Stormwater Design Guide

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massDOT
Massachusetts Department of Transportation

Contributors

This Stormwater Design Guide is the result of collaboration between many people. MassDOT would like to thank the Project Team (MassDOT Environmental Services Section and VHB) and the entities that contributed to the content (CEI, MassDOT Districts, and various MassDOT Departments).

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**During development of the Stormwater Design Guide*

Cover photo: Constructed stormwater wetlands treating runoff from I-190 in West Boylston before draining to Gates Brook © CEI

Foreword

Dear Reader,

It is with great pride that MassDOT presents the first update of our guidance on stormwater management, aptly named the Stormwater Design Guide (SDG). Since our last MassDOT (MassHighway) Storm Water Handbook, published in 2004, MassDOT's approach to stormwater design has been updated and refined. The SDG provides comprehensive guidance on stormwater control measures (SCMs) that, based on more than 25 years of experience, are supported and promoted by MassDOT to meet regulatory requirements. The SDG continues to focus on guidance for peak rate control, groundwater recharge, and water quality treatment and also incorporates the latest SCM performance values. Designers should use this SDG to understand MassDOT's approach to integrating low impact development measures and/or structural SCMs into every MassDOT project. Such efforts will improve on-site conditions and promote the health of our local water resources.

Sincerely,

Henry L. Barbaro

Henry Barbaro
Stormwater Program Supervisor
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List of Abbreviations

CGP	Construction General Permit
CSP	Competent Soils Professional
CMR	Code of Massachusetts Regulations
CSW	Constructed Stormwater Wetland
CWA	Clean Water Act
DRGP	Dewatering and Remediation General Permit
DSV	Design Storage Volume
EPA	Environmental Protection Agency (see also US EPA)
E&S	Erosion & Sediment
IA	Impervious Area
IDDE	Illicit Discharge Detection and Elimination
ISD	Integrated Site Design
IWP	Impaired Waters Program
IWPA	Interim Wellhead Protection Area
LID	Low Impact Development
LUHPPL	Land Uses with Higher Potential Pollutant Loads
LTPPP	Long-Term Pollution Prevention Plan
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation, Highway Division
MCM	Minimum Control Measure
MEP	Maximum Extent Practicable
M.G.L	Massachusetts General Law
MS4	Municipal Separate Storm Sewer System
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&M	Operation and Maintenance
ORW	Outstanding Resource Water
PDDG	Project Development and Design Guide
QPA	Qualifying Pervious Area
ReV	Required Recharge Volume
ROW	Right-of-Way
SCM	Stormwater Control Measure
SHWT	Seasonal High Water Table
SOP	Standard Operating Procedure
SWMP	Stormwater Management Plan
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TOC	Time of Concentration
TP	Total Phosphorus
TSS	Total Suspended Solids
TS4	Transportation Separate Storm Sewer System
US EPA	United States Environmental Protection Agency (referred to herein as EPA)
UIC	Underground Injection Control
VFS	Vegetated Filter Strip
WLA	Waste Load Allocations
WPA	Massachusetts Wetlands Protection Act
WQC	Water Quality Certification
WQDF	Water Quality Data Form
WQV	Water Quality Volume

Preface

Purpose and Scope

As presented herein by the Massachusetts Department of Transportation, Highway Division (MassDOT), the Stormwater Design Guide (SDG) provides direction to professionals involved in the planning, design, permitting, and maintenance of stormwater management systems for roadways, bridges, and highway facilities. The purpose of the SDG is to provide guidance for clarity and consistency on:

- The application of the Massachusetts Department of Environmental Protection (MassDEP) Stormwater Management Standards (the Stormwater Standards) and the Massachusetts Stormwater Handbook to MassDOT projects
- Compliance with the National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer System (MS4) and anticipated requirements from MassDOT's Transportation Separate Storm Sewer System (TS4)
- A range of MassDOT policies on stormwater topics (e.g., design approach)

The SDG reflects the experiences of contractors and MassDOT personnel involved in project design and construction, as well as in the operation and maintenance (O&M) of highway drainage systems. While the SDG contains the most applicable information for MassDOT designers, it is not a comprehensive guide for all topics related to stormwater design. Designers must use their engineering judgement and refer to other relevant materials as necessary.

The following stormwater-related topics are mentioned in the SDG but not discussed in detail:

- Source controls
- Routine maintenance (e.g., mowing)
- Construction-phase stormwater controls
- Illicit discharge detection and elimination
- Roadway drainage design

While outside the scope of the SDG, these topics are an integral part of MassDOT's stormwater management program and support the goal of minimizing pollutant loading from MassDOT's drainage system while maintaining a properly functioning system. The SDG provides references to other materials that cover these topics, as applicable.

Stormwater Challenges for MassDOT Projects

As a transportation agency, public safety is MassDOT's highest priority. MassDOT's mission is to "…deliver excellent customer service and safety to people traveling in the Commonwealth. We work to provide our nation's safest and most reliable transportation system to strengthen our economy and quality of life." To address safety concerns associated with high-speed and high-volume roadways, MassDOT must comply with stringent roadway design criteria within its right-of-way corridors, which can limit the options for stormwater management.

Most MassDOT projects are improvements and/or upgrades to existing transportation infrastructure that have existing constraints. Roadway and bridge projects are linear and occupy a relatively narrow corridor that traverse many diverse engineered and natural features, and can extend for miles and often cross watershed boundaries. Typical constraints along MassDOT projects include limited land especially along developed areas, utility conflicts, presence of ledge, and high groundwater—all of which present challenges to meeting the Stormwater Standards.

Furthermore, MassDOT owns and maintains an extensive network of roadways and associated stormwater system infrastructure. MassDOT owns approximately 4,600 miles of roadway consisting of limited access highways, multi-lane highways, major and minor collector roads, ramps, tunnels, other minor roads, and over 4,000 bridges. The MassDOT roadway system covers the entire state of Massachusetts, including Martha's Vineyard and Nantucket, and crosses through all major watersheds. MassDOT drainage infrastructure consists of over 120,000 catch basins and 1,400 stormwater control measures (SCMs).

In light of the magnitude, importance, and intensive use of MassDOT's infrastructure, as well as the stringent safety design criteria, the SDG provides a customized approach to meet regulatory requirements. The SDG outlines practical solutions for regulatory compliance by providing a wide range of mitigation options that can be adapted to the unique site constraints associated with MassDOT projects.

MassDOT-Specific Guidance

In providing guidance specific to MassDOT projects and to comply with MassDOT's MS4/TS4 Permit, there are approaches to regulatory compliance where the SDG varies compared to the current MassDEP Massachusetts Stormwater Handbook (published in 2008). These variations provide consistency, applicability, flexibility, and clarification for MassDOT projects and include the following:

- MassDOT's interpretation of new stormwater discharges provides flexibility and allows reconfiguration of existing discharges providing the change improves water quality and reduces impacts to resources (**Section 2.2.1**, Standard 1).
- MassDOT uses the Environmental Protection Agency (EPA) pollutant removal curves for compliance with the MS4/TS4 Permit and meeting Total Maximum Daily Load (TMDL) requirements (**Section 2.1.3**).
- MassDOT promotes the use of the most recent National Oceanic and Atmospheric Administration precipitation resource for hydrologic and hydraulic analysis (**Section 2.2.1**, Standard 2).
- When necessary, the Macro Approach (**Section 2.3.4**) can be used to meet the requirements partially or fully for Standard 2 (Peak Rate Attenuation), Standard 3 (Recharge), Standard 4 (Water Quality), and Standard 7 (Redevelopment).
- SCM (previously known as Best Management Practice or BMP) categorization and design criteria (**Chapter 4**) have been customized for MassDOT applications including:
  - Linear practices
  - Use of bioretention SCMs for peak rate control
  - Porous pavement design
- Hoods for deep-sump catch basins are required under additional specific conditions (**Section 4.1.1**).

- Inlet grates, including open curb inlets, are allowed when designed in accordance with the MassDOT Project Development Design Guide (PDDG)[1] (**Section 4.1.1**).
- Flexibility is allowed in the access design to SCMs to maximize treatment volumes and minimize environmental impacts (**Section 4.7.3.2**).
- Frequency and nature of SCM maintenance are based on inspections and whether the SCM is functioning as intended.

MassDEP is currently revising the Massachusetts Stormwater Handbook and will address the topics listed above. The next edition of the SDG will incorporate MassDEP's revisions accordingly.

How to Use This Guide

Designers should follow the SDG's guidance on stormwater management for all MassDOT projects and refer to other regulatory and design references (e.g., EPA and MassDEP regulations and guidance, MassDOT PDDG) when necessary. Specifically, designers should refer to the PDDG for other site planning considerations such as roadside elements, roadway drainage, erosion control, pavement design, shared use paths and greenways, landscape and aesthetics, and wildlife accommodation.

The SDG is organized into five chapters. The following summarizes the content of each chapter and describes how each chapter should be used by the designer.

Chapter 1 introduces a variety of stormwater management principles, applicable federal and state regulations, and MassDOT's approach to stormwater management. Designers should use this chapter to understand the background and regulatory context for stormwater management in MassDOT projects.

Chapter 2 provides guidance for designing MassDOT stormwater management in compliance with federal and state regulations. Designers should use this chapter to understand regulatory requirements and how they apply to their project before starting their design. This chapter is not intended to serve as the sole resource for regulatory requirements and permitting. It should be used in conjunction with, and as a supplement to, EPA and MassDEP regulations. The designer is responsible for reviewing the most current regulatory requirements and design criteria.

Chapter 3 describes MassDOT's approach to Integrated Site Design (ISD) for stormwater management and establishes the process that designers should follow to develop stormwater designs. Many of the contextual elements that support the ISD approach are promoted in MassDOT's PDDG. Designers should use this chapter to select low impact development (LID) approaches and SCM types that best suit the project site. Designers should understand regulatory requirements from Chapter 2 before using this chapter. Once the designer applies LID and SCM measures for their site, they should use Chapter 4 to guide the design of structural SCMs.

1 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

Chapter 4 presents the design guidelines for structural SCMs supported by MassDOT. Designers should use this chapter to support the design of structural SCMs for the project site. Designers should understand regulatory requirements from Chapter 2 and MassDOT's approach to ISD in Chapter 3 before using this chapter to better select, locate, and design SCMs to achieve stormwater management goals.

MassDOT developed the Water Quality Data Form (WQDF)[2] as a companion tool to the SDG to inform designers about stormwater treatment requirements for discharges to impaired waters and to collect data on SCMs and their treatment effectiveness. Designers use the WQDF to understand project- and watershed-specific treatment requirements and provide MassDOT with critical project and SCM data throughout the design process.

All MassDOT projects require the submittal of the WQDF no later than the 25% design stage. Additional submittals may be warranted to provide MassDOT updated project and SCM information. More information on the WQDF is provided in **Section 2.3.2**.

Additionally, MassDOT developed the following templates[3] to be used by the designer during MassDEP Wetlands Protection Act permitting.

The MassDOT Stormwater Management Report template should be used by MassDOT designers to create a stormwater management report that documents the project's compliance with the Stormwater Standards. The report is incorporated into the Notice of Intent, which is filed with municipal conservation commissions for wetlands permitting.

The MassDOT O&M Plan and Long-Term Pollution Prevention Plan (LTPPP) templates should be used by designers to create an O&M Plan and LTPPP specific to their projects' stormwater management systems and in compliance with MassDEP Standards 4 and 9.

For MassDOT-executed municipal projects, where MassDOT funds and/or constructs the project and the municipality retains ownership upon completion of construction, the design should follow all applicable guidelines of the SDG.

At the completion of MassDOT-executed municipal projects, the municipality retains ownership and is responsible for operating and maintaining the stormwater management system.

Additional Support

The SDG provides designers the most relevant guidance for stormwater design specific to MassDOT projects, including regulations, design approach and criteria, and MassDOT policy. There will undoubtedly be design scenarios that warrant further discussion, and when this occurs, the MassDOT Environmental Services Section is available for additional consultation and guidance.

2 See MassDOT WQDF at: https://www.mass.gov/service-details/stormwater-management-massdot-environmental-services

3 See MassDOT Stormwater Management Report, O&M Plan, and LTPPP templates at: https://www.mass.gov/service-details/stormwater-management-massdot-environmental-services

1
Introduction

This chapter of the Guide introduces a variety of stormwater management principles, applicable federal and state regulations, and MassDOT's approach to stormwater management. **Designers should use this chapter to understand the background and purpose for stormwater management in MassDOT projects.**

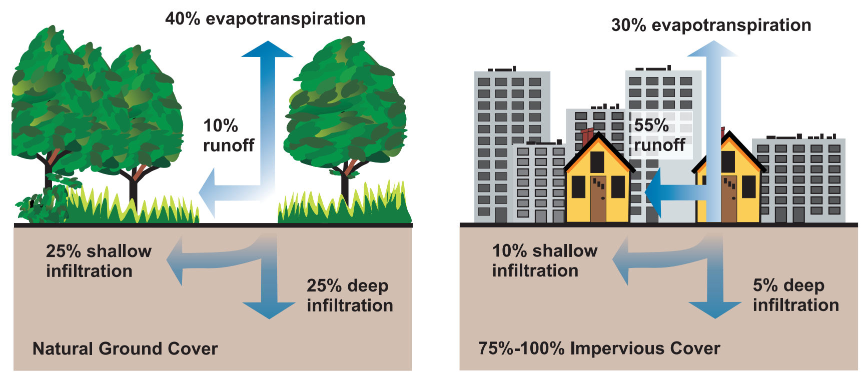
1.1 Background on Stormwater

Stormwater runoff is produced during precipitation (or snowmelt) events when the quantity of precipitation (or snowmelt) exceeds the surface storage and infiltration capacity of the land surface.

In a natural, undeveloped watershed, virtually all of the land surface is pervious (e.g., forest, grasslands). When precipitation falls on vegetation or the ground, some of that water is intercepted and/or absorbed by the vegetation. The remaining water either recirculates into the atmosphere via evapotranspiration or percolates through the soil to the underlying groundwater. Precipitation that is not intercepted, absorbed, or infiltrated flows overland as runoff to a downgradient receiving water (e.g., streams, wetland resource areas).

With respect to stormwater management, natural undeveloped land provides water quality and hydrologic benefits to receiving waters through various mechanisms:

- Runoff is intercepted or detained until it either infiltrates to groundwater or evaporates to the atmosphere.



Relationship between impervious cover and surface runoff © EPA

- Detaining runoff promotes infiltration, which recharges groundwater, buffers water temperatures, and contributes to base flows.
- The velocity of runoff (and consequently, erosion and sediment transport) is generally slow for typical rain events.
- As runoff percolates through vegetation and soils, pollutants and impurities are removed through natural biological, chemical, and physical processes.

Although precipitation is generally considered to be clean, runoff that passes over developed, impervious surfaces can become contaminated with pollutants. If left untreated, the polluted runoff can become a significant contributor of poor water quality to receiving waters.

Historically, in developed watersheds, the act of development has resulted in a reduction of non-uniform, vegetated surfaces and an increase in uniform, impervious surfaces. With respect to stormwater management, impervious surfaces can have adverse environmental impacts in a variety of ways. Impervious surfaces:

- Within developed areas can collect/store pollutants that originate from various sources. Pollutants may include sediment, nutrients, trash, hydrocarbons, and metals. These pollutants can have a negative impact on the water quality of receiving waters.
- Do not intercept and detain stormwater. Rather, impervious surfaces reduce the time of concentration and efficiently direct stormwater to drainage conduits that often have direct connections to receiving waters. Stormwater reaches receiving waters more quickly, which can exacerbate local and regional flood conditions.
- Are typically warmer than natural, pervious, vegetated areas. Stormwater that has extended contact with hot surfaces can contribute to thermal impacts on receiving waters.
- Increase the quantity and velocity of surface runoff and the likelihood that erosion will occur along unprotected portions of the overland flow path, at the outfall, and in receiving waters.
- Prevent infiltration and reduce the opportunity for stormwater treatment through filtration, uptake through soil media and vegetative material, and replenishment of groundwater.

1.1.1 Stormwater Management

As described above, the impervious areas associated with an urbanized landscape can be a major contributor to water quality pollutants and results in an increase in rate and volume of stormwater runoff. To mitigate for pollutants in stormwater, non-structural or structural stormwater control measures (SCMs) should be implemented.

Non-structural SCMs generally include source controls and Integrated Site Design (ISD) approaches. ISD is a holistic approach to integrating environmentally sensitive design elements (including low impact development [LID] strategies and structural controls) into transportation projects; it is discussed further in **Chapter 3.**

Source controls are practices with the goal to prevent or reduce pollution. Examples include:

- Public education
- Installing anti-litter signage on highways
- Reducing use of de-icing salt or sand on roadways
- Quick clearance and management of fuel spills
- Illicit discharge detection and elimination
- Pet waste management
- Covering salt sheds or chemical storage areas
- Stabilizing slopes and shoulders

This SDG does not focus on source control practices as they are managed programmatically by MassDOT.

Structural SCMs are typically implemented to reduce the impact of concentrated runoff on adjacent receiving waters. Structural SCMs reduce the impact of runoff in the following ways:

- Infiltration measures reduce the volume of surface runoff, replenish groundwater, remove pollutants via filtration, and reduce thermal impacts to receiving waters.
- Treatment measures remove pollutants from stormwater through diverse mechanisms, including settling, filtration, adsorption, vegetative uptake, etc.
- Detention measures create storage areas that reduce flow velocities (and resultant erosion), remove pollutants via settling, and reduce the peak rate of runoff discharging to receiving waters.

The impacts of development and impervious cover on a watershed can be mitigated by using Stormwater Control Measures to simulate the processes that occur under natural conditions.

Constructed stormwater wetland with sediment forebay © BSC Group

1.1.2 Pollutants in Roadway Runoff

Stormwater runoff from roadways can contribute to the degradation of water quality in receiving waters and can be a source of pollutants. These pollutants can be derived from erosion, atmospheric deposition, leaf litter, vehicle track-on, anthropogenic sources, fuel/lubricant leaks from vehicles, and highway construction activities. In addition, stormwater runoff that originates from, or flows over, hot pavement or is conveyed on exposed surfaces (such as paved waterways) may adversely affect temperature conditions in receiving waters and wetland resource areas, including cold-water fisheries. Regardless of the source, drainage systems along roadways can convey pollutants to receiving waters if runoff is not properly treated.

The potential impacts of highway runoff on receiving waters have been analyzed through the MassDOT Impaired Waters Program (IWP) **(Section 1.2.2).** The following subsections provide background on the stormwater pollutants that MassDOT addresses through the IWP either through nonstructural or structural controls. These pollutants include sediment, phosphorus, nitrogen, pathogens, metals, chloride, hydrocarbons, temperature, and trash.

Mercury is a pollutant that was evaluated through the IWP but is not included this SDG. Based on the 2007 Northeast Regional Mercury Total Maximum Daily Load (TMDL) report, the source of mercury in Massachusetts' water bodies is considered to be atmospheric deposition from coal-fired energy-generating facilities.

1.1.2.1 Sediment

Sedimentation and turbidity can occur in the aquatic environment as a result of soil erosion, suspended sediment, and/or organic matter. Excess sediment accumulation in water resources such as wetlands can alter the natural hydrology and potentially harm ecosystems. Additionally, because pollutants tend to sorb to particles, sediments can bring pollutants with them as they move through the environment.

For land uses such as roadways, sediment can accumulate from soil erosion of adjacent lands and deposition from highway vehicles. Sediment is transported to receiving waters through direct washoff via sheet flow and conveyance through the drainage system. Sediment, especially fine-grained suspended sediment, is a significant transport mechanism for pollutants in highway runoff.

MassDOT employs source control measures and structural SCMs to reduce sediment in highway runoff. Pretreatment SCMs are especially effective at removing sediment and are typically located close to the highway edge where they can be more easily inspected and maintained.

1.1.2.2 Phosphorus

Phosphorus is often the limiting nutrient for plant and algal growth in freshwater bodies. Excess phosphorus leads to increased plant and algal growth, contributing to higher turbidity and lower dissolved oxygen, which negatively impacts aquatic life. High algal growth rates correspond to high organic decay rates, which are also associated with low dissolved oxygen, as well as objectionable odors and other undesirable conditions.

Although fertilizers are not used by MassDOT, they are a common source of phosphorus within developed watersheds. Excess phosphorus either runs off directly to the drainage system or binds to sediment. High-velocity runoff containing sediment increases phosphorus loading to receiving waters.

Phosphorus residue from natural sources (e.g., leaf litter, sediment) and anthropogenic sources (e.g., fertilizers, vehicle track-on) builds up on the impervious cover of roadways. Stormwater runoff washes the phosphorus residue into drainage systems and ultimately to receiving waters. Therefore, to reduce the impact of impervious cover and phosphorus loading, MassDOT simulates predevelopment conditions through the use of LID and SCMs.

In general, practices that promote infiltration and vegetative uptake reduce phosphorus loads to surface waters. MassDOT prefers to employ infiltration SCMs to address phosphorus.

1.1.2.3 Nitrogen

Nitrogen is often the limiting nutrient for plant and algal growth in saltwater resources. Excess nitrogen in saltwater can lead to excess plant and algal growth, which can lead to higher turbidity and lower dissolved oxygen—two conditions that can have significant negative impacts to aquatic life. As is true with fresh waters, high algal growth rates correspond to high organic decay rates, which are also associated with low dissolved oxygen as well as objectionable odors and other undesirable conditions.

Within developed watersheds, a common source of nitrogen is fertilizers, agriculture, and wastewater. Although not related to MassDOT activities, nitrogen may reach receiving waters from surface and subsurface flows, including effluent from septic systems.

Mitigation measures for nitrogen in the roadway setting primarily consist of:

- Illicit Discharge Detection and Elimination (IDDE)
- End-of-pipe treatments and other improvements to increase biological uptake and filtration through organic materials

MassDOT prefers to employ infiltration SCMs to address nitrogen through filtration.

1.1.2.4 Pathogens

Pathogenic bacteria are a concern when they come into contact with people, either directly or indirectly, through contaminated water. While fecal coliform, Escherichia Coli (E.coli), and Enterococcus are naturally found in the intestines of warm-blooded animals, including humans, some strains are pathogenic, causing illness or disease. Pathogens can become a public health and safety problem when they are present:

- In drinking water supplies
- In shellfish-growing and harvesting areas
- At bathing/swimming beaches

In undeveloped watersheds, the primary sources of pathogens include wildlife and waterfowl. Pathogen growth is controlled by a variety of natural processes, including settling, infiltration, and exposure to light.

Excess algal growth in a brook due to nutrient loading © VHB

Roadways are not a significant source of pathogens; however, they can be a conveyor of pathogens to receiving waters. Most pathogens in stormwater originate from wildlife, waterfowl, pet waste, and agricultural sources such as farm animals. Sometimes pathogens originate from illicit sewage connections or sewage leaks. Pathogens from these sources can enter the roadway drainage system and discharge to receiving waters.

Previous assessments conducted as part of the MassDOT IWP in pathogen-impaired watersheds indicate that pathogen concentrations in stormwater vary greatly, both temporally and spatially. Additionally, studies suggest that concentrations of bacteria are typically higher in urban areas than rural areas but that pathogen loading from highways is lower than other urban sources.[4]

MassDOT has adopted programmatic stormwater management measures consistent with the National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4) to address pathogen contributions to receiving waters. These programmatic measures focus on controlling pathogen sources (e.g., public education on proper management of pet waste, illicit discharge detection and elimination) and maintaining the functionality of stormwater management systems and include MassDOT's:

- Drainage Connection Policy[5]
- Drainage Tie-In Standard Operating Procedure (SOP)[6]
- Illicit Discharge Detection and Elimination Review
- Operation and Maintenance (O&M) Program

Additionally, because pathogens can bind to soil particles, infiltration SCMs support the reduction of pathogen loading to receiving waters.

1.1.2.5 Metals

Metals, including but not limited to, cadmium, lead, copper, and zinc are generally not found in high concentrations in local water bodies, but are found in roadway runoff due to motor vehicle components (e.g., brake pad dust). In some areas in Massachusetts, surface waters may contain arsenic that originates from geologic formations. With the exception of naturally occurring arsenic, metals typically originate from an anthropogenic source, including:

- Residue from automotive tires
- Residue from automotive brakes
- Undercarriage-wash from tire spray
- Agricultural pesticides
- Atmospheric deposition from automobile exhaust
- Atmospheric deposition from power plants or other sources of combustion

Because metals can bind to sediments, MassDOT implements source control measures and structural SCMs to reduce sediment and associated metals to receiving waters.

1.1.2.6 Sodium and Chlorides

Sodium and chlorides are salt components that are very soluble in water and difficult to remove once dissolved. High levels of chlorides can be toxic to freshwater plants and animals, and high levels of sodium can impact water supplies.

MassDOT applies chloride-based salts to roadways as part of its snow and ice management activities during the winter months. MassDOT aims to maintain roadway safety while minimizing potential environmental impacts and costs as part of its winter maintenance

4 See Description of MassDOT's Application of BMP 7U for Pathogen Related Impairments (8 Dec. 2014) at: https://www.mass.gov/doc/year-5-impaired-waters-assessment-1-attachment-5-bmp-7u-pathogen-methodology/download

5 See MassDOT Highway Engineering Directive P-06-002 (26 Jun. 2006) at: https://www.mass.gov/service-details/massdot-highway-engineering-directives

6 See Connection or Discharge to any MassDOT Drainage System Standard Operating Procedure (19 Mar. 2012) at: https://www.mass.gov/doc/connection-or-discharge-to-any-massdot-drainage-system-sop-0/download

program. MassDOT conducts salt application as efficiently as possible using tools and technologies to enhance winter maintenance operations, such as:

- Liquid deicers for pre-wetting and pretreatment
- Closed-loop controllers for improved efficiency
- Road weather information systems
- Pavement friction sensors

These measures are outlined in the Environmental Status and Planning Report (ESPR)[7] for MassDOT's Snow and Ice Control Program.

In areas denoted as "reduced salt areas" where high sodium levels have been found in drinking water sources, MassDOT may substitute salts with sand. However, sand does little for maintaining safe road travel, especially on high-speed roads. Sand can also negatively impact drainage systems and nearby receiving waters by increasing sedimentation and turbidity. For this reason, MassDOT relies on its anti-icing measures (e.g., closed loop controllers, pre-wetting paved surfaces); since 2011, MassDOT has dramatically reduced sand use on highways for snow and ice control.

1.1.2.7 Hydrocarbons

Hydrocarbons in roadway runoff originate from automobile emissions and other byproducts, as well as from local emissions (e.g., commercial and residential heating systems). Leaks of vehicle fuels and lubricants can also contribute hydrocarbons in runoff. A roadway's stormwater management system can act as a conveyor of hydrocarbons to receiving waters.

MassDOT installs hoods in catch basins at targeted locations to contain floatable hydrocarbons. For hydrocarbons sorbed to particulate matter, MassDOT employs practices that remove sediment from stormwater (e.g., catch basins, SCMs, forebays, etc.).

1.1.2.8 Temperature

Water temperature affects the physical properties of water (e.g., salinity, solubility of dissolved gasses) and is therefore an important measure of water quality. Warmer water holds less dissolved oxygen while increasing the metabolic and respiratory demands of aquatic organisms, thereby stressing the ecosystem. Impervious cover in a watershed increases runoff while absorbing and transmitting heat to stormwater surface flows, resulting in larger volumes and rates of runoff with higher temperatures. Warmer stormwater runoff can cause thermal impacts to water resources such as cold-water fisheries.

For water bodies sensitive to temperature, MassDOT considers the use of country drainage instead of closed drainage systems, pavement disconnection, and infiltration SCMs to reduce the temperature of runoff and minimize thermal impacts to water resources.

1.1.2.9 Trash

In addition to being an unsightly public nuisance, trash can impact water quality as it decomposes and may be harmful to terrestrial and aquatic organisms and their habitat. Trash can also clog drainage conveyance systems and impede the SCM function. Roadway drainage systems can act as a conveyor of trash to receiving waters.

MassDOT addresses trash through non-structural and structural approaches. MassDOT has a robust anti-litter initiative focused on removing highway trash before it has a chance to be conveyed to receiving waters. The initiative's programs include Sponsor-A-Highway, Adopt-A-Highway, Adopt-A-Visibility Site, and the state's Inmate Labor Program, which all involve the clean-up of litter along highways. For structural measures, grates on catch basins act as the first defense to keep trash out of the drainage system. If their use is warranted, hoods in catch basins can inhibit floating trash from entering the piped system. MassDOT performs street sweeping, catch basin cleaning, and SCM maintenance to remove sediment and associated pollutants (including trash) from the drainage system and keep it operating properly.

7 MassDOT. Snow and Ice Control Program Environmental Status & Planning Report. https://eeaonline.eea.state.ma.us/EEA/MEPA-eMonitor/home

1.2 Regulatory Context

Stormwater management measures must consider and achieve compliance with federal and state regulations. This section introduces regulations pertaining to stormwater that are applicable to MassDOT projects. **Chapter 2** describes regulatory compliance requirements in greater detail.

1.2.1 Environmental Protection Agency Stormwater Management Programs

The Federal Clean Water Act (CWA) authorizes the US EPA to address water pollution by regulating discharges to waters of the United States and to address stormwater runoff as a source of pollution to receiving waters. The EPA has promulgated rules under the NPDES program to meet the requirements of the CWA. The EPA NPDES[8] program provides regulations for stormwater discharges from three general categories of sources: industrial activities, construction activities, and municipal separate storm sewer systems (MS4s).

1.2.1.1 Municipal and Transportation Separate Storm Sewer System Permits

Under the NPDES program, the EPA and Massachusetts Department of Environmental Protection (MassDEP) issue the General Permit for Stormwater Discharges from Small MS4s in Massachusetts. The permit was initially issued in 2003 and the jurisdiction includes the urbanized areas of Massachusetts.[9] EPA and MassDEP issued a new permit in 2016 for regulated Massachusetts municipalities, although MassDOT was not included as a regulated entity. Instead, EPA and MassDEP have designated MassDOT for coverage under an individual TS4 Permit for its stormwater discharges.

8 See NPDES Stormwater Program Permit Program in New England at: https://www.epa.gov/npdes-permits/npdes-stormwater-permit-program-new-england

9 For information on the current status of this permit program and how it affects MassDOT, contact the MassDOT Environmental Services Section at: https://www.mass.gov/massdot-environmental-services

The TS4 Permit has not been released yet. This section provides discussion of the anticipated content of the TS4 Permit.

The TS4 follows the same general format/requirements of the MS4 permit. The MS4/TS4 Permit requires implementation of the following six minimum control measures (MCMs):

1. **Public Education & Outreach** requires MassDOT to educate and inform its constituents of the impacts that stormwater runoff can have on water resources.
2. **Public Participation/Involvement** involves engaging the public in programs, projects, and activities that promote environmental stewardship and a sense of ownership and responsibility with regard to water quality.
3. **Illicit Discharge Detection & Elimination** requires MassDOT to identify and eliminate connections to the stormwater drainage network that originate from a non-stormwater source (e.g., septic system effluent, grey-water, other non-allowed non-stormwater discharges).
4. **Construction Site Runoff Control** requires MassDOT to take measures to reduce impacts to water quality during regular construction activities, specifically pertaining to erosion and sediment (E&S) control. If applicable, adherence to the CGP is necessary to comply with this MCM.
5. **Post-Construction Runoff Control** requires MassDOT to implement permanent, structural SCMs to mitigate potential impacts to runoff water quality.
6. **Pollution Prevention/Good Housekeeping** requires MassDOT to conduct regular maintenance to prevent potential sources of pollution.

In addition to these six measures, the anticipated TS4 Permit requires MassDOT to address stormwater discharges to impaired waters both with and without TMDLs and provides associated guidance.

The MassDOT Stormwater Management Plan (SWMP) outlines MassDOT programs that address each of the six MCMs and the impaired waters requirements. The SWMP describes each action for meeting the measures, provides measurable goals for each action, and sets a schedule for implementing new measures. MassDOT revises the SWMP on an as-needed basis to describe the programs that meet the MCMs of the MS4/TS4 Permit.

In general, the SWMP addresses MassDOT's activities on a programmatic level whereas this SDG focuses on project-specific stormwater management. This SDG supplements the SWMP with information relevant to MCM #5 (post- construction runoff control), MCM #6 (good housekeeping), and impaired waters/TMDL compliance. **Section 2.1.1** herein addresses compliance with the anticipated TS4 Permit as it relates to water quality treatment.

1.2.1.2 Construction General Permit

The EPA's Construction General Permit (CGP)[10] covers discharges from construction activities involving equal to or greater than one acre of earth disturbance. **Section 2.1.2** addresses the applicability of the CGP to MassDOT projects.

1.2.1.3 Impaired Waters and Total Maximum Daily Loads (TMDLs)

Under the 2003 MS4 General Permit, EPA required owners of MS4s to provide additional measures (beyond the six MCMs) to reduce discharges of pollutants to impaired water bodies. Consequently, MassDOT developed the IWP. The program is designed to evaluate MassDOT's contributions to stormwater-related impairments and implement mitigation measures, as necessary, to address MassDOT's contributions and meet TMDL targets.

A **TMDL** is the maximum pollutant load that a water body can receive and still meet the appropriate water quality standards.

Impaired waters are waters that do not meet the State Water Quality Standards.

Every two years MassDEP assesses the state's water bodies for conformance with State Water Quality Standards based on its assigned use and develops a list of water bodies, known as the Integrated List of Waters, as part of the requirements of Section 303(d) of the Federal CWA.[11] If a water body does not meet the Water Quality Standards for its use, then MassDEP designates it as "impaired," and MassDEP is required to develop a TMDL for the water body as mandated by the CWA. MassDEP has prepared TMDLs[12] for dozens of water bodies in Massachusetts.

Existing ditch retrofitted into an infiltration linear practice © MassDOT

10 See Stormwater Discharges from Construction Activities at: https://www.epa.gov/npdes/stormwater-discharges-construction-activities

11 See most recent Integrated List of Waters at: https://www.mass.gov/lists/integrated-lists-of-waters-related-reports

12 See lists of TMDLs at: https://www.mass.gov/lists/total-maximum-daily-loads-by-watershed

TMDLs are determined based on rigorous scientific study of the contributing area. A TMDL report establishes waste load allocations (WLAs) for point sources contributing pollutants to the impaired water body (including certain stormwater sources) and load allocations (LAs) for other non-regulated sources of pollution (including non-point sources). Dischargers within the watershed are required to implement controls to meet the WLA targets appropriate for landuses. TMDL compliance is evaluated on a watershed-scale and their requirements are implemented through the EPA NPDES program.

303d List Categories for Water Bodies

Category 1: Water bodies that meet all water quality testing criteria. (There are no Category 1 waters in Massachusetts due to a statewide advisory by the Massachusetts Department of Public Health on the consumption of fin fish due to mercury contamination.)

Category 2: Water bodies that do not have pollution levels that exceed the Water Quality Standards.

Category 3: Water bodies with insufficient data to determine impairment status.

Category 4:

4A: Impaired water bodies with a final TMDL actively under implementation.

4B: Impaired water bodies where there is a program in place that is expected to eliminate pollution levels that exceed Water Quality Standards.

4C: Water bodies that are impaired by a non-pollutant (e.g., invasive aquatic plants) that cannot be addressed through a TMDL. (Note: Category 4C water bodies are not impaired as a result of stormwater.)

Category 5: Impaired water bodies that require a TMDL and do not have a dedicated mitigation plan in place.

The MassDOT IWP aligns with the anticipated TS4 Permit requirements and focuses on implementing mitigation measures for discharges within watersheds of:

- An impaired water body with a TMDL (Category 4A)
- An impaired water body without a TMDL (Category 5)
- An adjacent state's TMDL

Section 2.1.1.1 provides more information on the MassDOT IWP and approaches to TMDL compliance.

1.2.2 Massachusetts Regulations Pertaining to Stormwater Management

MassDEP regulates the discharge of stormwater to designated Resource Areas and/or associated Buffer Zones through the following:

- Massachusetts Wetlands Protection Act (WPA) regulations[13]
- Section 401 Water Quality Certification (WQC) for Discharge of Dredged or Fill Material regulations[14] (Section 401 of the Federal CWA as implemented at the state level through the Massachusetts Clean Water Act)

These regulations include the MassDEP Stormwater Management Standards (the Stormwater Standards). The Stormwater Standards are further defined and specified in the Massachusetts Stormwater Handbook.[15]

This section introduces the WPA, Section 401 WQC, and the Stormwater Standards. **Section 2.4** includes detailed discussion of the applicability of the regulations and standards to select MassDOT projects.

13 See 310 CMR 10.00. For Stormwater Standards, see 310 CMR 10.05(6)(k) through (q)

14 See 314 CMR 9.00. For Stormwater Standards, see 314 CMR 9.06(6)(a) through (e)

15 See Massachusetts Stormwater Handbook (Feb. 2008) at: https://www.mass.gov/guides/massachusetts-stormwater-handbook-and-stormwater-standards

MassDEP is currently revising the Massachusetts Stormwater Handbook and the Stormwater Standards. The next edition of the SDG will incorporate MassDEP's revisions accordingly.

1.2.2.1 Wetlands Protection Act (WPA)

The WPA and its regulations have jurisdiction over activities within designated Resource Areas and associated Buffer Zones, such as:

- Any wetland, water body, Land Under Water Bodies and Waterways, Land Subject to Tidal Action, or land within the 100-foot buffer
- 200 feet from any perennial stream (200-foot Riverfront Area)
- The 100-year floodplain (Bordering Land Subject to Flooding/Land Subject to Coastal Storm Flowage)

Projects within these areas must comply with the WPA (including the Stormwater Standards) and submit a Notice of Intent (NOI) or Request for a Determination of Applicability (RDA) to receive approval from the issuing authority (i.e., local conservation commissions or MassDEP).

Designers of MassDOT projects must be familiar with the WPA and WQC regulations, which should be referred to directly, to determine project-specific applicability and requirements.The WPA does not apply to some roadway improvement projects (e.g., bridge replacements). While a project may not be under WPA jurisdiction, it may still require a Section 401 WQC, and thus be subject to the Stormwater Standards.

1.2.2.2 401 Water Quality Certification (WQC) Regulations

Under Section 401 of the Federal CWA, activities proposing discharges to water bodies or wetlands require a state WQC. MassDEP must certify that projects requiring federal permits will not violate the State Water Quality Standards.[16]

16 See 314 CMR 4.00

MassDEP has coordinated the Section 401 WQC Program with the state's WPA Program. Therefore, most projects approved by local conservation commissions or MassDEP under the WPA are not subject to further review under the 401 WQC Program.

Some projects, including those that have proposed large wetland impacts (i.e., greater than 5,000 sf of bordering and isolated vegetated wetlands or land under water)[17] and those that are not subject to the WPA (e.g., bridge replacements), require an individual 401 WQC. For these projects, the Section 401 WQC Regulations include specific provisions for stormwater discharges. The Section 401 WQC Regulations provide criteria that define a project's jurisdictional applicability.

Further general information about the applicability of the Stormwater Standards under the Section 401 WQC Regulations may be found in the Massachusetts Stormwater Handbook (Vol. 1, Ch. 2).

1.2.2.3 MassDEP Stormwater Management Standards

MassDEP developed the Stormwater Standards to protect wetlands and water resources, from pollution and the impacts of development, through the implementation of a wide variety of stormwater management strategies. The Stormwater Standards are incorporated into both the WPA and WQC Regulations.

The Massachusetts Stormwater Handbook, published in 2008, presents the 10 Stormwater Standards and their detailed requirements. The designer should consult MassDEP's website for updates to the Stormwater Standards, applicable regulations, and current policies and procedures regarding the design and permitting of stormwater management systems.

Section 2.2 discusses each of the Stormwater Standards and describes the documentation and calculations required to comply with the requirements of the Standards for MassDOT projects. **Section 2.4** includes a discussion of the applicability of the Stormwater Standards to select MassDOT activities and projects.

17 See 314 CMR 9.04

Survey of threatened plant, Engelmann's Umbrella-sedge, at Spy Pond in Arlington, Massachusetts © VHB

1.2.3 Other Regulatory Programs

Roadway and bridge design and associated stormwater management projects may impact areas that require regulatory approvals that are not addressed in this SDG. Refer to the MassDOT Project Development and Design Guide (PDDG)[18] and associated forms and checklists to determine the comprehensive permitting needs for individual projects.

Additional design and permitting requirements may include, but are not limited to, the following:

- Stream Crossing Standards for habitat connectivity:
  - Section 404 of the Federal CWA
  - Section 10 of the Rivers and Harbors Act of 1899
  - 314 CMR 9.00 (401 WQC)
  - 310 CMR 10.00 (WPA)
- Compensatory storage and No-Rise certification for work in a regulatory floodplain:
  - 44 CFR 60.3 (Floodplain Management)
  - 310 CMR 10.00 (WPA)
- Construction, dredging, and filling in tidelands, great ponds, and coastal and inland waterways:
  - Chapter 91, The Massachusetts Public Waterfront Act
- Compliance with Massachusetts Environmental Policy Act (MEPA) and National Environmental Policy Act (NEPA):
  - Endangered species protections, including the Endangered Species Act (ESA) at the federal level and Natural Heritage and Endangered Species Program (NHESP) at the state level
  - Historic resource protections (Section 106) at the federal level and Massachusetts Historical Commission (Chapter 254) at the state level

18 See MassDOT PDDG (2006) at: https://www.mass.gov/lists/design-guides-and-manuals

1.3 Stormwater Management for MassDOT Projects

It is MassDOT's policy to require structural stormwater measures in certain situations, in addition to meeting MassDEP and EPA regulatory requirements.

