.010	0.000	67.55	0.013	0.006
67.04	0.010	0.000	67.56	0.013	0.006
67.05	0.010	0.000	67.57	0.013	0.006
67.06	0.010	0.001	67.58	0.013	0.006
67.07	0.010	0.001	67.59	0.013	0.007
67.08	0.010	0.001	67.60	0.013	0.007
67.09	0.010	0.001	67.61	0.013	0.007
67.10	0.010	0.001	67.62	0.013	0.007
67.11	0.010	0.001	67.63	0.013	0.007
67.12	0.010	0.001	67.64	0.013	0.007
67.13	0.010	0.001	67.65	0.013	0.007
67.14	0.010	0.001	67.66	0.013	0.008
67.15	0.010	0.001	67.67	0.013	0.008
67.16	0.010	0.002	67.68	0.014	0.008
67.17	0.010	0.002	67.69	0.014	0.008
67.18	0.010	0.002	67.70	0.014	0.008
67.19	0.011	0.002	67.71	0.014	0.008
67.20	0.011	0.002	67.72	0.014	0.008
67.21	0.011	0.002	67.73	0.014	0.008
67.22	0.011	0.002	67.74	0.014	0.009
67.23	0.011	0.002	67.75	0.014	0.009
67.24	0.011	0.002	67.76	0.014	0.009
67.25	0.011	0.003	67.77	0.014	0.009
67.26	0.011	0.003	67.78	0.014	0.009
67.27	0.011	0.003	67.79	0.014	0.009
67.28	0.011	0.003	67.80	0.014	0.009
67.29	0.011	0.003	67.81	0.014	0.010
67.30	0.011	0.003	67.82	0.014	0.010
67.31	0.011	0.003	67.83	0.014	0.010
67.32	0.011	0.003	67.84	0.014	0.010
67.33	0.011	0.003	67.85	0.015	0.010
67.34	0.011	0.004	67.86	0.015	0.010
67.35	0.012	0.004	67.87	0.015	0.010
67.36	0.012	0.004	67.88	0.015	0.011
67.37	0.012	0.004	67.89	0.015	0.011
67.38	0.012	0.004	67.90	0.015	0.011
67.39	0.012	0.004	67.91	0.015	0.011
67.40	0.012	0.004	67.92	0.015	0.011
67.41	0.012	0.004	67.93	0.015	0.011
67.42	0.012	0.004	67.94	0.015	0.012
67.43	0.012	0.005	67.95	0.015	0.012
67.44	0.012	0.005	67.96	0.015	0.012
67.45	0.012	0.005	67.97	0.015	0.012
67.46	0.012	0.005	67.98	0.015	0.012
67.47	0.012	0.005	67.99	0.015	0.012
67.48	0.012	0.005	68.00	0.015	0.012
67.49	0.012	0.005	68.01	0.016	0.013
67.50	0.012	0.005	68.02	0.016	0.013
67.51	0.012	0.006	68.03	0.016	0.013

Stage-Area-Storage for Pond 1: Infiltration Basin (continued)

Elevation (feet)	Surface (acres)	Storage (acre-feet)	Elevation (feet)	Surface (acres)	Storage (acre-feet)
68.04	0.016	0.013	68.56	0.020	0.022
68.05	0.016	0.013	68.57	0.020	0.023
68.06	0.016	0.013	68.58	0.020	0.023
68.07	0.016	0.014	68.59	0.020	0.023
68.08	0.016	0.014	68.60	0.020	0.023
68.09	0.016	0.014	68.61	0.020	0.023
68.10	0.016	0.014	68.62	0.020	0.024
68.11	0.016	0.014	68.63	0.020	0.024
68.12	0.016	0.014	68.64	0.021	0.024
68.13	0.016	0.014	68.65	0.021	0.024
68.14	0.017	0.015	68.66	0.021	0.024
68.15	0.017	0.015	68.67	0.021	0.025
68.16	0.017	0.015	68.68	0.021	0.025
68.17	0.017	0.015	68.69	0.021	0.025
68.18	0.017	0.015	68.70	0.021	0.025
68.19	0.017	0.015	68.71	0.021	0.025
68.20	0.017	0.016	68.72	0.021	0.026
68.21	0.017	0.016	68.73	0.021	0.026
68.22	0.017	0.016	68.74	0.021	0.026
68.23	0.017	0.016	68.75	0.021	0.026
68.24	0.017	0.016	68.76	0.022	0.026
68.25	0.017	0.017	68.77	0.022	0.027
68.26	0.018	0.017	68.78	0.022	0.027
68.27	0.018	0.017	68.79	0.022	0.027
68.28	0.018	0.017	68.80	0.022	0.027
68.29	0.018	0.017	68.81	0.022	0.028
68.30	0.018	0.017	68.82	0.022	0.028
68.31	0.018	0.018	68.83	0.022	0.028
68.32	0.018	0.018	68.84	0.022	0.028
68.33	0.018	0.018	68.85	0.022	0.028
68.34	0.018	0.018	68.86	0.022	0.029
68.35	0.018	0.018	68.87	0.022	0.029
68.36	0.018	0.019	68.88	0.022	0.029
68.37	0.018	0.019	68.89	0.023	0.029
68.38	0.018	0.019	68.90	0.023	0.030
68.39	0.019	0.019	68.91	0.023	0.030
68.40	0.019	0.019	68.92	0.023	0.030
68.41	0.019	0.019	68.93	0.023	0.030
68.42	0.019	0.020	68.94	0.023	0.030
68.43	0.019	0.020	68.95	0.023	0.031
68.44	0.019	0.020	68.96	0.023	0.031
68.45	0.019	0.020	68.97	0.023	0.031
68.46	0.019	0.020	68.98	0.023	0.031
68.47	0.019	0.021	68.99	0.023	0.032
68.48	0.019	0.021	69.00	0.023	0.032
68.49	0.019	0.021	69.01	0.024	0.032
68.50	0.019	0.021	69.02	0.024	0.032
68.51	0.020	0.021	69.03	0.024	0.033
68.52	0.020	0.022	69.04	0.024	0.033
68.53	0.020	0.022	69.05	0.024	0.033
68.54	0.020	0.022	69.06	0.024	0.033
68.55	0.020	0.022	69.07	0.024	0.034

Stage-Area-Storage for Pond 1: Infiltration Basin (continued)

