STORMWATER MANAGEMENT REPORT

Ashumet Boat Ramp - Falmouth, MA

November 2023

Cape Cod Boat Ramp Stormwater Retrofit Project

Partner: Association to Preserve Cape Cod
Owner: Massachusetts Office of Fishing and Boating Access
Owner: Town of Falmouth

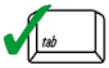
Horsley Witten Group

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

Checklist for Stormwater Report

A. Introduction

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



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

The Stormwater Report must include:

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

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

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

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

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

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

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

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

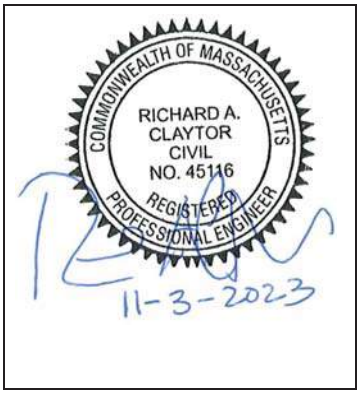
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature



Signature and Date

Checklist

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

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

- ☐ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☒ Reduced Impervious Area (Redevelopment Only)
- ☒ Minimizing disturbance to existing trees and shrubs
- ☐ LID Site Design Credit Requested:
  - ☐ Credit 1
  - ☐ Credit 2
  - ☐ Credit 3
- ☐ Use of "country drainage" versus curb and gutter conveyance and pipe
- ☒ Bioretention Cells (includes Rain Gardens)
- ☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- ☐ Treebox Filter
- ☐ Water Quality Swale
- ☒ Grass Channel
- ☐ Green Roof
- ☒ Other (describe): Porous Pavement, Public Education Signage

Standard 1: No New Untreated Discharges

- ☒ No new untreated discharges
- ☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☐ Static ☒ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

Standard 9: Operation and Maintenance Plan

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

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

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

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

Standard 10: Prohibition of Illicit Discharges

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

☐ An Illicit Discharge Compliance Statement is attached;

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

STORMWATER MANAGEMENT REPORT

ASHUMET BOAT RAMP
CAPE COD BOAT RAMP STORMWATER RETROFIT PROJECT
FALMOUTH, MA

Table of Contents

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

The purpose of this report is to describe existing and proposed site drainage conditions at the Ashumet Boat Ramp, as well as measures to prevent stormwater pollution during and after construction. This project is part of a regional effort led by the Association to Preserve Cape Cod (APCC) to improve water quality at public boat ramps on Cape Cod by implementing green stormwater infrastructure (GSI) retrofits. The main goal for this site is to better manage and treat stormwater runoff from the parking lot and boat ramp access road prior to entering Ashumet Pond. The project also aims to provide public outreach on the benefits of GSI and overarching watershed issues using interpretive signage.

The project includes the following structural and non-structural stormwater control measures (SCMs):

- Sediment Forebays for Pretreatment
- Bioretention Areas for Treatment
- Porous Pavement and Pavement Reduction
- Buffer Restoration
- Public Educational Signage

Since the proposed stormwater management system is a retrofit project undertaken solely to improve water quality at the site, it falls under the redevelopment category in accordance with the Massachusetts Stormwater Management Standards (MASMS 2008), as described in Massachusetts Stormwater Handbook, Volume 1 Chapter 1. As a redevelopment project, the design is required to meet the MASMS standards to the maximum extent practicable (MEP).

As shown in **Table 1,** the proposed project meets or exceeds each standard**,** except the water quality and water quantity standard, which is met to the MEP. The goal of the proposed treatment SCMs (bioretentions) designs are to capture and treat the full one inch of runoff of their contributing drainage areas. Due to space constraints, one of the SCMs is slightly undersized. Additionally, a small portion of the site could not be captured due to site constraints (the boat ramp area). Overall, this project will significantly improve conditions at the Ashumet Boat Ramp and reduce on-going impacts to Ashumet Pond.

Table 1. Project MASMS Compliance Summary

	Minimum Standard	Type	Compliance	Report Reference(s)
1	**New Stormwater Conveyances**	Narrative	Yes	Section 3.2
2	**Water Quantity**	Calculation	MEP	Section 4.3/Table 7/Appendix B
3	**Recharge**	Calculation	Yes	Section 4.2/Table 6/Appendix B
4	**Water Quality**	Calculation	MEP	Section 4.1/Table 4/Table 5/Appendix B
5	**Land Uses with Higher Potential Pollutant Loading**	Narrative	Not Applicable	Section 2.0
6	**Critical Areas**	Narrative	Not Applicable	Section 2.3
7	**Redevelopment**	Narrative	Yes	Section 4.0
8	**Erosion Control**	Narrative	Yes	Section 4.4/Appendix G
9	**Operation and Maintenance**	Narrative	Yes	Section 4.5/Appendix E
10	**Illicit Discharges**	Narrative	Yes	Section 4.6

1.0 INTRODUCTION

This report provides a summary of the stormwater management systems proposed for the Ashumet Boat Ramp in Falmouth, MA, a State-owned, Town-operated boat ramp (**Figure 1**). The Massachusetts Office of Fishing and Boating Access (MA OFBA) and the Falmouth Department of Marine and Environmental Services (MES) are proposing this project in collaboration with the Association to Preserve Cape Cod (APCC) as a part of a regional effort (Cape Cod Boat Ramp Stormwater Retrofit Project) to improve water quality at public boat ramps across Cape Cod. The proposed project has been designed to retrofit existing impervious areas for water quality improvements while also improving overall site conditions. This report describes the existing and proposed site conditions and the practices to be implemented to reduce stormwater discharges and pollutants during and after construction. As required for retrofit projects, the stormwater system for the project has been designed to conform to the requirements of the Massachusetts Stormwater Standards (MASMS) to the maximum extent practicable.

1.1 Background

Freshwater ponds and coastal embayments across Cape Cod are significantly degraded by nutrient and bacteria impairment. Land uses, including stormwater runoff and fertilizer use, contribute on average 20% of the controllable nitrogen load within our coastal watersheds (Cape Cod Commission 208 Plan, 2015) and bacterial contamination, including cyanobacteria, regularly causes closures of beaches. In report (APCC's 2022 State of the Waters), 90% of the coastal embayments and 39% of the freshwater ponds assessed received unacceptable water quality scores. These high nutrient loads are of concern for the environment, our coastal economy, and public health as they negatively impact habitat for fish and shellfish and can result in unsafe conditions for swimming, fishing, and boating. Public boat ramps are a common source of pollution in areas of high recreational use. As such, these locations have been targeted by APCC's regional project.

As part of an EPA Southeast New England Program (SNEP) Watershed Grant, APCC and partners first identified 20 public boat ramps across 10 Cape Cod towns in need of improved stormwater management. Concept designs for each of these twenty sites were ranked based on various criteria including potential pollutant removal (i.e., load and drainage area), water quality status of the associated waterbody, construction cost and feasibility, and additional human use and resource benefits (restored shellfish and anadromous fish habitat, proximity to environmental justice communities, improved climate resiliency, opportunity for public education, etc.). With additional funding from a CZM FY23 Coastal Habitat and Water Quality Grant, 25% and 75% designs were developed for seven high-ranking priority sites, including this one at Ashumet Pond, Falmouth, MA. This project is focused on the parking lot, driveway, and pond buffer of the boat ramp site, but not upgrades to the ramp itself.

1.2 Project Goals

The purpose of this project is to improve water quality in Ashumet Pond by reducing or eliminating pollutant loads from stormwater runoff at the public boat ramp using green stormwater infrastructure (GSI) stormwater control measures (SCMs). Specifically, the project aims to maximize pollutant removal

(% bacteria, nitrogen and phosphorus) and water quality volume treated, improving this freshwater fish resource.

1.3 Design Methodology

The design was completed by the following tasks:

- Preliminary field assessment of the site and contributing drainage area to identify usage, physical and environmental constraints and opportunities, and long-term operation and maintenance concerns
- Determination of drainage areas and land coverage within the project area
- Selection of structural and non-structural SCMs best suited to site conditions and project goals
- Structural SCM sizing and performance estimates (described further below)
- Hydrologic/Hydraulic Modeling (described further below)
- Grading and layout of site plan
- Erosion control plan development
- Operation and maintenance (O&M) plan development

SCM Performance Estimates

The proposed SCMs were selected and sized to maximize pollutant load removals. Since the waterbody this site drains to has water quality impairments, the SCMs were chosen to maximize not only total suspended solids (TSS) removal, but total phosphorus (TP), total nitrogen (TN), and bacteria load reductions as well. MASMS was used as a reference for TSS removal estimates for bioretentions, but the more recently developed pollutant load removal curves (USEPA 2021 & Paradigm Environmental 2019) were used for TP, TN, and bacteria.[1]

Hydrologic/Hydraulic Modeling

Existing and proposed conditions for the project area were modeled using HydroCAD software, which combines USDA Soil Conservation Service hydrology and hydraulic techniques (commonly known as SCS TR-55 and TR-20) to generate hydrographs. Conditions were evaluated for the water quality event (storm that produces 1 inch of runoff, or a roughly 1.2-inch rain event) as well as larger storm events, including the 2-, 10-, 25- and 100-year 24-hour Type III storm events. The rainfall depths used for each storm event are the NOAA+ values (NOAA Atlas 14 90% Upper Confidence value multiplied by 0.9) (NOAA NWS, 2017). Rainfall values are included in **Appendix A**.

2.0 Existing Conditions

The Ashumet Boat Ramp is a popular water access point for Ashumet Pond. The site is located within a mile of a mapped minority and income environmental justice population (**Figure 3**). As a State-owned boat ramp through the MA OFBA, the area is intended for fishing and boating purposes only – users are

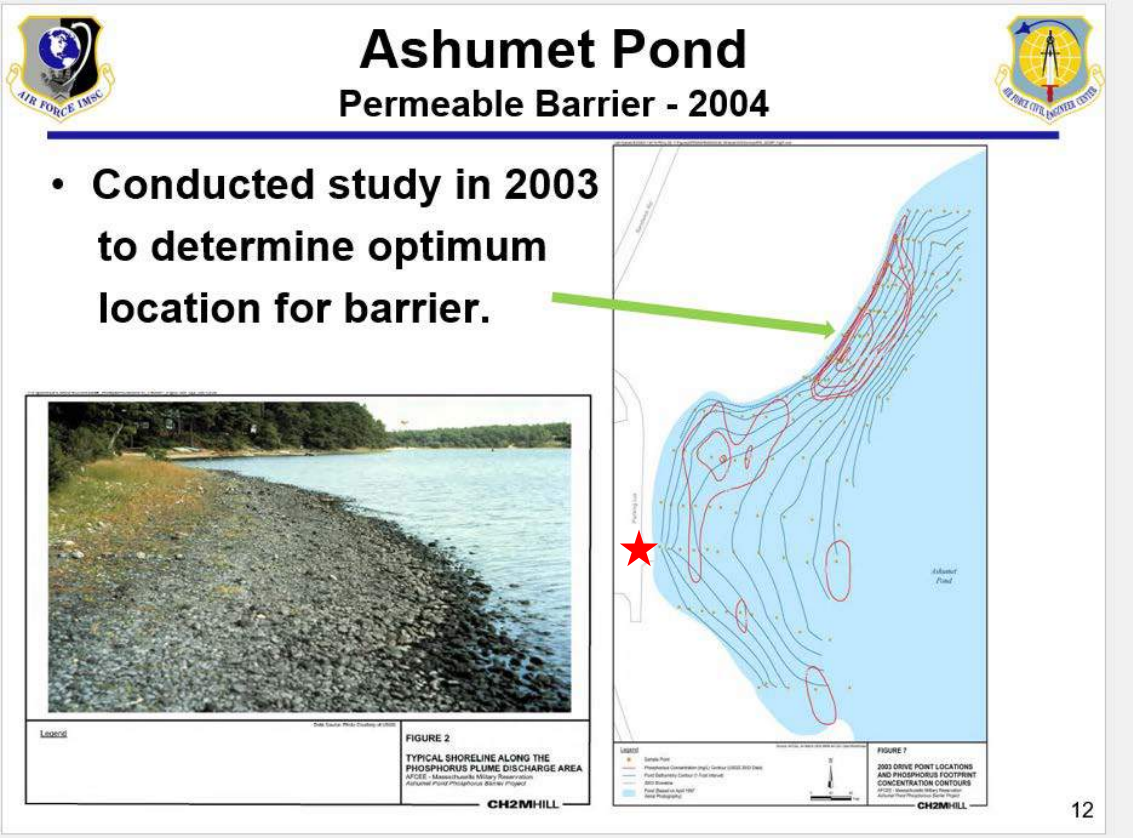
[1] It is important to note that these curves have a crosswalk to help users determine which specific curve to reference: for infiltrating bioretentions (no liners/underdrains), the appropriate curve is the Surface Infiltration (Soil infiltration rate = 2.41 in/hr) Performance Curve.

not meant to use the area around the boat ramp as a beach. This land use is not classified as a land use with higher potential pollutant loads (LUHPPL) and thus, is not subject to MASMS **Standard 5**.

The project site includes a parking area and a one-lane boat ramp accessed by a driveway off Sandwich Road (**Figure 2**) – the access drive is partially within Town-owned right-of-way while the remainder of the site is on State-owned property. The parking area has a drive aisle with parking on only one side, including 26 trailer spaces and 2 additional handicap-accessible trailer spaces. The existing pavement at the site is aging, with visible cracks and spalling throughout. There is a USGS groundwater monitoring well located at the sound end of the parking lot. There is no existing stormwater management infrastructure nor other utilities at this site. Ramp users are currently using the pond buffer on both sides of the ramp for loading, unloading, and beach activity.

The project site is also the location of remediation activities to reduce impacts from a phosphorus plume from Joint Base Cape Cod (JBCC) Wastewater Treatment Plant, which operated from 1936-1995, as well as stormwater drainage systems from the base (Davis, 2022). Specifically, a permeable reactive barrier (PRB) (also called a geochemical barrier) was installed in 2004 just to the north of our project site (see below). A JBCC representative reviewed the proposed soil test pit locations prior to that work and determined that the PRB would not be impacted (Forbes pers comm, 2023).

Excerpt from powerpoint presentation showing location of permeable reactive barrier relative to the boat ramp, which is indicated with a red star (Davis, 2022)



2.1 Receiving Water and Watershed

Ashumet Boat Ramp discharges stormwater into Ashumet Pond, a groundwater-fed kettle pond with no outlet. The pond is in the Cape Cod Watershed and is popular for fishing as it is stocked with trout in the spring and fall. However, it is listed as impaired (Category 5 – TMDL required) for dissolved oxygen, mercury, total phosphorus, and abnormal fish deformities, erosions, lesions, tumors by the most recent Massachusetts DEP 303(d) – 2018/2020 Integrated list of Waters (MA96004) (**Figure 4**), and APCC's State of the Waters Report lists it as unacceptable for nutrient loading.

2.2 Drainage Area

The boat ramp's existing contributing drainage area is approximately 1.53 acres (DA1). Just over half of the drainage area is impervious cover (0.78 acres). The entirety of DA1 directly drains to the boat ramp, modeled as Study Point 1 (SP1). See the existing conditions drainage area map and a detailed breakdown of land cover in **Appendix A,** as well as the existing HydroCAD model report in **Appendix B.**

2.3 Resource Areas

HW wetland biologists delineated several resource areas at the site in December 2022. A full description of these resource areas is included in **Appendix C**, and their locations and associated buffers are shown on the plans in **Appendix G**. The wetland resource areas include Bank; and the 75-Foot Buffer Zone A No Disturb Area and the 100-foot Buffer Zone B outer buffer to Bank. Additional resource areas present adjacent to the site include Land Under Waterbodies and Waterways (LUW). Bank is present around the perimeter of Ashumet Pond. There were invasive species observed in the wooded areas of the site. These include gray willow and multiflora rose.

According to the most recent version of the *Massachusetts Natural Heritage Atlas* (15th Edition, August 1, 2021), portions of the site lie within areas of *Estimated Habitat of Rare Wildlife and Certified Vernal Pools* (EH 377) and/or *Priority Habitat of Rare Species* (PH 280) as designated by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) (**Figure 3**). The area is not located within a FEMA Flood Hazard Zone, as shown in the wetland memo (**Appendix C**). Since the site does not discharge near a public beach area, shellfishing area and/or anadromous fish run, it is not considered a critical area and is not subject to MASMS **Standard 6**.

2.4 Soils

Soils data from the Natural Resources Conservation Service (NRCS) indicate that the soils within the drainage area to the site are composed of Merrimac fine sandy loam, 3-8% slopes. The entire drainage area (1.53 acres) is within this one soil type and is classified as hydrologic soil group (HSG) A.

Two test pits were conducted at the site on January 31, 2023 to evaluate subsurface conditions and estimated seasonal high groundwater (ESHGW) based on evidence of mottling or redox. Test pits were conducted just off pavement in two areas: the hillside off the southwest corner of the parking lot, and just south of the entrance drive. The parent material of the native soil unit, Merrimac Fine Sandy Loam, is loamy glaciofluvial, comprising mostly outwash plains, terraces, and moraine landforms. The test pits

were witnessed and logged by an HW Massachusetts Title 5 Approved Soil Evaluator; results are shown in **Table 2** below. In TP-1, redoximorphic mottling was observed at an elevation of 46.4', and seepage was observed at an elevation of 43.7'. No groundwater features were observed in TP-2. See **Appendix D** for soil test pit logs.

Table 2. Test Pit (TP) Results

Test Pit ID	Surface Elevation (ft)	Pit Bottom Elevation (ft)	ESHGW Elevation (ft)	Soil Texture(s)	Design Infiltration Rate (in/hr)	Notes
TP-1	56.4	43.4	46.4	Medium Sand	8.27	Redox 120"
TP-2	60.4	50.4	50.4	Medium Sand	8.27	No GW

Since Ashumet Pond is a kettle pond with no outlet, during wet months/years, the pond will be much higher than during average or dry month/years. Thus, during those times, the groundwater at the site will be similarly quite a bit higher. The U.S. Geological Survey (USGS) has a monitoring well on site close to the boat ramp itself. The data on this well (MA-FSW 239-0121) was obtained from the USGS website. The data includes monthly readings for the past 30 years. Due to its close proximity to Bioretention 1, this data was used to determine more typical groundwater elevations rather than the extreme high. For this retrofit design at Bioretention 1, we used the median groundwater elevation to better represent the conditions at the site for the majority of the time; results are shown in **Table 3** below. See **Appendix D** for the monitoring well data.

Table 3. Monitoring Well MA-FSW 239-0121 data statistics

Well #	Surface Elevation	Lowest Water Elevation	Median Water Elevation	Highest Water Elevation
MA-FSW 239-0121	50.0	41.7	43.8	46.8

3.0 Proposed Conditions

The proposed project consists of the following stormwater and related site development improvements:

- Resurfaced parking lot and boat ramp access road to better direct runoff while maintaining current parking spaces and required drive aisle and parking space dimensions;
- GSI including bioretention areas and porous asphalt;
- Reduction in overall impervious cover;
- Buffer restoration; and
- Protection of as many existing mature trees as possible.

The proposed GSI system is designed to meet the following major objectives:

- Capture, treat, and infiltrate at least the first one inch of runoff; and
- Engage the community with interpretive signage.

3.1 Drainage Areas

The boat ramp's contributing drainage area under proposed conditions is the same as existing, with a total of approximately 1.53 acres. However, the proposed project is reducing impervious cover by roughly 4,500 square feet, dropping the total impervious cover just below 50%. The drainage area (DA1) was subdivided for the proposed conditions in order to model flows to the proposed SCMs. The proposed DA1 drainage areas are DA1A (Parking Lot), DA1B (Entrance), and DA1C (Boat Ramp). The proposed SCMs were added as "ponds" in the HydroCAD model. The proposed porous asphalt was modeled with a reduced curve number (CN = 40) per the Rhode Island Stormwater Design and Installation Standards Manual (2015). The entire drainage area continues to discharge runoff to Study Point 1 (SP1).

See the proposed conditions drainage area map and a detailed breakdown of land cover in **Appendix A,** as well as the proposed HydroCAD model report in **Appendix B.**

3.2 Structural Stormwater Control Measures (SCMs)

The proposed stormwater management includes a GSI approach to capture, treat, infiltrate, and detain runoff by using the following SCMs. There are two stormwater GSI practices proposed throughout the site – both of which are bioretention areas. Pretreatment will be provided with sediment forebays, and overflows from large storm events will flow out of the SCM inlets and/or an overflow structure. Additionally, porous pavement is proposed for a portion of the parking lot to increase infiltration and reduce runoff. The stormwater management systems were designed to meet **Standard 1**, so that no new untreated stormwater runoff will be directed to any off-site areas or resource areas. Runoff from contributing impervious areas will be treated by the proposed practices.