MassDOT requires structural stormwater measures when:

- As dictated by the WQDF to meet impaired waters and TMDL requirements
- The proposed project will result in a significant increase of impervious cover
- Drainage-related issues have been identified as having an adverse impact on existing conditions and warrant the use of SCMs

MassDOT has adopted Integrated Site Design (ISD) as a holistic design approach to address the diverse design requirements for bridge and roadway projects as discussed in **Chapter 3**. ISD emphasizes stormwater management as an integral part of the design process. MassDOT's approach to ISD addresses stormwater management by:

- Reducing and disconnecting impervious surfaces so that they do not directly discharge to receiving waters
- Extending flow paths to increase travel time to the receiving waters
- Providing vegetation to shade and cool the surfaces along the overland flow path.

Site design practices that minimize the creation of impervious cover, preserve the greatest amount of vegetation, and promote the infiltration of stormwater runoff should be identified and prioritized at the earliest stages of roadway project design

If it is determined that SCMs are required for a project, conceptual SCMs should be included in the 25% design submission to MassDOT. Coordination with the MassDOT Environmental Services Section (MassDOT Environmental) is encouraged prior to this submittal. SCMs should complement existing conditions, and the locations should be chosen based on maximizing SCM performance.

Chapter 3 of this SDG provides detailed guidance for identifying and implementing ISD and evaluating the feasibility of structural SCMs at project sites, with respect to the conditions and constraints common to MassDOT roadway and bridge projects.

Chapter 4 provides detailed information on the suitability and design of the SCMs supported by MassDOT.

Well-vegetated infiltration basin © VHB

1.3.1 MassDOT Drainage Tie-in Policy

To control the impacts of runoff being received by MassDOT drainage systems, MassDOT currently prohibits existing or new tie-ins to its drainage infrastructure, unless authorized by an access permit, as specified in the "Drainage Connection Policy"[19] and "Connection or Discharge to any MassDOT Drainage System SOP."[20]

Applications for Drainage Tie-in Permits include a comprehensive review of drainage alternatives and are reviewed and approved at the District level. MassDOT may choose to issue a permit or require the applicant to disconnect tie-ins.

1.3.2 Reference Materials for MassDOT Projects

Table 1-1 presents a list of stormwater design references that the designer should use, in conjunction with this SDG, to develop designs and prepare permit documentation for MassDOT projects. The table includes links to references on MassDOT standard practices and applicable federal and state regulatory standards.

19 See MassDOT Highway Engineering Directive P-06-002 (26 Jun. 2006) at: https://www.mass.gov/service-details/massdot-highway-engineering-directives

20 *MassDOT. Connection or Discharge to any MassDOT Drainage System Standard Operating Procedure.* 19 Mar. 2012. https://www.mass.gov/doc/connection-or-discharge-to-any-massdot-drainage-system-sop-0/download

Table 1-1. Primary Reference Materials for MassDOT Stormwater Management Design and Permitting

Note: Click on the bold reference title for a direct link to the material. The reference materials with bold italic titles do not have web links available.

	Title	Primary Topic(s)
MassDEP	**Massachusetts Stormwater Handbook**	Describes the compliance requirements for the MassDEP Stormwater Management Standards in detail.
MassDEP	**MassDEP Stormwater Management Checklist**	Required as part of the NOI submittals to document compliance with MassDEP Stormwater Management Standards; prepared in conjunction with a typical Stormwater Management Report.
MassDEP	**MassDEP Erosion and Sediment Control Manual**	Describes best management practices for erosion and sediment control for projects that may affect the land or water resources.
MassDEP	**MassDEP Hydrology Handbook for Conservation Commissioners**	Describes hydrologic and hydraulic data and calculations under the Massachusetts WPA.
MassDOT	**MassDOT Drainage Connection Policy/Connection or Discharge to any MassDOT Drainage System Standard Operating Procedure (SOP)**	Include the MassDOT policy and SOP for addressing non-highway connections to MassDOT drainage systems.
MassDOT	***MassDOT Erosion and Sediment Control Field Guide (2013)***	Describes the design, installation, and inspection and maintenance requirements for construction period erosion and sediment controls for roadway and bridge projects.
MassDOT	***MassDOT NPDES Individual TS4 Permit***	Identifies MassDOT's requirements for stormwater compliance in urban areas and provides requirements and guidance on post-construction measures, impaired waters and TMDLs, O&M.
MassDOT	**MassDOT PDDG**	A project development and design guide that provides MassDOT designers guidance for transportation improvement projects.
MassDOT	**MassDOT SWMP**	Describes MassDOT policies and programs with respect to compliance with the MS4/TS4 Permit. It includes a description of MassDOT activities for addressing the six MCMs including programmatic source-control and good housekeeping practices.
MassDOT	**MassDOT Template: O&M Plan and LTPPP**	Provides guidance on MassDOT conventions for Long-Term Pollution Prevention Plans (LTPPPs) and Operation and Maintenance Plans (O&M Plans).
MassDOT	**MassDOT Template: Stormwater Management Report**	Provides guidance on MassDOT reporting conventions with respect to compliance with the Stormwater Standards and TMDLs.
MassDOT	**MassDOT Water Quality Data Form (WQDF)**	Guides the designer with respect to compliance with the MassDOT Impaired Waters Program, TMDLs, and reporting under the MS4/TS4 Permit and collects important project and SCM data.
Other	**National Association of City Transportation Officials (NACTO) Urban Street Stormwater Guide**	Provides best practices for sustainable stormwater management designs to be used in public right-of-way. It covers green infrastructure such as bioretention designs, stormwater trees, and permeable pavement, and provides insight on innovative street design strategies.

2

Regulatory Compliance

This chapter provides guidance for designing MassDOT stormwater management systems in compliance with federal and state regulations. **Designers should use this chapter to understand regulatory requirements and how they apply to their project before starting their design. This chapter is not intended to serve as the sole resource for regulatory requirements and permitting. It should be used in conjunction with, and as a supplement to, EPA and MassDEP regulations. The designer is responsible for reviewing the most current regulatory requirements and design criteria.**

Chapter 2 continues the discussion from Chapter 1 with respect to federal and state regulations pertaining to stormwater. All MassDOT projects must be designed to:

- Comply with federal and state regulations pertaining to stormwater
- Be consistent with MassDOT standards and practices

The following sections provide specific guidance on the applicability of the regulations to MassDOT projects and the documentation required to demonstrate compliance.

2.1 US EPA Stormwater Management Programs

Section 1.2.1 introduced the NPDES stormwater program, an EPA program authorized under the Federal Clean Water Act (CWA) to address stormwater runoff as a source of pollution by regulating discharges to Waters of the US. This section addresses NPDES compliance as it applies to MassDOT projects and properties.

2.1.1 NPDES Permit for Transportation Separate Storm Sewer System

The TS4 Permit has not been released yet. This section provides discussion of the anticipated content of the TS4 Permit.

This section includes select guidance to address anticipated TS4 requirements, which include the six minimum control measures (MCMs) and the additional measures for impaired waters. The parts of the TS4 Permit that overlap with the scope of this SDG are post-construction stormwater management (MCM #5), good housekeeping and pollution prevention (MCM #6), and water quality treatment requirements for impaired waters and Total Maximum Daily Loads (TMDLs).

The TS4 Permit's post-construction MCM #5 requires that for applicable projects, stormwater management systems are designed to be consistent with, or more stringent than, the requirements of the 2008 Massachusetts Stormwater Handbook. It also requires water quality treatment measures at the project-scale that are different from those in MassDEP's current Standard 4. See Standard 4 in **Section 2.2.1** for the description of MassDOT's water quality treatment approach to satisfy both federal and state regulatory requirements.

TS4 Permit MCM #5 has different water quality treatment requirements than MassDEP's current Standard 4.

The TS4 Permit's good housekeeping MCM #6 requires MassDOT to perform maintenance on structural stormwater control measures (SCMs) and infrastructure through an Operation and Maintenance (O&M) Program and to develop Stormwater Pollution Prevention Plans (SWPPPs) for MassDOT maintenance facilities. SWPPPs require quarterly monitoring at facilities where pollutants are potentially exposed to stormwater. Note that MassDOT highway property is not under jurisdiction of the NPDES Multi-Sector General Permit (MSGP) for Stormwater Discharges Associated with Industrial Activities.

The TS4 Permit stipulates how to comply with TMDL requirements for contributions to impaired water bodies with a final TMDL and provide treatment to address impaired waters. MassDOT created the Impaired Waters Program (IWP) for compliance with the 2003 Municipal Separate Storm Sewer System (MS4) General Permit to address stormwater discharges to impaired waters. This program will continue to be implemented as part of TS4 Permit compliance, and designers will receive project-specific guidance on how to address these requirements through the MassDOT Water Quality Data Form (WQDF).

Because the requirements of the TS4 Permit may change when it is reissued (every 5 years), designers should consult with the MassDOT Environmental Services Section to determine the status of the permit and relevant criteria.

TS4 Permit requirements are applicable to MassDOT roadway and facility projects located in urban areas with disturbance greater than or equal to one acre, although MassDOT's policy is to implement TS4 Permit requirements on a statewide basis.

2.1.1.1 MassDOT Impaired Waters Program

The goal of the MassDOT IWP is to reduce pollutants that originate from MassDOT properties and drain to receiving waters that are identified and listed as impaired in accordance with Section 303(d) of the Federal CWA. The focus of the MassDOT IWP is to:

- Determine if runoff from MassDOT property is causing or contributing to impairments due to stormwater related pollutants
- Implement a specific mitigation plan to address MassDOT contributions to those impairments and to meet TMDL reduction requirements

Designers will receive project-specific guidance for making progress towards MassDOT's TMDL and impaired waters requirements through the WQDF.

In accordance with the anticipated TS4 Permit, MassDOT implements its IWP to address numeric TMDL targets and to make incremental progress for waters with non-numeric targets or no TMDL according to the approaches listed in **Table 2-1**.

Table 2-1. MassDOT Impaired Waters Program Approaches

Impaired Water/TMDL Status	TS4 Permit Requirements	MassDOT IWP Approach to Compliance
All stormwater-impaired[21] waters, regardless of TMDL status	• Implement incremental stormwater improvements through the IWP (approaches described on the right). • If covered by a TMDL, follow TS4 Permit requirements below.	• Incorporate Integrated Site Design (ISD) including structural controls to maximum extent during programmed projects to address impairment/pollutant of concern. • Track treatment provided by individual measures at project-scale using data from WQDFs. • Track total treatment provided at watershed-scale for annual reporting to EPA.
TMDL with numeric targets included in the TS4 Permit	• Meet load reduction targets over prescribed timeframe as defined in the TS4 Permit.	• Implement SCMs as identified by the IWP to meet load reduction targets identified in the TS4 Permit.
TMDL with non-numeric targets included in the TS4 Permit	• Implement controls focused on pollutant of concern through the IWP.	• Implement SCMs as identified by the IWP to make incremental treatment progress.

Sediment forebay in ponded condition © MassDOT

MassDOT tracks treatment provided by individual SCMs in order to account for compliance on a watershed-scale. Implementing control measures through both retrofit and programmed projects is essential to incrementally meeting watershed goals. Stormwater treatment implemented as part of programmed projects is typically the most cost-effective way for MassDOT to meet treatment goals.

For project-level compliance with MassDOT IWP, the designer is required to use the WQDF (**Section 2.3.2**) to:

- Understand MassDOT-specific watershed requirements and project goals
- Design SCMs to minimize the discharge of pollutants to impaired waters and meet requirements
- Submit the amount of increase/decrease to impervious cover and associated SCM and treatment data for MassDOT review and overall accounting

21 Impairments that may be attributed to roadway stormwater runoff.

2.1.2 NPDES Construction General Permit

MassDOT roadway and bridge projects are often subject to the requirements of the NPDES Construction General Permit (CGP).[22] The NPDES stormwater program requires permits for discharges from construction activities that disturb one or more acres of land. Construction activities include the clearing, grading, and excavation of land, and other construction-related activities (e.g., stockpiling of fill material, placement of raw materials at the site) that could lead to the mobilization of pollutants.

Coverage under the CGP requires project operators to file an electronic Notice of Intent (NOI) with the EPA Region 1 office a minimum of 14 days prior to starting work. All project operators, individuals, or entities that exert operational authority over the project, must file an NOI. On MassDOT projects, this generally requires both MassDOT (and/or the owner of the roadway) and the contractor to each file an NOI. The project operator is required to prepare a Construction SWPPP, which must be implemented during the construction period and be readily accessible at the construction site. The SWPPP contains a description of construction-period erosion and sediment (E&S) controls that can also fulfill the requirements of MassDEP Stormwater Standard 8.

While this SDG does not cover design and implementation of construction-period controls, it is MassDOT's policy to control E&S during construction to protect water resources as discussed in Standard 8 in **Section 2.2.1**.

Projects may apply for a Small Construction Activity Waiver instead of obtaining coverage under the CGP if the project will disturb less than five acres of land and when erosion is unlikely. Projects may be eligible for this waiver if there is an approved TMDL that addresses this specific issue or an equivalent analysis is performed that shows controls are not needed to protect water quality.

22 See Stormwater Discharges from Construction Activities at: https://www.epa.gov/npdes/stormwater-discharges-construction-activities

If the project will discharge stormwater to an Outstanding Resource Water (ORW), as designated in the Massachusetts Surface Water Quality Standards,[23] the construction contractor must file Form WM 15: NPDES General Permit NOI[24] with MassDEP under the Surface Water Discharge Permit Program. The submittal should include a copy of the CGP NOI, the WM 15 Checklist for Construction General Permit, and the SWPPP for the project site.

2.1.3 NPDES Dewatering and Remediation General Permit

Depending on the nature of the project's activities, the NPDES General Permit for Dewatering and Remediation Activity Discharges (DRGP)[25] may be required.

The DRGP is required for discharges of groundwater, stormwater, potable water, and surface water from sites that produce 1.0 million gallons per day or less, as a result of the following dewatering and remediation activities:

1. Site remediation
2. Site dewatering
3. Infrastructure dewatering/remediation
4. Material dewatering

23 See 314 CMR 4.00

24 See WM 15: NPDES General Permit Notice of Intent at: https://www.mass.gov/how-to/wm-15-npdes-general-permit-notice-of-intent

25 See Dewatering and Remediation General Permit (DRGP) at: https://www.epa.gov/npdes-permits/dewatering-and-remediation-general-permit-drgp

Discharges from construction dewatering of groundwater intrusion and/or stormwater accumulation from sites less than one acre and short-term and long-term dewatering of foundation sumps into water resources also require coverage under the DRGP.

To obtain coverage under the DRGP, the applicant must submit an NOI to EPA a minimum of 30 days in advance of the discharge; however, permit coverage is not approved until EPA has reviewed the NOI and notified the operator in writing of its determination. Therefore, the applicant should be aware of estimated EPA approval timelines, which may range from one to three months, and plan the project schedule accordingly. Discharges to an ORW are not allowed under the DRGP without special authorization from MassDEP.

2.2 Massachusetts Regulations Pertaining to Stormwater

Section 1.2.2 introduced the Massachusetts regulations pertaining to stormwater management, including:

- Massachusetts Wetlands Protection Act (WPA) regulations[26]
- Section 401 Water Quality Certification (WQC) for Discharge of Dredged or Fill Material regulations (Section 401 of the Federal CWA as implemented at the State level through the Massachusetts Clean Water Act)[27]

These regulations include the MassDEP Stormwater Management Standards (the Stormwater Standards), which are presented in the following section. MassDOT projects must comply with all applicable State regulations. Some MassDOT projects are considered to have minimal impact to water resources and are exempt from, or only partially subject to, requirements of the WPA and/or 401 WQC, including the Stormwater Standards. These allowances are described further in **Section 2.4.**

2.2.1 MassDEP Stormwater Management Standards

The Massachusetts Stormwater Handbook, published in 2008, presents the 10 Stormwater Standards, their requirements, and detailed information on compliance.[28] The designer should consult MassDEP's website for updates to the Stormwater Standards, applicable regulations, and current policies and procedures regarding the design and permitting of stormwater management systems.

Table 2-2 lists the Stormwater Standards.

MassDEP is currently revising the Massachusetts Stormwater Handbook and the Stormwater Standards. The next edition of the SDG will incorporate MassDEP's revisions accordingly.

26 See 310 CMR 10.00. For Stormwater Standards, see 310 CMR 10.05(6)(k) through (q).

27 See 314 CMR 9.00. For Stormwater Standards, see 314 CMR 9.06(6)(a) through (e).

28 See Massachusetts Stormwater Handbook (Feb. 2008) at: https://www.mass.gov/guides/massachusetts-stormwater-handbook-and-stormwater-standards

Table 2-2. MassDEP Stormwater Management Standards*

The Stormwater Standards in Table 2-2 were published in 2008 and are current as of this SDG's issuance. MassDEP is currently revising the Stormwater Standards. The next edition of the SDG will incorporate MassDEP's revisions accordingly.

1. No new stormwater conveyances (e.g., outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.
2. Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.
3. Loss of annual recharge to groundwater shall be eliminated or minimized through the use of infiltration measures, including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.
4. Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This Standard is met when:
    a. Suitable measures for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained
    b. Structural stormwater control measures are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook
    c. Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook
5. For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable. If, through source control and/or pollution prevention, all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, and stormwater runoff, the proponent shall use the specific structural stormwater BMPs determined by the Department to be suitable for such uses as loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53 and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.
6. Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other Critical Area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook. A discharge is near a Critical Area if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors. Stormwater discharges to Outstanding Resource Waters and Special Resource Waters shall be removed and set back from the receiving water or wetland and receive the highest and best practical method of treatment. A "stormwater discharge" as defined in 314 CMR 3.04(2)(a)1 or (b) to an Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply.
7. A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural stormwater control measure requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.
8. A plan to control construction-related impacts, including erosion, sedimentation, and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.
9. A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.
10. All illicit discharges to the stormwater management system are prohibited.

*As defined in 310 CMR 10.05(6)(k) through (q) and 314 CMR 9.06(6)(a) through (e). For detailed information on the Stormwater Standards, refer to the Massachusetts Stormwater Handbook. The Stormwater Standards are subject to change when the regulations are amended.

MassDEP has two definitions for project types based on their development category: new development and redevelopment.

New development = project area that is currently undeveloped

Redevelopment = projects that include:

- Maintenance and improvement of existing roadways including widening less than a single lane, adding shoulders, correcting substandard intersections, and improving existing drainage systems and repaving
- Development, rehabilitation, expansion and phased projects on previously developed sites provided the redevelopment results in no net increase in impervious area
- Remedial projects specifically designed to provide improved stormwater management such as projects to separate storm drains and sanitary sewers and stormwater retrofit projects[32]

Examples of new development for MassDOT projects include:

- New roads
- New intersections/interchanges
- Major realignments
- New rest areas
- New parking lots
- New maintenance depots or buildings
- New bridges

Under MassDEP's definitions, portions of a project may be categorized as new development while other portions are categorized as redevelopment.

Projects that are considered both new development and redevelopment include construction of new travel lanes ("Add -a-Lane" projects), expansion of existing rest areas, and other projects where development adds impervious cover to the existing site.

The following pages present each MassDEP standard and provide guidance on compliance for MassDOT projects. Each standard's section includes:

- MassDEP standard language (in green)
- A summary of requirements in relation to MassDEP new development or redevelopment designation
- MassDOT's approach to compliance
- MassDOT's evaluation methodology
- Applicability to maximum extent practicable (MEP) as a redevelopment
- Allowance to use the MassDOT Macro Approach to meet requirements on a project-wide scale (**Section 2.3.4**)
- Information on congruency with other standards

29 See 310 CMR 10.04.

Standard 1—No New Untreated Discharges

No new stormwater conveyances (e.g., outfalls) may discharge untreated stormwater directly to, or cause erosion in, wetlands or waters of the Commonwealth.

The purpose of Standard 1 is to make sure that all new stormwater discharges:

- Are preceded by a stormwater management treatment train[30] that achieves compliance with Standard 4 (Water Quality)
- Will cause no physical damage (e.g., erosion) to a wetland resource at the downstream end of a conveyance

Development Category	Requirements
MassDEP Redevelopment	• Discharges must be retrofitted for outlet protection to prevent erosion to the MEP. • Stormwater runoff must be treated in compliance with Standard 4 to the MEP. • Existing conditions must be improved.
MassDEP New Development	• Discharges must have outlet protection to prevent erosion. • Stormwater runoff must be treated in compliance with Standard 4.

MassDOT Approach to Compliance

This standard is met by implementing water quality treatment upstream of new discharges and to the MEP for existing discharges. All projects require outlet protection at discharges. **Chapter 4** includes design guidance for structural SCMs and accessories that may be used to prevent erosion at discharges and to meet the water quality treatment requirements of Standard 4.

30 A treatment train is a collection of SCMs in series designed to provide water quality treatment.

Stormwater discharges should be located so they are set back from receiving waters. Discharges are not allowed in wetland resources areas except for Riverfront Area, Bordering Land Subject to Flooding (BLSF), Isolated Land Subject to Flooding (ILSF), and Land Subject to Coastal Flowage (LSCSF).[31]

Stormwater retrofits for a MassDOT redevelopment project may include reconfiguration of the existing drainage system. The following are examples of what are considered existing stormwater discharges.

1. **Relocation of a discharge to provide greater distance between the discharge and resource area**, provided that the relocation is within the same wetland system as the original discharge and the relocated discharge does not have a lower time of concentration (TOC) or results in erosion or scour to wetland resource areas. Examples include relocation of a discharge:
   - From a bridge deck, bridge foundations, bridge headwalls, or other ancillary bridge component to an adjacent area so that the outfall is farther away from a wetland resource area
   - Along the linear roadway path such that it discharges farther upland of a land resource area
   - To provide a greater TOC

31 See 310 CMR 10.05(6)(k) and 314 CMR 9.06(6)(a)

2. **Relocation of a discharge to provide additional treatment and/or improve existing conditions.** Examples include relocation of a discharge:
   - To install a SCM
   - To provide enhanced scour protection
   - To provide bank stabilization

3. **Combining two or more existing discharges into a single discharge**, provided that any combined discharge shall be designed to have a greater TOC than that of the original separate discharges and does not result in erosion or scour to wetland resources. Examples include:
   - Elimination of a discharge that was not environmentally protective (e.g., causing scour, direct discharge)
   - Redirection of runoff to an area that is more environmentally protective (e.g., greater separation from resource area, greater TOC, more stormwater treatment, enhanced scour protection, bank stabilization)

Outlet with flared end section and riprap apron © Stantec

MassDOT Evaluation Method

The designer should complete water quality treatment calculations as described under Standard 4 to demonstrate that stormwater receives the prescribed amount of treatment prior to discharge.

To demonstrate that new discharges will not cause erosion, the designer should determine the maximum velocity at the discharge and design the appropriate length and width of apron and lining materials (e.g., vegetation, riprap) to resist erosion at this velocity. Designers should refer to Section 8.4 of the MassDOT PDDG[32] on riprap design methods for guidance on these computations and how to demonstrate that discharges will not cause scour or erosion.

Congruency with Other Standards

New discharges are prohibited within Zone I or Zone A unless essential to the operation of the public water supply (see Standard 6 for more on this topic).

When the designer shows the project achieves compliance with Standard 4 (Water Quality), then the treatment requirement of this standard is also met.

32 See Section 8.4 of the MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

Standard 2—Peak Rate Attenuation

Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.

The purpose of Standard 2 is to prevent projects that affect stormwater runoff volumes, rates, and discharge points from having adverse impacts on downstream resource areas.

Development Category	Requirements
MassDEP Redevelopment	• Post-development peak discharge rates must not exceed pre-development peak discharge rates to the MEP. • Existing conditions must be improved.
MassDEP New Development	• Post-development peak discharge rates must not exceed pre-development peak discharge rates.

If a project requires compensatory flood storage, available flood storage should not include the volume of SCMs.[33] For compensatory flood storage, designers should assume SCMs would be full during a flood event and unavailable for storage. Compensatory flood storage analysis should be calculated separately from peak flow analysis.

MassDOT Approach to Compliance

This standard is met by first implementing the Integrated Site Design (ISD) process with a focus on increasing flow paths and TOCs for stormwater, as discussed in **Chapter 3**. Next the designer should implement structural SCMs that provide peak rate control to reduce post-development peak rates. **Chapter 4** includes design guidance for structural SCMs and accessories.

To meet this standard, the designer may consider:

- Increasing small-volume retention/detention storage in linear practices and topographic depressions using check dams (**Section 4.6.1**)
- Increasing retention/detention storage at intermediate locations along the stormwater flow path instead of a single downgradient location

MassDOT Evaluation Method

The designer must demonstrate compliance by calculating and comparing peak flow rates (not including freeboard) at design points for the 2- and 10-year, 24-hour design events for pre- and post-development conditions. The designer must also evaluate the impact of peak discharges from the 100-year, 24-hour design event to off-site property. If this evaluation shows that increased off-site flooding will occur from peak discharges from the 100-year 24-hour storms, SCMs must also be provided to attenuate these discharges.

The designer must determine the peak runoff volumes and rates using NRCS Technical Release 55 and Technical Release 20 (TR-55 and TR-20) methodologies.[34] For further information, refer to the MassDEP Hydrology Handbook for Conservation Commissioners.[35]

33 See 310 CMR 10.57(4)(a)1 for requirements related to compensatory flood storage.

34 See Section 8.4 of the MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

35 MassDEP. Hydrology Handbook for Conservation Commissioners. Mar. 2002. https://www.mass.gov/files/documents/2016/08/wa/hydrol.pdf

The designer should use the precipitation frequency estimates from National Oceanic and Atmospheric Administration (NOAA) Atlas 14[36] to develop the rainfall values for design events. However, the values must be greater than estimates in the National Weather Service Technical Paper 40 (TP-40) to show compliance with the Stormwater Standards.

Other precipitation resources may become available as climate change data is collected and refined.

For new development, calculations should show peak flow rates do not increase under post-development conditions at each design point. When peak rates cannot be controlled at each design point, the designer may use the MassDOT Macro Approach (**Section 2.3.4**).

For redevelopment, peak rates should not increase under post-development conditions to the MEP.

NOAA Atlas 14 is MassDOT's preferred precipitation data source but must be checked against TP-40 to make sure the higher estimate is used for peak flow calculations.

Congruency with Other Standards

SCMs designed to achieve peak rate control may also be used to meet the requirements for Standard 3 (Recharge) and Standard 4 (Water Quality).

SCMs must be designed with consideration for Standard 5 (Land Uses with Higher Potential Pollutant Loads [LUHPPLs]) and Standard 6 (Critical Areas) in the project area.

SCMs may also be used to achieve compliance with other requirements related to the MassDOT IWP and applicable TMDLs.

Infiltration basin in ponded condition © MassDOT

36 See NOAA Atlas 14 at: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

Standard 3—Recharge

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

The purpose of Standard 3 is to make sure that the volume of runoff infiltrated to groundwater under post-development conditions is the same or more than the volume of runoff infiltrated under pre-development conditions.

Development Category	Requirements
MassDEP Redevelopment	• Size SCMs to infiltrate the required recharge volume (ReV) to the MEP. • Existing conditions must be improved.
MassDEP New Development	• ReV must be provided at a minimum.

If a project, with either new or existing impervious cover, includes any of the following conditions, it is allowed to comply with this standard to the MEP:

- The land surface is comprised solely of hydrologic soil group (HSG) C and D soils and bedrock.
- Underlying soils are classified as contaminated or contamination has been capped in place (**Section 3.1.5.2**).
- An Activity and Use Limitation has been registered or filed in accordance with Massachusetts Contingency Plan regulations 310 CMR 40.1070 through 310 CMR 40.1099 for the site that precludes inducing runoff to the groundwater.
- Groundwater from the proposed recharge location flows directly toward a solid waste landfill or sites classified under M.G.L Chapter 21E.

MassDOT Approach to Compliance

This standard is met by first implementing the ISD process with a focus on preserving vegetation and natural depressions and lengthening flow paths. The designer should identify pavement disconnection to qualifying pervious areas (QPAs) and vegetated filter strips and reduce existing impervious cover where possible. Next the designer should implement infiltration SCMs that recharge the ReV.

Siting and design considerations that affect the ability to implement SCMs for recharge in the Right-of-Way (ROW) are discussed in **Chapter 3** and in detail in **Section 4.8**.

The designer should meet pretreatment requirements prior to discharging to infiltration SCMs. Additional pretreatment is required for infiltration SCMs in the following cases (**Section 4.8.2**):

- Soils with Rapid Infiltration Rate (i.e., saturated hydraulic conductivity >2.4 in/hr)
- Stormwater systems that receive runoff from LUHPPLs
- Stormwater systems that discharge to Critical Areas

Designers must endeavor to provide recharge within watersheds to public drinking water supplies, but must locate SCMs outside of Zone I and Zone A drinking water supply protection areas. The designer should discuss suitability of the SCM location with the water supplier if the SCM is proposed within the Zone II or Interim Wellhead Protection Areas (IWPAs).

MassDOT Evaluation Method

The designer should demonstrate compliance by showing that the proposed recharge volume meets or exceeds the ReV.

Designers should disconnect impervious cover to encourage dispersed recharge and identify as many QPAs as possible to minimize the ReV.

The designer should calculate the ReV for the site's total impervious area (IA, excluding pavement disconnection to a QPA, see **Section 4.2.1**). The ReV equals a depth of runoff corresponding to the soil type HSG multiplied by the IA under post-development covering that soil type:[37]

$$ReV = F \div 12 \times IA$$

where:

ReV = required recharge volume, ft^3

F = target depth factor associated with each HSG, in

HSG	F
A	0.60
B	0.35
C	0.25
D	0.10

IA = total pavement and rooftop area on the post-development site minus disconnected impervious areas to QPAs, ft^2

If a site contains multiple HSGs, the designer should sum the ReV for each IA within each HSG to calculate the total ReV for the site.

37 MassDEP. Massachusetts Stormwater Handbook. Vol. 3, Ch. 1, Feb. 2008.

The designer should then calculate the storage volume of infiltration SCMs using the methods described in the Massachusetts Stormwater Handbook (Vol. 3, Ch. 1). Using the static method, the storage volume available for ReV is considered the SCM volume below the lowest outlet. If the designer chooses to use one of the dynamic methods ("Simple Dynamic" or "Dynamic Field") to size the infiltration SCM, storage volume may be smaller but additional pretreatment requirements apply (**Section 4.8.2**).

The designer shall make every attempt to provide recharge throughout the project site so that infiltration is evenly dispersed. If all runoff from the IA does not drain to a QPA or an infiltration SCM, a "capture area adjustment" calculation may be required, as described in the Massachusetts Stormwater Handbook (Vol. 3, Ch. 1). At a minimum, runoff from 65% or more of the site's IA cover should be directed to the SCMs intended to infiltrate the ReV.

If an infiltration SCM is in the same subwatershed as a vernal pool, designers must determine if the proposed recharge location will alter the hydrologic regime of the vernal pool. Analysis can be done with a water budget using the Thornthwaite[38] method or equivalent.

For new development, calculations should show the design infiltrates the ReV. The designer may use the MassDOT Macro Approach (**Section 2.3.4**) to meet this Standard on a project-wide scale when compliance cannot be practicably met at each design point.

For redevelopment, calculations should show the design infiltrates the ReV to the MEP.

38 Thornthwaite, C.W. An Approach Toward a Rational Classification of Climate. Geographical Review, Vol. 38, 1948, pp. 55-94. http://www.brr.cr.usgs.gov/projects/SW_MoWS/Thornthwaite.html

Congruency with Other Standards

SCMs used to achieve compliance with this standard may also be used to achieve compliance with Standard 2 (Peak Rate Attenuation) and Standard 4 (Water Quality).

SCMs must be designed with consideration for Standard 5 (LUHPPLs) and Standard 6 (Critical Areas) in the project area.

SCMs may also be used to achieve compliance with other requirements in the TS4 Permit and with the MassDOT IWP and applicable TMDLs.

Infiltration linear practice © MassDOT

Standard 4—Water Quality Treatment

Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This Standard is met when:

a. Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained;

b. Structural stormwater control measures are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and

c. Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.

The purpose of Standard 4 is to reduce the concentration of pollutants in stormwater runoff by providing source control (e.g., deicing salt application, pet waste management) and water quality treatment measures.

The MassDEP Standard requires the designer to develop a stormwater treatment system that will remove 80% of the average annual post-construction TSS load from a volume of stormwater runoff, referred to as the Water Quality Volume (WQV), prior to the design point. This Standard also requires pretreatment of runoff (e.g., sediment forebays, deep-sump catch basins) and the implementation of source control practices and pollution prevention as defined in a long term pollution prevention plan (LTPPP).

Development Category	Requirements
MassDEP Redevelopment	• Develop an LTPPP • Provide pretreatment and 80% TSS reduction for the WQV to the maximum extent practicable and improve existing conditions • Follow requirements provided in the WQDF
MassDEP New Development	• Develop an LTPPP • Must provide pretreatment and 80% TSS reduction for the WQV • Follow requirements provided in the WQDF

If a project, with either new or existing impervious cover is considered maintenance/improvements of existing roadways, it is allowed to comply with this Standard to the maximum extent practicable. Maintenance / improvement of existing roadways is defined as activities that are exclusively limited to:

- Widening less than a single lane
- Adding shoulders
- Correcting substandard intersections
- Improving existing drainage systems
- Repaving projects

MassDOT Approach to Compliance

These requirements are met by first following the ISD process. **Chapter 3** discusses the ISD process, including siting and design considerations that affect the ability to implement SCMs for water quality treatment in the ROW. Through the ISD process, designers should implement low impact development (LID) measures, then structural SCMs to provide pretreatment and the required water quality treatment. **Chapter 4** includes design guidance for pretreatment SCMs, treatment SCMs, and accessories.

Additional pretreatment is required by MassDEP for SCMs in the following cases (**Section 4.8.2**):

- Soils with Rapid Infiltration Rate (i.e., saturated hydraulic conductivity >2.4 in/hr)
- Stormwater systems that receive runoff from LUHPPLs
- Stormwater systems that discharge to Critical Areas

MassDOT Evaluation Method

Designers should use the TSS reductions table found within the Massachusetts Stormwater Handbook to demonstrate 80% TSS reduction for a Water Quality Volume (WQV) equal to 0.5 inches times the Impervious Area (IA). The designer should use a WQV equal to 1.0 inches times the IA of the post-development project site when a discharge is:

- From LUHPPLs
- In soils with Rapid Infiltration Rates (i.e., saturated hydraulic conductivity >2.4 in/hr)
- Within a Zone II or IWPA
- Near or to the following Critical Areas:
  - ORW
  - Special Resource Waters
  - Bathing beaches
  - Shellfish growing areas
  - Cold-water fisheries

For new IA, calculations should show the design provides the required treatment of WQV at each design point. When it becomes impracticable for the required treatment to be met at each design point, the designer may use the MassDOT Macro Approach (**Section 2.3.4**) to meet this standard on a project-wide scale.

For existing IA, calculations should show the design treats the required WQV to the MEP and improves existing conditions.

Congruency with Other Standards

Treatment SCMs used to achieve compliance with Standard 4 may also be used to meet requirements of Standard 2 (Peak Rate Attenuation) and Standard 3 (Recharge). Treatment SCMs must be designed with consideration for Standard 5 (LUHPPLs) and Standard 6 (Critical Areas) in the project area.

The source control and pollution prevention component of Standard 4 is incorporated into compliance documentation for Standard 5 (LUHPPLs), Standard 6 (Critical Areas), Standard 8 (E&S Control), and Standard 9 (O&M Plan).

Standard 5—Land Uses with Higher Potential Pollutant Loads

For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable. If, through source control and/or pollution prevention, all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, and stormwater runoff, the proponent shall use structural SCMs suitable for such uses. Stormwater discharges from land uses with higher potential pollutant loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53 and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.

The purpose of Standard 5 is to apply additional pollution prevention measures to those areas identified as Land Uses with Higher Potential Pollutant Loads (LUHPPLs).

Development Category	Requirements
MassDEP Redevelopment	If the Project's land use is considered a LUHPPL: • If infiltration SCMs are proposed, provide pretreatment (44% TSS removal) to the MEP. • Provide treatment of the 1.0-inch runoff depth over the IA to the MEP.
MassDEP New Development	If the Project's land use is considered a LUHPPL: • If infiltration SCMs are proposed, provide pretreatment (minimum 44% TSS removal). • Provide treatment of at least the 1.0-inch runoff depth over the IA.

The entirety or portions of the following MassDOT facilities may be considered LUHPPLs:

- Maintenance facilities
- Service plazas with amenities including gas stations

The following MassDOT facilities are not considered LUHPPLs:

- Roadways
- Bridges
- Rest areas and Park-and-Ride lots with fewer than 1,000 vehicle trips per day
- Covered sand and salt storage facilities

Refer to the next page for information related to the regulatory definition of a LUHPPL and a list of the activities, structures, and uses that may cause an area to be designated as a LUHPPL.

MassDOT Approach to Compliance

This standard is met by implementing source control, pollution prevention measures, and, if necessary, structural SCMs to minimize the discharge of stormwater from LUHPPLs.

Source control and pollution prevention measures include:

- Measures to eliminate or minimize stormwater coming into contact with the particular land use that has potential to generate high concentrations of pollutants (e.g., store materials in sealed containers or under shelter/rooftop, move activities indoors)
- Provisions for spill containment (e.g., booms, caps, covers, pneumatic plugs, absorbent materials)

LUHPPLs

Standard 5 specifies additional treatment requirements for stormwater management facilities that receive runoff from Land Uses with Higher Potential Pollutant Loads (LUHPPLs).

LUHPPLs include:[39]

- Land uses that are subject to a NPDES Multi-Sector General Permit (MSGP) and an individual NPDES Permit
- Auto fueling facilities (gas stations)
- Exterior fleet storage and/or maintenance areas
- Exterior vehicle service and equipment cleaning areas
- Marinas and boatyards
- Parking lots with high-intensity use (e.g., 1,000 vehicle trips per day or more)
- Confined disposal facilities
- Disposal sites

The presence of the following structures or activities may cause an area to be classified as a LUHPPL:

- Underground storage tanks
- Above-ground storage of liquid hazardous materials
- Uncovered or uncontained storage of road or parking lot de-icing and sanding materials
- Sand and gravel excavation operations

Infiltration basin with additional pretreatment and outlet control structure near LUHPPL. Note that structures within the clear zone should comply with the AASHTO Roadside Design Guide. © MassDOT

39 See 310 CMR 10.04, 314 CMR 9.02, and 310 CMR 22.20-21.

Siting and design considerations that affect the ability to use SCMs in LUHPPLs are discussed in **Chapter 3**. **Chapter 4** includes design guidance for structural SCMs and accessories.

SCMs should be chosen based on their suitability to treat discharges from the specific type of LUHPPL. All MassDOT SCMs except for porous pavement may be used to treat runoff from LUHPPLs.

MassDOT Evaluation Method

Designers should work closely with MassDOT Environmental Services Section (MassDOT Environmental) to determine the applicability of Standard 5 to a project site and to address stormwater management issues for these facilities. Designers should determine if the project site receives run-on from other properties that may be considered LUHPPLs and, if so, how to minimize or eliminate run-on.

Designers should also consider ways to minimize the area of a site, or the component of a stormwater treatment train, that is affected by runoff from the LUHPPL and therefore subject to Standard 5.

SCMs should be sized to treat a minimum runoff depth of 1.0 inch over the total IA of the post-development site. Additional pretreatment (44% TSS removal) is required for infiltration SCMs that treat stormwater from LUHPPLs (e.g., two pretreatment SCMs in series that each provide 25% TSS removal).

Congruency with Other Standards

Source control measures required as part of Standard 4 (Water Quality) and described in the LTPPP and/or the O&M Plan as part of Standard 9 may be used to document compliance with this standard.

Treatment SCMs used to achieve compliance with this standard may also be used to achieve compliance with Standard 2 (Peak Rate Attenuation), Standard 3 (Recharge), and Standard 4 (Water Quality). The stormwater treatment train used to achieve compliance with Standard 4 (Water Quality) must be designed to treat a runoff depth of 1.0 inch or greater for a LUHPPL.

Compliance with this standard supports compliance requirements for MassDOT facilities under the Good Housekeeping MCM of the MS4/TS4 Permit.

Service plaza with gas station on I-90 which is considered a LUHPPL. Note that structures within the clear zone should comply with the AASHTO Roadside Design Guide. © VHB

Standard 6—Critical Areas

Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other Critical Area, require the use of the specific source control and pollution prevention measures and the specific structural SCMs to be suitable for managing discharges to such areas. A discharge is near a Critical Area if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors.

Direct stormwater discharges to Outstanding Resource Waters and Special Resource Waters shall be removed and set back from the receiving water or wetland and receive the highest and best practical method of treatment. A "stormwater discharge" as defined in 314 CMR 3.04 (2)(a)1 or (b) to an Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply.

The purpose of Standard 6 is to prescribe additional measures to address stormwater quality and quantity in areas identified as critical natural resource areas that may be affected by the project.

Development Category	Requirements
MassDEP Redevelopment	If the Project discharges near or to a Critical Area: • If infiltration SCMs are proposed, provide pretreatment (44% TSS removal) to the MEP. • Provide treatment of the 1.0-inch runoff depth over the IA to the MEP.
MassDEP New Development	If the Project discharges near or to a Critical Area: • If infiltration SCMs are proposed, must provide pretreatment (minimum 44% TSS removal). • Must provide treatment of at least the 1.0-inch runoff depth over the IA.

MassDOT owns and maintains many roadways that discharge to locations that meet the definition of a Critical Area. See the next page for detailed information on Critical Areas.

MassDOT Approach to Compliance

This standard is met by implementing specific source control, pollution prevention measures, LID, and structural SCMs suitable for managing discharges to Critical Areas.

Source control and pollution prevention measures include:

- Proper management and application of snow and de-icing chemicals
- Provisions for spill containment

Siting and design considerations that affect the ability to implement SCMs in Critical Areas are discussed in **Chapter 3**. Designers should avoid new discharges to Critical Areas and relocate existing discharges to provide buffers and pavement disconnection, if possible.

