

NEW HAMPSHIRE STORMWATER MANUAL

February 2025

UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

COMPREHENSIVE ENVIRONMENTAL INC

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

Table of Contents

1 Introduction 1
1.1 Manual Background 1
1.2 New Hampshire's Approach to Stormwater Management 2
2 Stormwater Management Overview 4
2.1 Fundamentals of Stormwater Management 4
2.2 Stormwater Management Tools 10
2.3 Stormwater Grants and Funding Opportunities 19
3 Regulations and Permitting 21
3.1 Federal Regulations and Permit Programs 21
3.2 State Regulations and Permit Programs 29
3.3 Local Regulations 35
4 Design Criteria and Example Calculations 36
4.1 Overview 36
4.2 Water Quality Volume (WQV) and Pollutant Removal 40
4.3 Water Quality Flow (WQF) 46
4.4 Groundwater Recharge Volume (GRV) 50
4.5 Design Infiltration Rate 53
4.6 Effective Impervious Cover (EIC) and Undisturbed Cover (UDC) 56
4.7 Channel Protection (CP) 57
4.8 Peak Runoff Control 59
5 Site Planning and Design 64
5.1 Overview of the Site Design Process 64
5.2 Low Impact Development 68
5.3 Selecting Appropriate Structural Stormwater Control Measures 72
5.4 Stormwater Retrofits 91
5.5 Operation, Maintenance, Inspection, and Source Control 92
6 Erosion and Sediment Control 98
6.1 Overview 98
6.2 Principals of Erosion and Sediment Control 98
6.3 Erosion and Sediment Control Planning 104
6.4 Selection of Erosion and Sediment Control Measures 108
6.5 Inspection and Maintenance of Erosion and Sediment Control Measures 110

List of Figures

Figure 2-1. What is a Watershed?

Figure 4-1. Example EPA Performance Curve for an Infiltration Basin

Figure 4-2. Unit Peak Discharge (q_u) for NRCS (SCS) Type II Rainfall Distribution (Exhibit 4-II)

Figure 4-3a. NOAA Atlas 14 Graphical Interface

Figure 4-3b. Example NOAA Atlas 14 Results Table

List of Tables

Table 2-1. Summary of Common Stormwater Pollutants

Table 2-2. Summary of Stormwater-related Funding Programs

Table 3-1. Summary of MS4 Permit Minimum Control Measures (MCM)

Table 3-2. Summary of New Hampshire Stormwater-Related Permits

Table 3-3. Summary of Local Regulatory Mechanisms Required by the New Hampshire MS4 Permit

Table 4-1. Design Criteria Summary

Table 5-1. Stormwater Control Measure Convention Crosswalk and Selection Factors

Table 5-2. SCM Treatment Unit Operations and Processes (UOPs)

Table 5-3. General Suitability of SCMs to Treat Common Stormwater Pollutants

Table 5-4. Summary of SCM Restrictions Associated with High-Load and Protected Resources

Table 5-5. Watershed Resource Criteria

Table 6-1. Selection of Construction Period Erosion and Sediment Control Measures

List of Appendices

Appendix A. Stormwater Control Measure Fact Sheets

Appendix B. Erosion and Sediment Control Fact Sheets

List of Abbreviations

AoT	Alteration of Terrain
BMP	Best Management Practice
CGP	Construction General Permit
CN	Curve Number
CP	Channel Protection
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DRGP	Dewatering and Remediation General Permit
DSV	Design Storage Volume
E&SC	Erosion and Sediment Control
EIC	Effective Impervious Cover
EPA	Environmental Protection Agency
FDC	Flow Duration Curves
GI	Green Infrastructure
GP	General Permit
GRV	Groundwater Recharge Volume
HSG	Hydrologic Soil Group
IA	Impervious Area
IDDE	Illicit Discharge Detection and Elimination
ISR	Internal Storage Reservoir
LID	Low Impact Development
MCM	Minimum Control Measure
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer System
MSGP	Multi-Sector General Permit
MTD	Manufactured Treatment Device
NHDES	New Hampshire Department of Environmental Services
NOAA	National Oceanic Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCC	Northeast Regional Climate Center
NRCS	Natural Resource Conservation Service
O & M	Operation and Maintenance
ORW	Outstanding Resource Water

RD	Runoff Depth
RUSLE	Revised Universal Soil Loss Equation
SCM	Stormwater Control Measure
SHWT	Seasonal High-Water Table
SNEP	Southeast New England Program
SOP	Standard Operating Procedure
SPCC	Spill Prevention, Control, and Countermeasures
SSSNNE	Society of Soil Scientists of Northern New England
SWMP	Stormwater Management Program
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UDC	Undisturbed Cover
UIC	Underground Injection Control
UNHSC	University of New Hampshire Stormwater Center
UOP	Unit Operation and Process
USDA	United States Department of Agriculture
WBP	Watershed-based Plan
WMB	Watershed Management Bureau
WPS	Watershed Protection Standard
WQC	Water Quality Certification
WQF	Water Quality Flow
WQV	Water Quality Volume

Definitions

This section includes a list of commonly used terms in the New Hampshire Stormwater Manual that are not defined in the Alteration of Terrain regulations. For regulatory definitions, refer to Env-Wq 1502. This is not an exhaustive list of definitions.

- Best Management Practices (BMPs) means, for purposes of stormwater management, construction period erosion and sedimentation control practices and post-construction good housekeeping practices, including but not limited to: source controls; pollution prevention measures; operating procedures and practices to control site runoff; spillage or leaks; sludge or waste disposal; or drainage from raw material storage. For purposes of post-construction stormwater management, see the definition of Stormwater Control Measure.
- Catchment Scale Controls. For purposes of stormwater management, Low Impact Development, Stormwater Control Measures, and Best Management Practices, that treat or store 1-inch or less of runoff and, in aggregate, account for the total pollutant removal required on-site. Catchment Scale Controls are designed to reduce, treat, and infiltrate stormwater at its source and provide stormwater management options within rights-of-ways or on sites that have limited space for traditional sized Stormwater Control Measures. They include, but are not limited to, plant and soil-based systems such as filtering bioretention, rain gardens, dry wells, and porous pavement that are designed as specified in **Appendix A** of the New Hampshire Stormwater Manual [2025 Edition], to achieve pollutant removal credits using the U.S. Environmental Protection Agency Performance Curves.
- First Flush. Stormwater runoff in the beginning of a storm. Pollutants in this initial runoff are typically at concentrations that are higher than at the middle or end of a storm. The first flush in New Hampshire can be approximated as the first 1.0-inch of runoff.
- Gray Stormwater Infrastructure. Stormwater management systems that are designed to move stormwater away from structures and the built environment. They include but are not limited to curbs, gutters, drains, piping, detention basins, subsurface infiltration structures and wet basins.
- Green Stormwater Infrastructure. Stormwater management systems that mimic nature and treat stormwater at its source by allowing stormwater to infiltrate, by reducing storm flows to sewer systems or receiving areas, and by harvesting stormwater for reuse. Green Stormwater Infrastructure includes Stormwater Control Measures such as bioretention that use plant or soil systems for treatment, porous pavement or other permeable surfaces or substrates, cisterns, and landscaping.
- Illicit Discharge means a discharge that is not entirely comprised of stormwater, except pursuant to a National Pollutant Discharge Elimination System (NPDES) permit (other than the NPDES permit for discharges from a municipal separate storm sewer) and discharges resulting from firefighting activities. Notwithstanding the foregoing, an illicit discharge does not include discharges from the following activities or facilities: firefighting, water line flushing, landscape irrigation, uncontaminated ground water, 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 and water used to clean residential buildings without detergents.
- Low Impact Development (LID) means innovative stormwater management systems that are modeled after natural hydrologic features. LID manages rainfall at the source using uniformly distributed, decentralized, micro-scale controls. LID uses small, cost-effective landscape features located at the lot level. LID takes the form of techniques (e.g., porous pavement) or practices (e.g., reduced front yard setback).

- Pre-treatment means structural and nonstructural Stormwater Control Measures (SCMs) used as part of a treatment train, designed, operated, and maintained to remove an initial amount of a pollutant such as Total Suspended Solids from stormwater runoff prior to discharge to a structural treatment or conveyance practice. Examples of Pre-treatment SCMs are deep sump catch basins and proprietary manufactured separators (structural).
- Retrofit Projects means, for purposes of stormwater management, projects that make site-specific changes designed solely to improve water quality, reduce peak discharge rates, increase recharge, or reduce or eliminate combined sewer overflows (CSO). Retrofit Projects are not new development or maintenance.
- Stormwater Control Measure (SCM) means a structural or nonstructural technique for managing stormwater to prevent or reduce point or nonpoint source pollutants from entering surface waters or ground waters. A nonstructural Stormwater Control Measure includes but is not limited to source control, some Low Impact Development techniques or practices, street cleaning and pollution prevention measures. A structural Stormwater Control Measure includes, but is not limited to, a basin, discharge outlet, swale, rain garden, filter, some Low Impact Development techniques or practices, or other stormwater treatment practice or measure either alone or in combination, including without limitation, any overflow pipe, conduit, weir control structure that:
    - Is not naturally occurring.
    - Is not designed as a wetland replication area.
    - Has been designed, constructed, and installed for the purpose of conveying, collecting, storing, discharging, recharging, or treating stormwater.
- Total Maximum Daily Load (TMDL) means the sum of a receiving water's individual waste load allocations and load allocations and natural background, which, together with a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality, represents the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards in all seasons.
- Total Phosphorus (TP) means the total phosphorus content in stormwater including all particulate and dissolved phosphorus, in both organic and inorganic forms.
- Total Suspended Solids (TSS) means solids suspended in stormwater, determined using EPA Method 160.2 (1971).

Funding

This Manual was funded in part through a Clean Water Act grant from the U.S. Environmental Protection Agency and the Clean Water State Revolving Fund through the New Hampshire Department of Environmental Services.

Acknowledgements

A special thank you to the many individuals who provided their time and assistance in the creation of this manual. Your knowledge, dedication, and passion are invaluable and have contributed to a beneficial resource for individuals and entities to assist in the protection of our precious New Hampshire water resources.

Manual Project Team

Theodore Diers, *NHDES Assistant Water Division Director*

Emily DiFranco, (*formerly CEI*)

Nicole Haggerty, *CEI*

Robert Hartzel, *CEI*

Erin Holmes, (*formerly NHDES*)

Dr. James Houle, *University of New Hampshire Stormwater Center*

Stephen Landry, *Watershed Management Bureau*

Deborah Loiselle, *Watershed Management Bureau*

David Neils, *NHDES Watershed Management Bureau Administrator*

David Roman, *CEI*

Provided Support and Assistance

William Arcieri, *(formerly VHB)*

Rebecca Balke, *City of Manchester*

Andrea Bejtlich, *NHDES Watershed Management Bureau*

Jeff Blecharczyk, *NHDES Wetlands Bureau*

Steven Couture, *NHDES Watershed Management Bureau*

Pauline Crocker, *NHDES Watershed Management Bureau*

Dr. Shane Csiki, *NHDES State Geological Survey*

Jennifer Czysz, *Strafford Regional Planning Commission*

Provided Support and Assistance (continued)

Calvin Diessner, *NHDES Wetlands Bureau*
Kenneth Edwardson, *NHDES Watershed Management Bureau*
Hayley Franz, *NHDES Wastewater Engineering Bureau*
Danielle Gato, *EPA Region 1*
Mark Hemmerlein, *NHDOT*
Judith Houston, *NHDES Watershed Management Bureau*
Dale Keirstead, *NHDES Wetlands Bureau*
Brandon Kernen, *Drinking Water and Groundwater Bureau*
Zach Lorch, *NHDES Wastewater Engineering Bureau*
Benjamin Lundsted, *City of Manchester*
Ridgely Mauck, *NHDES Alteration of Terrain Bureau*
Jeffrey Marcoux, *NHDES Watershed Management Bureau*
Theresa McGovern, *VHB*
Kevin Nyhan, *NHDOT*
Kyle Pimental, *Strafford Regional Planning Commission*
Michael Schlosser, *NHDES Alteration of Terrain Bureau*
Sally Soule, *NHDES Watershed Management Bureau*
Matthew Stamas, *EPA Region 1*
Eliza Styczynski, *NHDES Wastewater Engineering Bureau (formerly NHDES)*
Thomas Swenson, *NHDES Watershed Management Bureau*
Newton Tedder, *EPA Region 1*
James Tilley, *NHDES Watershed Management Bureau*
Mary Ann Tilton, *NHDES Wetlands Bureau*
Dawn Tuomala, *Town of Merrimack*
Michelle Vuto, *EPA Region 1*
Jonathan Whaland, *NHDES Drinking Water and Groundwater Bureau*
Ethan Widrick, *NHDES Wastewater Engineering Bureau (formerly NHDES)*
Matthew Wood, *NHDES Watershed Management Bureau*
Gretchen Young, *City of Rochester*

1 Introduction

New Hampshire's water resources are an invaluable part of our history, culture, and landscape. We rely on these resources to provide clean drinking water, vital habitat, and a healthy place for recreation such as fishing, swimming, and boating. With increased development and associated increases in stormwater runoff and pollution, the quality of many of these resources has become more difficult to protect and maintain.

The impacts of stormwater runoff and pollution are wide ranging. In a natural environment, precipitation has the opportunity to infiltrate into the soil. As the area of impervious surfaces (e.g., roads, rooftops, etc.) increases, the impact of increased frequency, volume, and flow rate of stormwater runoff can result in issues such as the destabilization of downstream channels and an increase in pollutants that enter waterbodies.



East Branch Pemigewasset River (Photo courtesy of NHDES)

1.1 Manual Background

Over the past few decades, New Hampshire stormwater programs and guidance documents have been developed to provide municipalities, property owners, designers, developers, and regulatory personnel with tools to help minimize the impacts of development and balance the needs of a healthy environment with those of social and economic growth; including the original New Hampshire Stormwater Manual (Manual) developed in 2008. The Manual was developed by the New Hampshire Department of Environmental Services (NHDES) with the goal of providing a reference guide for the selection, design, and application of measures to manage stormwater from newly developed and redeveloped properties, while meeting environmental objectives of New Hampshire regulations.

In response to evolving science and available technologies for stormwater management as well as new and increasing local and federal permit requirements, an assessment of the 2008 Manual was conducted in 2020 as a collaborative effort of NHDES, the United States Environmental Protection Agency (EPA), New Hampshire municipalities, stormwater experts, and practitioners. In general, this assessment identified specific areas of the existing Manual to update (e.g., best practices, stormwater regulations) and new material to include (e.g., climate change, detailed information on site design/ evaluation). The 2020 assessment laid the groundwork for this updated Manual, which was developed through a partnership between NHDES and the University of New Hampshire Stormwater Center (UNHSC), with consulting assistance from Comprehensive Environmental, Inc. (CEI). NHDES and the UNHSC intend to update this Manual on a regular basis commensurate with the state of the practice and advancing science.

1.2 New Hampshire's Approach to Stormwater Management

The 2025 revision of the Manual is a guidance document and planning tool for municipalities, developers, designers, and members of regulatory boards, commissions, and agencies involved in stormwater programs in New Hampshire. As this Manual is a non-regulatory guidance document, it is the responsibility of individuals to ensure that all applicable regulations are met. This Manual serves as:

- A **resource for developers and engineers** in site planning, source control, and pollution prevention measures, as well as the selection and application of Stormwater Control Measures (SCMs) to protect the surface waters of the state from potential adverse impacts of construction and post-construction stormwater runoff. "Surface waters" include lakes, ponds, rivers, streams, wetlands, and tidal waters.
- A **resource to local and state government officials**, involved in project review or approval, such as planning and zoning boards, town and city engineers, planners, conservation commissions, and New Hampshire state agencies to ensure awareness of state and federal stormwater requirements, and that projects are reviewed in a consistent manner.
- A **source of information** on state and federal stormwater programs and their requirements that apply to development projects in New Hampshire, and a resource for selecting management measures to meet those requirements.



New name, same function...

The stormwater community has adopted **SCMs** as the new term for what had previously been called Best Management Practices (BMPs).

The name is new but the goal is the same: reduce downstream quality and quantity impacts of stormwater through **structural, nonstructural**, and **source control** techniques. In addition to SCMs, **recommended practices** for activities such as construction and winter road management can also reduce the impacts of pollutants on downstream waterbodies.

In addition, this Manual presents the **current (2025) state-of-the-practice for stormwater management** in New Hampshire. Historically, stormwater management design focused primarily on conveying stormwater from a site as quickly as possible to reduce localized flooding. This approach relied on conveyance infrastructure such as curb and gutter and piping systems, which quickly discharged runoff to the nearest waterbody and was often paired with "end-of-pipe" detention/ retention-type systems (e.g., stormwater detention ponds) to reduce peak runoff discharge rates. This past approach focused on peak flow control and proved to be detrimental to downstream waterbodies and water supplies by:

- Increasing the frequency, magnitude, and duration of channel forming flows.
- Altering stream channel morphology (alignment, cross-section geometry, and streambed composition).
- Reducing groundwater recharge and stream baseflows.

- Increasing pollutant load to receiving waterbodies, specifically increasing the load of nutrients, sediment, and bacteria in local waterways.

Although conveyance infrastructure and end-of-pipe practices still play an important role in stormwater management, *the key to effective management of stormwater runoff is to reduce the volume of stormwater generated, promote infiltration to mimic the natural hydrology, and manage stormwater at its source. Proper infrastructure sizing of SCMs is also important.* To align with current state-of-the-practice, New Hampshire's approach to stormwater management includes the following:

- Objectives to limit increased impervious surface and preserve important stormwater treatment functions of natural vegetated areas (see **Chapter 4**).
- Guidance on site design techniques to better manage impervious surfaces and control stormwater quantity and quality impacts close to its source. See **Chapter 5** for information on Low Impact Development (LID) techniques which incorporate the natural function of plants and soil to slow stormwater flow, attenuate pollutants, and promote infiltration to native soils.

How Does This Manual Relate to Stormwater Management Permitting?



As noted above, the primary goal of this Manual is to present the state-of-the-practice for stormwater management in New Hampshire. This Manual also provides guidance on stormwater design criteria required by various local, state, and federal regulations and permitting programs (*see **Chapter 3** – Regulations and Permitting*).

As the science and available technologies for stormwater management are constantly evolving, the state-of-the-practice may in some cases be "a step ahead" or differ from regulatory requirements and related design criteria which are only updated periodically. Contact applicable regulatory programs (*as described in **Chapter 3***) for the most up-to-date rules and regulations.



Designers and property owners are encouraged to manage stormwater based on the state-of-the-practice whenever possible. The **"plus" icon** to the left is provided to aid users of this Manual in identifying where recommended design criteria may **exceed or differ from state permitting requirements**. This guidance represents the latest science-based research and represents where the field is heading.

2 Stormwater Management Overview

2.1 Fundamentals of Stormwater Management

2.1.1 Hydrologic and Water Quality Impacts

Hydrologic Impacts

Land development can alter the natural flow of water. Development removes natural vegetation and introduces impervious surfaces, such as roads, rooftops, driveways, and parking areas. Precipitation falling on impervious areas can no longer soak into the ground and vegetation can no longer slow down the rate of flow. Because of this, developed areas generate more stormwater runoff, and this runoff reaches waterbodies more quickly. Stormwater runoff picks up sediment and other pollutants in its flow path, and carries these pollutants to waterbodies. The increased runoff can also result in erosion of the land surface, conveying the resulting sediment load to nearby waterbodies.

Hydrologic impacts from land development may include:



- Changes to stream flow.
- Increased stormwater runoff volumes.
- Increased peak runoff discharges.
- Increased stormwater runoff velocities.
- Increased frequency of bankfull and near bankfull events.
- Increased flooding.
- Increased sediment migration.
- Reduced groundwater recharge.
- Lower stream baseflows (dry weather flows).
- Damage or loss of stream crossing infrastructure not related to age or condition (such as undersized culverts).

Changes to Stream Geomorphology:

- Stream widening and bank erosion.
- Changes in flow velocities.
- Unnatural stream degradation (downcutting) or aggradation (rise in channel elevation due to sediment deposition) due to changes in flows, grade control alterations, or sediment load.
- Other changes in streambed due to increased sedimentation.
- Loss of riparian vegetation and canopy.
- Increased flood elevation.
- Isolation of the primary channel from its natural floodplain, resulting in further changes in channel geometry.

Changes to Aquatic Habitat:

- Habitat degradation - channel scour, streambank erosion, riparian vegetation loss, sediment deposition, and impacts to benthic habitat.
- Loss of riffle/ pool structure.
- Reduced stream baseflows.
- Increased temperatures.
- Decline in abundance and biodiversity of fish and benthic organisms.
- Loss of connectivity across habitats.

Water Quality Impacts

In addition to the hydrologic impacts from development activities, stormwater runoff impacts water quality. Land development and urbanization of the landscape increases the discharge of pollutants in stormwater runoff. Development introduces new sources of stormwater pollutants and provides impervious surfaces that accumulate pollutants between storms. Traditional stormwater collection and conveyance systems (pipes and gutters) allow stormwater pollutants to quickly wash off during storm or snowmelt events and discharge to downstream receiving waters. In undeveloped areas, natural processes, such as infiltration, interception, depression storage, filtration by vegetation, and evaporation, reduce the quantity of stormwater runoff and minimize pollutants. Impervious areas decrease the natural stormwater treatment functions of watersheds and increase the potential for water quality impacts in receiving waters.

Common stormwater pollutants, their sources, and potential water quality impacts are listed in the table below. These pollutants are picked up and carried by stormwater runoff and discharged to waterbodies. Fortunately, there are ways to lessen the water quality impacts of these changes through environmentally sensitive site planning, education, and voluntary and regulatory programs. Implementing better site design techniques and Stormwater Control Measures (SCMs) not only reduce the volume and velocity of stormwater runoff leaving a site but can also reduce pollutant runoff that can threaten water quality.

Harmful Algal Blooms and Stormwater:

Marine and fresh waters contain thousands of species of microscopic algae. Most are beneficial and harmless. However, some species of algae and cyanobacteria can cause harm, either through the production of potent toxins or through the accumulated biomass during their “blooms.”

Blooms with the potential to harm human health or aquatic ecosystems are referred to as harmful algal blooms, or HABs. **HABs may increase with the delivery of stormwater with high nutrient concentrations**. For more information about HABs including a link to New Hampshire’s Cyanobacteria Plan, see the NHDES Harmful Algal Bloom web page.



(Photo courtesy of NHDES)

Table 2-1. Summary of Common Stormwater Pollutants

Pollutant	Potential Sources	Potential Water Quality Impacts
Excess Nutrients *(Nitrogen, Phosphorus)*	Animal waste, fertilizers, failing septic systems, illicit sanitary connections, combined sewer overflows (CSOs), landfills, exhaust/ emissions, atmospheric deposition, erosion, and sedimentation.	Nuisance and/ or toxic algal growth, ammonia toxicity, reduced clarity, hypoxia, pollutant recycling from sediments.
Sediments	Construction sites, streambank erosion, forestry practices, grazing and crop lands, winter treatment of roads and parking surfaces.	Increased turbidity, lower dissolved oxygen, deposition of sediments, aquatic habitat alteration.
Pathogens *(Bacteria, Viruses)*	Animal waste, failing septic systems, illicit sanitary connections, CSOs.	Shellfish bed closures, beach closures, contamination of drinking water supplies.
Hydrocarbons *(Oil, Grease)*	Industrial processes, commercial processes, automobiles, emissions, fluid leaks, improper oil disposal.	Toxicity of water column, bioaccumulation.
Synthetic Organic Chemicals *(VOCs, PCBs, PAHs)*	Application of herbicides and pesticides, industrial processes, seal coating, commercial processes.	Toxicity of water column, bioaccumulation.
Deicing Materials *(Salt, other chemicals)*	Road salting and uncovered salt storage, snowmelt.	Toxicity of water column, contamination of drinking water supplies.
Thermal Impacts	Stormwater runoff from warm impervious surfaces, loss of shade from decreased riparian canopy.	Increased water temperatures, reduced dissolved oxygen levels, impacts to aquatic organisms requiring cold water.
Metals *(e.g., Zinc, Cadmium, Lead, Aluminum, Iron)*	Vehicle emissions, brake dust, tire debris, industrial processes, other urban sources.	Toxicity of water column, bioaccumulation.

2.1.2 Emerging Contaminants in Stormwater

In addition to the pollutants listed in the table above, other stormwater pollutants may include "emerging contaminants" that may be harmful but are not yet regulated. The EPA defines emerging contaminants "*as a term used by water quality professionals to describe pollutants that have been detected in water bodies that may cause ecological or human health impacts, and typically are not regulated under current environmental laws*."[1] Sources of these pollutants include agriculture, industrial manufacturing processes, urban stormwater runoff, ordinary household products (such as soaps and disinfectants), and pharmaceuticals that are conveyed to municipal wastewater treatment facilities and subsequently discharged to surface waters. A variety of emerging contaminants that may be present in stormwater, including the following examples:

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

PFAS are a family of over 5,000 synthetic chemicals. PFAS have been widely used since the 1940s in commercial, industrial, and household products and applications, including production of water-resistant materials, fire suppression foams, non-stick cookware, stain removers, etc. PFAS are used for their properties to resist heat, oil, grease, and water. Once released to the environment, PFAS are persistent, and may cause deleterious health effects. New Hampshire has adopted drinking water standards, and will soon adopt soil standards, for PFAS. In most cases, PFAS is not a pollutant commonly associated with stormwater. However, in certain areas, high concentrations of PFAS concentrations may impact stormwater management options. The NHDES New Hampshire PFAS Response web page has information about PFAS and where it has been identified in the state.

Microplastics and Nanoplastics

Microplastics (plastic particles ranging in size from 5 millimeters to 1 nanometer) and nanoplastics (smaller than 1 nanometer) enter the environment through the breakdown of larger plastic items, or through release of microfibers from synthetic clothing and other products. They have been found in every ecosystem on earth and pose potential risks to human and aquatic life. For more information, see the EPA Microplastics Research web page.

Pharmaceuticals and Personal Care Products (PPCPs)

These substances include chemicals found in prescription and over-the-counter medications, as well as personal care products like soaps, lotions, fragrances, and cosmetics. PPCPs can enter the environment through disposal of unused or expired products, or through excretion of active ingredients by humans and animals. For more information, see the EPA web page on Contaminants of Emerging Concern including Pharmaceuticals and Personal Care Products.

Tire Anti-Degradants (6PPD)

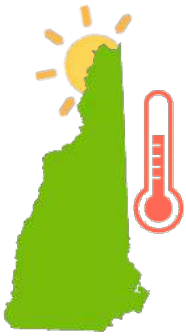
These substances are used to extend the life of tires by preventing the cracking and breakdown of rubber as it reacts with ozone over time. 6PPD enters the environment via tire fragments and particles on the road and has been shown to be a toxic aquatic contaminant. For more information, see the Interstate Technology Regulatory Council web page on Tire Anti-Degradants.

To date, more research is necessary to identify SCMs that have potential to effectively remove most emerging contaminants from stormwater. Treatment options for these types of pollutants often involve

[1] Interim Best Management Practices for Emerging Contaminants in Certified Biosolids, 2022. NHDES. Accessed at: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/web-29.pdf

carbon media amendment, a practice that requires frequent maintenance and has been developed as a drinking water treatment practice when needed. Research shows that filtration practices may remove microplastics. However, as stormwater can deliver emerging contaminants to receiving waters, it is important for environmental managers to develop strategies for site-specific treatment. This may include source control strategies such as efforts to promote proper disposal of PPCPs and regulations limiting the production and use of chemicals such as PFAS. Other strategies may include monitoring to identify and reduce known pollutant sources.

2.1.3 Climate Change and Stormwater Management



New Hampshire continues to be affected by the extreme weather events associated with climate change. These events, including frequent intense storms, extreme temperatures, ice storms, inland and coastal flooding, intense rainfall, etc., have the potential to impact stormwater infrastructure. In response, the state has implemented policies and programs to increase its adaptation and resilience to climate change. Efforts to address the linkage between climate change and stormwater include:

- Strategies found in the New Hampshire Climate Action Plan.
- The New Hampshire Department of Transportation has implemented projects to improve the resilience of the state's transportation infrastructure, including retrofits of culverts to convey larger flow volumes and other flood control measures.
- The New Hampshire Department of Environmental Services Coastal Program works with New Hampshire's coastal communities to address their unique set of stormwater issues and design considerations in response to climate change by providing grant assistance, technical assistance, as well as New Hampshire-specific climate science and adaptation strategies. Many of these issues are outlined in the 2019-2020 New Hampshire Coastal Flood Risk Summary Report.
- NHDES has funding programs (See **Chapter 2.3**) which support efforts to improve the water quality function, flow capacity, and flood resiliency of the state's stormwater infrastructure, including funding implementation of projects such as restoration of vegetated buffers and Low Impact Development (LID) SCMs (e.g., open space preservation, bioretention systems, permeable pavements, etc.).
- The University of New Hampshire has developed the New Hampshire Climate Assessment (2021) outlining the potential impacts of climate change on New Hampshire.

In promoting climate change resiliency, vulnerability, and criticality, NHDES is committed to ensuring that related programs and policies are consistent with the NHDES Statement on Environmental Justice. This policy outlines the state's commitment to addressing environmental justice and equity issues and provides guidance on how to integrate these principles into the state's environmental decision-making process.

Benefits of Low Impact Development in Addressing Climate Change

Stormwater management projects should be designed with a goal of improving the adaptation and resiliency of communities to climate change. Whenever feasible, stormwater management design should consider incorporating LID into traditional gray infrastructure projects such as culverts, pipes, pumps, and roads. LID, often referred to as Green Infrastructure, is a combination of **nonstructural** (i.e., can be

implemented without an engineering component) and **structural SCMs** used to preserve and leverage natural vegetation advantages, minimize impervious surfaces, slow down travel times of overland flow, and reduce stormwater runoff.

The goal of a Green Infrastructure SCM is primarily to treat the water quality volume (WQV) first flush and to recharge water to make the land use change associated with a developed site hydrologically transparent. The WQV and recharge depth focus on more common events and not the extreme events such as the 10-year rainfall depth (which occur less than 1 percent of the time). Designs for extreme rainfall depths are technically very different from the smaller, WQV, however they essentially require storing runoff and slowly letting it out or trying not to generate the additional runoff in the first place. A WQV design centers on water quality improvement and volume reduction from common storms. Design for flooding from extreme rainfall centers on runoff volume and peak flow control. Climate change plays a massive role in control measures intended to reduce flooding, but is irrelevant to water quality design other than ensuring that the system can safely and securely process the non-design events.

Designing stormwater management projects so that new infrastructure is adequately sized to handle future increases in runoff will extend the longevity of these systems. **Chapter 4 (Design Criteria and Example Calculations)** provides more information on designing resilient SCMs that control for peak discharge rates and stormwater runoff volumes. In general, stormwater systems are designed to be their own hydraulic controls. However, groundwater and surface waters may rise to levels that ultimately intersect or create a backwater on the stormwater systems. Consequences from these instances are to reduce the hydraulic and water quality performance of the stormwater systems by making them prematurely bypass inflows before treating them. To this end, sea level rise and groundwater rise in coastal areas should be considered for the expected design life of the stormwater infrastructure, specifically to ensure that sea level rise does not result in stormwater system backwater.

LID techniques provide multiple benefits to a community including improving water quality, reducing flooding, increasing groundwater recharge, reducing energy use, improving air quality, reducing the urban heat island effect, providing recreational opportunities, and providing wildlife habitat. Tools such as EPA's Opti-Tool are becoming increasingly available to quantify and value the co-benefits of LID to allow communities to compare the life-cycle cost and value of LID options with traditional gray infrastructure projects.[2]

[2] Green Infrastructure Benefits Valuation Tool, 2018. Earth Economics. Accessed at https://giexchange.org/wp-content/uploads/2019/05/Green-Infrastructure-Valuation-Tool-User-Guide-Version_1.01.pdf

2.2 Stormwater Management Tools

A variety of tools are available to assist in managing stormwater quantity and quality. Some key tools and approaches are summarized in the sections below.