Sediment Forebays

Porous sediment forebays are provided for pretreatment of the runoff from the paved surfaces to allow for sediment and other debris to settle out prior to conveyance into the bioretention areas.

Bioretention Areas (BIO)

A bioretention area (BIO) is a shallow depression used to treat stormwater runoff using a specific planting soil and plants to filter runoff. The method combines physical filtering and adsorption with bio-geochemical processes to remove pollutants. The system consists of an inflow component, a pretreatment element, a shallow ponding area planted with appropriate native plant species (tolerant to both wet and dry periods as well as other site conditions such as wind, salt, shade, etc.), an overflow structure, and an emergency overflow weir. Some BIOs located in areas with poor drainage or high groundwater are lined and/or have underdrains, while others located in sandy soils greater than 2 feet above ESHGW can just infiltrate the treated runoff.

Two infiltrating BIOs are proposed for the parking lot and driveway. These BIOs capture, treat, and infiltrate up to the first inch of runoff from the contributing drainage areas. Due to space constraints BIO-1 was designed to treat 98% of the first inch of runoff, while BIO-2 is able to treat the full first inch.

During larger storm events, BIO-2 overflows back into the driveway and flows to BIO-1. BIO-1 has a drawdown structure that discharges treated runoff via a perforated pipe to Ashumet Pond. BIO-2 has greater than 2-feet separation to ESHGW as required. Depending on the fluctuating pond/groundwater elevation as described above, the subbase layers of BIO-1 may be in groundwater infrequently, but during more typical conditions, will meet the 2-foot separation. The BIOs will be planted with low-maintenance, native plantings tolerant of the varied site conditions. Plants were selected based on input from the Falmouth Conservation/MES Tech.

Porous Pavement

Porous pavement is designed to capture and infiltrate runoff while providing the stability of traditional pavement. The system consists of the pervious layer over a layer of crushed stone and sand filter. A portion of the runoff falling directly on the porous pavement will infiltrate, reducing overall runoff. At this site, porous pavement (3,600 sf) has been proposed for the trailer parking (10 spaces) furthest from the boat ramp, which are assumed to be the least frequently used spaces. These porous pavement spaces have also been designed to prevent "run-on" from the adjacent typical asphalt pavement, as this can lead to premature clogging.

3.3 Non-structural SCMs

The non-structural SCMs proposed at the site include buffer restoration, pavement reduction and public educational signage. Approximately 4,000 sf of buffer planting is being added to the bank of the pond to improve habitat and resiliency and prevent users from beaching in the area. Approximately 5,000 sf of pavement is proposed to be removed, and 3,600 sf of pavement will be converted to porous pavement, reducing the overall runoff volume. In addition, an interpretive sign is proposed south of the boat ramp. This sign will explain the GSI at the site as a part of the larger watershed issues discussed above and encourage GSI actions at home.

4.0 Stormwater Design Components

The proposed SCMs were designed to meet a variety of goals and regulatory requirements as discussed above. As a retrofit project for managing existing impervious cover, this design must specifically comply with the redevelopment standard (MASMS **Standard 7)** by meeting all standards to the maximum extent practicable. The project fully meets this standard, as described in detail below.

4.1 Water Quality

The main purpose of this retrofit project is to improve water quality. This section describes the treatment volumes and pollutant load reductions achieved by the proposed design and how they compare to the MASMS standards.

Treatment Volume

Per **Standard 4** of MASMS, the stormwater management system for a new development site within soils with a rapid infiltration rate (greater than 2.4 inches per hour) must be sized to treat the first one inch of runoff and remove 80% or more of the annual post-construction load of total suspended solids (TSS). As

a retrofit (falls under **Standard 7** - Redevelopment), the project is only required to meet this to the maximum extent practicable. However, the proposed bioretention areas were sized to treat nearly the full one-inch water quality volume (WQv) for their contributing drainage areas, and only a small portion of the site could not be captured and treated (DA1C-Boat Ramp). The proposed HydroCAD model results showing treatment of the water quality volume are included in **Appendix B** and summarized below in **Table 4**.

Table 4. Compliance with Water Quality Volume Requirements

DA ID	SCM ID	IA* (ac)	WQv Goal (ac-ft)	WQv Provided (ac-ft)**	% WQv Provided	Meets Requirement?	Notes
DA1A	BIO-1	0.40	0.034	0.0334	98%	MEP	Bioretention treats 98% of 1-inch runoff
DA1B	BIO-2	0.15	0.013	0.013	100%	Y	Bioretention treats 1-inch runoff
DA1C	NA	0.03	0.003	0	0%	MEP	Boat Ramp not captured for this retrofit project given space and land use
TOTAL SITE:		**0.59**	**0.050**	**0.046**	**93%**	**MEP**	**MEP for Retrofit Projects**

**Impervious Area (IA)*
***From HydroCAD results – see Attachment B for volume "discarded" for WQv Event*

Pollutant Load Reductions

The bioretention areas exceed the MASMS requirements for TSS removal and maximize removals of the other pollutants of concern. Estimated TSS, phosphorus, nitrogen, and bacteria removals for the proposed project are provided in **Table 5.** The proposed O&M Guide in **Appendix E** was developed to ensure that the stormwater system continues to function as it was designed into the future to maintain these levels of pollutant removal.

Table 5. Compliance with Water Quality Pollutant Load Reduction Requirements

DA ID	SCM ID	IA* (ac)	WQv Provided (ac-ft)**	Runoff Depth Treated (in)	TSS Removal (%)***	TP Removal (%)****	TN Removal (%)****	Bacteria Removal (%)*****	Meets Reqt?
DA1A	BIO-1	0.40	0.034	0.98	88%	98%	100%	100%	Y
DA1B	BIO-2	0.15	0.013	1.0	90%	98%	100%	100%	Y
DA1C	NA	0.03	0.000	0.0	0%	0%	0%	0%	MEP
TOTAL SITE:		**0.59**	**0.046**	**1.0**	**89%**	**98%**	**100%**	**100%**	**MEP**

**Impervious Area (IA)*
***From HydroCAD results – see Attachment B for volume "discarded" for WQv Event*
****From MASMS*
*****From MS4 NPDES Permit Appendix F Attachment 3 (USEPA 2021)*
******From Paradigm Environmental (2019)*

Long-term Pollution Prevention Plan

Source control is important to ensure long-term functionality of the proposed SCMs and protect downstream resources and habitat. A long-term pollution prevention plan specific to this site is provided as a part of the O&M Guide in **Appendix E**.

4.2 Recharge

Infiltrating treated runoff into the underlying native sands is a goal of this project. For new development projects, the MASMS requires a specific annual "recharge" volume (Rev) based on the HSG of the soil covered by new impervious surfaces, with a higher volume required for sandy soils (HSG A) and lower for silty, clayey soils (HSG D). This project is only required to provide infiltrate or recharge to the maximum extent practicable as a redevelopment project, as there is already pavement at the site.

However, the proposed SCMs actually provide more than required by **Standard 3**. A majority of stormwater runoff at the site is being directed to infiltrating bioretention systems in comparison to the existing conditions where runoff is mostly directly draining to the pond. Additionally, approximately 3,600 sf of porous pavement has been proposed within DA1A to provide infiltration and reduce runoff going to BIO-1.

Another requirement of **Standard 3** is that infiltrating SCMs must fully drain in 72 hours. The proposed HydroCAD model results showing nearly full recharge of the first inch of runoff by the bioretentions and the drawdown times (from full basins to empty) are included in **Appendix B** and summarized below in **Table 6.**

Table 6. Compliance with Recharge Requirements

DA ID	SCM ID	IA* (ac)	Soil HSG	Required Recharge Depth (in)	Rev Goal (ac-ft)	Rev Provided (ac-ft)**	% Rev Provided	Draw-down Time (hrs)***	Meets Reqt?	Notes
DA1A	BIO-1	0.40	A	0.6	0.020	0.034	168%	12	Y	Bioretention and Porous Pavement treats 98% of 1-inch runoff
DA1B	BIO-2	0.15	A	0.6	0.008	0.013	168%	12	Y	Bioretention recharges full 1-inch runoff
DA1C	NA	0.03	A	0.6	0.002	0	0%	NA	NA	Boat Ramp not captured for this retrofit project given space and land use
TOTAL SITE:		**0.59**			**0.03**	**0.047**	**159%**		Y	**Exceeds Requirement for Site**

**Impervious Area (IA)*

***From HydroCAD results – see Attachment B for volume "discarded" for WQv Event*

****From HydroCAD results – see Attachment B for hydrograph showing time from peak elevation to fully drained basins (WQv Event)*

4.3 Water Quantity

The main goal of this project is to improve water quality and habitat, but reducing water quantity impacts during large storm events was also prioritized. The bioretention areas, porous pavement, and reduction of pavement contributed to reducing peak flows and runoff volumes for the 2-, 10-, 25- and 100-year storms. The existing and proposed HydroCAD model results for these larger storm events are included in **Appendix B,** and the resulting peak flows and runoff volumes are summarized below in **Table 7** for both existing (EX) and proposed (PR) conditions. These results show that the proposed improvements will reduce peak flows and runoff volumes for all evaluated storms, and thus, fully meet the requirements of **Standard 2** of the MASMS.

Table 7. Summary of Existing and Proposed Condition Peak Flow Rates and Runoff Volumes

Study Point		Peak Flow, cfs				Runoff Volume, acre-ft			
		2-yr	10-yr	25-yr	100-yr	2-yr	10-yr	25-yr	100-yr
SP1	EX	2.88	4.25	5.26	7.04	0.224	0.341	0.433	0.593
	PR	0.67	2.42	3.52	5.18	0.069	0.138	0.199	0.321
Reduction	**%**	***77%***	***43%***	***33%***	***26%***	***69%***	***60%***	***54%***	***46%***

4.4 Erosion Control

Controlling erosion and sedimentation from the construction site is important to meet the overall water quality goals of this retrofit project, as well as to meet MASMS **Standard 8**. Given this site's size (> 1 acre of disturbance), a full Stormwater Pollution Prevention Plan (SWPPP) is required as part of the NPDES Construction General Permit and will be submitted by the contractor prior to construction. However, planning for effective erosion and sediment controls (ESCs) was important to this project's design, and so an ESC Plan is included in the design plans (**Appendix G**), along with a detailed sequence of construction activities and ESC notes. Visibility fence and/or silt socks are proposed at the limit of work to protect off-site areas and trees; silt socks are proposed along the downgradient edges of the area of disturbance. Additionally silt fence is proposed along the top of the boat ramp to create a sediment trap. A construction entrance will be installed to minimize tracking onto Sandwich Road. Areas for other sediment traps/basins have been identified for when the pavement is removed from the parking lot, exposing a large area of soil. Disturbed areas will be stabilized as soon as possible to minimize erosion and sedimentation with pavement, seeding and/or erosion control blankets, if necessary. A Pollutant Controls During Construction guide is also included in **Appendix F** that discusses these controls in more detail. With these layered ESCs implemented throughout the site, discharge of sediment-laden runoff during construction should be minimized to the maximum extent practicable.

The contractor will be required to establish these erosion controls prior to beginning any other project-related work. The ESC Plan will also establish the limit of work, beyond which the contractor will not be allowed to perform any work. It is the contractor's responsibility to monitor and correct erosion control practices throughout the duration of the project. Erosion control measures will not be removed until the project reaches completion as directed by the project engineer or landscape architect.

4.5 Operation and Maintenance

Ongoing maintenance is vital for long-term success at the site. All SCMs were designed to be low-maintenance in nature. These SCMs will be operated and maintained appropriately during construction and post-construction as required on the construction drawings and O&M Guide per MASMS **Standard 9** (**Appendix E and G**).

4.6 Illicit Discharges

There will be no illicit discharges to the existing system by the proposed project per MASMS **Standard 10**. The Long-Term Pollution Prevention Plan in the O&M Guide (**Appendix E**) includes measures to prevent future illicit discharges.

5.0 REFERENCES

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FIGURES

Horsley Witten Group
Sustainable Environmental Solutions

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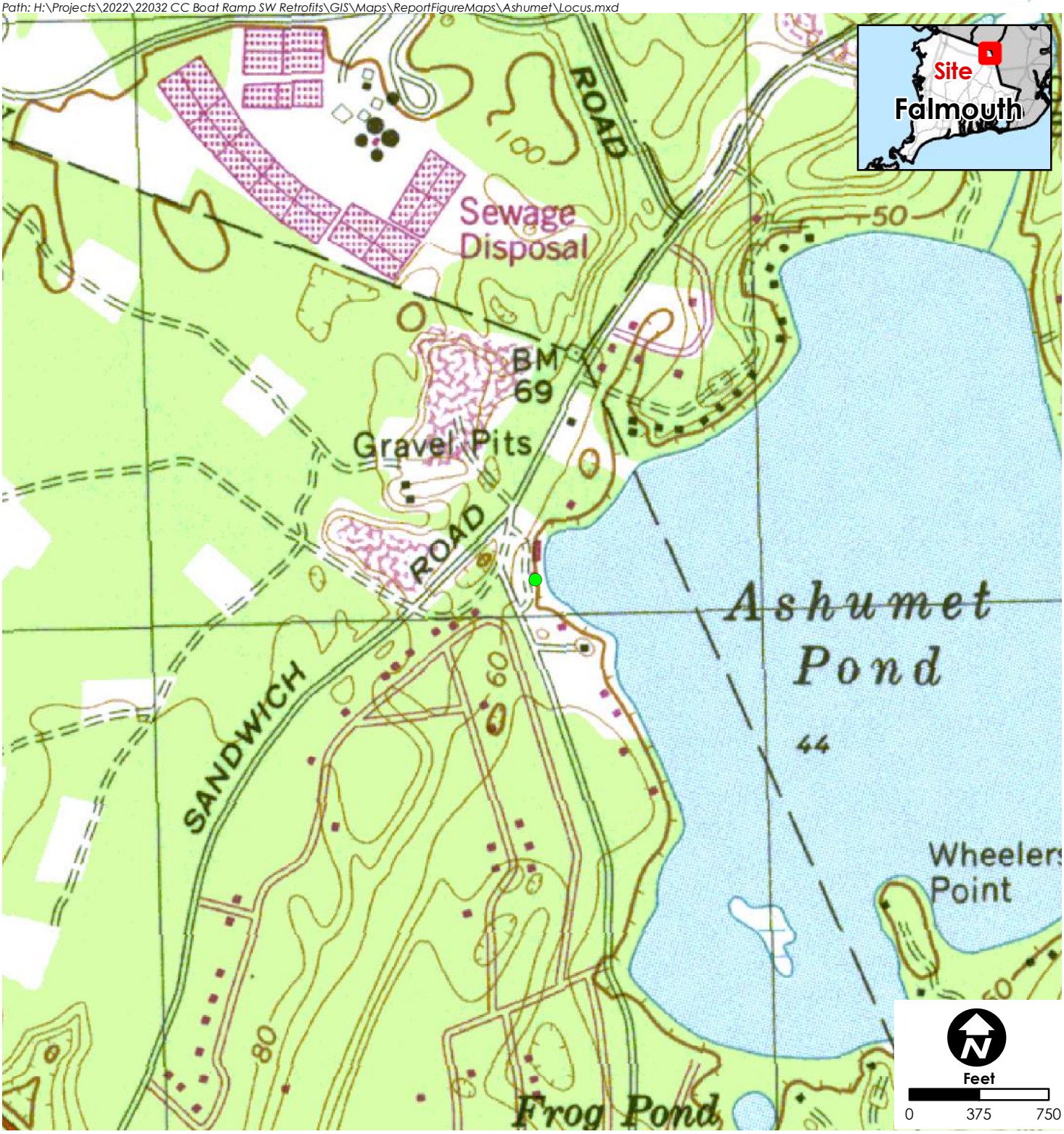

Date: 8/10/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

● Ashumet Pond Boat Ramp

ASHUMET POND Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Falmouth, MA

Figure 1
Locus Map

Horsley Witten Group
Sustainable Environmental Solutions

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Date: 8/10/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Ashumet Pond Boat Ramp
- Town Parcels

ASHUMET POND Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Falmouth, MA

Figure 2
Aerial

Horsley Witten Group
Sustainable Environmental Solutions

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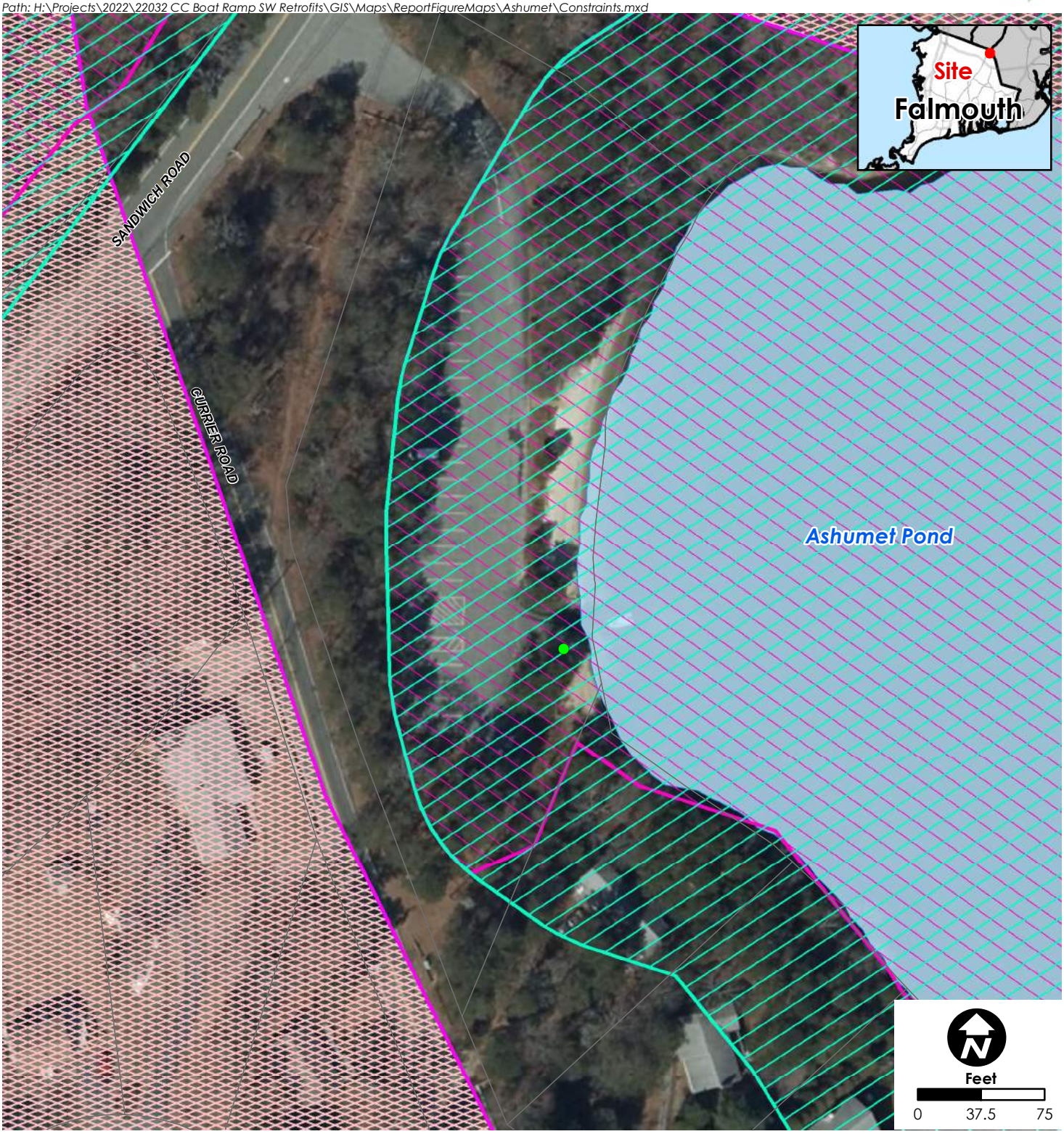

Date: 8/10/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Ashumet Pond Boat Ramp
- Town Parcels
- NHESP Priority Habitats of Rare Species
- NHESP Estimated Habitats of Rare Wildlife
- DEP Approved Zone II
- Shoreline
- Open Water