Elevation (feet)	Surface (acres)	Storage (acre-feet)	Elevation (feet)	Surface (acres)	Storage (acre-feet)
69.08	0.024	0.034	69.60	0.028	0.047
69.09	0.024	0.034	69.61	0.028	0.048
69.10	0.024	0.034	69.62	0.028	0.048
69.11	0.024	0.034	69.63	0.028	0.048
69.12	0.024	0.035	69.64	0.029	0.049
69.13	0.024	0.035	69.65	0.029	0.049
69.14	0.025	0.035	69.66	0.029	0.049
69.15	0.025	0.035	69.67	0.029	0.049
69.16	0.025	0.036	69.68	0.029	0.050
69.17	0.025	0.036	69.69	0.029	0.050
69.18	0.025	0.036	69.70	0.029	0.050
69.19	0.025	0.036	69.71	0.029	0.051
69.20	0.025	0.037	69.72	0.029	0.051
69.21	0.025	0.037	69.73	0.029	0.051
69.22	0.025	0.037	69.74	0.029	0.051
69.23	0.025	0.037	69.75	0.029	0.052
69.24	0.025	0.038	69.76	0.030	0.052
69.25	0.025	0.038	69.77	0.030	0.052
69.26	0.026	0.038	69.78	0.030	0.053
69.27	0.026	0.038	69.79	0.030	0.053
69.28	0.026	0.039	69.80	0.030	0.053
69.29	0.026	0.039	69.81	0.030	0.053
69.30	0.026	0.039	69.82	0.030	0.054
69.31	0.026	0.040	69.83	0.030	0.054
69.32	0.026	0.040	69.84	0.030	0.054
69.33	0.026	0.040	69.85	0.030	0.055
69.34	0.026	0.040	69.86	0.030	0.055
69.35	0.026	0.041	69.87	0.030	0.055
69.36	0.026	0.041	69.88	0.030	0.056
69.37	0.026	0.041	69.89	0.031	0.056
69.38	0.026	0.041	69.90	0.031	0.056
69.39	0.027	0.042	69.91	0.031	0.057
69.40	0.027	0.042	69.92	0.031	0.057
69.41	0.027	0.042	69.93	0.031	0.057
69.42	0.027	0.042	69.94	0.031	0.057
69.43	0.027	0.043	69.95	0.031	0.058
69.44	0.027	0.043	69.96	0.031	0.058
69.45	0.027	0.043	69.97	0.031	0.058
69.46	0.027	0.044	69.98	0.031	0.059
69.47	0.027	0.044	69.99	0.031	0.059
69.48	0.027	0.044	70.00	**0.031**	**0.059**
69.49	0.027	0.044			
69.50	0.027	0.045			
69.51	0.028	0.045			
69.52	0.028	0.045			
69.53	0.028	0.045			
69.54	0.028	0.046			
69.55	0.028	0.046			
69.56	0.028	0.046			
69.57	0.028	0.047			
69.58	0.028	0.047			
69.59	0.028	0.047			

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Standard 4: Water Quality Volume Summary

$$V_{WQ} = (D_{WQ} / 12 \text{ in/ft}) \times (A_{IMP} \times 43{,}560 \text{ SF/Ac}) \text{ where:}$$

V_{WQ} = Required Water Quality Volume [CF]

D_{WQ} = Water Quality Depth : 1-inch for discharges within a Zone II or Interim Wellhead Protection Area, to or near critical areas, runoff from LUHPPL, or exfiltration to soil with infiltration rate 2.4 in/hr or greater; ½-inch for discharges to other areas.

A_{IMP} = Post-development Impervious Area; may exclude roof top areas [Ac]

Required Water Quality Volume:

Drainage Area/ Treatment Train	New A_{IMP} [Ac]	D_{WQ} [in]	V_{WQ} Required [CF]	
PDA-1A	0.000	1	0	
PDA-1B	0.334	1	1,212	
PDA-2	0.034	1	123	
Total Required Water Quality Volume:			1,336	Cubic Feet
			0.031	Ac-ft

Provided Water Quality Volume:

Drainage Area/ Treatment Train	BMP	Water Quality Volume Provided [CF]	
PDA-1B	WQS	1,212	
PDA-1B	Infiltration Basin	1,144	
Total Provided Water Quality Volume:		2,356	Cubic Feet

WATER QUALITY VOLUME PROVIDED IS GREATER THAN OR EQUAL TO THE REQUIRED WATER QUALITY VOLUME, THEREFORE PROPOSED STORMWATER MANAGEMENT DESIGN IS IN COMPLIANCE WITH STANDARD 4.

JOB NO. 3203.02 COMPUTED BY: NBB CHECKED BY: MC

JOB: Rocky Maple Lane DATE: 11/16/21 DATE: 11/17/2021

Stage-Area-Storage for Pond 1: Infiltration Basin

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
67.00	409	0	67.52	546	248
67.01	412	4	67.53	549	254
67.02	414	8	67.54	552	259
67.03	417	12	67.55	554	265
67.04	420	17	67.56	557	270
67.05	422	21	67.57	559	276
67.06	425	25	67.58	562	282
67.07	427	29	67.59	565	287
67.08	430	34	67.60	567	293
67.09	433	38	67.61	570	299
67.10	435	42	67.62	573	304
67.11	438	47	67.63	575	310
67.12	441	51	67.64	578	316
67.13	443	55	67.65	581	322
67.14	446	60	67.66	583	327
67.15	449	64	67.67	586	333
67.16	451	69	67.68	589	339
67.17	454	73	67.69	591	345
67.18	457	78	67.70	594	351
67.19	459	82	67.71	596	357
67.20	462	87	67.72	599	363
67.21	464	92	67.73	602	369
67.22	467	96	67.74	604	375
67.23	470	101	67.75	607	381
67.24	472	106	67.76	610	387
67.25	475	111	67.77	612	393
67.26	478	115	67.78	615	399
67.27	480	120	67.79	618	405
67.28	483	125	67.80	620	412
67.29	486	130	67.81	623	418
67.30	488	135	67.82	625	424
67.31	491	139	67.83	628	430
67.32	493	144	67.84	631	437
67.33	496	149	67.85	633	443
67.34	499	154	67.86	636	449
67.35	501	159	67.87	639	456
67.36	504	164	67.88	641	462
67.37	507	169	67.89	644	469
67.38	509	174	67.90	647	475
67.39	512	180	67.91	649	481
67.40	515	185	67.92	652	488
67.41	517	190	67.93	655	495
67.42	520	195	67.94	657	501
67.43	523	200	67.95	660	508
67.44	525	206	67.96	662	514
67.45	528	211	67.97	665	521
67.46	530	216	67.98	668	528
67.47	533	221	67.99	670	534
67.48	536	227	68.00	673	541
67.49	538	232	68.01	676	548
67.50	541	238	68.02	680	555
67.51	544	243	68.03	683	561

Stage-Area-Storage for Pond 1: Infiltration Basin (continued)

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
68.04	687	568	68.56	868	973
68.05	690	575	68.57	872	981
68.06	694	582	68.58	875	990
68.07	697	589	68.59	879	999
68.08	701	596	68.60	882	1,008
68.09	704	603	68.61	886	1,016
68.10	708	610	68.62	889	1,025
68.11	711	617	68.63	893	1,034
68.12	715	624	68.64	896	1,043
68.13	718	631	68.65	900	1,052
68.14	722	639	68.66	903	1,061
68.15	725	646	68.67	906	1,070
68.16	729	653	68.68	910	1,079
68.17	732	660	68.69	913	1,088
68.18	736	668	68.70	917	1,097
68.19	739	675	68.71	920	1,107
68.20	743	683	68.72	924	1,116
68.21	746	690	68.73	927	1,125
68.22	750	697	68.74	931	1,134
68.23	753	705	68.75	934	1,144
68.24	757	713	68.76	938	1,153
68.25	760	720	68.77	941	1,163
68.26	764	728	68.78	945	1,172
68.27	767	735	68.79	948	1,181
68.28	771	743	68.80	952	1,191
68.29	774	751	68.81	955	1,200
68.30	778	759	68.82	959	1,210
68.31	781	766	68.83	962	1,220
68.32	785	774	68.84	966	1,229
68.33	788	782	68.85	969	1,239
68.34	791	790	68.86	973	1,249
68.35	795	798	68.87	976	1,258
68.36	798	806	68.88	980	1,268
68.37	802	814	68.89	983	1,278
68.38	805	822	68.90	987	1,288
68.39	809	830	68.91	990	1,298
68.40	812	838	68.92	994	1,308
68.41	816	846	68.93	997	1,318
68.42	819	854	68.94	1,001	1,328
68.43	823	863	68.95	1,004	1,338
68.44	826	871	68.96	1,008	1,348
68.45	830	879	68.97	1,011	1,358
68.46	833	887	68.98	1,015	1,368
68.47	837	896	68.99	1,018	1,378
68.48	840	904	69.00	1,022	1,388
68.49	844	913	69.01	1,025	1,398
68.50	847	921	69.02	1,028	1,409
68.51	851	930	69.03	1,032	1,419
68.52	854	938	69.04	1,035	1,429
68.53	858	947	69.05	1,039	1,440
68.54	861	955	69.06	1,042	1,450
68.55	865	964	69.07	1,046	1,461