2.2.1 Watershed Management Planning

What is a Watershed?

A watershed is a geographic area in which all water drains to a given waterbody such as a stream, river, lake, wetland, estuary, or ocean. Our landscape is made up of many interconnected watersheds. The boundary between each is defined by the line that connects the highest elevations around the waterbodies. New Hampshire watersheds often cross political boundaries of towns, cities, counties, states, and New Hampshire's border with Canada. This often requires that municipalities and other government agencies work together to address stormwater management concerns.[3]



Figure 2-1. What is a Watershed?

(Source: https://bewaterfriendly.com/our-water/watersheds/)

It is important to look at land use activities and potential sources of pollution across the entire watershed when trying to determine the cause of pollutants in downstream water bodies. It is also important, when planning for new development, or redevelopment, to recognize that impacts can be far reaching. Even if there is not a stream flowing through the site, stormwater runoff and the pollutants it carries will eventually

[3] Nine Regional Planning Commissions (RPCs) were established in New Hampshire to, among other things, increase communication between municipalities, promote intergovernmental cooperation, and coordinate development of the various regions. Learn more about RPCs at: http://www.nharpc.org.

end up in downstream surface waters. Because of this, stormwater management is most effective when addressed at a watershed scale with careful watershed management planning.

Watershed-based Plans

Watershed-based plans (WBPs) are tools for managing existing and future watershed conditions, including land use planning and addressing confirmed and/ or potential stormwater and nonpoint source pollution impacts on water quality. Plans identify existing pollution contributions and sources, establish water quality goals, estimate the reductions or limits of pollutants needed to meet water quality goals, and identify the actions needed to achieve pollutant reductions sufficient to reach these goals. WBPs prioritize recommended actions based on cost/ benefit analyses and set implementation timelines. They also describe potential sources of funding to carry out components of the plan, identify responsible partners relative to implementation activities and SCM maintenance, and provide measures to document success of implementation actions according to the following nine (a) through (i), elements for watershed-based planning as outlined by EPA and NHDES.[4]

Elements of a Watershed-based Plan (WBP)

- Identify **causes and sources of pollution** that need to be controlled to achieve water quality goals for the watershed.
- Determine **pollutant reductions needed** to achieve water quality goals for the watershed.
- Describe **management actions needed** to achieve the targeted pollutant load reductions and an identification of the critical areas where those actions will be implemented.
- Estimate **technical and financial assistance needed** to implement the watershed plan.
- Develop an **information/ education component** that will be used to enhance public understanding of and participation in the implementation of recommended watershed management actions.
- Develop a **schedule for implementing management actions** identified in the watershed-based plan.
- Develop **interim milestones** to track progress in implementing management actions identified in the watershed-based plan.
- Develop **criteria to measure progress** towards meeting water quality goals.
- Develop a **monitoring component** to evaluate the effectiveness of implementation efforts.

To see examples of WBPs for New Hampshire waters, visit the NHDES Publications web page.

[4] EPA provides multiple resources for developing watershed-based plans. Refer to the 2024 EPA Nonpoint Source Program and Grants Guidelines for States and Territories. Appendix B of the linked guidelines provides the Minimum Elements of a Watershed-Based Plan and links to additional EPA resources.

2.2.2 Municipal Stormwater Management Programs

Many municipalities are required to develop stormwater management programs as part of a Municipal Separate Storm Sewer System (MS4) permit under the EPA National Pollutant Discharge Elimination System (NPDES) program. However, **all municipalities are impacted by stormwater runoff and should develop stormwater management programs**. Further information about the MS4 program and other federal, state, and local regulatory programs can be found in **Chapter 3.** The programs listed below should be considered for development by **all** municipalities to address stormwater, regardless of MS4 status. The New Hampshire Stormwater Regional Coalitions have created detailed tools to assist municipalities in developing a stormwater management program. These tools are available on the New Hampshire Stormwater Regional Coalitions' MS4 website.

Stormwater Asset Management

Stormwater asset management is the process of planning, designing, operating, maintaining, and repairing a stormwater management system. Development and implementation of a stormwater asset management program plan can help reduce operating risks, financial costs, and address infrastructure challenges as the infrastructure continues to age and deteriorate. Asset management enables an organization or a community to examine the need for each asset as well as the performance of the assets. This, in turn, allows the organization or community to self-evaluate individual systems and determine their needs and funding strategies.

An Asset Management Program typically involves the following:

- Establishing a vision statement and identifying stakeholders.
- Establishing Level of Service (LOS) goals.
- Identifying and inventorying the location and type of all stormwater infrastructure such as catch basins, pipes, and detention ponds (including information about sizing, material type, install year, etc.).
- Assessing and prioritizing assets through a criticality analysis.
- Analyzing life cycle costs of each asset.
- Analyzing alternatives.
- Determining performance rating and metrics.
- Determining actions needed to ensure proper function of the stormwater system, including the development of Standard Operating Procedures (SOPs) and Operation and Maintenance (O & M) Plans for these actions.
- Setting priorities for maintenance and repair of stormwater infrastructure.
- Identifying a funding strategy to assist with financial planning.
- Identifying and implementing practices, such as LID, to improve the quality of stormwater runoff and reduce stormwater runoff volumes.
- Preparing a communication plan to inform stakeholders about the program and its capabilities.

The goal of asset management is to shift from "reactive" management of stormwater infrastructure to "proactive" management, thereby increasing the impact of stormwater infrastructure investments. This is an important step toward building sustainable communities.

For more information, reference the NHDES Asset Management Handbook and Toolkit or visit the NHDES Asset Management web page.

Stormwater Utilities[5]

As the challenges and costs of managing stormwater grow, many municipalities are exploring stormwater utilities as a sustainable option for funding stormwater management programs. Results of a 2022 survey conducted by Western Kentucky University identified 2,057 stormwater utilities nationwide, with 41 states and the District of Columbia having at least one stormwater utility. New Hampshire municipalities were given legal authority to form stormwater utilities in 2008 under NHRSA 149-I. Under this statute, stormwater utilities must address flood and erosion control, water quality management, ecological preservation, annual pollutant loads contained in stormwater discharges, and comply with applicable state and federal stormwater laws and regulations.

As of 2025, New Hampshire is one of several states without a stormwater utility. However, as of the writing of this document, several New Hampshire municipalities are actively researching the feasibility of a stormwater utility. More information on Stormwater Utilities and the efforts in New Hampshire communities can be found on New Hampshire's Stormwater Regional Coalitions' MS4 webpage.

How Does a Stormwater Utility Work?

Stormwater utilities are similar to dedicated municipal funds for public water and sewer utilities. A stormwater utility generates funding through user fees for properties in the stormwater utility district that are typically based on the property's area of impervious surfaces (e.g., roofs, roads, driveways, sidewalks, parking lots). Funding from stormwater utilities can be used for catch basin cleaning, SCM maintenance, street sweeping, stormwater infrastructure upgrades, implementation of nutrient control plans, and a variety of other stormwater management activities, in addition to the administrative costs of managing a stormwater program.

Benefits of a Stormwater Utility

- **Dedicated Funding Source**: Revenue generated by a stormwater utility can be used as a new, dedicated source of funds to supplement or replace the municipality's current stormwater management funding.
- **Sustainable Revenue:** Revenue generated by a stormwater utility is based on user fees and provides a constant, sustainable funding source that increases with the growth of the municipality. Sustainable funding allows municipal stormwater programs to operate on a stable basis to maintain existing infrastructure and adopt long-term planning for capital investments, maintenance enhancement, and staff support or development.
- **Shared Cost:** A stormwater utility shares the costs of stormwater management among users of the stormwater system and can increase the number of properties contributing funding to the stormwater management system.
- **Improved Watershed Stewardship:** Through incentive programs that reduce user fees, a stormwater utility encourages better stormwater management, such as the use of LID.

[5] Adapted from the NHDES Stormwater Utility fact sheet.

- **Facilitation of National Pollutant Discharge Elimination System (NPDES) Compliance:** Communities regulated under the Federal NPDES Stormwater Permitting Program are often more able to comply with the specific permit conditions contained in their Municipal Storm Sewer System (NH MS4) Permits.
- **Address Existing Stormwater Issues:** Stormwater utilities provide dedicated funding to address the following stormwater issues and many more:
    - **Flooding:** New Hampshire is experiencing more frequent, significant rainfall events that result in increased flooding and damage to infrastructure.
    - **Water Quality:** Stormwater runoff is a significant source of pollutants. Nonpoint source pollution contributes to approximately 90 percent of the water pollution problems in New Hampshire.[6]
    - **Aging Infrastructure:** Most existing municipal stormwater infrastructure, (e.g., pipes, culverts, and catch basins), have been in the ground for several decades and need repair, upgrade (size, orientation, alignment, etc.), replacement or removal.
    - **Undersized Infrastructure:** Most existing stormwater infrastructure (pipes, culverts, and catch basins) are undersized with respect to modern design capacity standards adding vulnerabilities to the stresses of increased runoff from current and future storm events.

Illicit Discharge Detection and Elimination Program

Illicit discharge detection and elimination (IDDE) programs identify and eliminate unauthorized discharges of pollutants to a storm drain system or to waterbodies. Illicit discharges represent a major cause for concern and can potentially impact public health. Examples of illicit discharges include:

- Broken or leaking sewer lines.
- Improperly connected sanitary lines/ cross connections tied into the storm sewer system.
- Illegal dumping of substances such as pet waste, oil, paint, recreational vehicle (RV) waste, etc.
- Failing septic systems.
- Garage/ building floor drain connections.
- Construction site runoff.
- Pesticides and fertilizer runoff.

IDDE programs protect water quality by identifying and eliminating illicit discharges of wastewater, chemicals, oil and grease, and other pollutants which should not be discharged into the storm drain system or directly into waterbodies. IDDE programs typically include the following:

- **Illicit Discharge Detection** through visual inspections, sampling, and other monitoring methods.
- **Illicit Discharge Elimination**, including actions such as repairing or replacing damaged sewer lines, replacing failing septic tanks, implementing SCMs, or educating the public about proper disposal of pollutants.

[6] From the New Hampshire Nonpoint Source Management Program Plan 2025-2029.

- **Legal Authority and Enforcement** to take actions against individuals, institutions, or businesses discharging pollutants illegally, such as issuing fines or penalties.
- **Public Education and Outreach** about the importance of preventing illicit discharges and promoting SCMs.

Many municipalities are required to develop an IDDE program to comply with the New Hampshire MS4 permit requirements. However, all municipalities are impacted by potential illicit discharges and should develop IDDE programs to properly address them. Every New Hampshire municipality should consider adopting a regulatory mechanism to prevent illicit discharges to their stormwater system and develop comprehensive IDDE programs to detect and eliminate any non-stormwater discharges entering their system. The New Hampshire Stormwater Regional Coalitions have developed detailed tools, including an ordinance template, to assist municipalities in creating a comprehensive IDDE program. These tools are available on the New Hampshire Stormwater Regional Coalitions' IDDE Program webpage.

NHDES Green SnowPro Certification Program

Commercial salt applicators can obtain Salt Applicator Certification through the NHDES Green SnowPro Program. The program offers training for winter road, parking lot, and sidewalk maintenance developed by the University of New Hampshire Technology Transfer (UNH T2) program with the goal of reducing use of de-icing salt in New Hampshire.

Commercial salt applicators certified by the NHDES Green SnowPro Certification Program and the property owners or managers who hire them are granted limited liability protection against damages or personal injury arising from snow and ice conditions. The administrative rules for the Voluntary Municipal Winter Maintenance Certification program (Municipal Green SnowPro) were adopted by the New Hampshire Department of Environmental Services (NHDES) in May of 2024. The Voluntary Municipal Green SnowPro offers three levels of certification for municipalities to consider: Standard, Advanced, and Expert. Unlike the Voluntary Commercial Green SnowPro Program where individual salt applicators are certified, the Voluntary Municipal Green SnowPro certifies the municipal program or department responsible for snow and ice management. A Standard municipal certification is on par with the Commercial Green SnowPro certification with a focus on calibration, salt accounting, and record keeping. In addition to all the Standard certification requirements, municipalities interested in pursuing an Advanced or Expert certification must implement and document salt reduction best management practices (BMPs). Municipalities select from an approved list of BMPs that allow flexibility and the ability to implement BMPs that best fit their winter management needs and budget.

Public Education and Outreach Program

Many municipalities are required to develop a comprehensive public education program to comply with the New Hampshire MS4 permit requirements. However, an educated public is integral to a successful municipal stormwater management program, regardless of MS4 permit status. The steps to developing effective public education and outreach efforts include:

Step 1: Establish Education and Outreach Goals

Make your education and outreach goals and related messaging as specific as possible. Example goals for stormwater education and outreach include:

- Educate homeowners and businesses about LID to manage stormwater runoff from their property such as rain gardens and vegetated buffers.
- Educate homeowners about proper disposal options for household hazardous waste.
- Promote reduced use of lawn fertilizers and chemicals and proper management of yard wastes (e.g., leaves, lawn clippings, etc.).
- Promote improved septic system maintenance.
- Improve public understanding of water quality impacts associated with pet waste and proper disposal.
- Educate public on the typical types of pollutants found in nonpoint source watershed runoff.

Step 2: Identify the Target Audience

Education and outreach programs and messaging should be tailored to communicate with specific target audiences. Target audiences for stormwater education and outreach include:

- Residential property owners.
- Commercial property owners and businesses.
- Waterfront property owners.
- Pet owners.
- Golf courses.
- Agricultural landowners (e.g., commercial farms, specialty farms, nonprofit animal rescue operations, and demonstration farms).
- Schools (e.g., K-12 education and universities).
- Outdoor recreational fields and complexes.
- Special interest groups (e.g., sportsmen clubs, garden clubs, etc.).

Step 3: Determine the Most Effective Way to Get Your Message to the Target Audience

After selecting your target audience, consider which outreach methods and products will most effectively engage them. Municipalities can often incorporate outreach messages within existing municipal public correspondence avenues (e.g., dog licensing, water/ sewer bills, tax bills, etc.). A variety of copyright-free education and outreach materials are available that can be used or adapted to meet your project's needs. Some key sources for these materials are available on the New Hampshire Stormwater Regional Coalitions' MS4 website and listed below.

New Hampshire Stormwater Information/ Education Resources

In addition to this Manual, the following are key resources for developing stormwater education programs:

- New Hampshire MS4 Resources public education and outreach.
- NHDES stormwater information and publications.
- NHDES Soak Up the Rain Program.
- UNH Stormwater Center publications and MS4 resources.
- U.S. EPA's Nonpoint Source Outreach Toolbox provides outreach materials to use or adapt for education and outreach messaging for your municipality.
- U.S. EPA's Soak Up the Rain materials.

Municipal Ordinances

Municipal ordinances are tools cities and towns can use to protect water quality. In some cases, municipalities are required to develop local ordinances as part of a stormwater program (as described in **Chapter 3.1.4**). Some municipalities will develop regulations that are more protective than federal or state regulations. At the local level, municipalities develop ordinances and other regulatory mechanisms that support nature-based development, site design review, and operations and maintenance programs to avoid impacts from increased stormwater runoff and climate change. Tools available to help municipalities develop these types of ordinances include:

- The New Hampshire Stormwater Regional Coalitions' New Hampshire MS4 webpage is a resource for New Hampshire's MS4 communities (as described in **Chapter 3.1.4**) and provides example municipal ordinances for illicit discharge detection and elimination (IDDE) programs and stormwater and land development regulations examples and templates.
- The Mass Audubon Bylaw Review Tool provides an Excel-based tool for municipalities to compare local land use regulations with best practices.

Easements and Deed Restrictions

Easements and deed restrictions are legal tools municipalities can use to meet stormwater management objectives. These tools can impose permanent restrictions on the use of properties or facilities, or to facilitate performance of necessary activities such as operation and maintenance.

Easements: An easement is an agreement between a landowner and an easement holder (e.g., a local government agency or a utility company), which gives the holder a right to use a defined part of the property for a specific purpose. Common examples of easements are ones established for a utility company to install, operate, and maintain power lines on a property or for a driveway extending over a neighboring property to access a landlocked property. Easements are typically documented in the deed to the property and filed with the Registry of Deeds in the county where the property is located. They are described in terms of the resource they are designed to protect and explain the restriction on the uses of the property or facility.

Easements may be used to help control stormwater quantity and protect water quality by providing:

- Access for construction and grading activities, where a project depends on off-site improvements.
- Access for construction and maintenance of conveyance and stormwater management facilities when there are or will be multiple property owners served by these facilities.
- Permanent access by parties responsible for stormwater system operation and maintenance to the facilities that must be maintained to ensure the long-term performance of the stormwater system.
- Provisions for municipal access where appropriate, either because the municipality will be the responsible operator, or the municipality will need to have access on an emergency or contingency basis.

Deed Restrictions: A deed restriction is a clause in a deed that limits the use of a property. Deed restrictions are usually initiated by the developer, possibly as a permit condition, and transfer with the property. They typically cannot be changed or removed by subsequent owners. Deed restrictions are filed with the New Hampshire County Registers of Deeds in the county where the property is located and the deed restriction language is included in all future real estate transactions.

Deed restrictions may be used to protect water quality by requiring:

- Buffers to wetlands, streams, rivers, lakes, ponds, estuaries, or other sensitive natural areas.
- Limitations on fertilizer, herbicide, and pesticide application.
- Limitations on clearing or removing vegetation.
- Maintenance of privately owned Stormwater Control Measures.

2.3 Stormwater Grants and Funding Opportunities

Brief descriptions of key funding sources related to stormwater management in New Hampshire are provided in the table below. Additional resources can be found on the NHDES Loans and Grants webpage. Although NHDES updates this page regularly, funding programs are constantly changing and should be checked on a regular basis. NHDES can provide the most current and up-to-date funding sources.

Table 2-2. Summary of Stormwater-related Funding Programs

Funding Program	Description
NHDES Watershed Assistance Grants	NHDES provides funding appropriated through EPA under Section 319 of the Clean Water Act for projects to restore impaired waters or protect high quality waters. Watershed Assistance Grants are targeted toward implementation of completed WBPs. Forty percent non-federal match is required.
NHDES Water Quality Planning Grants	NHDES provides funding appropriated through EPA under Section 604b of the Clean Water Act for water quality planning purposes. Eligible projects include water quality monitoring, design of stormwater retrofits and LID projects, adopting ordinances, meeting MS4 permit requirements to address priority water quality planning concerns, and development of WBPs.
NHDES Clean Water State Revolving Fund	The NHDES Clean Water State Revolving Fund (CWSRF) provides low-cost financial assistance for planning, design, and construction projects to municipalities, nonprofits, and local government entities for wastewater infrastructure projects (collection systems, pumping stations, and wastewater treatment) and water pollution control projects (stormwater planning, nonpoint source, and development of watershed protection/ restoration plans).
NHDES Coastal Resilience Grants	To help municipalities prepare for current and future coastal hazards, the New Hampshire Coastal Resilience Grant Program provides competitive funding for coastal community and habitat resilience projects.
Conservation Grant Program (Moose Plate)	Funding focus includes preservation, protection, and conservation of water quantity and quality; restoration, enhancement, or conservation of wildlife habitat; soil erosion prevention; flood mitigation; implementation and installation of SCMs respectively for agriculture; forestry; stormwater management; and land protection.
Aquatic Resource Mitigation Fund Program	Focuses on projects to restore natural resources within the context of a proposed land conservation effort. NHDES encourages projects providing connectivity to other protected resources or in close proximity to wetland impacts. Projects to benefit rare resources are viewed favorably.
Center for Land Conservation Assistance	Funds transaction costs for permanent land protection projects within New Hampshire coastal watershed areas.
Davis Conservation Foundation	Supports organizations with projects related to wildlife, wildlife habitat, environmental protection, or outdoor recreation. Projects that strengthen volunteer activity and community involvement in these categories are of particular interest.
National Fish and Wildlife Foundation, *Five Star and Urban Waters Restoration Program*	Provides funds to local partnerships for wetland, forest, riparian and coastal habitat restoration, with a focus on urban waters and watersheds.

Funding Program	Description
National Park Service – Rivers and Trails Program	Funds projects focused on protection of natural resources and enhancement of outdoor recreational opportunities.
Natural Resource Conservation Service (NRCS)	Financial/ technical assistance to landowners and agricultural producers for conservation practices to address natural resource concerns or opportunities to help save energy, improve soil, water, plant, air, animal and related resources on agricultural lands and non-industrial private forest.
New England Grassroots Environmental Fund	Funds projects focused on forestry and trails, with a focus on community-based environmental work.
Northeast Forests and Rivers Fund	Dedicated to restoring and sustaining healthy forests and rivers that provide habitat for native bird and freshwater fish populations in New England.
U.S. Fish and Wildlife Service Grants and Financial Assistance	The U.S. FWS provides financial assistance through grants and cooperative agreement awards to a variety of groups and organizations.
NOAA Climate Program Grants	NOAA's Climate Program Grants fund high-priority climate science assessments, decision support research, outreach education, and capacity building activities designed to advance the understanding of Earth's climate system.

3 Regulations and Permitting

How Does This Manual Relate to Stormwater Management Permitting?



The primary goal of this Manual is to present the state-of-the-practice for stormwater management in New Hampshire. This Manual also provides guidance on stormwater design criteria required by various local, state, and federal regulations and permitting programs (*see **Chapter 3** – Regulations and Permitting*).

As the science and available technologies for stormwater management are constantly evolving, the state-of-the-practice may in some cases be "a step ahead" or differ from regulatory requirements and related design criteria which are only updated periodically. Contact applicable regulatory programs (*as described in **Chapter 3***) for the most up-to-date rules and regulations.



Designers and property owners are encouraged to manage stormwater based on the state-of-the-practice whenever possible. The **"plus" icon** to the left is provided to aid users of this Manual in identifying where recommended design criteria may **exceed or differ from state permitting requirements**. This guidance represents the latest science-based research and represents where the field is heading.

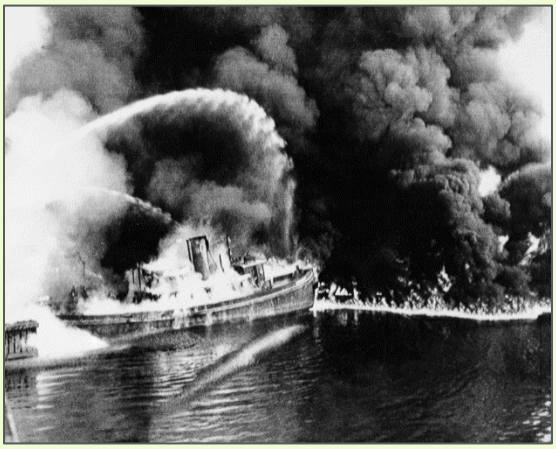
Federal, state, and local regulations and permitting programs related to stormwater aim to balance development with water quality protection. The Federal Clean Water Act, New Hampshire Water Pollution and Waste Disposal statute (RSA 485-A), and the New Hampshire Surface Water Quality Regulations (Env- Wq 1700) that implement RSA 485-A, are the primary regulatory authorities for the protection of water quality in New Hampshire. They are the basis for the various New Hampshire permitting and certification programs related to stormwater. In addition to the federal and state regulations, municipalities may develop additional regulations to protect water quality.

3.1 Federal Regulations and Permit Programs

The Federal Water Pollution Control Act of 1948 was the first major federal legislation to address water pollution. This legislation was significantly amended in 1972, when it became commonly known as the Clean Water Act (CWA). Additional revisions were incorporated in subsequent years. Today, the CWA provides the structure for regulating discharges of pollutants into the waters of the United States and regulating water quality standards for surface waters. A discussion of the major sections of the CWA that involve stormwater is provided below.

Cuyahoga River Fire

A 1969 fire on the Cuyahoga River in Cleveland, Ohio became the symbol of water pollution in America in the 1970s. Decades of pollution from nearby factories and sewage discharge had degraded water quality and a spark from train tracks near the river ignited oil slicks and industrial debris floating on its surface. Although this was not the first time the river had caught on fire, the 1969 fire engaged public interest as a picture of an earlier fire made the cover of *Time* magazine. This picture is often cited as a key impetus for the sweeping environmental reforms that led to amendment of the CWA in 1972.



Cuyahoga River Fire, Ohio
(Picture courtesy of EPA, 2021)

3.1.1 Federal CWA Sections 303 and 305 – Surface Water Quality Assessment

The CWA requires states to submit two surface water quality documents to the EPA every two years. Section 305(b) of the CWA requires submittal of a report (commonly called the "305(b) Report"), that describes the quality of its surface waters and an analysis of the extent to which all such waters provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities in and on the water.

The second document is typically called the "303(d) List," which is so named because it is a requirement of Section 303(d) of the CWA. The 303(d) List includes surface waters that are:

- Impaired or threatened by a pollutant or pollutants.
- Not expected to meet state water quality standards within a reasonable time even after application of best available technology standards for point sources or best practices for nonpoint sources.
- Require development and implementation of a comprehensive water quality study (a Total Maximum Daily Load (TMDL) study), which is designed to meet water quality standards.

Water quality standards include numeric and narrative criteria that must be met to protect the designated uses of the surface water such as swimming, boating, aquatic life integrity, shellfish and fish consumption, potential drinking water supply, and wildlife. Waters that do not meet these water quality standards are considered “impaired” and those requiring a TMDL are added to the 303(d) List.

See **Chapter 3.2.1** for more information on New Hampshire’s surface water quality standards.

Total Maximum Daily Loads (TMDLs)

For each waterbody on the 303(d) list, the state must identify the pollutant causing the impairment and assign a priority for development of Total Maximum Daily Loads (TMDLs). A TMDL is the calculation of

the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for a particular pollutant and serves as the starting point for restoring water quality. The TMDL process provides a path that should lead to restoration of an impaired waterbody and ultimately, de-listing the waterbody from the 303(d) list. The general components of a TMDL include:

- Identification of the major sources of a pollutant.
- Estimation of existing pollutant loads from point sources and nonpoint sources, including naturally occurring background sources.
- Inclusion of a margin of safety (MOS) that accounts for uncertainty and any lack of knowledge concerning the relationship between effluent limitations and water quality, which also accounts for seasonal variations.
- Calculation of the maximum load that the surface water can receive and still meet water quality standards.
- Allocation of the maximum load among point and nonpoint sources.
- Calculation of the reduction in pollutant load needed to achieve water quality standards.
- Recommendations for implementing the TMDL to achieve water quality standards.

Following the development of a TMDL by NHDES, it is subject to public review and comment, which typically lasts for thirty days. Once public comments have been addressed the final TMDL is submitted to EPA for approval. While the TMDL calculates numeric targets for meeting state water quality standards, an implementation plan and subsequent actions are key to meeting those targets. TMDL implementation plans are not required by the CWA but are frequently submitted to EPA as part of the TMDL.

3.1.2 Federal CWA Section 319 – Nonpoint Source Management Program

Section 319 of the CWA, established in 1987, provides federal guidance and funding to support activities that address nonpoint source pollution. These activities include technical assistance, education, outreach, and training, technology transfer, demonstration projects, and monitoring projects. Section 319 provides pass-through funding to the NHDES Watershed Assistance Section which provides direct financial assistance, through a competitive Watershed Assistance Grants (WAG) program, to municipalities, state agencies, regional planning commissions, county conservation districts, non-profit organizations, and other local groups. These entities are eligible to apply for WAGs to address nonpoint source pollution by implementing recommendations established within watershed-based plans to achieve water quality goals.

3.1.3 Federal CWA Section 401 – Water Quality Certification Program

Section 401 of the CWA requires applicants for a federal license or permit, including wetlands permits from the U.S. Army Corps of Engineers, to obtain a certificate from the state for any activity that may result in a discharge into waters of the United States. This includes wetlands, rivers, tidal waters, and other bodies of water. More information on the New Hampshire 401 Surface Water Quality Certification Program is provided in **Chapter 3.2.2.**

3.1.4 Federal CWA Section 402 – National Pollutant Discharge and Elimination System (NPDES) Program

Section 402 of the CWA established the National Pollutant Discharge Elimination System (NPDES) Program which prohibits the discharge of pollutants from a "point source" to waters of the United States. EPA defines a "point source" as any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff. Discharges from specific municipal and industrial operations to waters of the United States, including treated wastewater, process water, cooling water, as well as stormwater from certain urbanized areas, industrial activities, and construction sites are not authorized without a NPDES permit. In some states, this regulatory authority is delegated to state government for administration. In New Hampshire, the NPDES program is administered by the EPA New England (Region 1).

NPDES permits establish conditions and limitations for pollutants of concern to ensure that discharges are protective of water quality, which, for discharges of stormwater, may be met through the implementation of best practices and Stormwater Control Measures. *Individual* NPDES permits are tailored to an individual facility or system, while a *general* NPDES permit covers a group of dischargers with similar qualities within a given geographical location. More information on NPDES permits can be found on EPA's NPDES webpage. NPDES permits that involve stormwater are described in the sections below.

NPDES Stormwater Permits

In the 1987 amendment of the CWA (Federal Water Quality Act of 1987), stormwater runoff from urban areas, construction activities, and industrial sites were identified as sources of pollution to surface waters subject to NPDES permitting. These NPDES permits were released using a two-phased approach. The Phase I and Phase II Regulations were published in 1990 and 1999, respectively.

- **Phase I** regulations required operators of "medium and large" Municipal Separate Stormwater Sewer Systems (MS4s) (generally over 100,000 people) and dischargers of stormwater associated with certain industrial activities to obtain an individual NPDES permit to discharge stormwater.
- **Phase II** regulations required operators of "small" MS4s and dischargers associated with small construction activity, and stormwater discharges associated with industrial activity to be covered under a general stormwater permit.

More information can be found on the NPDES Stormwater Program webpage. The primary NPDES permits that address stormwater discharges in New Hampshire are described below.

Municipal Separate Stormwater Sewer System General Permit Program

To address these stormwater discharges from municipal sources, EPA created the Municipal Separate Storm Sewer Systems (MS4) Permit Program using the two-phased approached described above. The current Phase II Small MS4 General Permit (effective on July 1, 2018 for New Hampshire Small MS4s) requires all entities with MS4s and stormwater discharges from any MS4 "located in an urbanized area as

determined by the Decennial Census by the Bureau of Census" to apply for authorization to discharge under the permit. At the time of publication of this document, the Census Bureau had recently finalized revisions to its criteria for defining urban areas based on the results of the 2020 Decennial Census. For current definitions and applicability, refer to the EPA NPDES MS4 webpage.

In New Hampshire, the majority of MS4 permittees are located in the more populated southern and southeast corners of the State. The permit covers small MS4 permittees located in the State of New Hampshire including:

- Traditional Cities and Towns (NPDES Permit No. NHR04100).
- State, federal, county, and other publicly owned properties (NHR042000).
- State Transportation agency (NHR043000).

Each regulated entity is required to submit a Notice of Intent (NOI) briefly outlining how it will meet the six Minimum Control Measures (MCMs) and impaired waters requirements of the permit as well as requesting authorization to discharge under the new permit. These six MCMs are described in the table below. More detail regarding the New Hampshire-specific requirements of each MCM can be found in the 2017 NH Small MS4 General Permit.

Table 3-1. Summary of MS4 Permit Minimum Control Measures (MCM)

Minimum Control Measure	Description
MCM #1: Public Education and Outreach	Implement an education program that includes educational goals based on stormwater issues of significance within the MS4 area. The objective of a public education program is to increase knowledge and change behavior of the public so that pollutants in stormwater are reduced.
MCM #2: Public Involvement and Participation	Provide opportunities to engage the public to participate in the review and implementation of the permittee's Stormwater Management Program (SWMP).
MCM #3: Illicit Discharge Detection and Elimination (IDDE) Program	Implement an IDDE program to systematically identify and eliminate sources of non-stormwater discharges to the permittees MS4 and implement procedures to prevent such discharges.
MCM #4: Construction Site Stormwater Runoff Control	Develop an effective construction stormwater runoff control program to minimize or eliminate erosion and maintain sediment on construction sites so that it is not transported in stormwater and allowed to discharge to a water of the U.S. through the permittee's MS4.
MCM #5: Post-Construction Runoff Control	Minimize the water quality impact from new development and reduce the water quality impact due to stormwater runoff from a redeveloped site.
MCM #6: Good Housekeeping and Pollution Prevention	Implement an operations and maintenance program for permittee operations that includes a training component, has a goal of preventing or reducing pollutant runoff and protects water quality from all permittee operations.