*Site within 1 mile of Minority & Income EJ Communities

ASHUMET POND Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Falmouth, MA

Figure 3
Constraints

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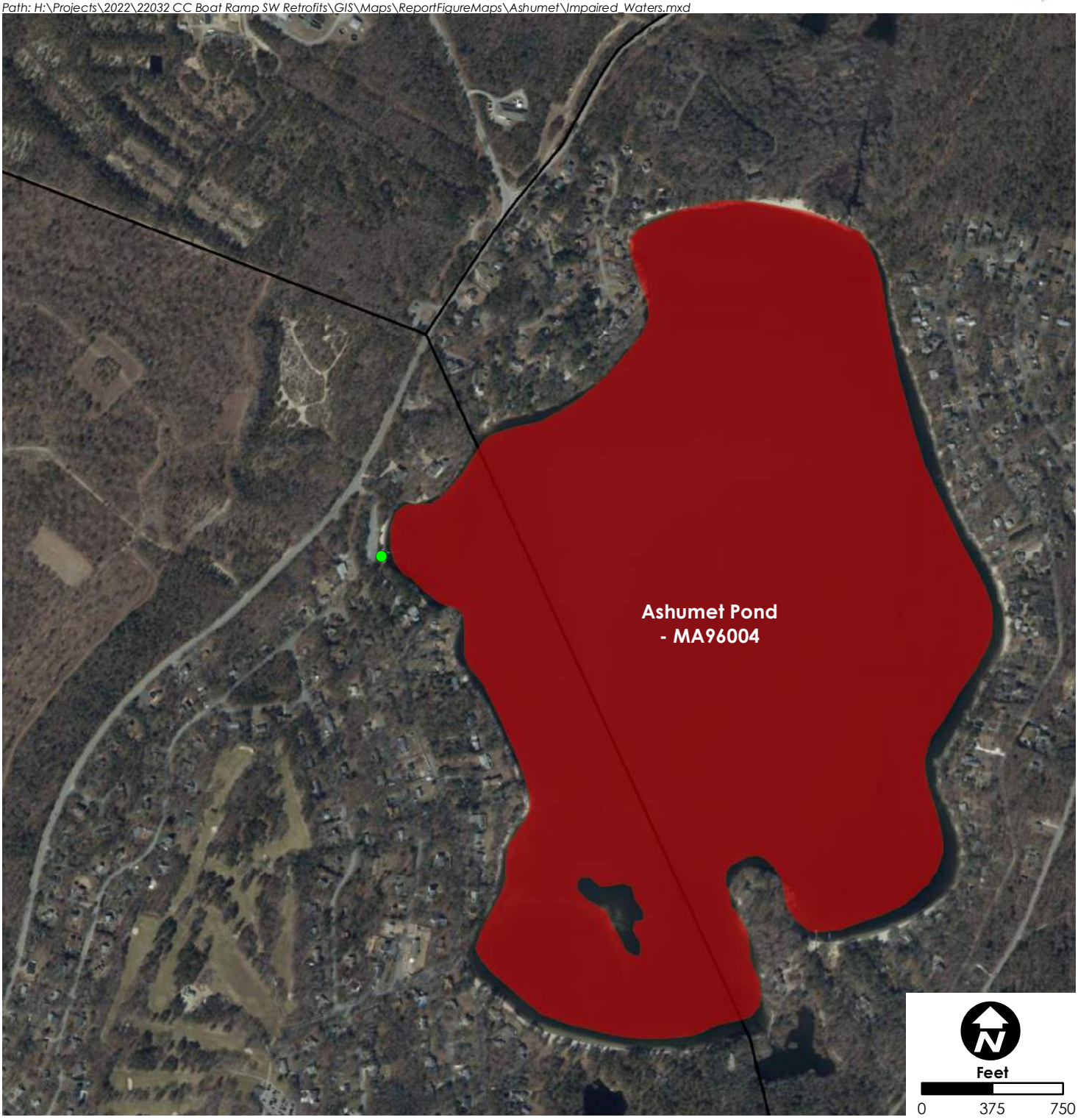

Date: 8/10/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Ashumet Pond Boat Ramp
- 5 - Impaired - TMDL required

ASHUMET POND Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Falmouth, MA

Figure 4
Impaired Waters

Horsley Witten Group
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Date: 8/10/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Ashumet Pond Boat Ramp
- USGS Monitoring Well (MA-FSW 239-0121)
- Town Parcels

Hydrologic Soil Group

- A

ASHUMET POND Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Falmouth, MA

Figure 5
Soils

APPENDIX A – Drainage Areas

- Existing and Proposed Drainage Areas Maps
- Land Coverage Summaries

LEGEND

DRAINAGE AREA BOUNDARY

WOODS

GRASS

PAVEMENT

IMP. AREA / TOTAL AREA (ACRES) — 1.00 / 5.00

DA1 DRAINAGE AREA

SP1 STUDY POINT

SOIL BOUNDARY

TIME OF CONCENTRATION FLOW PATH

2' CONTOUR

SOIL TYPES

254B MERRIMAC FINE SANDY LOAM 3-8% SLOPE (HSG A)

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Sustainable Environmental Solutions
90 Route 6A Sandwich, MA 02563
horsleywittengroup.com

Checked By: MW
Drawn By: JLV
Design By: JLV
Date: 5/30/23

Plan Set:
ASHUMET POND
CAPE COD BOAT RAMP STORMWATER
RETROFIT PROJECT - 25% DESIGN
FALMOUTH, MA

Plan Title:
EXISTING DRAINAGE AREA MAP

Prepared For:
Massachusetts Office of Fishing and Boating Access
1 Rabbit Hill Road
Westborough, MA
Phone:(508) 389-7810
Fax: —

Project Number:
22032

Sheet Number:
1 of 2

last modified: 08/02/23 printed: 08/02/23 by jv H:\Projects\2022\22032 CC Boat Ramp SW Retrofits\Drawings\ASHUMET\Misc\22032 ASHUMET DR.dwg

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Sustainable Environmental Solutions
90 Route 6A Sandwich, MA 02563
horsleywittengroup.com

Date: 5/30/23
Design By: JLV
Drawn By: JLV
Checked By: MW

Plan Set:
CAPE COD BOAT RAMP STORMWATER RETROFIT PROJECT - PERMITTING PLANS
FALMOUTH, MA
ASHUMET POND

Plan Title:
PROPOSED DRAINAGE AREA MAP

Prepared For:
Massachusetts Office of Fishing and Boating Access
1 Rabbit Hill Road
Westborough, MA
Phone:(508) 389-7810

Project Number:
22032

Sheet Number:
2 of 2

last modified: 08/14/23 printed: 08/14/23 by jv H:\Projects\2022\22032 CC Boat Ramp SW Retrofits\Drawings\ASHUMETMisc\22032 ASHUMET DR.dwg

BOAT RAMP AND PARKING AREA FALMOUTH, MA	Calc'd by:	JLV
	Checked by:	MW
Existing Drainage Conditions	Date:	8/14/2023

DRAINAGE AREAS	
DA1	**BOAT RAMP**

NOAA 14+ 24-hr Type III (inches)	
WQv	1.21
1-yr	3.13
2-yr	3.70
5-yr	4.63
10-yr	5.42
25-yr	6.65
100-yr	8.62
500-yr	11.34

DA1	**BOAT RAMP**					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	33,766	0.775				
Permeable	0	0.000				
Roof	0	0.000				
Water	0	0.000				
Woods	22,923	0.526		**Impervious**		
Grass	9,819	0.225		Area, ft^2	Area, *ac*	Percent
TOTAL	66,508	1.527		33,766	0.775	51

ALL	***ALL EX AREAS COMBINED***					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	33,766	0.775				
Permeable	0	0.000				
Roof	0	0.000				
Water	0	0.000				
Woods	22,923	0.526		**Impervious**		
Grass	9,819	0.225		Area, ft^2	Area, *ac*	Percent
TOTAL	66,508	1.527		33,766	0.775	51

BOAT RAMP AND PARKING AREA FALMOUTH, MA	Calc'd by:	JLV
	Checked by:	MW
Proposed Drainage Conditions	Date:	8/14/2023

DRAINAGE AREAS	
DA1A	**PARKING**
DA1B	**ENTRANCE**
DA1C	**BOAT RAMP**

NOAA 14+ 24-hr Type III (inches)	
WQv	1.21
1-yr	3.13
2-yr	3.70
5-yr	4.63
10-yr	5.42
25-yr	6.65
100-yr	8.62
500-yr	11.34

DA1A	**PARKING**		
Cover type	Area, ft^2	Area, *ac*	Note
Paved	17,612	0.404	
Permeable	3,603	0.083	
Roof	0	0.000	
Water	1,036	0.024	
Woods	20,036	0.460	
Grass	12,316	0.283	
TOTAL	54,603	1.254	

Impervious		
Area, ft^2	Area, *ac*	Percent
17,612	0.404	32

DA1B	**ENTRANCE**		
Cover type	Area, ft^2	Area, *ac*	Note
Paved	6,733	0.155	
Permeable	0	0.000	
Roof	0	0.000	
Water	535	0.012	
Woods	0	0.000	
Grass	3,266	0.075	
TOTAL	10,534	0.242	

Impervious		
Area, ft^2	Area, *ac*	Percent
6,733	0.155	64

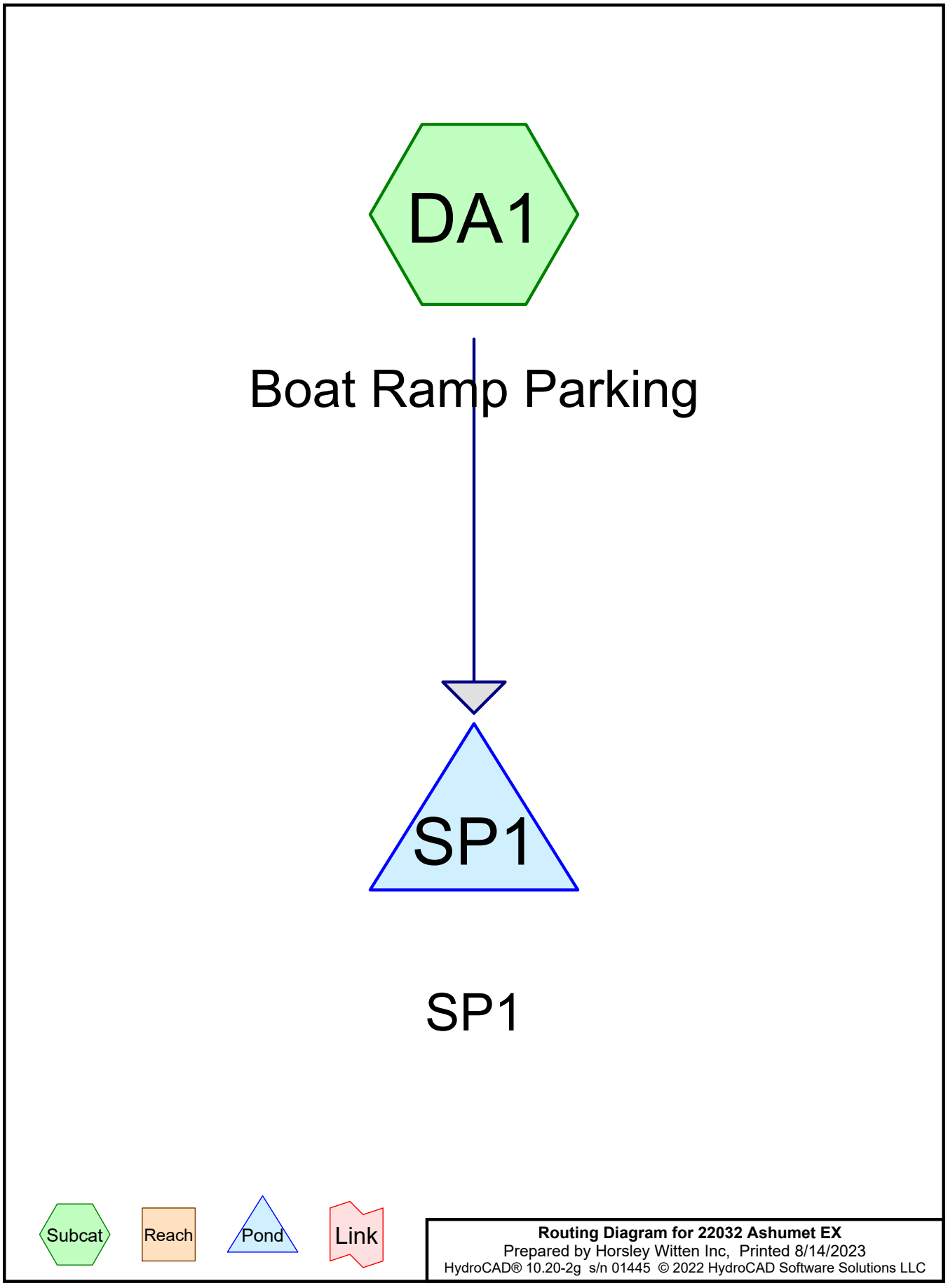
DA1C	BOAT RAMP					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	1,371	0.031				
Permeable	0	0.000				
Roof	0	0.000				
Water	0	0.000				
Woods	0	0.000		**Impervious**		
Grass	0	0.000		Area, ft^2	Area, *ac*	Percent
TOTAL	1,371	0.031		1,371	0.031	100

ALL	***ALL PR AREAS COMBINED***					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	25,716	0.590				
Permeable	3,603	0.083				
Roof	0	0.000				
Water	1,571	0.036				
Woods	20,036	0.460		**Impervious**		
Grass	15,582	0.358		Area, ft^2	Area, *ac*	Percent
TOTAL	66,508	1.527		25,716	0.590	39

APPENDIX B – Hydrologic/Hydraulic Model Results

HydroCAD® Results

- Existing
- Proposed



Routing Diagram for 22032 Ashumet EX
Prepared by Horsley Witten Inc, Printed 8/14/2023
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Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	WQv	Type III 24-hr		Default	24.00	1	1.17	2
2	2-YR	Type III 24-hr		Default	24.00	1	3.70	2
3	10-YR	Type III 24-hr		Default	24.00	1	5.42	2
4	25-YR	Type III 24-hr		Default	24.00	1	6.65	2
5	100-YR	Type III 24-hr		Default	24.00	1	8.62	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.225	39	>75% Grass cover, Good, HSG A (DA1)
0.775	98	Paved parking, HSG A (DA1)
0.526	30	Woods, Good, HSG A (DA1)
1.527	**66**	**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.225	0.000	0.000	0.000	0.000	0.225	>75% Grass cover, Good	DA1
0.775	0.000	0.000	0.000	0.000	0.775	Paved parking	DA1
0.526	0.000	0.000	0.000	0.000	0.526	Woods, Good	DA1
1.527	**0.000**	**0.000**	**0.000**	**0.000**	**1.527**	**TOTAL AREA**	

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: Boat Ramp Parking Runoff Area=66,508 sf 50.77% Impervious Runoff Depth=0.49"
Tc=5.0 min CN=WQ Runoff=0.85 cfs 0.062 af

Pond SP1: SP1 Inflow=0.85 cfs 0.062 af
Primary=0.85 cfs 0.062 af

Total Runoff Area = 1.527 ac Runoff Volume = 0.062 af Average Runoff Depth = 0.49"
49.23% Pervious = 0.752 ac 50.77% Impervious = 0.775 ac

Summary for Subcatchment DA1: Boat Ramp Parking

Runoff = 0.85 cfs @ 12.07 hrs, Volume= 0.062 af, Depth= 0.49"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr WQv Rainfall=1.17"

Area (sf)	CN	Description
22,923	30	Woods, Good, HSG A
9,819	39	>75% Grass cover, Good, HSG A
33,766	98	Paved parking, HSG A
66,508		Weighted Average
32,742		49.23% Pervious Area
33,766		50.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5 min**

Summary for Pond SP1: SP1

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

Inflow Area = 1.527 ac, 50.77% Impervious, Inflow Depth = 0.49" for WQv event
Inflow = 0.85 cfs @ 12.07 hrs, Volume= 0.062 af
Primary = 0.85 cfs @ 12.07 hrs, Volume= 0.062 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: Boat Ramp Parking Runoff Area=66,508 sf 50.77% Impervious Runoff Depth=1.76"
Tc=5.0 min CN=WQ Runoff=2.88 cfs 0.224 af

Pond SP1: SP1 Inflow=2.88 cfs 0.224 af
Primary=2.88 cfs 0.224 af

Total Runoff Area = 1.527 ac Runoff Volume = 0.224 af Average Runoff Depth = 1.76"
49.23% Pervious = 0.752 ac 50.77% Impervious = 0.775 ac

Summary for Subcatchment DA1: Boat Ramp Parking

Runoff = 2.88 cfs @ 12.07 hrs, Volume= 0.224 af, Depth= 1.76"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YR Rainfall=3.70"

Area (sf)	CN	Description
22,923	30	Woods, Good, HSG A
9,819	39	>75% Grass cover, Good, HSG A
33,766	98	Paved parking, HSG A
66,508		Weighted Average
32,742		49.23% Pervious Area
33,766		50.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5 min**

Summary for Pond SP1: SP1

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

Inflow Area = 1.527 ac, 50.77% Impervious, Inflow Depth = 1.76" for 2-YR event
Inflow = 2.88 cfs @ 12.07 hrs, Volume= 0.224 af
Primary = 2.88 cfs @ 12.07 hrs, Volume= 0.224 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: Boat Ramp Parking Runoff Area=66,508 sf 50.77% Impervious Runoff Depth=2.68"
Tc=5.0 min CN=WQ Runoff=4.25 cfs 0.341 af

Pond SP1: SP1 Inflow=4.25 cfs 0.341 af
Primary=4.25 cfs 0.341 af

Total Runoff Area = 1.527 ac Runoff Volume = 0.341 af Average Runoff Depth = 2.68"
49.23% Pervious = 0.752 ac 50.77% Impervious = 0.775 ac

Summary for Subcatchment DA1: Boat Ramp Parking

Runoff = 4.25 cfs @ 12.07 hrs, Volume= 0.341 af, Depth= 2.68"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-YR Rainfall=5.42"

Area (sf)	CN	Description
22,923	30	Woods, Good, HSG A
9,819	39	>75% Grass cover, Good, HSG A
33,766	98	Paved parking, HSG A
66,508		Weighted Average
32,742		49.23% Pervious Area
33,766		50.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5 min**

Summary for Pond SP1: SP1

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

Inflow Area = 1.527 ac, 50.77% Impervious, Inflow Depth = 2.68" for 10-YR event
Inflow = 4.25 cfs @ 12.07 hrs, Volume= 0.341 af
Primary = 4.25 cfs @ 12.07 hrs, Volume= 0.341 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: Boat Ramp Parking Runoff Area=66,508 sf 50.77% Impervious Runoff Depth=3.40"
Tc=5.0 min CN=WQ Runoff=5.26 cfs 0.433 af

Pond SP1: SP1 Inflow=5.26 cfs 0.433 af
Primary=5.26 cfs 0.433 af

Total Runoff Area = 1.527 ac Runoff Volume = 0.433 af Average Runoff Depth = 3.40"
49.23% Pervious = 0.752 ac 50.77% Impervious = 0.775 ac

Summary for Subcatchment DA1: Boat Ramp Parking

Runoff = 5.26 cfs @ 12.07 hrs, Volume= 0.433 af, Depth= 3.40"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-YR Rainfall=6.65"

Area (sf)	CN	Description
22,923	30	Woods, Good, HSG A
9,819	39	>75% Grass cover, Good, HSG A
33,766	98	Paved parking, HSG A
66,508		Weighted Average
32,742		49.23% Pervious Area
33,766		50.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5 min**

Summary for Pond SP1: SP1

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

Inflow Area = 1.527 ac, 50.77% Impervious, Inflow Depth = 3.40" for 25-YR event
Inflow = 5.26 cfs @ 12.07 hrs, Volume= 0.433 af
Primary = 5.26 cfs @ 12.07 hrs, Volume= 0.433 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: Boat Ramp Parking Runoff Area=66,508 sf 50.77% Impervious Runoff Depth=4.66"
Tc=5.0 min CN=WQ Runoff=7.04 cfs 0.593 af

Pond SP1: SP1 Inflow=7.04 cfs 0.593 af
Primary=7.04 cfs 0.593 af

Total Runoff Area = 1.527 ac Runoff Volume = 0.593 af Average Runoff Depth = 4.66"
49.23% Pervious = 0.752 ac 50.77% Impervious = 0.775 ac