Stage-Area-Storage for Pond 1: Infiltration Basin (continued)

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
69.08	1,049	1,471	69.60	1,231	2,064
69.09	1,053	1,482	69.61	1,234	2,076
69.10	1,056	1,492	69.62	1,238	2,089
69.11	1,060	1,503	69.63	1,241	2,101
69.12	1,063	1,513	69.64	1,245	2,113
69.13	1,067	1,524	69.65	1,248	2,126
69.14	1,070	1,535	69.66	1,252	2,138
69.15	1,074	1,545	69.67	1,255	2,151
69.16	1,077	1,556	69.68	1,258	2,163
69.17	1,081	1,567	69.69	1,262	2,176
69.18	1,084	1,578	69.70	1,265	2,189
69.19	1,088	1,589	69.71	1,269	2,201
69.20	1,091	1,600	69.72	1,272	2,214
69.21	1,095	1,610	69.73	1,276	2,227
69.22	1,098	1,621	69.74	1,279	2,240
69.23	1,102	1,632	69.75	1,283	2,252
69.24	1,105	1,643	69.76	1,286	2,265
69.25	1,109	1,655	69.77	1,290	2,278
69.26	1,112	1,666	69.78	1,293	2,291
69.27	1,116	1,677	69.79	1,297	2,304
69.28	1,119	1,688	69.80	1,300	2,317
69.29	1,123	1,699	69.81	1,304	2,330
69.30	1,126	1,710	69.82	1,307	2,343
69.31	1,130	1,722	69.83	1,311	2,356
69.32	1,133	1,733	69.84	1,314	2,369
69.33	1,137	1,744	69.85	1,318	2,382
69.34	1,140	1,756	69.86	1,321	2,396
69.35	1,143	1,767	69.87	1,325	2,409
69.36	1,147	1,779	69.88	1,328	2,422
69.37	1,150	1,790	69.89	1,332	2,435
69.38	1,154	1,802	69.90	1,335	2,449
69.39	1,157	1,813	69.91	1,339	2,462
69.40	1,161	1,825	69.92	1,342	2,476
69.41	1,164	1,836	69.93	1,346	2,489
69.42	1,168	1,848	69.94	1,349	2,502
69.43	1,171	1,860	69.95	1,353	2,516
69.44	1,175	1,871	69.96	1,356	2,529
69.45	1,178	1,883	69.97	1,360	2,543
69.46	1,182	1,895	69.98	1,363	2,557
69.47	1,185	1,907	69.99	1,367	2,570
69.48	1,189	1,919	70.00	**1,370**	**2,584**
69.49	1,192	1,931			
69.50	1,196	1,943			
69.51	1,199	1,955			
69.52	1,203	1,967			
69.53	1,206	1,979			
69.54	1,210	1,991			
69.55	1,213	2,003			
69.56	1,217	2,015			
69.57	1,220	2,027			
69.58	1,224	2,039			
69.59	1,227	2,052			

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Proprietary Water Quality Inlet Sizing

Step 1: Define Minimum Flow Rate per Water Quality Inlet to Treat Desired Water Quality Volume

Water quality inlets are sized based on flow rate; therefore expressing Water Quality Volume as a flow rate based on the percentage of cumulative average volume captured ensures systems are sized to achieve the desired Water Quality treatment level.

$Q = (q_u)(A)(WQV)$ where:

Q = peak flow rate associated with first 1.0-inch of runoff [CFS]

q_u = The Peak Discharge [CFS/mi^2/in] Massachusetts DEP Standard Method to Convert Required Water Quality Volume to a Discharge Rate for Sizing Flow Based Manufactured Proprietary Stormwater Treatment Practices

A = Contributing Drainage Area, Impervious Surface Only [Ac]

WQV = The Water Quality Treatment Depth [In]

WQI No.	A (Ac)	Tc (Min)	WQV (in)	q_u (csm/in)	Q (cfs)
WQS-1	0.33	6.0	1.0	774	0.40
Total	0.33	Acres			

Step 2: Size Water Quality Inlet as recommended by Manufacturer

See attached Sizing Report(s) for recommended model(s).

Step 3: Water Quality Volume Provided by WQI unit(s)

Total Impervious Area Treated by WQI unit(s):	0.33	Acres
	14,549	SF
Treated Water Quality Depth : (accounted for by Average Water Quality Flow Rate)	1.0	inches
Total Water Quality Volume provided by Water Quality Inlets:	**1,212**	**CF**

JOB NO. 3203.02 COMPUTED BY: NBB CHECKED BY: MC

JOB: Rocky Maple Lane DATE: 11/16/21 DATE: 11/17/2021

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Riprap Apron Sizing

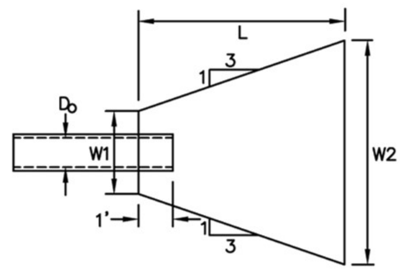
Median Stone Sizing:

$$D_{50} = 0.2D_0\left(\frac{Q}{\sqrt{g}D_0^{2.5}}\right)^{\frac{4}{3}}\left(\frac{D_0}{TW}\right)$$

Where:
D_0 = Maximum Inside Pipe Diameter (ft)
D_{50} = Median Riprap Diameter (ft)
Q = Peak Discharge Rate from Hydraulic Design (cfs)
TW = Tailwater Depth (ft); (Use $0.4D_0$ if TW is unknown, max $1.0D_{o)}$
g = Gravitational Acceleration Constant = 32.2 ft/s^2

Apron Sizing:

D_{50} [In]	Apron Length (L) [ft}	Apron Depth [In]	Apron Width At Beginning (W_1)[ft]	Apron Width At End (W_2) [ft]
5	$4D_0$	$3.5D_{50}$	$3D_0$	$3D_0 + \frac{2}{3}L$
6	$4D_0$	$3.3D_{50}$	$3D_0$	$3D_0 + \frac{2}{3}L$
10	$5D_0$	$2.4D_{50}$	$3D_0$	$3D_0 + \frac{2}{3}L$
14	$6D_0$	$2.2D_{50}$	$3D_0$	$3D_0 + \frac{2}{3}L$
20	$7D_0$	$2.0D_{50}$	$3D_0$	$3D_0 + \frac{2}{3}L$
22	$8D_0$	$2.0D_{50}$	$3D_0$	$3D_0 + \frac{2}{3}L$



FLARED END SECTION	PIPE DIAMETER (D_0) (FEET)	50-YEAR STORM FLOW (Q) (CFS)	TAILWATER (TW) [ft]	MEDIAN STONE DIAMETER (D_{50}) (INCHES)	APRON LENGTH (L) (FEET)	APRON DEPTH [In]	APRON WIDTH AT BEGINING (W_1) [ft]	APRON WIDTH AT END (W_2) [ft]
FE-01	1.0	2.26	0.4	5	4.00	17.5	3.0	5.7

Notes
[1] Calculations performed in accordance with Hydraulic Engineering Circular No. 14, Third Edition; Hydraulic Design of Energy Dissipaters for Culverts and Channels, dated July 2006.
[2] Pipe shall extend 1 foot into riprap.
[3] For maximum pipe size of 60".
[4] FE-01 flow taken from 100-year storm flow in HydroCAD

JOB NO. 3203.02 COMPUTED BY: NBB CHECKED BY: MC
JOB: Rocky Maple Lane DATE: 11/16/21 DATE: 11/17/2021

GROUNDWATER MOUNTIND CALCULATION SUMMARY

OBJECTIVE

To determine the maximum groundwater mounting height beneath the infiltration basin.