In addition to the six MCMs, permittees that discharge to certain impaired waters are required to meet additional requirements as outlined in Appendices F and H of the New Hampshire MS4 Permit. Water quality limited waters are any waterbodies that do not meet applicable water quality standards, including

waterbodies listed in Categories 4a and 5 on the "303(d) List." These impaired waters fall into one of two categories as described in Section 2.2 of the 2017 New Hampshire Small MS4 General Permit:

- Impaired waters **with** approved TMDL (subject to Appendix F requirements of New Hampshire Small MS4 General Permit).
- Impaired waters **without** approved TMDL (subject to Appendix H requirements of New Hampshire Small MS4 General Permit).

Depending on the specific impairment and TMDL status, additional requirements may include the development of a pollutant-specific plan (i.e., Lake Phosphorus Control Plans or Nutrient Source Identification reports), enhancements to the general MCM requirements such as additional public education and outreach messages, and the implementation of additional Stormwater Control Measures (SCMs). More detail regarding the specific impaired waters requirements for permittees can be found in Appendix F and Appendix H of the New Hampshire Small MS4 General Permit.

The New Hampshire Stormwater Regional Coalition has developed detailed tools to assist permittees in developing a stormwater management program. These tools are available on the New Hampshire Stormwater Regional Coalitions' MS4 webpage. Additional tools can be found on the EPA Region 1 Stormwater Tools in New England webpage.

Construction General Permit Program

EPA's Construction General Permit (CGP) Program regulates stormwater discharges from construction activities and authorizes the discharge of stormwater from construction sites that disturb one acre or more of land, and from smaller sites that are part of a larger common plan of development that disturb one or more acres in total. The 2022 CGP became effective on February 17, 2022, and replaced previous versions of the permit. Key requirements of the current CGP include:

- Develop a Stormwater Pollution Prevention Plan (SWPPP) and keep it up to date.
- Complete and submit a Notice of Intent (NOI) to EPA via the NPDES eReporting Tool (NeT).
- Implement erosion and sediment controls and pollution prevention practices throughout the entire construction project.
- Conduct required inspections to verify compliance with the permit. Inspections may only be conducted by a qualified person who has either: (1) completed the EPA construction inspection course and passed the exam, or (2) holds a current construction inspection certification or license from a program that covers the same core material as EPA's inspection course.
- Conduct routine maintenance and take corrective action to fix problems with controls or discharges.
- Complete documentation of all site inspections, dewatering inspections, and corrective actions.
- Comply with turbidity monitoring requirements for dewatering discharges to sensitive waters (if applicable).
- Comply with any State, Tribal, or territory-specific requirements in Part 9 of the permit.

More detail regarding the specific requirements of the permit can be found in the 2022 NPDES CGP for Stormwater Discharges from Construction Sites.

Multi-Sector General Permit Program

EPA's Multi-Sector General Permit (MSGP) Program regulates industrial stormwater discharges. The 2021 MSGP became effective on September 29, 2021. The 2021 MSGP contains provisions for 29 different industrial sectors to implement control measures and specific requirements vary based on the specific sector. Sectors include a wide range of industrial activities including timber products, primary metals, salvage yards, and textile mills among many others. The primary requirement for all sectors is the development of a site-specific Stormwater Pollution Prevention Plan (SWPPP) as well as monitoring and inspection requirements. More detail regarding the specific requirements of the permit can be found on EPA's MSGP webpage.

Dewatering and Remediation General Permit Program

The Dewatering and Remediation General Permit (DRGP) Program provides EPA NPDES coverage for discharges of groundwater, stormwater, potable water, or surface water that are a result of four types of dewatering and remediation activities:

- Site remediation.
- Site dewatering.
- Infrastructure dewatering/ remediation.
- Material dewatering.

In New Hampshire the DRGP became effective on August 2, 2022. Primary requirements include discharge limitations and SCM requirements as well as monitoring, record-keeping, and reporting requirements. More detail regarding the specific requirements of the permit can be found in the 2022 NPDES DRGP.

Great Bay Total Nitrogen General Permit Program

The Great Bay estuary is a network of tidal rivers, inland bays, and coastal harbors that extends inland from the mouth of the Piscataqua River between Kittery, Maine and New Castle, New Hampshire to Great Bay and the Upper Piscataqua River. Over 52 New Hampshire and Maine municipalities are entirely or partially located within the watershed.

To address nitrogen pollution to Great Bay, EPA Region 1 issued a NPDES Great Bay Total Nitrogen (TN) General Permit for Wastewater Treatment Facilities in New Hampshire (NHG50A000) on November 24, 2020, which became effective on February 1, 2021. This permit establishes TN effluent limitations, monitoring requirements, reporting requirements and standard conditions for the thirteen (13) eligible wastewater treatment facilities (WWTFs) in New Hampshire that discharge to Great Bay.

Although this permit primarily addresses wastewater, New Hampshire municipalities covered under this permit have the option to implement the permit's adaptive management framework (AMF) through voluntary approaches that address additional AMF elements described in the permit including ambient monitoring, pollution tracking, and nitrogen reduction planning. The framework allows municipalities to achieve TN reductions through a combination of wastewater, stormwater, and other nonpoint source

controls while providing an opportunity to expand their understanding of the Great Bay estuary and the most effective tools for protection and restoration.

More detail on specific requirements of the permit and the AMF can be found on EPA's Great Bay Total Nitrogen General Permit webpage for New Hampshire.

3.1.5 Federal CWA Section 404 – Discharge of Dredged or Fill Material

Section 404 of the CWA establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g., certain farming and forestry activities).

In New Hampshire, most wetland permits issued by the NHDES Wetlands Bureau (see **Chapter 3.2.4**) also serve as federal permits under Section 404 through the Department of the Army General Permits for the State of New Hampshire. For the 23 activity types listed, these General Permits specify disturbance thresholds which determine if permit authorization is required through the NHDES Wetlands Bureau or if an Individual Permit is required through the U.S. Army Corps of Engineers (typically for larger projects).

3.1.6 Federal CWA Section 604(b) – Water Quality Program

The 604(b) Water Quality Program of the federal Clean Water Act provides for funding to states for regional water quality management planning activities. The EPA awards 604(b) grants to states, which in turn make awards to regional planning, interstate organizations, municipalities, state agencies, county conservation districts, non-profit organizations, and other local groups, to protect or restore surface waters. Section 604(b) Water Quality Planning Grants are awarded to eligible applicants by NHDES each year to support development of watershed-based plans, corridor management plans on designated rivers, and other water quality focused planning initiatives.

3.2 State Regulations and Permit Programs

3.2.1 New Hampshire Surface Water Quality Standards

Under the CWA, states are required to establish surface water quality standards and assess whether surface waters meet those standards (See **Chapter 3.1.1**). New Hampshire surface water quality standards reside in Env-Wq 1700 and RSA 485-A.

Water quality standards consist of three main parts:

- Designated use(s).
- Numerical or narrative criteria to protect designated use(s).
- Antidegradation provisions.



"Surface waters" include lakes, ponds, rivers, streams, wetlands, and tidal waters.

Designated Uses

Designated uses are the desirable uses that surface waters should support, such as swimming and healthy aquatic life. Env-Wq 1702.17 of the New Hampshire's surface water quality regulations (Env-Wq 1700) defines the designated uses for New Hampshire surface waters. All of New Hampshire's surface waters are considered suitable for the following designated uses:

- Swimming and Other Recreation in and on the Water which is sometimes differentiated as Primary Contact Recreation (e.g., swimming) and Secondary Contact Recreation (e.g., boating).
- Aquatic Life Integrity.
- Fish Consumption.
- Shellfish Consumption (tidal waters only).
- Wildlife.
- Potential Drinking Water Supply after adequate treatment.

In the context of stormwater management, it is important to note that "waste assimilation" is not a New Hampshire designated use and is not an acceptable designated use under the Clean Water Act.

Water Quality Criteria

Water quality criteria are designed to protect a specific designated use. Criteria may be narrative (e.g., free from substances that settle to form harmful benthic deposits) or numeric (e.g., dissolved oxygen shall be greater than 5 milligrams per liter). Numeric criteria may take the form of a water concentration or an aquatic life tissue concentration and, while some criteria are not to be exceeded at any time, other criteria have specifically defined frequency and durations to protect a particular designated use. Criteria are used to determine compliance with surface water quality standards. If a waterbody meets or is better than the water quality criterion, then the waterbody is said to support the related surface water quality standard and the associated designated use is supported by that action. However, if a waterbody does not meet the water quality criterion, then the waterbody is said to not support the related surface water quality standard and is considered impaired for that designated use.

Antidegradation Provisions

Antidegradation provisions are intended to minimize degradation of a state's surface waters by preserving and protecting existing and designated uses of waterbodies. New Hampshire's antidegradation rules which are under Env-Wq 1708, specify requirements for proposed activities that would lower surface water quality. For example, if an applicant proposes to discharge additional pollutants into a waterbody, the rules require the applicant to submit to NHDES all information that is necessary for NHDES to determine how the proposed discharge will impact the level of water quality needed to maintain and protect existing and designated uses of the waterbody. The rules also specify procedures for NHDES to review applications for activities that would adversely affect surface water quality of a waterbody. In New Hampshire, antidegradation rules apply to the following:

- Any proposed new or increased activity, including point and nonpoint source discharges of pollutants that would lower water quality or affect the designated use.
- A proposed increase in loadings to a waterbody when associated with existing activities.
- An increase in flow alteration over an existing alteration.
- All hydrologic modification, such as dam construction or water withdrawals.

NHDES has developed detailed guidance for New Hampshire MS4 permittees on how to meet New Hampshire's antidegradation provisions. The antidegradation requirements are based on obtaining information about the existing and proposed water quality of a waterbody. NHDES ensures compliance with those requirements during review of state permit applications. NHDES implements New Hampshire's surface water quality standards through various state permitting and certification programs, including the following: the Water Quality Certification Program, the Alteration of Terrain Permitting Program, the Wetlands Permitting Program, and the Shoreland Protection Permitting Program. These programs are described in the sections below.

3.2.2 New Hampshire 401 Water Quality Certification Program

The New Hampshire Water Quality Certification (WQC) Program protects surface water quality and uses (such as swimming and aquatic life integrity) by ensuring compliance with New Hampshire surface water quality standards. The WQC program is authorized by New Hampshire RSA 485-A:12, III. Water Quality Certification for federal NPDES permits are administered by the NHDES Wastewater Engineering Bureau. All other WQCs are administered by the NHDES Watershed Management Bureau (WMB). Water Quality Certifications issued by the WMB typically include enforceable conditions, including monitoring requirements, to ensure compliance with surface water quality standards.

Water Quality Certification is required for any activity specified under Section 401 of the federal Clean Water Act (CWA) as well as for any surface water withdrawal or diversion that must be registered under RSA 488:3 and was not in active operation as of September 5, 2008 (see RSA 485-A:12, III). Section 401 of the CWA requires an applicant for any federal license or permit for any activity that may result in a discharge into waters of the United States (33 USC §1341) to provide the federal licensing or permitting agency with a WQC granted by the State to ensure that the discharge complies with applicable water quality requirements. Federal regulations under Title 40 Code of Federal Regulations (40 CFR) Part 121 specify federal requirements that apply to all certifications required under section 401 of the CWA. For federally-issued NPDES permits issued under Section 402 of the CWA, EPA must also comply with the Section 401 certification federal regulations in 40 CFR 124, Subpart D. Other federal agencies may also

have Section 401 certification regulations specific to their licensing and permitting programs. Applicants for activities that are authorized under federal general permits including, but not limited to, the U.S. Army Corps of Engineers Section 404 of the CWA general permits, do not need to submit an application for WQC to NHDES because NHDES has already issued a WQC for activities covered under those general permits.

3.2.3 New Hampshire Chapter 1500 Alteration of Terrain Permitting Program

The New Hampshire Alteration of Terrain (AoT) Permitting Program regulates the control and treatment of stormwater from large developments under the AoT Program Rules (Env-Wq 1500, formerly Env-Ws 415). AoT permits are issued by the NHDES AoT Program and are required when a project proposes either of the following:

- Disturb an area of more than 100,000 square feet (50,000 square feet, if any portion of the disturbance is within the protected shoreland).
- Disturb an area of more than 2,500 square feet sloped at a grade of 25 percent or greater within 50 feet of the protected shoreland reference line, as defined in RSA 483-B.

In addition to these larger disturbances, the AoT General Permits by Rule apply to smaller sites. This permitting program applies to earth moving operations, including industrial, commercial, and residential developments as well as sand pits, gravel pits, and rock quarries.

AoT regulations provide specific design criteria relevant to stormwater management for large developments. Project applicants and proponents should always reference the AoT regulations to obtain the most current requirements – i.e., they are periodically updated to reflect the latest science. These regulations include requirements for:

- Pollutant Discharge Minimization (Env-Wq 1507.03).
- Groundwater Recharge (Env-Wq 1507.04).
- Channel Protection (Env-Wq 1507.05).
- Peak Runoff Control (Env-Wq 1507.06).
- Protection of Water Quality (Env-Wq 1507.07).



As the science and available technologies for stormwater management are constantly evolving, the state-of-the-practice may in some cases be "a step ahead" or differ from regulatory requirements and related design criteria which are only updated periodically. **Chapters 4 and 5 and the SCM Fact Sheets (Appendix A)** of this Manual describe stormwater management design criteria calculations and site planning and design with state-of-the-practice in mind while relating these criteria to specific AoT requirements, where appropriate.

Designers, property owners, and local jurisdictions are encouraged to manage stormwater based on the state-of-the-practice whenever possible. **The "plus" icon above is provided to aid users of this Manual in identifying where recommended design criteria may exceed or differ from state permitting requirements.** *Contact applicable regulatory programs (as described in this Chapter) for the most up-to-date rules and regulations.*

3.2.4 New Hampshire Wetland Rules

A wetlands permit from the NHDES Wetlands Bureau is generally required for activities located in wetlands and surface waters, such as excavation, removal, filling, dredging and construction of structures in any of the following areas:

- Wetlands (and vernal pools).
- Surface waters (marshes, streams, ponds, lakes) and associated banks.
- Upland tidal buffer zone (100 feet from the highest observable tide line).
- Prime wetland buffer (100-foot buffer surrounding wetlands).
- Sand dunes and tidal flats.

Permits are required in accordance with the Fill and Dredge in Wetlands Act (RSA 482-A) and its associated rules (Env-Wt 100-1000). Protection of water quality is specifically regulated under these rules per Env-Wt 307.03, including requirements related to the selection of water quality control measures, specifications for these measures, performance standards, etc.

The type of permit and authorization required for wetlands projects is dependent on the type of project and resource impact. Project applicants and proponents should always reference the Wetlands rules and regulations to obtain the most current requirements – i.e., they are periodically updated to reflect the latest science. More information on wetland permit applications can be found on the Wetland Bureau's Permit Assistance webpage, the NHDES Wetland Forms: NH Online Forms System - NHDES - Wetlands, and Project Specific Technical Assistance: Technical Assistance | NH Department of Environmental Services.

Note: The majority of NHDES wetland permits serve as federal permits under Section 404 of the Clean Water Act (CWA) through the Department of the Army General Permits (GPs) for the State of New Hampshire. *See **Chapter 3.1.5** for more information about CWA Section 404 and the GPs.*

3.2.5 New Hampshire Comprehensive Shoreland Water Quality Protection Act

The Shoreland Water Quality Protection Act (RSA 483-B) and its associated rules (Env-Wq 1400) establish a protected shoreland area in which vegetation removal, excavation, fill, and development is regulated. The protected shoreland are those lands located within 250 feet of a public water, as defined by RSA 483-B:4, XVI. Within the protected shoreland, excavation, fill, and construction generally require a shoreland permit from NHDES. However, in cases where development occurs within the bank of a waterbody, a wetland permit may be required instead of a shoreland permit. More information on shoreland permit applications can be found on the NHDES Protected Shoreland webpage.

3.2.6 New Hampshire Underground Injection and Control Program

The Underground Injection Control (UIC) Program is a federal program managed by NHDES. Facilities that recharge stormwater to the ground or groundwater are required to register such a discharge with the NHDES Underground Injection Control (UIC) Program in accordance with the Env-Wq 402 rules. Commonly, such subsurface infiltration structures are drywells, but other disposal methods and structures are also subject to registration. Depending on the project, a completed registration application can be

submitted to either the UIC program or the Alteration of Terrain (AoT) Bureau. Links to all groundwater discharge and UIC applications can be found on the NHDES groundwater discharge and UIC web page. Program contacts can also be found on the webpage as well.

Information obtained in the registration application includes but not limited to:

- Historic use of the site.
- Location of the discharge.
- Use of pre-treatment and capacity of the system.
- Type of infiltration structure to be used.
- How the system will be monitored and maintained.
- Facility and property owner contact information.

3.2.7 Summary of New Hampshire Stormwater Related Permits

Table 3-2. Summary of New Hampshire Stormwater-Related Permits

Permit Program	Description	Resources
Municipal Separate Storm Sewer Systems (MS4) Permit	A federal NPDES permit that regulates stormwater discharge from MS4-designated New Hampshire municipalities and other MS4 operators. This permit establishes six Minimum Control Measures (MCMs) that are required for compliance.	EPA's New Hampshire MS4 Webpage New Hampshire Stormwater Regional Coalitions' MS4 webpage
Construction General Permit (CGP)	A federal NPDES permit that regulates stormwater discharges from construction sites that disturb greater than or equal to 1 acre, and from smaller sites that are part of a larger development that disturbs at least 1 acre in total.	EPA's 2022 CGP webpage
Multi-Sector General Permit (CGP)	A federal NPDES permit that regulates stormwater discharges from industrial sites.	EPA's MSGP webpage
Dewatering and Remediation General Permit (DRGP)	A federal NPDES permit that regulates four types of dewatering and remediation activities, including site remediation, site dewatering, infrastructure dewatering/ remediation, and material dewatering.	EPA's DRGP webpage
Great Bay Total Nitrogen General Permit (GBTNGP)	A federal NPDES permit that establishes Total Nitrogen limitations and other requirements for WWTFs in the Great Bay watershed. The permit allows for reduction of TN through wastewater and stormwater controls.	Great Bay Total Nitrogen General Permit webpage
New Hampshire 401 Water Quality Certification (WQC)	The WQC program ensures that a project will comply with State water quality standards. Water Quality Certification for federal National Pollutant Discharge Elimination System (NPDES) permits are administered by the NHDES Wastewater Engineering Bureau. All other WQCs are administered by the NHDES Watershed Management Bureau.	New Hampshire's Water Quality Certification (WQC) program webpage New Hampshire Surface Water Quality Regulations (Env-Wq 1700)
New Hampshire Alteration of Terrain (AoT) Permit	Requires the control and treatment of stormwater for certain land disturbance projects (including projects that disturb more than 100,000 square feet, 50,000 square feet in protected shoreland and projects that disturb a grade of 25 percent or greater within 50 feet of the reference line of the protected shoreland).	New Hampshire's Alteration of Terrain (AoT) webpage
New Hampshire Wetlands Permit	Required for projects such as excavation, removal, filling, dredging and construction of structures that are located in wetlands, surface waters, 100-foot tidal and prime wetland buffer zones, banks, and sand dunes.	New Hampshire's Wetlands webpage
Shoreland Permit	Required for projects occurring in the "protected shoreland" area (within 250 feet of a waterbody).	New Hampshire's Protected Shoreland webpage
Underground Injection and Control (UIC) Program	Required for facilities that recharge stormwater to the ground and groundwater.	New Hampshire's Groundwater Discharge webpage
Local Permits	Community specific but may include illicit discharge protections, construction, and post-construction site stormwater runoff controls, etc.	Local regulations

3.3 Local Regulations

In addition to the federal and state regulations, municipalities may develop additional regulations to protect surface water quality. When determining the permitting requirements for a project, it is important to review local regulations to ensure compliance. Local regulations are either required by a state or federal permitting program or are adopted by a municipality to be protective of surface water quality. As part of the New Hampshire MS4 program (as described in **Chapter 3.1.4**), MS4 permittees are required to develop and implement regulatory mechanisms to address stormwater discharges. Specific local regulatory mechanisms that are required under the New Hampshire MS4 permit are shown in the table below.

Table 3-3. Summary of Local Regulatory Mechanisms Required by the New Hampshire MS4 Permit

Minimum Control Measure	Description
MCM 3: Illicit Discharge Detection and Elimination (IDDE) Program	Prohibits illicit discharges to the MS4 and requires removal upon discovery.
MCM 4: Construction Site Stormwater Runoff Control	Requires the use of sediment and erosion control practices at construction sites; controls construction site waste.
MCM 5: Post-Construction Site Controls	Requires submission of as-built drawings; develops stormwater controls and pollutant removal standards.

The New Hampshire Stormwater Regional Coalitions have developed detailed tools to assist permittees (including municipalities) in developing local regulations and ordinances. These tools are available on the New Hampshire Stormwater Regional Coalitions' MS4 webpage.

4 Design Criteria and Example Calculations

How Does This Manual Relate to Stormwater Management Permitting?



The primary goal of this Manual is to present the state-of-the-practice for stormwater management in New Hampshire. This Manual also provides guidance on stormwater design criteria required by various local, state, and federal regulations and permitting programs (*see **Chapter 3** – Regulations and Permitting*).

As the science and available technologies for stormwater management are constantly evolving, the state-of-the-practice may in some cases be "a step ahead" or differ from regulatory requirements and related design criteria which are only updated periodically. Contact applicable regulatory programs (*as described in **Chapter 3***) for the most up-to-date rules and regulations.



Designers and property owners are encouraged to manage stormwater based on the state-of-the-practice whenever possible. The **"plus" icon** to the left is provided to aid users of this Manual in identifying where recommended design criteria may **exceed or differ from state permitting requirements**. This guidance represents the latest science-based research and represents where the field is heading.

4.1 Overview

This Chapter presents design criteria and applicable example calculations for sizing Stormwater Control Measures (SCMs) to protect the state's waters from the adverse impacts of development. A summary of design criteria is included in **Table 4-1**, with detailed descriptions and example calculations provided in subsequent sections. In addition to these design criteria, other SCM-specific criteria also apply to the design of stormwater management practices as detailed in **Appendix A**. If there is any discrepancy between the information presented here and applicable regulations such as the Alteration of Terrain regulations (Env-Wq 1500), the regulations take precedence. Project applicants are responsible for design of projects in compliance with applicable regulations and should refer to them directly to verify applicable criteria.

As indicated in **Chapter 1.2**, designers and property owners are encouraged to manage stormwater based on the **state-of-the-practice** wherever possible. The "plus" icon, as shown on the following page, is provided to aid users of this Manual in identifying where recommended design criteria may exceed or differ from permitting requirements.

The ability to meet design criteria may be guided by multiple federal, state, and local requirements. This Manual advances a hierarchy of controls designed to guide professionals toward meeting standards with up-to-date science-based guidance. Stormwater Control Measures are introduced in tiers that represent their ability to meet pollutant reduction and site design criteria for groundwater recharge and

peak runoff control. These groups are solely meant for guidance. Project applicants or proponents must ensure that all regulatory requirements are met. Tiers are further discussed in **Chapter 5.3.1**.



New name, same function...

The stormwater community has adopted **SCMs** as the new term for what had previously been called Best Management Practices (BMPs).

The name is new but the goal is the same: reduce downstream quality and quantity impacts of stormwater through **structural, nonstructural**, and **source control** techniques. In addition to SCMs, **recommended practices** for activities such as construction and winter road management can also reduce the impacts of pollutants on downstream waterbodies.

Watershed Protection Standard



Research performed by U.S. Environmental Protection Agency (EPA) in the Taunton Massachusetts Watershed indicates that incorporation of Low Impact Development (LID) practices should be combined with filtration and infiltration Green Infrastructure SCMs to meet water quality volume-based standards (e.g., MassDEP, EPA MS4) and post-development hydrology through the reduction of stormwater runoff. By developing watershed-scaled flow duration curves (FDCs), the study demonstrated that as development occurs, instream high flows become higher (ecosurplus = flooding), while instream low flows become lower (ecodeficit = drought). The goal is to drive the watershed's FDC back to balanced pre-development conditions based on strategic implementation of stormwater controls, specifically filtration and infiltration practices. The study found that implementation of a requisite set of stormwater controls to achieve an approximate 1-inch retention volume at the site level resulted in "*de facto attainment of a pre-development hydrological condition*" (based on "static" sizing).

Given results of this research, a **Watershed Protection Standard (WPS)** has been developed to provide communities with a resilient site development alternative for stormwater management that protects and restores watershed and water resource health from impacts associated with future development activities. The WPS is the preferred option to meet on-site stormwater management standards, although it is understood that various strategies exist to meet a range of post-construction compliance standards. The approach is outlined below:

- **Site Design**: First, adopt key site design principles that emphasize pre-development hydrology, minimize impacts, and preserve natural watershed functions – i.e., maintain pre-development drainage and groundwater recharge patterns, apply dispersed use Low Impact Development (LID) techniques, and minimize disturbance of natural soils (see **Chapter 5.2** for more information).
- **Retention:** Next, design infiltration SCMs or select filtration SCMs for retention such that the resulting Design Storage Volume (DSV) is expected to yield no increase in nutrient discharge. The University of New Hampshire's Stormwater Center (UNSHC) has developed a tool to standardize sizing of SCM's for retention and is accessible at: https://scholars.unh.edu/stormwater/114/. (See **Table 5-1** for a list of SCMs applicable to the WPS.)
- **Treatment:** If retention sizing cannot be met because of site specific conditions, alternative compliance may be achieved by designing for 90 percent TSS, 60 percent TP, and 50 percent TN pollutant removal (see **Chapter 4.2**).
- **Other Requirements**: Finalize design to meet all applicable regulatory requirements and design criteria (e.g., recharge volume, peak rate, channel protection) – design criteria are summarized in **Table 4-1**.

The WPS performance standard for retention was derived from examining how natural vegetated land with varying soil conditions functions under existing climatic conditions over long periods of time. A combination of continuous simulation hydrologic modeling, climatic data, and research conducted in the development of stormwater nutrient load export rates for the New Hampshire and Massachusetts MS4 permits, and literature on evapotranspiration were used to estimate stormwater runoff volumes, groundwater recharge, and nutrient export conditions associated with pre-development natural conditions and post development impervious cover.

Table 4-1. Design Criteria Summary

Design Criteria	Description
Watershed Protection Standard (WPS)	Implement sequentially as summarized on preceding page. Use UNHSC calculation tool to size the Design Storage Volume (DSV) of applicable SCMs based on the Runoff Depth (RD) from impervious area (https://scholars.unh.edu/stormwater/114/).
Water Quality Volume (WQV) and Pollutant Removal[7]	**WQV = (P)(Rv)(A)** • P = 1-inch of rainfall • Rv = unitless runoff coefficient, Rv = 0.05 + 0.9(I) • I = percent impervious cover draining to the structure converted to decimal form • A = total site area draining to the structure Pollutant removals of at least 90 percent TSS, 60 percent TP, and 50 percent TN are also recommended. Use EPA Performance Curves to calculate.
Water Quality Flow (WQF)	**WQF = (q_u)(WQV)** • WQV = water quality volume calculated in accordance with above • q_u = unit peak discharge from TR-55 exhibits 4-II and 4-III Variables needed for Exhibits 4-II and 4-III: • Ia = the initial abstraction = 0.2S • S = potential maximum retention in inches = (1000/CN) – 10 • CN = water quality depth curve number = 1000/ (10+5P+10Q–10[Q^2 + 1.25(Q)(P)]$^{0.5}$) • P = 1-inch of rainfall • Q = the water quality depth in inches = WQV/A • A = total area draining to the design structure
Groundwater Recharge Volume (GRV)	**GRV = (A_I)(R_d)** • A_I = the total area of effective on-site impervious surface after development • R_d = groundwater recharge depth-based hydrologic soil groups, as follows: Soil Group — R_d (inches) A — 0.40 B — 0.25 C — 0.10 D — 0.00
EIC and UDC[8]	**%EIC** = area of effective impervious cover/ total drainage area within a project area x 100 **%UDC** = area of undisturbed cover/ total drainage area within a project area x 100

[7] Different WQV and Pollutant Removal requirements apply to the following: (1) any project that would result in a discharge of stormwater within one-quarter mile of a surface water of the state impaired for phosphorus or nitrogen, a class A surface water, a lake or pond, or within a watershed of a surface water that is an outstanding resource water (ORW) as defined in Env-Wq 1708.04(a), and (2) Redevelopment projects as detailed in **Chapter 4.2.1**.

[8] **Note:** There are no specific design criteria / requirements for EIC and UDC, but in general, EIC should be reduced and UDC maximized to the maximum extent practicable.

Design Criteria	Description
Channel Protection (CP)	• 2-year, 24-hour post-development peak flow ≤ pre-development peak flow and post-development storm volume has increased by less than 0.1 acre-feet or post-development peak flow is less than 2 cubic feet per second or site discharges to a large receiving waterbody defined in **Chapter 4.7**; or • 2-year, 24-hour post-development peak flow ≤ 50 percent pre-development peak flow; or • 2-year, 24-hour post-development peak flow ≤ 1-year, 24-hour pre-development peak flow.
Peak Discharge Control	• Post-development peak discharge rates cannot exceed pre-development peak discharge rates for the 10- and 50-year, 24-hour storm events. • Consider designing to higher rainfall depths and the 100-year storm for applicable sites.

4.2 Water Quality Volume (WQV) and Pollutant Removal

4.2.1 Criteria

The Water Quality Volume (WQV) is the amount of stormwater runoff from a rainfall event that should be captured and treated to remove the majority of stormwater pollutants on an average annual basis. The recommended WQV is the volume of runoff associated with the first 1-inch of rainfall.

Water Quality Volume (WQV) Requirements for Redevelopment Projects

As defined in Env-Wq 1502.53, "Redevelopment" means to undertake construction on property where development activities occurred more than 10 years prior to the proposed development activities and where the area of existing impervious cover is 60 percent or greater of the area of the property, including any abutting properties under the control of the property owner.

For Redevelopment projects, except where the project solely consists of utility work or asphalt maintenance work meeting the conditions listed in Env-Wq 1503.03(a) or (b):

- Stormwater treatment practices for stormwater runoff from existing impervious cover shall be designed for 30 percent or greater of the WQV or WQF, as applicable.
- Stormwater treatment practices for pervious areas being converted to impervious cover shall be designed for the WQV or WQF, as applicable.

Note: Redevelopment projects are subject to all other AoT Requirements for Permanent Methods for Protecting Water Quality (Env-Wq 1507) in the same way as new development (e.g., Env-Wq 1507.04 Groundwater Recharge, Env-Wq 1507.05 Channel Protection, and Env-Wq 1507.06 Peak Runoff Control).

Additional Pollutant Removal Requirements for Discharges Near Surface Waters

Any project that would result in a discharge of stormwater within one-quarter mile of a surface water of the state impaired for phosphorus or nitrogen, a class A surface water, a lake or pond, or within a watershed of a surface water that is an outstanding resource water (ORW) as defined in Env-Wq 1708.04(a) are subject to additional pollutant removal requirements as outlined in Env-Wq 1507.03(b) through (d).

Additional Pollutant Removal Recommendations



Depending on the selected Stormwater Control Measure (SCM), the 1-inch WQV is generally consistent with the 2017 New Hampshire Small MS4 Permit which requires that stormwater treatment practices be implemented that can treat and remove 90 percent of Total Suspended Solids (TSS), 60 percent of Total Phosphorus (TP), and 50 percent of Total Nitrogen (TN) from the total average annual post-construction load generated from impervious surface area on the site.