Summary for Subcatchment DA1: Boat Ramp Parking

Runoff = 7.04 cfs @ 12.07 hrs, Volume= 0.593 af, Depth= 4.66"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-YR Rainfall=8.62"

Area (sf)	CN	Description
22,923	30	Woods, Good, HSG A
9,819	39	>75% Grass cover, Good, HSG A
33,766	98	Paved parking, HSG A
66,508		Weighted Average
32,742		49.23% Pervious Area
33,766		50.77% Impervious Area

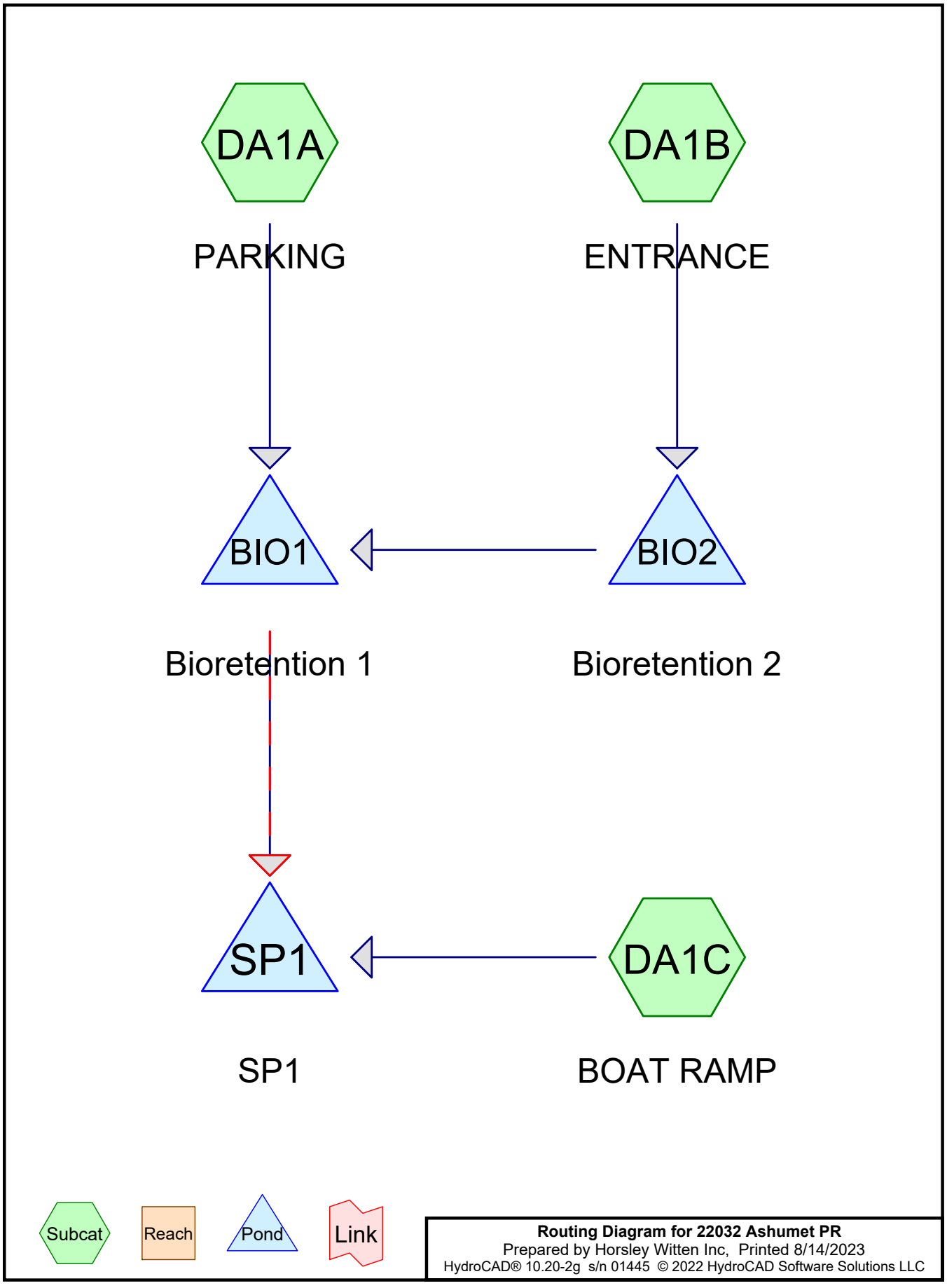
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, 5 min**

Summary for Pond SP1: SP1

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

Inflow Area = 1.527 ac, 50.77% Impervious, Inflow Depth = 4.66" for 100-YR event
Inflow = 7.04 cfs @ 12.07 hrs, Volume= 0.593 af
Primary = 7.04 cfs @ 12.07 hrs, Volume= 0.593 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs



Routing Diagram for 22032 Ashumet PR
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Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	-WQv	Type III 24-hr		Default	24.00	1	1.17	2
2	2-YR	Type III 24-hr		Default	24.00	1	3.70	2
3	10-YR	Type III 24-hr		Default	24.00	1	5.42	2
4	25-YR	Type III 24-hr		Default	24.00	1	6.65	2
5	100-YR	Type III 24-hr		Default	24.00	1	8.62	2

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
15,583	39	>75% Grass cover, Good, HSG A (DA1A, DA1B)
25,721	98	Paved parking, HSG A (DA1A, DA1B, DA1C)
3,603	40	Permeable pavers (DA1A)
1,568	98	Water Surface, 0% imp, HSG A (DA1A, DA1B)
20,038	30	Woods, Good, HSG A (DA1A)
66,513	**61**	**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Sub Num
15,583	0	0	0	0	15,583	>75% Grass cover, Good	
25,721	0	0	0	0	25,721	Paved parking	
0	0	0	0	3,603	3,603	Permeable pavers	
1,568	0	0	0	0	1,568	Water Surface, 0% imp	
20,038	0	0	0	0	20,038	Woods, Good	
62,910	**0**	**0**	**0**	**3,603**	**66,513**	**TOTAL AREA**	

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1A: PARKING Runoff Area=54,600 sf 32.23% Impervious Runoff Depth=0.33"
Tc=5.0 min CN=WQ Runoff=0.47 cfs 1,486 cf

Subcatchment DA1B: ENTRANCE Runoff Area=0.242 ac 64.05% Impervious Runoff Depth=0.66"
Tc=5.0 min CN=WQ Runoff=0.18 cfs 580 cf

Subcatchment DA1C: BOAT RAMP Runoff Area=1,371 sf 100.00% Impervious Runoff Depth=0.96"
Tc=5.0 min CN=98 Runoff=0.03 cfs 109 cf

Pond BIO1: Bioretention 1 Peak Elev=47.46' Storage=480 cf Inflow=0.47 cfs 1,486 cf
Discarded=0.06 cfs 1,459 cf Primary=0.04 cfs 27 cf Secondary=0.00 cfs 0 cf Outflow=0.10 cfs 1,486 cf

Pond BIO2: Bioretention 2 Peak Elev=59.69' Storage=182 cf Inflow=0.18 cfs 580 cf
Discarded=0.03 cfs 580 cf Primary=0.00 cfs 0 cf Outflow=0.03 cfs 580 cf

Pond SP1: SP1 Inflow=0.04 cfs 136 cf
Primary=0.04 cfs 136 cf

Total Runoff Area = 66,513 sf Runoff Volume = 2,175 cf Average Runoff Depth = 0.39"
61.33% Pervious = 40,792 sf 38.67% Impervious = 25,721 sf

Summary for Subcatchment DA1A: PARKING

Runoff = 0.47 cfs @ 12.07 hrs, Volume= 1,486 cf, Depth= 0.33"
Routed to Pond BIO1 : Bioretention 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr -WQv Rainfall=1.17"

	Area (sf)	CN	Description
	17,598	98	Paved parking, HSG A
	12,316	39	>75% Grass cover, Good, HSG A
	1,045	98	Water Surface, 0% imp, HSG A
	20,038	30	Woods, Good, HSG A
*	3,603	40	Permeable pavers
	54,600		Weighted Average
	37,002	36	67.77% Pervious Area
	17,598	98	32.23% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1B: ENTRANCE

Runoff = 0.18 cfs @ 12.07 hrs, Volume= 580 cf, Depth= 0.66"
Routed to Pond BIO2 : Bioretention 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr -WQv Rainfall=1.17"

Area (ac)	CN	Description
0.155	98	Paved parking, HSG A
0.075	39	>75% Grass cover, Good, HSG A
0.012	98	Water Surface, 0% imp, HSG A
0.242		Weighted Average
0.087	47	35.95% Pervious Area
0.155	98	64.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1C: BOAT RAMP

Runoff = 0.03 cfs @ 12.07 hrs, Volume= 109 cf, Depth= 0.96"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr -WQv Rainfall=1.17"

Area (sf)	CN	Description
1,371	98	Paved parking, HSG A
1,371	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Pond BIO1: Bioretention 1

Inflow Area = 65,142 sf, 37.38% Impervious, Inflow Depth = 0.27" for -WQv event
Inflow = 0.47 cfs @ 12.07 hrs, Volume= 1,486 cf
Outflow = 0.10 cfs @ 12.48 hrs, Volume= 1,486 cf, Atten= 79%, Lag= 24.7 min
Discarded = 0.06 cfs @ 12.48 hrs, Volume= 1,459 cf
Primary = 0.04 cfs @ 12.48 hrs, Volume= 27 cf
Routed to Pond SP1 : SP1
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf
Routed to Pond SP1 : SP1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 47.46' @ 12.48 hrs Surf.Area= 1,097 sf Storage= 480 cf

Plug-Flow detention time= 56.4 min calculated for 1,485 cf (100% of inflow)
Center-of-Mass det. time= 56.4 min (838.3 - 781.9)

Volume	Invert	Avail.Storage	Storage Description
#1	46.95'	3,049 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
46.95	780	0	0
47.00	800	39	39
47.50	1,120	480	519
48.00	2,000	780	1,299
48.50	5,000	1,750	3,049

Device	Routing	Invert	Outlet Devices
#1	Discarded	46.95'	**2.410 in/hr Exfiltration over Surface area**
#2	Device 3	47.45'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	45.26'	**12.0" W x 1.5" H Box Culvert** L= 88.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 45.26' / 45.00' S= 0.0030 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.13 sf
#4	Secondary	48.12'	**20.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.06 cfs @ 12.48 hrs HW=47.46' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.06 cfs)

Primary OutFlow Max=0.03 cfs @ 12.48 hrs HW=47.46' (Free Discharge)
└**3=Culvert** (Passes 0.03 cfs of 0.32 cfs potential flow)
└**2=Orifice/Grate** (Weir Controls 0.03 cfs @ 0.39 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=46.95' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond BIO2: Bioretention 2

Inflow Area = 10,542 sf, 64.05% Impervious, Inflow Depth = 0.66" for -WQv event
Inflow = 0.18 cfs @ 12.07 hrs, Volume= 580 cf
Outflow = 0.03 cfs @ 12.54 hrs, Volume= 580 cf, Atten= 84%, Lag= 28.0 min
Discarded = 0.03 cfs @ 12.54 hrs, Volume= 580 cf
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf
Routed to Pond BIO1 : Bioretention 1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 59.69' @ 12.54 hrs Surf.Area= 524 sf Storage= 182 cf

Plug-Flow detention time= 45.9 min calculated for 580 cf (100% of inflow)
Center-of-Mass det. time= 45.8 min (827.7 - 781.9)

Volume	Invert	Avail.Storage	Storage Description
#1	59.25'	770 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
59.25	300	0	0
60.00	680	368	368
60.50	930	403	770

Device	Routing	Invert	Outlet Devices
#1	Primary	60.00'	**3.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	59.25'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.03 cfs @ 12.54 hrs HW=59.69' (Free Discharge)
└**2=Exfiltration** (Exfiltration Controls 0.03 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=59.25' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond SP1: SP1

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

Inflow Area = 66,513 sf, 38.67% Impervious, Inflow Depth = 0.02" for -WQv event
Inflow = 0.04 cfs @ 12.48 hrs, Volume= 136 cf
Primary = 0.04 cfs @ 12.48 hrs, Volume= 136 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1A: PARKING Runoff Area=54,600 sf 32.23% Impervious Runoff Depth=1.19"
Tc=5.0 min CN=WQ Runoff=1.59 cfs 5,415 cf

Subcatchment DA1B: ENTRANCE Runoff Area=0.242 ac 64.05% Impervious Runoff Depth=2.40"
Tc=5.0 min CN=WQ Runoff=0.62 cfs 2,107 cf

Subcatchment DA1C: BOAT RAMP Runoff Area=1,371 sf 100.00% Impervious Runoff Depth=3.47"
Tc=5.0 min CN=98 Runoff=0.12 cfs 396 cf

Pond BIO1: Bioretention 1 Peak Elev=48.15' Storage=1,670 cf Inflow=2.01 cfs 5,998 cf
Discarded=0.16 cfs 3,377 cf Primary=0.37 cfs 2,440 cf Secondary=0.26 cfs 181 cf Outflow=0.79 cfs 5,998 cf

Pond BIO2: Bioretention 2 Peak Elev=60.15' Storage=475 cf Inflow=0.62 cfs 2,107 cf
Discarded=0.04 cfs 1,523 cf Primary=0.49 cfs 583 cf Outflow=0.53 cfs 2,107 cf

Pond SP1: SP1 Inflow=0.67 cfs 3,017 cf
Primary=0.67 cfs 3,017 cf

Total Runoff Area = 66,513 sf Runoff Volume = 7,917 cf Average Runoff Depth = 1.43"
61.33% Pervious = 40,792 sf 38.67% Impervious = 25,721 sf

Summary for Subcatchment DA1A: PARKING

Runoff = 1.59 cfs @ 12.07 hrs, Volume= 5,415 cf, Depth= 1.19"
Routed to Pond BIO1 : Bioretention 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YR Rainfall=3.70"

	Area (sf)	CN	Description
	17,598	98	Paved parking, HSG A
	12,316	39	>75% Grass cover, Good, HSG A
	1,045	98	Water Surface, 0% imp, HSG A
	20,038	30	Woods, Good, HSG A
*	3,603	40	Permeable pavers
	54,600		Weighted Average
	37,002	36	67.77% Pervious Area
	17,598	98	32.23% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1B: ENTRANCE

Runoff = 0.62 cfs @ 12.07 hrs, Volume= 2,107 cf, Depth= 2.40"
Routed to Pond BIO2 : Bioretention 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YR Rainfall=3.70"

Area (ac)	CN	Description
0.155	98	Paved parking, HSG A
0.075	39	>75% Grass cover, Good, HSG A
0.012	98	Water Surface, 0% imp, HSG A
0.242		Weighted Average
0.087	47	35.95% Pervious Area
0.155	98	64.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1C: BOAT RAMP

Runoff = 0.12 cfs @ 12.07 hrs, Volume= 396 cf, Depth= 3.47"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YR Rainfall=3.70"

Area (sf)	CN	Description
1,371	98	Paved parking, HSG A
1,371	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Pond BIO1: Bioretention 1

Inflow Area = 65,142 sf, 37.38% Impervious, Inflow Depth = 1.10" for 2-YR event
Inflow = 2.01 cfs @ 12.08 hrs, Volume= 5,998 cf
Outflow = 0.79 cfs @ 12.31 hrs, Volume= 5,998 cf, Atten= 61%, Lag= 13.5 min
Discarded = 0.16 cfs @ 12.31 hrs, Volume= 3,377 cf
Primary = 0.37 cfs @ 12.31 hrs, Volume= 2,440 cf
Routed to Pond SP1 : SP1
Secondary = 0.26 cfs @ 12.31 hrs, Volume= 181 cf
Routed to Pond SP1 : SP1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 48.15' @ 12.31 hrs Surf.Area= 2,907 sf Storage= 1,670 cf

Plug-Flow detention time= 48.0 min calculated for 5,998 cf (100% of inflow)
Center-of-Mass det. time= 48.0 min (801.3 - 753.3)

Volume	Invert	Avail.Storage	Storage Description
#1	46.95'	3,049 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
46.95	780	0	0
47.00	800	39	39
47.50	1,120	480	519
48.00	2,000	780	1,299
48.50	5,000	1,750	3,049

Device	Routing	Invert	Outlet Devices
#1	Discarded	46.95'	**2.410 in/hr Exfiltration over Surface area**
#2	Device 3	47.45'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	45.26'	**12.0" W x 1.5" H Box Culvert** L= 88.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 45.26' / 45.00' S= 0.0030 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.13 sf
#4	Secondary	48.12'	**20.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.16 cfs @ 12.31 hrs HW=48.15' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.16 cfs)

Primary OutFlow Max=0.37 cfs @ 12.31 hrs HW=48.15' (Free Discharge)
└**3=Culvert** (Barrel Controls 0.37 cfs @ 2.95 fps)
└**2=Orifice/Grate** (Passes 0.37 cfs of 12.06 cfs potential flow)

Secondary OutFlow Max=0.26 cfs @ 12.31 hrs HW=48.15' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Weir Controls 0.26 cfs @ 0.41 fps)

Summary for Pond BIO2: Bioretention 2

Inflow Area = 10,542 sf, 64.05% Impervious, Inflow Depth = 2.40" for 2-YR event
Inflow = 0.62 cfs @ 12.07 hrs, Volume= 2,107 cf
Outflow = 0.53 cfs @ 12.12 hrs, Volume= 2,107 cf, Atten= 14%, Lag= 2.8 min
Discarded = 0.04 cfs @ 12.12 hrs, Volume= 1,523 cf
Primary = 0.49 cfs @ 12.12 hrs, Volume= 583 cf
Routed to Pond BIO1 : Bioretention 1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 60.15' @ 12.12 hrs Surf.Area= 755 sf Storage= 475 cf

Plug-Flow detention time= 66.2 min calculated for 2,107 cf (100% of inflow)
Center-of-Mass det. time= 66.2 min (819.8 - 753.7)

Volume	Invert	Avail.Storage	Storage Description
#1	59.25'	770 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
59.25	300	0	0
60.00	680	368	368
60.50	930	403	770

Device	Routing	Invert	Outlet Devices
#1	Primary	60.00'	**3.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	59.25'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.04 cfs @ 12.12 hrs HW=60.15' (Free Discharge)
└**2=Exfiltration** (Exfiltration Controls 0.04 cfs)

Primary OutFlow Max=0.49 cfs @ 12.12 hrs HW=60.15' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 0.49 cfs @ 1.08 fps)

Summary for Pond SP1: SP1

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

Inflow Area = 66,513 sf, 38.67% Impervious, Inflow Depth = 0.54" for 2-YR event
Inflow = 0.67 cfs @ 12.30 hrs, Volume= 3,017 cf
Primary = 0.67 cfs @ 12.30 hrs, Volume= 3,017 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1A: PARKING Runoff Area=54,600 sf 32.23% Impervious Runoff Depth=1.87"
Tc=5.0 min CN=WQ Runoff=2.34 cfs 8,492 cf

Subcatchment DA1B: ENTRANCE Runoff Area=0.242 ac 64.05% Impervious Runoff Depth=3.67"
Tc=5.0 min CN=WQ Runoff=0.91 cfs 3,221 cf

Subcatchment DA1C: BOAT RAMP Runoff Area=1,371 sf 100.00% Impervious Runoff Depth=5.18"
Tc=5.0 min CN=98 Runoff=0.17 cfs 592 cf

Pond BIO1: Bioretention 1 Peak Elev=48.24' Storage=1,948 cf Inflow=3.09 cfs 9,783 cf
Discarded=0.19 cfs 4,383 cf Primary=0.37 cfs 3,740 cf Secondary=1.92 cfs 1,659 cf Outflow=2.48 cfs 9,783 cf

Pond BIO2: Bioretention 2 Peak Elev=60.21' Storage=519 cf Inflow=0.91 cfs 3,221 cf
Discarded=0.04 cfs 1,931 cf Primary=0.80 cfs 1,290 cf Outflow=0.84 cfs 3,221 cf

Pond SP1: SP1 Inflow=2.42 cfs 5,991 cf
Primary=2.42 cfs 5,991 cf

Total Runoff Area = 66,513 sf Runoff Volume = 12,306 cf Average Runoff Depth = 2.22"
61.33% Pervious = 40,792 sf 38.67% Impervious = 25,721 sf