CONCLUSION(S)

The mounding analysis indicates that the groundwater elevation would rise approximately 0.406-feet to infiltrate the required volume. Therefore, it can be concluded that the rise in groundwater elevation will not prohibit the infiltration basin from dewatering within 72 hours.

CALCULATION METHODS

1. Estimated maximum groundwater mounding height calculated using Hantush equation.

ASSUMPTIONS

1. Vertical hydraulic conductivity [R] (unsaturated zone) is equal to the infiltration rate of the proposed infiltration basin = 2.41 in/hr = 4.82 ft/day.
2. Horizontal hydraulic conductivity [K] (saturated zone) is 200 ft/day based on data provided in USGS Report 86-4053A for mixed sand and gravel.
3. Specific yield [Sy] is 0.26 based on data provided in GSWS Paper 1662-D for Medium Sand
4. Estimated saturated thickness [hi(0)] is 10.00 ft based upon observed seasonal high groundwater and additional field observations during subsurface explorations.
5. ½ the length of infiltration basin (in x direction) [x] = 10 ft
6. ½ the width of infiltration basin (in y direction) [y] = 10 ft
7. The infiltration basin takes approximately 14.385 hours (t=0.599 days) to dewater.

SOURCES OF DATA/ EQUATIONS

1. Hantush equation spreadsheet published by the USGS.
2. Page 2 of USGS Report 86-4053A, *Yield and Quality of Ground Water from Stratified-Drift Aquifers, Taunton River Basin, Massachusetts: Executive Summary,* 1989.
3. Page D1 of GWSWS Paper 1662-D, *Specific Yield – Compilation of Specific Yields for Various Materials,* 1967.
4. *Massachusetts Stormwater Handbook,* 2008

REV	CALC. BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
0	NBB	11/16/2021	MC	11/17/2021	MC	11/17/2021

NBB/320302CS004A

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

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

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

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

Conversion Table

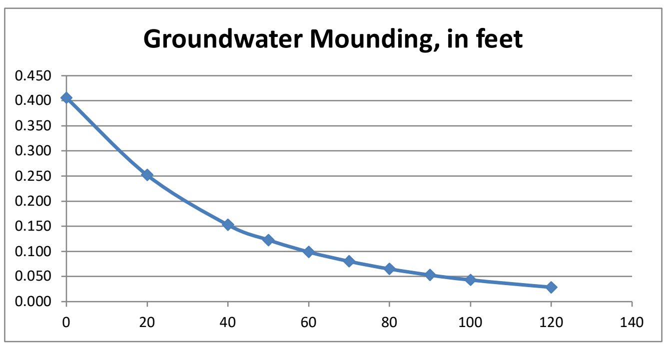
inch/hour	**feet/day**
0.67	1.33
2.00	4.00
hours	**days**
36	1.50

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

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

Ground-water Mounding, in feet	**Distance from center of basin in x direction, in feet**
0.406	**0**
0.252	**20**
0.153	**40**
0.123	**50**
0.099	**60**
0.080	**70**
0.065	**80**
0.053	**90**
0.043	**100**
0.028	**120**

Re-Calculate Now



Disclaimer

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

YIELD AND QUALITY OF GROUND WATER FROM STRATIFIED-DRIFT AQUIFERS, TAUNTON RIVER BASIN, MASSACHUSETTS: EXECUTIVE SUMMARY

By Wayne W. Lapham and Julio C. Olimpio

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 86-4053A

Prepared in cooperation with

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
DIVISION OF WATER RESOURCES

Boston, Massachusetts
1989

PHYSICAL SETTING AND HYDROGEOLOGY OF THE BASIN

The Taunton River basin covers 530 mi^2 (square miles) of Bristol, Norfolk, and Plymouth Counties in southeastern Massachusetts. All or parts of the cities of Attleboro, Brockton, Fall River, New Bedford, and Taunton, and 36 towns are in the basin (fig. 1). The basin is drained by the Matfield, Town, and Taunton Rivers.

Tributary streams include the Canoe, Nemasket, Wading, Threemile, and Winnetuxet Rivers. Surface-water drainage is generally southward toward Mount Hope Bay, a part of Narragansett Bay at Fall River.

Stratified-drift deposits cover about 62 percent of the basin. These deposits are primarily ice-contact, outwash, and lake-bottom sediments, which were deposited in preglacial bedrock valleys and in water-filled depressions in the till and bedrock surface during retreat of the last glacier. The sediments are composed of sand, gravel, cobbles, silt, and clay. The drift ranges in thickness from zero to about 200 ft (feet) in some of the deep preglacial bedrock valleys. The thickest deposits are lake-bottom deposits composed of fine sand interbedded with silt and clay. Stratified-drift deposits are more abundant in the central and southern parts of the basin than in the northern part of the basin. In the northern one-third of the basin, stratified drift fills narrow, north-south trending valleys, which are bordered by till and bedrock uplands.

Yields of wells in the fine-grained stratified-drift deposits are usually no more than a few gallons per minute (gal/min) whereas yields of wells in the coarse-grained stratified drift may exceed 300 gal/min. The coarse-grained parts of the stratified-drift deposits form the major aquifers in the basin. In the northern part of the basin, these aquifers are long, narrow, and thin, and have saturated thicknesses that range from about 20 ft to somewhat more than 100 ft. The widths of the stratified-drift aquifers generally range from 0.1 to 1.5 mi (miles), and their lengths generally range from 1 to 5 mi.

Twenty-six stratified-drift aquifers in the northern half of the basin were studied in detail (fig. 2). These aquifers were selected because current and projected 1990 water-supply deficits are greatest in the northern half of the basin, affecting 14 of 19 municipalities. In contrast, only one of nine municipalities in the southern half of the basin is projected to have a deficit (Richard Thibedeau, Massachusetts Division of Water Resources, written commun.,1984). The 26 aquifers also were selected because the use of ground water as the sole source of supply is greatest in the northern half of the basin. Fifteen of 19 municipalities in the northern half of the basin use ground water as compared to 4 of 9 municipalities in the southern half of the basin.

The 26 stratified-drift aquifers were identified as areas of stratified drift that have a transmissivity equal to or greater than 1,337 ft^2/d (square feet per day), which is equivalent to 10,000 gallons per day per foot. The aquifers underlie or are near major rivers or tributaries. The aquifers are composed mostly of layers of sand and gravel but include some interbedded layers of silt and clay. John R. Williams (U.S. Geological Survey, written commun., 1982) determined that the hydraulic conductivity of fine-to-coarse gravel ranges from about 150 to 500 ft/d (feet per day), mixed sand and gravel averages about 200 ft/d, and fine-to-coarse sand ranges from about 25 to 150 ft/d. The transmissivity of the stratified drift is equal to the product of its hydraulic conductivity and saturated thickness. Therefore, equal transmissivities at different locations in an aquifer may be the result of thin deposits of high-conductivity drift or thick deposits of low-conductivity drift. Transmissivity exceeds 4,000 ft^2/d in small areas in nearly all 26 aquifers. In a few areas, where the stratified drift is thick or has a high hydraulic conductivity, transmissivity exceeds 10,000 ft^2/d.