As part of the **sequential WPS** design approach introduced in **Chapter 4.1**, it is recommended, that all projects target pollutant removals of 90 percent TSS, 60 percent TP, and 50 percent TN, particularly when on-site retention goals cannot be met. Applicable SCMs in this Manual have been organized into "tiers" to help designers select SCMs that can most easily meet this goal. For example, a properly designed infiltration basin can be designed with a significantly smaller WQV than 1-inch to provide 90 percent TSS, 60 percent TP, and 50 percent TN removal. See **Chapter 5** and **Appendix A** for more information on SCM Tiers.

4.2.2 Calculation Methods

Water quality volume and pollutant removals can be calculated using two methods:

- **Method 1**: Calculate the 1-inch WQV
- **Method 2**: Calculate percent pollutant removals using the EPA Performance Curves.[9]

Determination of the method to use is situational based on best professional judgement and applicability of the project to certain regulatory requirements.

Method 1: Calculate the 1-Inch WQV

WQV should be calculated using the following equation:

WQV = (P)(Rv)(A)

Where:

P = 1-inch

Rv = the unitless runoff coefficient, Rv = 0.05 + 0.9(I)

I = the percent effective impervious cover draining to the structure, in decimal form

A = total site area draining to the structure

Note: Infiltrating SCMs should be designed to drain the WQV within 24 to 48 hours, but must be designed to drain the WQV within at least 72 hours. See **Chapter 4.4** for calculation guidance.

[9] Refer to the UNHSC webpage (https://extension.unh.edu/stormwater-center/ms4-resources) for the most current EPA Performance Curves in graphical and tabular format.

Method 1: Example WQV Calculation

Given: Size a sediment forebay to capture at least 10 percent of the WQV. The rainfall depth (P) is 1-inch. The total drainage area is 0.80 acres; 0.60 acres of this area is impervious.

Solution:

Step 1: Calculate the 1-inch WQV.

$I = IA / A = 0.60 \text{ ac} / 0.80 \text{ ac} = 0.75$

$Rv = 0.05 + 0.9 (I) = 0.05 + 0.9 (0.75) = 0.725$

$WQV = (P)(Rv)(A) = (1 \text{ in}) (0.725) (0.80 \text{ ac}) = 0.58 \text{ ac-in}$

Step 2: Convert to cubic feet.

$WQV = 0.58 \text{ ac-in } (43560 \text{ ft}^2/\text{ac}) (1 \text{ ft} / 12 \text{ in}) = 2{,}100 \text{ ft}^3$

Step 3: Calculate 10 percent of the WQV for the sediment forebay.

$WQV = (0.10) (2{,}100 \text{ ft}^3) = 210 \text{ ft}^3$

Method 2: Calculate Percent Pollutant Removals Using the EPA Performance Curves

The EPA Performance Curves can be used to determine pollutant removal for SCMs with an established curve. Refer to the "SCM Convention Crosswalk" for a list of SCMs with an available EPA Performance Curve (**Table 5-1**). The most current EPA Performance Curves are provided on the University of New Hampshire Stormwater Center (UNHSC) webpage (https://extension.unh.edu/stormwater-center/ms4-resources). The below steps may be used to compute the minimum required Design Storage Volume (DSV) of a SCM based on known pollutant removal targets.[10]

Step 1: Determine the contributing impervious drainage area to be treated by the SCM.

Step 2: Select the SCM(s) that will be used to provide pollutant removal, then select the corresponding EPA Performance Curves. If the SCM uses infiltration or filtration for treatment, determine a design infiltration rate in accordance with **Chapter 4.5**. If the selected in-situ saturated hydraulic conductivity (Ksat) does not match those provided by the EPA Performance Curve, use the EPA Performance Curve for the infiltration rate that is nearest to, but less than, the determined infiltration rate – for example, if the field measured Ksat at the SCM's location and soil layer depth is determined to be 0.73 inches per hour, use the EPA Performance Curve for 0.52 inches per hour (see below for an example). Interpolating the result between the two bounding infiltration curves is also acceptable.

Step 3: Use the EPA Performance Curve to calculate the minimum runoff depth (RD) from the upstream impervious area that the SCM must treat to meet pollutant removal requirements. RD is the depth of runoff the SCM is designed to instantaneously hold. RD does not equate to a storm event depth and is not the same as the amount of precipitation that falls over the watershed during a given

[10] The steps provided are only appropriate when the contributing drainage area to the SCM is all impervious. There is an iterative process to account for SCMs that accept runoff from both impervious and pervious areas. Refer to Appendix F Attachment 3 of the 2017 NH Small MS4 Permit for detailed guidance and an example calculation for a contributing drainage area with impervious and pervious surfaces.

rain event. It is the amount of volume the SCM can store and hold normalized to the contributing impervious drainage area. The EPA Performance Curves refer to RD as the "Physical Storage Capacity." See below example and **Figure 4-1** for an example on how to calculate RD based on known pollutant removal targets.

Step 4: Calculate the minimum required design storage volume (DSV) that the SCM must hold to meet pollutant removal targets. The DSV includes permanent system treatment volume and does not include volume associated with peak rate or flood control (i.e., volume above the primary outlet control). The minimum required DSV is calculated as the required RD needed to meet pollutant removal targets multiplied by the total post-construction impervious area (IA) that drains to the SCM.

DSV = (RD)(IA)

Where:

DSV = SCM design storage volume.

RD = runoff depth from impervious areas.

IA = the impervious area that drains to the SCM.

Step 5: Size specific SCM dimensions based on the minimum required DSV. Each SCM will have a different method of calculating this volume. The 2017 NH Small MS4 Permit, Attachment 3 to Appendix F, Table 3-5 provides equations to calculate the DSV for each SCM that has a performance curve. The UNHSC codified these equations into a sizing tool.

Calculating Pollutant Removals Based on a Known DSV

The above methodology is used to compute the minimum DSV of a SCM based on a known pollutant removal target. The EPA Performance Curves can also be used to determine the runoff depth (RD) and associated pollutant removal percentages based on a known DSV.

To calculate pollutant removal percentages based on a known DSV, calculate **RD = DSV / IA**. The resulting RD would then be applied to the EPA Performance Curves to determine the pollutant removal. The DSV would be obtained as described in **Step 5**.

Method 2: Example Calculation using the EPA Performance Curves

Given: One (1) acre of high-density residential area is proposed to be developed as impervious area. An infiltration basin is proposed to treat the impervious area. The design infiltration rate is 0.73 inches per hour (in/hr) as determined in accordance with **Chapter 4.5**. Determine the minimum required SCM Design Storage Volume to meet 90 percent TSS removal, 60 percent TP removal, and 50 percent TN removal.

Solution:

Step 1: IA = 1 acre.

Step 2: Obtain the "Infiltration Basin" EPA Performance Curve.[11]

- There are six performance curves available for Infiltration Basins based on the design infiltration rate of the underlying soils. The curves include the following infiltration rates: 0.17 in/hr, 0.27 in/hr, 0.52 in/hr, 1.02 in/hr, 2.41 in/hr, and 8.27 in/hr.
- The design infiltration rate is 0.73 in/hr. The rate that is closest to, but less than 0.73 in/hr is 0.52 in/hr. Use the curve for 0.52 in/hr.

Step 3: The minimum depth of runoff from the impervious area, RD, that the Infiltration Basin must treat is obtained from the selected EPA Performance Curve with a design infiltration rate of 0.52 inches per hour (see **Figure 4-1**).

- Per **Figure 4-1**, The minimum RD to meet pollutant removal targets are as follows: 90 percent TSS = approximately 0.32 inches; 60 percent TP = approximately 0.25 inches; 50 percent TN = less than 0.1 inches. Therefore, the SCM should be sized for a RD of at least 0.32 inches using TSS as the limiting factor to meet all three pollutant removal targets.

Step 4: Calculate the minimum required DSV.

$DSV = RD * IA$

$DSV = (RD/ 12 \text{ in/ft}) (IA * 43{,}560 \text{ ft}^2/\text{ac})$

$DSV = (0.32 \text{ in} / 12 \text{ in/ft}) (1 \text{ ac} * 43{,}560 \text{ ft}^2/\text{ac})$

$DSV = 1{,}162 \text{ ft}^3$

(Resulting Pollutant Removals: TSS = 90 percent; TP = 68 percent, TN= 83 percent).

The remaining step would then be to calculate SCM dimensions that can hold the minimum DSV in accordance with **Step 5**.

[11] Refer to the UNHSC webpage (https://extension.unh.edu/stormwater-center/ms4-resources) for the most current EPA Performance Curves in graphical and tabular format.

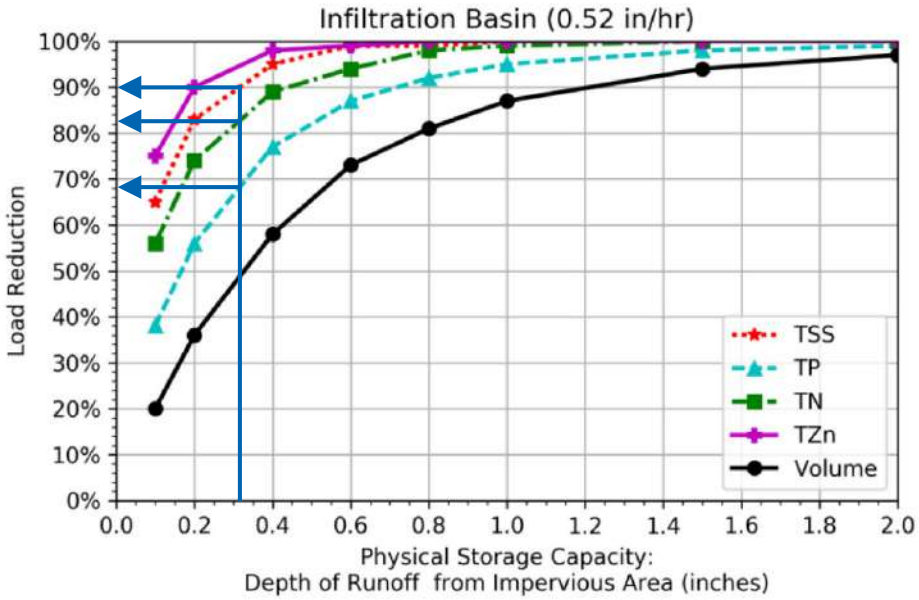


Figure 4-1. Example EPA Performance Curve for an Infiltration Basin

(Blue line depicts percent pollutant load reduction from previous example; note that a RD of 1-inch would result in significantly higher pollutant removals)

Additional Resources for Pollutant Tracking and Accounting

Refer to the following websites for the latest resources for pollutant tracking and accounting:

- UNHSC webpage: https://extension.unh.edu/stormwater-center
  - EPA Performance Curves: https://extension.unh.edu/stormwater-center/ms4-resources
- NHDES MS4 Resources webpage: https://www.nhms4.des.nh.gov/
  - NHDES Pollutant Tracking and Accounting Project (PTAP) resources: https://www.nhms4.des.nh.gov/nh-resources/pollutant-tracking-and-accounting-project-ptap

4.2.3 Additional Considerations

The following should be considered when designing SCMs to provide pollutant removal.

- Stormwater Control Measures should be designed for future maintenance activities and to be accessible for proposed maintenance activities.
- Separate calculations should be completed for each site outlet to demonstrate that pollutant removals are met throughout the site on an area weighted average.
- Pollutant removal should be optimized to address any existing downstream water quality impairments or known local water quality concerns.
- Stormwater Control Measures should be designed to meet local and state setback requirements, particularly with private or public water supplies and any designated natural resource buffer setbacks.

4.3 Water Quality Flow (WQF)

4.3.1 Criteria

Some treatment practices such as flow-through treatment swales[12] and flow-through devices are more appropriately designed based on peak flow rate, rather than water quality volume (WQV), since they are designed to treat higher flow rates, thereby requiring less storage volume. The Water Quality Flow (WQF) is used to determine a flow rate associated with the WQV, for sizing flow-based treatment and pre-treatment SCMs (e.g., Flow-Through Treatment Swales, Pre-treatment Swales, Flow-Through Devices – see SCM descriptions in **Appendix A**). The WQF is calculated using the WQV and the Natural Resource Conservation Service (NRCS), TR-55 Graphical Peak Discharge Method.

The use of the NRCS, TR-55 Graphical Peak Discharge Method in conjunction with the WQV is the preferable method for computing the peak flow associated with the water quality design storm, since it can more appropriately estimate peak flows associated with smaller storm events and can also be used to predict stormwater runoff volumes.

Note on Manufactured Treatment Devices

There are several flow-based Manufactured Treatment Devices (MTDs) not specified in this Manual. The flow-based sizing method discussed below may not be applicable to certain MTDs. Any proposed MTD may require additional verification and should be designed in accordance with Env-Wq 1508.11 or other relevant regulations. Refer to the Washington State Technology Assessment Protocol (TAPE) for information on how MTDs are rigorously verified in other states – TAPE also includes a list of approved devices and their anticipated performance based on approved design parameters (e.g., loading rates).

[12] Flow-based swales are generally used for conveyance and should be differentiated from volumetrically-sized swales that provide infiltration and detention, which can use the appropriate EPA Performance Curve.

4.3.2 Calculation Methods

WQF should be calculated using the following equations and steps.

Step 1: Compute the unit peak discharge Curve Number (CN) using the following equation.

$$\mathbf{CN = 1000/ (10+5P+10Q–10[Q^2 + 1.25(Q)(P)]^{0.5})}$$

Where:

CN = unit peak discharge Curve Number

P = 1-inch

Q = the water quality depth in inches = WQV / A

WQV = water quality volume (calculations shown in previous section)

A = total area draining to the design structure

Important: This CN is not the same as the subcatchment's CN which is selected based on the land use and soil type. Rather it is a representative CN used to convert the water quality depth to a flow rate.

Step 2: Compute the time of concentration (tc) using the methods described in Chapter 3 of TR-55.

Step 3: Calculate potential maximum retention (S) in inches using the following equation:

$$\mathbf{S = (1000/CN) – 10}$$

Step 4: Calculate initial abstraction (I_a) using the following equation:

$$\mathbf{I_a = 0.2S}$$

Step 5: Read the unit peak discharge (q_u) from TR-55 Exhibits 4-II or 4-III (see **Figure 4-2**) based on the project's location.

Step 6: Compute the water quality flow (WQF) using the following equation:

$$\mathbf{WQF = (q_u)(WQV).}$$

Example Calculation: Water Quality Flow (WQF)

Given: Location of project: Concord, New Hampshire

- P = 1-inch for New Hampshire
- A = 1 acre draining to the structure, 60 percent impervious cover
- tc = 12 minutes (0.2 hours)

Solution:

Step 1: Compute the CN.

First Compute WQV, then solve for Q

WQV = (P)(Rv)(A)

Rv = 0.05 + 0.9(I) = 0.05 + 0.9(0.60) = 0.59

WQV = (1 in)(0.59)(1 ac) = **0.59 ac-in**

Q = WQV / A = 0.59 ac-in / 1 ac = 0.59 in

Note that Q is not a function of area, as it may appear.

Q reduces to:

Q = (P)(Rv)(A) / (A) = P * Rv so when P = 1-inch, **Q = Rv**

$CN = 1000 / (10 + 5P + 10Q - 10[Q^2 + 1.25(Q)(P)]^{0.5})$

$= 1000 / (10 + 5(1\text{ in}) + 10(0.59) - 10[0.59^2 + 1.25(0.59\text{ in})(1\text{ in})]^{0.5})$ = **95.4**

Steps 2, 3, and 4: Compute tc, S, and I_a

S = (1000 / CN) – 10 = 1000 / 95.4 – 10 = 0.48 in

Ia = 0.2S = 0.2(0.48) = 0.10 in

Ia/P = 0.10 in / 1 in = **0.10**

Step 5: Read q_u from **Figure 4-2**

Concord is in the Type III rainfall distribution zone, therefore use exhibit 4-III from TR-55 and find q_u in (csm/in) where Ia/P = 0.10 (solution above) and Tc = 0.2 hours (given information) *Note csm = cfs/mi²*

q_u = **560 cfs / mi² / in**

Step 6: Compute WQF

WQF = (q_u)(WQV) = 560 cfs/mi²/in * 0.59 ac-in * (1 mi² / 640 ac)

WQF = 0.52 cfs

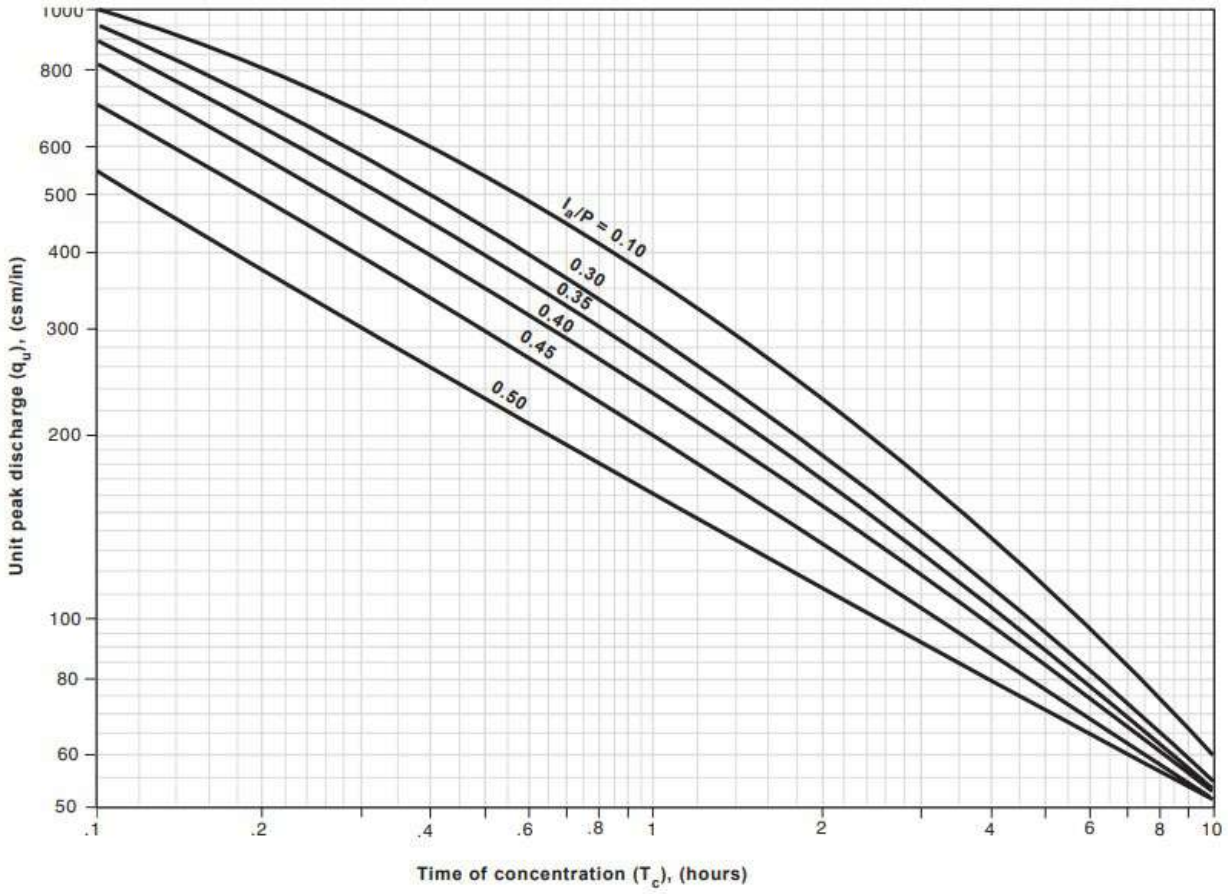


Figure 4-2. Unit Peak Discharge (q_u) for NRCS (SCS) Type II Rainfall Distribution (Exhibit 4-II)

4.4 Groundwater Recharge Volume (GRV)

4.4.1 Criteria

The purpose of the Groundwater Recharge Volume (GRV) criterion is to protect groundwater resources by minimizing the loss of annual pre-development groundwater recharge from proposed development. Under this approach, a portion of runoff from larger storms, and most runoff from smaller precipitation events, is captured and infiltrated using appropriate SCMs. See below for a listing of the target groundwater recharge depth (R_d) based on Hydrologic Soil Group (HSG).

The objective of the groundwater recharge criterion is to maintain water table elevations, stream baseflow, and wetland moisture levels and to filter stormwater runoff before it reaches receiving waters. Maintaining pre-development groundwater recharge conditions can also reduce the volume of runoff that must be managed to meet other design criteria (i.e., water quality, channel protection, and peak flow control), and thus the overall size and cost of stormwater management practices.

Watershed Protection Standard



Use of the Watershed Protection Standard (WPS) approach, as introduced in **Chapter 4.1**, removes the need for calculating the Groundwater Recharge Volume unless regulatory requirements apply (e.g., Env-Wq 1504.12, Calculation of Groundwater Recharge Volume*)*. If regulatory requirements do not apply, the GRV is only necessary when the WPS cannot be met.

4.4.2 Calculation Methods

Practices that provide recharge should be sized based on the following general steps.[13]

Step 1: Determine the required Groundwater Recharge Volume (GRV). The GRV includes permanent system treatment volume and does not include volume associated with peak rate or flood control (i.e., volume above the primary outlet control). The GRV should be calculated based on the site soils and the following equation.

$$\mathbf{GRV = (A_I)\ (R_d)}$$

Where:

A_I = the total effective area of impervious surfaces that will exist on the site after development

R_d = the groundwater recharge depth-based on the USDA/ NRCS hydrologic soil group, as follows:

[13] Note: As of 2025, the calculation of the GRV to size recharge SCMs as outlined in this section complies with AoT requirements. State-of-the-practice requirements (i.e., the WPS approach) intend to replace the need for this calculation to meet antidegradation goals better.

Soil Group	Runoff Potential	Rd (inches)
A	Lowest	0.40
B	Moderately Low	0.25
C	Moderately High	0.10
D	Highest	0.00

Step 2: Determine the Design Storage Volume (DSV) of the SCM that can hold the GRV (i.e., the permanent volume under the primary outlet control). Each SCM will have a different method of calculating the DSV. The 2017 NH Small MS4 Permit, Attachment 3 to Appendix F, Table 3-5 provides equations to calculate the DSV for each SCM that has a performance curve. The UNHSC codified these equations into a sizing tool.

Step 3: Infiltration practices must be designed to completely drain the DSV within 72 hours. Verify that the bottom of the recharge practice can drain the DSV in at least 72 hours. This can be calculated conservatively as follows:

$$\mathbf{D_T = DSV / (Ksat)\ (A_B)}$$

Where:

D_T = Calculated drain time

DSV = SCM design storage volume beneath any overflow or peak control orifice to meet groundwater recharge and/ or pollutant removal requirements

Ksat = Design infiltration rate (see **Chapter 4.5**)

A_B = Bottom area of the SCM

Example Calculation: Groundwater Recharge Volume (GRV)

Given: The total project area is 10 acres with 1.5 acres of impervious area. The impervious area will cover 1 acre of HSG A soil and 0.5 acres of HSG C soil. Size a stone filled infiltration trench to capture the GRV for this project and verify that it can drain in 72 hours. A design infiltration rate of 0.65 inches per hour has been calculated in accordance with **Chapter 4.5**.

Note: *Most infiltration trenches also include other backfill materials. Gravel has been selected for this example for simplicity.*

Solution:

Step 1: Calculate the required GRV.

GRV = $(A_I)(R_d)$

Weighted R_d = [(1 ac)(0.40 in) + (0.5 ac)(0.10 in)] / 1.5 ac = 0.30 in

GRV = 1.5 ac * 0.30 in = **0.45 ac-in**

To convert to cubic feet, *if desired:*

GRV = **0.45 ac-in** (43,560 ft^2 /ac) (1 ft/ 12 in) = **1,630 ft^3**

GRV = 1,630 ft^3

Step 2: Determine potential infiltration trench sizing and verify that the Design Storage Volume (DSV) can hold the GRV. Assume a porosity of 40 percent (0.40). The DSV equation for an infiltration trench is obtained via the 2017 Small MS4 Permit (Attachment 3 of Appendix F, Table 3-5) as follows:

DSV = (Bottom area) * (Depth of stone) * (Porosity of stone)

Select dimensions of 5 ft deep by 100 ft long by 10 ft wide of active storage.

DSV = (100 * 10) (5) (0.4) = 2,000 ft^3

DSV (2,000 ft^3) > GRV (1,630 ft^3)

Step 3: Verify that proposed infiltration trench can drain the DSV in 72 hours.

The bottom width, A_B, is 100 ft by 10 ft = 1,000 ft^2

D_T = DSV / (Ksat) (A_B)

D_T = 2,000 ft^3 / (0.65 in/hr) (1 ft / 12 in) (1,000 ft^2) = **37 hrs**

37 hrs < 72 hrs, OK

Note: The SCM in this simplified example is only sized to capture the GRV. SCMs will commonly be designed to meet multiple design criteria (e.g., recharge, pollutant removal, and peak reductions). If this SCM were designed to provide pollutant removal and to treat the 1-inch WQV, the required DSV and subsequent SCM dimensions would be much larger. Computations should demonstrate that the volumes required by each applicable design criteria are provided by the single practice.

4.4.3 Additional Considerations

The following should be considered when designing SCMs to provide groundwater recharge.

- If more than one soil type is present at the site, a weighted recharge depth should be computed based on the area of each soil group present.
- Infiltration rates and feasibility for designing groundwater recharge practices should be carefully evaluated in accordance with **Chapter 4.5**.
- Groundwater recharge practices should meet water supply setback criteria identified in Env-Wq 1508.02.
- On some sites, existing soils or other conditions may severely constrain the use of infiltration systems for recharging groundwater such as those with Hydrologic Soil Group (HSG) D soils. Note that the HSG may be obtained from the NRCS Web Soil Survey or the Society of Soil Scientists of Northern New England (SSSNNE). Examples include sites underlain by marine clays, sites in areas of karst geology, and urban redevelopment areas. In these areas, the recharge volume requirement may be reduced. However, stormwater management systems should still be provided to treat the full WQV and nonstructural practices should be implemented to the maximum extent practicable to reduce stormwater runoff (e.g., filter strips that treat rooftop or parking lot runoff, sheet flow discharge to forested buffers, and grass channels that treat roadway runoff).
- Groundwater levels are increasing in conjunction with sea level rise from climate change. Additional considerations for incorporating rising water levels into project planning for coastal flood resilience can be found in the New Hampshire Coastal Flood Risk Summary Part II: Guidance for Using Scientific Projections.
- Implementation of systems that infiltrate stormwater and contribute to groundwater recharge may not be appropriate in areas with history of contaminated soils. Additional guidance on Implementing Stormwater Infiltration Practices at Vacant Parcels and Brownfield Sites is provided by EPA.
- Additional requirements applicable to systems that infiltrate stormwater and that would contribute to groundwater recharge are listed with the specific SCM descriptions included in **Appendix A** and Env-Wq 1508.17.

4.5 Design Infiltration Rate

4.5.1 Criteria

There are several SCMs that rely on stormwater infiltration (e.g., infiltrating practices, filtering practices, and groundwater recharge practices) as summarized by **Table 5-1** and detailed in **Appendix A**. Field testing and computation of an appropriate infiltration rate is critical for the effectiveness of these SCMs. This section outlines the procedures for selecting a design infiltration rate for those SCMs.

4.5.2 Calculation Methods

For **each** infiltrating or filtering SCM, perform the following steps:

Step 1 (Site Evaluation): Perform a review of the site to evaluate potential infiltration feasibility for the project. The site evaluation is necessary to ensure that infiltration practices, unlined filtering practices, and groundwater recharge practices are **not installed in the following areas**:

- Within groundwater protection areas, where the stormwater comes from a high-load area.
- Within areas that have contaminants in groundwater above the ambient groundwater quality standards established in Env-Or 603.03.
- Within areas having soil above site-specific soil standards developed pursuant to Chapter Env-Or 600.
- In any area, if the stormwater comes from areas that have contaminants in soil above site-specific soil standards.
- In any area, if the stormwater comes from areas with underground storage tanks regulated under RSA 146-C or aboveground storage tanks regulated under RSA 146-A, where gasoline is dispensed or otherwise transferred to vehicles.
- Within areas having slopes greater than 15 percent unless the system has been carefully engineered to prevent seepage forces from causing instability.
- Within areas where the design infiltration rate is less than 0.50 inches per hour. For filtering practices such as a bioretention area or permeable pavement, no minimum infiltration rate should be required if these facilities are designed with a “daylighting” underdrain system. Use Ksat values published by the SSSNNE for initial screening.
- Within areas having soils with infiltration rates greater than 10 inches per hour unless the stormwater has first been treated by an acceptable SCM, or the soil has been amended to reduce the infiltration rate and the reduction is confirmed by further testing. Use Ksat values published by the SSSNNE for initial screening.

Step 2 (Site Testing): Once the site evaluation is complete, it is necessary to assess infiltration feasibility by digging test pits or taking borings at each proposed SCM location as specified by Env-Wq 1504.13. Use results from the test pits or borings to prepare an infiltration feasibility report that evaluates the elevation and location of the seasonal high-water table (SHWT as defined in Env-Wq 1502.56), bedrock elevation, soil profile descriptions, and other factors. See below for a standardized boring/ test pit protocol.

Step 3 (Calculation of Design Infiltration Rate): If the site evaluation and testing demonstrate that infiltration is feasible, calculate a design infiltration rate for each proposed SCM. Calculation of a design infiltration rate is accomplished via one of three methods depending on the observed soil types: 1) field measurements; 2) laboratory testing results; or 3) published saturated hydraulic conductivity values (Ksat) from the Society of Soil Scientists of Northern New England (SSSNNE). Refer to Env-Wq 1504.14 to determine the appropriate method for the observed soil type. Field measurement methods currently accepted by AoT are described in Env-Wq 1504.14(c). Other measurement methods, such as the Modified Philip Dunn infiltrometer test (ASTM D8152), could be considered.

Standardized Test Pit/ Boring Protocol

Test pits and/ or borings are required in the infiltration area to a minimum depth of 5 feet below the proposed bottom of the infiltration facility. The following steps describe the main elements necessary to support test pit/ boring requirements:

- Excavate a test pit or drill a boring to a depth of at least 5 feet below the proposed facility bottom or to the depth of bedrock or the SHWT, whichever is less. Test pits should be of adequate size, depth, and construction to allow a person to enter and exit the pit and complete a morphological soil profile description. If borings are drilled, continuous soil borings should be taken using a bucket auger, probe, split-spoon sampler, or Shelby tube. Samples should have a minimum 2-inch diameter. A minimum number of test pits and/ or borings should be provided as designated in Env-Wq 1504.13.
- Determine depth to SHWT (if potentially within 5 feet below the base of the facility).
- Determine U.S. Department of Agriculture (USDA) or Unified Soil Classification (USC) System soil textures at the proposed bottom and to 5 feet below the bottom of the infiltration facility.
- Describe soil horizons and determine depth to bedrock (if within 5 feet of proposed bottom of facility).
- The location of the test pit or boring should correspond to the SCM location; test pit/ soil boring stakes should be clearly labeled and left in the field for inspection and surveyed location.

4.5.3 Additional Considerations

The following should be considered to enhance the use of, or avoid problems with, an infiltration facility:

- Groundwater monitoring wells can be used to determine the SHWT. Large sites considered for infiltration systems may need to be evaluated for the direction of groundwater flow. This would require a minimum of three groundwater monitoring wells to determine the flow direction.
- One or more areas within a development site may be selected for infiltration. A development site with many areas suitable for infiltration is a good candidate for a dispersed approach to infiltration. Smaller infiltration devices dispersed around a development are usually more sustainable than a single regional device that is more likely to have maintenance and groundwater mounding problems.
- Stormwater infiltration devices may fail prematurely if there is:
    - An inaccurate estimation of the design infiltration rate.
    - An inaccurate estimation of the SHWT.
    - Excessive compaction or sediment loading during construction.
    - Inadequate pre-treatment of post-development stormwater flows.
    - Inadequate maintenance of the infiltration system and pre-treatment facilities.
- No construction-related sediment should enter the infiltration device. This includes sediment resulting from initial site grading as well as subsequent home building and related construction. If possible, rope off areas selected for infiltration during grading and construction. This will preserve

the infiltration rate and extend the life of the device. In addition, infiltration facilities should only be placed into service after the contributing areas are fully stabilized.