Summary for Subcatchment DA1A: PARKING

Runoff = 2.34 cfs @ 12.07 hrs, Volume= 8,492 cf, Depth= 1.87"
Routed to Pond BIO1 : Bioretention 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-YR Rainfall=5.42"

	Area (sf)	CN	Description
	17,598	98	Paved parking, HSG A
	12,316	39	>75% Grass cover, Good, HSG A
	1,045	98	Water Surface, 0% imp, HSG A
	20,038	30	Woods, Good, HSG A
*	3,603	40	Permeable pavers
	54,600		Weighted Average
	37,002	36	67.77% Pervious Area
	17,598	98	32.23% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1B: ENTRANCE

Runoff = 0.91 cfs @ 12.07 hrs, Volume= 3,221 cf, Depth= 3.67"
Routed to Pond BIO2 : Bioretention 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-YR Rainfall=5.42"

Area (ac)	CN	Description
0.155	98	Paved parking, HSG A
0.075	39	>75% Grass cover, Good, HSG A
0.012	98	Water Surface, 0% imp, HSG A
0.242		Weighted Average
0.087	47	35.95% Pervious Area
0.155	98	64.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1C: BOAT RAMP

Runoff = 0.17 cfs @ 12.07 hrs, Volume= 592 cf, Depth= 5.18"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-YR Rainfall=5.42"

Area (sf)	CN	Description
1,371	98	Paved parking, HSG A
1,371	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Pond BIO1: Bioretention 1

Inflow Area = 65,142 sf, 37.38% Impervious, Inflow Depth = 1.80" for 10-YR event
Inflow = 3.09 cfs @ 12.08 hrs, Volume= 9,783 cf
Outflow = 2.48 cfs @ 12.14 hrs, Volume= 9,783 cf, Atten= 20%, Lag= 3.7 min
Discarded = 0.19 cfs @ 12.14 hrs, Volume= 4,383 cf
Primary = 0.37 cfs @ 12.14 hrs, Volume= 3,740 cf
Routed to Pond SP1 : SP1
Secondary = 1.92 cfs @ 12.14 hrs, Volume= 1,659 cf
Routed to Pond SP1 : SP1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 48.24' @ 12.14 hrs Surf.Area= 3,433 sf Storage= 1,948 cf

Plug-Flow detention time= 44.4 min calculated for 9,783 cf (100% of inflow)
Center-of-Mass det. time= 44.4 min (801.0 - 756.6)

Volume	Invert	Avail.Storage	Storage Description
#1	46.95'	3,049 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
46.95	780	0	0
47.00	800	39	39
47.50	1,120	480	519
48.00	2,000	780	1,299
48.50	5,000	1,750	3,049

Device	Routing	Invert	Outlet Devices
#1	Discarded	46.95'	**2.410 in/hr Exfiltration over Surface area**
#2	Device 3	47.45'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	45.26'	**12.0" W x 1.5" H Box Culvert** L= 88.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 45.26' / 45.00' S= 0.0030 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.13 sf
#4	Secondary	48.12'	**20.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.19 cfs @ 12.14 hrs HW=48.24' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.19 cfs)

Primary OutFlow Max=0.37 cfs @ 12.14 hrs HW=48.24' (Free Discharge)
└**3=Culvert** (Barrel Controls 0.37 cfs @ 2.99 fps)
└**2=Orifice/Grate** (Passes 0.37 cfs of 13.43 cfs potential flow)

Secondary OutFlow Max=1.91 cfs @ 12.14 hrs HW=48.24' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Weir Controls 1.91 cfs @ 0.81 fps)

Summary for Pond BIO2: Bioretention 2

Inflow Area = 10,542 sf, 64.05% Impervious, Inflow Depth = 3.67" for 10-YR event
Inflow = 0.91 cfs @ 12.07 hrs, Volume= 3,221 cf
Outflow = 0.84 cfs @ 12.10 hrs, Volume= 3,221 cf, Atten= 8%, Lag= 2.0 min
Discarded = 0.04 cfs @ 12.10 hrs, Volume= 1,931 cf
Primary = 0.80 cfs @ 12.10 hrs, Volume= 1,290 cf
Routed to Pond BIO1 : Bioretention 1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 60.21' @ 12.10 hrs Surf.Area= 784 sf Storage= 519 cf

Plug-Flow detention time= 61.6 min calculated for 3,221 cf (100% of inflow)
Center-of-Mass det. time= 61.6 min (813.3 - 751.7)

Volume	Invert	Avail.Storage	Storage Description
#1	59.25'	770 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
59.25	300	0	0
60.00	680	368	368
60.50	930	403	770

Device	Routing	Invert	Outlet Devices
#1	Primary	60.00'	**3.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	59.25'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.04 cfs @ 12.10 hrs HW=60.21' (Free Discharge)
└**2=Exfiltration** (Exfiltration Controls 0.04 cfs)

Primary OutFlow Max=0.79 cfs @ 12.10 hrs HW=60.21' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 0.79 cfs @ 1.28 fps)

Summary for Pond SP1: SP1

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

Inflow Area = 66,513 sf, 38.67% Impervious, Inflow Depth = 1.08" for 10-YR event
Inflow = 2.42 cfs @ 12.14 hrs, Volume= 5,991 cf
Primary = 2.42 cfs @ 12.14 hrs, Volume= 5,991 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1A: PARKING Runoff Area=54,600 sf 32.23% Impervious Runoff Depth=2.44"
Tc=5.0 min CN=WQ Runoff=2.96 cfs 11,099 cf

Subcatchment DA1B: ENTRANCE Runoff Area=0.242 ac 64.05% Impervious Runoff Depth=4.62"
Tc=5.0 min CN=WQ Runoff=1.14 cfs 4,063 cf

Subcatchment DA1C: BOAT RAMP Runoff Area=1,371 sf 100.00% Impervious Runoff Depth=6.41"
Tc=5.0 min CN=98 Runoff=0.21 cfs 732 cf

Pond BIO1: Bioretention 1 Peak Elev=48.28' Storage=2,090 cf Inflow=3.92 cfs 12,988 cf
Discarded=0.20 cfs 5,045 cf Primary=0.38 cfs 4,997 cf Secondary=2.96 cfs 2,945 cf Outflow=3.54 cfs 12,988 cf

Pond BIO2: Bioretention 2 Peak Elev=60.24' Storage=547 cf Inflow=1.14 cfs 4,063 cf
Discarded=0.04 cfs 2,173 cf Primary=1.01 cfs 1,889 cf Outflow=1.05 cfs 4,063 cf

Pond SP1: SP1 Inflow=3.52 cfs 8,675 cf
Primary=3.52 cfs 8,675 cf

Total Runoff Area = 66,513 sf Runoff Volume = 15,894 cf Average Runoff Depth = 2.87"
61.33% Pervious = 40,792 sf 38.67% Impervious = 25,721 sf

Summary for Subcatchment DA1A: PARKING

Runoff = 2.96 cfs @ 12.07 hrs, Volume= 11,099 cf, Depth= 2.44"
Routed to Pond BIO1 : Bioretention 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-YR Rainfall=6.65"

	Area (sf)	CN	Description
	17,598	98	Paved parking, HSG A
	12,316	39	>75% Grass cover, Good, HSG A
	1,045	98	Water Surface, 0% imp, HSG A
	20,038	30	Woods, Good, HSG A
*	3,603	40	Permeable pavers
	54,600		Weighted Average
	37,002	36	67.77% Pervious Area
	17,598	98	32.23% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1B: ENTRANCE

Runoff = 1.14 cfs @ 12.07 hrs, Volume= 4,063 cf, Depth= 4.62"
Routed to Pond BIO2 : Bioretention 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-YR Rainfall=6.65"

Area (ac)	CN	Description
0.155	98	Paved parking, HSG A
0.075	39	>75% Grass cover, Good, HSG A
0.012	98	Water Surface, 0% imp, HSG A
0.242		Weighted Average
0.087	47	35.95% Pervious Area
0.155	98	64.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1C: BOAT RAMP

Runoff = 0.21 cfs @ 12.07 hrs, Volume= 732 cf, Depth= 6.41"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-YR Rainfall=6.65"

Area (sf)	CN	Description
1,371	98	Paved parking, HSG A
1,371	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Pond BIO1: Bioretention 1

Inflow Area = 65,142 sf, 37.38% Impervious, Inflow Depth = 2.39" for 25-YR event
Inflow = 3.92 cfs @ 12.08 hrs, Volume= 12,988 cf
Outflow = 3.54 cfs @ 12.12 hrs, Volume= 12,988 cf, Atten= 10%, Lag= 2.3 min
Discarded = 0.20 cfs @ 12.12 hrs, Volume= 5,045 cf
Primary = 0.38 cfs @ 12.12 hrs, Volume= 4,997 cf
Routed to Pond SP1 : SP1
Secondary = 2.96 cfs @ 12.12 hrs, Volume= 2,945 cf
Routed to Pond SP1 : SP1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 48.28' @ 12.12 hrs Surf.Area= 3,673 sf Storage= 2,090 cf

Plug-Flow detention time= 42.5 min calculated for 12,982 cf (100% of inflow)
Center-of-Mass det. time= 42.5 min (804.7 - 762.2)

Volume	Invert	Avail.Storage	Storage Description
#1	46.95'	3,049 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
46.95	780	0	0
47.00	800	39	39
47.50	1,120	480	519
48.00	2,000	780	1,299
48.50	5,000	1,750	3,049

Device	Routing	Invert	Outlet Devices
#1	Discarded	46.95'	**2.410 in/hr Exfiltration over Surface area**
#2	Device 3	47.45'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	45.26'	**12.0" W x 1.5" H Box Culvert** L= 88.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 45.26' / 45.00' S= 0.0030 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.13 sf
#4	Secondary	48.12'	**20.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.20 cfs @ 12.12 hrs HW=48.28' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.20 cfs)

Primary OutFlow Max=0.38 cfs @ 12.12 hrs HW=48.28' (Free Discharge)
└**3=Culvert** (Barrel Controls 0.38 cfs @ 3.01 fps)
└**2=Orifice/Grate** (Passes 0.38 cfs of 13.77 cfs potential flow)

Secondary OutFlow Max=2.96 cfs @ 12.12 hrs HW=48.28' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Weir Controls 2.96 cfs @ 0.93 fps)

Summary for Pond BIO2: Bioretention 2

Inflow Area = 10,542 sf, 64.05% Impervious, Inflow Depth = 4.62" for 25-YR event
Inflow = 1.14 cfs @ 12.07 hrs, Volume= 4,063 cf
Outflow = 1.05 cfs @ 12.10 hrs, Volume= 4,063 cf, Atten= 7%, Lag= 1.9 min
Discarded = 0.04 cfs @ 12.10 hrs, Volume= 2,173 cf
Primary = 1.01 cfs @ 12.10 hrs, Volume= 1,889 cf
Routed to Pond BIO1 : Bioretention 1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 60.24' @ 12.10 hrs Surf.Area= 801 sf Storage= 547 cf

Plug-Flow detention time= 58.9 min calculated for 4,063 cf (100% of inflow)
Center-of-Mass det. time= 58.9 min (810.1 - 751.2)

Volume	Invert	Avail.Storage	Storage Description
#1	59.25'	770 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
59.25	300	0	0
60.00	680	368	368
60.50	930	403	770

Device	Routing	Invert	Outlet Devices
#1	Primary	60.00'	**3.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	59.25'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.04 cfs @ 12.10 hrs HW=60.24' (Free Discharge)
└**2=Exfiltration** (Exfiltration Controls 0.04 cfs)

Primary OutFlow Max=1.00 cfs @ 12.10 hrs HW=60.24' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 1.00 cfs @ 1.39 fps)

Summary for Pond SP1: SP1

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

Inflow Area = 66,513 sf, 38.67% Impervious, Inflow Depth = 1.57" for 25-YR event
Inflow = 3.52 cfs @ 12.12 hrs, Volume= 8,675 cf
Primary = 3.52 cfs @ 12.12 hrs, Volume= 8,675 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1A: PARKING Runoff Area=54,600 sf 32.23% Impervious Runoff Depth=3.49"
Tc=5.0 min CN=WQ Runoff=4.18 cfs 15,900 cf

Subcatchment DA1B: ENTRANCE Runoff Area=0.242 ac 64.05% Impervious Runoff Depth=6.23"
Tc=5.0 min CN=WQ Runoff=1.55 cfs 5,468 cf

Subcatchment DA1C: BOAT RAMP Runoff Area=1,371 sf 100.00% Impervious Runoff Depth=8.38"
Tc=5.0 min CN=98 Runoff=0.28 cfs 957 cf

Pond BIO1: Bioretention 1 Peak Elev=48.33' Storage=2,290 cf Inflow=5.53 cfs 18,865 cf
Discarded=0.22 cfs 5,853 cf Primary=0.38 cfs 7,462 cf Secondary=4.55 cfs 5,551 cf Outflow=5.15 cfs 18,865 cf

Pond BIO2: Bioretention 2 Peak Elev=60.30' Storage=593 cf Inflow=1.55 cfs 5,468 cf
Discarded=0.05 cfs 2,503 cf Primary=1.40 cfs 2,966 cf Outflow=1.45 cfs 5,468 cf

Pond SP1: SP1 Inflow=5.18 cfs 13,970 cf
Primary=5.18 cfs 13,970 cf

Total Runoff Area = 66,513 sf Runoff Volume = 22,326 cf Average Runoff Depth = 4.03"
61.33% Pervious = 40,792 sf 38.67% Impervious = 25,721 sf

Summary for Subcatchment DA1A: PARKING

Runoff = 4.18 cfs @ 12.07 hrs, Volume= 15,900 cf, Depth= 3.49"
Routed to Pond BIO1 : Bioretention 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-YR Rainfall=8.62"

	Area (sf)	CN	Description
	17,598	98	Paved parking, HSG A
	12,316	39	>75% Grass cover, Good, HSG A
	1,045	98	Water Surface, 0% imp, HSG A
	20,038	30	Woods, Good, HSG A
*	3,603	40	Permeable pavers
	54,600		Weighted Average
	37,002	36	67.77% Pervious Area
	17,598	98	32.23% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1B: ENTRANCE

Runoff = 1.55 cfs @ 12.07 hrs, Volume= 5,468 cf, Depth= 6.23"
Routed to Pond BIO2 : Bioretention 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-YR Rainfall=8.62"

Area (ac)	CN	Description
0.155	98	Paved parking, HSG A
0.075	39	>75% Grass cover, Good, HSG A
0.012	98	Water Surface, 0% imp, HSG A
0.242		Weighted Average
0.087	47	35.95% Pervious Area
0.155	98	64.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment DA1C: BOAT RAMP

Runoff = 0.28 cfs @ 12.07 hrs, Volume= 957 cf, Depth= 8.38"
Routed to Pond SP1 : SP1

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-YR Rainfall=8.62"

Area (sf)	CN	Description
1,371	98	Paved parking, HSG A
1,371	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Pond BIO1: Bioretention 1

Inflow Area = 65,142 sf, 37.38% Impervious, Inflow Depth = 3.48" for 100-YR event
Inflow = 5.53 cfs @ 12.08 hrs, Volume= 18,865 cf
Outflow = 5.15 cfs @ 12.11 hrs, Volume= 18,865 cf, Atten= 7%, Lag= 1.9 min
Discarded = 0.22 cfs @ 12.11 hrs, Volume= 5,853 cf
Primary = 0.38 cfs @ 12.11 hrs, Volume= 7,462 cf
Routed to Pond SP1 : SP1
Secondary = 4.55 cfs @ 12.11 hrs, Volume= 5,551 cf
Routed to Pond SP1 : SP1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 48.33' @ 12.11 hrs Surf.Area= 3,986 sf Storage= 2,290 cf

Plug-Flow detention time= 37.0 min calculated for 18,858 cf (100% of inflow)
Center-of-Mass det. time= 37.0 min (805.4 - 768.4)

Volume	Invert	Avail.Storage	Storage Description
#1	46.95'	3,049 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
46.95	780	0	0
47.00	800	39	39
47.50	1,120	480	519
48.00	2,000	780	1,299
48.50	5,000	1,750	3,049

Device	Routing	Invert	Outlet Devices
#1	Discarded	46.95'	**2.410 in/hr Exfiltration over Surface area**
#2	Device 3	47.45'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	45.26'	**12.0" W x 1.5" H Box Culvert** L= 88.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 45.26' / 45.00' S= 0.0030 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.13 sf
#4	Secondary	48.12'	**20.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.22 cfs @ 12.11 hrs HW=48.33' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.22 cfs)

Primary OutFlow Max=0.38 cfs @ 12.11 hrs HW=48.33' (Free Discharge)
└**3=Culvert** (Barrel Controls 0.38 cfs @ 3.03 fps)
└**2=Orifice/Grate** (Passes 0.38 cfs of 14.19 cfs potential flow)

Secondary OutFlow Max=4.52 cfs @ 12.11 hrs HW=48.33' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Weir Controls 4.52 cfs @ 1.08 fps)

Summary for Pond BIO2: Bioretention 2

Inflow Area = 10,542 sf, 64.05% Impervious, Inflow Depth = 6.23" for 100-YR event
Inflow = 1.55 cfs @ 12.07 hrs, Volume= 5,468 cf
Outflow = 1.45 cfs @ 12.10 hrs, Volume= 5,468 cf, Atten= 7%, Lag= 1.8 min
Discarded = 0.05 cfs @ 12.10 hrs, Volume= 2,503 cf
Primary = 1.40 cfs @ 12.10 hrs, Volume= 2,966 cf
Routed to Pond BIO1 : Bioretention 1

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 60.30' @ 12.10 hrs Surf.Area= 829 sf Storage= 593 cf

Plug-Flow detention time= 54.9 min calculated for 5,468 cf (100% of inflow)
Center-of-Mass det. time= 54.9 min (805.9 - 751.0)

Volume	Invert	Avail.Storage	Storage Description
#1	59.25'	770 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
59.25	300	0	0
60.00	680	368	368
60.50	930	403	770

Device	Routing	Invert	Outlet Devices
#1	Primary	60.00'	**3.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	59.25'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.05 cfs @ 12.10 hrs HW=60.30' (Free Discharge)
└**2=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=1.40 cfs @ 12.10 hrs HW=60.30' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 1.40 cfs @ 1.56 fps)

Summary for Pond SP1: SP1

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

Inflow Area = 66,513 sf, 38.67% Impervious, Inflow Depth = 2.52" for 100-YR event
Inflow = 5.18 cfs @ 12.11 hrs, Volume= 13,970 cf
Primary = 5.18 cfs @ 12.11 hrs, Volume= 13,970 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

APPENDIX C – Wetland Resources Summary Memo

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

MEMORANDUM

To: Jordan Mora, APCC

From: Amy Ball, Wetland Scientist

Date: December 29, 2022

Re: Wetland Resources – Ashumet Pond Boat Ramp Stormwater Retrofit Site, Falmouth, MA

HW has prepared the following memo and site figures to document the wetland resource areas at the referenced site and to provide regulatory context for future work.

General Site Description

The site is located at the western extent of Ashumet Pond in East Falmouth, focused on the parking lot and boat launch, as well as the beach and vegetated area on the bank.

FEMA Designation

According to the FEMA National Flood Hazard Map (Community Panel No. 25001C0518J, effective July 16, 2014), the site is located outside of any Flood Hazard Areas; however, there is a Zone X area (Other Flood Hazard Areas with 0.2% annual chance of flooding) adjacent to the site, along the edge of the Ashumet Pond (**Figure 1**).

Figure 1. Excerpt from Federal Emergency Management Agency (FEMA) FIRMette for the subject site.

State-listed Rare Species Habitat and Open Space

According to the most recent version of the *Massachusetts Natural Heritage Atlas* (15th Edition, August 1, 2021), there are areas of *Estimated Habitat of Rare Wildlife* (EH 400) *and Certified Vernal Pools* and *Priority Habitat of Rare Species* (PH 455) located at the site, as designated by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) (**Figure 2**).