AQUIFER YIELDS

Estimates from Model Simulations

During severe drought, ground-water discharge from aquifers to streams is reduced or ceases, streamflow is at a minimum, and only small amounts of surface water are stored in wetlands and ponds. Consequently, water pumped from most aquifers in New England during severe drought is derived largely from storage in the aquifers. During normal climatic conditions, water pumped from an aquifer is derived from storage, intercepted ground-water discharge, and induced infiltration of surface water. To account for drought and normal conditions, two sets of aquifer-yield estimates were made for each of the 26 stratified-drift aquifers using simple ground-water flow models. "Short-term" aquifer yields during drought conditions were determined by considering only water from storage and are expressed as single values for several selected pumping periods. "Long-term" aquifer yields during normal

Specific Yield--Compilation of Specific Yields for Various Materials

GEOLOGICAL SURVEY WATER SUPPLY PAPER 1662-D

Prepared in cooperation with the California Department of Water Resources

HYDROLOGIC PROPERTIES OF EARTH MATERIALS

SPECIFIC YIELD—COMPILATION OF SPECIFIC YIELDS FOR VARIOUS MATERIALS

By A. I. Johnson

ABSTRACT

Specific yield is defined as the ratio of (1) the volume of water that a saturated rock or soil will yield by gravity to (2) the total volume of the rock or soil. Specific yield is usually expressed as a percentage. The value is not definitive, because the quantity of water that will drain by gravity depends on variables such as duration of drainage, temperature, mineral composition of the water, and various physical characteristics of the rock or soil under consideration. Values of specific yield, nevertheless, offer a convenient means by which hydrologists can estimate the water-yielding capacities of earth materials and, as such, are very useful in hydrologic studies.

The present report consists mostly of direct or modified quotations from many selected reports that present and evaluate methods for determining specific yield, limitations of those methods, and results of the determinations made on a wide variety of rock and soil materials. Although no particular values are recommended in this report, a table summarizes values of specific yield, and their averages, determined for 10 rock textures. The following is an abstract of the table:

Specific yields, in percent, of various materials

[Rounded to nearest whole percent]

Material	Number of determinations	Specific yield		
		Maximum	Minimum	Average
Clay	15	5	0	2
Silt	16	19	3	8
Sandy clay	12	12	3	7
Fine sand	17	28	10	21
Medium sand	17	32	15	26
Coarse sand	17	35	20	27
Gravelly sand	15	35	20	25
Fine gravel	17	35	21	25
Medium gravel	14	26	13	23
Coarse gravel	14	26	12	22

INTRODUCTION

PURPOSE AND SCOPE

The purpose of this report is to assist hydrologists in estimating the quantity of water in storage in ground-water reservoirs by providing

Attachment 6
Site Owner's Manual

Site Owner's Manual

Definitive Subdivision Plan of Rocky Maple Lane

Off Carver Road
Wareham, Massachusetts

Prepared for:
Brett Meredith
PO Box 359
Carver, Massachusetts 02330

Prepared by:

BEALS + THOMAS

November 19, 2021

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FIGURES

APPENDICES

1.0 INTRODUCTION

The Site Owner’s Manual complies with the Long-Term Pollution Prevention Plan (Standard 4) and the Long-Term Operation and Maintenance Plan (Standard 9) requirements of the 2008 Massachusetts Department of Environmental Protection (DEP) Stormwater Handbook. The Manual outlines source control and pollution prevention measures and maintenance requirements of stormwater best management practices (BMPs) associated with the proposed development.

2.0 SITE OWNER'S AGREEMENT

2.1 Operation and Maintenance Compliance Statement

Site Owner: Brett Meredith
PO Box 359
Carver, Massachusetts 02330

Responsible Party: Brett Meredith

Brett Meredith or their successors shall maintain ownership of the on-site stormwater management system as well as the responsibility for operation and maintenance during the post-development stages of the project. The site has been inspected for erosion and appropriate measures have been taken to permanently stabilize any eroded areas. All aspects of stormwater best management practices (BMPs) have been inspected for damage, wear and malfunction, and appropriate steps have been taken to repair or replace the system or portions of the system so that the stormwater at the site may be managed in accordance with the Stormwater Management Standards. Future responsible parties shall be notified of their continuing legal responsibility to operate and maintain the BMPs. The operation and maintenance plan for the stormwater BMPs is being implemented.

11/17/2

Responsible Party Signature Date

2.2 Stormwater Maintenance Easements

There are no off-site areas utilized for stormwater control, therefore no stormwater management easements are required. The Site Owner will have access to all stormwater practices for inspection and maintenance, including direct maintenance access by heavy equipment to structures requiring regular maintenance.

2.3 Record Keeping

The Site Owner shall maintain a rolling log in which all inspections and maintenance activities for the past three years shall be recorded. The Operation and Maintenance Log includes information pertaining to inspections, repairs, and disposal relevant to the project's stormwater management system. The Log is located in Appendix A.

The Operation and Maintenance Log shall be made available to the Conservation Commission and the DEP upon request. The Conservation Commission and the DEP shall be allowed to enter and inspect the premises to evaluate and ensure that the responsible party complies with the maintenance requirements for each BMP.

2.4 Training

Employees involved in grounds maintenance and emergency response will be educated on the general concepts of stormwater management and groundwater protection. The Site Owner's Manual will be reviewed with the maintenance staff. The staff will be trained on the proper course of action for specific events expected to be incurred during routine maintenance or emergency situations.

3.0 LONG-TERM POLLUTION PREVENTION PLAN

In compliance with Standard 4 of the 2008 DEP Stormwater Management Handbook, this section outlines source control and pollution prevention measures to be employed on-site after construction.

3.1 Storage of Materials and Waste

The site shall be kept clear of trash and debris at all times. Certain materials and waste products shall be stored inside or outside upon an impervious surface and covered, as required by local and state regulations.

3.2 Vehicle Washing

No commercial vehicle washing shall take place on site.

3.3 Routine Inspections and Maintenance of Stormwater BMPs

See Section 4.0 Long-Term Operation and Maintenance Plan, for routine inspection and maintenance requirements for all proposed stormwater BMPs.

3.4 Spill Prevention and Response

A contingency plan shall be implemented to address the spill or release of petroleum products and hazardous materials and will include the following measures:

1. Equipment necessary to quickly attend to inadvertent spills or leaks shall be stored on-site in a secure but accessible location. Such equipment shall include but not be limited to the following: safety goggles, chemically resistant gloves and overshoe boots, water and chemical fire extinguishers, sand and shovels, suitable absorbent materials, storage containers and first aid equipment (i.e. Indian Valley Industries, Inc. 55-gallon Spill Containment kit or approved equivalent).

2. Spills or leaks shall be treated properly according to material type, volume of spillage and location of spill. Mitigation shall include preventing further spillage, containing the spilled material in the smallest practical area, removing spilled material in a safe and environmentally-friendly manner, and remediation of any damage to the environment.

3. For large spills, Massachusetts DEP Hazardous Waste Incident Response Group shall be notified immediately at 888-304-1133 and an emergency response contractor shall be consulted.

3.5 Maintenance of Lawns, Gardens, and other Landscaped Areas

Lawns, gardens, and other landscaped areas shall be maintained regularly by the site owner. Vegetated and landscaped BMPs will be maintained as outlined in Section 4.0.

3.6 Storage and Use of Fertilizers, Herbicides, and Pesticides

All fertilizers, herbicides, and pesticides shall be stored in accordance with local, state, and federal regulations. The application rate and use of fertilizers, herbicides, and pesticides on the site shall at no time exceed local, state, or federal specifications.

3.7 Pet Waste Management

Pet owners shall be required to pick up after their animals and dispose of waste in the trash.

3.8 Snow and Deicing Chemical Management

Snow removal and use of deicing chemicals at the proposed development shall comply with the following requirements:

- Plowed snow shall be placed in the areas outside of wetland boundaries and stormwater best management practices. The following maintenance measures shall be undertaken at all snow disposal sites:
    - Debris shall be cleared from an area prior to using it for snow disposal.
    - Debris and accumulated sediments shall be cleared from the site and properly disposed of at the end of the snow season and no later than May 15.
- In accordance with the Massachusetts General Laws, Chapter 85, Section 7A, salt and other de-icing chemicals will be stored at an indoor location. Salt and other deicing chemicals shall be stored in accordance with Massachusetts General Law.
- Sand piles shall be contained and stabilized to prevent the discharge of sand to wetlands or water bodies, and, where feasible, covered.
- Salt storage piles shall be located outside of the 100-year floodplain.
- The application of salt on the proposed driveway shall at no time exceed state or local requirements.