- A groundwater mounding analysis is recommended for any SCM that meets at least one of the following criteria:
  - Has a watershed area to infiltration area ratio greater than 20.
  - Designed for greater than the 1-year, 24-hour storm event and a larger storm (e.g., 10-year, 24-hour storm) is required in the design.
  - There is less than 1 foot of unsaturated soil below the SCM infiltration surface and the estimated seasonal high groundwater table.
  - There is less than 4 feet of soil between the SCM bottom and bedrock, clay, or an impermeable layer.

  The mounding analysis may be performed using tools such as the United States Geological Survey (USGS) MODFLOW, the Hantush Method, or a 2D or 3D variably-saturated flow model. The more common Hantush Method was developed based on a set of simplified assumptions (e.g., vertical SCM slide slopes). A more detailed analytical method such as MODFLOW should be used if any of the simplified Hantush Method assumptions are not valid.

4.6 Effective Impervious Cover (EIC) and Undisturbed Cover (UDC)

4.6.1 Criteria

Effective Impervious Cover (EIC) as defined in Env-Wq 1502.20 means all impervious cover that is not disconnected from impervious cover. Undisturbed Cover (UDC) as defined in Env-Wq 1502.77 means a natural land surface whose permeability has not been altered by human activity. There are no specific design criteria for EIC or UDC; however, EIC should be reduced as feasible and UDC should be maximized as feasible.

4.6.2 Calculation Methods

Some AoT requirements call for calculations of the percent effective impervious cover (%EIC) and percent undisturbed cover (%UDC), such as requirements for deed restrictions or easements (Env-Wq 1504.07).

- %EIC is computed by dividing the area of effective impervious cover within a project area by the drainage area within a project area, using equal units of measure, and then multiplying the result by 100.
- %UDC is computed by dividing the area of undisturbed cover within a project area by the drainage area within a project area, using equal units of measure, and then multiplying the result by 100.

4.7 Channel Protection (CP)

4.7.1 Criteria

The purpose of this design criterion is to protect stream channels, downstream receiving waters, and wetlands from erosion and associated sedimentation resulting from urbanization within a watershed. This criterion limits the total amount of time that a receiving waterbody exceeds an erosion-causing threshold based on pre-developed conditions.

The combined flow to a single waterbody from a project site shall meet one of the following criteria:

- The 2-year, 24-hour post-development peak flow rate generated from the proposed disturbance is equal to or less than the 2-year, 24-hour pre-development peak flow rate and one of the following:
  - The 2 year, 24-hour post-development storm volume, directed to the nearest waterbody has not increased over the pre-development volume by more than 0.1 acre-feet.
  - The 2-year, 24-hour post-development peak flow rate directed to the nearest waterbody is less than 2 cubic feet per second.
  - The area directly discharges into a fourth order or greater river, a pond or lake greater than 10 acres, or tidal water.
- The 2-year, 24-hour post-development peak flow rate is less than or equal to 50 percent of the 2-year, 24-hour pre-development peak flow rate.
- The 2-year, 24-hour post-development peak flow rate is less than or equal to the 1-year, 24-hour pre-development peak flow rate.

4.7.2 Calculation Methods

See **Chapter 4.8** for a discussion of calculation methods to evaluate peak flow rates.

Example Calculation: Channel Protection (CP)

Given: Prior to development, stormwater is collected immediately off-site to one point of analysis (POA). After development, all stormwater is collected at the same POA after being treated and recharged, as necessary. The development will not discharge to a fourth order or greater river, a pond or lake greater than 10 acres, or tidal water.

- 1-year pre-development 24-hour peak discharge rate = 1.4 cfs with 0.24 ac-ft of runoff
- 2-year pre-development 24-hour peak discharge rate = 2.6 cfs with 0.34 ac-ft of runoff

Solution:

Criteria 1:

- 2-year, 24-hour post-development peak discharge should be **≤ 2.6 cfs**; and
- 2-year 24-hour post-development volume should be **≤ 0.44 ac-ft (**≤ 0.34 + 0.10); or
- 2-year, 24-hour post-development peak discharge should be **≤ 2.0 cfs**

Criteria 2:

- 2-year, 24-hour post-development peak discharge should be ≤ **1.3 cfs (**≤ 0.5 * 2.6 cfs)

Criteria 3:

- Or the 2-year, 24-hour post-development peak discharge rate should be ≤ **1.4 cfs**

4.8 Peak Runoff Control

4.8.1 Criteria

The purpose of peak runoff controls is to address increases in the frequency and magnitude of flooding caused by development. The criteria below should be met to control peak discharge rates leaving the site:

- The 10-year, 24-hour post-development peak flow rate should not exceed the 10-year, 24-hour pre-development peak flow rate for all flows leaving the site.
- The 50-year, 24-hour post-development peak flow rate should not exceed the 50-year, 24-hour pre-development peak flow rate for all flows leaving the site.
- A project area that directly discharges to a stream, river, lake, pond, wetland or estuary could be exempt from (1) and (2), above, if the applicant has provided supporting off-site drainage calculations for the 10-year and 50-year, 24-hour storm showing that at a point immediately downstream from the project site, the post-development peak flow rate from the site and the off-site contributing area does not exceed the pre-development peak flow rate at that point.
- The project should provide supporting information showing that there is no impact to properties as a result of developing within the 100-year floodplain.

Additional Peak Runoff Control Recommendations



Recent evidence indicates that the intensity and depth of precipitation is increasing during large return period storm events. Peak flow is a particularly important consideration when development is upstream of vulnerable infrastructure (e.g., undersized culverts). Designers should consider the following when determining peak runoff control design criteria:

- Compare potential rainfall depths from the Northeast Regional Climate Center (NRCC) and National Oceanic Atmospheric Administration (NOAA) Atlas 14. Select the higher rainfall depth for use in modeling peak runoff rates. (See **below** for how to determine design rainfall depths.)
- Design to a higher rainfall depth to account for potential future increases in rainfall depth during large return period storm events. The NRCC and NOAA Atlas 14 each provide a lower confidence rainfall depth and an upper confidence rainfall depth for the return period of interest – the median value is provided by default. Design to the upper confidence value where feasible to add additional resiliency into the design.
- Use a NRCC or NOAA Atlas 14 rainfall distributions for model simulations. NRCS Type II and Type III distributions were developed based on Technical Paper 40 and may no longer be representative of current conditions. The NRCC and NOAA Atlas 14 distributions will generally result in higher intensity rainfall and peak runoff values over the 24-hour design. (See **below** for how to obtain rainfall distributions.)
- Consider designing to a higher return period event such as the 100-year, 24-hour event for sites that discharge to receiving areas that are highly sensitive to changes in upstream development – e.g., urban areas with minimal natural floodplain storage; smaller receiving waterbodies such as intermittent streams or those with a Strahler Stream Order of 1 or 2.
- Consider incorporating Coastal Flood Risk Guidance for climate change resilience when determining peak runoff control design criteria.

4.8.2 Calculation Methods

Peak runoff control calculations should be performed as part of a Stormwater Drainage Report in accordance with Env-Wq 1504.09. The following additional calculation notes apply.

- Use NRCS methods (TR-20 or TR-55) to develop hydrographs and peak flow rates for the proposed development site. The hydrograph time interval (dT) in TR-20 should be no greater than 0.1 hours. All areas should be accounted for in the pre/ post runoff calculations. The total area that contributes flow to the site, including stormwater runoff entering the site through piped drainage or surface runoff from off-site sources, should be included even if a portion does not contribute flow to the site SCMs. The development's storm drain design should account for all runoff leaving the site.
- Topography may require evaluation at more than one location if flow leaves the site in more than one direction.
- Determine precipitation depth based on the Northeast Regional Climate Center (NRCC) or the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 (see examples below).
- Determine precipitation distribution using one of the options listed below.
    - **Option 1 – Obtain County-Specific NRCC or NRCS Distributions:** The Small Watershed Hydrology computer program may be used to develop design rainfall depths and distributions based on site location at the County level. There are four available NRCC distributions (Type A, Type B, Type C, and Type D) and two applicable NRCS distributions (Type II and Type III). The appropriate distribution must be selected based on site location. As indicated in **Chapter 4.8.1**, it is generally recommended that NRCC distributions be used to accommodate higher rainfall intensities. Note that proprietary versions of WinTR-55 may also be used to obtain NRCC or NRCS distributions. Consult with the relevant software developer for instructions.
    - **Option 2 – Site-Specific Distribution from NOAA Atlas 14**: Version 3.20 and later of the Project Formulation Hydrology computer program (WinTR-20) allow users to import a downloaded NOAA Atlas 14 data file directly into TR-20. Users must go to the NOAA Atlas 14 website, obtain precipitation frequency estimates for the design site, then download and import the data into WinTR-20. This results in a suite of site-specific 24-hour rainfall distributions for relevant design storms (*e.g.,* 10-, and 50-year storms). Customized rainfall distributions may also be developed using NOAA 14 with some proprietary versions of WinTR20. Consult with the software manufacturer to see if customized distributions may be developed using the NOAA Atlas 14 data. Step-by-step instructions for developing site-specific rainfall distributions based on site-specific NOAA Atlas 14 data are provided in Chapter 6 of the WinTR-20 User Guide (version 3.10).
- Any site that was wooded within the last ten years should be considered undisturbed woods for all pre-construction runoff conditions, regardless of clearing or cutting activities that may have occurred on the site during that pre-application period.
- Off-site areas should be modeled as present land use condition for all design storm events for both pre- and post-development calculations.
- The length of overland sheet flow used in time of concentration (tc) calculations should be limited to no more than 100 feet for pre- and post-development conditions. Refer to the National

Engineering Handbook Part 630, Chapter 15 for a table of maximum sheet flow lengths using the McCuen-Spiess limitation criteria.

Example of How to Obtain Site-Specific Rainfall Depth Using NOAA Atlas 14

Given: Use NOAA Atlas 14 to determine rainfall depths for the 10-year, 24-hour and 50-year, 24-hour storms for a peak runoff analysis at a site in New Hampshire. Also evaluate the Upper Confidence Level for the 100-year, 24-hour storm*.

Note: A similar process may be followed using the online NRCC/ NRCS Extreme Precipitation Tool.

Solution:

Step 1: Navigate to NOAA Atlas 14 (New Hampshire), then navigate to the project site, either by using latitude/ longitude or street address. Drag the red cross to refine the "point of interest" as needed. The below uses the centroid of New Hampshire as an example (**Figure 4-3a**).

Step 2: Make sure defaults are enabled for Data Type (Precipitation Depth is default), Units (English is default) and Time Series Type (Partial Duration is default)

Step 3: Scroll down to tabular precipitation frequency statistics.

Step 4: To determine design storm, select return period on horizontal row, and time length on the vertical column (**Figure 4-3b**).

Step 5: Each cell contains three values: the fitted value (Bolded), the lower confidence value, and the upper confidence value.

- The resulting median values for the 10-year, 24-hour and 50-year, 24-hour storms are 4.19 inches and 5.67 inches, respectively.
- The resulting upper confidence value for the 100-year, 24-hour storm is 8.44 inches.

* **Note**: It is recommended that the median value for the 100-year, 24-hour storm be evaluated at a minimum.

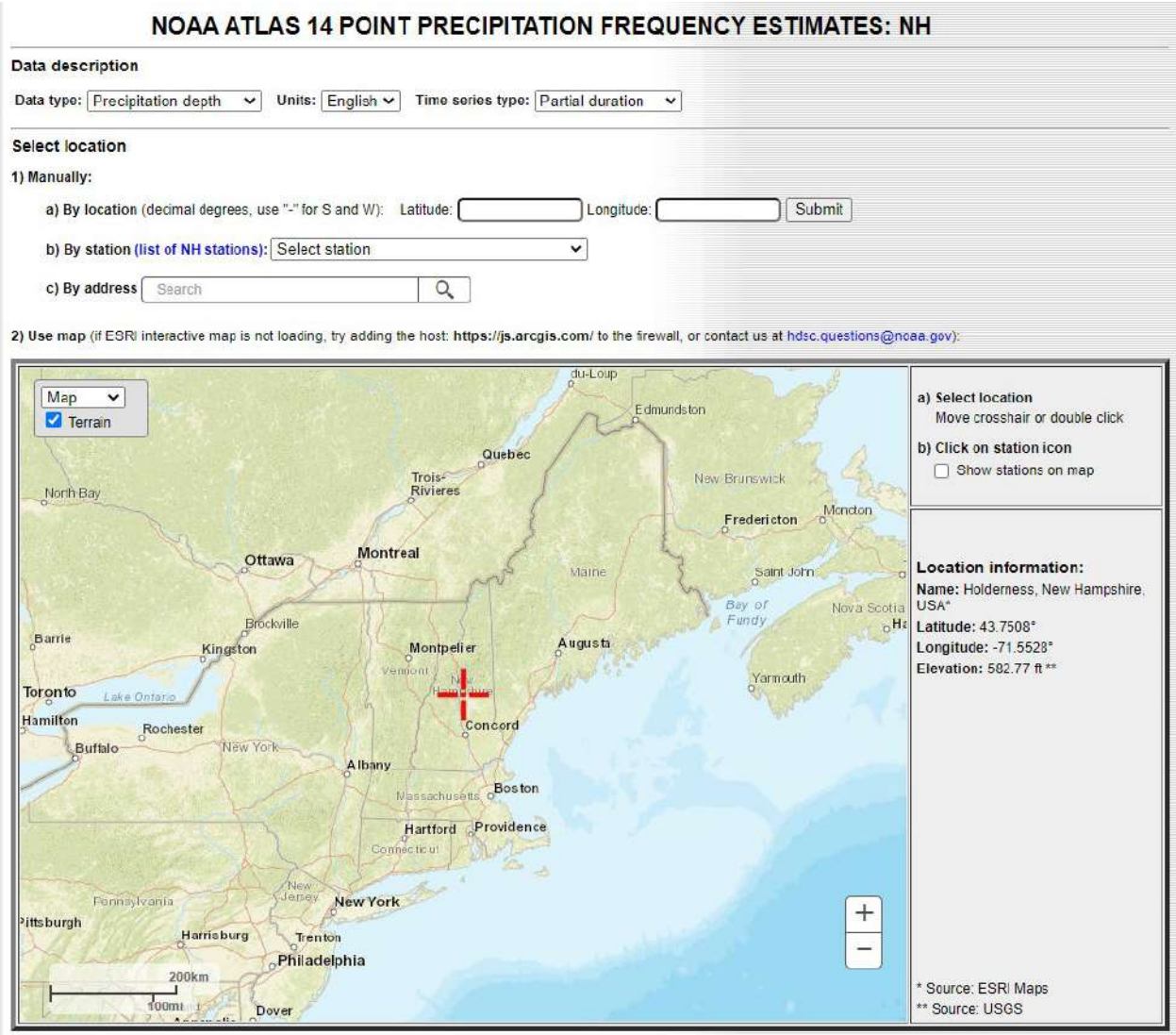


Figure 4-3a. NOAA Atlas 14 Graphical Interface. Red cross indicates "point of interest"

(Point of interest may also be identified using geographic coordinates, station name, or address.)

PF tabular | PF graphical | Supplementary information | Print page

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.279 (0.223-0.343)	0.337 (0.269-0.415)	0.432 (0.344-0.534)	0.511 (0.405-0.636)	0.620 (0.473-0.806)	0.702 (0.523-0.931)	0.788 (0.568-1.09)	0.885 (0.601-1.25)	1.02 (0.666-1.49)	1.14 (0.722-1.70)
10-min	0.395 (0.316-0.486)	0.478 (0.382-0.588)	0.613 (0.489-0.758)	0.724 (0.573-0.900)	0.878 (0.670-1.14)	0.994 (0.741-1.32)	1.12 (0.805-1.54)	1.25 (0.851-1.77)	1.45 (0.944-2.12)	1.62 (1.02-2.40)
15-min	0.465 (0.372-0.572)	0.562 (0.449-0.692)	0.720 (0.574-0.892)	0.852 (0.674-1.06)	1.03 (0.788-1.34)	1.17 (0.871-1.55)	1.31 (0.947-1.81)	1.48 (1.00-2.08)	1.71 (1.11-2.49)	1.90 (1.20-2.83)
30-min	0.642 (0.514-0.790)	0.776 (0.621-0.956)	0.996 (0.793-1.23)	1.18 (0.933-1.46)	1.43 (1.09-1.86)	1.62 (1.21-2.15)	1.82 (1.31-2.51)	2.04 (1.39-2.88)	2.37 (1.54-3.45)	2.64 (1.67-3.92)
60-min	0.819 (0.655-1.01)	0.991 (0.792-1.22)	1.27 (1.01-1.57)	1.51 (1.19-1.87)	1.83 (1.39-2.37)	2.07 (1.54-2.75)	2.32 (1.68-3.20)	2.61 (1.77-3.67)	3.03 (1.97-4.41)	3.37 (2.14-5.01)
2-hr	1.01 (0.813-1.23)	1.24 (0.997-1.52)	1.62 (1.30-1.98)	1.93 (1.54-2.38)	2.36 (1.82-3.06)	2.68 (2.02-3.56)	3.02 (2.22-4.19)	3.45 (2.35-4.82)	4.10 (2.68-5.94)	4.67 (2.97-6.89)
3-hr	1.15 (0.931-1.40)	1.42 (1.15-1.73)	1.85 (1.49-2.26)	2.21 (1.77-2.72)	2.71 (2.10-3.51)	3.08 (2.33-4.08)	3.48 (2.57-4.82)	3.98 (2.72-5.55)	4.77 (3.12-6.87)	5.46 (3.48-8.01)
6-hr	1.48 (1.21-1.79)	1.81 (1.47-2.18)	2.34 (1.90-2.84)	2.78 (2.24-3.39)	3.38 (2.64-4.34)	3.83 (2.92-5.04)	4.32 (3.20-5.93)	4.93 (3.38-6.81)	5.88 (3.86-8.39)	6.70 (4.29-9.75)
12-hr	1.93 (1.58-2.31)	2.31 (1.89-2.77)	2.93 (2.39-3.53)	3.44 (2.79-4.18)	4.15 (3.25-5.27)	4.68 (3.58-6.07)	5.24 (3.88-7.07)	5.91 (4.08-8.09)	6.91 (4.56-9.78)	7.75 (4.97-11.2)
24-hr	2.37 (1.96-2.83)	2.83 (2.34-3.37)	3.57 (2.94-4.27)	4.19 (3.42-5.04)	5.03 (3.96-6.33)	5.67 (4.35-7.28)	6.34 (4.70-8.44)	7.11 (4.93-9.65)	8.23 (5.45-11.5)	9.15 (5.90-13.1)
2-day	2.74 (2.29-3.25)	3.30 (2.75-3.91)	4.22 (3.50-5.01)	4.98 (4.10-5.95)	6.02 (4.77-7.52)	6.80 (5.26-8.68)	7.63 (5.70-10.1)	8.60 (6.00-11.6)	10.0 (6.68-14.0)	11.2 (7.28-16.0)
3-day	3.01 (2.52-3.55)	3.62 (3.03-4.28)	4.62 (3.85-5.47)	5.46 (4.51-6.49)	6.60 (5.25-8.21)	7.45 (5.78-9.48)	8.36 (6.27-11.0)	9.43 (6.59-12.6)	11.0 (7.35-15.3)	12.4 (8.02-17.5)
4-day	3.25 (2.73-3.82)	3.90 (3.27-4.58)	4.95 (4.14-5.85)	5.83 (4.83-6.91)	7.03 (5.61-8.72)	7.93 (6.17-10.0)	8.89 (6.67-11.7)	10.0 (7.01-13.4)	11.7 (7.80-16.1)	13.1 (8.49-18.4)
7-day	3.91 (3.31-4.57)	4.62 (3.90-5.40)	5.76 (4.84-6.76)	6.72 (5.60-7.92)	8.03 (6.43-9.88)	9.01 (7.04-11.3)	10.0 (7.56-13.1)	11.2 (7.91-14.9)	13.0 (8.70-17.8)	14.4 (9.39-20.1)
10-day	4.54 (3.86-5.29)	5.28 (4.48-6.16)	6.49 (5.48-7.59)	7.49 (6.28-8.81)	8.87 (7.13-10.9)	9.91 (7.76-12.4)	11.0 (8.28-14.2)	12.2 (8.63-16.1)	13.9 (9.39-19.0)	15.4 (10.0-21.4)
20-day	6.44 (5.50-7.44)	7.26 (6.20-8.40)	8.60 (7.31-9.98)	9.72 (8.20-11.3)	11.2 (9.09-13.6)	12.4 (9.76-15.3)	13.6 (10.2-17.3)	14.8 (10.6-19.4)	16.5 (11.2-22.3)	17.8 (11.7-24.5)
30-day	8.02 (6.89-9.24)	8.90 (7.63-10.3)	10.3 (8.83-11.9)	11.5 (9.77-13.4)	13.2 (10.7-15.8)	14.4 (11.4-17.6)	15.7 (11.8-19.7)	16.9 (12.1-22.0)	18.5 (12.6-24.9)	19.7 (12.9-27.0)
45-day	10.0 (8.64-11.5)	11.0 (9.44-12.6)	12.5 (10.7-14.4)	13.8 (11.7-15.9)	15.5 (12.6-18.5)	16.9 (13.4-20.5)	18.3 (13.7-22.7)	19.5 (14.0-25.2)	21.0 (14.3-28.1)	22.0 (14.5-30.1)
60-day	11.7 (10.1-13.4)	12.7 (11.0-14.5)	14.3 (12.3-16.4)	15.7 (13.4-18.1)	17.5 (14.3-20.8)	19.0 (15.0-22.9)	20.4 (15.3-25.2)	21.6 (15.5-27.8)	23.1 (15.8-30.7)	24.0 (15.8-32.6)

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

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

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format: Precipitation frequency estimates | Submit

Figure 4-3b. Example NOAA Atlas 14 Results Table

Values from above example are circled in "blue". The median design storm depth for the 100-year 24-hour storm is 6.34 inches as compared to 8.44 inches for the upper confidence interval.

5 Site Planning and Design

How Does This Manual Relate to Stormwater Management Permitting?



The primary goal of this Manual is to present the state-of-the-practice for stormwater management in New Hampshire. This Manual also provides guidance on stormwater design criteria required by various local, state, and federal regulations and permitting programs (*see **Chapter 3** – Regulations and Permitting*).

As the science and available technologies for stormwater management are constantly evolving, the state-of-the-practice may in some cases be "a step ahead" or differ from regulatory requirements and related design criteria which are only updated periodically. Contact applicable regulatory programs (*as described in **Chapter 3***) for the most up-to-date rules and regulations.



Designers and property owners are encouraged to manage stormwater based on the state-of-the-practice whenever possible. The **"plus" icon** to the left is provided to aid users of this Manual in identifying where recommended design criteria may **exceed or differ from state permitting requirements**. This guidance represents the latest science-based research and represents where the field is heading.

This Chapter presents a general overview of the site planning and design process, the selection of Stormwater Control Measures (SCMs), and Information on how to prepare post-construction maintenance and source control plans.

5.1 Overview of the Site Design Process

5.1.1 Identifying Permitting Requirements

Proposed projects may trigger several permitting programs at the local, state, or federal level. Common triggers may include, but are not limited to:

- Disturbing a significant land area.
- Performing work in or near wetlands.
- Performing work near other natural resource areas.

See **Chapter 3** for a detailed overview of potential permitting requirements and associated resources. It is the responsibility of the project applicant or proponent to identify relevant requirements and obtain approval prior to beginning work.

5.1.2 Identifying Documentation Requirements

Most proposed projects will require applications, design plans, and associated documentation depending upon applicable permitting requirements. Permitting requirements may be local (e.g., ordinances), State (e.g., AoT), or federal (e.g., MS4). Once potential permitting requirements are identified, the project applicant or proponent should perform a detailed review of applicable regulations and prepare all relevant documentation. For example, the following is a list of plans that are commonly required by projects with a stormwater management component per the NHDES Alteration of Terrain (AoT) permitting program regulations (i.e., Env-Wq 1500).

- Development Plan (Env-Wq 1504.05).
- Source Control Plan (Env-Wq 1504.08).
- Stormwater Drainage Report (Env-Wq 1504.09).
- Infiltration Feasibility Report (Env-Wq 1504.13).
- Long-term Inspections & Maintenance Plan (Env-Wq 1507.07).

Reach out to NHDES programs early in the process if there are any uncertainties or questions regarding the need for a permit or certification. A pre-application meeting can be requested by submitting a NHDES Pre-Application Meeting Request form.

5.1.3 Establishing Goals and Design Criteria

Once relevant permitting and documentation requirements are identified, a project applicant or proponent should establish goals and associated site design criteria. The primary goal of any project should be to avoid, minimize, or mitigate potential impacts to the site and surrounding resource areas. To meet this goal, design criteria should be established to maximize pollutant removal efficiencies and groundwater recharge and to reduce flooding potential through peak rate and volume controls for stormwater from the entire developed area. See **Chapter 4** for design criteria and guidance on how to perform calculations.

Stormwater management projects should also be designed with a goal of improving the adaptation and resiliency of communities to climate change. See **Chapter 2.1.3** for information on designing for climate change.

Watershed Protection Standard

As indicated in **Chapter 4.1**, a **WPS** approach to stormwater design is recommended by this Manual to support pre-development site hydrology:



- **Site Design**: Consider pre-development hydrology and encourage the use of Low Impact Development (LID) site design techniques to the maximum extent practicable (see **Chapter 5.2**).
- **Retention**: Design SCM Design Storage Volume (DSV) to meet retention goals (e.g., yield no increase in nutrient discharge) on a site-wide basis to the maximum extent practicable (see **Chapter 4.4**).
- **Treatment**: If on-site retention sizing cannot be met, alternatively design for 90 percent TSS, 60 percent TP, and 50 percent TN pollutant removal (see **Chapter 4.2**).
- **Other Requirements**: Finalize design to meet all applicable regulatory requirements (e.g., recharge, peak rate, channel protection).

5.1.4 Performing Site Analysis and Design

Once design goals and criteria are established, site design may be performed. The following provides a list of general site design steps with accompanying references to various sections of this Manual for more information.

- **Step 1**: Perform a site survey and review existing site conditions including, but not limited to: topography, drainage patterns, soils, the presence of wetland resource areas or other environmentally sensitive areas, high-load areas, existing or adjacent development, and existing utilities. See **Chapter 5.3.4** for more detailed evaluation criteria. It is also appropriate at this phase to identify site constraints and opportunities (e.g., contaminated soils, open space) that may influence design as well as programmatic needs (e.g., pedestrian access, parking).
- **Step 2**: Prepare a preliminary site plan of proposed development activities and accompanying Stormwater Control Measures (SCMs). Perform design using Low Impact Development (LID) site planning techniques described in **Chapter 5.2**. It is particularly important to preserve natural vegetation, minimize the creation of impervious surfaces, and to honor and maintain existing drainage patterns. Perform preliminary SCM selection based on guidance from **Chapter 5.3**.
- **Step 3:** Perform detailed SCM design and sizing to meet required design criteria. Perform sizing based on design criteria described in **Chapter 4** and design based on the **Appendix A** SCM Fact Sheets. Design and sizing will include several steps, including delineation of upstream drainage area to size the SCM to meet design criteria, soil sampling for applicable SCMs to verify suitability and infiltration rates of underlying soils and depth to the water table or bedrock, and preparation of required computations (e.g., peak rate, pollutant removal).
- **Step 4:** Consider obtaining a third-party review to verify that applicable regulations are met, that design criteria are met, and that LID site planning techniques have been implemented where feasible.

5.1.5 Introduction to Stormwater Control Measures

Design goals and associated design criteria can be met by implementing SCMs. Stormwater Control Measures are structural or nonstructural practices for managing stormwater to prevent or reduce nonpoint source pollutants from entering surface or groundwaters. Stormwater Control Measures are presented by this Manual in the following three categories.

- **Low Impact Development (LID)** is an environmental site design approach that combines nonstructural practices (i.e., can be implemented without an engineering component) and structural practices to preserve natural vegetation, minimize impervious surfaces, slow down times of concentration, and reduce stormwater runoff. Low impact development techniques also include implementation of distributed Green Infrastructure (GI) to preserve natural drainage pathways and reduce the impact from development. See **Chapter 5.2** for more information on LID techniques.
- **Nonstructural SCMs** are source controls or operating procedures (e.g., street sweeping) that are implemented to minimize the volume of stormwater runoff that comes into contact with potential pollutants. See **Chapter 5.5** for more information on recommended operating procedures and plans related to source control.
- **Structural SCMs** are practices that have been specifically designed, constructed, and installed for the purposes of conveying, collecting, storing, discharging, recharging, or treating stormwater. Structural SCMs also include distributed Green Infrastructure (e.g., green roofs, permeable pavement). See **Chapter 5.3** for more information on the selection of structural SCMs.

See **Appendix A** for fact sheets and recommended design criteria for specific SCMs.

SCM Implementation Order

Most project sites will require a combination of all three SCM types to meet design goals and criteria. The project applicant or proponent should initiate the design process by identifying LID techniques and source controls before considering structural SCMs to capture and attenuate the remaining stormwater runoff. LID techniques can reduce the required scale of structural SCMs, pavement, other drainage infrastructure, ongoing operations, and maintenance needs, and provide improved aesthetics and overall associated site costs.

5.2 Low Impact Development

5.2.1 Principles of LID Design

Stormwater runoff management traditionally focused on end-of-pipe methods to detain and treat stormwater. Although end-of-pipe methods have their place in stormwater management, when used alone they are often more costly and require more intensive maintenance than techniques that minimize stormwater runoff or treat it close to the source. Fortunately, there are many simple structural and nonstructural methods that can be incorporated into the planning process that maintain the natural landscape and preserve the hydrologic functions of a site (i.e., LID design approach). Applying the LID design approach can minimize the amount of generated stormwater runoff, decrease the required treatment volume by controlling stormwater runoff at the source, and dramatically decrease overall development costs by reducing sizing requirements of structural SCMs.

To effectively incorporate the LID design approach, the stormwater runoff from a site needs to be managed on a catchment scale. Accomplishing this often requires a shift in thinking. Instead of managing all of a site's stormwater runoff through one practice (e.g., collecting the stormwater runoff from a subdivision or a commercial development in one large stormwater pond), the stormwater runoff is addressed at the watershed and individual lot level through many different practices. For example, a site design might incorporate the use of rain barrels or dry wells to collect roof runoff, rain gardens to collect stormwater runoff from driveways or parking lots, and smaller stormwater ponds to collect stormwater runoff from common, open space areas.

Low Impact Development Design Approach

The LID design approach begins early in the site planning process, well before the designer makes decisions about density, placement of buildings, configuration of roadways and other infrastructure, and the design of larger scale structural SCMs. The approach discerns how water moves through the landscape under existing conditions, and then works with those site characteristics and drainage patterns to integrate the development design with natural drainage features and functions.

This design approach also requires a shift away from altering and grading a site to convey site stormwater runoff to a single discharge point, to instead, working with the existing topography and hydrology to maintain flow paths and maximize opportunities for natural flow attenuation and infiltration. This reduces the dependence of the development on downstream carrying and treatment capacity.

There are three major components to LID design:

- **Site Planning:** Plan sites to preserve natural vegetation, minimize the creation of impervious surfaces, and to honor and maintain existing drainage patterns. This type of planning requires an analysis of the site and its local setting to develop an understanding of natural features, existing drainage patterns, and the offsite infrastructure and water courses that will receive drainage from the project.
- **Hydrologic Management:** Prepare designs that provide for "disconnection" of impervious surfaces from the site drainage collection system. This may involve directing roof and other impervious area runoff as sheet flow to pervious areas, encouraging surface infiltration and water

quality treatment, to help reduce the added stormwater runoff resulting from these paved surfaces.