Critical Areas

Critical Areas, subject to the requirements of Standard 6, include:[40]

Recharge areas for public water supplies:

- Groundwater Sources
  - Zone I Wellhead Protection Areas
  - Zone II Wellhead Protection Areas
  - Interim Wellhead Protection Areas (IWPAs)
- Surface Water Sources
  - Zone A Surface Water Supply Protection Areas

Other surface waters:

- Bathing beaches
- Cold-water fisheries
- Shellfish growing areas
- Outstanding Resource Waters
- Special Resource Waters

Outstanding Resource Waters include:[41]

- Class A Public Water Supplies and their tributaries, including active and inactive reservoirs
- Wetlands bordering Class A, B, SB, or SA Outstanding Resource Waters
- Certified vernal pools

Outstanding Resource Water:
Middle Reservoir in Stoneham, Massachusetts © VHB

- Other waters, defined at the discretion of MassDEP, based on their outstanding socio-economic, recreational, ecological, and/or aesthetic values. See list of ORWs published in the Surface Water Quality Standards

Special Resource Waters include:

- Certain waters of exceptional significance, assigned at the discretion of MassDEP, which may include waters in national parks, state parks, or wildlife refuges

40 See Massachusetts Stormwater Handbook Vol. 1 Ch. 1 (Feb. 2008) at: https://www.mass.gov/guides/massachusetts-stormwater-handbook-and-stormwater-standards. Critical Area data is available through MassGIS at https://www.mass.gov/get-massgis-data

41 See 314 CMR 4.00

Chapter 4 includes design guidance for structural SCMs and accessories. All MassDOT SCMs except porous pavement and extended dry detention basins may be used in Critical Areas, with the following exceptions:

- Leaching basins are only allowed in cold-water fisheries and no other Critical Areas.
- The following SCMs are allowed in all Critical Areas except for cold-water fisheries:
  - Gravel wetlands
  - Constructed stormwater wetlands
  - Wet basins and wet linear practices

New discharges to Critical Areas should be avoided and existing discharges relocated to provide buffers and pavement disconnection, if possible.

SCMs should be chosen based on their suitability to treat pollutants that would otherwise discharge to the Critical Area.

Each Critical Area has unique characteristics that warrant a higher level of stormwater management and treatment as identified below. Additional information on SCM siting and design considerations near sensitive resources is provided in **Section 3.3.3.3**.

Public Water Supply

Designers should implement measures to protect public water supplies from nutrients, sediment, and other pollutants. In addition, there should be coordination with local first responders and the public water supply operator/owner to determine if other special provisions are warranted (e.g., structural spill containment measures).

New stormwater discharges to a Zone I or Zone A are prohibited for all types of projects unless essential to the operation of the public water supply. The designer should coordinate with public water supply owners to determine suitability of recharge in Zone II Wellhead Protection Areas.

Public water supplies warrant special attention for spill containment measures at SCMs. Spill kits, such as booms, caps, covers, pneumatic plugs, absorbent materials, etc., are the most versatile and reliable means for responding to spills. These measures are implemented at the local level by first responders, which includes local public safety departments (e.g., fire, police, public works, board of health). MassDOT works with first responders and/or public water supply owners to determine the best approach to protect water supplies and provides training and materials to carry out action plans.

Bathing Beaches and Shellfish-Growing Areas

The presence of pathogens in shellfish growing areas and bathing beaches can render these Critical Areas unsafe for human health. Pathogens originating from wastewater, wildlife, waterfowl, pet waste, and agricultural sources may be conveyed by stormwater runoff to receiving waters. Designers should implement treatment measures that minimize standing water and promote infiltration.

Cold-Water Fisheries

Cold-water fisheries are sensitive to thermal impacts. Designers should minimize standing water, promote infiltration, increase vegetation and vegetative cover (shading) along the flow path, and eliminate direct discharges to the cold-water fishery.

Special and Outstanding Resource Waters, Including Certified Vernal Pools and Bordering Wetlands

Each Special Resource Water and ORW has unique requirements for protection and conservation. Designers should implement treatment measures to protect these areas from the pollutants of concern by

Newly built constructed stormwater wetland © MassDOT

rerouting stormwater discharges to other areas or by treating stormwater in accordance with this standard. For certified vernal pools, stormwater should be recharged within the same subwatershed to maintain the hydrologic regime in accordance with Standard 3 (i.e., vernal pool should not dry out in between storm events or be constantly flooded, in comparison to its baseline hydrologic regime).

MassDOT Evaluation Method

The designer should identify Critical Areas in and adjacent to the project area early in the project planning process and evaluate the feasibility of implementing SCMs to address the unique considerations and constraints of each type of Critical Area.

Depending on the Critical Area and location of the project, the LTPPP should include spill containment measures (e.g., booms, caps, covers, pneumatic plugs, absorbent materials) and provisions to address spill containment procedures (e.g., providing training and materials to local first responders).

Designers must size SCMs to treat a minimum runoff depth of 1.0 inch over the total IA of the post-development site. If infiltration SCMs are proposed, designers should choose pretreatment SCMs that meet 44% TSS removal (e.g., two pretreatment SCMs in series that each provide 25% TSS removal).

Congruency with Other Standards

Treatment SCMs used to comply with this standard may also be used to achieve compliance with Standard 2 (Peak Rate Attenuation), Standard 3 (Recharge), and Standard 4 (Water Quality).

The stormwater treatment train used to achieve compliance with Standard 4 must be designed to treat a runoff depth of 1.0 inch or greater when discharging to a Critical Area.

Standard 7—Redevelopment

A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural SCM requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

The purpose of Standard 7 is to allow flexibility within the Stormwater Standards for project areas that have been previously developed.

Development Category	Requirements
MassDEP Redevelopment	• Show compliance with Standard 1 to the MEP for existing stormwater discharges. • Show compliance with Standards 2 and 3 to the MEP. • Show compliance with Standards 4, 5, and 6 for pretreatment and SCM requirements to the MEP. • Show full compliance with Standards 7, 8, 9, and 10. • Show improvement to existing conditions.
MassDEP New Development	Does not apply

MassDOT Approach to Compliance

Chapter 4 includes design guidance for structural SCMs and accessories that may be used to meet this standard.

For all development categories, it is MassDOT's policy to fully comply with the Stormwater Standards wherever possible. However, if site constraints prevent the project from achieving full compliance, MassDOT aims to improve the existing site conditions and meet the Stormwater Standards to the MEP. This may include ISD practices as discussed in **Chapter 3** and other means to protect resource areas, increase recharge, reduce discharge rates, and reduce pollutant loads.

MassDOT Evaluation Method

Designers should use MassDEP's Checklist for Redevelopment Projects[42] to evaluate redevelopment projects for compliance with Standard 7.

In accordance with the Massachusetts Stormwater Handbook and applicable regulations,[43] if full compliance with the Stormwater Standards cannot be met and the design achieves compliance with the MEP, the design team must demonstrate and document in the Stormwater Management Report that:

- The design team made all reasonable efforts to meet each of the Stormwater Standards
- The design team made a complete evaluation of possible stormwater management measures, including environmentally sensitive site design, LID techniques that minimize land disturbance and impervious surfaces, structural SCMs, pollution prevention, E&S control, and proper O&M plan for SCMs
- The design improves existing conditions and implements the highest practicable level of stormwater management

If the MassDOT Macro Approach (**Section 2.3.4**) is being proposed to meet Standards 2, 3, or 4, the designer must first demonstrate that the Standard cannot practicably be met at each design point and then show the calculations to support the Macro Approach.

42 MassDEP. Massachusetts Stormwater Handbook. Vol. 2, Ch. 3, Feb. 2008.

43 310 CMR 10.05(6)(o) and/or 314 CMR 9.06(6)(e)

Standard 8—Erosion and Sediment Control

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

The purpose of Standard 8 is to ensure construction-period E&S controls are implemented. These controls are required for all construction projects, including emergency repair projects. In general, the focus of E&S controls is to prevent the off-site export of sediment from the construction site, which occurs when on-site soils are mobilized by rain events and discharged to adjoining properties and/or receiving waters.

All MassDOT projects must have a plan to control erosion, sedimentation, and other pollutants during construction.

Development Category	Requirements
MassDEP Redevelopment or New Development	Must have an E&S control plan (and SWPPP, as applicable) in accordance with this Standard.

The Federal EPA NPDES stormwater program requires that all projects that disturb one or more acres of land file an electronic NOI to obtain coverage under the CGP[44] as described further under **Section 2.1.2**. As part of the CGP requirements, the contractor must prepare and implement a SWPPP. Compliance with the CGP is also a requirement under MCM #4 of the MS4/TS4 Permit. In addition to measures for controlling sediment discharge from the construction site, EPA may also require measures to control other pollutants of concern (e.g., phosphorus) in order to meet TMDL requirements.

44 See 2022 Construction General Permit (CGP) at: https://www.epa.gov/npdes/2022-construction-general-permit-cgp

MassDOT Approach to Compliance

To meet this standard, the designer must develop an E&S control plan. As part of the contract documents for the project, the designer must include E&S control details and pay items.

The designer should include E&S controls, construction-phase stormwater controls, construction dewatering controls, waste management, etc. on the project plans and in cost-estimating worksheets. The designer should consider the following:

- Properly placing perimeter controls
- Protecting resource areas
- Providing buffers adjacent to resource areas
- Designing controls so that runoff will be intercepted
- Installing measures to stabilize bare soils
- Including quantities of multiple installations of E&S controls for longer-duration projects that are active for multiple seasons (for repairs, if necessary)
- Minimizing limit of work and staging to reduce impacts to existing vegetation and soils

If the project requires coverage under the CGP, the designer should also include the NPDES SWPPP pay item (Standard Item 756.) in the contract documents. The specification for Standard Item 756. covers:

- The preparation and implementation of the SWPPP by the contractor
- The review and approval of the SWPPP by the MassDOT Resident Engineer prior to any site activities

- The preparation and submittal of the electronic NOI application to the EPA for coverage under the CGP
- The preparation and submittal of the "WM 15: NPDES General Permit NOI" to MassDEP (for projects discharging to an ORW). Refer to **Section 2.1.2** for more information.

The contractor is responsible for implementing the measures in the SWPPP, keeping the SWPPP up to date during construction, and performing the required inspections and reports. The MassDOT Resident Engineer is responsible for enforcing E&S control requirements, with ultimate jurisdiction remaining at the municipal and federal (EPA) level.

Silt sack © VHB

MassDOT Evaluation Method

The designer should consult MassDOT Environmental for current special provisions for construction-period controls and protocols and should adhere to guidance provided in **Section 4.8.3** on construction considerations (e.g., management and protection of infiltration areas). For additional guidance, the designer also should use the following resources, which contain detailed information about preparing construction period E&S control plans for MassDOT projects:

- The MassDOT Erosion and Sediment Control Field Guide (2013) includes detailed descriptions, photographs, and illustrations of E&S control measures that the designer may incorporate into the plans.
- Chapter 8 of the MassDOT Project Development & Design Guide,[45] Section 8.5—Erosion During Construction, includes a description of common construction period E&S control practices.
- The MassDEP "Erosion and Sediment Control Guidelines"[46] is an authoritative reference on erosion prevention measures.
- The Massachusetts Nonpoint Source Pollution Management Manual[47] provides an innovative user interface to present comprehensive detailed guidance on E&S controls for construction projects.

45 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

46 See Complete Erosion and Sedimentation Control Guidelines: A Guide for Planners, Designers, and Municipal Officials (May 2003) at: https://www.mass.gov/service-details/stormwater

47 See Massachusetts Nonpoint Source Pollution Management Manual at: https://megamanual.geosyntec.com/npsmanual/default.aspx

Standard 9—Operation and Maintenance Plan

A long-term O&M plan shall be developed and implemented to ensure stormwater management systems function as designed.

The purpose of Standard 9 is to ensure ongoing O&M during the life of the stormwater management system. All MassDOT projects must have an O&M plan for their stormwater management system.

Development Category	Requirements
MassDEP Redevelopment or New Development	Must have an O&M Plan in accordance with this Standard

MassDOT Approach to Compliance

To meet this standard, individual MassDOT projects must develop a project-specific O&M Plan as part of the NOI submission for approval by the local conservation commission. The MassDOT O&M Plan template[48] provides guidance to the designer on the content to include for their project.

Although currently each project needs its own O&M plan, MassDOT is developing a programmatic plan for stormwater O&M that will be implemented by each district.

MassDOT Evaluation Method

For MassDOT roadways and facilities, O&M is addressed at a statewide, programmatic level through the state's highway O&M program. MassDOT's approach is to inspect stormwater features regularly and provide maintenance as needed. Each MassDOT district office is responsible for implementing the O&M Plans for MassDOT-owned infrastructure within their respective jurisdictions.

For MassDOT-executed municipal projects, where MassDOT funds and/or constructs the project and the municipality retains ownership upon completion of construction, O&M of the stormwater management system becomes the responsibility of the municipality. In these situations, the O&M Plan should be developed in conjunction with the municipality and corroborated with the municipal Department of Public Works where the O&M Plan will be supported and implemented. MassDOT should obtain written certification from the municipality that, as owners of the SCM(s), they accept responsibility for implementing the O&M Plan.

Congruency with Other Standards

Compliance with this standard may be used to address compliance with Standard 4 (Water Quality) and Standard 7 (Redevelopment).

Infiltration basin with mature vegetation © MassDOT

48 See MassDOT's O&M Plan template at: https://www.mass.gov/service-details/stormwater-management-massdot-environmental-services

Standard 10—Prohibition of Illicit Discharges

All illicit discharges to the stormwater management system are prohibited.

The purpose of Standard 10 is to prevent or remove illicit discharges to a project's stormwater management system.

Development Category	Requirements
MassDEP Redevelopment or New Development	• Must have no illicit discharges connected to the stormwater management system • Must submit an Illicit Discharge Compliance Statement

Illicit discharges are discharges that do not consist entirely of stormwater. However, the following non-stormwater discharges are allowable under this Standard and the MS4/TS4 Permit:

- Firefighting
- Water line flushing
- Landscape irrigation
- Uncontaminated groundwater
- Potable water sources
- Foundation drains
- Air conditioning condensation
- Footing drains
- Individual resident car washing
- Flows from riparian habitats and wetlands
- Dechlorinated water from swimming pools
- Water used for street washing
- Water used to clean residential buildings without detergents

Typical illicit discharges may include:

- Sanitary wastewater either incorrectly connected or entering system through leaking pipes
- Effluent from septic systems either incorrectly connected to drainage system or entering by seepage from failed system
- Washwater (commercial car washes, laundromats, residential units, etc.)
- Activities from an industrial MS4 permit holder
- Sump pump operations that cannot meet the uncontaminated groundwater criteria above
- Stormwater contaminated by contact with process wastes, raw materials, toxic pollutants, hazardous substances, oil, and grease
- Improperly disposed household/automotive chemicals

Illicit discharges have the potential to enter MassDOT's stormwater management system through permanent or temporary piped connections, split manholes, deteriorating infrastructure, or overland flow. Priority areas include locations where a drainage system crosses under or is adjacent to a potentially deteriorated sewer line.

MassDOT Approach to Compliance

All MassDOT projects must provide an Illicit Discharge Compliance Statement as part of the NOI or 401 WQC applications certifying that, upon investigation, no illicit connections were found throughout the project area.

MassDOT compliance with this standard supports its IDDE Program, which is implemented to maintain compliance with the MS4/TS4 Permit, and is described in the MassDOT Stormwater Management Plan (SWMP).[49]

MassDOT currently prohibits existing or new tie-ins to its drainage infrastructure, unless authorized by a drainage access tie-in permit, as specified in the Drainage Connection Policy[50] and the Connection or Discharge to any MassDOT Drainage System Standard Operating Procedure (SOP).[51] New or modified tie-ins and existing unauthorized connections detected during project activities (even if they do not result in illicit discharges) are subject to the SOP.

Applications for drainage access tie-in permits include a comprehensive review of drainage alternatives, a demonstration of hardship conditions, and are reviewed and approved at the district level. MassDOT may choose to issue a permit or require the applicant to remove the connection, consistent with the MassDOT Drainage Connection Policy and SOP.

MassDOT Evaluation Method

The designer should review drainage plans and inspect the project site for interconnections to the stormwater management system and inform the MassDOT Project Manager (PM) of any identified. The MassDOT PM will coordinate with the District Permits Engineer to determine whether the connections are authorized. For unauthorized connections, the MassDOT PM and/or MassDOT Environmental will investigate the connections and if they are determined to be illicit, the connections will be managed through the IDDE program and/or through other agencies. If the connection is unauthorized but not illicit (i.e., conveys uncontaminated stormwater), the District will seek a Drainage Tie-in permit from the landowner.

If any potential illicit connections or discharges are identified during construction, the contractor should notify MassDOT's Resident Engineer, who will coordinate with the District Permits Engineer to confirm if the connections are authorized and the same process will be followed as described above.

Congruency with Other Standards

Compliance with this standard is used to support the MassDOT IDDE Program, which is required by the MS4/TS4 Permit.

49 See MassDOT Stormwater Management Plan (SWMP) at: https://www.mass.gov/service-details/stormwater-management-massdot-environmental-services

50 See MassDOT Highway Engineering Directive P-06-002 (26 Jun. 2006) at: https://www.mass.gov/service-details/massdot-highway-engineering-directives

51 See Connection or Discharge to any MassDOT Drainage System Standard Operating Procedure (19 Mar. 2012) at: https://www.mass.gov/doc/connection-or-discharge-to-any-massdot-drainage-system-sop-0/download

2.3 MassDOT Approaches and Documentation

MassDOT has developed standard approaches, tools, and documentation templates to meet stormwater management requirements for projects as required by the Stormwater Standards and MS4/TS4 Permit.

2.3.1 MassDOT Documentation for Stormwater Standards

Project-related documents that support MassDOT compliance with the Stormwater Standards include:

- MassDEP Checklist for Stormwater Management Report[52] certified and stamped by a licensed professional engineer
- Stormwater Management Report following the MassDOT template[53] including supporting worksheets, calculations, figures and design plans
- Stormwater O&M Plan and LTPPP following the MassDOT template[54]
- NPDES CGP SWPPP,[55] if applicable

Designers should prepare documents that are consistent with MassDOT templates , tools, and approaches.

MassDOT developed a Stormwater Management Report template that designers should use to document compliance with the Stormwater Standards as part of a WPA NOI filing with the local conservation commission (or a 401 WQC application with MassDEP). Stormwater Management Reports are not required for WPA Request for Determination of Applicability (RDA) filings.

52 See MassDEP Checklist for Stormwater Management Report at: https://www.mass.gov/files/documents/2016/08/pr/swcheck.pdf

53 See MassDOT Stormwater Management Report template at: https://www.mass.gov/service-details/stormwater-management-massdot-environmental-services

54 See MassDOT's O&M Plan and LTPPP templates at: https://www.mass.gov/service-details/stormwater-management-massdot-environmental-services

55 See EPA's SWPPP template at: https://www.epa.gov/npdes/construction-general-permit-resources-tools-and-templates#swppp

For projects that potentially affect impaired receiving waters with non-numeric TMDL targets or no TMDL, the designer should discuss how the SCMs were selected and designed to address receiving water infrastructure impairments in the Stormwater Management Report. The designer should describe source control measures (e.g., street sweeping, reduction of de-icing salt or sand on roadways, litter pick-up, etc.) in the LTPPP.

2.3.2 MassDOT Water Quality Data Form (WQDF)

The WQDF is a MassDOT tool that provides information to designers, such as the location of impaired water bodies and the requirements for treatment. It guides designers on which mitigation practices are appropriate. Information is then collected by the WQDF to document how the project meets treatment requirements and it creates records of the proposed SCMs for the project.

The project location is used to identify the watershed(s) to use to create project-specific requirements for structural controls. Watersheds include those to impaired water bodies with and without associated TMDLs. It is important to note that the WQDF provides guidance for requirements when selecting and designing SCMs consistent with this SDG.

The WQDF is a requirement of the Early Environmental Coordination Checklist submitted at 25% design. Additional submittals may be warranted to provide MassDOT with updated SCM designs.

MassDOT provides a calculator that allows designers to estimate SCM water quality performance using the SCM WQ Curves. MassDOT uses this information to track and inventory SCMs on an ongoing basis as incremental improvements are made to document MS4/TS4 Permit compliance at the watershed scale.

All MassDOT projects require the submittal of the WQDF no later than the 25% design stage. Additional submittals may be warranted to provide MassDOT updated project and SCM information.

2.3.3 MassDOT SCM Water Quality Curves

For select SCMs, EPA developed the SCM WQ Curves as a tool to quantify water quality treatment performance. The curves relate the depth of runoff treated (which is a function of SCM design storage volume) to the pollutant percent reduction.

The EPA MS4 and TS4 Permits require that the curves be used to calculate pollutant load reductions provided by structural SCMs. EPA's pollutant curves are based on the best available field data on SCM treatment performance.

Currently, EPA's WQ Curves are not used by MassDEP to show compliance with TSS removal requirements under Standard 4.

MassDOT incorporated the SCM WQ Curves into the WQDF for designers to estimate pollutant removals for meeting TS4 water quality requirements as well as TMDL targets for impaired waters. MassDOT may update SCM WQ Curves within the WQDF as supplemental data are collected or developed for additional SCMs.

Refer to the MassDOT WQDF for the most recent SCM Water Quality Curves used by MassDOT.

To supplement EPA's pollutant curves, MassDOT developed curves for estimating the reduction of effective impervious cover. While this parameter currently is not associated with any TMDL or impaired waters targets, effective impervious cover is a commonly used metric in the New England region that designers can use to quantify stormwater impacts and to help prioritize SCMs for their design.

2.3.4 MassDOT Macro Approach

The MassDOT Macro Approach is a design approach to meet the Stormwater Standards by evaluating the project in a holistic manner, rather than at each design point (i.e., location of interest chosen by the designer such as outfall, receiving water body, wetland, downstream culvert, etc.).

MassDOT roadway and bridge projects are fundamentally linear in nature, which presents permitting and stormwater management design challenges. Highways occupy a relatively narrow corridor that traverses many diverse engineered and natural features (e.g., topography, watershed divides) that can constitute a constraint. These constraints present unique design challenges for meeting stormwater management goals and drive MassDOT's need for alternative approaches to meet regulatory requirements. MassDOT may use the Macro Approach to help overcome these design challenges at the project scale.

The purpose of the Macro Approach is to achieve compliance with the Stormwater Standards on a project-wide scale.

As part of this process, the designer must first determine why it is impracticable to meet the specific standard at every design point. Constraints (e.g., proximity of wetlands, steep slopes, presence of bedrock, high groundwater, soils with poor infiltration capacity, limited ROW), existing development) can interfere with achieving the desired treatment levels. Once it is determined that the Stormwater Standards cannot practicably be met, the designer can employ the Macro Approach.

Table 2-3. Stormwater Standards Allowed for Use with Macro Approach

Standard 1—No New Untreated Discharges	☐
Standard 2—Peak Rate Attenuation	☑
Standard 3—Recharge	☑
Standard 4—Water Quality	☑
Standard 5—LUHPPLs	☐
Standard 6—Critical Areas	☐
Standard 7—Redevelopment	☐
Standard 8—E&S Control	☐
Standard 9—O&M Plan	☐
Standard 10—Prohibition of Illicit Discharges	☐

The Macro Approach gives the designer the ability to focus management efforts along the project where they can be most effective (i.e., where receiving waters or wetlands are most sensitive to highway runoff impacts). It may be impracticable to provide management measures along certain portions of the project area due to site constraints, while other portions of the project provide abundant opportunity for stormwater management. The flexibility of this approach enhances the practicability of meeting stormwater management objectives where resources matter most. The Macro Approach helps designers meet stormwater management goals either fully or to the MEP, depending on the project.

If the Macro Approach is used and the project still cannot meet the Stormwater Standards, MassDOT can seek a variance from MassDEP. Through a variance, MassDEP has flexibility to work with MassDOT to determine specific requirements based on project context, objectives, and constraints. Through a variance process, MassDEP may require additional compliance measures such as off-site mitigation or increased source controls.

The MassDOT Macro Approach:

1. **Identify downstream areas of potential impact and design points**, such as:
   - Wetland resource areas and other resources, including Critical Areas
   - Key hydraulic structures located downstream (e.g., bridges and culverts on major tributaries, or flood control structures such as existing dams)
   - Areas of potential flooding (e.g., areas identified in FEMA mapping and flood studies as subject to inundation during the one-percent-annual-chance flood, bordering land subject to flooding)

2. **Demonstrate that the Standards' requirements cannot be practicably met at every design point.** Provide:
   - Complete evaluation of all SCM categories, ISD practices, and LID techniques considered
   - Calculations showing the required and provided peak rates, recharge, or water quality treatment
   - Detailed description of why the design could not practicably achieve full compliance at all design points

3. **Explore combining design points, located within the same watershed to downstream water bodies, to reduce the number of discharge points for individual analysis.** If the designer explores this step, he or she should consider:
   - Maintenance of base flows to wetland resource areas that currently receive runoff
   - Effectiveness of peak rate control, recharge, and water quality treatment

   As part of this analysis, the designer may explore combining outfalls while minimizing any changes to drainage patterns that affect existing wetland resource areas. The design should not create disproportionate impacts to one wetland versus other wetlands.

4. **Design the overall highway drainage system to:**
   - Provide control of peak rates (if needed) at critical control points such as capacity-sensitive resource areas or structures
   - Prevent increased levels of flooding downstream or upstream of the project
   - Provide recharge within the same subwatershed and as close to the source of runoff as possible (note that "capture area adjustment" calculations may be necessary)
   - Provide water quality treatment as close to the source of runoff as possible
   - Provide erosion control and outlet protection at every discharge
   - Meet other stormwater management objectives as necessary

5. **Document use of the Macro Approach in the Stormwater Management Report** and at a minimum include the following:
   - Purpose for using the Macro Approach, including constraints
   - Demonstration that the Standard's requirements cannot be practicably met at every design point (see #2 above)
   - Description of the project area to which the approach is being applied, including constraints
   - The specific standard(s) to which the approach is being applied
   - Calculations for each standard using the Macro Approach
   - Demonstration that disproportionate impacts to any one wetland resource area are avoided
   - Explanation of how the design improves existing conditions and implements the highest practicable level of stormwater management for redevelopments

2.4 Applicability of Regulations Pertaining to Stormwater for MassDOT Projects

In general, a MassDOT project needs to comply with the Stormwater Standards when the project:

- Requires a filing under the WPA
- Requires a filing under Section 401 WQC
- Is subject to MCM #5 (post-construction stormwater management) under the MS4/TS4 Permit[56]

Depending on the scope of the project, some MassDOT projects are considered to have minimal impact to water resources and are exempt from, or only partially subject to, requirements of the WPA and/or 401 WQC, including the Stormwater Standards. The following sections describe regulatory applicability related to:

- Minor activities and routine roadway maintenance
- Stormwater management system maintenance
- Activities and facilities within Riverfront Area
- Emergency repairs
- Limited projects
- New footpaths, bikepaths, and other paths for pedestrian and/or non-motorized vehicle access
- Replacement bridges
- Stormwater retrofit projects
- Other regulatory elements

For all MassDOT projects, designers should improve existing conditions and repair any failing drainage systems.

If some components of the project are not subject to the Stormwater Standards, then the justification and/or documentation of which components do, and do not, apply should be included in the WPA and/or WQC filings.

56 Project disturbs greater than or equal to 1.0 acre and located within Urbanized Area.

2.4.1 Minor Activities and Routine Roadway Maintenance

Certain minor activities are not subject to the Wetlands Protections Act, provided the work is performed solely within the Buffer Zone to the resource area or within Riverfront Area, and in a manner that reduces potential for adverse impact to the resource area during and after construction using measures to stabilize disturbed areas. These projects do not require a NOI under the WPA. **Table 2-4** provides an excerpt of the list of qualified minor activities, including certain utility work, vegetation clearing, sign installation, and pavement repair/resurfacing.

MassDOT's maintenance program includes routine roadway maintenance activities to support the long-term serviceability of the state's roadway system. These efforts are essential to managing the integrity and safety of the roadway system. Routine roadway maintenance (e.g., line painting, bridge painting, guard rail replacement, slope repair) does not include the installation of drainage system infrastructure. Ditch cleaning and drainage pipe repair, which meet the definition of stormwater management system maintenance as described in **Section 2.4.2**, are also routine roadway maintenance activities.

The Stormwater Standards do not apply to minor activities and routine roadway maintenance, as these activities are unlikely to have any impact to wetland resource areas and do not require a regulatory review. However, if there is question about regulatory applicability, proposed work should be coordinated with the local conservation commission or a RDA may be submitted to avoid a potential violation. E&S controls may be required for some minor activities and routine roadway maintenance, depending on the site.

For cases where a RDA or NOI is filed in connection with routine roadway maintenance projects, MassDOT must submit documentation citing which Stormwater Standards are, and are not, applicable to the project.

Table 2-4. Minor Activities within Buffer Zone to Resources Areas and within Riverfront Area Not Subject to WPA[57]

a. Unpaved pedestrian walkways less than 30 inches wide for private use and less than three feet wide for public access on conservation property.

b. ★ Fencing, provided it will not constitute a barrier to wildlife movement; stonewalls; stacks of cordwood.

c. Vista pruning, provided the activity is located more than 50 feet from the mean annual high water line within a Riverfront Area or from Bordering Vegetated Wetland, whichever is farther. (Pruning of landscaped areas is not subject to jurisdiction under 310 CMR 10.00.).

d. ★ Plantings of native species of trees, shrubs, or groundcover, but excluding turf lawns.

e. The conversion of lawn to uses accessory to residential structures such as decks, sheds, patios, pools, replacement of a basement bulkhead and the installation of a ramp for compliance with accessibility requirements, provided the activity, including material staging and stockpiling is located more than 50 feet from the mean annual high-water line within the Riverfront Area, Bank or from Bordering Vegetated Wetland, whichever is farther, and erosion and sedimentation controls are implemented during construction. The conversion of such uses accessory to existing single family houses to lawn is also allowed. (Mowing of lawns is not subject to jurisdiction under 310 CMR 10.00).

f. ★ The conversion of impervious to vegetated surfaces, provided erosion and sedimentation controls are implemented during construction.

g. ★ Activities that are temporary in nature, have negligible impacts, and are necessary for planning and design purposes (e.g., installation of monitoring wells, exploratory borings, sediment sampling and surveying and percolation tests for septic systems provided that resource areas are not crossed for site access).

h. Installation of directly embedded utility poles and associated anchors, push braces or grounding mats/rods along existing paved or unpaved roadways and private roadways/driveways, and their existing maintained shoulders, or within existing railroad rights-of-way, provided that all work is conducted within 10 feet of the road or driveway shoulder and is a minimum of 10 feet from the edge of the Bank or Bordering Vegetated Wetland and as far away from resource areas as practicable, with no additional tree clearing or substantial grading within the buffer zone, and provided that all vehicles and machinery are located within the roadway surface during work.

i. Installation of underground utilities (e.g., electric, gas, water) within existing paved or unpaved roadways and private roadways/driveways, provided that all work is conducted within the roadway or driveway and that all trenches are closed at the completion of each workday.

j. Installation and repair of underground sewer lines within existing paved or unpaved roadways and private roadways/driveways, provided that all work is conducted within the roadway or driveway and that all trenches are closed at the end of completion of each workday.

k. Installation of new equipment within existing or approved electric or gas facilities when such equipment is contained entirely within the developed/disturbed existing fenced yard.

l. Installation of access road gates at public or private road entrances to existing utility right-of-way access roads, provided that all vehicles and machinery are located within the roadway surface during work.

m. Removal of existing utility equipment (poles, anchors, lines) along existing or approved roadways or within existing or approved electric, water or gas facilities, provided that all vehicles and machinery are located within the roadway surface during work.

continued on next page

★ Minor activities typically applicable to MassDOT projects.

57 See 310 CMR 10.02(2)(b)2

Table 2-4 (continued). Minor Activities within Buffer Zone to Resources Areas and within Riverfront Area Not Subject to WPA[58]

n. ★ Vegetation cutting for road safety maintenance, limited to the following:

   i. Removal of diseased or damaged trees or branches that pose an immediate and substantial threat to driver safety from falling into the roadway.

   ii. Removal of shrubbery or branches to maintain clear guardrails; such removal shall extend no further than six feet from the rear of the guardrail.

   iii. Removal of shrubbery or branches to maintain sight distances at existing intersections; such removal shall be no farther than five feet beyond the "sight triangles" established according to practices set forth in American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Streets, 2011, 6th edition, and such removal is a minimum of ten feet from a resource area, other than Riverfront Area.

   iv. Removal of shrubbery, branches, or other vegetation required to maintain the visibility of road signs and signals.

   v. Cuttings of shrubs and branches from mature trees will be performed with suitable horticultural equipment and methods that do not further damage the trees. To prevent the possible export of invasive plants, cut vegetation should be chipped and evenly spread on site, provided the chips are spread outside the buffer zone, and raked to a depth not to exceed three inches, clear of all drainage ways. Alternatively, all cuttings and slash shall be removed from the site and properly disposed.

o. ★ Installation, repair, replacement or removal of signs, signals, sign and signal posts and associated supports, braces, anchors, and foundations along existing paved roadways and their shoulders, provided that work is conducted as far from resource areas as practicable, and is located a minimum of 10 feet from a resource area, any excess soil is removed from the project location, and any disturbed soils are stabilized as appropriate.

p. ★ Pavement repair, resurfacing, and reclamation of existing roadways within the right-of-way configuration provided that the roadway and shoulders are not widened, no staging or stockpiling of materials, all disturbed road shoulders are stabilized within 72 hours of completion of the resurfacing or reclamation, and no work on the drainage system is performed, other than adjustments and/or repairs to respective structures within the roadway.

q. ★ The repair or replacement of an existing and lawfully located driveway servicing not more than two dwelling units provided that all work remains within the existing limits of the driveway and all surfaces are permanently stabilized within 14 days of final grade.

★ Minor activities typically applicable to MassDOT projects.

58 See 310 CMR 10.02(2)(b)2

2.4.2 Stormwater Management System Maintenance

Stormwater management systems (including SCMs) must be maintained in accordance with their approved O&M Plan to continue to perform as designed. Stormwater management systems installed in compliance with an Order of Conditions subsequent to April 1, 1983, may be maintained without requiring the filing of a RDA or NOI provided the following is true:

- The system was constructed in accordance with all applicable provisions of 310 CMR 10.00
- Work is limited to maintenance of the stormwater management system
- Work uses best practical measures to avoid and minimize impacts to wetland resources areas outside of the footprint of the stormwater management system[59]

Allowable maintenance is generally mowing, clearing of woody vegetation, or removal of accumulated sediment (but not altering the system). Maintenance of a stormwater management system is defined as work to keep a stormwater management system functional and in good repair so that it may continue to operate as originally designed. It does not include work that reduces capacity, increases discharge volume, adds more stormwater to the system, or reduces use (i.e., the treatment effectiveness) of above-ground SCMs.[60]

2.4.3 Activities and Facilities within Riverfront Area

As described in **Section 2.4.1**, certain minor activities and routine roadway maintenance may be conducted within Riverfront Area without requiring a NOI.

The WPA Regulations provide certain Riverfront Area exemptions for activities and facilities that existed on or prior to August 7, 1996.[61] Those activities and exempt (or grandfathered) facilities include:

- Excavations
- Structures
- Roads
- Vegetation-clearing
- Driveways
- Landscaping
- Utility lines
- Public marine cargo terminals
- Bridges over 2 miles long
- Parking lots

The exemption is not applicable if the proposed activities and facilities listed above fall within other resource areas or their Buffer Zones, except for the minor activities identified in **Table 2-3**, which must occur in the Buffer Zone to Bordering Vegetated Wetlands or Banks and not within the resource area itself.

All other MassDOT activities beyond routine roadway maintenance and minor activities within the Riverfront Area must comply with the Stormwater Standards and 310 CMR 10.58: Riverfront Area.

If a structural SCM is located within a Riverfront Area, construction of and/or alterations to the SCM does not count towards the calculation of square footage of alterations to Riverfront Area.

59 See 310 CMR 10.02(3)

60 See 310 CMR 10.04

61 See 310 CMR 10.58 (6)(a) and 310 CMR 10.02(2)(a)

The WPA Regulations state that the calculation of square footage of alteration to Riverfront Area shall exclude areas used for structural SCMs, provided there is no practicable alternative to siting these structures within the Riverfront Area and provided that wildlife corridors are maintained (e.g., no fencing around SCMs).[62]

2.4.4 Emergency Repairs

The safety of the public roadway system is paramount. Public roadway projects that address emergencies generally cannot be delayed for design, review, and permitting of stormwater management features. Examples of emergency repairs include, but are not limited to:

- Repair of pavement failures (e.g., washouts, subsidence)
- Stormwater pipe replacement in a roadway
- Removal of an obstruction in a roadway

The WPA Regulations and the Section 401 WQC Regulations state that the Stormwater Standards do not apply to emergency repairs to roads or their drainage systems.[42] However, E&S controls are always required.

Emergency repairs are not exempt from other applicable regulatory requirements. The designer should consult with the District Environmental Engineer to determine when an Emergency Certification from the appropriate issuing authorities (e.g., local conservation commission, MassDEP, Army Corps of Engineers) is required.

Emergency Certifications typically include:[64]

- Photographic evidence
- A site visit
- A written justification for emergency action

62 See 310 CMR 10.58(4)(d)1.d

63 See 310 CMR 10.05 (6)(l) and 314 CMR 9.06(6)(b)

64 See 310 CMR 10.06: Emergencies

Permitting after the issuance of an Emergency Certification is not required by WPA or 401 WQC Regulations. However, the designer should check with the local conservation commission to see if they require filing of a NOI after the work is complete, as some commissions may want to issue an Order of Conditions to document the emergency work.

As per the Section 401 WQC Regulations, repairs may take place without a certification in the event that immediate action is essential to avoid or eliminate a serious and immediate threat to the public health or safety or to the environment.[65] Most commonly, this applies to repairs following severe storms causing regional or statewide damage. In these instances, MassDEP may issue and publicize emergency authorizations that allow for repair to damaged property without local approval.

2.4.5 Limited Projects

The following types of MassDOT projects may be permitted as a limited project:[66]

- Maintenance and improvement of existing public roadways, but limited to widening less than a single lane, adding shoulders, correcting substandard intersections, and improving drainage systems
- The maintenance, repair and improvement (but not substantial enlargement except when necessary to reduce or eliminate a tidal restriction) of structures, including buildings, piers, towers, headwalls, bridges, and culverts that existed on November 1, 1987
- The routine maintenance and repair of road drainage structures including culverts and catch basins, drainage easements, ditches, watercourses and artificial water conveyances to ensure flow capacities that existed on November 1, 1987

Limited projects are not exempt from WPA Regulations but qualify for relief from strict compliance of the Resource Area performance standards. As appropriate, NOIs, or RDAs must be prepared and submitted for limited projects. Limited projects requiring a NOI must meet the Stormwater Standards but are classified as MassDEP

65 See 314 CMR 9.12

66 See 310 CMR 10.24(7) or 10.53(4)

redevelopment. See the next section for information on projects that widen roadways to less than a single lane specific to bike lanes, sidewalks, etc.

2.4.6 New Footpaths, Bikepaths, and Other Paths for Pedestrian and/or Non-motorized Vehicle Access

The Stormwater Standards state that the following projects are subject to compliance to the MEP:[67]

- Sidewalks
- Footpaths
- Bike travel lanes and paths
- Similar access ways for pedestrian and/or nonmotorized vehicles

In some cases, mitigation measures would cause greater impacts to resource areas than the projects themselves. This MEP provision offers some flexibility so that pedestrian paths may be constructed in areas where it is not practicable to fully meet the Stormwater Standards.

Designers should refer to the SCM screening process presented in **Chapter 3** and should prioritize:

- Minimizing impact areas (**Section 3.3**)
- Maximizing the use of pavement disconnection practices (**Section 4.2.1**)
- SCMs promoted by MassDOT in this SDG

2.4.7 Replacement Bridges

Bridge replacement projects covered under the Transportation Bond Bill, where the bridge replacement will be substantially the functional equivalent of, and in similar alignment to, the existing bridge, are exempt from certain permitting requirements. Regulatory exemptions include:

- WPA
- MEPA
- Chapter 91 (Public Waterfront Act)

These same bridge replacement projects must comply with the requirements of:

- Section 401 WQC
- The Stormwater Standards

Culverts that do not qualify as bridge replacements and convey an existing stream shall be in accordance with WPA Regulations, as follows.[68]

- For non-tidal crossings, comply with the Massachusetts River and Stream Crossing Standards to the MEP
- For tidal crossings, the tidal restriction shall be eliminated to the MEP

Replacement of existing stream crossings shall also comply with the latest version of the MassDOT Design of Bridges and Culverts for Wildlife Passage at Freshwater Streams Handbook.[69]

2.4.8 Stormwater Retrofit Projects

Stormwater retrofit projects include stand-alone structural measures and do not result in changes to the layout of, or increase in, impervious cover. Through the implementation of LID and structural SCMs, these projects improve existing conditions by improving the quality of runoff, creating storage to decrease peak runoff rates and reduce runoff volume, and providing increase in recharge.

These projects are subject to the Stormwater Standards, but because the goal of a stormwater retrofit project is to improve existing conditions, supporting calculations may be minimal compared to other MassDOT projects. Compliance for the project should be documented in accordance with **Section 2.3.1**.

67 See 310 CMR 10.05(6)(m)6.

68 See 310 CMR 10.24(10) and 310 CMR 10.54(4)(a)6.

69 See Massachusetts River and Stream Crossing Standards and MassDOT Design of Bridges and Culverts for Wildlife Passage at Freshwater Streams Handbook at: http://www.nae.usace.army.mil/Missions/Regulatory/Stream-and-River-Continuity/.