4.0 LONG-TERM OPERATION AND MAINTENANCE PLAN

This section outlines the stormwater best management practices (BMPs) associated with the proposed stormwater management system and identifies the long-term inspection and maintenance requirements for each BMP.

4.1 Stormwater Management System Components

The following table outlines the type and quantity of the BMPs and their general location. Please reference the site plan(s) provided in the Figures section for exact location.

BMP Type	Quantity	Location
Catch Basins	2	Throughout paved area.
Water Quality Structure	1	Throughout paved area.
Infiltration Basin	1	Northwestern portion of the site.

4.2 Inspection and Maintenance Schedules

4.2.1 General Maintenance for Mosquito Control

If necessary to minimize mosquito breeding, a licensed pesticide applicator shall apply larvicides, such as Bacillus sphaericus (Bs) to all catch basins sumps, and water quality inlets. Larvicides shall be applied in compliance with all pesticide label requirements, and will be applied during or immediately after wet weather, unless the product used can withstand extended dry periods. Ensure all manhole covers, and inspection ports are secure to reduce the likelihood of mosquitoes laying eggs in standing water.

4.2.2 Deep Sump and Hooded Catch Basins

Catch basins shall be inspected four times per year, including after the foliage season. Other inspection and maintenance requirements include:

- Units shall be cleaned (organic material, sediment and hydrocarbons 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.
    - Cleanout shall always occur after street sweeping.
- If any evidence of hydrocarbons is found during inspection, the material shall be immediately removed using absorbent pads or other suitable measures and disposed of legally.
- Remove other accumulated debris as necessary.

- Transport and disposal of accumulated sediment off-site shall be in accordance with applicable local, state and federal guidelines and regulations.

4.2.3 Proprietary Separators

Maintenance of proprietary separators shall be performed according the recommendations set forth by the manufacturer (see Appendix C. Proprietary Separator Technical Manual for complete installation, operation and maintenance procedures). Inspection and maintenance procedures for proprietary devices are provided below:

- Units shall be inspected post-construction, prior to being put into service.
- Units shall be inspected not less than twice per year following installation and no less than once per year thereafter.
- Units shall be inspected immediately after any oil, fuel or chemical spill.
- All inspections shall include checking the oil level and sediment depth in the unit.
- Removal of sediments/oils shall occur per manufacturer recommendations.
- A licensed waste management company shall remove captured petroleum waste products from any oil, chemical or fuel spills and dispose.
- OSHA confined space entry protocols shall be followed if entry into the unit is required.

4.2.4 Infiltration Basins

Infiltration basins shall be inspected and maintained after major storm events (rainfall totals greater than 2.5 inches in 24 hours) during the first three months of operation and twice a year and when there are discharges through the outlet control structure thereafter. Additionally, all pretreatment BMPs shall be inspected in accordance with the minimal requirements specified for those practices and after all major storm events. Inspections shall include the following measures:

- During and after major storm events, the length of time standing water remains in the basin shall be recorded.
  - If the time is greater than 72 hours, thoroughly inspect the basin for signs of clogging.

- A corrective action plan shall be developed by a qualified professional to restore infiltrative function. The Site Owner shall take immediate action to implement these corrective measures.

- Examine the outlet structure for evidence of clogging or outflow release velocities that are greater than the design velocity.
- Identify areas of sediment accumulation, differential settlement, cracking, and erosion within the basin.
- Inspect embankments for leakage and tree growth.
- Examine the health of the vegetation within the basin and on the embankments.

Corrective measures shall be taken immediately as warranted by the inspections. If any evidence of hydrocarbons is found during inspection, the material shall be immediately removed using absorbent pads or other suitable measures and legally disposed.

Preventative maintenance shall include the following activities:

- Mow the buffer area and basin bottom and side slopes, if vegetated.
- Remove trash, debris, and accumulated organic matter.
- Remove clippings after mowing.

4.3 Estimated Operation and Maintenance Budget

An operations and maintenance budget was prepared to approximate the annual cost of the inspections required in compliance with the DEP Stormwater Management Policy. The table below estimates the annual cost to inspect and maintain each proposed BMP, based on the requirements in Section 4.2.

BMP Type	# of BMPS	Annual O&M Cost (per BMP)[1]	Total Cost
Mosquito Control	1	\$50-\$100	\$50-\$100
Catch Basin	2	\$200-\$400	\$400-\$800
Water Quality Structure	1	\$100-\$300	\$100-\$300
Infiltration Basin	1	\$200-\$400	\$200-\$400
		Total	\$750-\$1600

[1] Annual maintenance cost is based on estimate of the cost to complete all inspection and maintenance measures outlined in Section 4.2. For BMPs that require sediment removal at regular intervals (i.e. every 5 or 10 years), the annual cost includes the annual percentage of that cost.

4.4 Public Safety Features

Multiple safety measures are proposed to protect the public and prevent pollutant contamination of the stormwater management system and other water resources. Proposed curbing, sidewalk, and tree plantings along the access driveway will prevent cars from inadvertently detouring down into the adjacent stormwater basin. It was designed to ensure protection to the public and prevent pollutant contamination of the stormwater management system and the municipal drainage system.

Figures

Refer to the Approved Definitive Subdivision Plans

Appendices

Appendix A

Operation and Maintenance Log

OPERATION AND MAINTENANCE LOG

This template is intended to comply with the operation and maintenance log requirements of the 2008 DEP Stormwater Management Handbook. Copies of this log should be made for all inspections and kept on file for three years from the inspection date.

Name/Company of Inspector:
Date/Time of Inspection:
Weather Conditions: (Note current weather and any recent precipitation events)

Stormwater BMP	Inspection Observations	Actions Required

Appendix B

List of Emergency Contacts

List of Emergency Contacts

Massachusetts DEP Hazardous Waste Incident Response Group
1-888-304-1133

Wareham Fire Department
Emergencies: Dial 911
273 Main Street
Wareham, MA 02571
Tel: (508) 295-2973
Fire Chief: Matt Rowley

Wareham Police Department
Emergencies: Dial 911
2515 Cranberry Highway
Wareham, MA 02571
Tel: (508) 295-9505
Chief of Police: John Walcek

Appendix C

Proprietary Separator Technical Manual

CONTECH® ENGINEERED SOLUTIONS

CDS Guide
Operation, Design, Performance and Maintenance

CDS®

Using patented continuous deflective separation technology, the CDS system screens, separates and traps debris, sediment, and oil and grease from stormwater runoff. The indirect screening capability of the system allows for 100% removal of floatables and neutrally buoyant material without blinding. Flow and screening controls physically separate captured solids, and minimize the re-suspension and release of previously trapped pollutants. Inline units can treat up to 6 cfs, and internally bypass flows in excess of 50 cfs (1416 L/s). Available precast or cast-in-place, offline units can treat flows from 1 to 300 cfs (28.3 to 8495 L/s). The pollutant removal capacity of the CDS system has been proven in lab and field testing.