- **Catchment-Scale Controls:** Use distributed structural SCMs to collect and manage the remaining stormwater runoff generated by the development designed to promote infiltration and water quality treatment through natural processes (such as filtration and sorption through engineered soils and uptake of nutrients by vegetation). Catchment-scale controls are typically designed to capture a smaller design storm (e.g., equal to 1-inch) and the first flush of runoff from a rain event, which can carry high concentrations of pollutants. Catchment-scale controls are typically most effective when distributed throughout a site. Implementation of catchment-scale controls can conserve natural drainage pathways and open space and significantly reduce the impact from development. Catchment-scale controls can also provide additional benefits beyond those related to water quality and drainage, such as increased property values, reduced energy costs, noise control, enhanced flood resiliency, and habitat for wildlife.

5.2.2 Site Planning Techniques

An overview of some commonly used LID site planning techniques (i.e., environmental site design) is provided below.

- **Minimize Disturbed Areas**. Any change in the landscape from the existing condition is considered a disturbance. Below is a list of design considerations to be used to avoid or limit disturbance.
  - Avoid and minimize alterations to natural resource areas and drainage paths.
  - Define the development envelope and clearly mark it on the plans and in the field.
  - Avoid the removal of trees.
  - Limit clearing and grading to the smallest amount required; disturbance should be limited to the building footprint, construction access and safety setbacks.
  - Cluster vegetated areas and connect them with vegetated corridors.
  - Cluster proposed impervious areas and disconnect them (see "**Disconnect Impervious Cover**" in **Chapter 5.2.3**).
  - Conserve as much of the site in natural or existing vegetated condition as possible, or in redevelopment activities, reduce the amount of effective impervious cover by removing or replacing existing impervious cover and disconnecting it. Pay particular attention to the conservation of sensitive areas, which can be identified in the NHDES Aquatic Restoration Mapper.
- **Maintain Natural Buffers**. Natural buffers are untouched pieces of land around streams, rivers, lakes, ponds, wetlands, estuaries, and other sensitive areas which intercept stormwater runoff from pervious and impervious areas and treat it through natural filtration, infiltration, and vegetative uptake. Maintaining natural buffers goes hand in hand with minimizing disturbed areas. See **Appendix A** fact sheet on "**Impervious Area Disconnection**" for more information on applicable design criteria for buffers.
- **Fit the Development to the Terrain**. Use natural site hydrology to inform the design to minimize stormwater runoff volumes.
  - Use existing drainage divides by maintaining existing site topography.

- Consider ridges for development and valleys for stormwater management (i.e., minimize “cut” and “fill” operations).
- Avoid development of steep slopes with high stormwater runoff potential.
- Identify areas with soils most conducive to infiltration and use them for that purpose.
- Strategically place impervious areas where soils are less conducive to infiltration, to minimize the loss of natural recharge.

- **Minimize Impervious Cover**. Impervious cover includes areas such as sidewalks, driveways, roadways, parking areas and rooftops.
  - Build “up” rather than “out.” For example, build two-story structures instead of single-story structures to maintain square footage while reducing the building footprint.
  - Reduce pavement within parking areas through careful design of efficient aisles and parking bays (e.g., parking on both sides versus one side of an aisle), coupled with the use of vegetated parking lot islands (instead of paved or gravel islands) with depressed planting beds to infiltrate stormwater runoff. Include curb cuts to help direct stormwater runoff from impervious cover to planting beds or other SCMs.
  - Employ narrower road or driveway widths.
  - Shorten driveway lengths where grade allows.
  - Use rural road design (i.e., open drainage) instead of curb, gutter, and piped roadway drainage (i.e., closed drainage).
  - Limit sidewalks to only one side of the road or consider pervious trails instead of sidewalks.
  - Reduce the amount and type of on-street parking – only on one side, or parallel instead of diagonal.

5.2.3 Hydrologic Management Techniques

An overview of some commonly used LID hydrologic techniques is provided below.

- **Disconnect Impervious Cover**. Redirect stormwater runoff from impervious surfaces away from the site drainage collection system. See **Appendix A** for design criteria for disconnection practices.
  - Maximize disconnection of impervious surfaces to qualifying pervious areas (see **Appendix A** fact sheet on “**Impervious Area Disconnection**” for design criteria).
  - Provide for collection of roof runoff for irrigation purposes (rain barrels and cisterns).
  - Maximize drainage flow paths over pervious areas.
  - Consider “open drainage” versus piped systems.
- **Establish Vegetated Buffers**. Establishment of vegetated buffers is a complementary practice to disconnection of impervious cover. See **Appendix A** fact sheet on “**Impervious Area Disconnection**” for design criteria.
- **Minimize Soil Compaction.** Even lawns and gravel-surfaced areas can perform as an impervious surface. A common misconception is that the infiltration capacity of a lawn should be

similar to that of a naturally vegetated area. This is often not the case because of soil compaction during construction. Consider the following methods to reduce the potential for compacted soils:

- Limit development to soils with low infiltration capacity such as hydrologic soils group C and D soils (note, however, that some areas classified as D soils may be wetland resource areas or may have water tables at or near the surface and may not be suitable for development). Hydrologic soil groups may be obtained from the NRCS Web Soil Survey or the Society of Soil Scientists of Northern New England (SSSNNE).
- Store machinery and equipment within the construction envelope to avoid unnecessarily disturbing areas that could remain vegetated.
- Store construction material and soil stockpiles within the construction envelope.
- Clearly mark on the plans and in the field the boundaries of disturbed areas.
- To the extent feasible, avoid repeated trafficking with construction equipment over areas that will be landscaped. Where construction traffic cannot be diverted, deeply scarify impacted soils to restore their infiltration capacity.
- If areas are proposed for stormwater infiltration, efforts will be required to avoid compaction of these areas by construction equipment or traffic, discharge of sediment laden waters to these areas during construction, and premature use of these areas for stormwater management prior to stabilization of these facilities and the contributing drainage area.

5.2.4 Catchment Scale Controls

An overview of some commonly used methods to incorporate distributed structural SCMs (i.e., Green Infrastructure) on a small scale at the catchment level throughout the site is provided below. Refer to **Appendix A** for fact sheets and applicable design criteria for the SCMs listed below.

- Minimize stormwater runoff from roofs (e.g., green roofs).
- Minimize stormwater runoff from pavements (e.g., permeable pavement).
- Convert concentrated flow to sheet flow (e.g., level spreaders).
- Manage sheet flow (e.g., vegetated buffers).
- Manage concentrated flow (e.g., vegetated channel SCMs).
- Manage discharges and maintain SCMs (e.g., dry wells, bioretention areas/ rain gardens, infiltration trenches, infiltration basins, roof dripline filters).

5.3 Selecting Appropriate Structural Stormwater Control Measures

To achieve objectives for the control and treatment of stormwater, development and redevelopment projects will generally require the implementation of one or more structural SCMs. A designer should first consider implementation of LID techniques and source controls to minimize the amount of stormwater runoff that must be treated by selected structural SCMs (see **Chapter 5.2** for a discussion of LID techniques).

Structural SCM selection must be based not only on the ability of each SCM to meet specific management objectives (such as peak rate control and water quality treatment), but also based on site specific pollutants of concern, constraints, and opportunities.[14] There is no single SCM that is appropriate for every site. The remainder of this section outlines considerations for screening and selecting the best SCM(s) based on site specific factors and treatment goals, including:

- Performance expectations.
- Treatment Unit Operations and Processes (UOPs).
- Pollutant removal capabilities.
- Land use.
- Physical feasibility.
- Watershed resources.
- Maintenance factors.
- Community, programmatic, and environmental factors.

The following discussion is intended as general guidance. The design and review of stormwater management systems must consider a wide range of factors that affect design. Final selection of SCMs will require professional judgment based on site-by-site analysis of stormwater management objectives and applicable constraints. Note that construction phase Erosion and Sediment Control (E&SC) practices are covered in **Chapter 6**.

[14] Specific SCM requirements for any project that would result in a discharge of stormwater within one-quarter mile of a surface water of the state impaired for phosphorus or nitrogen, a class A surface water, a lake or pond, or within a watershed of a surface water that is an outstanding resource water (ORW) as defined in Env-Wq 1708.04(a) are outlined in Env-Wq 1507.03.

What Structural SCMs are Available for Site Design?

Fact sheets and detailed design criteria for recommended structural SCMs are available in **Appendix A** for the following categories:

- Pre-treatment (e.g., deep sump catch basins).
- Treatment (e.g., bioretention systems).
- Conveyance (e.g., conveyance swales).

A list of all SCMs with relevant screening factors is also available in **Table 5-1**. The SCM list includes information on performance expectations (i.e., Tiers, as discussed in **Chapter 5.3.1**), a crosswalk to relate the different naming conventions used by the AoT and the EPA Pollutant Removal Performance Curves, applicable Unit Operation and Process (UOP) used by the SCM, and information on whether the SCM can meet AoT design criteria if properly designed. These factors are all discussed in more detail in the sections below.

Table 5-1. Stormwater Control Measure Convention Crosswalk and Selection Factors

	SCM Tier[1]	Chapter Env-Wq 1500 Reference[2]	Applicable EPA Performance Curve[3]	Unit Operation and Process (UOP)[4]	Can SCM Meet NHDES AoT (Env-Wq 1500) Design Criteria if Properly Designed?[5]			
					Pollutant Removal (*1507.03*)	Groundwater Recharge (*1507.04*)	Channel Protection *(1507.05)*	Peak Control *(1507.06)*
Nonstructural Source Controls[6]								
Catch Basin Cleaning	N/A	--	--	Source Control	No	No	No	No
Leaf Litter Pickup	N/A	--	--	Source Control	No	No	No	No
Snow and Ice Management	N/A	--	--	Source Control	No	No	No	No
Street Sweeping	N/A	--	--	Source Control	No	No	No	No
Structural Pre-treatment								
Deep Sump Catch Basin	N/A	1508.16 Deep Sump Catch Basins	--	Pre-treatment	TSS Only	No	No	No
Pre-treatment Swale	N/A	1508.14 Pretreatment Swales	--	Pre-treatment	TSS Only	No	No	No
Flow-Through Devices	N/A	1508.15 Flow-Through Devices	--	Pre-treatment	TSS Only	No	No	No
Sediment Forebay	N/A	1508.12 Sediment Forebays	--	Pre-treatment	TSS Only	No	No	No
Vegetated Filter Strip	N/A	1508.13 Vegetated Filter Strips	--	Pre-treatment	TSS Only	No	No	No
Structural Treatment								
Bioretention System (Infiltrating)	1	1508.07 Infiltration Practices	Infiltration Basin	Infiltration	Yes	Yes	Yes	Yes
"Hybrid" Bioretention System (i.e., Infiltrating Bioretention System with ISR)	1	1508.06 Bioretention System with ISR	Infiltration Basin	Infiltration/ Biological/ Chemical	Yes	Yes	Yes	Yes
Infiltration Basin	1	1508.07 Infiltration Practices	Infiltration Basin	Infiltration	Yes	Yes	Yes	Yes
Infiltration Trench	1	1508.07 Infiltration Practices	Infiltration Trench	Infiltration	Yes	Yes	Yes	Varies

	SCM Tier[1]	Chapter Env-Wq 1500 Reference[2]	Applicable EPA Performance Curve[3]	Unit Operation and Process (UOP)[4]	Can SCM Meet NHDES AoT (Env-Wq 1500) Design Criteria if Properly Designed?[5]			
					Pollutant Removal (*1507.03*)	Groundwater Recharge (*1507.04*)	Channel Protection (*1507.05*)	Peak Control (*1507.06*)
Permeable Pavement (Infiltrating)	1	1508.07 Infiltration Practices	Infiltration Trench	Infiltration	Yes	Yes	Yes	Yes
Subsurface Infiltration Chamber	1	1508.07 Infiltration Practices	Infiltration Trench	Infiltration	Yes	Yes	Yes	Yes
Bioretention System (Filtering)	2	1508.08 Filtering Practices	Biofiltration	Filtering	Yes	No	Yes	Yes
Bioretention with Internal Storage Reservoir (Filtering)	2	1508.06 Bioretention System with ISR	Biofiltration with ISR	Filtering/ Biological/ Chemical	Yes	No	Yes	Yes
Permeable Pavement (Filtering)	2	1508.08 Filtering Practices	Porous Pavement	Filtering	Yes	No	Yes	Yes
Dry Well	2	1508.07 Infiltration Practices	Infiltration Trench	Infiltration	Yes	Yes	No	Varies
Gravel Wetland	2	1508.05 Gravel Wetlands	Gravel Wetland	Biological	Yes	No	Yes	Yes
Impervious Area Disconnection[7]	2	1508.10 Vegetated Buffers	IA Disconnection	IA Disconnection	Yes	Yes	No	Varies
Leaching Catch Basin	2	--	Infiltration Trench	Infiltration	Yes	Yes	No	Varies
Roof Drip Edge (Infiltrating)	2	1508.07 Infiltration Practices	Infiltration Trench	Infiltration	Yes	Yes	No	Varies
Roof Drip Edge (Filtering)	2	1508.08 Filtering Practices	Biofiltration	Filtering	Yes	No	No	Varies
Stormwater Wetland	2	1508.04 Stormwater Wetlands	Gravel Wetland	Biological	Yes	No	Yes	Yes
Tree Box Filter (Infiltrating)	2	1508.07 Infiltration Practices	Infiltration Trench	Infiltration	Yes	Yes	No	Varies
Tree Box Filter (Filtering)	2	1508.08 Filtering Practices	Biofiltration	Filtering	Yes	No	No	Varies
Extended Dry Detention Pond	3	1508.03 Stormwater Ponds	Dry Pond	Settling	Yes	No	Yes	Yes
Flow-Through Treatment Swale	3	1508.09 Treatment Swales	Grass Swale	Settling	Yes	No	Yes	No
Green Roof	3	--	N/A - reduces EIC	EIC	No	No	No	Varies

	SCM Tier[1]	Chapter Env-Wq 1500 Reference[2]	Applicable EPA Performance Curve[3]	Unit Operation and Process (UOP)[4]	Can SCM Meet NHDES AoT (Env-Wq 1500) Design Criteria if Properly Designed?[5]			
					Pollutant Removal (*1507.03*)	Groundwater Recharge (*1507.04*)	Channel Protection (*1507.05*)	Peak Control (*1507.06*)
Rain Barrel/ Cistern (with reuse)	3	--	IA Disconnection (Storage)	IA Disconnection	Yes	No	No	Varies
Sand Filter	3	1508.08 Filtering Practices	Sand Filter	Filtering	Yes	No	No	Varies
Wet Pond	3	1508.03 Stormwater Ponds	Wet Pond	Settling	Yes	No	Yes	Yes
Structural Conveyance								
Conveyance Swale	N/A	1508.20 Conveyance Swales	--	--	No	No	Yes	No
Detention Basin	N/A	1508.18 Detention Basins	--	--	No	No	Yes	Yes
Flow Splitters	N/A	--	--	--	--	--	--	--
Permanent Outlet Protection	N/A	--	--	--	--	--	--	--
Stone Berm Level Spreader	N/A	1508.19 Stone Berm Level Spreaders	--	--	--	--	--	--
Terraced Slopes or Benching	N/A	1508.21 Earthen Terraced Slope or Benching	--	--	--	--	--	--

Notes:

[1]Tier Key:

Tier 1 Can typically be designed to meet the Watershed Protection Standard (WPS) for retention while providing the highest level of pollutant reduction and meeting site design criteria for groundwater recharge and peak runoff control.

Tier 2 Can typically provide a moderate level of pollutant reduction but may not meet all site design criteria.

Tier 3 Typically provide the lowest level of pollutant reduction and may not meet all site design criteria.

N/A May be an integral part of a conveyance system or treatment train but cannot meet site design criteria on their own.

[2] Infiltration and filtering practices as defined by Env-Wq 1500 may both qualify as groundwater recharge practices. For example, a bioretention system with an elevated underdrain or no underdrain (i.e., "**infiltrating**") may be eligible for groundwater recharge, while a bioretention system with a low underdrain (i.e., "**filtering**") would be classified as a filtering practice. See NHDES Alteration of Terrain Env-Wq 1508.17 for groundwater recharge requirements.

[3] Refer to **Chapter 4.2** for discussion of the EPA Performance Curves. The most current EPA PRCs can be found on the UNHSC webpage (https://extension.unh.edu/stormwater-center/ms4-resources) in graphical and tabular format.

[4] Refer to **Chapter 5.3.2** for discussion of UOPs.

[5] See **Appendix A** for more information on how individual SCMs can meet AoT design criteria and additional state-of-the-practice design recommendations. Site-specific limitations may disallow a specific SCM from meeting particular design criteria or regulatory requirements (e.g., if required setback distances cannot be met).

[6] While there are no applicable EPA Performance Curves, some nonstructural source controls have MS4 pollutant removal credit methods. See **Appendix A** for more information on nonstructural source controls.

[7] When designed as a vegetated buffer with an appropriate ratio of impervious to pervious area, Impervious Area Disconnection could be a Tier 1 SCM- i.e., provided that important design criteria are followed such as slope and vegetation density, IA Disconnection could provide 1-inch of groundwater recharge credit for the portion of the site that drains to the buffer based on the ratio of impervious area to pervious area and the Hydrologic Soil Group as follows: HSG A (2:1 maximum); HSG B (1:1 maximum); HSG C (1:2 maximum); HSG D (1:4 maximum). Impervious Area Disconnection also provides peak runoff control for smaller storms by reducing the Runoff Curve Number that is used for TR-55 peak runoff calculations.

5.3.1 Performance Expectations and Design Criteria

Stormwater Control Measures should be designed to reduce stormwater flows and protect water quality by meeting the project-specific objectives and associated criteria (e.g., pollutant removal, groundwater recharge, peak discharge control) determined by using the methodologies described in **Chapter 5.1 and 5.2**. The ability of any SCM to meet design criteria is contingent on careful design, installation, and maintenance. The general ability of each SCM to meet certain Env-Wq 1500 (i.e., AoT) design criteria when properly designed is outlined in **Table 5-1**. Design criteria and associated calculations are discussed in more detail in **Chapter 4**.

To aid in selection, applicable SCMs have been organized into four groups (Tier 1, Tier 2, Tier 3, and N/A) based on their ability to meet key design criteria, with Tier 1 generally providing the greatest stormwater benefits. These groups are solely meant for guidance. Project applicants or proponents must ensure that all regulatory requirements are met. Tiers are provided in **Table 5-1** and within each SCM's Fact Sheet (**Appendix A**).

1 **Tier 1** SCMs can typically be designed to meet the Watershed Protection Standard (WPS) for retention while providing the highest level of pollutant reduction and meeting site design criteria for groundwater recharge and peak runoff control.

2 **Tier 2** SCMs can typically provide a moderate level of pollutant reduction but may not meet all site design criteria.

3 **Tier 3** SCMs typically provide the lowest level of pollutant reduction and may not meet all site design criteria.

N/A **Non-Applicable** SCMs may be an integral part of a conveyance system or treatment train but cannot meet site design criteria on their own.

5.3.2 Stormwater Control Measure Unit Operations and Processes

Stormwater Control Measure selection should consider the primary goals of runoff reduction, pollutant removal, recharge, and peak rate reduction. Treatment Unit Operations and Processes (UOPs) are the basis for SCM performance, and therefore offer the basis for SCM selection to meet design goals. Treatment UOPs can be categorized as summarized by **Table 5-2**. The primary UOPs of each applicable SCM are listed in **Table 5-1**. See Chapter 4 of the Southeast New England Program (SNEP) 2022 New England Stormwater Retrofit Manual for more information on Treatment UOPs.

Table 5-2. SCM Treatment Unit Operations and Processes (UOPs)[1]

UOPs	Primary Pollutant Targeted	Example SCM
Hydrologic		
Evaporation and Transpiration	Runoff volume	Planted basins
Infiltration and Runoff Reduction	Runoff volume and associated pollutants	Infiltration systems
Attenuation	Peak flow	Extended detention basins
Physical		
Flotation	Oil/ grease, litter, vegetation	Catch basins with hoods
Screening	Gross pollutants, vegetation	Catch basin grates
Filtration	Suspended solids, bacteria	Bioretention system (filtering)
Sedimentation	Suspended solids	Wet pond
Enhanced Sedimentation and Swirl Concentration	Heavy solids	Hydrodynamic separator (flow-through device)
Biological		
Plant Metabolism	Dissolved nutrients	Bioretention systems
Nitrification/ Denitrification	Nitrogen	Bioretention with internal storage reservoir (ISR)
Chemical		
Adsorption	Dissolved nutrients	Bioretention with ISR
Precipitation	Dissolved inorganic pollutants	Alum addition to filter media
Coagulation	Colloidal solids	Chemical treatment
Ion Exchange	Heavy metals and phosphorus	Chemical treatment
Other		
Thermal/ Temperature Control	Temperature	Gravel wetland

[1]**Source:** SNEP 2022 New England Stormwater Retrofit Manual as adapted from the Minnesota Stormwater Manual

5.3.3 Pollutant Removal Capabilities

Stormwater Control Measure pollutant removal capabilities are dependent on many variables including proper selection, sizing, installation, proper placement on a site, and proper maintenance. To meet water quality goals, it is often recommended that SCMs are designed to treat the water quality volume (WQV) of stormwater runoff associated with the first 1-inch of rainfall. Treatment of the WQV is not pollutant specific and is a “catchall” for minimizing pollutant discharges of all types. For site specific water quality goals, designers must focus on the pollutant removal capabilities of certain SCMs relative to their tiers and functional UOPs. This applies to sites with requirements related to water quality limitations as defined in the 2017 New Hampshire Small Municipal Separate Storm Sewer (MS4) Permit and coastal communities regulated by the Great Bay Total Nitrogen General Permit (GBTNGP).

Table 5-3 below lists SCMs that are generally effective at providing significant reductions of target pollutants (i.e., TN, TP, TSS, metals) within a reasonably sized footprint. Actual pollutant removal efficiencies may be calculated for SCMs with an applicable EPA Performance Removal Curve based on guidance provided in **Chapter 4.2** to confirm goals are being met.

Table 5-3. General Suitability of SCMs to Treat Common Stormwater Pollutants[1,6]

	Applicable EPA Performance Curve[2]	Pollutant of Concern				
		TN	TP	TSS	Metals[3]	Bacteria[4]
Nonstructural Source Controls[5]						
Catch Basin Cleaning	--	No	No	No	No	No
Leaf Litter Pickup	--	No	No	No	No	No
Snow and Ice Management	--	No	No	No	No	No
Street Sweeping	--	No	No	No	No	No
Structural Treatment						
Bioretention System (Infiltrating)	Infiltration Basin	Yes	Yes	Yes	Yes	Yes
"Hybrid" Bioretention System	Infiltration Basin	Yes	Yes	Yes	Yes	Yes
Infiltration Basin	Infiltration Basin	Yes	Yes	Yes	Yes	Yes
Infiltration Trench	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Permeable Pavement (Infiltrating)	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Subsurface Infiltration Chamber	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Bioretention System (Filtering)	Biofiltration	No	Yes	Yes	Yes	Yes
Bioretention with ISR (Filtering)	Biofiltration with ISR	Yes	Yes	Yes	Yes	Yes
Permeable Pavement (Filtering)	Porous Pavement	Yes	Yes	Yes	Yes	Yes
Dry Well	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Gravel Wetland	Gravel Wetland	Yes	Yes	Yes	Yes	Yes
Impervious Area Disconnection	IA Disconnection	Yes	Yes	Yes	Yes	Yes
Leaching Catch Basin	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Roof Drip Edge (Infiltrating)	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Roof Drip Edge (Filtering)	Biofiltration	No	Yes	Yes	Yes	Yes
Stormwater Wetland	Gravel Wetland	Yes	Yes	Yes	Yes	Yes
Tree Box Filter (Infiltrating)	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Tree Box Filter (Filtering)	Biofiltration	No	Yes	Yes	Yes	Yes
Extended Dry Detention Pond	Dry Pond	No	No	No	Yes	Yes
Flow-Through Treatment Swale	Grass Swale	No	No	Yes	No	No
Green Roof	N/A - reduces EIC	No	No	No	No	No
Rain Barrel/ Cistern (with reuse)	IA Disconnection (Storage)	No	No	No	No	No
Sand Filter	Sand Filter	No	Yes	Yes	Yes	Yes
Wet Pond	Wet Pond	No	Yes	Yes	Yes	No

Notes:

[1] Table Key:

Yes = Likely to provide significant reduction of target pollutant.

No = Unlikely to provide significant reduction of target pollutant.

[2] Refer to **Chapter 4.2** for discussion of the EPA Performance Curves. The most current EPA PRCs can be found on the UNHSC webpage (https://extension.unh.edu/stormwater-center/ms4-resources) in graphical and tabular format.

[3] Metals include zinc, cadmium, lead, aluminum, and iron.

[4] Bacteria includes fecal coliform, *E. coli*, and enterococcus.

[5] Nonstructural Source Controls provide source control. While there are no applicable EPA Performance Curves, some controls have MS4 pollutant removal credit methods. See **Appendix A** for more information on Nonstructural Source Controls.

[6] SCMs were determined to provide a "significant" reduction in target pollutants as follows for this screening level table:

- **TSS (≥ 90%), TP (≥ 60%), TN (≥ 50%), Metals (≥ 80%)**: The EPA Performance Removal Curves were used with a target runoff depth (RD) from impervious area of approximately 1-inch. Infiltrating SCMs assumed an infiltration rate of 0.17 inches per hour. Zinc was used as an indicator of metals removal.
- **Bacteria**: The EPA Performance Removal Curves do not currently provide data on bacteria removal. Summary statistics from the International BMP Database were used to determine if the SCM provided a statistically significant decrease in bacteria.

5.3.4 Land Use Criteria

Most SCMs can be adapted for a particular land use provided that the physical feasibility factors discussed in **Chapter 5.3.5** can be met. However, there are some land uses, specifically high-load areas and water supply areas where the use of certain SCMs (i.e., infiltrating practices, filtering practices, unlined SCMs, etc.) is restricted to avoid potential contamination of water resources. These uses are described below, followed by a summary table of restrictions for SCM implementation in these areas (**Table 5-4**).

High-Load Areas

High-load areas are defined as:

- Any land use or activity in which regulated substances are exposed to rainfall or stormwater runoff, with the exception of road salt applied for deicing of pavement on the site.
- Any land use or activity that typically generates higher concentrations of hydrocarbons, metals or suspended solids than are found in typical stormwater runoff, including but not limited to:
  - Industrial facilities subject to the NPDES Multi-Sector General Permit, not including areas where industrial activities do not occur, such as at office buildings and their associated parking facilities or in drainage areas at the facility where a certification of no exposure pursuant to 40 CFR §122.26(g) will always be possible.
  - Petroleum storage facilities.
  - Petroleum dispensing facilities.
  - Vehicle fueling facilities.
  - Vehicle service, maintenance, and equipment cleaning facilities.
  - Fleet storage areas.
  - Public works storage areas.
  - Road salt facilities.
  - Commercial nurseries.
  - Non-residential facilities with uncoated metal roofs with a slope less than 20 percent.

- Facilities with outdoor storage, loading, or unloading of hazardous substances, regardless of the primary use of the facility.
- Facilities subject to chemical inventory under Section 312 of the Superfund Amendments and Reauthorization Act of 1986 (SARA).

Water Supply Areas

Water supply areas include water supply wells, groundwater protection areas, and water supply intake protection areas as defined below. The locations of water supply wells and groundwater protection areas are available from the NHDES OneStop Data Mapper. Note that users must register with NHDES to obtain permission to use this service.

- **Water Supply Well** – A well, as defined under RSA 482-B:2, that is used as a source of water for human consumption. Types of water supply wells are further defined in Env-Wq 1502 (e.g., community public water supply wells, non-community public water supply wells, private water supply wells).
- **Groundwater Protection Areas** – Wellhead protection areas (WHPAs) for community and non-transient, non-community public water supply wells; and areas of groundwater reclassified as GA1 or classified as GA2 pursuant to RSA 485-C and Env-Dw 901.
- **Water Supply Intake Protection Areas** – Areas within 250 feet from the normal high-water mark of a surface water source or its tributaries within 1/4-mile radius of an intake point, excluding areas outside the watershed of the surface water.

Water supply well setback distance requirements and other restrictions on SCMs installed near water supply resources are summarized by **Table 5-4**.

5.3.5 Physical Feasibility Factors

Physical site constraints such as the infiltration capacity of the soil, depth to bedrock or water table, size of the drainage area, and slope can limit the selection of SCMs. Depending on the physical site constraints, certain SCMs may be too costly to install or may be ineffective. Physical feasibility factors are described below.

Soil Infiltration Capacity

Soil infiltration capacity affects the design of stormwater management systems in several ways:

- In designing a site to minimize the generation of stormwater runoff, it is easier to maintain or mimic the natural hydrology of a site if impervious surfaces are located over areas that naturally have low infiltration capacity. This in turn helps minimize the loss of natural infiltration and/ or preserves higher-capacity soils for the siting of SCMs designed to promote infiltration.
- Soil infiltration capacity must be evaluated to determine whether infiltration practices can be used to remove pollutants from stormwater runoff or recharge stormwater runoff. If soil infiltration rates do not fall within accepted ranges (see below), then the top two feet, or more of soil must be amended to fall within these ranges or other SCMs will be required to provide water quality treatment.

- Soil infiltration capacity is ultimately used in the sizing of applicable infiltration practices. Soils with low infiltration capacity require SCMs with larger surface area than soils with high infiltration capacity.

The applicability of infiltration practices and groundwater recharge are summarized below. See **Chapter 4.5** for discussion on how to select a design infiltration rate.

Infiltration Practices, Unlined Filtering Practices, and Groundwater Recharge Practices should not direct stormwater into the following areas:

- Groundwater protection areas where the stormwater comes from a high-load area (as defined in **Chapter 5.3.4**).
- Areas that have contaminants in groundwater above the ambient groundwater quality standards established in Env-Or 603.03 or into soil above site-specific soil standards developed pursuant to Env-Or 600.
- Areas where the stormwater comes from areas that have contaminants in soil above site-specific soil standards developed pursuant to Env-Or 600.
- Areas where the stormwater comes from areas with underground storage tanks regulated under RSA 146-C or aboveground storage tanks regulated under RSA 146-A, where gasoline is dispensed or otherwise transferred to vehicles.
- Areas with slopes greater than 15 percent, unless the system has been carefully engineered to prevent seepage forces from causing instability.
- Areas where the infiltration rate is less than 0.5 inches per hour. (**Note**: If the project is not subject to AoT requirements (or if the project is subject to AoT requirements with no recharge credit taken), a carefully designed, elevated underdrain may enhance infiltration for rates up to 0.25 inches per hour. See the SNEP 2022 New England Stormwater Retrofit Manual for more information on elevated underdrains as referenced in **Chapter 5.4**.)

Table 5-4. Summary of SCM Restrictions Associated with High-Load and Protected Resources[1,2]

Protected Resources	Stormwater from High-Load Areas	Stormwater From Non High-Load Areas
All Areas	• No filtering or infiltration practices allowed from gasoline dispensing areas under state regulations RSA 146-A or RSA 146-C. • Use of unlined detention ponds or unlined swales prohibited. • Source control plan required.	• Pre-treatment is required prior to all filtering or infiltration practices. • Infiltration practices must have 3 feet of separation from the bottom of the practice to the seasonal high-water table (SHWT). • Filtering practices must have an impermeable liner or 1-foot of separation from the bottom of the filter course to the SHWT.
All Areas	• No infiltration or unlined filtering practices within areas identified by NHDES with contaminated soils or groundwater, as defined under Env-Or 600.	
Water Supply Wells	• Minimum setbacks between stormwater discharge and water supply wells (see Env-Wq 1508.02).	
Water Supply Wells	• No exemption to minimum setbacks.	• Exemption to minimum setbacks – if the stormwater management system receives stormwater runoff from less than 0.5 acre.

Groundwater Protection Areas	• Infiltration practices prohibited (RSA 485-C).
	• Unlined filtering practices prohibited.
		• Infiltration practices must have 4 feet of separation from the SHWT.
		• Filtering practice should have:
		  ○ Impermeable liner, or
		  ○ 24-inch depth of filter course, and
		  ○ At least 1-foot of separation from the filter course material to bedrock and SHWT.