2.4.9 Other Regulatory Elements

The following sections describe other regulatory elements that could affect SCM implementation, including:

- Whether SCMs are considered wetland resource areas
- Infiltration SCMs as underground injection wells

2.4.9.1 SCMs as Regulated Areas

SCMs that were constructed on or after November 18, 1996, and were built to comply with WPA Regulations and the Stormwater Standards, are not considered wetland resource areas.

This rule promotes, without prohibitions, the use of LID practices and above-ground SCMs that incorporate wetland-type features.

Created stormwater treatment wetlands are not considered jurisdictional wetlands and they do not have Buffer Zones.[49] They are stormwater treatment SCMs and are subject to ongoing maintenance in accordance with their approved O&M Plan.

Maintenance can be performed on SCMs constructed with wetland features, or that have developed such features over time, without requiring the filing of a RDA or NOI as long as the work meets the definition of stormwater management system maintenance as described in **Section 2.4.2**. In the context of roadways and highways, such "constructed wetlands" may include vegetated basins or linear practices, conventional drainage ditches, depressions, or other structures or features that convey, control, or treat roadway runoff.

70 See 310 CMR 10.02(2)(c)

2.4.9.2 Underground Injection Control (UIC) Regulations

An infiltration SCM that has a bored, drilled, driven shaft, or dug hole that is deeper than it is wide or has a subsurface fluid distribution system is considered a Class V injection well.[71] Typically, MassDOT SCMs are not considered Class V injection wells.

If an infiltration SCM is considered a Class V injection well, it is subject to the Underground Injection Control (UIC) Regulations.[72] The purpose of these regulations is to protect underground sources of drinking water by regulating the underground injection (i.e., by gravity or greater pressure through a well) of hazardous waste, fluids used for extraction of minerals, oil, and energy, and any other fluids having potential to contaminate groundwater. The regulations require the registration of Class V wells with MassDEP.

Wet basin © Horsley Witten Group

71 See more information on Class V stormwater drainage wells at: https://www.epa.gov/uic/stormwater-drainage-wells#what_is and https://www.mass.gov/underground-injection-control-uic

72 See 310 CMR 27.00

3
Integrated Site Design

This chapter describes MassDOT's approach to Integrated Site Design (ISD) for stormwater management and establishes the process that designers should follow to develop stormwater designs. Many of the contextual elements that support the ISD approach are promoted in the MassDOT Project Development and Design Guide (PDDG). Designers should refer to the PDDG for other context considerations for transportation projects such as roadside elements, roadway drainage, erosion control, pavement design, shared use paths and greenways, landscape and aesthetics, and wildlife accommodation. **Designers should use this chapter to select low impact development (LID) approaches and structural stormwater control measure (SCM) types that best suit the project site. Designers should understand regulatory requirements from Chapter 2 before using this chapter. Once designers select LID and SCM measures for their site, they should use Chapter 4 to guide the design of structural SCMs.**

ISD is a holistic approach to integrating environmentally sensitive design elements into transportation projects. ISD should be used in every MassDOT project.

This chapter is structured to lead the designer through each element of the ISD process:

- Understanding project context
- Defining and evaluating performance on project objectives
- Crafting design solutions to meet those objectives, including:
  - Low Impact Development (LID)
  - Structural stormwater control measures (SCMs)

The ISD approach for stormwater management prioritizes LID practices to minimize runoff and pollutants, and then implements structural SCMs for additional treatment when LID alone cannot fully satisfy stormwater requirements.

This chapter will first step through this process and then provide specifics about site design and selecting SCMs for a site.

Figure 3-1. Integrated Site Design Process

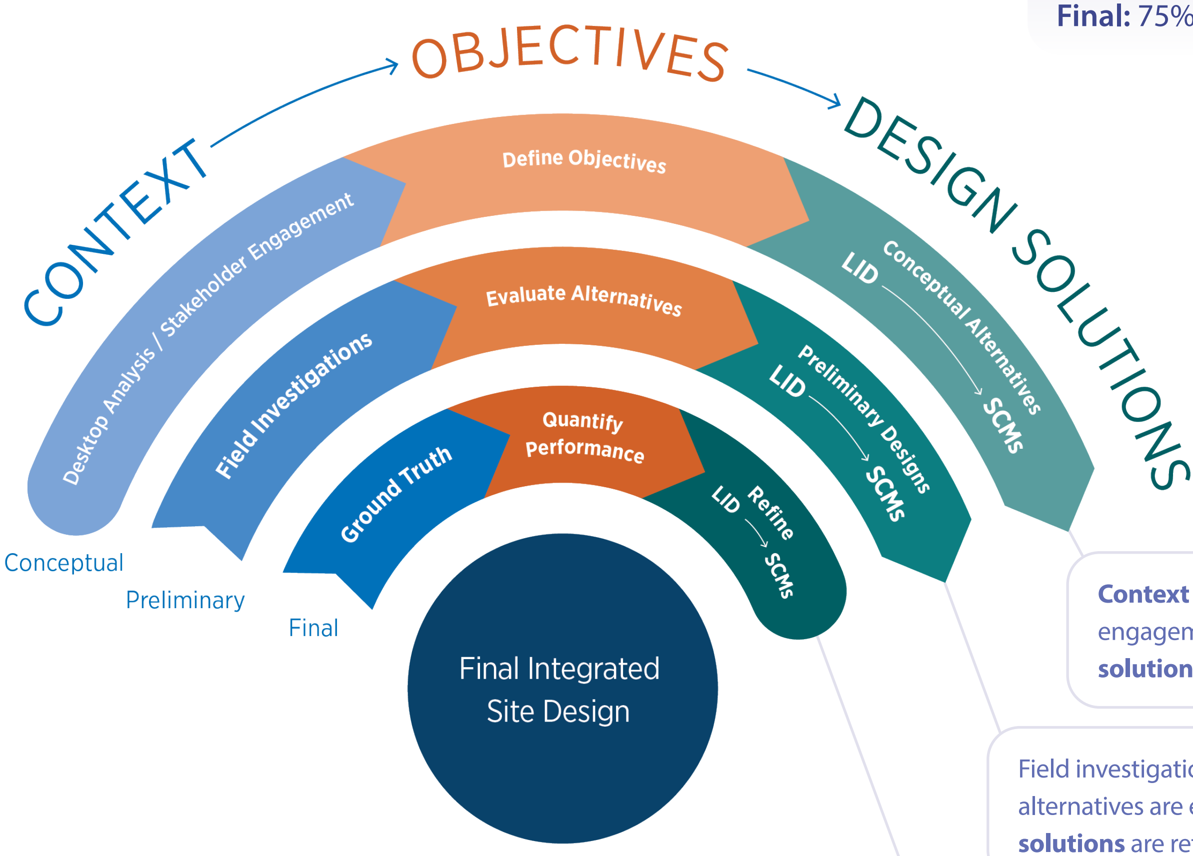
As shown in the figure below, Integrated Site Design is an iterative process to develop a deeper level of understanding and design at each phase. Project context, objectives, and design solutions (left to right) are identified and refined as a project moves through iterations of conceptual, preliminary, and final design (outward in).

Typical ranges of design phases

Conceptual: pre-design up to 25% design

Preliminary: 25% up to 75% design

Final: 75% design to PS&E submission



Context is determined through desktop analysis and stakeholder engagement. **Objectives** are defined. Conceptual **design solutions** are proposed that include both LID and SCMs.

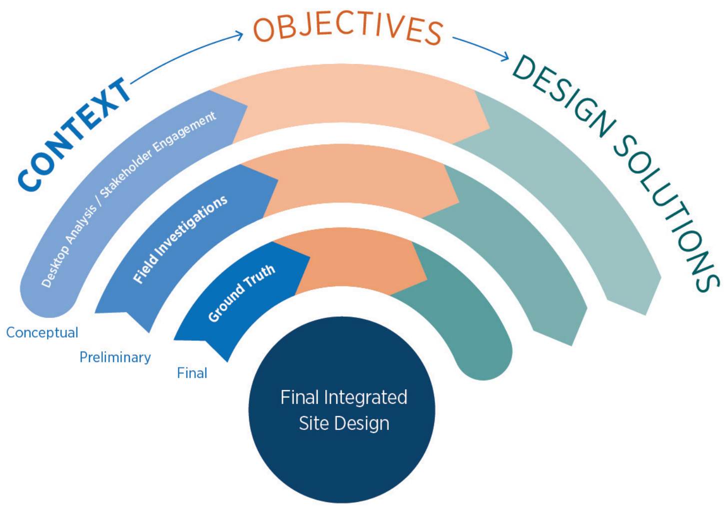
Field investigations are performed to provide better **context**, alternatives are evaluated to meet **objectives**, and **design solutions** are refined based on additional information.

The project **context** is ground-truthed, **objectives** are met through quantification of performance, and **design** is finalized.

Example of pavement disconnection between the Charles River and a bike path and roadway © VHB

While source controls are not discussed in this SDG, designers should consider site layout and develop SCMs with source control in mind (e.g., diverting runoff around areas where it can easily pick up and transport pollutants). Source controls are discussed in the MassDOT Stormwater Management Plan (SWMP).

3.1 Context



As illustrated in **Figure 3-1**, understanding project context is the first step in the ISD process, and specifically Context Sensitive Design[73] is a guiding principle for MassDOT project development.

Through this process, designers consider the character of the project area, values of the community, and needs of all roadway users. The ISD approach is an iterative process that requires an understanding of the unique position of each project within its natural, built, and cultural environment.

Learning about project context starts at the planning level during conceptual design phase with stakeholder engagement and desktop analyses using GIS and other available data. As the ISD process continues during preliminary design phase, the designer focuses on site-specific conditions through field observation and measurement by professional services (e.g., wetland delineations, geotechnical investigations). Finally, designers "ground truth" and refine the proposed design through additional site visits and stakeholder consultation during final design phase.

73 See Chapter 1.2 in MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

3.1.1 Stakeholders

Project stakeholders are groups or individuals that are involved in, have an interest in, or are affected by a proposed project. Identifying and engaging with stakeholders early in the project can help the design team better understand the project context and objectives, and improves the chance of support and timely approvals during design, permitting, and construction.

Stakeholders concerned with a project's stormwater management capabilities can include:

- MassDOT
- Municipal representatives including public works, engineering, planning, and historical commission
- Water suppliers and wellhead owners
- Utility owners
- Neighbors and citizen groups
- Environmental advocacy groups
- Permitting authorities (e.g., local conservation commissions, MassDEP, EPA)
- Federal Highway Administration

3.1.2 Watershed Context

Watershed context involves understanding the relationship between the project's drainage area and the encompassing watershed, including receiving water bodies and their water quality status. Designers need to identify these contextual elements early in the ISD process to determine targeted design solutions such as water quality treatment, peak rate reduction, recharge to address baseflow, and/or mitigation of erosion.

The watershed and water body context often drive the applicable regulatory requirements that will determine specific water quality objectives. MassDOT's Water Quality Data Form (WQDF) **(Section 2.3.2)** provides guidance and requirements for designers on how to meet MassDOT's goals and obligations for various watersheds. Designers can also access data on watersheds and water bodies through the MassGIS online viewer and downloadable data layers.

The Massachusetts Integrated List of Waters[74] (also known as 303(d) list) identifies water quality impairments, Total Maximum Daily Loads (TMDLs), and pollutants of concern for the receiving waters. TMDL reports, if applicable, further describe pollutant sources, waste load allocations (WLAs), and measures for reducing pollutant loads. Refer to **Section 2.1.1.1** for MassDOT's approach to impaired waters and TMDLs.

3.1.3 Land Use

To design effective, context-sensitive stormwater solutions, designers must understand the land uses and character of the project location and surrounding community. During the conceptual design phase of the ISD process, USGS topographic maps, GIS data layers, and orthographic photos are also used to identify and document land uses of the area, such as:

- Transportation facility type and users (e.g., roadway type, bridge, parking area, maintenance facility, service plaza with amenities, fleet storage)
- Urbanized areas under jurisdiction of the Municipal Separate Storm Sewer System (MS4) and Transportation Separate Storm Sewer System (TS4) permits
- Surrounding land use and land cover (e.g., wetlands, open fields, forest, structures/buildings, parks, residential neighborhoods)
- On-site utilities (e.g., sewage disposal, drinking water wells)
- Land Uses with Higher Potential Pollutant Loads (LUHPPLs)

Site visits and stakeholder engagement can further refine land use characterizations.

3.1.4 Resource Areas

As described in **Chapter 2**, federal and state policies and regulations govern activities, including stormwater management, within or

74 See most recent Integrated List of Waters at: https://www.mass.gov/lists/integrated-lists-of-waters-related-reports

affecting wetlands and ecological and cultural resource areas. These resource areas should be identified early in the design process to assist in the identification of project impacts. During the conceptual design phase, desktop analysis is used to identify the following resource areas and determine applicable regulations. These resources are then more precisely defined using field investigations.

- **Wetland resource area:** Through field investigations, wetland resource areas can be delineated and characterized in accordance with the Massachusetts Wetlands Protection Act (WPA) Regulations by a wetland scientist. If a vernal pool is encountered, the boundary should be assumed to coincide with the bordering vegetated wetland unless located in Bordering Land Subject to Flooding, which requires individual mapping.
- **Flood zone:** The FEMA National Flood Hazard Layer can be reviewed for location of the 100-year flood zone to determine if a project falls within a flood zone. The FEMA Flood Insurance Rate Maps should also be reviewed for draft or preliminary data, even though the data is not in effect, to understand if the project may be within a flood zone based on more recent data.

Wetland resource area in Athol, Massachusetts. © VHB

- **Critical Area:** Applicable GIS layers on MassGIS can be reviewed to determine if a project falls within or adjacent to a public water supply protection zone (Zone I, Zone II, IWPA, Zone A), bathing beach, cold-water fishery, shellfish growing area, Outstanding Resource Water (ORW), or Special Resource Water.
- **Wildlife habitat:** A desktop review followed by site investigations which, if necessary, can be performed by Massachusetts Natural Heritage & Endangered Species Program personnel to determine if the project will impact habitat of threatened or endangered species. Wildlife habitat should be identified and characterized if the project is within a wetland resource area.[75]
- **Vegetation:** Field visits can be used to determine location of mature trees and vegetation that should be protected, as well as any invasive plants that need to be controlled.
- **Stream crossings:** Desktop and/or field review can be used to identify any current or proposed stream crossings.
- **Cultural resources:** Early coordination with the local historical commission(s) and State Historic Preservation Office is encouraged. The MassDOT Cultural Resources Section can be consulted for early coordination with the Tribal Historical Preservation Officer, if necessary.

3.1.5 Site Conditions

The physical conditions of the project site as described in the following sections will drive the strategies and opportunities for stormwater mitigation. The characterization of site conditions should be refined as the project progresses from the conceptual design phase through preliminary and final design phases.

3.1.5.1 Soil, Groundwater, and Bedrock

Conceptual planning-level characterization of underlying soil may be conducted using the Natural Resources Conservation Service (NRCS) soils maps to identify areas well suited for infiltration or LID practices, including preservation of natural features and disconnection of impervious cover.

75 See Massachusetts Wildlife Habitat Protection Guidance for Inland Wetlands (Mar. 2006) at: http://umasscaps.org/pdf/wldhab.pdf.

During preliminary design of structural SCMs, MassDOT requires on-site subsurface investigations that characterize the drainage class of soils, seasonal high water table (SHWT) elevation, and depth to bedrock. Subsurface investigations include test pits and/or soil borings, reviewed by a Competent Soils Professional (CSP), at the actual locations and elevations where SCMs are proposed. In coastal areas, the investigation should also evaluate tidally influenced groundwater fluctuations.

MassDOT Environmental Services Section (MassDOT Environmental) prefers on-site subsurface investigations to be completed during the conceptual design phase to understand site opportunities and constraints for SCMs.

3.1.5.2 Hazardous Materials

During the conceptual design phase, the designer should review the MassDEP Bureau of Waste Site Cleanup (BWSC) online database of disposal sites to identify oil and/or hazardous materials (OHM) concerns. The presence of a disposal site indicates that a release of OHM has been reported to MassDEP. The designer should also identify any EPA Superfund Enterprise Management sites and MassDEP active or inactive landfills in the vicinity of the project site, which will assist in determining potential regulatory requirements. This review will identify if siting a stormwater management system is an available option pending the extent and type of OHM present, design features of SCMs (e.g., liners), and potential cost contingencies. The review also will help anticipate regulatory requirements during construction.

The designer should perform additional analysis when recharge is proposed at, or adjacent to, a site that:

- Is classified as contaminated, was capped in place, or has an Activity and Use Limitation (AUL) that precludes inducing runoff to the groundwater, pursuant to the Massachusetts Contingency Plan (310 CMR 40.0000)
- Is a solid waste landfill pursuant to 310 CMR 19.000
- Has groundwater that flows directly toward a solid waste landfill or disposal site

For these cases, the additional analysis must determine whether infiltration will cause or contribute to groundwater contamination.

The designer may review additional sources as part of this due diligence, including the MassDEP Underground Storage Tank Query Tool, the MassDEP Bureau of Solid Waste files (i.e., active/closed landfills), and any active or former hazardous waste generator lists. In addition, current and historical uses should be noted when possible for properties that are potential sources of contamination (e.g., on-site gasoline stations, landfills, rail corridors, etc.).

3.1.5.3 Structures

During the conceptual design phase, designers need to identify setback and protection requirements for structures. Structures include buildings, road subbase, bridge abutments, etc. and can be identified through aerial photography, site survey, record plans, and field observation. During subsequent phases, designers need to work with the project team to understand the constraints around these structures regarding stormwater management system design.

3.1.5.4 Utilities

During conceptual and preliminary design phases, utilities may be located by surveying visible utility facilities (e.g., manholes, valve boxes, etc.) and correlating this information with record plans. If necessary, geophysical methods (e.g., ground-penetrating radar) or other field methods may be used for locating underground utilities.

Above- and below-ground utilities in the project area may include electric, telecommunications, gas, water, sanitary sewer, stormwater piping, catch basins, manholes, and outfalls. In addition, properties adjacent to the ROW may contain water supply wells and on-site sewage disposal systems. Each of these utilities will have unique requirements for setbacks, protections, and/or relocations. For potentially affected utilities, the design team should coordinate directly with utility owners.

Vegetated I-95 Right-of-Way with potential for stormwater management © VHB

3.1.5.5 Topography

During desktop analysis, existing topography may be analyzed using USGS Topographic Quad maps, digital elevation models, contour data, and LiDAR. Site investigations and formal survey of the project site may be conducted during the conceptual or preliminary design phases.

3.1.5.6 Existing Site Drainage Conditions

During the conceptual design phase, evaluation of the existing condition of drainage infrastructure within the project area may include a review of mapping and record plans and discussion with drainage system owners. The utility and/or roadway owner can provide information on areas of localized flooding where drainage improvements may be needed. During field investigations, designers should also identify areas or infrastructure that are in poor condition and/or are not functioning well (e.g., a buried outfall).

3.1.5.7 Rights of Way, Property Boundaries, Easements

MassDOT maintains a permanent ROW along roadway alignments. The ROW is often limited to a corridor offset some distance from the roadway alignment centerline. Design teams can determine property boundaries and easements through review of record plans and site survey. Potential off-site stormwater management opportunities should be evaluated along the existing ROW as part of site investigations. Undeveloped and underutilized land is preferable when additional ROW is necessary to site SCMs.

3.1.5.8 Vegetation

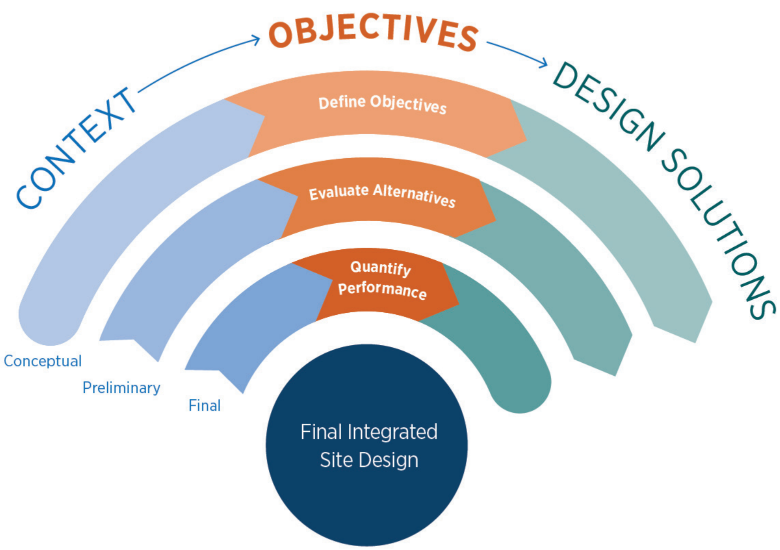
During the conceptual design phase, evaluation of existing vegetation should be performed. The limit of work and construction staging areas should be minimized to limit erosion and avoid impacts to existing vegetation and habitat. If invasive species are identified, remedial measures such as soils management and herbicide treatment should be considered.

3.1.6 Operations

Operations of site features including structural SCMs should help drive site design and SCM selection. The structural SCMs presented in **Chapter 4** are supported by MassDOT because they are relatively easy to construct, operate, inspect, and maintain.

For MassDOT-executed municipal projects, where the municipality retains ownership, the designer should make an advanced determination on the Department of Public Work's (DPW's) capabilities to operate and maintain the project's stormwater elements. Opportunities and constraints on the stormwater management system design will vary depending on project/stormwater management system owner and the capability of the O&M program. The expertise of maintenance staff or availability of funding may influence which structural SCMs the owner prefers for proper O&M.

3.2 Objectives



After project context is identified and refined, the next step in the design process is defining and clarifying project objectives.

As the largest owner of drainage infrastructure in the state, MassDOT's objective in terms of stormwater is to protect receiving waters by managing and treating stormwater discharges. Project objectives should support overall project goals, steer the design process, and provide criteria on how to evaluate design solutions at each phase. In the ISD process, objectives are defined at the beginning of the conceptual design phase, before design development starts.

After conceptual designs are developed and field investigations completed, the design team clarifies those objectives. For example, if soil evaluations discovered potentially hazardous materials, safe removal or remediation of those materials may be added to the list of objectives.

Once the objectives are clarified, designers complete their first round of evaluating alternative designs against the project objectives. For example, this may include evaluating LID practices and structural SCMs and pollutant reduction to the receiving water. **Section 3.3.3** provides considerations for evaluating SCM alternatives. Preferred alternatives that meet objectives advance to the next phase of design.

As the ISD progresses toward final design, designers complete a more detailed and comprehensive evaluation of performance on project objectives. The process to evaluate the performance of LID practices and structural SCMs on project objectives should be documented in one or more of the following deliverables:

- Preliminary Design Evaluation
- Stormwater Management Report
- WQDF

This section presents objectives of MassDOT projects and how they relate to stormwater.

3.2.1 Transportation

Improving transportation deficiencies is a primary objective of MassDOT projects. Transportation deficiencies may include one or more of the following:

- Traffic congestion
- Unsafe conditions
- Deteriorating facilities
- Lack of multimodal accommodation

To meet transportation project goals, stormwater management systems should be designed to:

- Remove runoff as efficiently as possible from the roadway
- Keep clear zones[76] free of steep slopes or objects/obstructions that may jeopardize the recoverability of errant vehicles (see **Section 4.7.3.3** for guidance on designing SCMs within clear zones)
- Protect public safety around standing water, particularly in areas with pedestrian access, with proper design of structural SCMs

76 Clear zones are traversable, unobstructed roadside areas beyond the edge of the traveled way, available for safe use by errant vehicles. Clear zone widths vary depending on the roadway attributes. Refer to the AASHTO Roadside Design Guide for additional information.

3.2.2 Regulatory Compliance

Chapter 2 describes the regulations that will drive stormwater designs. The primary objectives of stormwater management, as codified in federal, state, and local regulations, are to:

- Protect wetland resource areas and Critical Areas
- Prevent erosion and sedimentation
- Control the discharge rate of stormwater runoff to receiving waters
- Recharge groundwater
- Improve the quality of stormwater runoff

As described in **Chapter 2**, regulatory requirements will vary depending on the type and extent of proposed construction. For example, requirements for new impervious cover differ from those for existing impervious cover. In addition, requirements are dependent on the project context, including the receiving water (impairment and TMDL status), type of resource areas impacted (e.g., Critical Area), and whether the project is in the jurisdiction of the MS4/TS4 Permit. The regulatory requirements related to maintenance are the responsibility of MassDOT or, for MassDOT-executed municipal projects, the ultimate project owner. Documentation is done through MassDOT's WQDF and/or through applicable environmental permitting processes (e.g., WPA Notice of Intent [NOI], 401 Water Quality Certification [WQC] application, NPDES General Permit NOI, and Stormwater Pollution Prevention Plan [SWPPP]).

MassDOT stormwater projects must quantify and document compliance with regulatory requirements.

In addition to the stormwater provisions in the WPA and 401 WQC regulations, projects must comply with other applicable regulatory requirements (see **Section 1.2.3**) with objectives that include:

- Maintaining stream continuity and habitat at stream crossings
- Preventing impacts to habitat of threatened and endangered species
- Preventing incremental flooding and loss of floodplain
- Preserving historical and cultural resources

3.2.3 Stewardship

MassDOT prioritizes stewardship objectives beyond those required by regulations. These objectives are typically identified through stakeholder engagement. The following stewardship objectives are often incorporated into MassDOT projects:

- Provide transportation alternatives
- Improve pollinator habitat and connect habitat corridors
- Contain and prevent the spread of invasive plant species
- Reduce the urban heat island effect
- Enhance landscape aesthetics along highways, beautify neighborhoods, and enhance sense of place (i.e., placemaking)
- Educate the public about stormwater management and water quality
- Improve public access to open space and recreational areas

3.2.4 Operational

MassDOT prioritizes stormwater designs that are constructible, maintainable, and cost-effective. By implementing the ISD approach, prioritization of LID measures reduces the need for drainage infrastructure and associated O&M to the maximum extent practicable (MEP). After LID is incorporated into the design, structural SCMs are implemented to satisfy regulations fully. Operational objectives related to constructability, ease of inspection and maintenance, and costs, include the following:

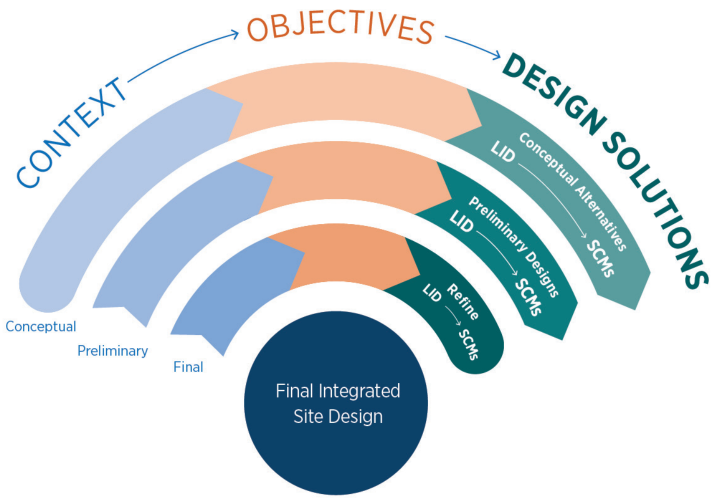
- Provide adequate access for construction
- Protect SCMs from construction-phase impacts (e.g., soil compaction and clogging)
- Minimize safety risks to maintenance personnel for SCM inspections and maintenance
- Minimize traffic disruption for routine operations, inspections, and maintenance

- Minimize time and effort required to operate, inspect, and maintain SCMs
- Minimize life-cycle costs, which include construction, operation, and maintenance
- Balance life-cycle costs with agency budgets

Note that in situations where MassDOT executes the design and/or construction of SCMs as part of a municipal roadway project, the municipality must agree, in writing, to be responsible for the long-term O&M of the SCMs.

Constructed stormwater wetland with extended detention © MassDOT

3.3 Design Solutions



MassDOT's overall stormwater approach includes programmatic measures, such as source controls and maintenance, in addition to design solutions such as LID practices and structural SCMs. This section focuses on the design solutions specifically. **Section 3.3.1** discusses approach, **Section 3.3.2** presents specific measures, and **Section 3.3.3** presents considerations that may influence SCM design and configuration. Design guidance for structural SCMs is provided in **Chapter 4**.

3.3.1 Design Approach

MassDOT prioritizes LID practices to minimize stormwater runoff and pollutants and to meet a broad range of objectives. LID maximizes the potential to mimic predevelopment conditions and infiltrate stormwater close to its source through practices such as preserving and enhancing natural vegetation, reducing impervious cover, disconnecting pavement, and maintaining predevelopment drainage patterns.

MassDOT's design approach to meet stormwater objectives uses both LID and structural SCMs. First, LID practices are implemented throughout the site. Second, SCMs are implemented as needed to satisfy regulations fully.

LID practices should be incorporated into the conceptual design during project planning and re-evaluated as the project progresses to preliminary and final design. Depending on project objectives, the following design references may be useful for incorporating LID measures into the project:

- NACTO Urban Street Design Guide[77]
- MassDOT Separated Bike Lane Guide[78]

Table 3-1 presents four LID practices promoted by MassDOT along with their benefits for meeting project objectives.

After the designer has evaluated and maximized the use of LID practices and determined which stormwater management objectives have not yet been met, the designer should consider structural SCMs to fulfill those remaining objectives. Structural SCMs can be used to meet many regulatory objectives, including scour protection, peak rate control, groundwater recharge, and water quality treatment, while also fulfilling transportation, stewardship, and operational objectives.

Structural treatment SCMs are organized into the following general categories in this SDG: infiltration, stormwater wetland, bioretention, and other SCMs. MassDOT prefers infiltration and surface SCMs over subsurface SCMs. Preference is based on operation and maintenance requirements, constructability, and efficacy.

For all stormwater pollutants of concern, infiltration SCMs are MassDOT's preferred option.

Table 3-2 presents the SCM categories promoted by MassDOT along with their benefits for meeting project objectives.

77 See NACTO Urban Street Design Guide at: https://nacto.org/publication/urban-street-design-guide/

78 See MassDOT Separated Bike Lane Planning & Design Guide at: https://www.mass.gov/lists/separated-bike-lane-planning-design-guide

Table 3-1. Summary of Benefits from LID Practices

	LID Practices			
Benefits (Performance on objectives)	**Preserve and Enhance Vegetation**	**Reduce Impervious Cover**	**Disconnect Pavement**	**Maintain Pre-Development Drainage Patterns**
Improve water quality	X	X	X	
Improve existing conditions	X	X	X	
Maintain or extend time of concentration	X	X	X	X
Reduce peak rate discharge	X	X	X	X
Reduce runoff volume	X	X		
Reduce required recharge volume		X	X	
Increase recharge	X	X	X	X
Reduce required pollutant load reductions		X	X	
Provide erosion control and outlet protection	X			
Minimize thermal impacts	X	X	X	X
Provide wildlife/fisheries habitat	X			X
Improve aesthetics	X	X		
Provide visual screening and noise abatement	X			
Support community values	X	X		

Table 3-2. Summary of Structural SCM Benefits

	SCM Category*		
Benefits (Performance on objectives)	**Infiltration SCMs**	**Stormwater Wetland SCMs**	**Bioretention SCMs**
Improve water quality	X	X	X
Reduce peak rate	X	X	X
Reduce discharge volume	X		
Increase recharge	X		
Minimize thermal impacts	X		X
Provide habitat		X	X
Improve aesthetics		X	X

*This includes both basins and linear practice configurations of the SCM category.

Whether or not a project is subject to the Stormwater Standards or the MS4/TS4 Permit, it is MassDOT's policy to require structural stormwater measures when:

- As dictated by the WQDF to meet impaired waters and TMDL requirements
- The proposed project will result in a significant increase of impervious cover
- Drainage-related issues have been identified as having an adverse impact on existing conditions and warrant the use of SCMs

SCMs should be designed with appropriate pretreatment. Designers should use treatment trains consisting of pretreatment and one or more structural SCMs to meet water quality objectives. SCMs should be designed in accordance with site constraints, regulatory requirements, operational and maintenance needs, design standards, and overall practicability.

3.3.2 Stormwater Measures

MassDOT designers should first implement LID practices and then structural SCMs in the design to meet stormwater objectives. This section presents these stormwater measures in order of MassDOT's preference.

Low Impact Development

The following four sections provide detail on the LID practices that MassDOT promotes.

3.3.2.1 Preserve and Enhance Vegetation

Vegetation performs many functions and plays a critical supportive role in stormwater management, including the reduction of runoff volume, soil erosion, and pollutant transport through the following mechanisms:

- Promotion of recharge
- Control of runoff velocity
- Moderation of stormwater temperatures
- Surface stabilization (i.e., erosion control)
- Interception and evapotranspiration

Preservation of existing vegetation around infiltration basin © MassDOT

To maximize stormwater treatment benefits, a designer should include the following measures into the design:

- Preserve existing vegetation, particularly mature, large-canopy trees to promote evapotranspiration and canopy interception
- Stabilize and establish vegetation along roadway embankments, shorelines, causeways, and other natural resource areas (see **Section 4.5.3** Vegetated Riprap)
- Increase vegetation along the flow path to provide shading and erosion control

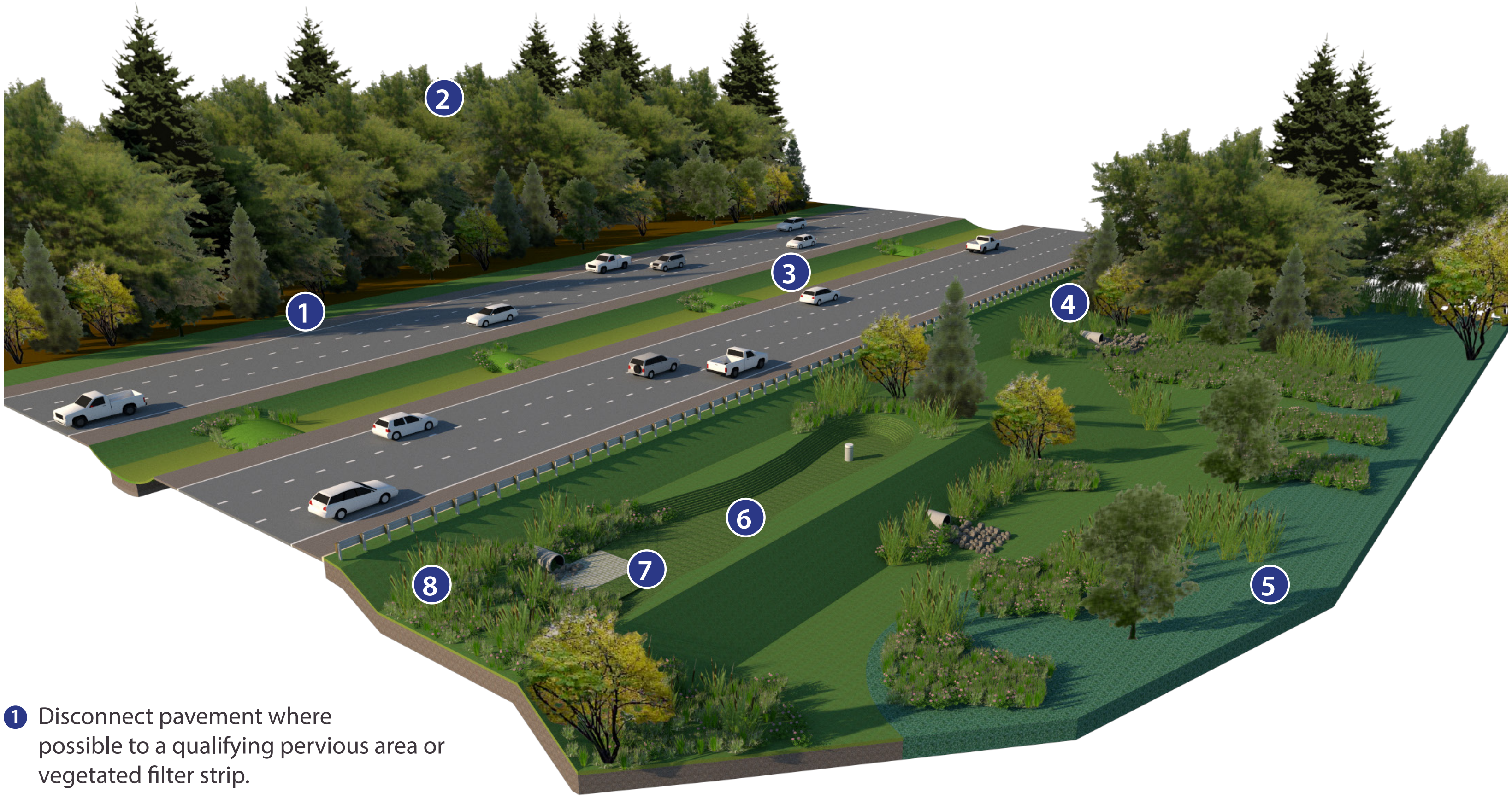
Meeting stormwater objectives through LID and structural SCMs can be achieved in various MassDOT settings, including urban and highway settings. As examples, Figures 3-2 and 3-3 illustrate how LID practices and SCMs can be incorporated into both settings.

Figure 3-2. Integrated Site Design Examples in an Urban Setting*

**Urban setting refers to space-constrained roadways without access control*

1. Preserve existing street trees.
2. Minimize impervious cover using pervious median.
3. Integrate stormwater treatment into traffic calming and pedestrian safety features, such as bioretention curb bump-outs.
4. Disconnect pavement where possible, such as grading sidewalks to drain to a qualifying pervious area or vegetated filter strip.
5. Include underdrain in porous pavement sidewalks where site conditions preclude infiltration.
6. Locate curb inlets to direct gutter flow into bioretention planter.
7. Select small-footprint SCMs like leaching basins to overcome space constraints.

Figure 3-3. Integrated Site Design Examples in a Highway Setting



1. Disconnect pavement where possible to a qualifying pervious area or vegetated filter strip.
2. Preserve existing trees and vegetation.
3. Grade in vegetated linear practices with check dams to slow flow and promote infiltration.
4. Relocate outfall to vegetated upland area if not able to direct runoff to a stormwater control measure.
5. Protect wetland resource areas.
6. Locate treatment in existing open areas where possible.
7. Maximize treatment capacity with infiltration measures, such as an infiltration basin with sediment forebay.
8. Establish and maintain vegetation to stabilize roadway embankment.

3.3.2.2 Reduce Impervious Cover

Reducing impervious cover improves stormwater management by increasing opportunities for recharge and infiltration and decreasing runoff volume and peak flow rates. Reducing impervious cover also has the co-benefit of helping to alleviate heat island effects.

To reduce the impact of impervious cover on stormwater quality, a designer should include the following measures into the design:

- Remove existing pavement where possible
- Minimize proposed pavement
- Use grassed islands or other natural groundcover instead of paved islands, where practicable
- Use permeable materials for slope stabilization
- Use porous pavement where it is suitable (see **Section 4.2.5**)

While roadway projects must adhere to safety design standards that specify pavement width and configuration, designers should evaluate and implement opportunities to reduce impervious cover where practicable.

3.3.2.3 Disconnect Pavement

Pavement disconnection is a stormwater management measure that diverts stormwater runoff from impervious cover to a vegetated upland area (natural or constructed) where treatment and recharge will occur (**Section 4.2.1**). This is a cost-effective and low maintenance measure that designers can use to reduce the effects of impervious cover.

When a vegetated area meets MassDEP's definition of a qualifying pervious area (QPA), it is considered an infiltration SCM, and the contributing impervious cover can be deducted from the area subject to water quality treatment and groundwater recharge requirements. The EPA recognizes impervious cover disconnection as a creditable measure for meeting post-construction and TMDL requirements.

Vegetated filter strip © MassDOT

Pavement disconnection can be achieved through simple techniques such as:

- Grading to direct stormwater, in the form of sheet flow, to QPAs or vegetated filter strips (VFSs)
- Adding curb cuts to direct stormwater to pervious areas
- Not adding curbing where curbing is not required
- Installing drainage inlets within pervious medians, shoulders, or beyond within the right-of-way

The LID practices of preserving existing vegetation and reducing impervious cover are consistent with and support the practice of pavement disconnection.

3.3.2.4 Maintain Pre-Development Drainage Patterns

Roadway designs should accommodate and maintain existing drainage patterns where practicable while integrating stormwater management measures. Maintaining existing drainage patterns reduces a project's potential to increase the site's time of concentration (TOC) and runoff velocities and volumes, while sustaining groundwater recharge.

To maintain predevelopment drainage patterns, a designer should include measures in the design to:

- Preserve natural depressions that act as natural detention/infiltration
- Preserve natural drainage divides to keep flow paths dispersed
- Minimize the use of curbs and closed drainage systems
- Grade to encourage sheet flow and lengthen flow paths
- Incorporate design features to slow runoff velocities and increase TOC (e.g., check dams in linear practices, outfalls located as far from receiving waters as possible)
- Minimize disturbance of natural channel surfaces
- Prevent soil compaction during construction

The designer should consult MassDOT Environmental on current special provisions for construction-phase controls and protocols (e.g., avoiding compaction of infiltration areas) that are continually evolving to implement best practices for preserving predevelopment drainage patterns.

Structural SCMs

Unless the LID practices, as incorporated into the project design, have fully met the project's stormwater objectives, then structural SCMs should be considered. The following five sections present the SCM categories.

3.3.2.5 Infiltration SCMs

Infiltration measures are stormwater management systems that exfiltrate into underlying soils and include:

- Pavement disconnection (i.e., QPAs and VFSs)
- Infiltration basins and infiltration linear practices
- Leaching basins
- Subsurface infiltration systems
- Porous pavement[79]

Infiltration linear practice. © MassDOT

MassDOT prioritizes infiltration measures because of their cost-effectiveness for addressing both stormwater quantity and quality objectives.