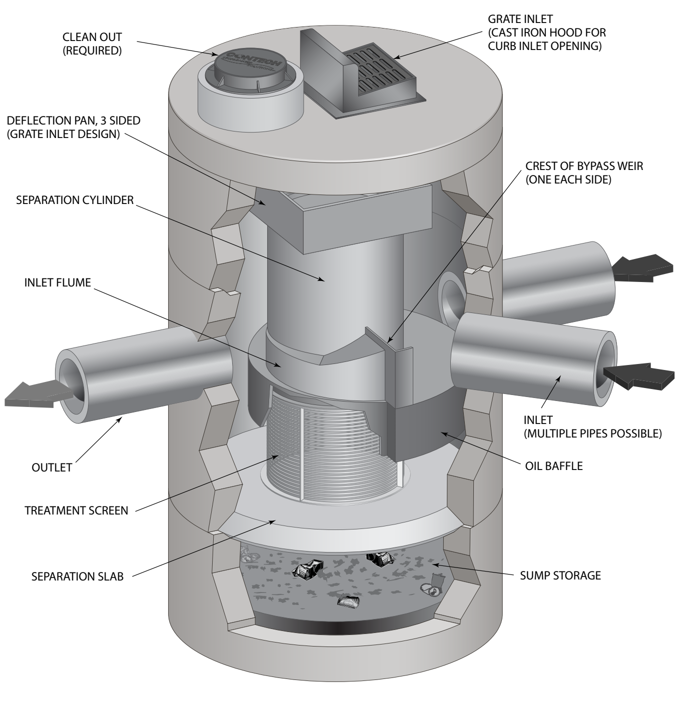
Operation Overview

Stormwater enters the diversion chamber where the diversion weir guides the flow into the unit's separation chamber and pollutants are removed from the flow. All flows up to the system's treatment design capacity enter the separation chamber and are treated.

Swirl concentration and screen deflection force floatables and solids to the center of the separation chamber where 100% of floatables and neutrally buoyant debris larger than the screen apertures are trapped.

Stormwater then moves through the separation screen, under the oil baffle and exits the system. The separation screen remains clog free due to continuous deflection.

During the flow events exceeding the treatment design capacity, the diversion weir bypasses excessive flows around the separation chamber, so captured pollutants are retained in the separation cylinder.



Design Basics

There are three primary methods of sizing a CDS system. The Water Quality Flow Rate Method determines which model size provides the desired removal efficiency at a given flow rate for a defined particle size. The Rational Rainfall Method™ or the and Probabilistic Method is used when a specific removal efficiency of the net annual sediment load is required.

Typically in the Unites States, CDS systems are designed to achieve an 80% annual solids load reduction based on lab generated performance curves for a gradation with an average particle size (d50) of 125 microns (μm). For some regulatory environments, CDS systems can also be designed to achieve an 80% annual solids load reduction based on an average particle size (d50) of 75 microns (μm) or 50 microns (μm).

Water Quality Flow Rate Method

In some cases, regulations require that a specific treatment rate, often referred to as the water quality design flow (WQQ), be treated. This WQQ represents the peak flow rate from either an event with a specific recurrence interval, e.g. the six-month storm, or a water quality depth, e.g. 1/2-inch (13 mm) of rainfall.

The CDS is designed to treat all flows up to the WQQ. At influent rates higher than the WQQ, the diversion weir will direct most flow exceeding the WQQ around the separation chamber. This allows removal efficiency to remain relatively constant in the separation chamber and eliminates the risk of washout during bypass flows regardless of influent flow rates.

Treatment flow rates are defined as the rate at which the CDS will remove a specific gradation of sediment at a specific removal efficiency. Therefore the treatment flow rate is variable, based on the gradation and removal efficiency specified by the design engineer.

Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydraulically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. The Rational Rainfall Method combines site-specific information with laboratory generated performance data, and local historical precipitation records to estimate removal efficiencies as accurately as possible.

Short duration rain gauge records from across the United States and Canada were analyzed to determine the percent of the total annual rainfall that fell at a range of intensities. US stations' depths were totaled every 15 minutes, or hourly, and recorded in 0.01-inch increments. Depths were recorded hourly with 1-mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Rainfall Method. Since most sites are relatively small and highly impervious, the Rational Rainfall Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS system are determined. Performance efficiency curve determined from full scale laboratory tests on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Probabilistic Rational Method

The Probabilistic Rational Method is a sizing program Contech developed to estimate a net annual sediment load reduction for a particular CDS model based on site size, site runoff coefficient, regional rainfall intensity distribution, and anticipated pollutant characteristics.

The Probabilistic Method is an extension of the Rational Method used to estimate peak discharge rates generated by storm events of varying statistical return frequencies (e.g. 2-year storm event). Under the Rational Method, an adjustment factor is used to adjust the runoff coefficient estimated for the 10-year event, correlating a known hydrologic parameter with the target storm event. The rainfall intensities vary depending on the return frequency of the storm event under consideration. In general, these two frequency dependent parameters (rainfall intensity and runoff coefficient) increase as the return frequency increases while the drainage area remains constant.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Method. Since most sites are relatively small and highly impervious, the Rational Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS are determined. Performance efficiency curve on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Treatment Flow Rate

The inlet throat area is sized to ensure that the WQQ passes through the separation chamber at a water surface elevation equal to the crest of the diversion weir. The diversion weir bypasses excessive flows around the separation chamber, thus preventing re-suspension or re-entrainment of previously captured particles.

Hydraulic Capacity

The hydraulic capacity of a CDS system is determined by the length and height of the diversion weir and by the maximum allowable head in the system. Typical configurations allow hydraulic capacities of up to ten times the treatment flow rate. The crest of the diversion weir may be lowered and the inlet throat may be widened to increase the capacity of the system at a given water surface elevation. The unit is designed to meet project specific hydraulic requirements.

Performance

Full-Scale Laboratory Test Results

A full-scale CDS system (Model CDS2020-5B) was tested at the facility of University of Florida, Gainesville, FL. This CDS unit was evaluated under controlled laboratory conditions of influent flow rate and addition of sediment.

Two different gradations of silica sand material (UF Sediment & OK-110) were used in the CDS performance evaluation. The particle size distributions (PSDs) of the test materials were analyzed using standard method "Gradation ASTM D-422 "Standard Test Method for Particle-Size Analysis of Soils" by a certified laboratory.

UF Sediment is a mixture of three different products produced by the U.S. Silica Company: "Sil-Co-Sil 106", "#1 DRY" and "20/40 Oil Frac". Particle size distribution analysis shows that the UF Sediment has a very fine gradation (d50 = 20 to 30 μm) covering a wide size range (Coefficient of Uniformity, C averaged at 10.6). In comparison with the hypothetical TSS gradation specified in the NJDEP (New Jersey Department of Environmental Protection) and NJCAT (New Jersey Corporation for Advanced Technology) protocol for lab testing, the UF Sediment covers a similar range of particle size but with a finer d50 (d50 for NJDEP is approximately 50 μm) (NJDEP, 2003).

The OK-110 silica sand is a commercial product of U.S. Silica Sand. The particle size distribution analysis of this material, also included in Figure 1, shows that 99.9% of the OK-110 sand is finer than 250 microns, with a mean particle size (d50) of 106 microns. The PSDs for the test material are shown in Figure 1.

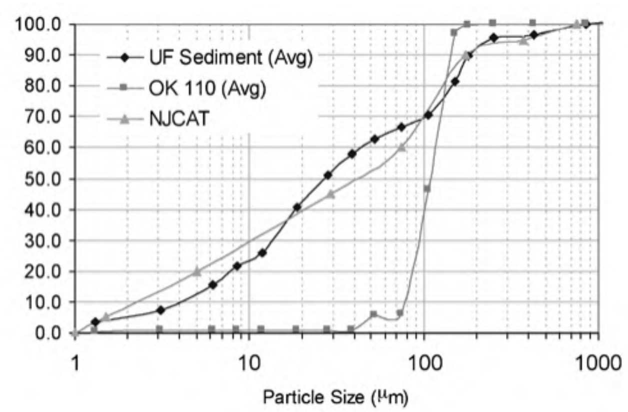


Figure 1. Particle size distributions

Tests were conducted to quantify the performance of a specific CDS unit (1.1 cfs (31.3-L/s) design capacity) at various flow rates, ranging from 1% up to 125% of the treatment design capacity of the unit, using the 2400 micron screen. All tests were conducted with controlled influent concentrations of approximately 200 mg/L. Effluent samples were taken at equal time intervals across the entire duration of each test run. These samples were then processed with a Dekaport Cone sample splitter to obtain representative sub-samples for Suspended Sediment Concentration (SSC) testing using ASTM D3977-97 "Standard Test Methods for Determining Sediment Concentration in Water Samples", and particle size distribution analysis.