Water Supply Intake Protection Areas (WSIPA)	• Infiltration practices must have 4 feet of separation from SHWT.
	• Filtering practice should have:
	  ○ Impermeable liner, or
	  ○ 24-inch depth of filter course, and
	  ○ 1-foot of separation from the bottom of the filter course material to bedrock and SHWT.
	• Minimum 100-foot setback between stormwater discharge and the WSIPA.	

WSIPA	• Shut-off mechanism required where bulk oil or hazardous material is transferred.	• Exemption to 100-foot setback – if the stormwater management system receives stormwater runoff from less than 0.5 acre.

Notes:

[1] High-load areas are defined in **Chapter 5.3.4**

[2] "Source Control Plans" are designed to minimize the volume of stormwater coming into contact with regulated substances. **Chapter 5.5.4** provides further discussion of the preparation of the Source Control Plan to specify necessary structural controls and/ or operational practices to minimize contact between stormwater and regulated substances.

Water Table

The depth to the SHWT will influence the selection of SCM practices to manage stormwater runoff. High groundwater may be appropriate for some SCMs where a permanent pool is required because groundwater interception will aid in maintaining such a pool. Other SCMs, such as infiltration structures, may not be appropriate if the separation between the bottom of the infiltration device and groundwater table is not sufficient to allow for water to drain from the device and adequately remove pollutants from stormwater runoff. See SCM specific design criteria in **Appendix A** for depth to SHWT requirements.

Drainage Area

Large drainage areas typically result in a greater volume and velocity of stormwater runoff than small drainage areas. Some SCMs can be sized to handle the contributing volume of stormwater runoff from small and large drainage areas. However, some SCMs provide more efficient treatment and are more appropriate for small drainage areas. Also, other SCMs (such as treatment ponds or wetlands) rely on larger drainage areas to help sustain permanent pools included in their design.

Slope

It is important to consider slope steepness in site design. The steeper the slope, the faster the water flows. Sites with steep slopes are more susceptible to erosion and the generation of sediment loads due to the increased velocity of the stormwater. In addition, storage of ponded stormwater on or adjacent to steep slopes may become a safety issue with groundwater breakthrough or overflows during large storm events. In selecting a SCM, the following should be considered:

- The slope at and adjacent to the treatment practice.
- The slope of the contributing drainage area.
- The slope of the flow path.

5.3.6 Watershed Resource Factors

It is important to look not only at the impacts the development will have at a site, but also how downstream resources may be impacted by development activities. **Table 5-5** summarizes the downstream water resources that should be considered when selecting SCMs. Each of these resources is discussed further below.

Table 5-5. Watershed Resource Criteria[1,2]

Category	Description
Sensitive Receiving Waters	Select SCMs based on sensitivities of receiving waters such as impaired waters, outstanding resources waters (ORWs), cold water fisheries, prime wetlands, and wetlands that have highly rated functions and values. For example, if cold water fisheries are present, select SCMs that will reduce thermal impacts and sediment transport (see discussion of UOPs in **Chapter 5.3.2**).
Water Supplies: Aquifers	Maximize infiltration following setbacks.
Surface Water Supplies and Lakes and Ponds	Select SCMs with high phosphorus, nitrogen, and sediment removal to reduce the frequency and severity of algal blooms and to mitigate cultural eutrophication. Select SCMs with high bacteria removal when waters are used for recreation.
Estuary and Coastal Areas	Select SCMs with high nitrogen and bacteria removal to reduce closure of swimming beaches and shellfish beds.
Designated Rivers	Select SCMs that will protect the unique characteristics and values of each designated river.

Notes:

[1] See **Table 5-3** for SCMs that may be effective at removing certain pollutants.

[2] Refer to NHDES online mapping tools, such as the Aquatic Restoration Mapper and Surface Water Quality Assessment Viewer, for locations of watershed resources.

Sensitive Receiving Waters

Impaired waters, outstanding resources waters (ORWs), cold water fisheries, prime wetlands, and wetlands that have highly rated functions and values are a few examples of receiving waters that may be more sensitive to development activities and could require additional measures to protect or restore their unique properties. Local regulations should be referenced to determine specific pollutants of concern and targets for impaired waters. Toxic pollutants such as metals, soluble organic compounds, and bacteria are of particular concern for waters that could serve as future water supply sources. Rivers that support cold water fisheries are very sensitive to increases in water temperature, which are often caused by stormwater running over warmer impervious surfaces that lack sufficient buffers to provide shade. Sediment transport from impervious surfaces or eroded areas can impact spawning beds and reduce available habitat. Downstream flooding, channel erosion, and sedimentation are important considerations.

Water Supplies: Aquifers and Surface Waters

Over 60 percent of New Hampshire residents rely on groundwater for their drinking water from either private wells or public water supply wells. Because of this, it is important to maintain adequate groundwater recharge rates and to avoid groundwater contamination to maintain adequate, high quality groundwater supplies for drinking water, as well as to maintain dry weather base flows in streams and rivers. Additional recharge may also help mitigate degradation of urban streams (i.e., urban stream

syndrome). As indicated in **Chapter 4.4**, a target recharge depth (i.e., retention) of up to 1-inch is recommended to help accomplish these goals.

The remaining residents in the state are served by public water supplies relying on surface water reservoirs. Surface water supplies are particularly susceptible to contamination by bacteria and other common stormwater pollutants such as nutrients (i.e., total nitrogen and total phosphorus), total suspended solids, metals, and chloride. Because of the potential for groundwater and surface water contamination of drinking water supplies, the NHDES has established SCM setback requirements (see discussion under "Land Use Criteria" **Chapter 5.3.4**). Stormwater Control Measure setback requirements are summarized in **Table 5-4** in relation to protected resources and high-load areas.

Lakes and Ponds

Lakes, ponds, and other freshwater systems are more sensitive to phosphorus loading than saltwater systems as phosphorus is typically the limiting nutrient in freshwater systems. Excess phosphorus in a freshwater system, such as a lake or a pond, can result in algal blooms and an increased rate of eutrophication. Because of this, development activities near lakes and ponds, as well as their tributaries, should include site design techniques and SCMs for sediment and nutrient removal.

Estuary and Coastal Areas

Estuaries and other coastal areas are more sensitive to nitrogen (versus phosphorus) loading compared to freshwater systems as nitrogen is typically the limiting nutrient in saltwater systems. The other major pollutant of concern in coastal waters is bacteria. New Hampshire's coastal beaches host nearly half a million visitors each year. New Hampshire coastal waters are also home to a variety of shellfish including clams and oysters, including commercial growing operations for public consumption. Public swimming beaches and shellfish beds are extremely sensitive to high bacteria levels. Significant storm and runoff events and excessive loading can carry bacteria and result in closures of swimming beaches and shellfish beds.

Designated Rivers

Designated rivers are recognized by the state for their important natural resources, historical significance, and their contribution to the river corridor community's quality of life. For this reason, each designated river is managed and protected in accordance with RSA 483. Construction activities within a quarter mile of designated rivers, including tributaries within that corridor, should consider the unique characteristics and values of each river as outlined in the specific river corridor management plan. For more information on designated rivers, including links to river corridor management plans, see the NHDES Rivers Management and Protection webpage.

5.3.7 Operation and Maintenance Factors

Regular Inspection and Maintenance

Stormwater Controls Measures should be designed for future maintenance activities. Regular inspections and maintenance are essential for long-term effectiveness of SCMs and to minimize costly repair and replacement. Nutrients, sediment, trash, and other debris can accumulate in SCMs and need to be removed periodically. If not properly maintained, the SCM will not operate as designed and will not provide effective treatment of stormwater runoff. This jeopardizes water quality and may violate permit

conditions. In addition, some permits (e.g., MS4 Permits) and/ or local regulations may require annual reporting on SCM inspections and associated maintenance actions.

All SCMs require routine inspection and maintenance, however, the frequency and difficulty of maintenance activities and the equipment needed varies. **Appendix A** summarizes the specific maintenance activities required by each SCM. Inspectors and those overseeing or performing maintenance should be well trained and thoroughly familiar with the as-built plans and Inspection and Maintenance (I&M) Plans for each SCM. Inspection and Maintenance Plans should be prepared by the designer who is familiar with the as-built plans.

Pre-treatment

Pre-treatment is intended to improve operation and maintenance. Pre-treatment SCMs, such as sediment forebays, can extend the life and function of downstream SCMs by reducing the amount of sediment accumulation in the primary treatment device; however, pre-treatment SCMs also require maintenance. Inspections and maintenance for pre-treatment SCMs may need to be more frequent than the primary SCM. For more information on pre-treatment, refer to Chapter 5 of the SNEP 2022 New England Stormwater Retrofit Manual.

Vegetated Stormwater Control Measures

Rain gardens, tree box filters, gravel wetlands and any SCMs with vegetation require special care when the vegetation is first established. Periodic watering may be necessary in times of drought. Drought or salt tolerant species may need to be specified when selecting vegetated SCMs, depending on their location.

Likelihood of Maintenance Being Performed

Even though requirements may be described in deeds, neighborhood association documents and performance bonds, it is possible that required SCM maintenance activities will be neglected. The chance of this happening increases when there is no oversight by a regulatory authority. An example would be a small, New Hampshire, non-MS4 community without a code enforcement officer. For these cases, SCMs without any important routine maintenance and those that would not be costly to repair upon failure should be chosen. It may also make sense to have design features that draw attention to the unit prior to failure, such as installing pre-treatment SCMs in series.

Accessibility for Inspections and Maintenance

It is important to provide adequate access for all necessary inspections, monitoring and maintenance when designing or selecting SCMs. Below ground structures and sensitive SCMs (see below) require special design features including utility access holes, cleanouts, water level monitoring wells, etc. Infiltration chambers may also need groundwater (quality) monitoring wells to comply with Underground Injection Control (UIC) permit requirements. Difficult access situations, including those with safety concerns, must also be considered. These include SCMs in close proximity to buildings, high traffic areas, vegetation in stormwater wetlands/ ponds and green roofs. Oil/ water separation SCMs must also address confined space entry concerns.

Sensitive Stormwater Control Measures

Portions of SCMs can be susceptible to damage during inspections and maintenance due to environmental factors. Liners, armor stone, and steep side slopes of basins can be damaged when

oversized vehicles are used to remove accumulated sediment. Sediment removal activities can also damage other SCM configurations, especially when vehicles such as backhoes are used. Loss of infiltration capacity is an important concern. Hand removal of sediment or use of specialized vacuum equipment may be the best option. In addition to human impacts (vehicles and vandalism), environmental factors such as damage from excessive hot or cold temperatures (drought); salt damage associated with stormwater runoff or through air deposition (corrosion); flooding and erosion damage; wildlife damage (animal burrows, damage to or loss of vegetation); should all be considered when designing or specifying SCMs to minimize maintenance requirements.

5.3.8 Community and Environmental Factors

It is important to think about how a SCM will fit into the community. Some community and environmental concerns that should be addressed in the selection and design of the SCM include:

- **Safety** – Does the SCM pose a safety risk? Knowledge of the surrounding community is needed to determine whether certain safety features need to be incorporated into the design and/ or whether some types of SCMs should be avoided altogether. For example, deep water, as in wet ponds, may be unsuitable for a residential area with small children or may require fencing to prevent access. Also, the proximity of a SCM to heavily trafficked areas or high speed roadways could pose safety issues to traffic, requiring guardrails or special maintenance access.
- **Aesthetics** – Some SCMs are more attractive than others and can be designed to blend in with the existing or proposed landscape. The surrounding land use and owners, abutters, residents, customers, and visitors should be considered when selecting and designing a SCM. For example, will the SCM be visible? Who will see the SCM?
- **Habitat** – Some SCMs, such as stormwater ponds and wetlands, can provide wildlife and wetland habitat. The need for this habitat should be considered when selecting and designing the SCM. Other SCMs are not wildlife friendly and may be prohibited in certain situations (e.g., deep sump catch basins with certain characteristics). Selection and designs should include special considerations for sites near habitats of sensitive or endangered species. To ensure wildlife friendly designs, coordination with the New Hampshire Fish and Game Department and/ or the U.S. Fish and Wildlife Services may be necessary.
- **Compatibility with Municipal Maintenance Programs** – Who will be responsible for SCM maintenance? What are the SCM maintenance requirements? Consider community needs when selecting and designing SCMs. If the community will be maintaining the SCM, make sure it is compatible with the community's available maintenance equipment capabilities and desired maintenance schedule. Note, maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- **Mosquito Control** – Will the SCM have permanent or long-term standing water (greater than 72 hours)? Community concerns about mosquito breeding and the diseases carried by mosquitoes should be considered when selecting and designing SCMs. Stormwater Control Measures that hold standing water for more than 72 hours may create breeding grounds for mosquitoes. Consider whether there is other standing water nearby and the surrounding land uses when deciding whether to use wet ponds, wetlands, or other SCMs with permanent standing water. When using SCMs that will have permanent pools, consider designs that maximize habitat for natural predators of mosquitoes.
- **Contamination Concerns** – Will the SCM be located near potential sources of surface or groundwater contamination? Consideration should be given to potential ramifications of designing SCMs near to or downgradient from contaminated sites that contain hazardous materials, store

harmful substances, or are a potential source of emerging contaminants discussed in **Chapter 2.1.2** (e.g., PFAS, microplastics, etc.). Stormwater Control Measures designed near contaminated sites should avoid the use of infiltration, should minimize contact between pollutant sources and stormwater runoff, and should be designed to meet mandated setbacks and other regulatory requirements.

5.4 Stormwater Retrofits

Stormwater retrofits are commonly defined as the addition of SCMs to a developed site. Retrofits may be designed to improve water quality, reduce peak runoff rates, increase recharge, or reduce or eliminate combined sewer overflows (CSO). Many existing SCMs or developments can be effectively retrofitted depending on site conditions and water quality goals. Retrofitting existing SCMs can reduce the adverse stormwater quantity and quality impacts caused by land development. It also allows for the opportunity to correct site nuisances, maintenance problems, and aesthetic concerns. All regulatory requirements or associated design criteria may not apply to a particular retrofit project. When certain regulatory requirements do not apply to a retrofit project, designers are encouraged to refer to the SNEP 2022 New England Stormwater Retrofit Manual (see below) for recommended retrofit design criteria.

Situations where retrofits are encouraged include:

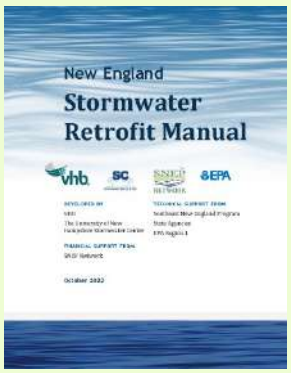
- Implementing SCMs as part of maintenance and planned construction.
- Demonstrating stormwater treatment to the maximum extent practicable (MEP).
- Implementing SCMs to meet Total Maximum Daily Load (TMDL) targets and other water quality permits.
- Implementing SCMs to meet the State of New Hampshire antidegradation requirements.
- Implementing SCMs to achieve water quality goal(s) established within watershed-based plans.
- Enhancing existing structural SCMs for improved pollutant removal efficiencies.

Challenges to stormwater retrofits include site limitations for the type, size, and location of potential SCMs. However, there are cost-effective and creative solutions available for even the most difficult sites.

The SNEP 2022 New England Stormwater Retrofit Manual

The SNEP 2022 New England Stormwater Retrofit Manual provides a framework to identifying and implementing retrofit opportunities, discusses the quantification of SCM stormwater benefits including those of catchment-scale controls, and provides design guidance for retrofit SCM variations.

For more information on stormwater retrofits, reference the SNEP 2022 New England Stormwater Retrofit Manual.



5.5 Operation, Maintenance, Inspection, and Source Control

The operation and maintenance of a stormwater management system and its individual components is as critical to system performance as the design. Operation and Maintenance (O&M) needs to be considered during the design phase. Implementation of source controls is also an important aspect of the operation of a site to prevent contaminants from mixing with stormwater runoff, thus minimizing the pollutants that need to be treated by the stormwater management system. This section addresses the operation and maintenance considerations of stormwater design, the preparation of an Inspection and Maintenance (I&M) Manual, and the preparation of a Source Control Plan.

The design process must give serious consideration to maintenance issues to develop stormwater management facilities with realistic maintenance expectations. Proper operation and maintenance will ensure that the stormwater system and individual SCMs will remain effective at removing pollutants as designed and meet New Hampshire's water quality objectives (see **Appendix A** for specific maintenance requirements for individual SCMs). Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7. Proper maintenance will:

- Maintain the volume of stormwater treated over the long term.
- Sustain the pollutant removal efficiency of the SCM.
- Reduce the risk of re-suspending sediment and other pollutants captured by the SCM.
- Prevent structural deterioration of the SCM and minimize the need for expensive repairs.
- Decrease the potential for failure of the SCM.

Without proper maintenance, SCMs are likely to become functionally impaired or to fail, providing reduced or no treatment of stormwater. Design must consider how SCMs and components will be accessed for inspection and maintenance, what activities are needed to maintain each SCM and component, the frequency these activities must be performed, and who will be responsible for inspection and maintenance. The location and sizing of SCMs must account for these considerations. The site design may also require development of easements, deed restrictions, and/or maintenance agreements to provide access to perform necessary maintenance and repairs.

5.5.1 Design and Construction Guidelines

The following design and construction guidelines address anticipated maintenance practices:

- **Provide Pre-treatment**: Pre-treatment is generally required for each SCM. Pre-treatment is a critical component for maintaining the life and function of downstream SCMs.
- **Provide Sediment Loading/ Removal Schedule**: Pre-treatment SCMs should be designed to accommodate a minimum of one year's worth of sediment and debris. The estimated annual sediment accumulation should be documented in the project design calculations. Sediment loadings from both pervious and impervious areas must be considered.

- For pervious areas, the Revised Universal Soil Loss Equation (RUSLE) recommends calculating sediment generated from the contributing watershed.[15]
- For roadways and parking areas, sand deposits from winter storm applications should be accounted for in the design of the pre-treatment system. This estimate should be based on local practices for the application of sand for ice management (traction). Absent such information, it is recommended to use a rate of 500 pounds per acre for sanding of parking areas and access drives, a sand density of 90 pounds per cubic foot and an assumed minimum frequency of ten sand applications per year. Sanding rates and numbers of storms may need to be adjusted based on specific application rates in a community.

- **Make Maintenance Needs Apparent**: For some SCM designs (such as ponded forebays, surface ponds or detention basins, and channels), the need for maintenance can be readily apparent from casual observation. Other SCMs, particularly underground structures, require disciplined inspection to monitor the conditions that warrant cleaning or that signal potential failure. The I&M Manual should clearly define the inspection frequency and the maintenance or failure indicators, so that the party responsible for maintenance is alerted to conditions warranting cleaning and repair. This is particularly true for off-line SCMs (see callout box below for more information on “off-line” SCMs), where bypass systems can automatically carry flows around the devices if they are in “failure” condition.
- **Provide Sediment Marker**: For SCMs that accumulate sediment, particularly pre-treatment sediment forebays, a sediment depth marker should be provided and properly placed to enable determination of an accurate and consistent depth of sediment when inspections are performed.
- **Design for Anticipated Pollutants**: Pre-treatment SCMs must be designed to capture anticipated pollutants, such as oil and grease, as well as floating trash. Design should provide for access to remove these materials. The I&M Manual should include directions for the use of appropriate means for removing and disposing of petroleum hydrocarbons and legal disposal of the waste.
- **Design for Accessibility**: All devices must be designed and located to be easily accessible for inspection and for the necessary equipment for maintenance. Formal access must be provided, and may require easements. Security devices (e.g., fencing) must also be designed to allow access for maintenance.

[15] U.S. Department of Agriculture. Revised Universal Soil Loss Equation (RUSLE). Available at: https://www.ars.usda.gov/southeast-area/oxford-ms/national-sedimentation-laboratory/watershed-physical-processes-research/docs/revised-universal-soil-loss-equation-rusle-welcome-to-rusle-1-and-rusle-2/

"In-line" versus "Off-line" Drainage Systems

- "In-line" or "online" drainage systems: The entire stormwater flow is conveyed to the SCM. The SCM must be designed to accommodate peak discharge rates.
- "Off-line" drainage systems: Only a portion of stormwater flow is conveyed to the SCM for treatment or recharge while excess flows are bypassed.

Traditionally, the design of stormwater drainage systems has been focused on the collection and conveyance of stormwater runoff offsite as rapidly and as efficiently as possible. In contrast, LID drainage designs focus on conforming as much as possible to natural drainage patterns and discharging to natural drainage paths or landscape features within the watershed. Catch basins and stormwater drainage networks are efficient flow conveyance structures, yet when water quality treatment and runoff volume reduction are the goals of a stormwater management plan, this may not be an advantage. Where possible, runoff should be allowed to flow across pervious surfaces or through grass channels and buffers. When it is necessary to design for a curb and gutter drainage network, using an off-line drainage configuration of deep sump catch basins is the most effective for coarse solids removal.

5.5.2 Inspection and Maintenance (I&M) Manual

The AoT regulations (Env-Wq 1507.07) require the development of an Inspection and Maintenance (I&M) Manual for stormwater management systems which identities responsible parties for implementing the required maintenance activities, details the activities that are necessary, and documents the implementation of the activities. A formal operation and maintenance plan for a stormwater management system will assist the party responsible for maintenance in understanding how the system functions and the maintenance activities needed to maintain that function. Such a plan clearly identifies inspection activities, schedules, record keeping requirements, and contingency measures for ensuring the long-term integrity of the stormwater management system. Typically, such a plan identifies each SCM used on the site, its associated drainage area, and its specific maintenance activities and schedules.

It is necessary to develop long-term maintenance of SCMs, and stipulate the establishment of a mechanism to provide for ongoing inspections and maintenance. Such a mechanism includes the preparation of an I&M Manual. The I&M Manual must include, at a minimum, the following:

- The names of the responsible parties who will implement the required reporting, inspection, and maintenance activities identified in the I&M Manual.
- The frequency of inspections.
- An inspection checklist to be used during each inspection.
- A requirement to photograph each SCM that is subject to the I&M requirement at each inspection of that SCM.
- An inspection and maintenance log to document each inspection and maintenance activity.
- A deicing log to track the amount and type of deicing materials applied to the site.
- A plan or figure showing the locations of all the SCMs described in the I&M Manual including designated snow storage areas that do no conflict with SCM locations on the site.
- Actions to be taken if any invasive species begin to grow in the SCMs and proper disposal of materials.

The responsible parties named in the I&M Manual are responsible for initiating I&M activities and ensuring the long-term effectiveness of the stormwater management system. All record keeping required by the I&M Manual shall be maintained by the responsible parties, and any transfer of responsibility for I&M activities or transfer in ownership shall be documented to NHDES in writing. If ownership of the property is transferred, the new property owner(s) becomes the responsible party(ies). If the property is a residential development for which a homeowners' association (HOA) will be established, the HOA becomes the responsible party. If the HOA is dissolved, the individual homeowners have joint and several liability for all I&M obligations outlined in the I&M Manual.

Common questions to consider when selecting SCMs and developing the I&M Manual:

- Does the responsible party have the authority, as well as the technical and financial resources, to carry out the I&M program?
- Does the owner/ responsible party understand how the system functions?
- Does the owner/ responsible party understand the maintenance requirements?
- Is there a legal mechanism needed and in-place for a municipality to perform corrective maintenance and back-charge the owner/ responsible party?
- Can inspections be easily performed, or can the facility be easily observed on a routine basis, so that the responsible party is readily aware of conditions requiring attention?
- Is equipment required for maintenance activity, and if so, is there adequate access?
- Are easements needed for access? Are easements needed for the public to obtain access for corrective action, even if the facility's primary maintenance is under private management?
- Are maintenance schedules adequate, or is the frequency of maintenance too high to be realistic?
- Can cleaning or other routine maintenance be conducted without requiring major repair or replacement of the SCM? For example, removal of sediment from an infiltration trench may require reconstructing the trench.
- Have provisions been considered for the proper disposal of waste materials from maintenance activities, including compliance with local, state, and federal regulations?
- Are the proposed maintenance activities consistent with regulatory requirements and obligations? Note, maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.

5.5.3 Inspection and Maintenance Resources

There are many inspection and maintenance resources available in the literature. Some commonly used resources are listed below.

- UNH Stormwater Center Operation and Maintenance guidance and checklists: https://www.unh.edu/unhsc/maintenance
- Implementing a Stormwater BMP Inspection & Maintenance Program A Guidance Manual for New Hampshire Municipalities— https://www.nhms4.des.nh.gov/mcm-and-appendices/mcm-5
- EPA Region 1 compiled guidance, standard operating procedures (SOPs) and templates— https://www.epa.gov/npdes-permits/stormwater-tools-new-england
- Minnesota Stormwater Manual: Operation and maintenance of green stormwater infrastructure best management practices— https://stormwater.pca.state.mn.us/index.php?title=Main_Page

5.5.4 Source Control Plan

Source control consists of structural and nonstructural SCMs to prevent pollutants from coming into contact with stormwater runoff. Project planning and design should consider measures to minimize or prevent the release of pollutants so they are not available for mobilization by stormwater runoff. Source control measures typically address the management of industrial materials and other substances that could be sources of pollutants at a site. This could include management of lawn care and landscaping activities, particularly with respect to the storage and use of fertilizers, herbicides, and pesticides; pavement sweeping and cleaning; and snow and ice management.

Project I&M Plans should include provisions for source control measures appropriate to the type and scale of the project. Alternatively, for projects with “high-load areas” or other projects posing potential greater risk for pollutant exposure to stormwater, a separate source control plan may be warranted. The AoT regulations require submittal of a source control plan for any high-load area and any commercial parking area with over 1,000 trip ends per day (as determined with reference to Trip Generation, published by Institute of Transportation Engineers, Washington, D.C., 7th Edition, 2003) (Env-Wq 1504.08).

The Source Control Plan should be developed to minimize the volume of stormwater coming into contact with regulated substances, and segregate relatively clean stormwater from stormwater with a potentially higher concentration of pollutants. The plan should address the following:

- An overview of how source controls, including structural or operational management practices, will prevent or minimize the number of regulated substances from mixing with clean stormwater.
- A plan showing the locations of snow storage areas.
- A list of regulated substances expected to be present on the site in quantities of 5 gallons or more.
- The location(s) of groundwater protection areas, if any, within 1,000 feet of the site perimeter.
- A plan depicting the drainage area with exposed regulated substances and the locations of stormwater practices or discharge points serving those areas.
- The locations and containment methods to be employed for storage of regulated substances.

- A plan depicting the locations where regulated substances will be handled, including the storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, finished product, by-product, or waste product.
- A description of spill prevention and control or containment measures or formal Spill Prevention, Control, and Countermeasures (SPCC) Plan.
- A list of responsible parties.
- A list of the phone numbers and mailing addresses of the owner of the facility.
- A training program to familiarize employees with the plan and to ensure its implementation.
- Provision for regular internal review, evaluation, and periodic update of the plan.

The owner of the site for which a Source Control Plan is required shall update the plan as necessary and certify every three years that the site is in compliance by completing and submitting a Source Control Plan Certification Form. For additional guidance, see NHDES Developing a Source Control Plan for High-Load Areas fact sheet.

6 Erosion and Sediment Control

6.1 Overview

Erosion and Sediment Control (E&SC) measures must be implemented on construction sites to prevent sediment deposition in New Hampshire's wetlands and waterways. An effective plan for the implementation of E&SC measures is key to minimizing erosion and subsequent pollution by sediments.

E&SC planning is done primarily through the development and implementation of planning documents, such as an Erosion and Sediment Control (E&SC) Plan or a Stormwater Pollution Prevention Plan (SWPPP). An E&SC Plan is a requirement of the NH Alteration of Terrain Permit (AoT), and a SWPPP is a requirement of the National Pollutant Discharge Elimination System (NPDES) Permit.

This Chapter provides guidance on:

- Principles of E&SC.
- E&SC planning, including the preparation of required plans.
- Selection of E&SC measures.
- Inspection and maintenance of E&SC measures.

6.2 Principles of Erosion and Sediment Control

Implementation of "common sense" practices can reduce a construction site's vulnerability to erosion and off-site discharge of sediment. It is easier, less expensive, and less environmentally damaging to prevent or reduce soil erosion than it is to control its transport, deposition, and subsequent cleanup. The following general E&SC principles may be used to guide site planning.

- **Provide simple, well-documented erosion and sediment control plans.**
    - The field documents used by the contractor should clearly identify the E&SC measures to be used, where they will be located, how they will be constructed, and how they must be maintained.
    - Details, limits, locations, and dimensions for erosion and sediment control measures should be included.
    - The E&SC Plan and/ or Stormwater Pollution Prevention Plan (SWPPP) should be readily accessible at the site to both the contractor and regulatory personnel performing inspections – see **Chapter 6.3** for more information.
    - Pre-construction meetings should be held to review the proposed control measures, address sensitive resource areas, and clearly identify responsible parties for implementing, maintaining, inspecting, and modifying E&SC measures, and for responding to contingency events.

- **Plan construction activities to account for sensitive site conditions.**
  - Protect and maximize existing native vegetation and natural forest floor.
  - Clearly flag areas to be protected in the field and provide construction barriers to prevent construction traffic outside of designated work areas.
  - Diffuse, disperse, and divert on-site stormwater runoff rather than concentrate it into channels.
  - Divert off-site stormwater runoff away from the immediate construction area to reduce the threat of erosion, to prevent off-site water from being contaminated, and reduce the volume that needs to be treated on the site.
  - Install additional E&SC measures when working adjacent to environmentally sensitive areas. In areas with particularly vulnerable or irreplaceable resources, back-up protection for primary E&SC measures should be provided. The following are examples of site and/ or construction characteristics that would warrant such additional protection:
    - Construction or soil disturbance within the watershed of a waterbody that is vulnerable to the addition of phosphorous, within 100 feet of an intermittent stream or wetland, or within 250 feet of a lake, pond, river, or perennial stream (shoreland protection area).
    - Construction that requires crossing a stream with a culvert or bridge.
    - Channel or slope construction on channels greater than 8 percent and slopes steeper than 4h:1v.
    - Channel or slope construction from September 15 to April 15, when no vegetation can grow.
    - Moderate (soil erodibility factor K greater than 0.25) to highly (K greater than 0.4) erodible soils that will be exposed for longer than one month. **Note**: Soil erodibility factor K is a component of the Revised Universal Soil Loss Equation (RUSLE) described in **Chapter 5.5.1**.

- **Minimize the area of exposed soil at one time.**
  - Plan to build large projects in smaller phases, rather than all at once. Do not clear-cut an entire project site at one time. Phasing needs to be done according to the size of the contractor's operation and ability to move material and stabilize exposed areas. Additionally, the phase sizes may have to be adjusted seasonally since operations may slow down or stabilization may take longer in colder months.
  - Provide temporary stabilization on disturbed soil until final grade and stabilization is reached (stabilization is defined in Appendix B Construction Phasing fact sheet).
  - Immediately seed and mulch areas ready for revegetation. Mulch should be anchored to protect the soil until vegetation is established.
  - Implement special measures during construction in the late fall, winter, and early spring months. Of particular concern are winter thaws and the early springtime, when normal rainfall combines with snowmelt to produce increased amounts of stormwater runoff. When subsoil material is frozen, stormwater runoff can easily mobilize the exposed layer of saturated surface soil.