Infiltration SCMs capture stormwater runoff and allow it to percolate through the soil to groundwater. They reduce stormwater volumes by taking advantage of native soil characteristics and their ability to infiltrate runoff. Infiltration measures should be used wherever possible, including in retrofit situations where available space may be limited. MassDOT prefers pavement disconnection along the ROW, surface SCMs, and leaching basins where space is less available. However, infiltration can only be achieved with suitable soils and adequate depth to groundwater (to minimize the effects of groundwater mounding). Other physical constraints (e.g., shallow depth to bedrock) may preclude the use of or limit the performance of infiltration SCMs.

3.3.2.6 Stormwater Wetland SCMs

Stormwater wetlands are stormwater treatment basins designed to simulate the hydrologic and biological conditions that occur in a natural wetland and include:

- Constructed stormwater wetlands
- Gravel wetlands

79 To be used only under special circumstances as discussed with MassDOT Environmental.

Bioretention area in an urban setting © VHB

Stormwater wetlands should be considered if groundwater elevations are too high and/or soils are too poorly drained to construct an infiltration SCM. Although they do not provide recharge to groundwater, stormwater wetlands can have high pollutant removal rates via vegetative uptake, biological processes, and filtration, and can be designed with additional storage to attenuate peak flows to a receiving water body.

3.3.2.7 Bioretention SCMs

Bioretention SCMs provide stormwater treatment by filtering runoff through vegetation and an engineered soil media and include bioretention areas and bioretention linear practices.

While bioretention practices may be designed as "exfiltrating," MassDOT uses bioretention where infiltration is not practicable due to site constraints and groundwater levels are too deep to support stormwater wetlands. Bioretention provides water quality treatment and can be designed with additional storage for peak rate attenuation if proper scour protection is provided.

Bioretention design can be adapted to a specific setting. For roadway applications, the vegetation component of bioretention may be designed for ease of maintenance. For urban applications, bioretention may be smaller in scale (e.g., rain gardens) and include a vegetation component designed for aesthetics.

3.3.2.8 Other SCMs

When site conditions do not support the above-mentioned SCMs, MassDOT implements the following SCMs to improve water quality, control peak rates, and/or improve existing conditions. These other SCMs include:

- Extended dry detention basins
- Wet basins and wet linear practices
- Vegetated riprap

Depending on site constraints and underlying soil conditions, extended dry detention basins, wet basins, or wet linear practices may be the only option for above-ground stormwater mitigation. Vegetated riprap can be implemented adjacent to bridge abutments or steep slopes to improve existing conditions when no other SCMs are a viable option.

3.3.2.9 Alternative SCMs

Alternative SCMs are novel treatment designs that are less common on MassDOT projects. MassDOT will update the WQDF as it accepts new SCMs to be included in designs. Designers are also encouraged to consult MassDOT Environmental during the SCM selection process if a novel SCM is being considered to meet unique project goals. Treatment credit for alternative SCMs may require discussion with regulators.

Designers should note that due to their inaccessibility for inspection, need for extended lane closures, difficulty/expense of clean-out, and limited treatment performance, MassDOT does not deem hydrodynamic separators to be practicable for use on MassDOT properties or along roadways in general. Accordingly, MassDOT will not fund these devices for use on municipal projects executed by MassDOT.

3.3.3 SCM Considerations

MassDOT has preferences for SCMs based on years of experience of roadway design and operations in the field. Each project's context has siting and design considerations that may suit certain SCM characteristics better than others to meet project objectives.

This section lists contextual elements that may affect design and construction, including project type, site constraints, sensitive resources, and O&M. Siting and design approaches are presented, and preferred or suitable SCM types are identified.

Once SCM types are determined, the designer should use **Chapter 4** to select specific SCMs based on detailed design guidance provided, including siting and design criteria and setback requirements.

This section helps the designer review contextual elements for their site and identify the critical factors for SCM siting, design, and configurations.

3.3.3.1 Project Type

Roadways (Urban and Highway Settings)

Siting and Design Approach

- Comply with roadway safety standards
- Evaluate space constraints and accessibility
- Minimize utility conflicts
- Consider community preferences
- Evaluate and minimize high-maintenance measures
- Consider DPW preferences if it is a MassDOT-executed municipal project

Suitable SCMs

- Surface SCMs
- Smaller SCMs distributed throughout the site

Bridges

Siting and Design Approach

- Consider constraints of resource areas and bridge foundational elements
- Determine if infiltration SCM has the potential to adversely affect an approach, abutment, or footing
- Minimize use of scuppers and evaluate viability of horizontal drainage
- Minimize contributing area to scupper infrastructure
- Evaluate potential need for energy dissipation
- Consider partnerships with adjacent landowners
- For small, rural bridges, maintain country drainage if possible

Suitable SCMs

- Slope treatments, including vegetated riprap
- Catch basins outside the bridge deck directed to outfalls as far from resources as possible to provide pretreatment and buffer (compared to scuppers directly discharging to resource area)
- SCMs in open areas beneath the bridge with shade-tolerant vegetation or other soil stabilization measure, if possible
- For country drainage, minimize structural SCMs and promote treatment through pavement disconnection (i.e., vegetated buffers)

Construction of Bridge Carrying Bill Delahunt Parkway over Old Swamp River in Rockland, Massachusetts © VHB

3.3.3.2 Site Evaluation and Potential Constraints

Soils

Siting and Design Considerations

- Conduct site-specific geotechnical analysis to characterize soils at the location of a potential SCM prior to the 25% design stage
- Consider potential for replacing unsuitable soil layers

Suitable SCMs

- Infiltration SCMs for areas with suitable soils
- Non-infiltrating SCMs for areas with poorly draining soils

Hazardous Materials

Siting and Design Considerations

- Minimize the quantity of hazardous materials removed and requiring special waste disposal
- For infiltration near contaminated areas, conduct additional analysis to confirm the contamination plume will not be mobilized or worsened by infiltration SCMs
- Consider contamination from nearby sites

Suitable SCMs

- Non-infiltrating SCMs
- Lined SCMs

Groundwater

Siting and Design Considerations

- Conduct site-specific geotechnical analysis to determine the SHWT at the location of a potential SCM prior to the 25% design stage
- Follow separation requirements for infiltration SCMs
- Groundwater levels for SCMs designed to be wet should sustain a permanent pool
- Groundwater levels for SCMs designed to be dry should allow the SCM to drain between storm events (typically a 72-hour drawdown period)
- Consider the impact of cut and fill activities, or underdrains beneath or along the roadway, on groundwater movement

Suitable SCMs

- Infiltration SCMs for areas with adequate separation to SHWT
- SCMs that require a permanent pool (e.g., stormwater wetlands) for areas that intercept groundwater

Bedrock

Siting and Design Considerations

- Conduct site-specific geotechnical analysis to determine the depth to bedrock at the location of a potential SCM prior to the 25% design stage
- Avoid costly excavation of significant quantities of bedrock
- Follow separation-to-bedrock requirements for infiltration SCMs

Suitable SCMs

- SCMs that require minimal excavation

Topography (e.g., site elevations, slopes)

Siting and Design Approaches

- Minimize excessive grading, including need for grading outside the ROW and/or into resource areas
- Seek to balance cut and fill (i.e., reuse soil) on-site
- Maintain existing drainage patterns where practicable
- Comply with ground cover requirements for stormwater features (i.e., depth of fill over drainage pipes)

Suitable SCMs

- Vegetated riprap for steeper slopes
- Pavement disconnection for flatter slopes

ROW, Property Boundaries, Easements

Siting and Design Considerations

- Evaluate available space considering roadway safety and setback requirements
- Consider potential for obtaining additional ROW as warranted
- Consider existing easements located on DOT property (e.g., Massachusetts Water Resources Authority, gas utilities, etc.)

Suitable SCMs

- Pavement disconnection and linear practices along highway layout (e.g., median or ROW)
- SCMs in open spaces at highway interchanges and roadway intersections

Utilities and Structures

Siting and Design Considerations

- Minimize the need to relocate existing utilities and structures
- Coordinate with specific utility owners for clearance, setbacks and required protection

Suitable SCMs

- SCMs that require minimal excavation
- Pavement disconnection and linear practices for linear spaces along highway layout

Vehicular Safety

Siting and Design Considerations

- Prioritize SCM locations outside of the clear zone
- Within clear zones, abide by Engineering Directive E-20-003.[80] Highlights include:
    - Longitudinal slope for check dams must be 12 horizontal to 1 vertical (12H:1V) or flatter
    - Final dressing material (e.g., cover for check dam) must be loam and seed
    - No structures allowed that protrude 6 inches or greater from grade (e.g., outlet control structures, headwalls, and yard drains)
    - Cannot exceed a height, or ponding depth, of 2 feet
    - No permanent standing water
    - Drawdown must occur within 72 hours after rainfall event (test pits or similar investigations may be required to inform this requirement)
    - Spacing between check dams shall have a minimum distance of 25 feet between toes-of-slope

Suitable SCMs

- Vegetated SCMs with no permanent pools within clear zones

80 See MassDOT Highway Engineering Directive E-20-003 (20 Feb. 2020) at: https://www.mass.gov/doc/location-and-design-of-stormwater-bmps/download

3.3.3.3 Sensitive Resources

LID measures and SCMs serve as one of MassDOT's most important methods for protecting sensitive resources. Protection of sensitive resources is complemented by source controls and other programs aimed at reducing pollutants and protecting resources (e.g., street sweeping, catch basin cleaning, litter pickup, reduction of winter sanding).

SCMs are prohibited from being sited in wetland resource areas with the exception of Riverfront Area, Land Subject to Coastal Storm Flowage, and Isolated or Bordering Land Subject to Flooding.

There are stormwater design approaches that benefit all sensitive resources. These include:

- Pavement disconnection
- SCMs set back from the sensitive resource as far as possible to maximize vegetated buffers
- Smaller SCMs distributed throughout the site

Sensitive resources that qualify as Critical Areas require additional pretreatment (see **Standard 6)**.

Table 3-3 provides specific siting and design considerations for each type of sensitive resource.

Table 3-3. Siting and Design Considerations for Sensitive Resources

Sensitive Resource	Critical Area	Siting and Design Considerations
Impaired Waters/TMDLs	☐	• Use the WQ Curves (see **Section 2.3.3**) to size SCMs to maximize cost-effective treatment • Follow project and watershed specific requirements provided by the WQDF • Use SCMs that increase flow paths to the impaired water body
Wildlife Habitat	☐	• Minimize impacts to habitat of threatened or endangered species • Minimize cutting, clearing, and impeding access to habitat (e.g., barriers, fences) • For stream crossings, maximize stream and habitat continuity
Public Water Supplies	☑	• Locate new outfalls or SCMs outside Zone A or Zone I (unless essential to the operation of the water supply) • Coordinate with public water supply owners to determine suitability of recharge in Zone II Wellhead Protection Areas • Coordinate with public water supply owners and first responders for any additional design elements for spill containment • Use SCMs that maximize treatment and increase flow paths
Cold-Water Fisheries	☑	• Avoid direct discharges • Use infiltration SCMs and minimize standing water • Provide vegetative cover (shading) such as vegetated riprap
Shellfish Growing Areas and Bathing Beaches	☑	• Avoid SCMs that create standing water to minimize propagation of pathogens and bacteria • Use infiltration or bioretention SCMs
Outstanding and Special Resource Waters	☑	• Minimize direct discharges to resource waters • Provide a minimum of 100-foot buffer between outfalls and resource waters • Near vernal pools, minimize alteration of natural hydrology and preserve Buffer Zones
Wetland Resources Areas	☐	
Vernal Pools	☑	

3.3.3.4 Operation and Maintenance (O&M)

This section provides the siting approaches and design considerations for SCMs relative to O&M.

In general, surface SCMs are well suited for meeting MassDOT O&M objectives.

Ease of Inspection and Maintenance

- Select SCMs with low long-term maintenance needs
- Avoid SCMs that require traffic disruptions during maintenance activities
- Design SCMs with adequate access for inspections and for typical maintenance equipment
- Minimize use of fencing
- Use pavers or granite curbing to fortify the bottom of SCM forebays for ease of sediment removal
- Consider use of SCM accessories such as staff gauges to provide a visual cue for initiating sediment removal

Sediment forebay with pavers for ease of sediment removal © CEI

Ease of Operation

- Prioritize SCMs that do not require special operating procedures, (e.g., the use of vacuum trucks, underground inspection, closed-space entry, frequent clean-outs)
- Design SCMs so they are compatible with local emergency response procedures for spill containment within Critical Areas

Construction Feasibility

- Locate SCMs to be accessible for proper construction
- Minimize soil compaction from construction routes and temporary cross-overs
- Avoid difficult/expensive construction techniques
- Minimize traffic impacts

Life Cycle Cost

- Avoid SCMs where the benefits do not justify the cost of installation, operation, maintenance, and/or repair
- Select the most cost-effective SCMs for achieving stormwater management objectives

4

Stormwater Control Measures

This chapter presents the design guidelines for structural stormwater control measures (SCMs) supported by MassDOT. **Designers should use this chapter to support the design of structural SCMs for their project site. Designers should understand regulatory requirements from Chapter 2 and MassDOT's approach to ISD in Chapter 3 before using this chapter to better select, locate, and design SCMs to achieve stormwater management goals.**

The SCMs presented in this SDG are supported by MassDOT because they are cost-effective; are simple to construct, operate, inspect, and maintain; and have a history of being successfully integrated into completed MassDOT roadway projects.

If the designer wishes to propose a SCM that is not included in this chapter, he/she should coordinate with the MassDOT Environmental Services Section (MassDOT Environmental) prior to commencing the design. Other types of SCMs will be considered on an as-needed and site-specific basis.

The first six sections in this chapter are categorized by SCM type and include information on each SCM and the associated design guidance. Within each SCM category, specific types are generally listed in MassDOT's descending order of preference.

All stormwater management designs shall conform to the MassDOT Project Development and Design Guide (PDDG), MassDOT engineering directives, and applicable updates and supplements regarding hydraulic analyses and drainage design.

Section 4.1 Pretreatment SCMs

- Deep-Sump Catch Basin
- Sediment Forebay
- Open-Graded Friction Course

Section 4.2 Infiltration SCMs

- Pavement Disconnection (Qualifying Pervious Area [QPA] and Vegetated Filter Strip [VFS])
- Infiltration Basin and Infiltration Linear Practice
- Leaching Basin
- Subsurface Infiltration System
- Porous Pavement

Section 4.3 Stormwater Wetland SCMs

- Constructed Stormwater Wetland (CSW)
- Gravel Wetland

Section 4.4 Bioretention SCMs

- Bioretention Area and Bioretention Linear Practice

Section 4.5 Other SCMs

- Extended Dry Detention Basin
- Wet Basin and Wet Linear Practice
- Vegetated Riprap

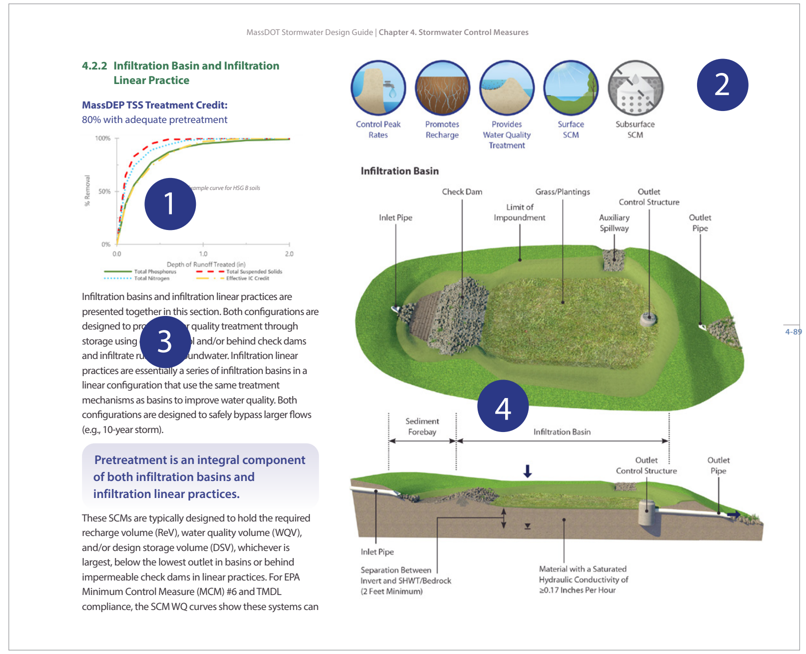
Section 4.6 SCM Accessories

- Check Dam
- Inlet and Outlet Treatment
- Low-Permeability Liner
- Subsurface Accessories
- Staff Gauge
- Oil/grit Separator

Each SCM section includes specific siting and design criteria, as illustrated and described in **Figure 4-1.** Additional design guidance is provided in list format after the first page of each SCM information sheet.

The last four sections of this chapter provide additional design considerations for all SCMs, infiltration SCMs, and those with specific configurations (e.g., basins and linear practices).

Figure 4-1. Example of first page of each SCM Information Sheet



1. When the SCM has a WQ Curve, the curve is shown as a small graph for reference; however, the WQ curves are provided at larger scale in the WQDF which the designer should use to calculate treatment. Note that the WQ Curves are approved by EPA but are still pending MassDEP's approval. Current MassDEP TSS removal treatment credits are provided for Standard 4 compliance.
2. The icons are used to help the designer quickly identify primary characteristics and functions of each SCM. Icons are grayed out and marked with a dashed line if not applicable to that SCM.

Control Peak Rates | Promotes Recharge | Provides Water Quality Treatment | Surface SCM | Subsurface SCM

3. Descriptions of the SCM explain how it can be used to meet the MassDEP Stormwater Management Standards (the Stormwater Standards) and MS4/TS4 permit requirements.
4. A not-to-scale graphic shows key components of the SCM.

4.1 Pretreatment SCMs

A pretreatment SCM is the first component in a treatment train to provide water quality improvement.

Pretreatment SCMs are intended to be simple, with easy access for inspection and cleaning. Their purpose is to reduce the mass of pollutants, typically sediment, entering more complex SCMs downstream in a treatment train.

Pretreatment performs these important functions:

- Extending the overall service life of the downstream SCM treatment area
- Collecting and retaining sediments that would otherwise cause clogging or accumulation
- Extending the clean-out interval
- Removing pollutants before infiltration to protect groundwater quality

MassDOT projects may use the following pretreatment SCMs:

- Deep-sump catch basin
- Sediment forebay
- Open graded friction course

In locations where site constraints preclude the use of other structural measures, MassDOT may use pretreatment SCMs as stand-alone measures to improve the water quality treatment capabilities of an existing drainage system. Use of these measures support the goal to improve existing conditions and provide water quality treatment to the maximum extent practicable (MEP).

This section on pretreatment SCMs does not include information on SCM WQ Curves because pretreatment SCMs do not receive EPA treatment credits on their own. SCM WQ Curves for treatment SCMs (e.g., infiltration, bioretention) assume pretreatment has already been provided.

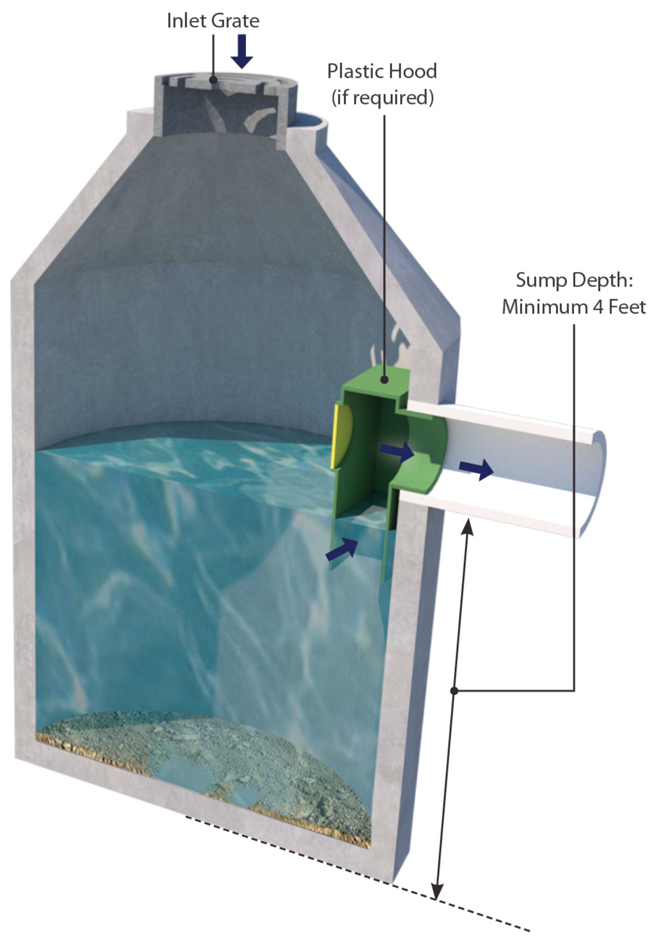
4.1.1 Deep-Sump Catch Basin

MassDEP TSS Treatment Credit: 25%

A deep-sump catch basin is a drop-inlet structure with features designed to filter out pollutants, including:

- An inlet grate to exclude trash and organic debris
- A deep-sump to collect and retain dense material (primarily sediment)
- If required, a plastic hooded outlet to retain floating material (primarily floating trash and to attenuate potential floatable spills)

Deep-sump catch basins may be used as water quality pretreatment when they are placed off-line as part of a closed stormwater management system. However, they provide no attenuation of peak flows (Standard 2) and no groundwater recharge (Standard 3).



Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Maximum contributing impervious area ≤ 10,000 square feet

Deep-sump catch basins should efficiently capture stormwater from the roadway without introducing additional hazards to roadway users.

Placement and spacing of deep-sump catch basins should be consistent with the MassDOT PDDG and consider:

- The size of the contributing area
- The hydraulic inlet capacity of the grates
- The safety of maintenance workers who will inspect and clean the structures
- The safety of roadway users including motorists, cyclists, pedestrians and others

Sump

Depth ≥ 4 feet

If sump depth of 4 feet cannot be attained due to site constraints (e.g., bedrock, utilities), the catch basin does not qualify for TSS pretreatment credit.

Inlet Grate

Grates should be cascade, parallel bar, or standard municipal grates designed in accordance with MassDOT PDDG.[81]

Grates must include a hook and lock feature to prevent dislodging. These hook and lock features are easily disabled in the field to provide access for maintenance and repairs. Grates should never be welded to the frame. On municipally owned facilities, municipal standard grates may be used in lieu of hook and lock grates per the direction of the affected municipality.

Hood

Hoods should be composed of plastic, never metal.

MassDOT shall at a minimum install hoods in the deep-sump catch basin outlets in the following locations:

- Along roadways in commercial areas
- Within rest areas
- In MassDOT maintenance yards
- Where open curb inlets are used
- Along highways where no other containment device is provided for a stormwater discharge to a Critical Area

Variations

The designer may consider specifying deep-sump manholes for sites where additional pretreatment is desirable but where space for other SCMs is limited. Covers for deep-sump manholes on roads with a posted speed limit of 45 mph or higher must also include a hook and lock feature to prevent dislodging.

Design References

- Hydraulic Engineering Circular 14 (HEC-14), Hydraulic Design of Energy Dissipaters for Culverts and Channels, Chapter 11 on Drop Structures[82]
- MassDOT PDDG, Chapter 8[83]
- MassDOT Standard Specifications for Highways and Bridges[84]
- MassDOT Construction Standard Details[85]

81 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals. Drainage systems designed in accordance with the MassDOT PDDG will provide a flow rate into grates that is ≤ 3 cubic feet per second.

82 See HEC-14 Hydraulic Design of Energy Dissipators for Culverts and Channels (Jul. 2006) at: https://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=13&id=129

83 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

84 See MassDOT Standard Specifications for Highways and Bridges at: https://www.mass.gov/lists/construction-specifications

85 See MassDOT Construction Standard Details at: https://www.mass.gov/lists/construction-details

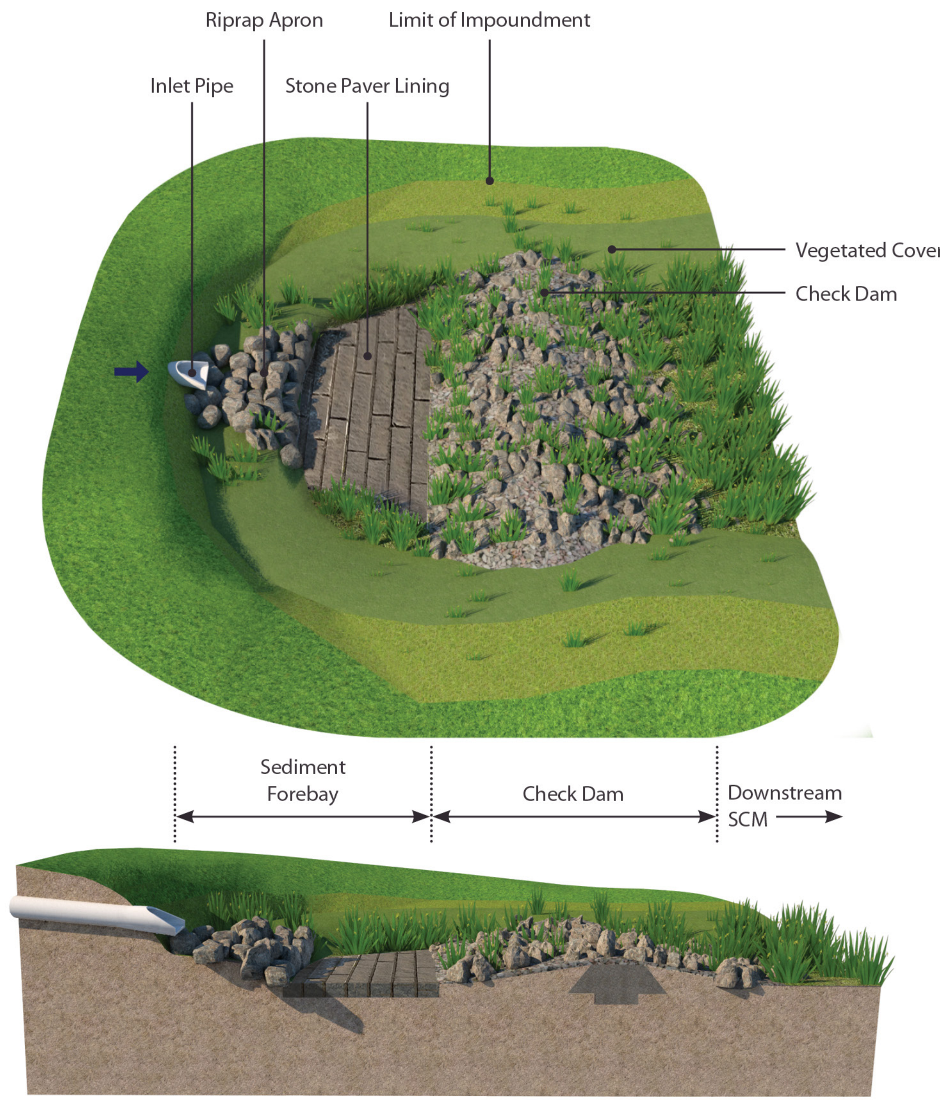
4.1.2 Sediment Forebay

MassDEP TSS Treatment Credit: 25%

A sediment forebay is a pretreatment SCM used to remove coarse sediment from stormwater through settling. Sediment forebays are typically integrated into the design of larger, more complex SCMs. MassDEP requires a sediment forebay as pretreatment for infiltration basins, constructed stormwater wetlands, gravel wetlands, extended dry detention basins, and wet basins.

Good design practice includes a sediment forebay for all inlets upstream of a surface SCM.

The first component of the sediment forebay is a riprap apron to dissipate energy and prevent erosion where runoff enters the forebay. The forebay bottom should be lined with flat stone pavers to provide a reinforced surface that is easy to maintain with equipment and/or shovels. Individual pavers should have a minimum depth of 4 inches and should be placed with 2-inch spacing on all sides. If stone pavers are not available, other rigid materials such as concrete pavers may be used. A forebay outlet may consist of either an impermeable check dam to hold back water or a permeable check dam that allows water to percolate.



Accessories

- Check dams as forebay outlet
- Inlet and Outlet Treatments (apron)
- Staff Gauge

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Site the sediment forebay upstream of treatment SCM
- Design volume ≥ 0.1 inch multiplied by the acreage of contributing impervious area
- The design drawdown period should be 72 hours or less
- Unless upstream of a wet SCM, bottom of forebay should be a minimum of two feet above the seasonal high water table (SHWT)

Sediment forebay © MassDOT

4.1.3 Open-Graded Friction Course

Control Peak Rates | Promotes Recharge | Provides Water Quality Treatment | Surface SCM | Subsurface SCM

MassDEP TSS Treatment Credit: N/A

Water quality treatment credits to be determined based on a pending USGS study.

Open-Graded Friction Course (OGFC) is a 1- to 2-inch surface layer of hot-mix asphalt lacking fine grain-sized aggregate. The aggregate materials (e.g., gravel, crushed stone) are graded to provide interconnected voids. Aside from making highways quieter, OGFC reduces hydroplaning, tire spray, and night glare. This, in turn, improves skid resistance and visibility, thereby providing a variety of safety benefits. OGFC also reduces pollutants in highway runoff by trapping particulates in the pavement voids and by reducing splash, which minimizes vehicular underwash.

OGFC should be considered as part of the pavement design process. OGFC should only be used if traffic and safety analyses determine it is suitable for the project. Before proposing OGFC, the designer will need to coordinate with the MassDOT Pavement Management Section.

MassDOT projects may use OGFC on redevelopment projects to improve existing conditions for Standard 7.

Siting and Design Criteria

- Consult with MassDOT Pavement Management Section
- Use of OGFC is limited to interstate and/or limited access highways (where there are minimal stopping and turning movements)
- OGFC is not suitable for treating runoff from areas outside the footprint of pavement (e.g., runoff from adjacent areas)
- Roadway cross-slope should be designed at 2%, although cross-slope may vary with superelevation

Materials

- Consult with MassDOT Pavement Management Section
- Materials and installation of OGFC should be consistent with specifications in the latest edition of the MassDOT Standard Specification for Highways and Bridges and current supplements

Design References

- MassDOT PDDG, Chapter 9[86]
- MassDOT Standard Specifications for Highways and Bridges[87]

86 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

87 See MassDOT Standard Specifications for Highways and Bridges at: https://www.mass.gov/lists/construction-specifications

4.2 Infiltration SCMs

Infiltration SCMs provide a high level of water quality treatment. Pollutant removal occurs through filtration through soil before infiltrating to groundwater.

Infiltration SCMs are MassDOT's preferred option. Infiltration practices should be considered wherever site and soil conditions are favorable.

Infiltration SCMs primarily address groundwater recharge requirements and water quality treatment requirements, but can also be designed to address peak rate requirements.

MassDOT projects may use the following infiltration SCMs:

- Pavement disconnection (QPAs and VFSs)
- Infiltration basin and infiltration linear practice
- Leaching basin
- Subsurface infiltration system
- Porous pavement

The designer should exercise care when designing infiltration SCMs for roadway applications. Due to long-term pavement stability and O&M considerations, infiltration practices should not be placed underneath travel lanes. Pavement strength and integrity depend on adequate drainage of the substructure of the road. Infiltration practices should not compromise the long-term performance of the roadway and its associated structures (such as retaining walls and bridges).

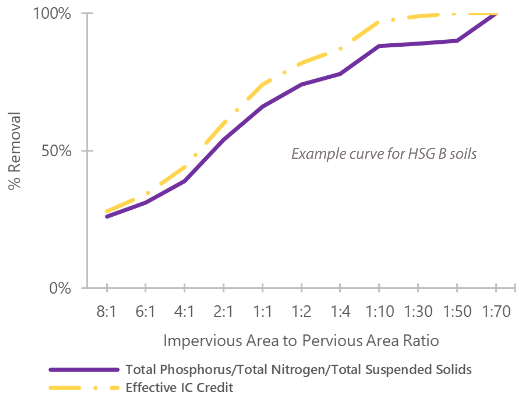
Without adequate pretreatment, infiltration SCMs are susceptible to clogging. If debris and sediment loads are not controlled, the infiltration SCM will perform poorly and need frequent, costly maintenance. Additionally, infiltration systems require pretreatment to qualify for TSS removal credit. MassDEP pretreatment requirements vary depending on site conditions and on the classification of the downgradient receiving water (see **Section 4.8.2**).

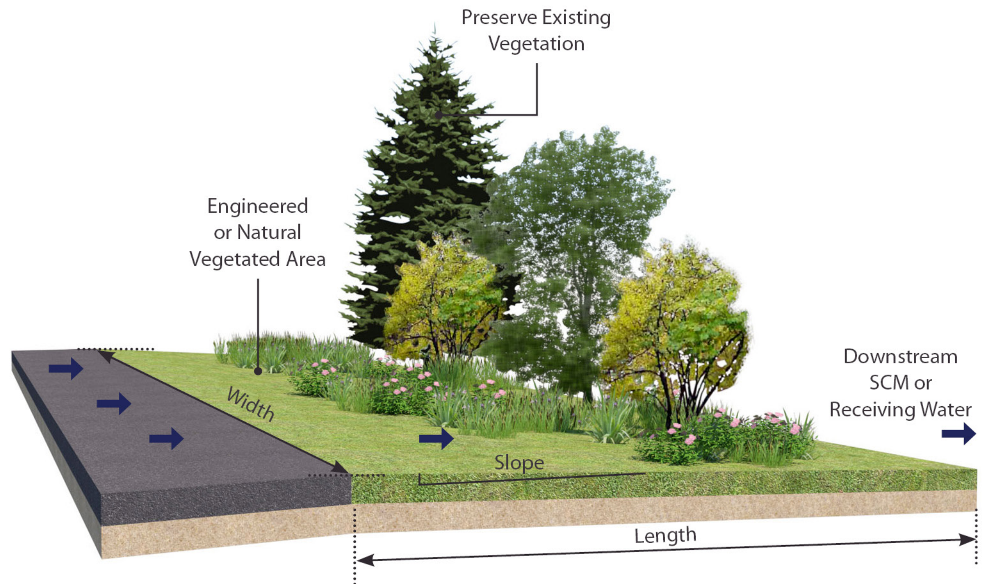
Design guidance common to all infiltration SCMs is described in **Section 4.8**.

Pavement disconnection (vegetated filter strip) © VHB

4.2.1 Pavement Disconnection

MassDEP TSS Treatment Credit: See Table 4-1





Pavement disconnection is a low impact development measure that is also considered an infiltration SCM. This design approach involves directing runoff from impervious areas to vegetated upland areas, which may be intentional or incidental, engineered or natural. Vegetated upland areas reduce runoff velocities, provide a natural-surface disconnection between impervious surfaces, and provide water quality treatment. Pollutant removal occurs through the filtration and storage of sediment at the base of the vegetative material and infiltration through underlying soils.

Runoff from the contributing impervious areas must be distributed evenly so the vegetated upland area receives only sheet flow. Site grading (or a level spreader) should encourage evenly dispersed sheet flow and prevent the formation of concentrated flow to the pervious vegetated surface.

For treatment credit purposes, MassDEP categorizes pavement disconnection into a QPA or VFS, while EPA does not make this distinction. **Table 4-1** presents the treatment credits provided by MassDEP and EPA.

Table 4-1. MassDEP and EPA Treatment Credits for QPAs and VFSs

Regulatory Jurisdiction	Qualifying Pervious Area	Vegetated Filter Strip
MassDEP WPA Jurisdiction	Contributing impervious area is removed from area requiring recharge under Standard 3 and area requiring treatment under Standard 4	MassDEP Standard 4 TSS treatment credit: • 10% for VFS with a length ≥25 and < 50 feet • 45% for VFS with a length ≥50 feet
EPA TS4 Permit Jurisdiction	No distinction between the categories for EPA post-construction treatment credit and TMDL compliance. Use the SCM WQ Curves in the WQDF to calculate pollutant removal based on the soil type and the ratio of impervious area to pervious area.	

For all pavement disconnection practices, the following design guidance applies.

Accessories

- Lever spreader (if necessary)
- Low-permeability liner (if necessary)

Pretreatment

- None
- Could serve as pretreatment for downstream SCMs

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)

Pervious area may be natural or engineered.

Site grading upstream of the pervious area should promote sheet flow, or measures should be taken to disperse flow and prevent erosion, such as a level spreader. Slopes and vegetated cover must prevent channelized flow within pervious area.

End of pervious area must be at least 50 feet from the edge of a vegetated wetland resource area (other than Riverfront Area, Land Subject to Coastal Storm Flowage and Lands Subject to Flooding) or bank and must not extend into the inner 50 feet of the Buffer Zone.

Pervious area must be lined if used in Land Uses with Higher Potential Pollutant Loads (LUHPPLs) or Critical Areas.

Vegetation

Vegetated areas must be maintained as an integral component of the SCM. Consult with the MassDOT Landscape Design Section for soil amendment and vegetation specifications.

Storage Volume/ Sizing

In general, treatment performance is based on ratio of impervious to pervious area.

- See **Table 4-2** for MassDEP specific requirements

Table 4-2 provides the MassDEP's design criteria to meet the categories for QPAs and VFSs.

Table 4-2. MassDEP's Design Criteria for Pavement Disconnection Categories

	Qualifying Pervious Area	Vegetated Filter Strip
Slope	≤5%	≤6%
Length[88]	For MassDEP Standard 4 TSS treatment credit, must be equal to or greater than length of the flowpath across the contributing impervious area	Minimum 25 feet
Width[89]	No less than the width of the contributing impervious area	
Contributing Impervious Area	For MassDEP Standard 4 TSS treatment credit, length of contributing impervious area should be no more than 75 feet. Note that the QPA must be larger than the contributing impervious area.	
Soils and Siting Criteria	Locate in Hydrologic Soil Groups A, B or C. Vertical separation to SHWT should be a minimum of two feet above seasonal high groundwater and two to four feet above bedrock.	Any HSG, except in soils with high clay content. No requirement for vertical separation to SHWT, but there should be no indication of standing water in the area.

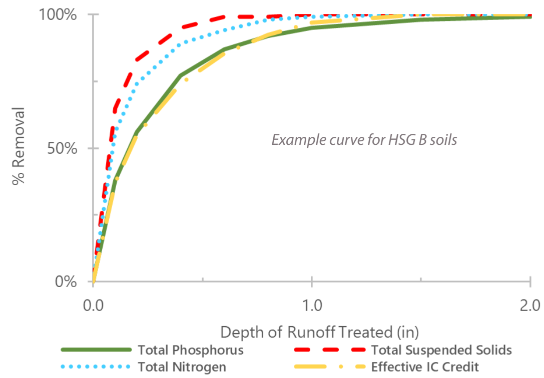
88 MassDOT defines length as the dimension parallel to flow, as shown on the graphic.

89 MassDOT defines width as the dimension perpendicular to flow, as shown on the graphic.

4.2.2 Infiltration Basin and Infiltration Linear Practice

MassDEP TSS Treatment Credit:

80% with adequate pretreatment

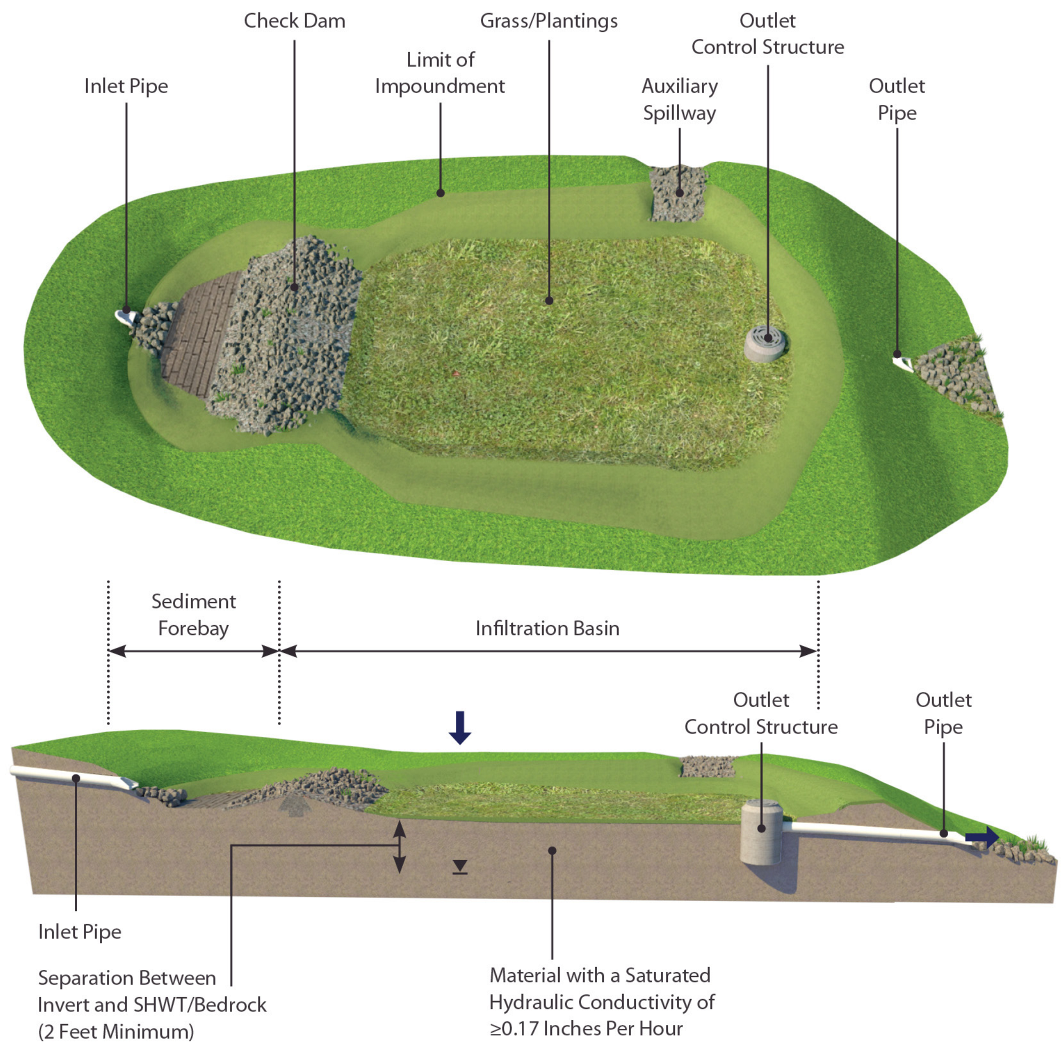


Infiltration basins and infiltration linear practices are presented together in this section. Both configurations are designed to provide water quality treatment through storage using outlet control and/or behind check dams and infiltrate runoff to groundwater. Infiltration linear practices are essentially a series of infiltration basins in a linear configuration that use the same treatment mechanisms as basins to improve water quality. Both configurations are designed to safely bypass larger flows (e.g., 10-year storm).