Results and Modeling

Based on the data from the University of Florida, a performance model was developed for the CDS system. A regression analysis was used to develop a fitting curve representative of the scattered data points at various design flow rates. This model, which demonstrated good agreement with the laboratory data, can then be used to predict CDS system performance with respect to SSC removal for any particle size gradation, assuming the particles are inorganic sandy-silt. Figure 2 shows CDS predictive performance for two typical particle size gradations (NJCAT gradation and OK-110 sand) as a function of operating rate.

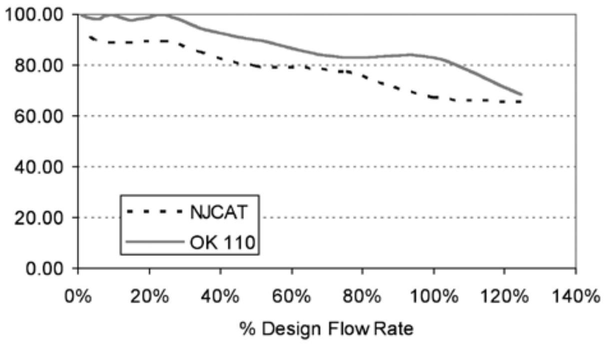


Figure 2. CDS stormwater treatment predictive performance for various particle gradations as a function of operating rate.

Many regulatory jurisdictions set a performance standard for hydrodynamic devices by stating that the devices shall be capable of achieving an 80% removal efficiency for particles having a mean particle size (d50) of 125 microns (e.g. Washington State Department of Ecology — WASDOE - 2008). The model can be used to calculate the expected performance of such a PSD (shown in Figure 3). The model indicates (Figure 4) that the CDS system with 2400 micron screen achieves approximately 80% removal at the design (100%) flow rate, for this particle size distribution (d50 = 125 μm).

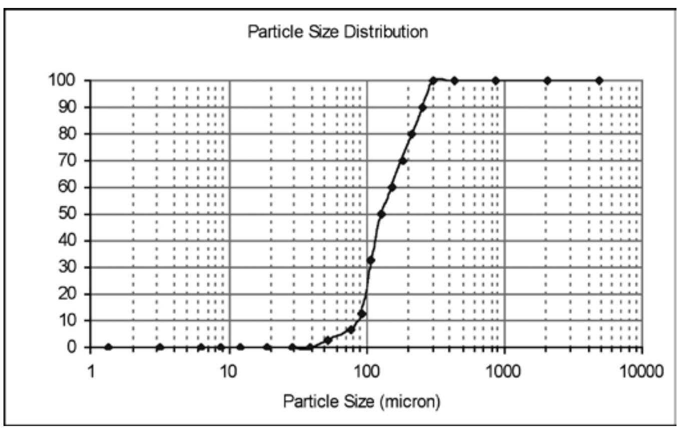


Figure 3. WASDOE PSD

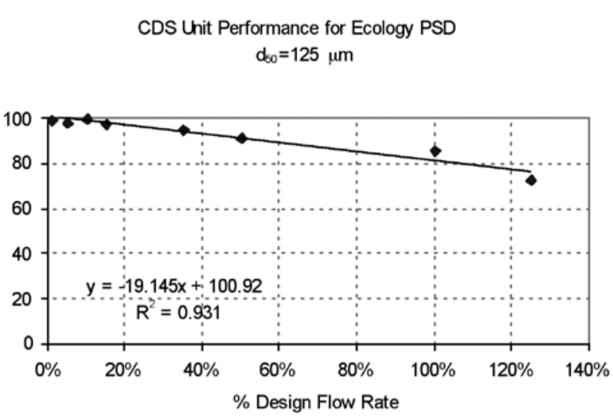


Figure 4. Modeled performance for WASDOE PSD.

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.

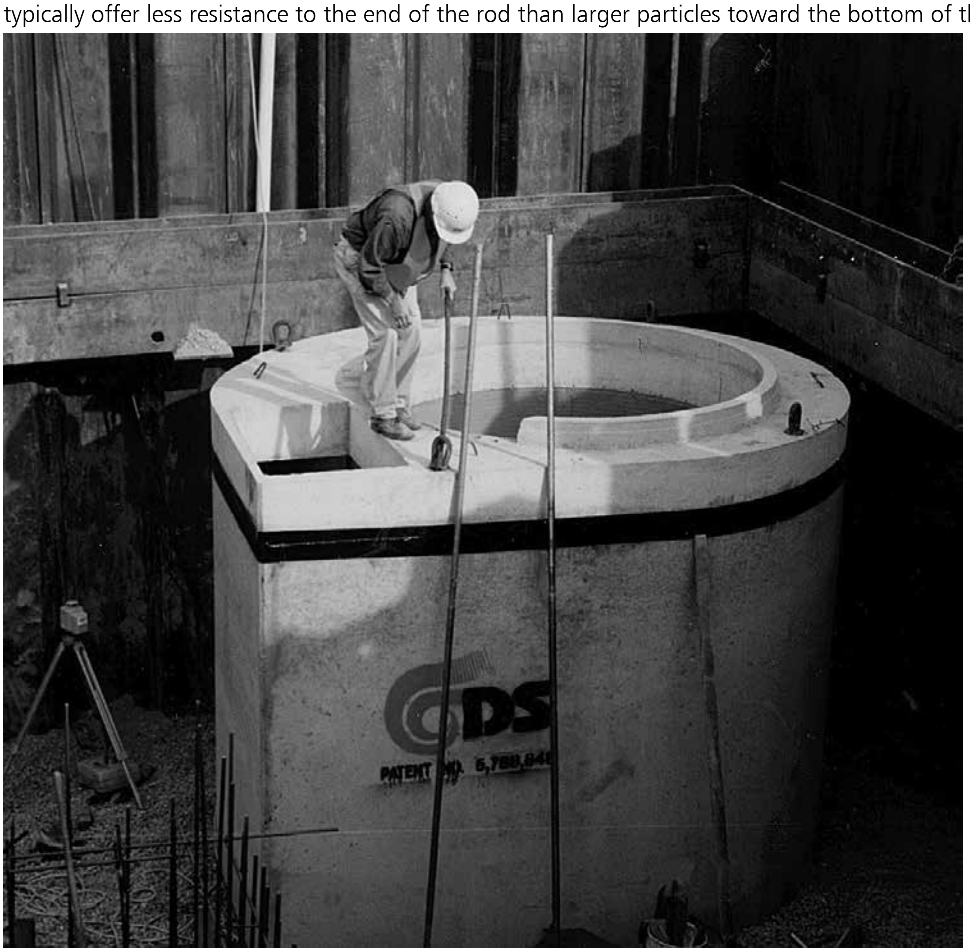
In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill. Motor oil and other hydrocarbons that accumulate on a more routine basis should 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 cleaned 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. Check your local regulations for specific requirements on disposal.

CDS Model	Diameter		Distance from Water Surface to Top of Sediment Pile		Sediment Storage Capacity	
	ft	m	ft	m	y^3	m^3
CDS1515	3	0.9	3.0	0.9	0.5	0.4
CDS2015	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
CDS3025	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

Note: To avoid underestimating the volume of sediment in the chamber, carefully lower the measuring device to the top of the sediment pile. Finer silty particles at the top of the pile may be more difficult to feel with a measuring stick. These finer particles typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.



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.

SUPPORT

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

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