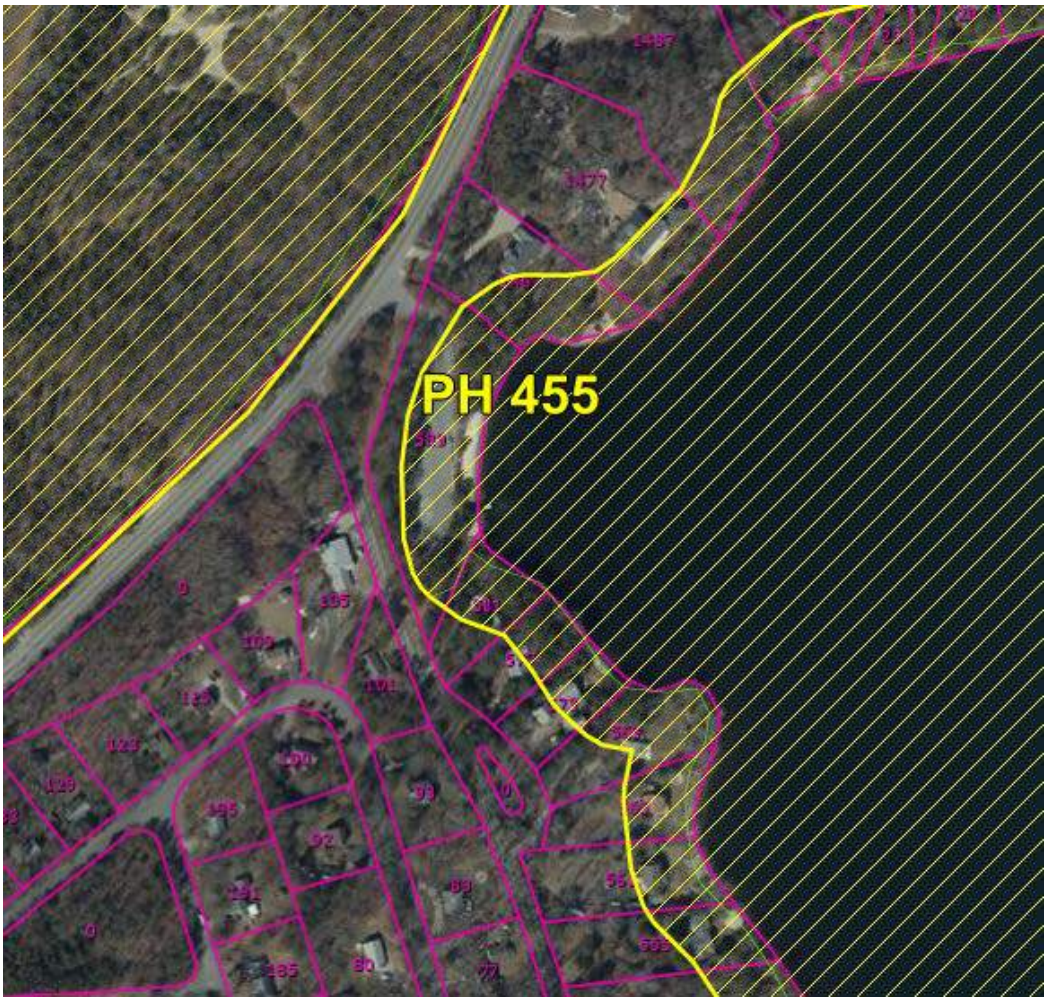


Figure 2. Rare species habitat (Source: MassMapper 2022).

Wetland Resource Areas

The site supports freshwater wetland resource areas, as defined under the Massachusetts *Wetlands Protection Act* (M.G.L. Ch. 131 § 40) and the Town of Falmouth Wetland Protection By-law (Chapter 235) and their respective regulations. Horsley Witten Group, Inc. (HW) wetland biologists identified and delineated these resource areas during a site visit on December 29, 2022. Jurisdictional areas identified on or adjacent to the site include Bank and 100-foot Buffer Zone to Bank, which includes the 75-foot Zone A No Disturb Area and the Zone B Outer Buffer

Area. Additional resource areas present adjacent to the site include Land Under Waterbodies and Waterways (Locally Land Under Water Bodies).

HW followed wetland resource area identification and on-site delineation procedure guidelines described in the Massachusetts Department of Environmental Protection (MassDEP) handbook, entitled *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act* (March, 1995), Massachusetts Wetlands Protection Act (M.G.L. Ch. 131 § 40), and its implementing Regulations (310 CMR 10.00), and the Town of Falmouth *Wetland Protection By-law* (Chapter 235) and associated Falmouth Wetland Regulations.

Prior to conducting field delineations, HW reviewed existing source data, including USGS Geological Survey 7.5 minute topographic maps, Massachusetts Department of Environmental Protection (MassDEP) wetlands source data available through the Massachusetts Geographic Information System (MassGIS), USDA Natural Resources Conservation Service (NRCS) soils survey, U.S. Fish and Wildlife Service National Wetland Inventory (NWI) maps, and other source data to identify the presence of jurisdictional wetlands and waters of the United States within the site. This information was used to compile base mapping to assist in the understanding of the hydrologic variables, soils conditions, and vegetation communities (where applicable).

A brief description of the regulatory definitions and the observed resources areas is provided below.

Bank

Bank is defined at 310 CMR 10.54(2)(a) as "…*the portion of land surface which normally abuts and confines a water body. It occurs between a water body and a vegetated bordering wetland and adjacent floodplain, or, in the absence of these, it occurs between a water body and an upland. A Bank may be partially or totally vegetated, or it may be comprised of exposed soil, gravel or stone. The upper boundary of a Bank is first observable break in the slope or the mean annual flood level, whichever is lower. The lower boundary of a Bank is the mean annual low flow level"* [310 CMR 10.54(2)(c)].

Bank is present around the perimeter of Ashumet Pond (**Photo 1**). HW used a combination of observed variables to determine the mean annual flood level/top of Bank, including water line markings and adventitious roots along the base of the existing woody vegetation growing on the Bank and changes in vegetative cover. The coastal plain pond shore contains residual plant material from the previous season's above-ground growth (dried stems, leaves, etc.) which HW identified to the genus level as sedges (*Carex spp.*) and smartweeds (*Persicaria spp.*). Common species observed in the area immediately upgradient of the bank include highbush blueberry (*Vaccinium corymbosum*), white meadowsweet (*Spiraea alba*), southern arrowwood (*Virburnum dentatum*), switchgrass (*Panicum virgatum*), and roundleaf greenbrier (*Smilax rotundifolia*). The adjacent upland areas of the site contained species including pitch pine (*Pinus rigida*), switchgrass (*Panicum virgatum*), American holly (*Ilex opaca*), black cherry (*Prunus serotina*), and eastern redcedar (*Juniperus virginiana*).

HW delineated the landward boundary of the Bank with a series of consecutively numbered blue flagging stations labeled BANK 1 – BANK 18.

Photo 1. Looking south at the Bank present along Ashumet Pond's perimeter.

Invasive Species

Invasive or Likely Invasive species (as defined by the Massachusetts Invasive Plant Advisory Group) were present at the site. The lining of the bank contained a high density of invasive plant species, including gray willow at the northern and southern sections of the site and multiflora rose at the northern end of the site. The Massachusetts Invasive Plant Advisory Group identifies invasive plant species as "non-native species that have spread into native or minimally managed plant systems in Massachusetts," and which "cause economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems." For future planning purposes, the client may wish to develop a management plan for reducing or eliminating these plants at this site to allow for the establishment of naturally vegetated protective buffers to the wetland resource areas.

If you have any questions regarding our findings, or if HW may be of further assistance, please do not hesitate to contact me directly at aball@horsleywitten.com or at (508) 833-6600.

APPENDIX D – Soil Test Pit Logs

Commonwealth of Massachusetts

City/Town of Falmouth

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

C. On-Site Review

Deep Observation Hole Number: 1 (Hole #) | 1/31/23 (Date) | 830 (Time) | 40F Snow (Weather) | 41º38'01.79"N (Latitude) | 70º32'27.47"W (Longitude)

1. Land Use: Parking lot (e.g. woodland, agricultural field, vacant lot, etc.) | Scrub oak & pine (Vegetation) | No (Surface Stones (e.g. cobbles, stones, boulders, etc.)) | 35% (Slope (%))

Description of Location: Off southwest corner of parking area, over guard rail

2. Soil Parent Material: Loamy glaciofluvial over sandy glaciofluvial | Outwash plains, terraces (Landform) | Footslope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances From: Open Water Body 150 feet | Property Line 20 feet | Drainage Way feet | Drinking Water Well feet | Wetlands feet | Other feet

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

5. Groundwater Observed: ☑ Yes ☐ No If Yes: 152" Depth weeping from pit | 152" Depth standing water in hole

Soil Log

Depth (in)	Soil Horizon/ Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles/Stones			
0-8	A	LS	10YR 2/1						SG	Fr	
8-20	Bw	LS	10YR 4/6						SG	Fr	
20-30	C	G-MS	10YR 7/3				30		SG	Fr	
30-36	Ab	LS	10YR 3/2						SG	Fr	
36-120	C1	G-MS	10YR 6/6	120"	10YR 3/1	100	30		SG	Fr	
120-156	C2	MS	10YR 7/4						SG	Fr	

Additional Notes: Some strata of sand only in C1

Commonwealth of Massachusetts

City/Town of Falmouth

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

C. On-Site Review

Deep Observation Hole Number: 2 (Hole #) | 1/31/23 (Date) | 930 (Time) | 40F Snow (Weather) | 41º38'05.47"N (Latitude) | 70º32'27.31"W (Longitude)

1. Land Use: Parking lot (e.g. woodland, agricultural field, vacant lot, etc.) | Scrub oak & pine (Vegetation) | No (Surface Stones (e.g. cobbles, stones, boulders, etc.)) | 35% (Slope (%))

Description of Location: Off south edge of entrance drive

2. Soil Parent Material: Loamy glaciofluvial over sandy glaciofluvial | Outwash plains, terraces (Landform) | Shoulder (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances From: Open Water Body 150+ feet | Property Line 10 feet | Drainage Way feet | Drinking Water Well feet | Wetlands feet | Other feet

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

5. Groundwater Observed: ☐ Yes ☑ No If Yes: _____ Depth weeping from pit _____ Depth standing water in hole

Soil Log

Depth (in)	Soil Horizon/ Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles/Stones			
0-9	Ap	LS	10YR 3/1						SG	Fr	
9-20	Bw	LS	10YR 4/6						SG	Fr	
20-96	C1	G-MS	10YR 7/2				30		SG	Fr	
96-120	C2	MS	10YR 7/3						SG	Fr	

Additional Notes: Some strata of sand only in C1

MA-FSW 239-0121 - U.S. Geological Survey

Overall Water Level Statistics (Depth to water, feet below land surface)

Lowest Water Level	Median Water Level	Highest Water Level	First Measurement Date	Last Measurement Date	Number of Measurements	Years of Record	Latest Value	Latest Percentile
8.32	6.25	3.16	1993-07-14	2023-07-31	5141	30.0	6.74	15.8
Statistics Calculated 2023-08-01								

Monthly Water Level Statistics (Depth to water, feet below land surface)

Month	Lowest Median	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	Highest Median	Number of Measurements	Years of Record
Jan	8.22	7.68	7.19	6.84	5.73	4.85	4.59	17	17
Feb	7.91	7.4	6.9	6.4	5.24	4.65	4.49	15	15
Mar	7.88	7.35	6.35	5.82	4.94	4.34	4.15	14	14
Apr	7.36	6.99	5.92	5.6	4.6	4.0	3.5	15	15
May	7.17	6.92	6.28	5.8	4.61	4.1	3.39	17	17
Jun	6.87	6.69	6.27	5.5	4.77	4.31	3.76	16	16
Jul	7.1	6.9	6.6	6.21	5.10	4.52	4.49	17	17
Aug	7.43	7.33	6.97	6.4	5.5	5.13	5.05	16	16
Sep	7.8	7.7	7.23	6.5	5.6	5.4	5.35	16	16
Oct	7.97	7.89	7.66	6.87	5.97	5.48	5.28	16	16
Nov	8.16	7.9	7.07	6.7	5.97	5.52	5.23	16	16
Dec	8.25	8.13	7.4	6.84	6.01	5.09	4.97	15	15
Statistics Calculated 2023-08-01									

Year	Month	Median
2021	07	7.1
2004	07	6.9
2016	07	6.66
2017	07	6.62
2022	07	6.6
2014	07	6.6
2015	07	6.5
2023	07	6.48
1993	07	6.46
2012	07	6.21
2009	07	5.25
2018	07	5.23
2020	07	5.12
2019	07	5.11
2013	07	5.09

Year	Month	Median
2011	07	4.73
1998	07	4.53
2010	07	4.49
2017	01	8.22
2023	01	7.68
1994	01	7.54
2016	01	7.28
2015	01	7.25
2013	01	7.13
1998	01	6.96
2021	01	6.92
2004	01	6.91
2018	01	6.84
2014	01	6.84
2022	01	6.59

APPENDIX E – Operation and Maintenance Guide

Stormwater Operations & Maintenance Guide

Ashumet Boat Ramp

Table of Contents

APPENDICES

1. INTRODUCTION

This document provides a general description along with the operation and maintenance requirements for the Ashumet Boat Ramp Stormwater Retrofit project at 589 Currier Road, Falmouth MA. The responsible parties are required to inspect and maintain all measures as outlined in this maintenance guide throughout the year. Site maintenance is divided into three categories as outlined below.

1. Green Stormwater Infrastructure
    - Structural Components
    - Structural Maintenance Schedule
    - Planting
    - Landscape Maintenance Schedule
    - Weed Guide

2. General Site Maintenance
    - Trash & Debris
    - Pet Waste
    - Pavement Sweeping
    - Contributing Drainage Areas
    - Snow Removal
    - De-icing

3. Long-Term Pollution Prevention Measures

2. RESPONSIBLE PARTIES AND BUDGET

The Ashumet Boat Ramp is located on property owned by the Commonwealth of Massachusetts, Department of Fish and Game, Office of Fishing and Boating Access. However, a portion of the access drive is on Town-owned ROW. Thus, both the State and the Town will provide staff, volunteers as possible, and funding for the long-term O&M at the site. The estimated average annual O&M budget for the proposed system is shown below:

- **Bioretentions (2):** **$1,000**
  ($500/Bio)
- **Porous Pavement:** **$3,000**
  ($1,500/cleaning)

Owner and operator contact information is provided below:

Owner: **Commonwealth of Massachusetts**
Contact: **Department of Fish and Game - Office of Fishing and Boating Access**
Doug Cameron, Director
1 Rabbit Hill Rd.
Westborough, MA 01581
doug.cameron@mass.gov
617-828-3532

Owner: **Town of Falmouth**
Contact: **Department of Public Works**
Peter M. McConarty, Director
416 Gifford Street
Falmouth, MA 02540
dpw@falmouthma.gov
508-457-2543

Contact: **Department of Marine and Environmental Services**
Gregg Fraser, Director
180 Scranton Avenue
Falmouth, MA 02649
gregg.fraser@falmouthma.gov
508-457-2550

Owner - Signature:_____ Date:_____

Operator - Signature:_____ Date:_____

Operator - Signature:_____ Date:_____

3. GREEN STORMWATER INFRASTRUCTURE

3.1. How Does Green Infrastructure Work?

Green Stormwater Infrastructure (GSI) is a nature-based approach to stormwater treatment and management. These stormwater practices or "treatment areas" are designed to mimic nature and use the natural filtration properties of soil and plants to remove pollutants from stormwater runoff prior to discharging to the municipal drainage system or waterbodies.

GSI relies on the following basic steps to function properly. Structural components of the practices facilitate the functioning of the steps. If one of these steps, or components, does not work properly, the entire system can be compromised and the GSI practice itself could be contributing to maintenance problems. This can lead to landscape nuisances, more frequent maintenance and costly repairs/improvement. The steps are:

1. ***Collect*** (Inlets)
2. ***Move Water*** (Conveyance) if needed, can come after capturing sediment
3. ***Capture Sediment*** (Pretreatment)
4. ***Treat and Manage*** (Filter, Infiltrate or Store)
5. ***Overflow*** (Structures and Spillways)

3.2. What is required for Maintenance?

As these are nature-based systems that rely on plant upkeep, the maintenance for GSI typically falls under landscape and general site maintenance services. Proper operation and maintenance (O&M) are vital to its long-term viability. Regularly scheduled maintenance can prevent system failures due to sediment build-up, damage, or deterioration. The maintenance requirements, outlined in this guide, are critical to ensure proper treatment, maintain storage capacity and preserve the visual integrity.

General maintenance includes the following:

1. Removing sediment from the pretreatment practices used to capture sediment.
2. Maintaining the proper drainage function and pollutant removal capacity of the systems.
3. Maintaining healthy native trees, plants, and vegetative cover as well as the removal of unwanted weeds and invasive species.

It is recommended that all practices be maintained regularly as part of the routine landscape maintenance or at a minimum four times per year and after major rain events:

- **Early Spring**: during spring cleanup
- **Summer:** during lawn mowing and other routine site maintenance
- **Early Fall:** when leaves begin to fall
- **Late Fall/Early Winter:** after all the leaves have fallen during leaf removal
- **After major storm events**: 2" of rain or greater.

The following sections describe the general function and landscape maintenance of each practice on the site. Included in the appendices is a specific Inspection Report for each practice type (**Appendix A**) along with a plan showing the location of the items to be inspected and maintained (**Appendix B**).

3.3. What practices are used at this site?

The following practices are present at this site:

a. Bioretention Areas: A bioretention area is a stormwater management practice to manage and treat stormwater runoff using a conditioned planting soil bed or "filter" media and plants to filter runoff captured in a shallow depression. The method combines physical filtering and adsorption with bio-geochemical processes to remove pollutants.

b. Porous Pavement: Porous pavements are designed to capture and infiltrate runoff. The areas of porous pavement have been placed to ensure they do not collect runoff from the traditional impervious pavement, as this can clog the pervious pavement. Regular maintenance is critical to the success of this practice.

The maintenance for the green infrastructure is divided into two categories:

a. The **Structural Components** that make up the basic steps of a functioning system.

b. The **Plantings** that are the landscape and filtration element.

Each category is further described in the sections below.

4. STRUCTURAL COMPONENTS: BIORETENTION AREAS

Structural Components

1. ***Collect***: Stormwater runoff is directed to paved flume inlets(s) and/or grass channel where stormwater enters the bioretention area.

2. ***Capture Sediment***: Sand and debris settle out within sediment forebays.

3. ***Move Water:*** The stormwater discharges directly to the bioretention area via a check dam weir.

4. ***Treat and Manage***: Stormwater overtops the forebay check dam and flows through the planted bioretention area. Plants slow the water down, and the soil media and plant roots filter the runoff, removing nutrients and bacteria. The treated water then infiltrates into the soil below or overflows as described below.

5. ***Overflow***: During larger rain events, the water level will rise and overflow either into the outlet structure or back out the paved flume.

MAINTENANCE SCHEDULE: BIORETENTION AREAS

A site inspection of the bioretention components shall be conducted at least twice a year in the Spring and Fall, and after major storm events (2" of rain or greater). Debris and trash should be removed monthly (between April and November) and sediment removal should occur during the two site inspections and during the monthly debris and trash inspections as needed. See the calendar below and the Inspection Report in **Appendix A** for more information.

Bioretention General Maintenance Schedule												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Task	**Frequency & Time of the Year**											
Site Inspection				**X**							**X**	
Debris & Trash Removal				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Sediment Removal				**X**	x	x	x	x	x	x	**X**	

should **also** be completed after major storm events

X required inspection

x as needed

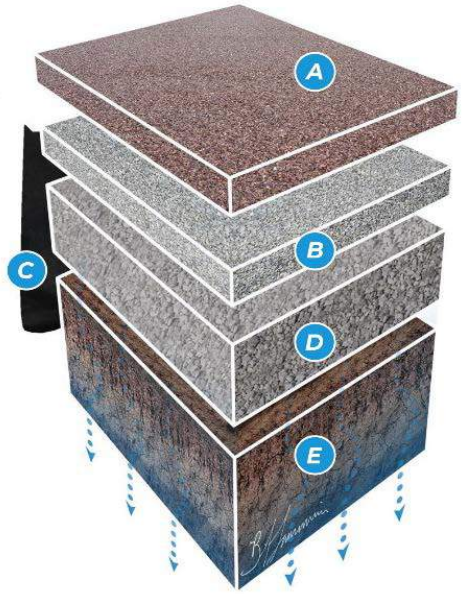
- When removing trash and debris during monthly inspections look for:
  - If sediment is > 3" in paver lined sediment forebays. Ensure sediment does not cause blockage of inlet weirs. If it is, remove sediment.
  - If standing water does not drain after 48 hours. See Inspection Report for action items.

- After rain event look for:
  - If standing water does not drain after 48 hours. See Inspection Report for action items.

Use a shovel to clear stone and sediment from the inlets.