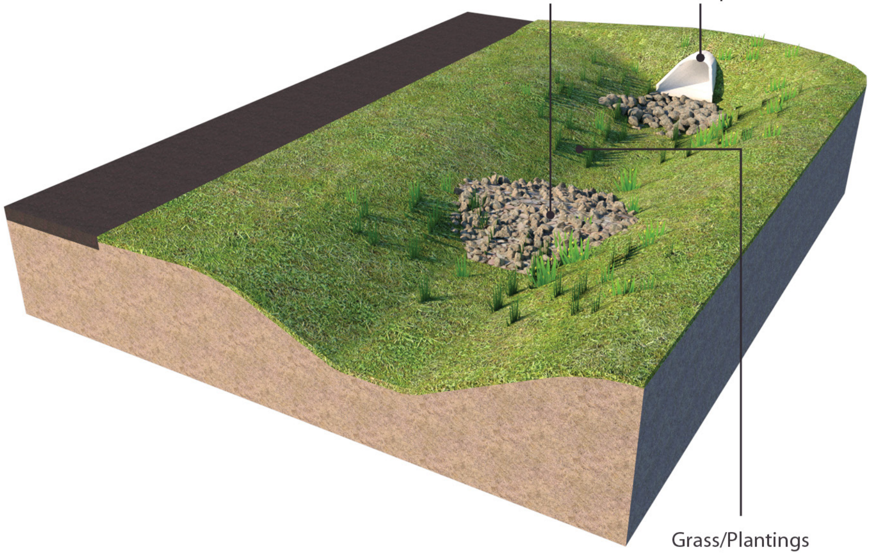
Pretreatment is an integral component of both infiltration basins and infiltration linear practices.

These SCMs are typically designed to hold the required recharge volume (ReV), water quality volume (WQV), and/or design storage volume (DSV), whichever is largest, below the lowest outlet in basins or behind impermeable check dams in linear practices. For EPA Minimum Control Measure (MCM) #6 and TMDL compliance, the SCM WQ curves show these systems can

Infiltration Basin



Infiltration Linear Practice



Infiltration basin © VHB

often be sized much smaller to cumulatively achieve the required pollutant percent reductions. Peak rates should be controlled through appropriate sizing of the SCM and design of outlet control structure(s) (see **Section 4.9.2.2** for information on outlet control structure design).

The surface of infiltration basins and infiltration linear practices are typically vegetated. The specified vegetation (e.g., grass) should remain viable within the SCM for the range of conditions that may occur.

Accessories

- Inlet and outlet treatments
- Check dams (for linear practices)

Pretreatment

- Pretreatment is required as an integral part of the design.
- Additional pretreatment may be required in accordance with the Pretreatment and Design Criteria (**Section 4.8.2**) for infiltration SCMs.

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Design Guidance for Infiltration SCMs (**Section 4.8**)
- Design Guidance for Basins (**Section 4.9**)
- Design Guidance for Linear Practices (**Section 4.10**)

For basins, the bottom slope should be less than or equal to 1%. Otherwise, incorporate terraced, no-slope cells or consider a linear practice design.

Storage Volume

Provide a storage volume below the lowest level outlet for basins or behind the impermeable check dams for linear practices to achieve compliance with the following, as applicable:

- Standard 3 (Recharge)
- Standard 4 (Water Quality)

Design the volume and outlet control structure(s) to achieve compliance with:

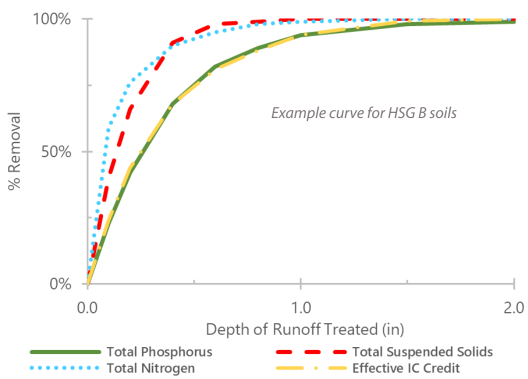
- Standard 2 (Peak Rate Attenuation)

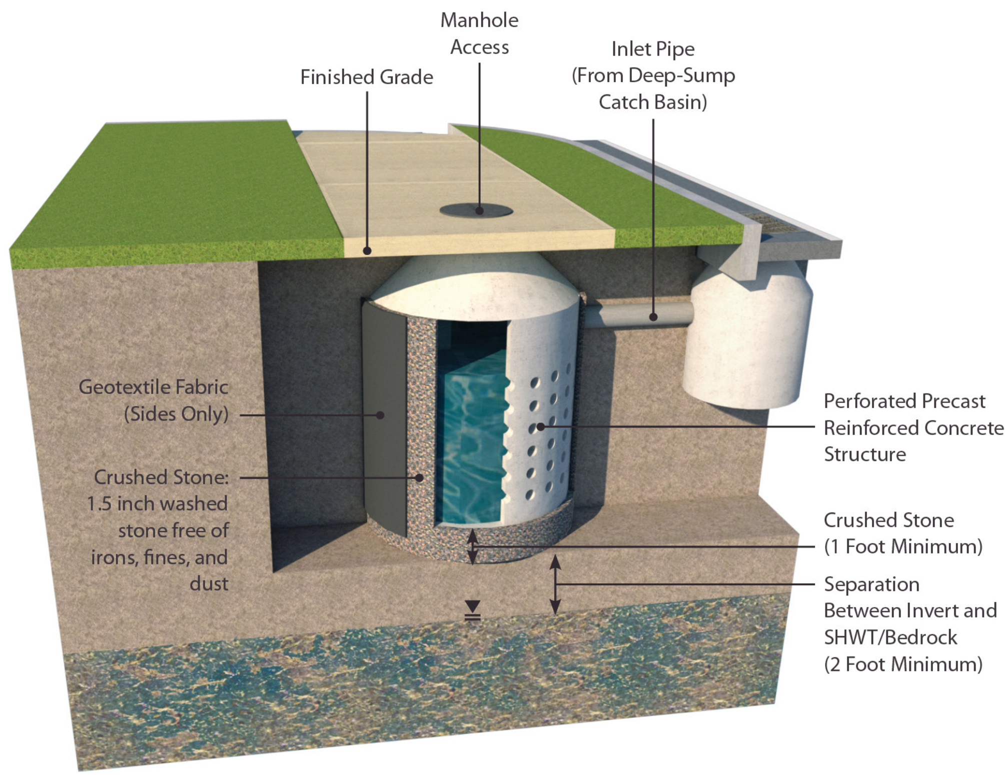
Follow requirements provided by the WQDF to meet impaired waters and TMDL goals.

4.2.3 Leaching Basin

MassDEP Equivalent SCM = Leaching Catch Basin

MassDEP TSS Treatment Credit:
80% with deep-sump catch basin and offline





The MassDOT leaching basin consists of a precast concrete manhole structure with perforated sides and bottom with only an inlet pipe(s). Stormwater drains out of the leaching basin through a layer of crushed stone before filtering through soils and into groundwater. Leaching basins are located off-line in a piped system so that no drainage structures are located downstream from the structure, although multiple leaching basins may be connected in series.

Leaching basins should only be sited in areas with well-drained soils. Leaching basins are installed on and surrounded by a layer of uniformly graded, washed, 1.5-inch crushed stone with a void space of approximately 40%. The crushed stone should be isolated from adjacent soils with a permeable, non-woven geotextile fabric placed vertically along the sides. Typically, geotextile fabric is not installed at the bottom of the system due to potential for clogging.

A comprehensive leaching basin design includes locating the structure offline and provisions to accommodate overflows if runoff volume exceeds the capacity of the structure. Where necessary, leaching basins can have a frame and grate to accommodate overflows; however this is only allowed where the leaching basin is surrounded by pervious cover.

Appropriate stormwater pretreatment must be achieved prior to the leaching basin.

Leaching basins are typically preceded by deep-sump catch basins that provide the minimum level of pretreatment required for infiltration systems. Site conditions or proximity to resource areas may prompt the need for additional pretreatment (see **Section 4.8.2)**.

Pretreatment

- Pretreatment is required
- Pretreatment is not required if the basin only accepts stormwater from nonmetal roofs (in any location) or metal roofs located outside Zone II Wellhead Protection Areas, Interim Wellhead Protection Areas (IWPAs), and industrial sites
- Refer to Pretreatment and Design Criteria (**Section 4.8.2**) for infiltration SCMs

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Design Guidance for Infiltration SCMs (**Section 4.8**)

Storage Volume

Provide a storage volume equal to volume of structure plus void space within crushed stone below inlet invert to achieve compliance with the following, as applicable:

- Standard 3 (Recharge)
- Standard 4 (Water Quality)

Follow requirements provided by the WQDF to meet impaired waters and TMDL goals.

Design References

- MassDOT PDDG, Chapter 8[90]
- MassDOT Standard Specifications for Highways and Bridges[91]
- MassDOT Construction Standard Details[92]

90 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

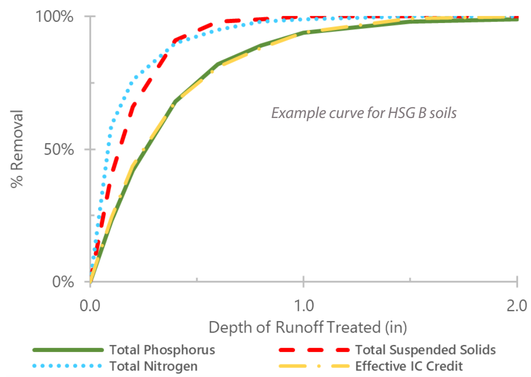
91 See MassDOT Standard Specifications for Highways and Bridges at: https://www.mass.gov/lists/construction-specifications

92 See MassDOT Construction Standard Details at: https://www.mass.gov/lists/construction-details

4.2.4 Subsurface Infiltration System

MassDEP Equivalent SCM = Subsurface Structures

MassDEP TSS Treatment Credit: 80%

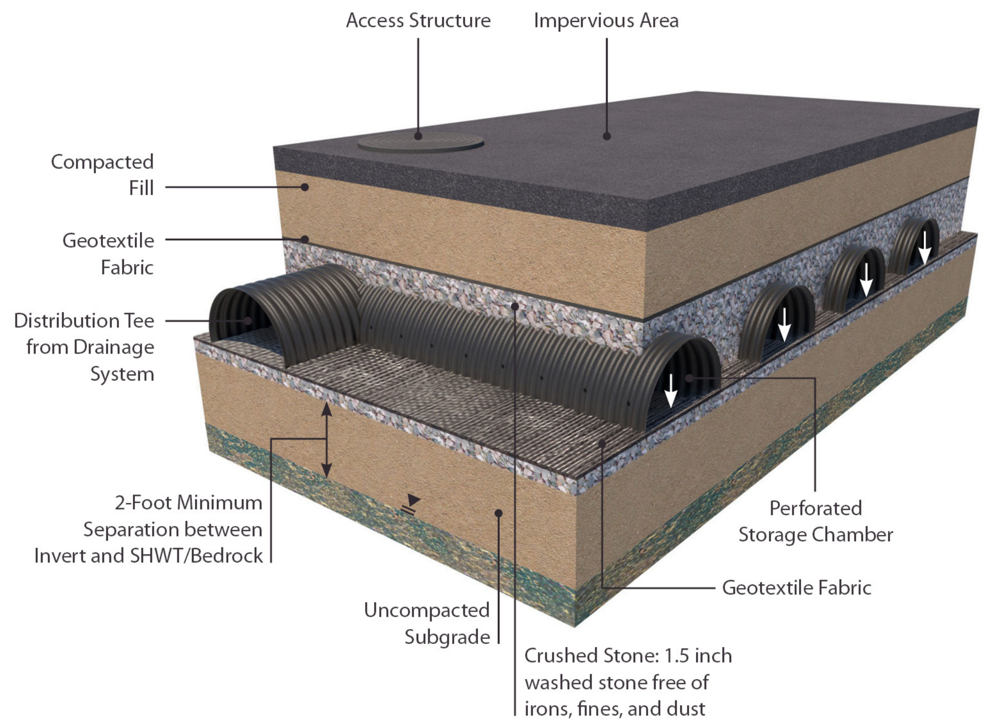


Subsurface infiltration systems are underground systems designed to detain stormwater and release it to groundwater through infiltration. Pollutant removal occurs through filtration mechanisms. Similar to the infiltration basin design principles, the ReV, WQV, and/or DSV is considered the storage volume below the lowest outlet. Design may be enhanced to provide peak rate control.

Subsurface infiltration systems are ideally suited as off-line SCMs.

Subsurface infiltration systems may be constructed out of many different materials with special consideration to keep designs simple, including:

- Perforated pipes
- Precast concrete chambers or galleries
- Plastic chambers or galleries
- Uniformly graded, washed, crushed stone



Subsurface infiltration systems are installed on and surrounded by a layer of uniformly graded washed, 1.5-inch crushed stone with a void space of approximately 40%. The void space within the aggregate is conventionally counted as part of the storage volume of the system. The crushed stone should be isolated from adjacent soils with a permeable, non-woven geotextile fabric in accordance with the manufacturer's recommendations.

Subsurface infiltration systems are not preferred by MassDOT on typical projects because they can be difficult to inspect, maintain, and repair. However, these systems may be preferable for projects that create a large amount of impervious area such as new parking lots or rest areas. If a subsurface infiltration system is needed, the design should include accommodations for access and maintenance, including access manholes, observation/monitoring wells, and cleanout ports as necessary.

Accessories

- Observation/monitoring wells
- Cleanout ports

Pretreatment

- Pretreatment is required.
- Refer to Pretreatment and Design Criteria (**Section 4.8.2**) for infiltration SCMs.

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Design Guidance for Infiltration SCMs (**Section 4.8**)

Storage Volume

Provide a storage volume equal to the structure volume plus void space within the crushed stone below the lowest level outlet to achieve compliance with the following, as applicable:

- Standard 3 (Recharge)
- Standard 4 (Water Quality)

Design the volume and outlet control structure(s) to achieve compliance with:

- Standard 2 (Peak Rate Attenuation)

Follow requirements provided by the WQDF to meet impaired waters and TMDL goals.

Design References

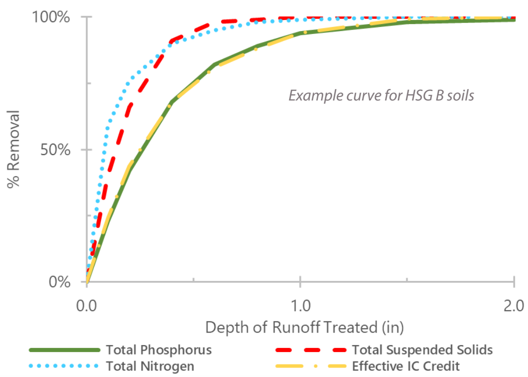
MassDOT PDDG, Chapter 8.[93]

93 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

4.2.5 Porous Pavement

MassDEP Equivalent SCM = Porous Pavement (exfiltrating)

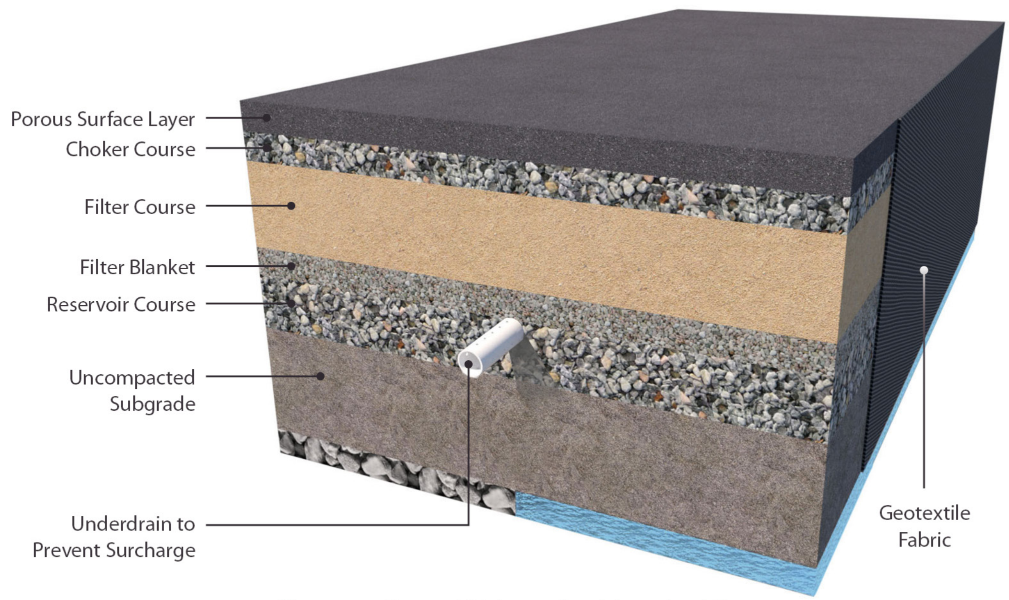
MassDEP TSS Treatment Credit:
80% if stores the WQV and drains within 72 hours



Porous pavement is a pavement system designed to allow stormwater to infiltrate through a permeable surface, base, and sub-base. Porous pavement systems provide water quality treatment through filtration and infiltration mechanisms. MassDOT's preferred design for porous pavement is as an exfiltrating system with an underdrain within the reservoir layer to prevent surcharge conditions.

Porous pavement design should be coordinated with the MassDOT Pavement Management Section.

In general, surface material may consist of porous hot-mix asphalt or porous cement concrete where the aggregate is uniformly graded to produce interconnected voids.



The composition and thickness of each layer should be coordinated with the MassDOT Pavement Management Section.

The base and sub-base materials function as structural support to the roadway and include a choker course, a filter course, a filter blanket, a storage (reservoir) course, and an underdrain. The porous pavement system should be isolated from adjacent soils with a permeable, non-woven geotextile fabric placed vertically along the sides. Use of a geotextile fabric under the reservoir course is typically not recommended due to potential for clogging; however, fabric is sometimes warranted to prevent the mixing of crushed stone and underlying native soil for site-specific reasons.

Porous pavement may be used in areas where the pavement will remain relatively free of accumulated solids and where heavy vehicles are prohibited and sharp turning movements are not possible. Examples of such areas include sidewalks, pathways not intended for motor vehicle use, or park and ride lots for passenger cars only. Porous pavement is not suitable for use in areas defined as Land Uses with Higher Potential Pollutant Loads (LUHPPLs)[94] or Critical Areas (Standard 6) and should not be used in areas that need winter sanding. If a construction project occurs adjacent to porous pavement, erosion and sediment (E&S) controls must be rigorously controlled to prevent sedimentation and clogging.

Accessories

- Observation/monitoring wells
- Underdrain
- Cleanout ports

Pretreatment

- Pretreatment is provided within the SCM before water infiltrates to underlying soils.
- May be used in soils with Rapid Infiltration Rates (saturated hydraulic conductivity >2.4 in/hr)

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Design Guidance for Infiltration SCMs (**Section 4.8**)

Limit run-on to the porous pavement to reduce the likelihood and rate of failure. Porous pavement should not treat an area larger than its own footprint.

Siting and Design Criteria (continued)

On sloped sites, consider vertical, impermeable barriers within the filter and reservoir courses to prevent breakout.

Design the layout to safely accommodate overflows for the 10-year, 24-hour design event (may need catch basins and outlets).

Aggregate Design

Materials
Consult with MassDOT Pavement Management Section

Choker Course
Thickness = 4–8 inches, uniformly graded, washed, crushed stone

Filter Course
Thickness = 8–12+ inches, poorly graded sand or bankrun gravel

Filter Blanket
Thickness ≥ 3 inches, pea stone gravel

Reservoir Course
The depth of the reservoir course must be sized to fully store the entire WQV, ReV, and/or DSV, whichever is greatest, in the void spaces of the crushed stone.

Total Thickness
≥ 65% of the frost depth

Storage Volume

Provide a storage volume within the void space of the reservoir course below the invert of the overflow underdrain to achieve compliance with the following, as applicable:

- Standard 3 (Recharge)
- Standard 4 (Water Quality)

Follow requirements provided by the WQDF to meet impaired waters and TMDL goals.

Design References

- University of New Hampshire Stormwater Center. UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds. Durham, NH. 2016.[95]
- MassDOT PDDG, Chapter 9[96]

94 See definition of LUHPPLs in **Section 2.2.1**.

95 See UNH Design Specifications at: https://extension.unh.edu/stormwater-center/pubs-specs-info

96 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

4.3 Stormwater Wetland SCMs

Stormwater wetland SCMs are designed to mimic natural wetland systems by providing water quality treatment through several mechanisms, such as settling, physical and chemical sorption, microbial and vegetative uptake, and storage.

Individual designs must consider site-specific information relative to watershed hydrology, groundwater hydrology, site soils conditions, and hydraulic behavior of receiving waters.

MassDOT projects may use the following wetland SCMs:

- Constructed stormwater wetland (CSW)
- Gravel wetland

A stormwater wetland SCM mimics a natural wetland system.

This section provides guidance for developing four types of CSW designs. The variations in the designs make it possible for CSWs to function in a range of site conditions. The variations also include enhancements that may be used to meet other design goals, such as peak rate control.

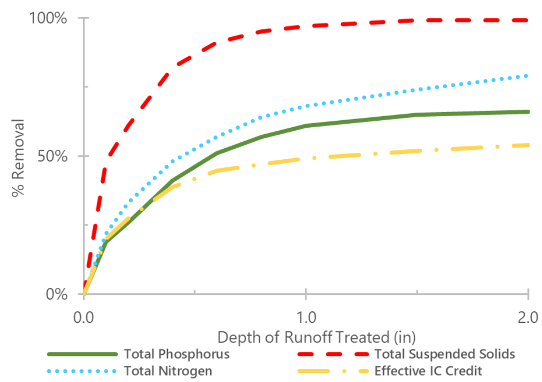
A gravel wetland is designed with a subsurface gravel reservoir to enhance water quality treatment through microbial uptake.

Massachusetts Wetlands Protection Act (WPA) Regulations explicitly prohibit CSWs and gravel wetlands from qualifying as "wetland replications." They are not considered wetlands under the jurisdiction of federal, state, or local agencies and may not be used to meet project replication requirements.

Constructed stormwater wetland in good working order © Horsley Witten Group

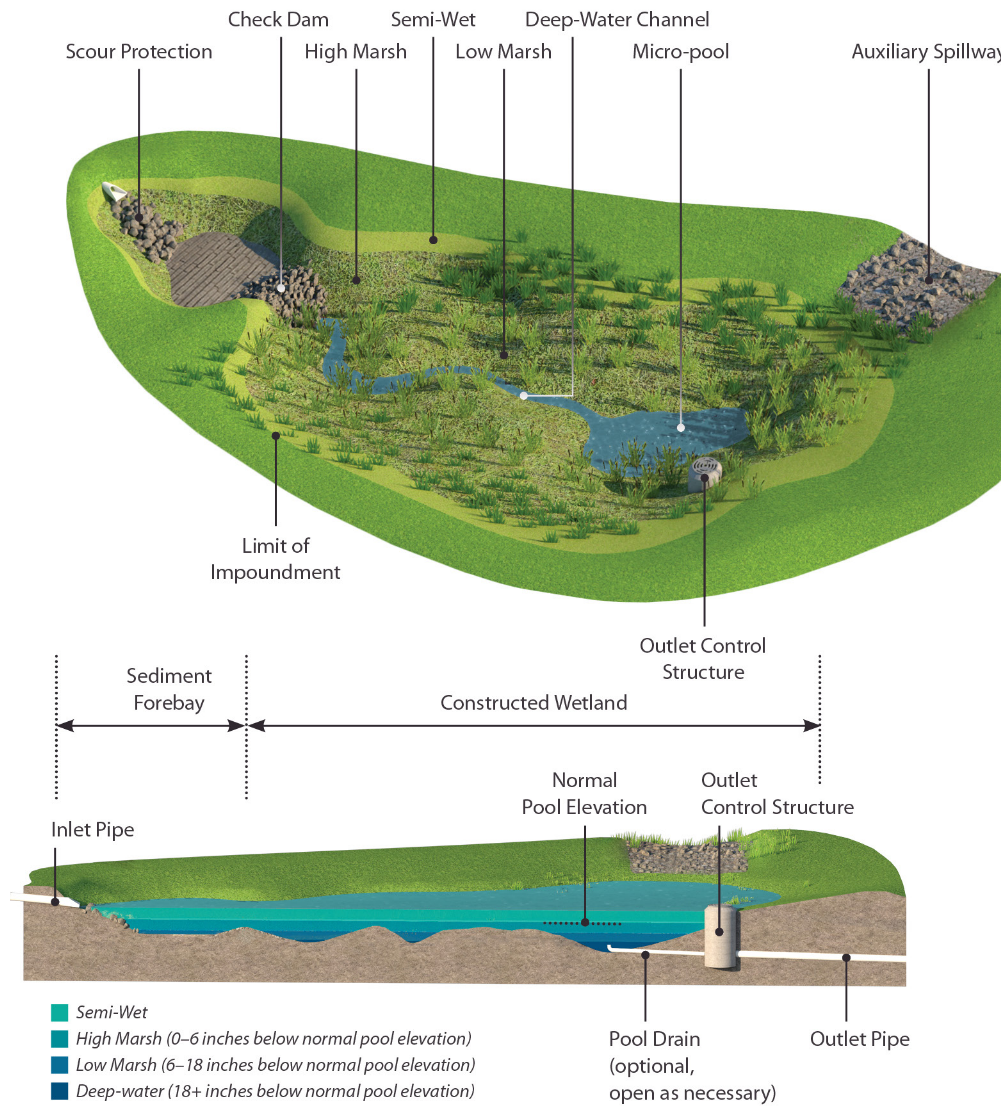
4.3.1 Constructed Stormwater Wetland

MassDEP TSS Treatment Credit:
80% with sediment forebay



A CSW is a basin designed to simulate wetland conditions. It consists of a sediment forebay and basin that provide zones of varied and diverse moisture and vegetation conditions. At least 75% of the CSW area should consist of hydrophytic vegetation.

CSWs can be sited as an in-line or off-line component of a stormwater treatment train. The CSW must be sited in an area where stormwater inflows or groundwater levels are sufficient to maintain a permanent pool of water (normal pool elevation) during all seasons. If the CSW cannot be sustained by groundwater, the designer may consider a low-permeability liner or choose a different SCM (e.g., bioretention).



Variations to the surface area and volume of each wetland design zones result in unique wetland systems that can meet variations in site-specific design requirements. Four common types of CSW designs are:

- Shallow marsh systems
- Basin/wetland systems
- Extended detention systems
- Pocket wetlands

If no liner is used, project documentation should include a water budget to demonstrate that the design range of water levels can be sustained by normal groundwater and surface flows. The designer should use the Thornthwaite Method[97] or equivalent method to develop the water budget.

Accessories

- Check dams
- Inlet and outlet treatments
- Low-permeability liner (if necessary)

Pretreatment

A sediment forebay is required as an integral part of the design.

See **Table 4-3** for specific requirements for sediment forebays for each of the four common types of design.

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Design Guidance for Basins (**Section 4.9**)
- Must be sited in an area where stormwater inflow or groundwater can maintain a permanent pool during all seasons unless a liner is used
- Not allowed within clear zones

Design characteristics common to all wetland types:

- Length to width ratio: ≥ 2:1

Siting and Design Criteria (continued)

If a deep-water feature is included in the design, include a safety bench around the permanent pool. Safety benches should be designed 10 feet wide with a slope of 10 horizontal to 1 vertical (10H:1V) at, or just above, normal pool elevations.

Common CSW design types:

Shallow marshes are designed with sinuous low-flow channels that link low and high marsh cells. They provide a high level of water quality treatment and occupy a relatively large footprint. Most of the surface area is occupied by high and low marsh which is where the WQV and/or DSV is stored (0-18 inches below the normal pool elevation).

Basin/wetland systems are composed of several cells in series, including a sediment forebay, a wet basin, and a shallow marsh. The basin/wetland system occupies a smaller footprint than a shallow marsh system and provides a high level of water quality treatment. Most of the surface area is occupied by, and most of the WQV and/or DSV is stored in, deep-water areas.

The **extended detention wetland** is ideal for providing a high level of water quality treatment for locations where peak flow attenuation may be required. Most of the surface area is occupied by marsh, but most of the WQV and/or DSV is stored and controlled above the normal pool in the typically dry areas. The detention time should be between 12-24 hours and water levels should return gradually to normal within 24 hours of the rain event.

Pocket wetlands are ideal for small contributing areas. Most of the surface area is occupied by high and low marsh, and the WQV and/or DSV is stored between those marsh elevations (0-18 inches below the normal pool elevation). There are no deep-water areas.

See **Table 4-3** for design parameters for each wetland type.

97 Thornthwaite, C.W. *An Approach Toward a Rational Classification of Climate*. Geographical Review, Vol. 38, 1948, pp. 55-94. http://www.brr.cr.usgs.gov/projects/SW_MoWS/Thornthwaite.html

Wetland Design Zones

Design zones for stormwater wetlands include:

Deep-water Zone
The deep-water zone is located between 1.5 and 6 feet below the elevation of the normal pool.

Components of the constructed wetland that make up the deep-water zone may include the forebay, the micro-pool, and the deep-water channels.

The micro-pool has a depth between 1.5 and 6 feet and is located near the outlet.

Floating vegetation may also occupy the deep-water zone.

Low Marsh Zone
The low marsh zone is located between 6 and 18 inches below the elevation of the normal pool. Some emergent wetland plant species occupy the low marsh zone.

High Marsh Zone
The high marsh zone is located between 0 and 6 inches below the elevation of the normal pool. Emergent wetland plant species will occupy the high marsh zone more densely than the low marsh zone.

Semi-Wet Zone
The semi-wet zone is located just above the elevation of the normal pool and is intermittently inundated by stormwater. The semi-wet zone will support the growth of wetland plants.

Construction stormwater wetland © VHB

Wetland Vegetation Design

The wetland vegetation design should be performed by a qualified wetland scientist. The designer should consult the Natural Resources Conservation Service (NRCS) plant database to aid in plant selection.

In general, the vegetation design should:[98]

- Specify species that are adaptable to the applicable range of depth/ frequency/duration of inundation and local sunlight conditions
- Prioritize perennial species that establish themselves rapidly
- Establish successional species (i.e., woody species) after herbaceous species

Species listed by the Massachusetts Invasive Plants Advisory Group (MIPAG) as "Invasive, Likely Invasive, or Potentially Invasive" should not be included.[99] Avoid woody plants that are known wildlife herbivory preferences. Consult with MassDOT Landscape Design Section for typical specifications.

Storage Volume

Provide a storage volume consistent with **Table 4-3** to achieve compliance with the following:

- Standard 4 (Water Quality)

Design the volume and outlet control structure(s) to achieve compliance with:

- Standard 2 (Peak Rate Attenuation)

Follow requirements provided by the WQDF to meet impaired waters and TMDL goals.

98 See NRCS Plants Database at: https://plants.usda.gov/home

99 See Massachusetts Invasive Plants Advisory Group (MIPAG) Species Lists at: https://www.massnrc.org/mipag/

Table 4-3. MassDEP Design Criteria for Constructed Stormwater Wetlands

Design Parameter	TYPE OF CONSTRUCTED STORMWATER WETLAND			
	Shallow Marsh	**Basin/Wetland**	**Extended Detention Wetland**	**Pocket Wetland**
Constructed Wetland Surface Area (SA)[A] to Drainage Area Ratio	≥ 0.02	≥ 0.01	≥ 0.01	≥ 0.01
Primary Spillway	See Design Guidance for Basins (**Section 4.9**). Consider a multi-stage outlet control structure.			See Auxiliary Spillway design criteria
Extended Detention[B]	Not Allowed	24 – 72 hours[C]	24 – 72 hours	24 – 72 hours[C]
Allocation of Surface Area (%) (wet pool[D]/low marsh/high marsh/semi-wet)	15 / 40 / 40 / 5	45 / 25 / 25 / 5	10 / 40 / 40 / 10	10 / 45 / 40 / 5
Allocation of WQV (%) (wet pool/low and high marsh/extended detention)	30 / 70 / 0	70 / 30 / 0 *See E*	20 / 30 / 50	20 / 80 / 0 *See E*

Target Allocations by Zone	% SA	% WQV	% SA	% WQV	% SA	% WQV	% SA	% WQV
Sediment Forebay[E]	5	10	*See F*		5	10	5	10
Micro-pool	5	10	5	10	5	10	5	10
Deep-water Channel[G]	5	10	40	60	0	0	0	0
Low Marsh	40	45	25	20	40	20	45	55
High Marsh	40	25	25	10	40	10	40	25
Semi-wet	5	0	5	0	10	50	5	0

A The constructed wetland surface area includes the wet pool, deep-water, high and low marshes, and the semi-wet zones.

B Extended detention volume is the additional volume above the WQV (except for the extended detention wetland, which is treated differently).

C Optional.

D Wet pool = sediment forebay + micro-pool + deep-water zones.

E Values for the % WQV assume that the water quality volume depth is 1 inch. For locations where the WQV depth is 0.5 inches, assume 10% of the WQV must be provided in the sediment forebay and the rest may be provided in the constructed wetland.

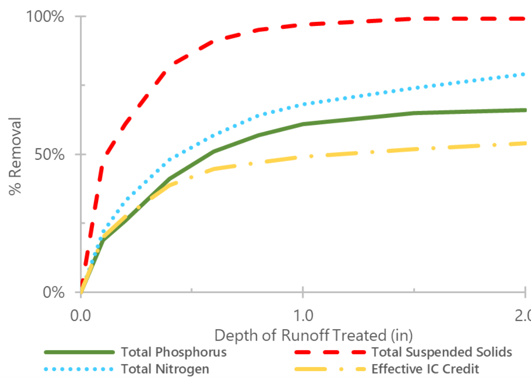
F Basin/wetland forebay: Forebay storage must not be counted as part of the WQV provided by the constructed wetland. The sediment forebay should be sized to treat a volume equal to or greater than 0.1-inch x Impervious Area.

G Included as part of the "basin" volume in basin/wetland design.

4.3.2 Gravel Wetland

MassDEP TSS Treatment Credit:

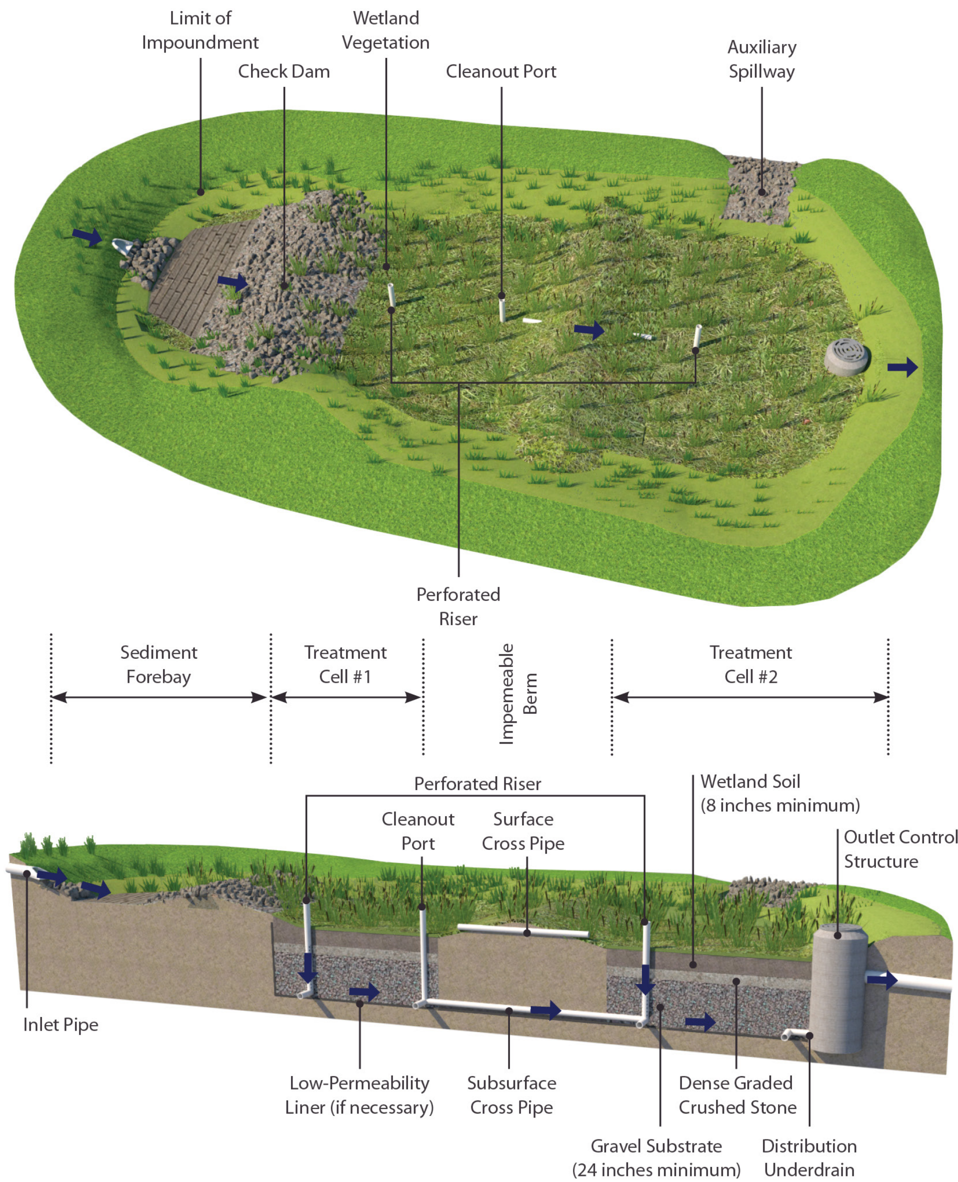
80% with sediment forebay



A gravel wetland is a surface basin with subsurface components. It consists of a sediment forebay and a basin with one or more subsurface treatment cells located in series. Cells consist of a layer of wetland soil, dense-graded crushed stone, and "gravel" substrate (crushed stone). Treatment occurs in each cell as stormwater passes horizontally through the anaerobic, microbe-rich, gravel substrate.

Near the surface of gravel wetlands, oxygen exchange with the atmosphere provides an aerobic treatment environment. Subsurface components provide an anaerobic treatment environment.

A typical gravel wetland is designed to be continuously saturated with water at a depth that begins 4 inches below the surface. If underlying soils are very permeable, a low-permeability liner or a soil layer with low hydraulic conductivity should be used to minimize infiltration, preserve horizontal flow through the gravel, and maintain the wetland vegetation of the gravel wetland.



If no liner is used, project documentation should include a water budget to demonstrate that the design range of water levels can be sustained by normal groundwater and surface flows. Use the Thornthwaite Method[100] or equivalent method to develop the water budget.

Existing extended dry detention basins can be retrofitted with the use of a low-permeability liner and converted into gravel wetlands if a higher level of water quality treatment is desired.

Accessories

- Check dams
- Inlet and outlet treatments
- Low-permeability liner (if necessary)
- Cleanout ports
- Observation/monitoring wells

Pretreatment

A sediment forebay is required as an integral part of the design.

Gravel wetland © MassDOT

100 Thornthwaite, C.W. *An Approach Toward a Rational Classification of Climate*. Geographical Review, Vol. 38, 1948, pp. 55-94. Available online at: http://www.brr.cr.usgs.gov/projects/SW_MoWS/Thornthwaite.html

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Design Guidance for Basins (**Section 4.9**)

Gravel wetlands can be potentially located in areas with:

- Poorly drained soils
- Soil contamination (with the use of a low-permeability liner)
- High groundwater

Treatment cells can also be stepped/terraced to meet site grades.

Treatment cell(s) should be constructed with the following:

- Thickness of soil layer: ≥ 8 inches
- Thickness of dense-graded crushed stone layer: ≥ 3 inches
- Thickness of gravel substrate layer (uniformly graded, washed, crushed stone with a median ¾-inch diameter): ≥ 24 inches

The University of New Hampshire Stormwater Center recommends gravel wetlands adhere to the following specifications:

- Outlet invert elevation: 4–8 inches below the wetland soils surface
- Residence time: 24–30 hours
- Horizontal travel distance: ≥ 15 feet

The gravel substrate may be isolated from adjacent soils with a low-permeability liner depending on site specific conditions.

Wetland Vegetation Design

The wetland vegetation design should be performed by a qualified wetland scientist. The designer should consult the NRCS plant database to aid in plant selection. In general, the vegetation design should:[101]

- Specify species that are adaptable to:
  - › The applicable range of depth/ frequency/ duration of inundation
  - › Local sunlight conditions
- Prioritize perennial species that establish themselves rapidly
- Establish successional species (e.g., woody species) along with herbaceous species, if desirable

Species listed by the Massachusetts Invasive Plants Advisory Group (MIPAG) as "Invasive, Likely Invasive, or Potentially Invasive" should not be included.[102] Avoid woody plants that are known wildlife herbivory preferences. Consult with MassDOT Landscape Design Section for typical specifications.

Storage Volume

Provide a storage volume to achieve compliance with the following:

- Standard 4 (Water Quality)
  - Pretreatment: 10% of the WQV
  - Treatment cell(s): 90% of the WQV

Design the volume and outlet control structure(s) to achieve compliance with:

- Standard 2 (Peak Rate Attenuation)

Follow requirements provided by the WQDF to meet impaired waters and TMDL goals.

Gravel wetland © VHB

Design References

University of New Hampshire Stormwater Center. UNHSC Subsurface Gravel Wetland Design Specifications. Durham, NH.[103]

101 See NRCS Plants Database at: https://plants.usda.gov/home

102 See Massachusetts Invasive Plants Advisory Group (MIPAG) Species Lists at: https://www.massnrc.org/mipag/

103 See UNH Design Specifications at: https://extension.unh.edu/stormwater-center/pubs-specs-info

4.4 Bioretention SCMs

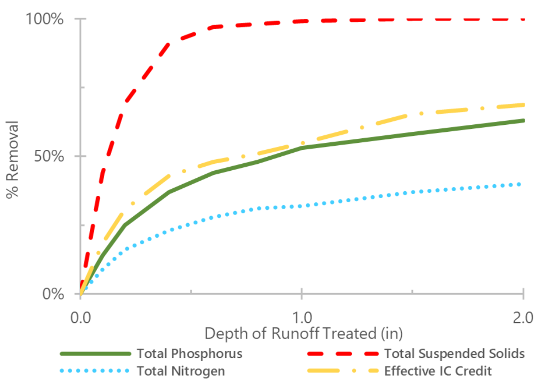
Bioretention practices provide water quality treatment through filtration of stormwater using vegetation and engineered soil media.

Bioretention practices should be considered at locations where a high level of water quality treatment is desired but infiltration is not practical (e.g., poorly draining soils).

4.4.1 Bioretention Area and Bioretention Linear Practice

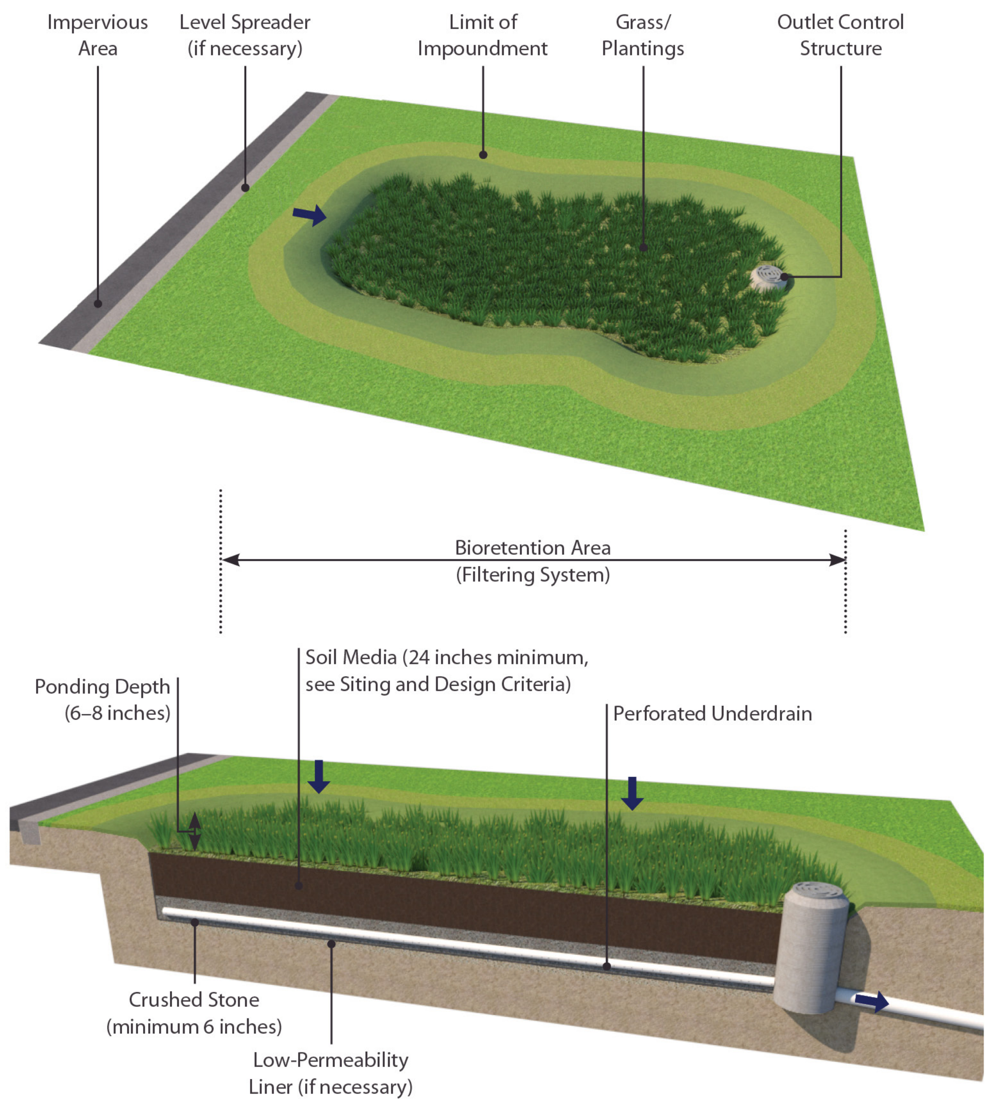
MassDEP TSS Treatment Credit:

90% with adequate pretreatment



This section presents bioretention areas and bioretention linear practices together. Both configurations are designed to provide water quality treatment by impounding water with either outlet control structures or impermeable check dams and use settling, vegetative uptake, microbial processes, and filtration mechanisms to treat stormwater. Bioretention linear practices are essentially a series of bioretention areas in a linear configuration that use the same filtration mechanisms to provide water

Control Peak Rates | Promotes Recharge | Provides Water Quality Treatment | Surface SCM | Subsurface SCM

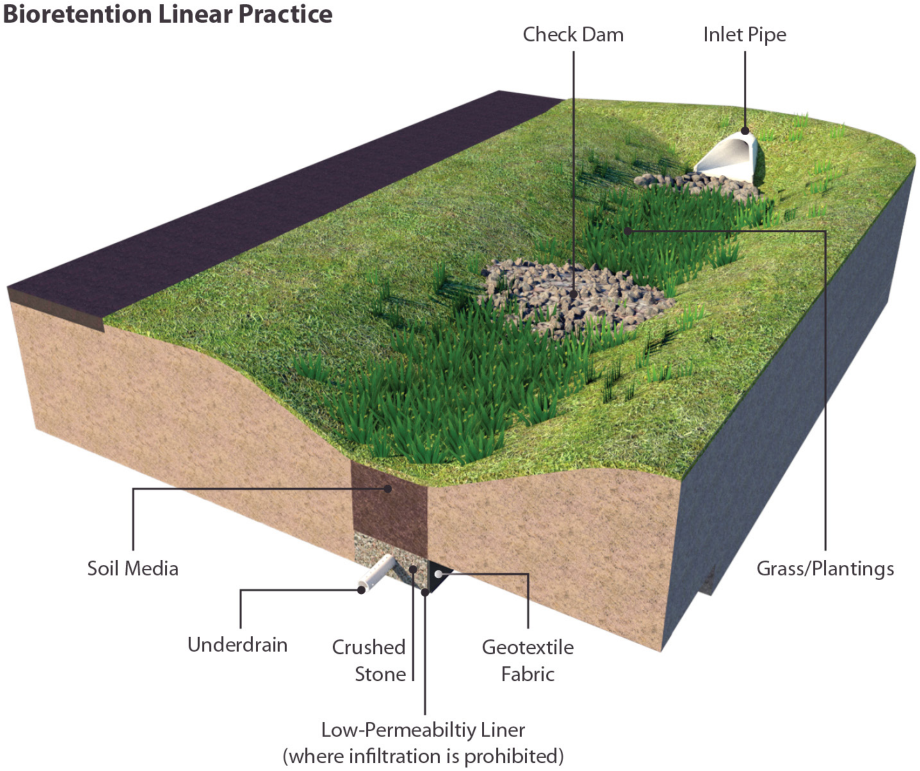


quality treatment. Both configurations are designed to safely bypass larger flows (e.g., 10-year storm).

MassDOT uses bioretention SCMs, with underdrains, in areas that are unsuitable for infiltration (e.g., poorly draining soils, areas where infiltration is prohibited). Bioretention SCMs are especially useful for treatment of roads with country drainage due to the existing stormwater patterns of sheet flow. However, infiltration SCMs are preferred where site conditions allow.

Bioretention requires specialized vegetation and soil media. The planting design element can be used to blend the bioretention area into the landscape. From minimally managed natural landscapes to more manicured urban sites, plant species selection and layout should be consistent with the surroundings. Plants should be drought-resistant, non-invasive, and able to tolerate intermittent ponding and occasional road salts.

Bioretention Linear Practice



Accessories

- Check dams (for linear practices)
- Inlet and outlet treatments (level spreader if necessary)
- Low-permeability liner (where infiltration is prohibited)
- Underdrain

Pretreatment

- Pretreatment is required to prevent clogging from sediment

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Design Guidance for Basins (**Section 4.9**)
- Design Guidance for Linear Practices (**Section 4.10**)

Soil media thickness:

- ≥ 24 inches if plantings include shallow rooted plants and grasses
- ≥ 30 inches if plantings include woody and/or herbaceous shrubs. (Trees should not be planted within bioretention areas if a low-permeability liner is included in the design).
- ≥ 30 inches if the bioretention system is intended to be used for nitrogen removal

Table 4-4 provides guidance on bioretention soil media.

Variations

Tree-box filters are simple media filters that are best suited as a pretreatment or infiltration SCM in ultra-urban areas (see Massachusetts Stormwater Handbook, Vol. 2, Ch. 2). Given the increased importance of O&M for tree-box filters, coordinate with MassDOT Environmental and the post-construction owner to determine if resources will be available for proper O&M before proposing tree-box filters.

Storage Volume

Provide storage volume equal to the void space volume in the soil media, plus the ponding water volume for basins or behind the impermeable check dams, for linear practices to achieve compliance with the following:

- Standard 4 (Water Quality)

Design the volume and outlet control structure(s) to achieve compliance with:

- Standard 2 (Peak Rate Attenuation)

Follow requirements provided by the WQDF to meet impaired waters and TMDL goals.

Design References

University of New Hampshire Stormwater Center. UNHSC Design Specifications for Bioretention Soil Mix. Durham, NH. 2017[104]

Table 4-4. Bioretention Soil Media Characteristics[105]

The bioretention soil media should be uniform, free of stones, stumps, roots, or similar materials larger than 0.187 inches. No compost should be used in the planting mix unless specified by the engineer. The designer should refer to the UNH Bioretention Soil Specification for acceptable soil amendments, except for peat which MassDOT does not use.

Organic Content: 3 to 10% by volume

Soil pH: between 6 and 7

Cation Exchange Capacity (sodium saturation):
Minimum 10 mEq/100 mL at pH of 7.0

Particle Size Distribution:

Particle Type	Particle Size (in)	Percent by Dry Weight
Very Coarse Sand/Gravel	0.079 – 0.187	5% Maximum
Sand	0.017 – 0.079	80–90%
Silt	0.003 – 0.017	15% Maximum
Clay	<0.003	5% Maximum

104 See UNH Design Specifications at: https://extension.unh.edu/stormwater-center/pubs-specs-info

105 Refer to the UNH Design Specifications for additional guidance on bioretention soil media specifications at: https://extension.unh.edu/stormwater-center/pubs-specs-info

4.5 Other SCMs

MassDOT projects use variations of other SCMs that are not as common but still perform a water quality treatment function, control peak rates, or improve existing conditions. These SCMs include:

- Extended dry detention basin
- Wet basin and wet linear practice
- Vegetated riprap

The extended dry detention basin is designed for peak rate control and detains the WQV and/or DSV for an extended period of time to allow solids to settle to the bottom of the basin.

The wet basin or wet linear practice is designed to maintain a permanent pool and is located where groundwater is near the surface. The wet basin provides water quality treatment and peak rate control.

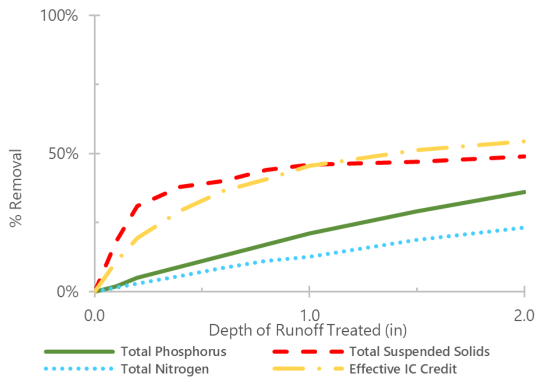
The vegetated riprap is typically used adjacent to bridge abutments to improve existing conditions when no other SCMs are feasible. It does not currently receive water quality treatment credits.

Wet basin © VHB

4.5.1 Extended Dry Detention Basin

MassDEP TSS Treatment Credit:

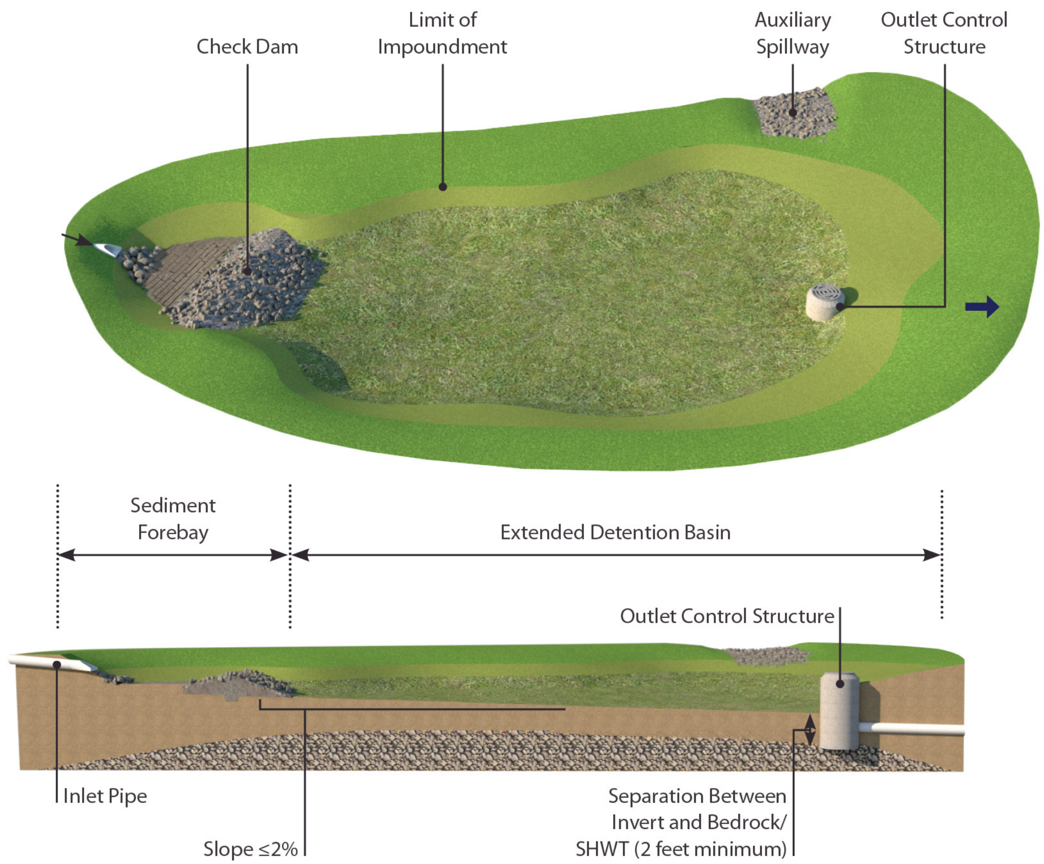
50% with sediment forebay



An extended dry detention basin is a surface impoundment designed to detain the WQV and/or DSV for a duration of 24 to 72 hours. The extended detention period provides some pollutant removal through settling and is therefore eligible for water quality treatment credit.

An extended dry detention basin has limited capacity to capture sediment and should only be used if the reduction of peak rates is the primary objective, not water quality treatment. Extended dry detention basins cannot be used for discharges to areas defined as Critical Areas.

A low-permeability liner is required if incidental infiltration is not permitted (e.g., if pretreatment requirements are not met for soils with Rapid Infiltration Rates or areas affected by LUHPPLs). An underdrain may also be required to meet drawdown requirements.



Accessories

- Check dams
- Inlet and outlet treatments
- Low-permeability liner (if necessary)
- Underdrain (if necessary)
- Staff gauge

Pretreatment

A sediment forebay is required as an integral part of the design.

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Design Guidance for Basins (**Section 4.9**)
- Longitudinal slope ≤ 2%
- Length to width ratio of basin: ≤ 2:1
- WQV and/or DSV drawdown is 24 – 72 hours. Minimum 24 hours allows time for coarse and finer particulates to settle.

Storage Volume

Provide a storage volume within the basin to achieve compliance with Standard 4 (Water Quality). The low-flow orifice should be sized to provide a minimum detention time of 24 hours for the brimful WQV and/or DSV; that is, with the discharge beginning from storage of the full WQV/DSV until the entire volume drains out of the basin.

Design the volume and outlet control structure(s) to achieve compliance with:

- Standard 2 (Peak Rate Attenuation)

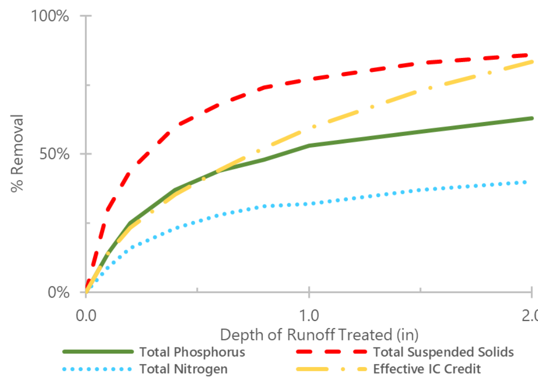
Follow requirements provided by the WQDF to meet impaired waters and TMDL goals.

Extended detention basin and outlet control structure © MassDOT

4.5.2 Wet Basin and Wet Linear Practice

MassDEP TSS Treatment Credit:

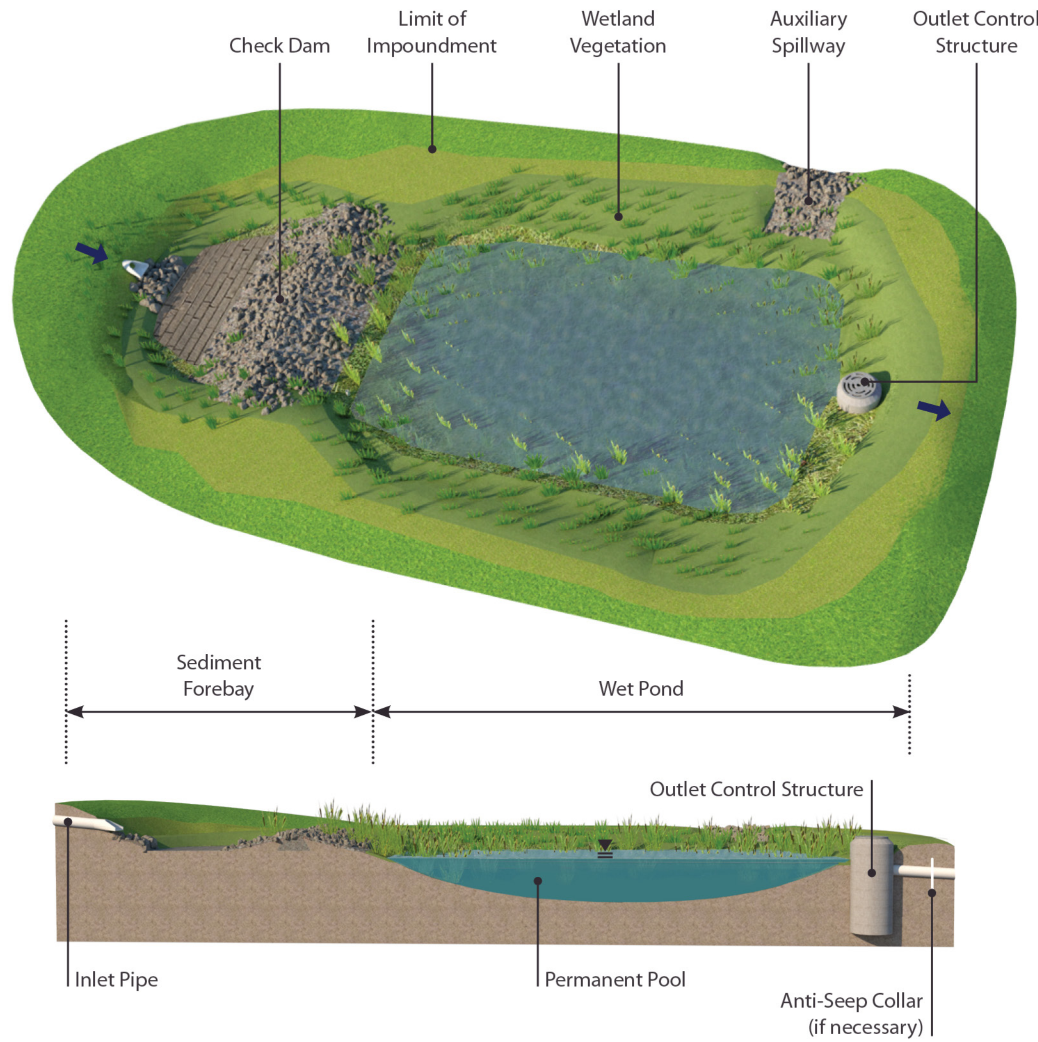
80% with sediment forebay



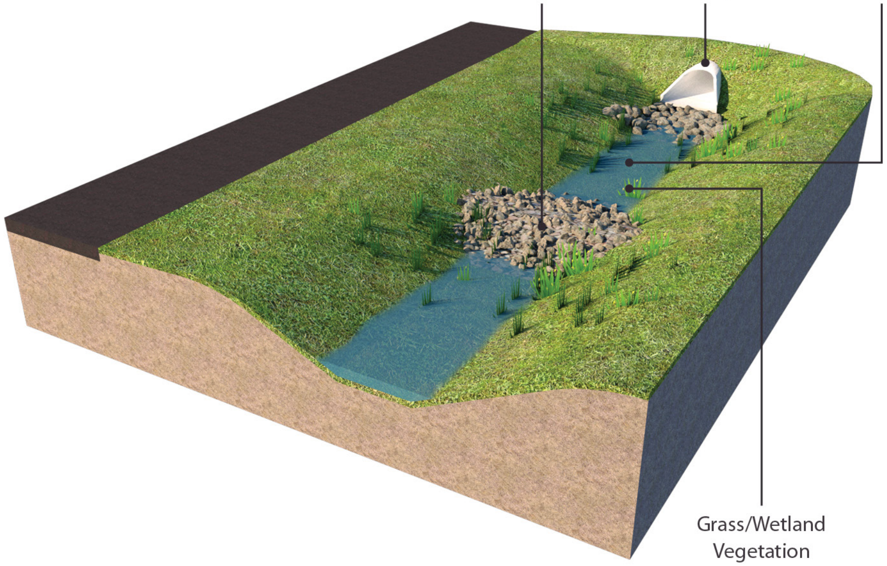
Wet basins and wet linear practices are presented together in this section. Both configurations are designed to maintain a permanent storage volume and detain stormwater to attenuate peak discharge rates. Wet linear practices are essentially a series of wet basins in a linear configuration that use the same settling and storage mechanisms as basins to provide pollutant removal. Both configurations are designed to safely bypass larger flows (e.g., 10-year storm).

Wet SCMs should ideally be sited in areas where stormwater inflows or groundwater levels are sufficient to maintain a permanent pool of water at least most of the year.

At locations that are inadequate for infiltration (e.g., less than two feet of separation to SHWT) but would not support a CSW (e.g., groundwater table does not supply a year-round, constant water level), wet SCMs should be considered. At these locations, the wet SCM may function as an infiltration SCM during drier months and provide benefits, including increased groundwater recharge and water quality treatment.



Wet Linear Practice




Wet basin © MassDOT

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Design Guidance for Basins (**Section 4.9**)
- Design Guidance for Linear Practices (**Section 4.10**).
- Permanent pool average depth: 3–6 feet
- Permanent pool maximum depth: 8 feet
- Not allowed within clear zones

If a deep-water feature is included in the design, include a safety bench around the permanent pool. Safety benches should be designed 10 feet wide with a slope of 10H:1V at, or just above, normal pool elevations. Fencing around SCMs should be minimized, but if a safety bench is unable to be included or there are additional perceived safety hazards, a fence must be included.

Storage Volume

Provide a storage volume within the basin or behind the impermeable check dams of the linear practice to achieve compliance with the following:

- Standard 4 (Water Quality):
  permanent pool volume ≥ 2 times the WQV

Design the volume and outlet control structure(s) to achieve compliance with:

- Standard 2 (Peak Rate Attenuation)

Follow requirements provided by the WQDF to meet impaired waters and TMDL goals.

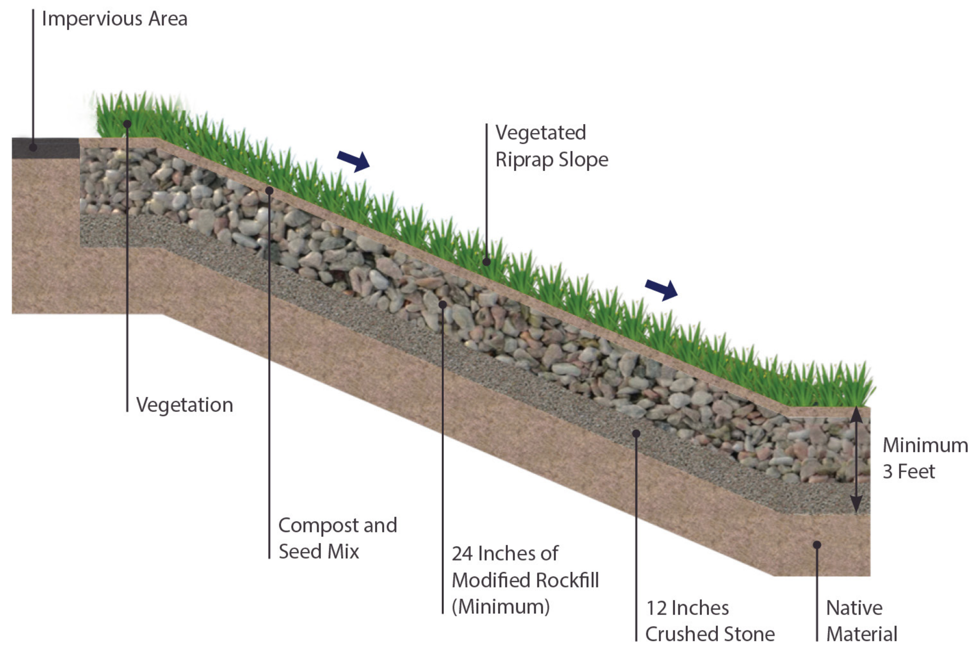
4.5.3 Vegetated Riprap

Does not currently receive water quality treatment credit but improves existing conditions.

Vegetated riprap, also referred to as "compost over modified rockfill," is used to reduce the quantity and improve the quality of stormwater runoff along riprap or rockfill roadway embankments that receive sheet flow.

Vegetated riprap is constructed by covering a modified rockfill embankment with a layer of compost mulch mixed with seed. Vegetation that grows within the rockfill increases evapotranspiration, promotes infiltration, cools runoff by shading the rock surface, and improves riparian habitat. The slope of the fill material may be modified to include pockets where trees and shrubs may be planted to provide additional shading.

This SCM is most often used to improve existing conditions on redevelopment projects and to reduce the thermal impacts of runoff to cold-water fisheries.



Accessories

Inlet and outlet treatments (level spreader, if necessary)

Siting and Design Criteria

- Design Guidance for All SCMs (**Section 4.7**)
- Preferred in areas that discharge to cold-water fisheries (Standard 6)
- To reduce potential for scour, the compost mulch and vegetation must not extend below the elevation of Ordinary High Water.
- If directly discharging to a water body, slope design and vegetation require special considerations, and the designer should coordinate with MassDOT Environmental and Landscape Design Sections.
- The compost mulch should be a low-phosphorus mix and soluble salts should not exceed 5.0 mmhos/cm (dS/m).
- Thickness of compost mulch layer ≥ 3 inches

Design References

The designer should consult with the MassDOT Landscape Design Section for guidance on appropriate compost mulch and seed specifications.

4.6 SCM Accessories

This section presents the accessories identified in each SCM information sheet that the designer may integrate into the design. Refer to MassDOT Standard Specifications for more details on SCM accessories.[106] The accessories presented include:

- Check dam
- Inlet and outlet treatment
- Low-permeability liner
- Subsurface accessories
- Staff gauge
- Oil/grit separator

4.6.1 Check Dam

Many SCMs call for earthen or stone berms to either contain stormwater or to control the flow of stormwater through or out of the SCM. Different types of berms, designed and constructed to perform different functions, may include embankments, spillways, and check dams. Embankment and spillway design principles are described in Design Guidance for Basins (**Section 4.9**). Check dam design principles are described below.

A check dam is a permeable or impermeable berm placed within a SCM, often between sediment forebays and downstream SCMs. They are also used within basins and linear practices to control the orientation of the flow path and the velocity of flow through the respective SCM.

Check dams placed within basins and linear practices should not cause undesirable tailwater conditions or surcharge conditions. In addition, they should not be placed within or affect a regulated natural resource area.

Check dams may be constructed out of earth or stone, and their surface may be stone or vegetated. Vegetated surfaces are preferred in applications where mowing is required (e.g., highway medians and in clear zones). Stone surfaces are preferred in applications where overflow velocities may be erosive to vegetative cover or where the ability to mow around/outside clear zones is limited.

106 See MassDOT Standard Construction Specifications at: https://www.mass.gov/lists/construction-specifications

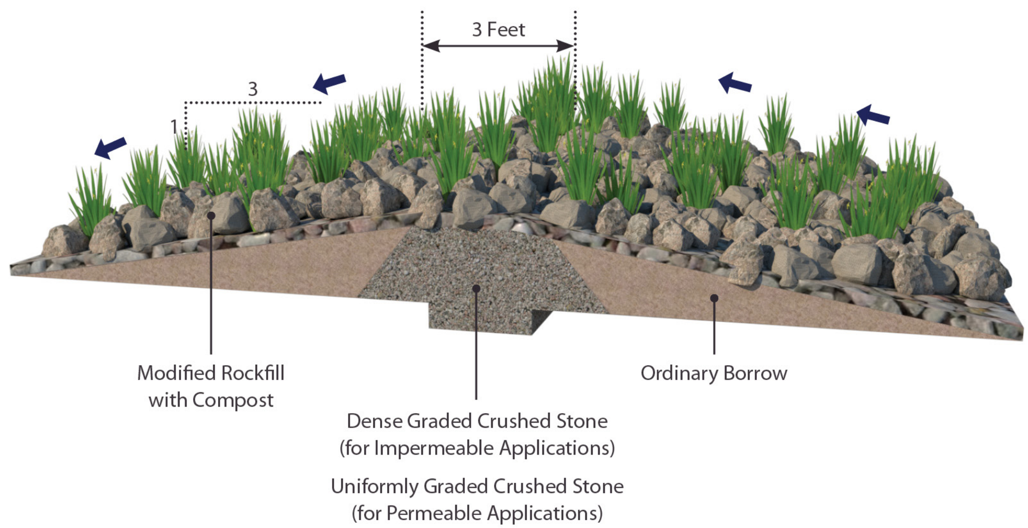
Impermeable check dams are designed to hold water and prevent flow through the berm to promote infiltration to groundwater. The impermeable core is constructed of a low-permeability, dense-graded crushed stone.

Permeable check dams are designed to allow flow to percolate through the berm. Use of permeable check dams is appropriate in cases where the upgradient SCM must be designed to dewater in a certain period of time and infiltration to groundwater is not possible.

Four variations of check dam design are described and shown below for illustrative purposes.

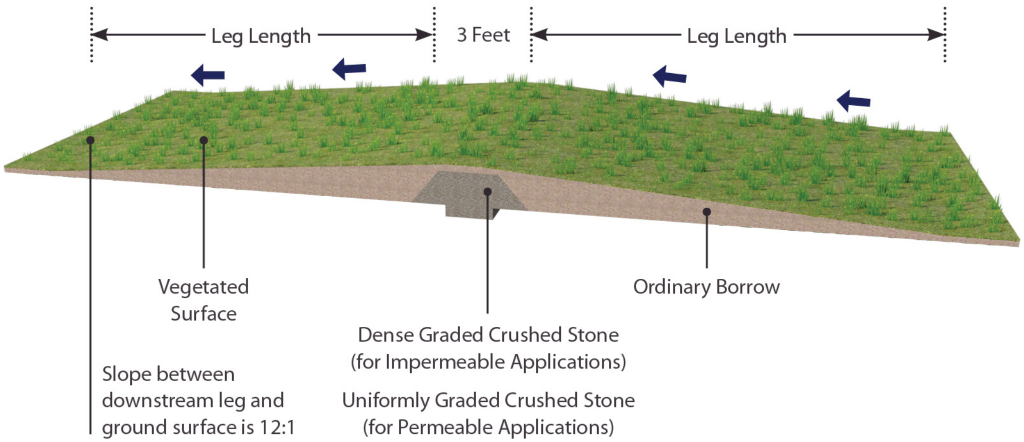
Variation	Allowed in Clear Zone	Surface Material	Core
1	No	Modified Rockfill	Dense-graded crushed stone
2	No		Uniformly graded crushed stone
3	Yes	Vegetation and Soil	Dense-graded crushed stone
4	Yes		Uniformly graded crushed stone

Check Dam Variations 1 and 2



Check dam variations 1 and 2 should have a maximum longitudinal slope of 3H:1V and are not allowed within clear zones. Clear zone widths depend on traffic volumes and speeds and on roadside geometry as described in Section 5.6 of the PDDG.[107] Check dam variations 1 and 2 are allowed behind guardrail, but there should be 10 feet of separation between the edge of check dam and guard rail to allow for mower access. If 10 feet of separation to the guard rail cannot be attained, the maximum longitudinal slope should be 6H:1V to allow a mower to drive over them.

Check Dam Variations 3 and 4



Check dam variations 3 and 4 are allowed within clear zones if they are designed in compliance with MassDOT Engineering Directive E-20-003.[108] Further information is provided in **Section 4.7.3.3**. To minimize potential hazards, check dams within clear zones have the following requirements:

- Slope is 12H:1V between the downstream check dam leg and ground surface.
- Length of check dam legs is determined based on slope of the linear practice:

Linear Practice Slope (%)	Leg Length (Feet)
0 - 2.8	24
>2.8 - 5.0	36

107 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

108 See MassDOT Highway Engineering Directive E-20-003 (20 Feb. 2020) at: https://www.mass.gov/doc/location-and-design-of-stormwater-bmps/download

Infiltration linear practice with check dams behind guard rail © VHB

4.6.2 Inlet and Outlet Treatment

Stormwater management systems typically require special treatment at discharge locations, where stormwater flow transitions between closed and open systems, or between subsurface and surface SCMs. These inlet and outlet treatments may be combined as necessary to provide controlled, non-erosive transitions within, or at the terminus of, a stormwater system:

- Paved waterways
- Flared end sections and aprons
- Level spreaders
- Plunge pools

Inlets, outlets, and associated erosion control and energy-dissipation treatments should be designed to accommodate the hydraulic conditions anticipated during the design event without causing scour or erosion to vegetated or earthen surfaces.

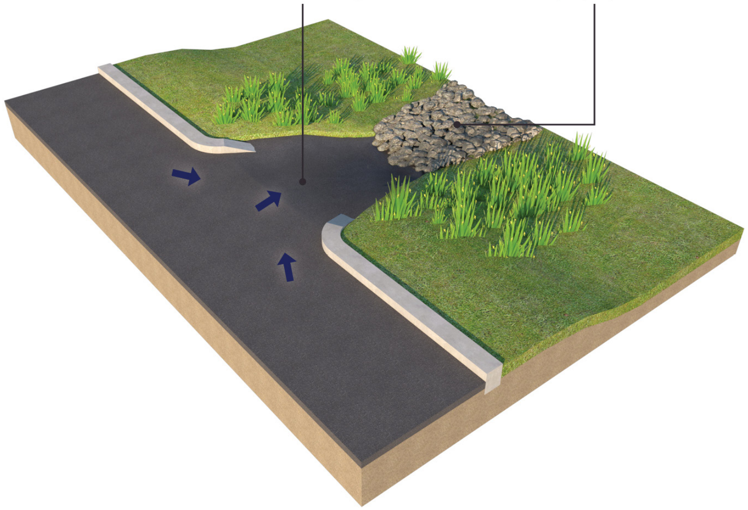
MassDOT stormwater infrastructure must be designed to convey a minimum of the 10-year, 24-hour design event.

This section addresses typical inlet and outlet measures and associated energy-dissipation structures that MassDOT uses in roadway stormwater management systems. Refer to the following resources for in-depth design guidance on inlet and outlet treatments:

- MassDOT PDDG, Chapter 8[109]
- HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channels[110]

4.6.2.1 Paved Waterway

Paved waterways are sloped, hardened surfaces that MassDOT uses to convey stormwater from the edge of a roadway down a slope to an adjacent receiving area such as a vegetated area, receiving water, treatment SCM, or to be collected by drainage infrastructure. Paved waterways may be placed at curb-cuts along roadways that have curb edge treatments or at locations where stormwater flow will concentrate along roadways that have no curb edge treatments. Paved waterways are often combined with stone aprons in areas where flow velocities at the end of the paved waterway may be erosive to the receiving area.



109 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

110 See HEC-14 Hydraulic Design of Energy Dissipators for Culverts and Channels (Jul. 2006) at: https://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=13&id=129

4.6.2.2 Flared End Section and Apron

Flared end sections are structures (typically precast concrete) attached to pipe ends to transition the pipe to the embankment, provide a non-erosive surface, and spread the flow of stormwater. Aprons are rough, hardened surface treatments placed at pipe ends to dissipate energy, prevent erosion, and reduce the velocity of stormwater. Aprons are typically composed of riprap, or MassDOT Standard Item "Stone for Pipe Ends."

MassDOT commonly uses flared end sections and aprons at pipe outlets within sediment forebays, linear practices, and at outfalls. These practices slope downward and flare outward in the direction of flow. Design parameters include:

- Length, width, and angle of the flared end section
- Length, width, slope and thickness of apron
- Size of riprap material

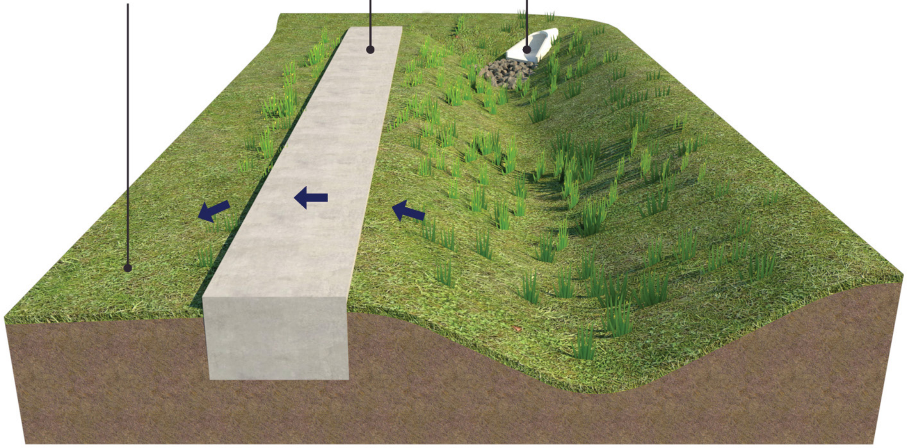
The apron should be designed to remain stable under the anticipated design conditions. Section 8.4 of the PDDG provides guidance on the design of outlet protection including riprap and apron sizing.[111]

Paved waterway © Stantec

111 See Section 8.4 of the MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

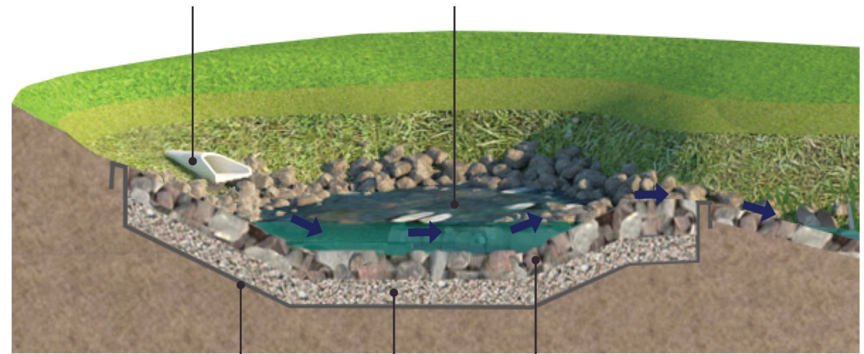
4.6.2.3 Level Spreader

A level spreader is any type of obstruction in a flow path that transitions concentrated flow to sheet flow. It may be constructed of monolithic stone, concrete (precast or cast-in-place), or vegetated earth. To function properly, the level spreader must be constructed stable and level. Design parameters include the length, width, and depth of material to provide a flat, level surface. Level spreaders are typically placed at the top of a slope to distribute water evenly over a vegetated surface. Level spreaders can be useful for the design of pavement disconnection practices (**Section 4.2.1**).