See Plantings section for information on plantings maintenance of the bioretention area. Use the plantings maintenance calendar to combine maintenance efforts.

5. STRUCTURAL COMPONENTS: POROUS PAVEMENT



A Porous Pavement
B Choker Course
C Filter Fabric *(Sidewalls Only)*
D Filter Course
E Approved Subsoil

Structural Components

1. ***Collect***: Stormwater runoff is absorbed directly into the pervious surface when it rains.
2. ***Capture Sediment***: Porous pavements are designed for minimal run-on from permeable surfaces (like lawn areas) and no runoff from impervious pavement, so sediment should be minimal. Sediment will filter into the porous pavement and will eventually clog.
3. ***Move Water:*** The stormwater filters through the surface material and choker courses.
4. ***Treat and Manage***: The stormwater is treated as it flows through the filter course into the underlying native soils.
5. ***Overflow***: During larger rain events, once the porous pavement and gravel below are saturated, additional runoff will flow downgradient to the bioretention and then down to the boat ramp and out to the pond.

MAINTENANCE SCHEDULE: POROUS PAVEMENT

A site inspection of the porous pavement shall be conducted at least twice a year in the Spring and Fall, and after major storm events (2" of rain or greater). See the calendar below.

Pervious Pavement and Pavers General Maintenance Schedule												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Task	**Frequency & Time of the Year**											
Site Inspection				**X**				**X**				
Debris & Trash Removal				**X**	x	x	x	x	x	x	**X**	
Sediment Removal	x	x	x	**X**	x	x	x	x	x	x	**X**	x

should **also** be completed after major storm events

X required inspection

x as needed

Frequent cleaning and maintenance is critical to prevent clogging of porous surfaces. To keep the surface clean, sweep the porous pavement using vacuum sweepers at least twice a year.

No sanding or de-icing is permitted. Full porous pavement replacement will be conducted every 10-20 years or as determined necessary due to field conditions.

6. PLANTINGS

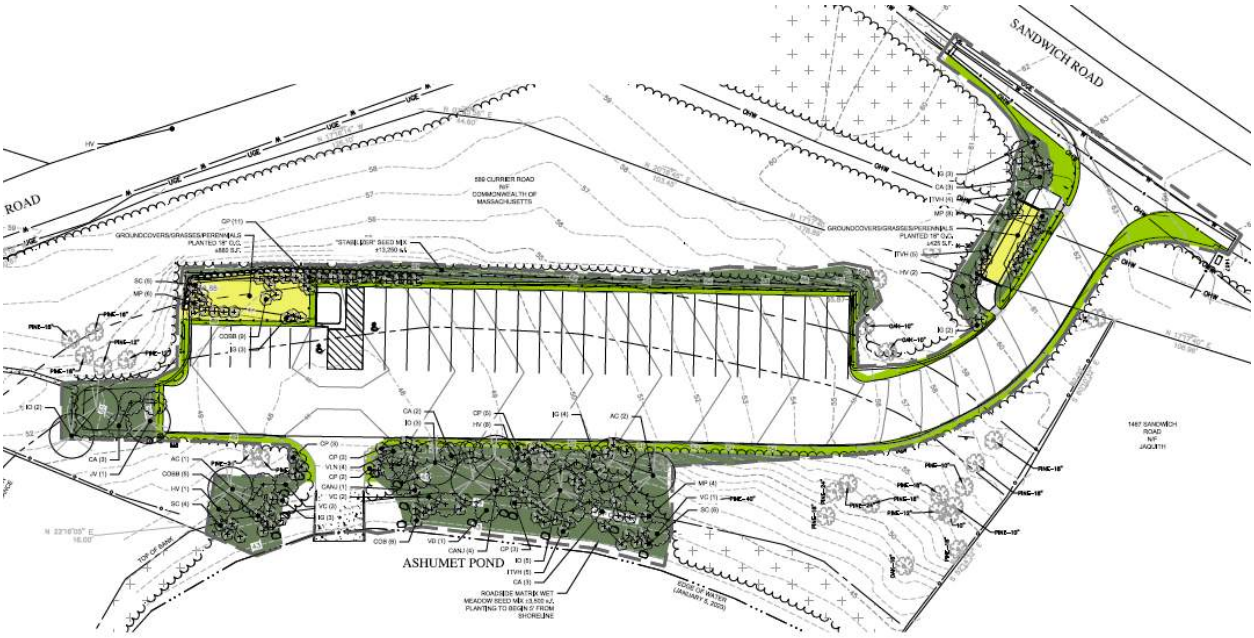
6.1. Plantings

The planting design for the site consists of three landscape maintenance areas. The “mow” area which consists of turf, the “no mow” areas (two Bioretention areas), and the natural buffer. The plantings maintenance checklist is included in **Appendix A**, and the full planting plan is available in **Appendix C**.

“Mow” Areas

No “Mow” Area (Bioretentions)

Natural Buffer



PLANTINGS: "MOW" AREAS MAINTENANCE

There is an area of the site that is allowed to be maintained as "mowed" lawn as necessary. Landscape maintenance of "mowed" lawn areas includes the following:

Seeding

Loam and reseed bare spots with a seed mix that matches existing species.

Mowing/Weed Whacking

Cut only 1/3 of vegetation. Do not mow during drought periods or when excessively wet. Depending on height of grasses and the time of year, grass cuttings/stalks may need to be raked and removed from site.

Watering

Allowing the lawn areas to "brown" is desired. Water only during drought conditions or during reseeding establishment period.

Fertilizing

No fertilizer shall be used.

Weeding

Weeding should be limited to invasive and weedy species (see section 3.6 Weed Identification below and the Weed Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf). Non-chemical methods (hand pulling and hoeing) are required; chemical herbicides should be avoided. Properly remove and dispose of all invasive species off site as to prevent colonization elsewhere, this includes disposal on land beyond the project area.

Monitoring

During the establishment period, walk the mow areas monthly during the first year to look for invasive species, bare spots and identify potential pest or disease problems. Properly remove and dispose of all invasive species as to prevent colonization elsewhere, this includes disposal on land beyond the project area.

Debris & Trash

Remove and properly dispose of litter from all areas prior to mowing.

PLANTINGS: NO "MOW" AREA MAINTENANCE (BIORETENTION AREAS)

By design, plants in bioretention areas are meant to flourish throughout the growing season leaving dry standing stalks during the dormant months. Plants do not require fertilizers or waterin(except during drought or establishment period). This area is designated as "no mow." Frequent mowing would eliminate selected meadow species, may promote the growth of undesirable plants, and require additional maintenance and watering. It is recommended this area be cut back no more than one time per year and only as necessary. Remove and replace vegetation as necessary, using the appropriate species as shown on the Planting Plan. The best time to plant is in early to mid-fall or early to mid-spring. Specific maintenance activities of the "no mow" area include:

Seeding

Loam and reseed bare spots with the specified seed mix as shown on the Planting Plan.

Cutting Back

Recommend cutting with shears a maximum of once a year in early spring. Otherwise, allow areas to grow to their natural heights (12" to 36") to maintain a meadow appearance. Do NOT cut area lower than 6" – maintain sporadic wooden stakes on site at 6" height to provide visual cues during cutting. Depending on height of grasses and the time of year, grass cuttings/stalks may need to be raked and removed from site so as not to clog the bioretention. Use a leaf blower as needed to assist in clean-up.

Pruning

Prune trees and shrubs to remove deadwood and low hanging branches.

Watering

Water only during drought conditions or during reseeding establishment period.

Fertilizing

No fertilizer shall be used.

Weeding

Weeding should be limited to invasive and weedy species (see section on Weed Identification below and the Weed Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf). Non-chemical methods (hand pulling and hoeing) are required; chemical herbicides should be avoided. Properly remove and dispose off site all invasive species as to prevent colonization elsewhere; this includes disposal on land beyond the project area.

Monitoring

During the establishment period, walk the "no mow" areas monthly without the intent to cut, but to look for invasive species, bare spots and identify potential pest or disease problems.

Debris & Trash

Remove and properly dispose litter from all areas.

PLANTINGS: NATURAL BUFFER AREAS MAINTENANCE

This area is intended to increase the natural buffer to the adjacent pond and is not to be disturbed. Maintenance of natural buffer areas includes the following:

Monitoring

Walk the buffers to look for potential invasive species and identify potential disease.

Weeding

Weeding should be limited to invasive and weedy species (see section 3.6 Weed Identification below and the Weed Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf). Non-chemical methods (hand pulling and hoeing) are required; chemical herbicides should be avoided. Properly remove and dispose of all invasive species as to prevent colonization elsewhere; this includes disposal on land beyond the project area.

Watering

Water only during drought conditions or during the plant establishment period.

Debris & Trash

Remove and properly dispose litter from all natural areas.

PLANTINGS: REPLACEMENTS

The plants that thrive in bioretention areas are typically quite drought tolerant due to the filter profile having a top layer of planting soil and sandy soil media below. They need to be able to withstand periods of inundation after storm events; however, when it doesn't rain, there will be less water held naturally in the sand than in other soil types for the plants to use, so they need to tolerate dry periods as well.

Specifying plants native to the area increases the ecosystem benefits by helping to support native wildlife like pollinators.

If replacements are needed, use the planting plan as a guide (see **Appendix C**). However, if all the plants of a certain species have not done well in the bioretention area or other locations on the site, do not replace with that same species. Rather, replant with one or more of the other species that has thrived under the conditions or have a plant professional choose a different species based on current photos of the site.

Site specific considerations for plants in bioretention areas should be:

- Preferably native
- Drought tolerant
- Tolerant of inundation for 24 hours
- Size constraints:
    - taller perennials at the bottom of the bioretention
    - shorter perennials on the side slopes
- Shade tolerant
- Culturally important
- A mix of different types of plants that will create a resilient plant community: cold & warm season grasses, perennials, groundcovers in all areas.

PLANTINGS: MAINTENANCE SCHEDULE

By design, plants in the bioretention area are meant to help filter the stormwater as it passes through and flourish throughout the growing season. The plants do not require fertilizers or mulch, and, after establishment, only need water during periods of drought. Remove and replace vegetation as necessary, using the appropriate species as discussed in the no-mow section above. Weeding and monitoring for invasive species should occur quarterly during the growing season. An annual spring "clean up" includes cutting last season's growth of the perennials and pruning as needed. See the calendar below, the Plantings Maintenance Checklist in **Appendix A**, the Weed Identification section, and the Weed Identification Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf for more information.

Bioretention Landscape Maintenance Schedule												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task	Frequency & Time of the Year											
Cutting				**X**								
Mowing				x	**X**	x	x	x	x	x		
				x	x	**X**	x	x	x	x		
Weeding				**X**		**X**			**X**			
Monitoring				**X**		**X**			**X**			
Watering						x	x	x	x			
Seeding				x	x				x	x		
Plant Replacement				x	x				x	x		

"Mow" Areas
No "Mow" Areas (Bioretention Areas)
All areas

X required
x as needed

- Trash and debris are removed during monthly structural component inspections but can also be completed during landscape maintenance visits for weeding and monitoring.

Yellow Toadflax *(Linaris vulgaris)*

Redroot Pigweed- (*Amaranthus retroflexus)*

Smartweed *(Polygonum lapathifolium)*

Dandelion *(Taraxacum officinale)*

Fireweed *(Erechtites hieracifolia)*

Spotted Spurge (Euphorbia maculata)

Crabgrass *(Digitaria ischaemum)*

Crabgrass with seedheads

Ragweed (*Ambrosia artemisiifolia*)

Japanese Knotweed (Polygonum cuspidatum)

Ragweed (*Ambrosia artemisiifolia*)

Oriental Bittersweet (*Celastrus orbiculatus*)

Green Foxtail (Setaria viridis)

Norway Maple Tree Seedling (Acer platanoides)

Catalpa Tree Seedling (Catalpa speciosa)

Purple Loosestrife (*Lythrum salicaria*)

Field Bindweed (*Convolvulus arvensis*)

Black Swallow-wort (*Cynanchum louisea*)

7. GENERAL SITE MAINTENANCE

General site maintenance includes the following requirements:

Trash & Debris

Remove and properly dispose of all trash and debris.

Pet Waste

Visitors to the site are encouraged to pick up after their pets. Remove and properly dispose of all pet waste left behind. Pet waste should be picked up and disposed of properly to reduce bacteria and nutrient levels in stormwater.

Pavement Sweeping

Paved roadways should be mechanically swept, at a minimum of once per year in early spring, to remove accumulated sand and sediment debris. Porous pavement should be swept using a vacuum sweeper at least twice a year.

Snow Removal

Due to the potential for plant damage, snow piling and or removal is NOT recommended in the bioretention areas.

De-Icing

When de-icing compounds are necessary for areas draining to the green stormwater infrastructure, the least harmful chemicals should be used. Excessive salting should be avoided. Use of large amounts of sand should also be avoided, since it may obstruct the conveyance system. Ice removal is NOT permitted in the bioretention areas or porous pavement.

8. LONG-TERM POLLUTION PREVENTION MEASURES

Long-term pollution prevention measures implemented at the site reduce pollutants in stormwater discharges. The following precautions will be employed on an on-going basis.

Spill Prevention & Control Measures

To minimize the risk of spills or other accidental exposure of materials and substances to stormwater runoff, the following material management is to be used when working on site.

- Any materials stored on-site will be stored in a neat, orderly manner in their appropriate containers.
- Products will be kept in their original containers with the original manufacturer's label.
- Substances will not be mixed with one another unless recommended by the manufacturer.
- Manufacturers' recommendations for proper use and disposal will be followed.
- The contractor's supervisor will be issued this Guide to ensure proper use and disposal of materials.

Materials or substances listed below may be present on-site for maintenance and care should be taken to avoid spills:

- Petroleum Based Products

The following product-specific measures will be followed on-site:

- *Petroleum Products* - All on-site vehicles will be monitored for leaks and receive preventative maintenance to reduce the chance of leakage.
- *Grass Clipping, Leaf Litter and Plant Debris* – are to be removed from the property and not disposed on site.

APPENDIX A – Maintenance Checklists

- Bioretention Areas
- Porous Pavement
- Landscaping

Operation and Maintenance Checklist
Ashumet Boat Ramp

Date:

Time:

Inspector:

Maintenance Item	Description	Maintenance (Y/N)
1, 2 & 3. Inlet Flumes, Grass Channel, Sediment Forebays, and Check Dam Weirs		
Debris Cleanout	Remove all trash, leaf litter and debris from the inlet flumes, grass channel and forebays.	
Sediment/Organic Debris Removal	Check for clogging and sediment accumulation that impacts inflow and outflow. Remove and properly dispose of when sediment is >3" in forebays. Remove/cut any vegetation that sprouts through voids in stone, pavement, or pavers.	
Erosion	Check for areas of erosion (gullies, animal burrowing, or overtopping), particularly near check dam weirs, perimeter, and guard rail posts. Repair as necessary and return to design grades.	
Actions to be taken:		
4. Bioretention Areas		
Debris Cleanout	Remove trash and debris from the surface.	
Erosion	Signs of erosion gullies, animal burrowing, or overtopping are observed. Repair as necessary.	
Sediment/Organic Debris Removal	Remove sediment accumulation and properly dispose when accumulation is greater than or equal to 3 inches.*	
Water Draining properly	If standing water is observed in bioretention areas for more than 48 hours after a storm event, rototill or aerate the bottom 6 inches to breakup any hard-packed sediment, and re-plant as needed. Check for leaf litter, debris, and sediment accumulation in overflow outlet structure that impacts inflow to chambers. If accumulation present, schedule cleaning. Check for sediment accumulation and/or standing water that indicates clogging in the chambers. If sediment or standing water is observed in chambers (use inspection ports) for more than 48 hours after a storm event, clean out chambers per manufacturer's instructions in **Appendix C**.*	
Actions to be taken:		

Operation and Maintenance Checklist
Ashumet Boat Ramp

Maintenance Item	Description	Maintenance (Y/N)
5. Overflow Structures: Overflow Structure		
Debris Cleanout	Remove all trash, leaf litter and debris from the overflow structure in BIO-1.	
Sediment/Organic Debris Removal	Check for clogging and sediment accumulation that impacts inflow and outflow.	
Actions to be taken:		
Porous Pavement		
Debris Removal	Remove trash from paved and perimeter areas. Sweep surface.	
Vacuum	Vacuum surface to clean pores of debris and sediment with a commercial vacuum system.	
Structure	Repair cracking or other structural issues as found during inspection.	
Actions to be taken:		
General Site Maintenance		
Debris Removal	Remove trash from perimeter areas.	
Pet Waste Removal	Remove any pet waste from perimeter areas.	
Pavement Sweeping	Sweep road minimum once a year after spring thaw.	
Contributing drainage area	Confirm that contributing drainage area stabilized – stabilize as necessary.	
Snow Removal	Ensure snow piles do no block inlet structures and are not placed in the green stormwater infrastructure.	
De-Icing	Do not remove ice in the bioretention areas. If needed on road, use de-icing compounds with the least harmful chemicals. Avoid excessive salting or large amounts of sand.	
Actions to be taken:		

*Sediment shall be disposed of offsite in a pre-approved location.

Plantings Maintenance Checklist
Ashumet Boat Ramp

Location:

Date:

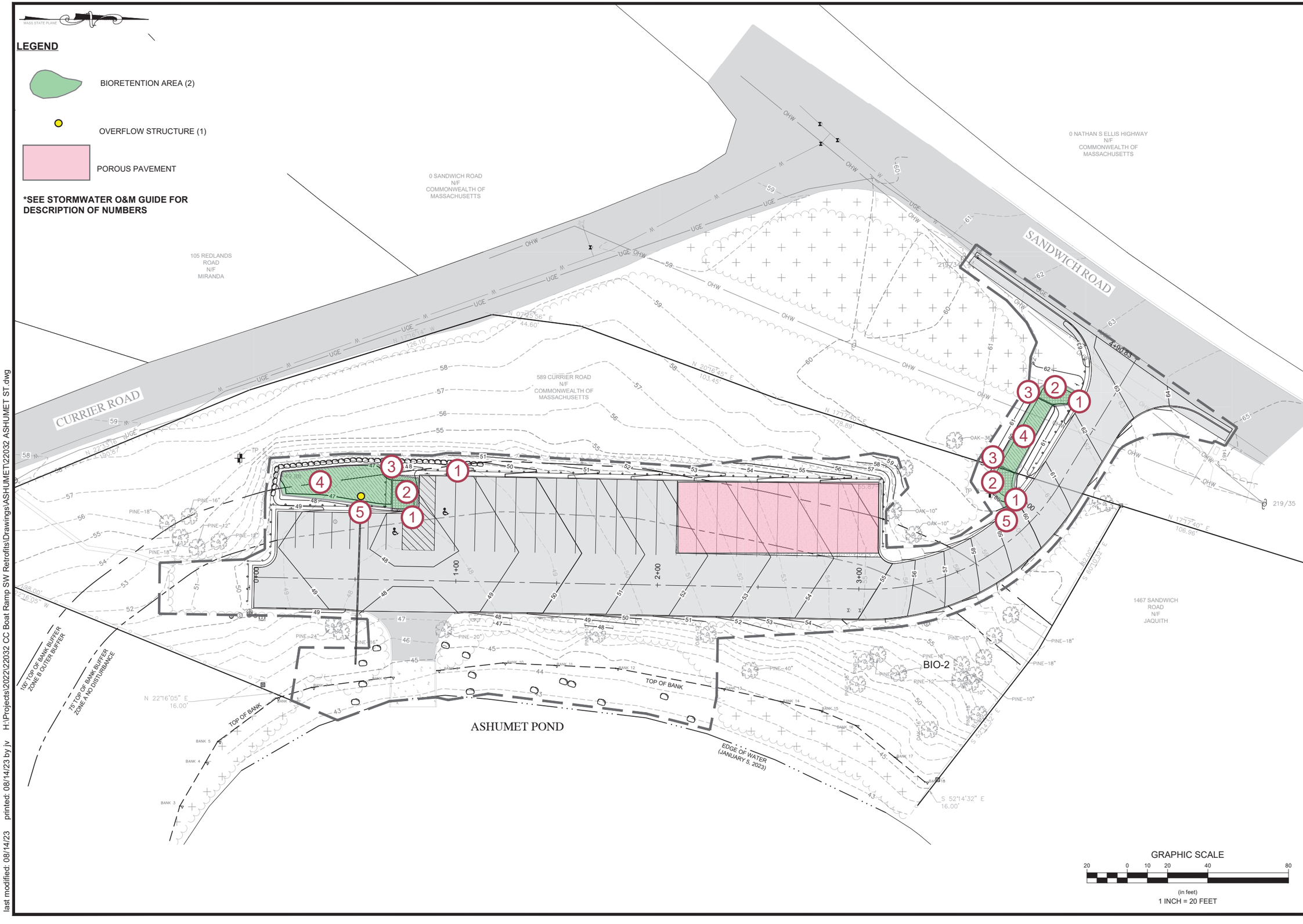
Inspector:

Task	Description	Complete (Y/N)
Cutting	• Cut with shears once a year in the early spring. • Do not cut lower than 6". • Blow out leaves and cuttings for easy removal. • Remove cuttings so the bioretention area does not clog.	
Mowing	• Mow twice a year or more frequently as needed with a mulching mower or weed whacker depending on the frequency of cutting. • Bag clippings as needed and dispose of off site. • Maintain a cutting height of 3" or greater. • Leave the grass taller in the warmer months. • Trim edges when necessary.	
Weeding	• Weeding should be limited to invasive and exotic species, which can overwhelm the desired plant community.* • Non-chemical methods including hand pulling and hoeing are recommended. • Chemical herbicides are not allowed.	
Monitoring	• Look for potential invasive species and identify potential disease. Remove and dispose of all invasive species.* (see weeding)	
Watering	• During establishment or drought conditions, plants should be watered a minimum of once every seven to ten days.	
Seeding	• Loam and re-seed bare spots with the specified seed mix as shown on the Planting Plan.	
Plant Replacement	• Replace/replant diseases, unhealthy or dead plans to maintain a healthy plant community	
Fertilizing	NONE	
Mulch	NONE	
Actions to be taken:		

*Invasive species shall be disposed of offsite in a pre-approved location.