4.6.2.4 Plunge Pool

A plunge pool is a small basin lined with riprap or other suitable armoring to resist erosion. Plunge pools function as energy dissipation and scour protection devices and are typically used in applications where flow may experience an abrupt transition (e.g., at a pipe outlet or a drop structure). A plunge pool is designed to trigger a hydraulic jump and establish a predictable tailwater condition. Flow into a plunge pool typically is rapid and turbulent, while flow out of a plunge pool typically is slow and calm. Design parameters of a plunge pool include the width, length, and depth



of the pool itself and the composition (grain size and thickness) of the stone material that lines the pool. HEC-14 provides detailed design guidance applicable for plunge pool design (refer to the guidance on stilling basins, riprap basins and aprons).[112] The designer should provide documentation (i.e., scour calculations) to demonstrate the plunge pool will remain stable under the anticipated design conditions.

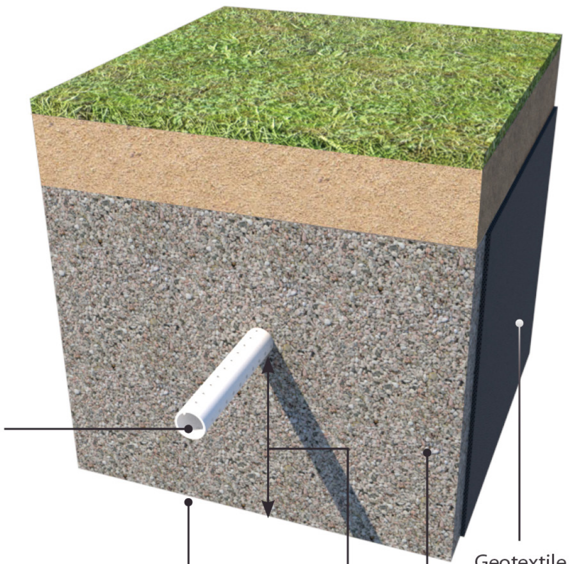
4.6.3 Low-Permeability Liner

Low-permeability liners are used to prevent the migration of stormwater out of, or groundwater into, a SCM. They may be constructed of impermeable geotextile materials or low-permeability earthen materials (e.g., clay). To be classified as a low-permeability liner, the material must have a maximum in-situ hydraulic conductivity of less than 0.03 ft/day. The designer should evaluate the impacts of buoyancy on the liner if high groundwater is a concern.

112 See HEC-14 Hydraulic Design of Energy Dissipators for Culverts and Channels (Jul. 2006) at: https://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=13&id=129

4.6.4 Subsurface Accessories

4.6.4.1 Underdrain



Underdrains are used to prevent the accumulation of standing water in SCMs that provide filtration or where infiltration rates may be seasonally impacted and underdrains are necessary to meet drawdown and safety requirements.

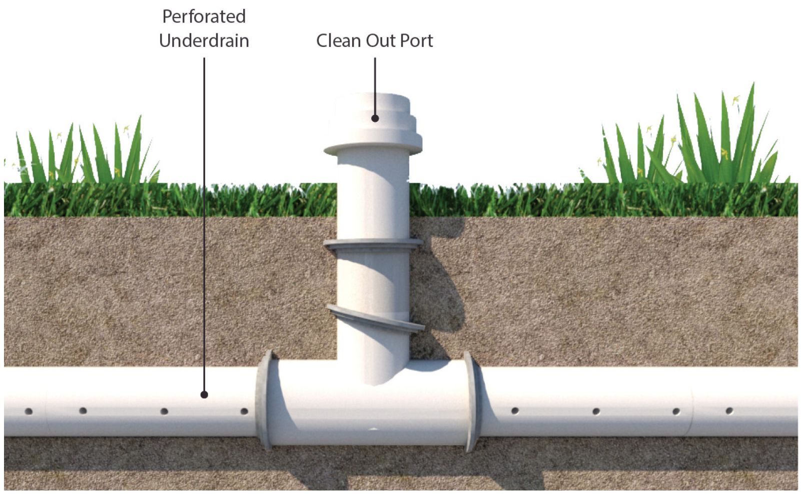
The typical underdrain consists of a perforated pipe embedded in a subsurface trench that is backfilled with uniformly graded, washed, crushed stone. Underdrain designs should include cleanout ports (**Section 4.6.4.2**) and may include observation/monitoring wells (**Section 4.6.4.3**).

If the underdrain is used in a SCM that is intended to provide groundwater recharge, the perforated pipe should be used for overflow and must be set above the bottom of the SCM such that the ReV, WQV, and/or DSV is stored in the voids below the pipe invert, as demonstrated in the figure to the left.

If the underdrain is used in a SCM that is not intended to provide groundwater recharge, the underdrain should be placed at the bottom SCM directly above a low-permeability liner. The underdrain will allow water to drain out of the system while the liner isolates the SCM from adjacent material and prevents groundwater from seeping into the system.

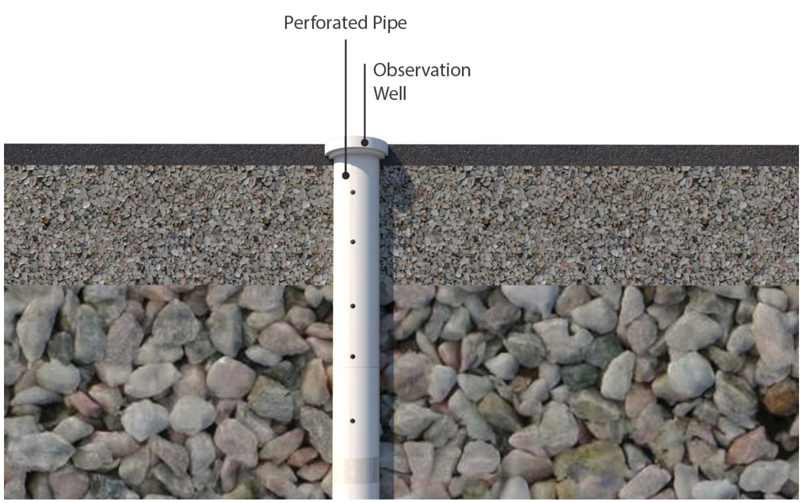
Bioretention linear practice with underdrain being installed (note pipe within crushed stone) © VHB

4.6.4.2 Cleanout Port



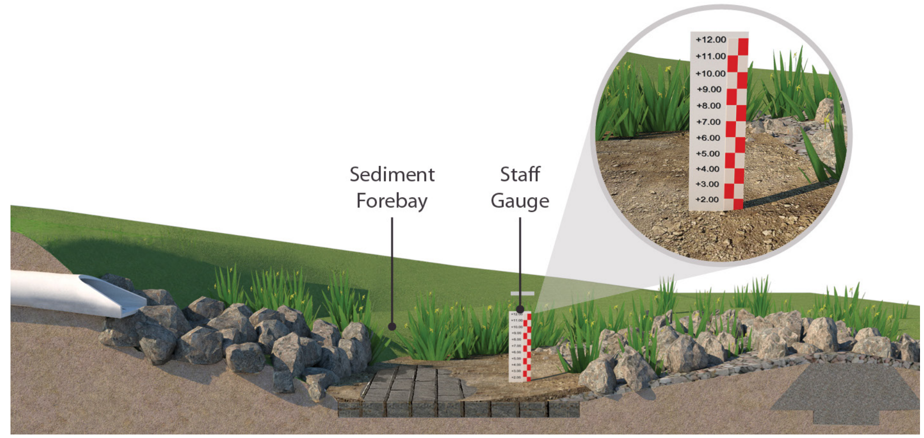
A cleanout port, commonly referred to as a cleanout, is a vertical capped pipe that is connected to an underdrain or some type of subsurface infiltration systems to provide access for maintenance purposes. The port is used to remove accumulated sediments or other blockages. Cleanouts are typically constructed of four-inch or six-inch diameter solid high-density polyethylene (HDPE) or polyvinyl chloride (PVC) pipes.

4.6.4.3 Observation/Monitoring Well



An observation well, also commonly referred to as a monitoring well, is a vertical capped pipe that is connected to a subsurface SCM or underdrain system. Observation wells are used to observe water levels and rates of drawdown. Observation wells are typically constructed of four-inch or six-inch diameter perforated HDPE or PVC pipes.

4.6.5 Staff Gauge



A staff gauge is a device that provides a visual cue for initiating sediment removal within a pretreatment or treatment SCM. The staff gauge indicates the depth of sediment within the SCM and should be marked to indicate the level at which cleanout activities are necessary. Staff gauges may be integral components of sediment forebays. They can also be useful components of any SCM that accumulates sediment.

4.6.6 Oil/Grit Separator

Oil/grit separators are underground devices used to separate heavy particulates, floating debris, and pollutants from stormwater. Due to their relative inaccessibility and other operational limitations, oil/grit separators are not typically designed for roadway applications.

4.7 Design Guidance for All SCMs

Sections 4.1–4.6 provide SCM-specific design criteria. This section describes general design criteria applicable to all SCMs presented in this SDG regardless of whether the measure is designed to infiltrate, is considered a surface or subsurface SCM, or is a basin or linear practice.

In addition, if the SCM is designed to infiltrate, the designer should also refer to **Section 4.8**, Design Guidance for Infiltration SCMs.

The designer should refer to **Section 4.9**, Design Guidance for Basins, and **Section 4.10**, Design Guidance for Linear Practices, for additional and more detailed design considerations specific to basins and linear practices.

4.7.1 Soil Evaluation

A soil evaluation must be completed to determine if the site is suitable for infiltration. See the Massachusetts Stormwater Handbook (Vol. 3, Ch. 1) for a full description of the staged procedure to perform a soil evaluation. A summary of the stages is presented below.

Stage 1: Review NRCS Soil Survey and Perform Site Visit

- Use the NRCS Soil Survey to determine the hydrologic soil group (HSG) of the soils in the project area.
- A Competent Soils Professional (CSP) should conduct a site visit to note any deviations in site conditions as compared to the NRCS Soil Survey.

If the NRCS Soil Survey and the observations made by the CSP are inconsistent, the CSP should:

- Perform soil textural analysis to characterize the soils present on site
- If fill is present, conduct a soils textural analysis of the parent material below the fill layer

If soils are suitable for infiltration SCMs, the designer should continue to Stage 2. If not suitable, then the designer should consider stormwater wetland SCMs, bioretention SCMs, or other SCMs for the design.

Stage 2: Determine Site Conditions at the Locations of Proposed SCMs

Dig test pits so that the CSP can:

- Perform a soil textural analysis at the actual locations and soil layer(s) through which infiltration is proposed
- Determine the depth/elevation of the seasonal high water table (SHWT)
- Determine the in-situ saturated hydraulic conductivity at the actual location and soil layer where recharge is proposed if the designer uses the "Dynamic Field" method[113] to calculate ReV. Note: if the designer uses the static or "Simple Dynamic" method to calculate ReV, in-situ tests are not required because the designer should use the saturated hydraulic conductivities using applicable Rawls Rates[114] which are based on the HSG at the actual location and soil layer where recharge is proposed.

For leaching basins, data collection should include a minimum of one soil sample at each proposed location. For infiltration basins, data collection should include a minimum of three soil samples and additional soil samples such that there is a minimum of one soil sample for every 5,000 square feet of basin area. For infiltration linear practices, data collection should include a minimum of one soil sample every 100 feet.

113 Requirements for using the "Dynamic Field" method are provided in MassDEP. Massachusetts Stormwater Handbook. Vol. 3, Ch. 1, Feb. 2008.

114 Rawls, W.J., D.L. Brakensiek, and K.E. Saxton. Estimation of Soil Water Properties. Trans. ASAE, Vol. 25, 1982, pp. 1316–1320.

Stage 3: Identify HSGs On-Site and at Locations of Proposed Infiltration

The CSP should use the information gathered in Stages 1 and 2 to identify the HSG composition for the site and the infiltration capacity at the actual locations and soil layer(s) through which recharge is proposed.

Stage 4: Prepare a Plan Identifying HSGs for the Site

As part of the Stormwater Management Report, the designer should show the delineated HSGs, locations where infiltration is proposed, and locations of soil borings/test pits on a figure(s).

4.7.1.1 Field Tests

This section describes the data collection methods, approved by MassDEP, for determining the suitability of a site for an infiltration SCM. See the Massachusetts Stormwater Handbook (Vol. 3, Ch. 1) for more information on the field tests.

Soil Textural Analysis

The Soil Textural Analysis, used to determine the relative composition of sand, silt, and clay in soil, must be conducted using the methods described in Section 618.71 (Texture Class, Texture Modifier, and Terms Used in Lieu of Texture) of the NRCS National Soil Survey Handbook.[115]

115 See NRCS National Soil Survey Handbook at: https://www.nrcs.usda.gov/resources/guides-and-instructions/national-soil-survey-handbook

In-Situ Saturated Hydraulic Conductivity

As stated above, an in-situ test for saturated hydraulic conductivity only need be conducted at the proposed locations for infiltration if the designer uses the "Dynamic Field" method to calculate ReV. The field test must simulate the "field-saturated condition" and must be conducted by a CSP. A Title V Percolation Test is not acceptable for saturated hydraulic conductivity. Acceptable tests include:

- Guelph permeameter (ASTM D5126-90 Method)
- Falling head permeameter (ASTM D5126-90 Method)
- Double ring permeameter or infiltrometer (ASTM D3385-03, D5093-02, D5126-90 Methods)
- Amoozemeter or Amoozegar permeameter[116]

Seasonal High Water Table

The preferred method for determining the elevation of the SHWT is based on identifying redoximorphic (redox) features (soil mottling) formed by oxidation/reduction in the soil. If soil characteristics are difficult to analyze (e.g., floodplain soils, soils from very dark parent material) and no redox features are present, then other, more labor-intensive methods, may be required to determine SHWT.

If redox features are not present, the design team may need to install push-point wells or piezometers to measure actual groundwater elevations. Preferably, the measurements should be taken in the spring, when groundwater is expected to be high. Note that observed groundwater levels are not equivalent to SHWT elevations. The design team should use the USGS Frimpter Method[117] to convert the observed groundwater levels to SHWT elevations for use in SCM design activities. In coastal areas, the tidal influence on groundwater levels should be considered.

116 Amoozegar, A. *Advances in the Measurement of Soil Physical Properties: Bringing Theory into Practice*. edited by G. C. Topp, W. D. Reynolds, R. E. Green, Soil Science Society of America, Vol. 30, Ch. 3, 1992, pp. 31–42.

117 Frimpter, Michael. Probable High Ground-Water Levels in Massachusetts. U.S. Geological Survey, Mar. 1981. https://pubs.usgs.gov/of/1980/1205/report.pdf

4.7.2 Setbacks

Setbacks are the minimum required distances between a SCM and a structure or resource area. The designer should consider the following setback requirements when designing a SCM:

Table 4-5. Setbacks for All SCMs[118]

Adjacent Structure or Resource Area	Minimum Distance to SCM
Soil Absorption System for Title 5 Systems	50 feet
Building Foundations (including slabs)	10 feet*
Private Well	100 feet
Public Groundwater Drinking Supply Wells	Outside Zone I. May be located within a Zone II or IWPA if the water supply owner approves.**
Surface Drinking Water Supply and their tributaries	Outside Zone A
Surface Waters (other than drinking water supply and their tributaries)	50 feet
Property Line	10 feet
Certified Vernal Pools	100 feet

*Any subsurface SCM or stormwater piping that falls within 10 feet of the footprint of a building (including parking garages) must comply with the State Plumbing Code.

**The designer should discuss suitability of the SCM location with the water supply owner if the SCM is proposed within the Zone II or IWPAs.

The designer should review the setback requirements for all SCMs (Table 4-5) and additional setbacks for specific SCMs (Table 4-6), as safeguards to protect resources, structures, and property rights. Where more than one setback applies, the greatest distance controls.

In addition to the setbacks for all SCMs, the designer should consider the following setbacks for specific SCMs, as identified in the Massachusetts Stormwater Handbook (Vol. 2, Ch. 2).

Table 4-6. Additional Setbacks for Specific SCMs

SCM	Minimum Distance to SCM
Extended Dry Detention	• 25 feet to a septic system tank
Infiltration Basin	• 50 feet to any slope greater than 15% • Additional setback distance to private wells (more than 100 feet) may be required depending on hydrogeological conditions. • If located downslope, 10 feet to any building foundations (including slab foundations without basements). If located upslope, 100 feet to building foundations.
Porous Pavement	• 20 feet to cellar foundations. 10 feet to slab foundations still applies as shown in Table 4-5. • 100 feet to surface waters (instead of 50 feet as shown in Table 4-5)

The designer should coordinate with utility companies for site-specific setbacks.

The designer may need to consider distances greater than setbacks to provide for slope stability, protection of structures, and the satisfactory performance (e.g., access for operation and maintenance) of the SCM.

118 MassDEP. Massachusetts Stormwater Handbook. Vol. 1, Ch. 1, Feb. 2008, Table RR and Table CA 2.

4.7.3 General Design Practices

This section describes general design practices applicable to all SCMs.

Stormwater management designs should conform to the MassDOT PDDG, MassDOT engineering directives, and applicable updates and supplements regarding hydraulic analyses and drainage design.

4.7.3.1 Surface Material Design

Chapter 3 describes the importance of vegetative cover with respect to stormwater quality and stormwater management.

In general, for surface SCMs, vegetated surfaces are preferred over crushed stone, riprap, or other hardened surfaces. Such armoring should be used only where anticipated flow concentrations and velocities will prevent establishment of vegetation.

Soils for vegetated surfaces, typically a blend of grasses and/or flowering plants, must be prepared for optimum establishment of vegetation. Typical soil design may include a combination of imported soils, or a blend of on-site soil with amendments, with a finish depth ranging from 6 to 12 inches, depending on application. Consult with MassDOT Landscape Design Section for typical specifications for a soil design and seed mix.

MassDOT considers SCM vegetation to be a key component of the design. Basins, linear practices, and surrounding areas should be planted with vegetation, including seeding, trees, and/or shrubs, as appropriate. Constructed earthen embankments designed for water impoundment should never be planted with woody vegetation (i.e., trees or shrubs) and should be maintained clear of such vegetation due to potential piping along roots.

4.7.3.2 Access Design

The designer should site SCMs with consideration for access.

All components of a SCM, including inlets, outlets, treatment areas, and underground features, must be accessible to facilitate inspection and cleanout. If a SCM must be located in an area with constrained access, the designer may consider over-sizing pretreatment practices.

The intended access should never cross directly over a structure or spillway unless the structure or spillway has been designed to accommodate the structural loads of maintenance vehicles.

The subsurface components of SCMs must be sited so that they are accessible by the appropriate maintenance equipment. The SCM information sheets identify which measures require cleanout ports or observation/monitoring wells.

Surface SCMs should include staff gauges or other markers to indicate sediment depth to facilitate inspection and maintenance.

4.7.3.3 Safety Design

The designer should evaluate SCMs for compliance with general safety requirements for roadway design, as stated in the MassDOT PDDG.

This section focuses on SCM-related safety issues, including clear zones, sight distance, and fencing.

Clear Zones

The following are general design criteria for SCMs proposed within clear zones:

- Use only check dam variations 3 and 4 (vegetated cover) within clear zones. See **Section 4.6.1** for more details on requirements for these check dams.
- Structures (e.g., outlet control structures, headwalls, yard drains) should not protrude six inches or more above grade.

- SCMs designed to store water temporarily should not exceed a ponding depth greater than two feet (e.g., lowest outlet no more than two feet above bottom of SCM).
- SCMs that require permanent pools should not be used within clear zones.
- Design for a minimum distance of 25 feet between toe-of-slope of check dams in series.

Sight Distance

If the SCM will include plantings, trees, or shrub placement, the design must comply with the applicable sight distance requirements as stated in PDDG Section 3.7.[119]

Fencing

Fencing around SCMs should be minimized so as to not impede inspection and maintenance. Generally, fencing is not necessary at inaccessible areas, such as within a median, loop ramps of an interchange, or along an interstate or other limited access roadway. Fencing should not be installed at locations where it may pose a hazard. If the SCM has a deep permanent pool, the designer should consider including fencing to prevent unauthorized access.

Physical barriers should allow for the following:

- Access for maintenance activities
- Wildlife passage (minimum of six-inch clearance between ground and fencing)
- Direct access for wildlife to reach wetlands and water bodies (fencing is prohibited within Riverfront Area)

Generally, basins with slopes no steeper than 3H:1V and standing water two feet deep or less have a low safety risk and fencing should be avoided to not impede inspection and maintenance. Basin SCMs that include a deep-water feature but no fencing must include a safety bench in the design, 10 feet wide with a slope of 10H:1V, located at or just above the normal pool elevation.

4.7.3.4 Other Design Considerations

Buoyancy

The designer should review impacts of buoyancy on closed structures located in groundwater and, if it is a concern, the design should include mitigation measures for buoyancy (e.g., weep holes, extended base, ballast).

Groundwater Seepage

The designer should review components of the stormwater management system for the potential of unwanted groundwater (i.e., seepage) to enter the system. If this is not desired, mitigation measures (e.g., low-permeability liners, rubber gaskets between pipe connections and structures) should be included in the design.

Drawdown

The designer should review the need for a low-level drain (e.g., pool drain) in the SCM to perform full drawdown to support maintenance and rehabilitation efforts.

Resuspension

Off-line SCMs are preferred over in-line SCMs to minimize resuspension of sediment during large storms. An offline configuration can be achieved using a bypass weir or structure. If a SCM is designed as an in-line structure, it must have sufficient hydraulic outlet capacity to safely pass design storms.

119 See MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

4.8 Design Guidance for Infiltration SCMs

This section describes additional criteria for infiltration SCMs, which include any basin, linear practice, or precast structure that is designed to exfiltrate stormwater to underlying soils and into groundwater.

In addition, refer to **Section 4.9**, Design Guidance for Basins, and **Section 4.10**, Design Guidance for Linear Practices, for more detailed design considerations of basins and linear practices.

4.8.1 Soils and Siting Criteria

The designer should follow the staged approach presented under **Section 4.7.1**, Soil Evaluation. See the Massachusetts Stormwater Handbook (Vol. 3, Ch. 1) for a full description of the stages for soil evaluation and field tests.

Infiltration SCMs must be sited in areas with appropriate soil and groundwater conditions.

Infiltration SCMs may be suitable in areas where:

- Bedrock or other impermeable soil layer (e.g., clay) is at least two feet below the proposed bottom surface of the SCM
- The SHWT is a minimum of two feet below the proposed bottom surface of the SCM
- The infiltration rate of soils under the elevation of the SCM bottom is ≥ 0.17 inches per hour, or site-specific geotechnical investigations of this soil layer indicate the full storage volume will infiltrate within 72 hours

Infiltration practices need additional pretreatment in areas where infiltration may occur so quickly that runoff reaches groundwater or receiving waters before any biological, physical, or chemical treatment processes can take place (e.g., soils with Rapid Infiltration Rates defined as soils with saturated hydraulic conductivity > 2.4 in/hr).

For infiltration systems proposed in fill, the designer should conduct a soil textural analysis in both the fill material and the underlying parent materials. The infiltration rate of the more restrictive layer should be used to size the infiltration SCM. If materials in the area of proposed recharge are classified as solid or hazardous waste, other locations for recharge must be considered. Depending on the site, such debris or waste may be removed in accordance with applicable Solid and Hazardous Waste Regulations and replaced with clean material suitable for infiltration.[120]

4.8.2 Pretreatment and Design Criteria

Appropriate pretreatment must be provided as part of a treatment train prior to an infiltration SCM.

The Stormwater Standards establish the required level of pretreatment for infiltration SCMs. They require that:

- Pretreatment removes 25% of TSS prior to any infiltration SCM.
- Pretreatment removes 44% of TSS prior to infiltration when:
  - › The infiltration SCM discharges to a Critical Area
  - › The soils underlying the infiltration SCM have Rapid Infiltration Rates (i.e., saturated hydraulic conductivity >2.4 in/hr)
  - › The infiltration SCM accepts runoff from a LUHPPL

Runoff from a metal roof within specific Critical Areas, including Zone II Wellhead Protection Areas and IWPAs and/or at an industrial site, requires a treatment train if the stormwater is to be infiltrated. The treatment train should include a SCM capable of removing metals (e.g., bioretention SCMs, stormwater wetland SCMs, extended dry detention basins, wet SCMs) and treat 44% of TSS before the infiltration SCM. Pretreatment of 44% of TSS is not required if the stormwater originates from a non-metal roof or originates from a metal roof outside a Zone II or IWPA.

All infiltration SCMs and pretreatment basins/sumps should dewater within 72 hours so that standing water does not become habitat for breeding mosquitos, and the storage volume for recharge is available during the next precipitation event.

120 See 310 CMR 19.000, 30.000, and 40.000

4.8.3 Construction Considerations

Although this SDG does not focus on construction-period stormwater controls, the designer should understand that infiltration SCMs need to be protected during construction activities to maintain the functionality of the SCM under built conditions. Stormwater runoff generated from a site during construction activities typically has higher TSS concentrations compared to built conditions and has potential to clog permeable soils with fine sediments and silt, lowering the performance and capacity of infiltration.

Permanent infiltration SCMs should never be used to provide temporary E&S control during construction activities or be used for managing construction dewatering activities.

The designer should incorporate the following considerations for infiltration SCMs in the design plans and specifications, as applicable:

- Specify the addition of soil amendments and/or tillage of the basin floor to a depth of 12 inches to restore infiltration capacity following final grading
- Specify a vegetated layer that includes dense turf or salt- and water-tolerant, rapidly germinating grass seed (do not specify sod). Native grass mixes may be used where appropriate but should be discussed with MassDOT Landscape for an appropriate blend.
- Specify vegetated surface basins to be spread with loam or compost and then seeded immediately after completion of grading

To maximize the performance of the infiltration SCM(s), the following should be considered for inclusion in the design plans, specifications, and/or E&S control plan (e.g., Stormwater Pollution Prevention Plan [SWPPP]):

- Prohibit discharge of runoff from disturbed areas or construction dewatering to the SCM
- Temporarily install liner at SCM locations to protect infiltration capacity and then remove and dispose liner at end of construction
- Prohibit construction traffic at the location of the SCM
- Prohibit construction activities that would compact the earth at the location of the SCM
- Encourage the use of light earth-moving equipment at the location of the SCM
- Prohibit construction during periods of heavy rainfall
- Prohibit discharge of runoff into the SCM until any unstable surfaces, including the bottom and side slopes, are fully stabilized
- If possible, phase construction of project so that infiltration SCMs are built last

Following final grading, the infiltration SCM should be tested for saturated hydraulic conductivity at the surface to confirm that the SCM fully dewaters within the required 72 hours. If testing reveals the SCM will not dewater within the required time, the SCM may warrant soil tilling to aerate the bottom surface.

Infiltration basin under construction © MassDOT

4.9 Design Guidance for Basins

Many of the SCMs described in this SDG are designed in a basin configuration where the width is greater than the depth. Basin designs typically include provisions for receiving and discharging stormwater and storing/treating water within the basin.

Stormwater basins that are eligible for MassDEP water quality treatment credits must have pretreatment.

Basins may be formed by excavating material from stable ground or by constructing an impoundment. Generally, a constructed impoundment consists of earthen embankments and a minimum of two outlets: an outlet control structure and an auxiliary spillway.

Basin designs must consider site-specific information relative to watershed hydrology, soil conditions, storage volume of the impoundment, hydraulic characteristics of inlet and outlet structures, and tailwater conditions of the receiving waters. In some cases, the design of the constructed impoundment may be subject to regulatory review and licensing under governmental dam safety statutes, rules, and regulations.

Basins should be designed by professional engineers with experience in the analysis and design of embankments and spillways.

4.9.1 Hydrologic and Hydraulic Evaluation

The designer should perform a hydrologic and hydraulic (H&H) analysis of the proposed basin to determine the peak runoff volume and peak rate using NRCS TR-55 and TR-20 methodologies.[121] The hydrologic analysis should produce design event hydrograph(s) and should include calculations to route the design event hydrograph through the basin storage and outlet structures. The results of the hydraulic analysis should provide the peak water surface elevation within the impoundment and the peak discharge rates and velocities at the outlet structure(s). For further information, refer to the MassDEP Hydrology Handbook for Conservation Commissioners.[122]

Basins should be designed so that the inlet, side slopes, bottom, and outlet can withstand scour conditions during the 2- and 10- year design events. Design the auxiliary outlet to safely pass the 100-year design event.

MassDOT prefers off-line structures. If a stormwater basin SCM is designed as an in-line structure, the basin must have sufficient hydraulic outlet capacity to safely pass design storms.

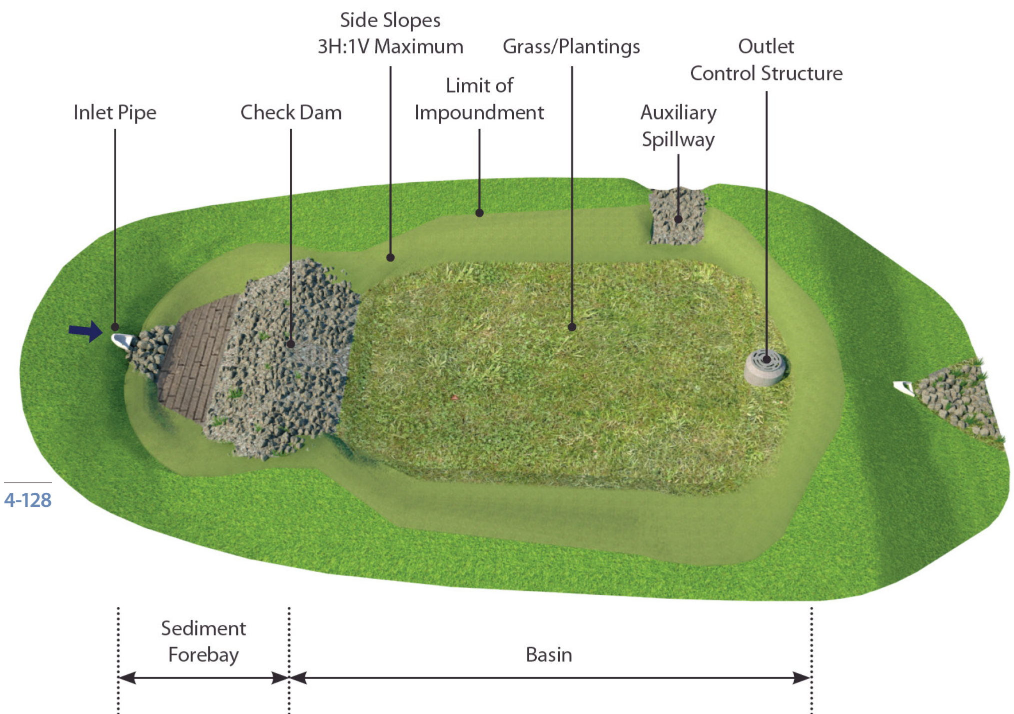
Designers should perform a check on upstream drainage structures to review tailwater conditions. At a minimum, there should be 0.75 feet between the peak water surface elevation and the surface elevation of any manhole or inlet. Refer to Chapter 8 of the PDDG for MassDOT-specific guidance on hydraulic analyses of roadway drainage systems.

121 See Section 8.4 of the MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

122 MassDEP. Hydrology Handbook for Conservation Commissioners. Mar. 2002. https://www.mass.gov/files/documents/2016/08/wa/hydrol.pdf

4.9.2 Basin Design Elements

MassDOT basin designs must include considerations for several elements related to water quality treatment, groundwater recharge, capacity, and stability.



4.9.2.1 Embankment Design

Basins with constructed embankments should be designed to safely receive, store, and discharge stormwater.

A complete basin design with embankments should incorporate the following:

- Top width to provide structural stability and access
- Side slopes to provide structural stability
- Non-erosive surface material
- Suitable subsurface material and foundation conditions
- Freeboard capacity during the design event (e.g., one foot minimum for 100-year design event)
- Allowance for post-construction settlement
- Provisions for controlling undesirable vegetation on embankment slopes
- Seepage control (e.g., impervious core if necessary)
- Where pipes or other conduits penetrate the embankment, provisions for filter diaphragms (i.e., zone of filter material such as well-graded sand) or anti-seep collars to prevent "piping" of stormwater along exterior surface of conduit. See guidance from NRCS for more information on filter diaphragms and anti-seep collars[123]

Wet basin and outlet control structure © MassDOT

123 See NRCS National Engineering Handbook Chapter 45 on Filter Diaphragms at: https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17751.wba

MassDOT prefers vegetated surface treatments over crushed stone, riprap, or other hardened surfaces. The side slopes of embankments should be designed to be stable under vegetated conditions and blend into existing natural contours. If side slopes are vegetated, the side slopes should be no steeper than 3H:1V. Steeper slopes are difficult to mow. If slopes steeper than 3H:1V are used, the designer must provide documentation to demonstrate that the embankment slope and reinforcement material will be stable under saturated and dry weather conditions and will be safe to access and maintain.

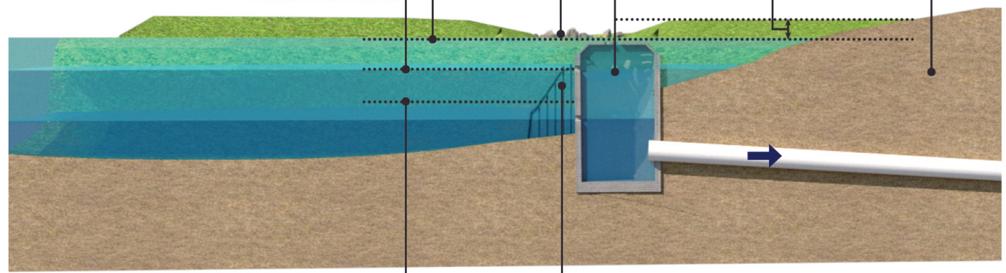
If a deep-water feature is included in the design, include a safety bench that is 10 feet wide with a slope of 10H:1V at, or just above, the normal pool elevation around the entire internal perimeter of the deep-water feature or consider fencing.

Basins with embankments that meet the following criteria are considered dams as defined in the Massachusetts Dam Safety Rules[124] (although the designer should check the most recent version of the rules for the latest regulations):

- The basin is an artificial/constructed impoundment with a constructed embankment AND one of the following is true:
  - The constructed embankment is greater than six feet in height
  - The constructed impoundment's maximum storage capacity is more than 15 acre-feet of water

To avoid introducing another type of sensitive asset into its inventory, it is not MassDOT's intent to own and operate dams. Therefore, MassDOT discourages large stormwater basins that meet these criteria.

4.9.2.2 Outlet Control Structure



Basin SCMs should have an outlet control structure designed to include:

- Capacity for controlled release of design storms (multiple-stage control of peak discharges)
- Capacity for overflow in storms exceeding design capacity of impoundment
- Provisions for intercepting and managing trash, debris, and floating pollutants, such as a trash rack at the outlet
- Accessibility for routine maintenance and emergency servicing
- Provisions to prevent piping along exterior of conduit
- Provisions for drawdown and maintenance of permanent pools
- Provision for energy dissipation measures at outlets (e.g., aprons, plunge pools)

124 See 302 CMR 10.00

4.9.2.3 Auxiliary Spillway

Basin SCMs should be designed to include an overflow device (e.g., emergency spillway) that will safely convey stormwater out of the SCM to the receiving area. The auxiliary spillway should be designed to include:

- Protection of the integrity of embankment (generally, the auxiliary spillway should not be located in the embankment, but rather, in undisturbed earth)
- Capacity to pass the routed design emergency storm (often, the 100-year event, but may be another event based on applicable regulations)
- Stability during the design event
- Volume to provide adequate freeboard (minimum one foot of freeboard between auxiliary spillway flowing at full capacity and the embankment crest)
- Provisions for energy dissipation measures at outlets (e.g., aprons, plunge pools)

In cases where applicable regulations do not specify design storm criteria for auxiliary spillways, MassDOT recommends that the design provide capacity to convey the 100-year design event. The design for the auxiliary spillway should assume the 100-year storm is routed through the basin assuming the starting water elevation is at the elevation of the spillway and infiltration does not occur.

Auxiliary spillway © MassDOT

4.10 Design Guidance for Linear Practices

Some of the SCMs described in this SDG can be designed in more linear fashion, thus forming a linear practice. MassDOT linear practices typically include provisions for receiving, storing/treating, and discharging stormwater.

Linear practices presented in this SDG include:

- Infiltration linear practices
- Bioretention linear practices
- Wet linear practices

While MassDOT linear practices are similar in shape to swales and channels as described in the Massachusetts Stormwater Handbook, their primary function is treatment versus conveyance. Linear practices detain and treat stormwater through a series of small basins created by check dams.

The check dams in linear practices are designed to retain or detain the WQV and/or DSV while safely bypassing larger flows (e.g., 10-year storm).

In most cases, linear practices are formed by excavating material from stable ground. Sometimes, linear practices are formed by constructing a berm along one side of a slope. Linear practices can be implemented by retrofitting simple conveyance swales and ditches to provide water quality treatment.

4.10.1 Hydrologic and Hydraulic Evaluation

Similar to basins, the designer should perform a H&H analysis of the proposed linear practice to determine the peak runoff volume and peak rate using NRCS TR-55 and TR-20 methodologies.[125] The hydrologic analysis should produce design event hydrograph(s) and include calculations to route the design event hydrograph through the linear practice and over check dams. The results of the hydraulic analysis should provide the peak water surface elevation and velocities within the linear practice and the peak discharge rates and velocities at the outlet. For further information, refer to the MassDEP Hydrology Handbook for Conservation Commissioners.[126]

Linear practices should be designed so that the inlet, side slopes, bottom, and outlet can withstand scour conditions during the 2- and 10-year design events.

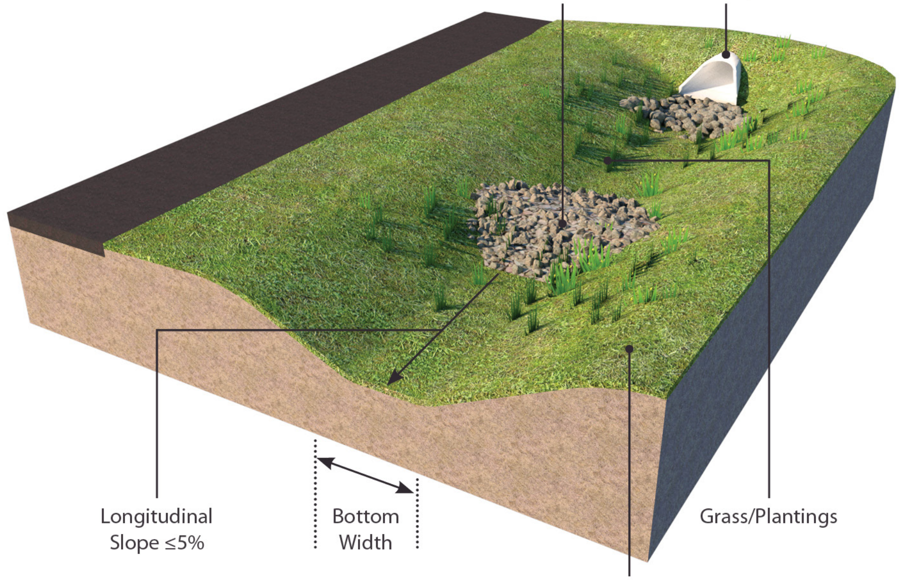
Freeboard for a linear practice should consist of at least 0.75 feet between the peak water surface elevation and the elevation of the edge of pavement. When reviewing freeboard results, designers should assume the linear practice is full (i.e., water ponded behind check dams) and that no infiltration occurs during the analysis. Refer to Chapter 8 of the PDDG for MassDOT-specific guidance on hydraulic analyses of drainage systems.

4.10.2 Linear Practice Design Elements

MassDOT linear practices must be designed and constructed to bypass stormwater safely and without causing resuspension of sediments or erosion.

125 See Section 8.4 of the MassDOT PDDG at: https://www.mass.gov/lists/design-guides-and-manuals

126 MassDEP. Hydrology Handbook for Conservation Commissioners. Mar. 2002. https://www.mass.gov/files/documents/2016/08/wa/hydrol.pdf



Impermeable check dams should be placed at intervals along the length of the linear practice to retain stormwater for water quality treatment, reduce flow velocities, and promote groundwater recharge. Refer to **Section 4.6.1** for more guidance on check dam design. The cumulative storage volume behind the check dams is used to determine the WQV, ReV, and/or DSV that the linear practice provides.

A complete linear practice design should specify:

- Geometry (rectangular, triangular, trapezoidal, parabolic)
- Bottom width (typically between 2 and 8 feet)
- Side slopes (3H:1V maximum for stability, access, and maintenance)
- Longitudinal slope (minimum slope 0.5%, maximum slope 5%)
- Lining material (vegetated surfaces are preferred)
- Capacity in accordance with the PDDG (10-year, 24-hour design event with minimum 0.75 feet of freeboard to edge of pavement)
- Maximum velocities (recommend subcritical [tranquil] flow that does not exceed a velocity of 5 feet per second)

Linear practice slope and vegetation should be designed so stormwater does not exceed critical erosive velocities. General rules are as follows:

- For slopes up to 2%, vegetate the surface with grass or sod
- For slopes between 2% and 3%, vegetate the surface with loam and seed and include a jute mesh erosion control blanket
- For slopes between 3% and 5%, use a designed, reinforced lining such as a permanent erosion control blanket

Linear practices are not promoted on slopes greater than 5%. Paved waterways or other reinforced channels may be appropriate for steep slopes.

For detailed guidance, the designer should refer to PDDG Chapter 8, HEC-15 Design of Roadside Channels with Flexible Linings,[127] and HEC-22, Urban Drainage Design Manual.[128]

127 See HEC-15 Design of Roadside Channels with Flexible Linings (Sep. 2005) at: https://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=15&id=32&CFID=145395759&CFTOKEN=b0fa27709563ae02-2A8B110E-BCA1-4679-1DE7E4109CB0711F

128 See Urban Drainage Design Manual (Aug. 2013) at: https://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=22&id=140

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