"Mowed" Areas
No "Mow" Areas (Bioretention Areas)
All areas

APPENDIX B – Overall SCM Locations



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Revisions

Rev.	Date	By	Appr.	Description

Horsley Witten Group, Inc.
Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

Date: JUNE 2023 | Designed By: - - | Drawn By: JLV | Checked By: MW

Plan Set: CAPE COD BOAT RAMP STORMWATER RETROFIT PROJECT - 25% DESIGN ASHUMET POND FALMOUTH, MA

Plan Title: OVERALL SCM LOCAITONS

Prepared For:
Massachusetts Office of Fishing and Boating Access
1 Rabbit Hill Road
Westborough, MA
Phone: (508) 389-7810
Fax: —

Survey Provided By:
Horsley Witten Group, Inc.
90 Route 6A
Sandwich, MA 02563
Phone: (508) 833-6600
Fax: (508) 833-3150
Dated: January 5, 2023

Registration:

DRAFT
NOT FOR CONSTRUCTION

Project Number: 22032 | Sheet: 1 of 4

Sheet Number: C - 1

APPENDIX C – Planting Plan

MASS STATE PLANE

KEY

DECIDUOUS TREE

EVERGREEN TREE

SHRUB

BIORETENTION PLANTING

SEED MIX #1

SEED MIX #2

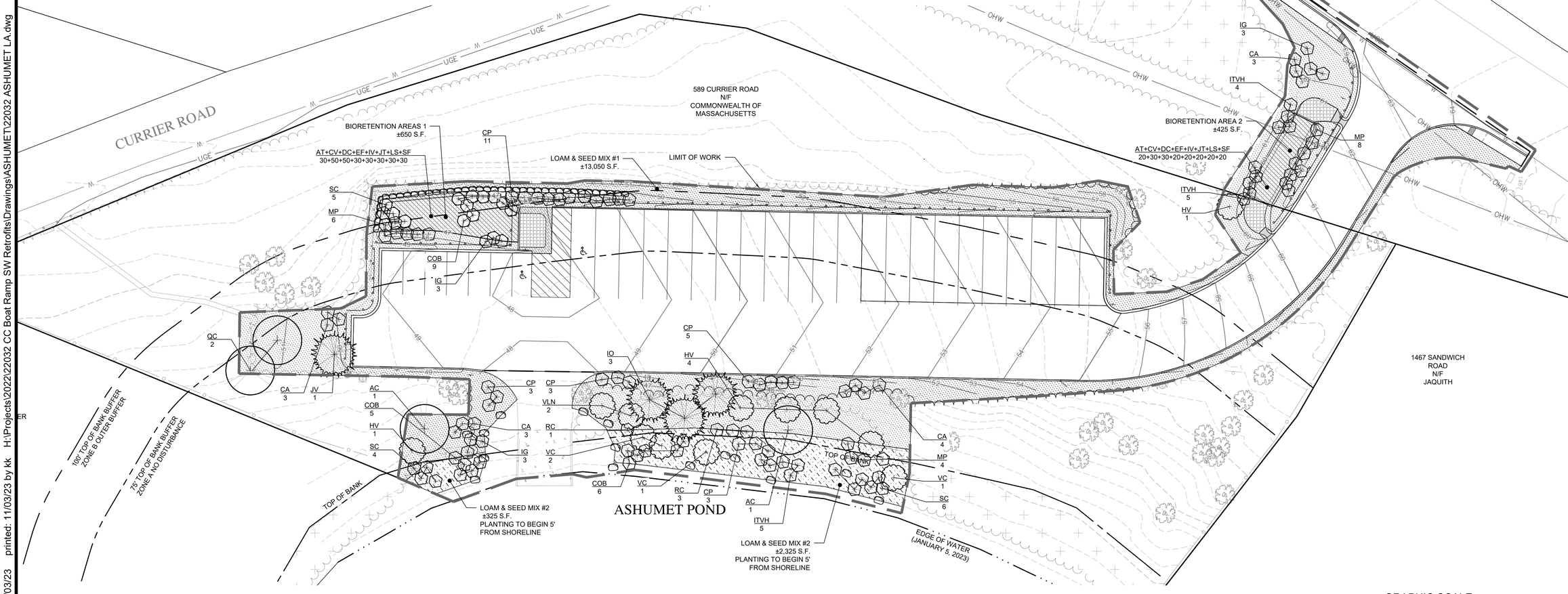
Master Plant List

Key		Botanical Name	Common Name	Size	Spacing
		Deciduous Trees			
AC	2	*Amelanchier canadensis*	Shadblow Juneberry	5/6' B&B	As Shown
QC	2	*Quercus coccinea*	Scarlet Oak	2.5-3" cal.	As Shown
		Evergreen Trees			
IO	3	*Ilex opaca*	American Holly	5/6' B&B	As Shown
JV	1	*Juniperus virginiana*	Eastern Red Cedar	8'/10' B&B	As Shown
		Shrubs			
COB	20	*Cephalanthus occidentalis*	Button Bush	#3	As Shown
CA	13	*Clethra alnifolia*	White Summer Sweet	#2	As Shown
CP	25	*Comptonia peregrina*	Sweet Fern	4" pot	As Shown
HV	6	*Hammamelis virginiana*	Common Witch Hazel	2/3' B&B	As Shown
IG	9	*Ilex glabra*	Inkberry	24/30" B&B	As Shown
ITVH	14	*Itea virginica*	Virginia Sweetspire	#3	As Shown
MP	18	*Myrica pensylvanica*	Bayberry	3/4' B&B	As Shown
RC	4	*Rosa carolina*	Carolina Rose	#2	As Shown
SC	15	*Sambucus canadensis*	American Elderberry	#2	As Shown
VC	4	*Vaccinum corymbosum*	Highbush Blueberry	#2	As Shown
VLN	2	*Viburnum lentago*	Nannyberry	#7	As Shown
		Bioretention Plantings			
AT	50	*Asclepias tuberosa*	Butterfly Weed	#1	18" O.C.
CV	80	*Carex vulpinoida*	Fox Sedge	plugs	12" O.C.
DC	80	*Deschampsia cespitosa*	Tufted Hair Grass	#1	24" O.C.
EF	50	*Eupatorium fistulosum*	Joe Pye Weed	#1	36" O.C.
IV	50	*iris versicolor*	Blue Flag	#1	18" O.C.
JT	50	*Juncus tenuis*	Slender Rush	plugs	12" O.C.
LS	50	*Liatris spicata*	Blazing Star	#1	24" O.C.
SF	50	*Solidago flexicaulis*	ZigZag Goldenrod	#1	18" O.C.

	Seed Mixes	
13,050 SF	**SEED MIX #1: Lavoie Horticulture "Stabilizer Mix"**	
	Deschampsia flexuosa	Wavy Hair Grass
	Schizachyrium scoparium	Little Bluestem
	Andropogon gerardi	Big Bluestem
	Agrostis perennans	Upland Bent Grass
	Agrostis scabra	Rough Bent Grass
	Festuca x spp	Blue X Hard Fescue
	Festuca glauca	Blue Fescue
	Elymus canadensis	Candada Wild Rye
	Carex swanii	Swan Sedge
	Solidago sempervirens	Seaside Goldenrod
	Asclepias tuberosa	Butterfly Milkweed
	Coreopsis lanceolata	Lance-Leaved Coreopsis
	Trifolium repens spp.	Micro-Clover
	Trifolium repens	White Clover
	Chamaecrista fasciculata	Partridge Pea
	Desmodium canadense	Tick Trefoil
2,650 SF	**SEED MIX #2: New England Wetland Plants Roadside Matrix Wet Meadow Seed Mix**	
	Elymus riparius	Riverbank Wild Rye
	Elymus virginicus	Virginia Wild Rye
	Festuca rubra	Red Fescue
	Panicum virgatum	Switch Grass
	Carex scoparia	Blunt Broom Sedge
	Cornus amomum	Silky Dogwood
	Carex lurida	Lurid Sedge
	Iris versicolor	Blue Flag
	Asclepias incarnata	Swamp Milkweed
	Viburnum dentatum	Arrow Wood Viburnum
	Aster novae-angliae (Symphyotrichum novae-anglia)	New England Aster
	Eupatorium perfoliatum	Boneset
	Eupatorium maculatum (Eutrochium maculatum)	Spotted Joe Pye Weed
	Sambucus canadensis	Elderberry

PLANTING LAYOUT NOTES

1. FOR AREAS WITH MIXED GROUNDCOVERS / GRASSES AND/OR PERENNIALS (SHOWN AS HATCHED AREAS ON PLANS), DO NOT PLANT IN A PATTERN OR WITH LARGE AREAS OF THE SAME SPECIES. RANDOMLY PLANT AS INDICATED ON THE PLANTING PLANS INTO SMALL GROUPINGS OF THE SAME SPECIES TO CREATE A MORE NATURALISTIC APPEARANCE. PLANT THE SAME PLANT SPECIES IN GROUPS OF 3-7 AND NOT LARGER THAN 7, DEPENDING ON THE OVERALL NUMBER OF PLANTINGS.
2. ALL BIORETENTION BASIN PLANTINGS SHALL BE PLANTED WITH A MIX OF GROUNDCOVERS / GRASSES / PERENNIALS AT SPACING SPECIFIED IN THE PLANT LIST.



PERMITTING SET ONLY
NOT FOR CONSTRUCTION

GRAPHIC SCALE
20 0 10 20 40 80
(in feet)
1 INCH = 20 FEET

Revisions

Rev.	Date	By	Appr.	Description

Horsley Witten Group, Inc.
Sustainable Environmental Solutions
www.horsleywitten.com
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508-833-3150 fax

Checked By: BRK
Drawn By: KAK
Designed By: KAKME
Date: NOVEMBER 2023

Plan Set: ASHUMET POND
CAPE COD BOAT RAMP STORMWATER
RETROFIT PROJECT - PERMITTING PLANS
FALMOUTH, MA

Plan Title: PLANTING PLAN

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Sheet : 8 of 9
Sheet Number: C - 8

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APPENDIX F – Pollutant Controls During Construction

POLLUTANT CONTROLS DURING CONSTRUCTION

1.1 Structural Practices

The following are the structural practices that will be implemented as part of the construction activity.

- Visibility Fence/Sediment Silt Sock Barrier will be installed prior to commencement of construction. The visibility fence will keep construction equipment within the limit of work, and the silt sock will be used on the downgradient portions of the limit of work to allow water to flow through it while keeping sediment on site. The Town will be informed upon their installation so that they may inspect these barriers prior to construction. Portions of these barriers will be replaced and/or repaired as necessary. Barriers will be installed parallel to land slope at the perimeter of the work site, as shown on the Plans. Details are provided in the Plans.

- Silt Fence will be installed prior to commencement of construction at the top of the boat ramp to provide extra sediment control at the boat ramp as this is the existing low point of the parking lot. They will be inspected daily and repaired/replaced as necessary.

- Silt Sacks (or approved equivalent) will be installed at identified overflow structures and following construction of the proposed overflow structures to prevent sedimentation during construction. The silt sack will be emptied/replaced and disposed of off-site if damage is observed.

- Sediment Traps/Basins. The bioretention area(s) will be graded to within one foot of design elevations until site is fully stabilized to capture sediment during construction. Heavy equipment will not be allowed to operate on the surface location where the systems are planned because soil compaction can adversely impact their long-term performance. Light earth-moving equipment will be used for excavation and construction of the systems. All excavated materials from the area will be removed and disposed of in an approved location. All sediment traps/basins will be inspected at least once every seven calendar days and immediately after storm events by the Construction Manager.

- Construction Entrance will be installed following pavement removal. All construction vehicles must use this access point to ensure sediment is not tracked off site.

- Slope Stabilization will occur immediately upon obtaining final grades as shown on the project site plans. Areas that fail to stabilize will be re-graded to final grade and stabilized as necessary. Amount of land disturbed will be minimized to reduce potential for erosion and sedimentation. Stabilization measures shall be initiated within 14 days following the end of construction at each portion of the site and as soon as practicable.

The entire stormwater management system including pipe, structures, and bioretention areas will be inspected upon completion of construction. Sediment will be removed from all elements of the

stormwater management system. All control measures must be installed and maintained in accordance with manufacturer's specifications, good engineering practices, and in accordance with this report (every seven calendar days and after storm events). If inspections show that a control has failed or been installed incorrectly, the Operator must replace or modify it within 24 hours.

1.2 Stabilization Practices

The amount of land disturbed during construction will be minimized to reduce the potential for erosion and sedimentation. Prompt surface stabilization will be provided to control erosion in areas where disturbances cannot be avoided during construction. Stabilization measures shall be initiated within 14 days following the end of construction at each portion of the site. Exceptions to this requirement are allowable when snow cover prevents the initiation of stabilization within 14 days, in which case such measures shall be undertaken as soon as possible.

Stabilization measures that will be, or may be, used during construction are described below:

- Temporary Seeding – Temporary seeding of disturbed surfaces with fast-growing grasses (annual rye) to provide greater resistance to stormwater runoff and/or wind erosion for areas where construction has temporarily ceased.

- Permanent Seeding – Permanent seeding of surfaces with vegetation, including but not limited to grass, trees, bushes, and shrubs, to stabilize the soil. Establishing a permanent and sustainable ground cover at a site stabilizes the soil while reducing the sediment content in runoff.

- Permanent Planting –establish all planting as required at the completion of the project.

- Erosion Control Blankets - install erosion control blankets along all slopes greater than 3:1.

- Mulching – materials, including but not limited to hay, grass, woodchips, straw, and gravel will be placed on the soil surface to cover and hold in place disturbed soils.

Temporary seeding or other soil stabilization measures will be provided where construction activities have ceased at the site. Topsoil stockpiles will be temporarily seeded or covered to prevent erosion and will be surrounded with silt fence or silt sock. When the site's final grade has been established, permanent vegetation will be planted on the disturbed areas. The vegetation will consist of grass, shrubs, bushes, and trees in the locations indicated on the plans.

1.3 Other Types of Controls

Additional controls/practices will be undertaken to reduce pollution in stormwater runoff flows which include, but are not limited to, control of off-site mud tracking from construction site, dust suppression, proper sanitary waste disposal, earthwork procedures timed and conducted in manners aimed to minimize erosion and sedimentation, snow removal plans, proper management of waste materials,

proper management of hazardous waste, proper material stockpiling, and spill prevention and control measures.

- Dust Suppression – Water sprays shall be used to control dust during extended dry periods during construction.

- Earthwork – The exposure of disturbed surfaces to stormwater and potential stormwater erosion will be minimized by well-organized earthwork procedures. Stabilization procedures shall be undertaken in accordance with this report. Grubbing during wet seasons will be avoided if feasible.

- Snow Removal Plan – Plowed snow collected from the roadway and parking areas will be deposited onto free draining, pervious surfaces, away from the sites drainage conveyance structures to maximize infiltration.

- Waste Materials – Dumpsters rented from a licensed solid waste management company will be used to store solid waste and debris that cannot be recycled, reused or salvaged. The dumpsters will meet all local and state solid waste management regulations. Dumpsters will be covered when refuse is not being directly deposited or withdrawn from them. Potentially hazardous wastes will be separated from normal wastes, including segregation of storage areas and proper labeling of containers. Removal of all waste from the site will be performed by licensed contractors in accordance with applicable regulatory requirements and disposed of at either local or regional approved facilities. Waste materials will not be buried on-site. All site personnel will be instructed regarding the correct procedures for waste disposal. Notices stating these procedures will be posted at the site. Solvents and flushing materials used during construction and pre-operational cleaning will be provided, handled, managed, and removed by the contractor for appropriate off-site disposal.

- Hazardous Waste Materials – Any disposal of hazardous materials will be completed using the required paperwork. Copies will be provided to the Engineer and to the city.

- Spill Prevention and Control Measures – To minimize the risk of spills or other accidental exposure of materials and substances to stormwater runoff, the following material management practices will be used throughout the project:

    - An effort will be made to store only enough products required to do the job.

    - All materials stored on-site will be stored in a neat, orderly manner in their appropriate containers and, if possible, under a roof or other enclosure.

    - Products will be kept in their original containers with the original manufacturer's label.

    - Substances will not be mixed with one another unless recommended by the manufacturer.

- Whenever possible, the maximum amount of a product will be used before disposing of the container.
- Manufacturers' recommendations for proper use and disposal will be followed.
- The site superintendent will conduct daily inspections to ensure proper use and disposal of materials.

To reduce the risk associated with hazardous materials used on the site, the following practices will be used:

- Products will be kept in original containers unless they are not resealable.
- Original labels and material safety data sheets will be retained and kept on-site; they contain important product information.
- If surplus product must be disposed of, manufacturers' or local and state recommended methods for proper disposal will be followed.

- Materials List - Materials or substances listed below are expected to be present on-site during construction:

- Concrete	- Fertilizers
- Asphalt	- Petroleum Based Products
- Paints (enamel and latex)	- Cleaning Solvents
- Metal Studs	- Wood
- Concrete	- Tar
- Sealants	- Adhesives

The following product-specific practices will be followed on-site:

Petroleum Products - All on-site vehicles will be monitored for leaks and receive preventative maintenance to reduce the chance of leakage. Petroleum products will be stored in tightly sealed containers which area clearly labeled. Any asphalt substances used on-site will be applied according to the manufacturers' recommendations.

Paints – All containers will be tightly sealed and stored indoors when not required for use. Excess paint will not be discharged to the storm sewer system but will be properly disposed of according to the manufacturers' instructions or state and local regulations.

Concrete Trucks – Concrete trucks will not be allowed to wash out or discharge surplus concrete or drum wash water on the site.

In addition to the good housekeeping and material management practices discussed in the previous sections of this plan, the following practices will be followed for spill prevention and cleanup:

- Manufacturers' recommended methods for spill cleanup will be clearly posted, and site personnel will be made aware of the procedures and location of the information and cleanup supplies.

- Materials and equipment necessary for spill cleanup will be kept in the material storage area on-site. Equipment and materials will include, but not be limited to, brooms, dust pans, mops, rags, gloves, goggles, speedi-dry, sand, sawdust, and plastic and metal trash containers specifically for this purpose.

- All spills will be cleaned up immediately after discovery. Spills large enough to reach the storm water system will be reported to the National Response Center at 1-800-424-8802.

- The spill area will be kept well ventilated and personnel will wear appropriate protective clothing to prevent injury from contact with a hazardous substance.

- Spills of toxic or hazardous material will be reported to the appropriate state or local government agency, regardless of the size.

- The site superintendent responsible for the day-to-day site operations will be the spill prevention and clean-up coordinator. He will designate at least three other site personnel who will receive spill prevention and cleanup training. These individuals will each become responsible for a particular phase of prevention and cleanup. The names of responsible spill personnel will be posted in the material storage area and in the on-site office trailer.

APPENDIX G – Site Plans