- **Provide for stability of constructed channels/ swales.**
  - The project engineer must design new channels/ swales for stability and capacity. Channel/ swale linings must be designed to withstand anticipated velocities.
  - The capacity and stability of constructed channels/ swales are designed based upon the final stabilized condition. Partially constructed swales are vulnerable to erosion and extreme damages. Constructed channels/ swales should be stabilized as soon as possible after their installation. Temporary stabilization measures (such as erosion control mats, check dams, or other measures) should be planned where channels will be vegetated to provide for erosion protection when grass is becoming established.
- **Protect cut and fill slopes caused by construction activities.**
  - Construction activities must consider the structural stability of cut and fill slopes. Terracing/ benching or other SCMs may be required to maintain slope stability and to adequately handle anticipated stormwater runoff. A geotechnical evaluation by a Professional Engineer with appropriate expertise may be required to identify and design proper SCMs.
  - Plan for control of groundwater seepage on cut slopes, where encountered.
  - Intercept stormwater runoff from areas above newly exposed slopes and divert and disperse it to a stable area.
  - Convey the water down the slope in a stabilized conveyance SCM or slope-drain.
  - Stabilize slopes as soon as possible following grading activity.
  - Increased inspection frequency may be required for problematic areas such as steep slopes.
- **Protect storm drain inlets and culverts from sediment.**
  - Provide construction sequencing, erosion controls, sediment traps, and other measures to keep sediment-laden water away from inlets.
  - Install sediment barriers, sediment traps or other inlet protection controls at inlets to prevent sediment from entering downstream drainage systems or culverts.
  - Clean catch basins, drainage pipes, and culverts if significant sediment is deposited.
- **Avoid tracking mud into roadways.**
  - Install and maintain stone construction exits at the intersection of the construction access and any paved road.
  - Provide tire washing devices for vehicles before they leave the construction site.
  - Frequently sweep and remove all construction related debris and tracked soil from all adjacent paved roadways.
- **Use wildlife friendly erosion and sedimentation techniques in accordance with U.S. Fish and Wildlife Guidelines.**
  - Avoid:
    - Use of plastic netting of any type, including “photodegradable” netting.
    - Leaving E&SC measures in place beyond the immediate need for erosion control.

    - Silt fences reinforced with metal mesh or plastic mesh.
  - Instead, try:
    - Use of natural fiber netting or no netting. If netting is used, it should be loose weave, non-welded, movable jointed netting (leno or gauze).
    - 100 percent biodegradable materials.
    - Rectangle (elongated) mesh is better than square.
    - Stake erosion control blankets and mats to ground so all edges are secured with wooden stakes.
    - Bury edges of blankets and mats.
    - Remove E&SC measures as soon as they are no longer needed.
    - Hydraulically-applied erosion control products.

- **Implement measures to keep pollutants away from disturbed soils**.
  - Install perimeter controls or containment around masonry areas or concrete washout areas.
  - If on-site fuel storage is necessary, ensure that it has adequate secondary containment. Avoid double walled fuel tanks unless additional secondary containment is provided.
  - Securely anchor portable toilets to prevent potential tipping.
  - Store construction materials such as paints in a waterproof enclosure or container.
  - Monitor construction equipment for potential fluid leaks or fuel spills.
  - Keep a fully stocked “spill kit” with absorbent materials easily accessible. Staff should be properly trained on the location of these stored materials to enable emergency response as needed.

- **Monitor E&SC measures and adjust them to meet changing conditions.**
  - Monitor installed E&SC measures and maintain and supplement them as construction and weather conditions require – see **Chapter 6.5** for more information.
  - Designate inspection tasks and frequencies and a responsible party to perform inspections and follow-up adjustments and repairs.
  - Designate a responsible party to monitor weather.
  - Post erosion and sediment control plan drawings in the project field office.
  - Document changes to the E&SC Plans and/ or SWPPP. Changes can be hand-written and strikeouts in the original document. Verify any changes with the project engineer and obtain written approval.
  - Monitor and replenish stored erosion control supplies and equipment to respond to the occurrence of unforeseen weather conditions and erosion and sediment problems.
  - Store records of inspection, maintenance, corrective action at the site.

- **Remove temporary erosion and sedimentation controls.**
  - When construction activity has ceased and permanent stabilization is achieved, temporary E&SC measures (such as silt fencing, diversions, perforated risers) need to be removed.
  - Refer to the E&SC Plan and/ or SWPPP for the items that must be removed and designate a party responsible for this activity.
  - All facilities should be cleaned of accumulated sediment, with the removed material graded onto the site and stabilized or removed for suitable off-site disposal.

Quick Reference List for Erosion and Sediment Control Implementation

Effective E&SC depends on clear coordination of construction activities and a commitment by all project and construction staff to work responsibly to minimize site disturbances and prevent degradation of water quality. Preventing erosion during severe storms requires good judgment and timely action.

- Plan and phase project to address stormwater issues and construction implementation throughout the project.
- Mark soil disturbance limits on the site before starting construction.
- Recognize and protect nearby sensitive areas.
- Match erosion control strategies with construction activities.
- Communicate changes in construction sequence and resulting erosion control strategies.
- Monitor weather and plan for major and severe weather events.
- Recognize the potential impact of frozen soils or frost during rain events and spring thaw, particularly in cut areas.
- Install sediment barriers before disturbing soils.
- Understand the characteristics of site soils (i.e., potential to create off-site turbidity) and limit the amount of soil disturbance at any one time.
- Divert, disperse, and direct water run-on away from construction activity areas and toward stabilized areas.
- Any constructed or impacted steep slopes and swales/ channels should be stabilized immediately.
- Inspect and repair erosion controls and sediment trapping measures before and after every storm.
- Stabilize all disturbed soils before winter.
- Limit earthwork in the winter.
- Remove temporary erosion controls when soils on the site are permanently stabilized.
- Divert, disperse, and direct treated stormwater run-off from construction areas to stabilized natural upland areas wherever possible. Management of off-site discharges should be performed in a manner to avoid creating localized flooding or impacts to adjacent properties.

6.3 Erosion and Sediment Control Planning

Erosion and sediment control planning is done primarily through the development and implementation of planning documents, such as an Erosion and Sediment Control (E&SC) Plan or a Stormwater Pollution Prevention Plan (SWPPP). An E&SC Plan is a requirement of the NH Alteration of Terrain Permit (AoT), and a SWPPP is a requirement of the National Pollutant Discharge Elimination System (NPDES) Permit. These documents must be developed as part of the application for their respective permits. It is noted that while significant portions of an E&SC Plan and a SWPPP contain similar information, there are specific requirements for each plan. In situations where both a NH AoT Permit and a NPDES permit are required for a single project, the documents can be joined to contain all pertinent information required under both programs. Although formal E&SC Plans are often only developed for a project requiring a NH AoT permit, it is recommended that one be developed and implemented for all projects.

There are multiple types of E&SC Plans depending on location of the project and proposed work, which may have specific requirements. An additional requirement of the 2017 New Hampshire Small Municipal Separate Storm Sewer (MS4) Permit is the development of a Construction Site Stormwater Runoff Control Program for sites disturbing one acre or more. The program must contain provisions for proper erosion and sediment control to ensure that stormwater runoff from construction sites discharging to the MS4 is consistent with applicable permit requirements. This program is separate from the requirements of other NPDES permits (i.e., the Construction General Permit) and must include the following features:

- An ordinance or other regulatory mechanism that requires the use of E&SC measures.
- Written procedures for site plan review, site inspections, and enforcement of E&SC measures.
- Requirements for construction operators to implement an erosion and sediment control program.

For a complete list of requirements of the Construction Site Stormwater Runoff Control Program, refer to the MS4 permit. The New Hampshire Stormwater Regional Coalition has developed detailed tools to assist permittees in developing a stormwater management program. These tools are available on the New Hampshire Stormwater Regional Coalitions' MS4 webpage.

6.3.1 Erosion and Sediment Control Plans

The NH AoT Permit and subsequent preparation of an E&SC Plan is required by NHDES for projects with earth moving operations, including industrial, commercial, and residential developments, as well as sand pits, gravel pits, and rock quarries, that meet one or more of the following criteria:

- Disturbs an area of more than 100,000 square feet (50,000 square feet, if any portion of the disturbance is within the protected shoreland).
- Disturbs an area of more than 2,500 square feet sloped at a grade of 25 percent or greater within 50 feet of the protected shoreland reference line, as defined in RSA 483-B.

The E&SC Plan generally consists of two components: 1) a **narrative** describing the project, E&SC measures, and implementation procedures; and 2) **drawings** showing plans and details of the specified E&SC measures. The narrative may appear as notes on the drawings, but more typically, it is provided as a separate document due to its length, particularly in larger projects that have more than one construction phase. For sites where the E&SC measures require engineering analysis and design, the hydrologic and hydraulic calculations and other support documentation may be part of or appended to the narrative plan.

The drawings should have separate sheets for the phasing of the project and for the placement of E&SC measures. Detailed drawings should also be provided to clearly show the dimensions, locations, materials, and installation details for the E&SC measures.

See below callout boxes for a list of information that should be included in the **narrative** and **drawings** of the E&SC Plan. For all E&SC Plan requirements, refer to Env-Wq 1504.

Typical Erosion and Sediment Control Plan Narrative Elements

- **Description of the nature of construction activities** including:
  - Size of the property and total area expected to be disturbed.
  - Existing site conditions and conditions of adjacent areas that might be affected by the proposed clearing and grading (streams, wetlands, property lines, and buildings).
- **Detailed description of critical areas on the site**, including:
  - Areas that have a potential for serious erosion problems (such as steep slopes, highly erodible soils, areas exposed to stormwater runoff discharged from other areas of the site).
  - Water resources that must be protected from discharges of sediment.
- **Detailed construction-phase plan** for sequencing construction and stormwater management activities including:
  - Dates that grading will begin and stabilization will be completed, as determined by the contractor.
  - Specific limits on the time frame between initial exposure of soils by construction activity to the temporary or final stabilization of those surfaces.
  - Specific time frames when temporary and permanent seed mixes may be used.
- **Description of an inspection and maintenance program** including:
  - Provisions for frequency of inspections (both routine and storm related), repair and reconstruction of damaged structures, cleanout and disposal of trapped sediment, duration of the maintenance program, and final disposition of the measures when site work is complete.
  - Designation of responsible parties for installation and maintenance of erosion and sediment control measures, monitoring and inspection, and emergency response. Prior to initiating construction, specific persons should be identified in the plan, together with contact information for both normal business hours and during contingencies.
- **Brief description of the measures that will be used to control erosion and sedimentation** on the site and when these measures will be implemented. This should include:
  - A description of measures anticipated for installation at specific stages of construction,
  - Contingency practices for addressing erosion and sediment problems as they arise.

Typical Erosion and Sediment Control Drawing Elements

Site plans should show the following information:

- All areas of undisturbed cover that will remain undisturbed.
- All water features and critical areas within or near the project site, such as streams, lakes, wetlands, as well as the aerial extent of erodible soils.
- Any existing and proposed open or closed drainage systems and any stormwater discharge points, as well as the direction of water flow.
- Existing buffers and vegetated areas that must be retained and protected.
- Existing and proposed impervious or otherwise disturbed surfaces (e.g., roadways, driveways, sidewalks, structures).
- Existing and proposed contours at sufficient interval and scale to identify stormwater runoff patterns.
- Limits of clearing and grading.
- Setbacks and clearances from property lines, water resources, and other features as provided by applicable regulations and permit requirements.
- Proposed general construction phasing and any required sequencing of site disturbance activities. Detailed construction phasing and sequencing plans need to be documented in the SWPPP or E&SC Plan by the selected contractor.
- The locations, limits, and types of erosion and sediment control measures, including the aerial extent of vegetative treatments.

Construction detail drawings should show the following information:

- Detailed drawings of erosion and sediment control structures and measures, showing dimensions, locations, materials, installation requirements, and other detailed information needed for proper application of the controls.
- General sizing and other design criteria for control measures that may vary in the field, depending on site conditions (e.g., sediment traps sized based on contributing area, limits on length of slope and contributing area draining to silt fence). Specific sizing and design should be finalized in the SWPPP or E&SC Plan by the selected contractor.
- Inspection and maintenance notes.

6.3.2 Stormwater Pollution Prevention Plans

Preparation and submission of a Stormwater Pollution Prevention Plan (SWPPP) is a requirement of the following NPDES permits:

- The NPDES **Construction General Permit (CGP)**, for sites which disturb one acre or more of land and for smaller sites that are part of a larger, common plan of development that together disturb one or more acres.
- The NPDES **Multi-Sector General Permit (MSGP)**, for stormwater discharges associated with certain industrial sectors (MSGP SWPPPs are specifically tailored toward control of stormwater at a wide variety of industrial sites that are already developed and may not always require specific erosion or sediment controls unless the site is temporarily being impacted by construction activities).
- The NPDES **Small Municipal Separate Storm Sewer Systems (MS4) Permit**, for permittee-owned or operated facilities such as maintenance garages, public works yards, transfer stations, and other waste handling facilities where pollutants are exposed to stormwater.

More information on these permits is provided in **Chapter 3**.

The purpose of a SWPPP is to identify potential sources of pollutants that may reasonably be expected to affect the quality of the stormwater discharges, to provide a description of the implementation of control measures to ensure reduction of pollutants in stormwater discharges, and to ensure compliance with the specific NPDES permits. The SWPPP must include a plan to implement both pollution prevention and erosion/ sedimentation controls during construction.

SWPPPs must include similar information as that required by the AoT E&SC with a narrative and drawings. Refer to the CGP, MSGP, and MS4 permit for all applicable SWPPP requirements as referenced in **Chapter 3**. A current copy of the SWPPP must be kept at the site or at an easily accessible location so that it can be made available at the time of an on-site inspection or upon request.

Stormwater Pollution Prevention Plan Guidance Resources

EPA has developed guidance on preparing SWPPPs compliant with the permit as listed below:

- **CGP SWPPP Guidance:** EPA Construction General Permit Resources, Tools, and Templates: SWPPP Templates
- **MSGP SWPPP Guidance:** EPA Developing Your Stormwater Pollution Prevention Plan: A Guide for Industrial Operators
- **MS4 SWPPP Guidance:** EPA Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites

6.4 Selection of Erosion and Sediment Control Measures

To achieve objectives for erosion and sediment control, construction projects will require implementation and maintenance of several E&SC measures throughout the life of the project.

- **Erosion controls** are typically the first line of defense and are intended prevent the detachment and transportation of soil particles from repetitive impacts such as raindrops and sheet flow.
- **Sediment controls** are typically the last line of defense and are intended to intercept or trap eroded sediment before it is discharged into stormwater conveyance systems or nearby waterbodies.

Erosion and sediment controls should be designed and implemented using the principles of control as discussed in **Chapter 6.2**.

Selection of E&SC measures is based on several site-specific factors (e.g., steepness of topography, existing cover type, adjacent resources, extent of clearing and grubbing). Erosion and sediment control can be implemented and planned by using a combination of control measures that are appropriate and can be specifically tailored for each site. **Table 6-1** provides a starting point for designers to select site specific control measures based on their intended control objective(s). The table considers factors such as prevention of soil displacement, natural resource degradation, movement of runoff through the site under various phases, on-site interception of sediment in site stormwater runoff, and cold weather site stabilization.

Refer to **Appendix B** for detailed Fact Sheets for each E&SC measure listed in the table.

Table 6-1. Selection of Construction Period Erosion and Sediment Control Measures[1]

Stormwater Control Measure	Env-Wq-1500 Reference	Control Objective													
		Cold Weather Stabilization	Prevent natural resource degradation	Prevent soil displacement by raindrop splash	Prevent sheet and rill erosion	Prevent wind erosion	Prevent gully erosion	Convey construction runoff	Intercept sediment, sheet flow, slope length < 100 ft	Intercept sediment, sheet flow, slope length > 100 ft	Intercept sediment, area < 5 acres	Intercept sediment, area > 5 acres	Intercept sediment from construction traffic	Intercept sediment from excavation dewatering	Enhance settling of fine silts and clays
Erosion Control Measures															
Construction Phasing	1505.03-1505.06	●	●	●	●	●	●								
Dust Control	--	○	●			●									
Surface Roughening	--	○	●		●		●			○					
Soil Stockpile Practices	--	●	●	●	●	●									
Temporary and Permanent Mulching	1506.01	●	●	●	●	●									
Temporary and Permanent Vegetation	1506.02		●	●	●	●	●								
Temporary Erosion Control Blanket and Matting	1506.03	●	●	●	●	●	●								
Diversion Ditch/ Berm	1506.12	●	●		●		●	●		○					
Slope Drain	--		●				●	●							
Tree Preservation and Protection	--														
Sediment Control Measures															
Silt Fence	1506.04	●	●						●		○				
Turbidity Curtain	--														
Erosion Control Mix Berm	1506.05	●	●						●		○				
Filter Sock	--														
Straw or Hay Bale Barrier[2]	1506.06	●	●						●		○				
Temporary Check Dam	1506.07	○	●								○				
Temporary Storm Drain Inlet Protection	1506.08	●	●								○				
Temporary Construction Exit	1506.09	●	●										●		
Temporary Sediment Trap	1506.10	○	●								●			●	
Temporary Sediment Basin	1506.12	○	●								●	●		●	
Construction Dewatering	1506.11	○	●					●						●	
Flocculants	1506.13		●												●

Notes:

[1] Table Key: ● Applicable ○ May be applicable with careful design

[2] Straw and hay bales were historically used for many different E&SC measures. Many applications of straw and hay bales for erosion and sediment control are ineffective due to their composition, inappropriate placement, inadequate installation, lack of maintenance, or a combination of these factors. For these reasons, the United States Environmental Protection Agency (EPA) recommends carefully considering other E&SC measures first. For example, consider silt fence for perimeter controls, stone check dams for diversion channels, erosion control blanket and matting for slope protection, filter sacks for inlet protection, silt sacks for construction dewatering, and prefabricated washout containers for concrete washout structures. Refer to the U.S. EPA Fact Sheet for Straw or Hay Bales for more information.

6.5 Inspection and Maintenance of Erosion and Sediment Control Measures

Erosion and sediment control measures must be monitored, inspected, and maintained throughout construction activities to ensure proper functionality as summarized in the below sections.

6.5.1 Monitoring

To ensure the successful performance of E&SC measures, it is essential to monitor the control measures and other construction activities, and to adjust, modify, and install additional controls to address evolving conditions. During construction, site conditions undergo frequent and sometimes continual change as earthwork activity proceeds, construction moves from one phase to another, and previously disturbed areas are then stabilized. Changing weather conditions, construction traffic, and other conditions can affect the condition and performance of erosion and sediment control measures. As time passes, E&SC measures and finished or partially stabilized surfaces are subject to wear and incidental damage. Control measures must be maintained in serviceable condition to remain effective.

Because of these changing site conditions, the contractor must continually monitor and adjust E&SC measures to ensure that they perform as intended and that they receive appropriate and timely inspection and maintenance. This should include I&M adjustments to frequencies and protocols based on seasonal changes that may impact how measures perform.

6.5.2 Inspection and Maintenance



During construction activities, E&SC measures must be inspected at least weekly and after every rain event of 0.5 inches or more as required in Env-Wq 1505.02. However, these frequencies may need to be adjusted based on other local and federal permit requirements if they apply to a site. For example, the NPDES CGP requires inspection at least weekly or biweekly and within 24 hours of a storm event of 0.25 inches or more. The contractor should assign a qualified person or persons who have the responsibility and authority for the implementation, operation, monitoring, and maintenance of E&SC measures to conduct inspections. The qualified personnel should be knowledgeable in the principles and practice of erosion and sediment controls and possesses the skills to assess conditions at the construction site that could impact stormwater quality and the effectiveness of any E&SC measures selected to control the quality of stormwater discharges from the construction activity.

The person's responsibilities should include:

- Ensuring measures stipulated in design plans and permit documents are installed in the required locations.
- Inspecting the site and arranging for installation of additional controls where and when required.
- Periodically inspecting E&SC measures that have been installed, to confirm that the measures are functional and meeting their intended purposes.

- Arranging for cleaning, maintenance, or repairs of modifications of the E&SC measures, as indicated by such inspection. Each E&SC measure included in this Manual has a Fact Sheet with associated inspection and maintenance requirements listed (see **Appendix B**). Repairs and modifications may not be covered in the Fact Sheets, as those will be specific based on the damage and occurrence. These may have to be carefully evaluated and tailored to meet overall E&SC goals on the site.
- Planning and adjusting inspection and maintenance frequencies based on site specific permits or changes in conditions (these may have to be selected based on the most stringent permit requirement):
    - Many E&SC measures require inspections at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.25 inch or greater; others require daily inspection or ongoing monitoring, particularly during periods of continual rainfall.
    - More frequent inspections than those identified in the **Appendix B** fact sheets may be necessary for sites that are heavily traveled, when weather conditions are severe, and before major storms.
- Arranging for corrective action when control measures fail or are found to be otherwise ineffective. The person should coordinate with a professional experienced in erosion and sediment control (and any approving agency when that agency's approval is required) to assess the reason for failure and determine a course of action to restore the function of the measure, or install an alternative measure.
- Ensuring all E&SC measures are properly installed and maintained on the construction site before predicted major storms. A major storm is defined as a storm predicted by the National Office of Atmospheric Administration (NOAA) Weather Service with warnings of flooding, severe thunderstorms or similarly severe weather conditions or effects.
- Arranging for the timely revision, as warranted, of any Storm Water Pollution Prevention Plan (SWPPP) prepared for the project.
- Maintaining records of inspections, maintenance activities, corrective actions, repairs, and completion of permanent stabilization measures.

6.5.3 Contingency Measures

The E&SC Plan and/ or SWPPP should include provisions for addressing construction contingencies, specifically tailored to the site conditions and water resources associated with the project. At a minimum, the contractor should provide for the following:

- A designated responsible person(s) for conducting the inspection and the follow-up adjustments and repairs, with the authority to implement necessary adjustments and additions to erosion and sediment controls to meet evolving conditions and address emergency problems. Around-the-clock contact information for the person(s) should be furnished to municipal authorities (and NHDES personnel, as applicable), to facilitate communications during emergency events.
- A dedicated stock of common materials for use in addressing erosion or sediment contingencies. Examples include, but are not necessarily limited to:
    - Spare silt fence, hay or straw bales, or erosion control mix for use as temporary sediment barriers.

- Stockpile of mulch material for use in stabilizing areas damaged by weather or construction, along with mulch anchoring material.
- Spare erosion control mat.
- Stockpile(s) of geotextile fabric and stone of suitable size and quantity for repairing construction exits, check dams, and channel linings.

6.5.4 Additional References

For additional guidance on erosion and sediment control on particular projects such as trail construction, routine roadway and utility maintenance, gravel road maintenance, timber harvesting operations, and shoreline projects, see the following references.

- "Best Management Practices for New Hampshire Marinas", NHDES Pollution Prevention Program, 2001.
- "Best Management Practices Manual, Utility Maintenance in and Adjacent to Wetlands and Waterbodies in New Hampshire", NH DNCR, 2019.
- "Best Management Practices for Routine Roadway Maintenance Activities in New Hampshire", New Hampshire Department of Transportation, 2019.
- "Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads", Kennebec County Soil and Water Conservation District and Maine Department of Environmental Protection Bureaus of Land Resources and Water Quality, 2016.
- "New Hampshire Best Management Practices for Erosion Control on Timber Harvesting Operations", University of New Hampshire Cooperative Extension, 2016.
- "New Hampshire Best Management Practices for Erosion Control During Trail Maintenance and Construction", New Hampshire Department of Natural and Cultural Resources (NH DNCR), 2017.
- "Wetlands Best Management Practices for Avoidance and Minimization", New England Interstate Water Pollution Control Commission, 2019.

Appendix A:

Stormwater Control Measure Fact Sheets

A. Stormwater Control Measure Fact Sheets

This Appendix presents fact sheets for a selection of **Stormwater Control Measures (SCMs)** that may be used for projects in New Hampshire. Fact sheets for erosion and sediment control practices are provided separately in **Appendix B**. Stormwater Control Measure (SCM) fact sheets are grouped into the following categories:

- Nonstructural source controls.
- Structural pre-treatment.
- Structural treatment.
- Structural conveyance.

Extensive literature exists that describes the SCMs listed in this Manual, with many comprehensive texts on their selection, siting, design, and maintenance. Consulting professionals, engineers and persons performing technical reviews are expected to consult the design reference literature currently considered as accepted practice. If there is any discrepancy between the information presented here and applicable regulations such as the Alteration of Terrain (AoT) regulations, the regulations take precedence. Project applicants must design projects to comply with applicable local, state, and federal regulations and should refer to them directly to verify applicable criteria. **Note**: Any SCM that meets New Hampshire's definition of a dam must be designed to meet applicable requirements as administered by the New Hampshire Department of Environmental Protection's Dam Bureau.[1]

Where Can I Find More Information on SCMs?



- In this Manual:
  - **Chapter 4** provides information on calculations required to size SCMs to meet design criteria.
  - **Chapter 4.1** discusses a Watershed Protection Standard (WPS) and design approach to support pre-development hydrology.
  - **Chapter 5** discusses site planning and design principles.
  - **Chapter 5.3** provides guidance on SCM selection.
- For a more holistic look of system design elements:
  - Southeast New England Program (SNEP) 2022 New England Stormwater Retrofit Manual.
  - U.S. Department of Agriculture National Resources Conservation Service (USDA NRCS) National Engineering Handbook, Part 630.

[1] New Hampshire's definition of a Dam: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/dam-definiton.pdf; NHDES Dam Bureau: https://www.des.nh.gov/water/dam-maintenance-and-management.

Do Any SCMs Include "State-of-the-Practice" Recommendations?



As noted in **Chapter 1**, the primary goal of this manual is to present the state-of-the-practice for stormwater management in New Hampshire. The "plus" icon to the left is included on the fact sheets of applicable SCMs to aid users of this Manual in identifying where recommended design criteria may exceed or differ from regulatory requirements.

Stormwater Control Measures (SCMs) have been organized into **three tiers** based on their ability to meet key design criteria including pollutant removal, groundwater recharge, and peak runoff control.

1

Tier 1 SCMs can typically be designed to meet the Watershed Protection Standard (WPS) for retention while providing the highest level of pollutant reduction and meeting site design criteria for groundwater recharge and peak runoff control. Tier 1 SCMs can typically reduce pollutants commonly associated with stormwater (i.e., Total Phosphorus, Total Nitrogen, Total Suspended Solids, Bacteria, Metals). See **Chapter 5.3** for more details on selecting appropriate SCMs.

2

Tier 2 SCMs can typically provide a moderate level of pollutant reduction but may not meet all site design criteria.

3

Tier 3 SCMs typically provide the lowest level of pollutant reduction and may not meet all site design criteria.

N/A

Non-Applicable SCMs may be an integral part of a conveyance system or treatment train but cannot meet site design criteria on their own.

A list of SCM fact sheets with accompanying links is provided in the table below.

Note: Example design schematics are provided on each fact sheet to show general examples of SCMs. Terminology between the design guidance provided in the text and the example schematics may differ.

Table of Stormwater Control Measure (SCM) Fact Sheets

Description	Tier
Nonstructural Source Controls	
Catch Basin Cleaning	N/A
Leaf Litter Pickup	N/A
Snow and Ice Management	N/A
Street Sweeping	N/A
Structural Pre-treatment	
Deep Sump Catch Basin	N/A
Pre-treatment Swale	N/A
Flow-Through Devices	N/A
Sediment Forebay	N/A
Vegetated Filter Strip	N/A
Structural Treatment	
Bioretention System (Infiltrating)	1
"Hybrid" Bioretention System	1
Infiltration Basin	1
Infiltration Trench	1
Permeable Pavement (Infiltrating)	1
Subsurface Infiltration Chamber	1
Bioretention System (Filtering)	2
Bioretention with Internal Storage Reservoir (Filtering)	2
Permeable Pavement (Filtering)	2
Dry Well	2
Gravel Wetland	2
Impervious Area Disconnection	2
Leaching Catch Basin	2
Roof Drip Edge (Infiltrating)	2
Roof Drip Edge (Filtering)	2
Stormwater Wetland	2
Tree Box Filter (Infiltrating)	2
Tree Box Filter (Filtering)	2
Extended Dry Detention Pond	3
Flow-Through Treatment Swale	3
Green Roof	3
Rain Barrel/ Cistern (with reuse)	3
Sand Filter	3
Wet Pond	3
Structural Conveyance	
Conveyance Swale	N/A
Detention Basin	N/A
Flow Splitters	N/A
Permanent Outlet Protection	N/A
Stone Berm Level Spreader	N/A
Terraced Slopes or Benching	N/A

Nonstructural Source Controls

Catch Basin Cleaning

Catch basins are chambers which allow surface stormwater runoff to enter the stormwater conveyance system. Most catch basins are built at the curb line and have a low area below the invert of the outlet pipe (i.e., sump) intended to retain coarse sediment. By trapping sediment, the catch basin minimizes solids that may clog the drain pipes and be carried to receiving waterbodies. To maintain their ability to trap sediment and prevent flooding, catch basins must be cleaned periodically.

Aesthetic and water quality benefits from the removal of sediment, decaying debris, and highly polluted water from catch basins include reducing foul odors, reducing suspended solids, and reducing the load of oxygen-demanding substances that reach receiving waters (EPA, 1999). Catch basin cleaning is also a requirement of the New Hampshire MS4 General Permit. The permit requires routine inspections, cleaning, and maintenance such that no catch basin at any time will be more than 1/2 full. For unpermitted communities, this should be a target goal. Refer to the permit for additional requirements for New Hampshire MS4 catch basin operations and maintenance.

Design Considerations

- Catch basin cleaning should be performed at all facilities, including roadways, that have an on-site stormwater system that includes catch basins and drainage utility access holes. Although catch basin cleaning is easily implemented, it is often overlooked in overall stormwater management plans.
- Full implementation of catch basin cleaning should include removal of debris from grate openings as well as removal of debris from the catch basin itself.
- Catch basin cleaning is difficult during the winter when snow and ice are present.
- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.

Design Guidance

- Typically, a catch basin should be cleaned if the depth of the deposits is greater than or equal to 1/2 the depth from the basin floor to the invert of the lowest pipe or opening into or out of the basin. If a catch basin significantly exceeds the 1/2 depth standard during annual inspection, then it should be cleaned more frequently.
- Material removed from catch basins is usually disposed of in conventional landfills. However, sediment and debris removed from catch basins can potentially be classified as hazardous waste. As a result, materials removed from catch basins must be chemically analyzed to determine how they should be stored, treated, and disposed of. For more information on proper management of catch basin waste materials, see the New Hampshire Department of Environmental Services (NHDES) Management of Municipal Roadway Soils fact sheet.

Pollutant Removal Credits

The New Hampshire MS4 General Permit does allow for nutrient reduction credits for Total Phosphorus and Total Nitrogen for catch basin cleaning. Permittees may earn credits if the minimum sump storage capacity of 50 percent is maintained throughout the year. For more information on catch basin cleaning credit calculations, refer to Appendix F of the New Hampshire MS4 General Permit.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement	Catch Basin Cleaning
Pollutant Removal (AoT 1507.03)[3]	No
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	No

[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

[3] *See discussion on Pollutant Removal Credits for catch basin cleaning above.*

References

Environmental Protection Agency (EPA). *Storm Water O&M Fact Sheet: Catch Basin Cleaning.* EPA 832-F-99-011. 1999. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=200044BA.TXT.

EPA. *2017 NH Small MS4 General Permit*. Original 2017. Modified 2020. Available at: https://www3.epa.gov/region1/npdes/stormwater/nh/2017-small-ms4-general-permit-nh-mod.pdf.

EPA. *2017 NH Small MS4 General Permit Appendix F: Requirements of Approved Total Maximum Daily Loads*. Original 2017. Modified 2020. Available at: https://www3.epa.gov/region1/npdes/stormwater/nh/2017-appendix-f-sms4-nh-mod.pdf.

NHDES. *Environmental Fact Sheet: Management of Municipal Roadway Soils*. SW-38. 2023. Available at: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/sw-38.pdf.

Leaf Litter Pickup

Leaf litter is a significant source of nutrients (i.e., phosphorus and nitrogen) in stormwater runoff, especially during the fall season. As leaf litter decays on streets or in the storm drain system, it releases excess phosphorus and nitrogen. Leaf litter can be carried by rain and melting snow and washed into storm drains. Once in the storm drain system, leaves may enter nearby waterbodies and harm aquatic plants and animals by smothering natural vegetation. In addition, excessive amounts of nutrients in waterbodies can lead to accelerated effects of eutrophication, contributing to excess algae and odors (USGS, 2019).

Through proper handling and disposal of leaf litter, the amount of phosphorus in stormwater runoff, and the receiving waterbodies, can be minimized.

Design Considerations

- Municipalities may benefit from starting a municipal leaf collection program to remove leaves and other yard debris from streets and municipal properties and to prevent excess nutrients from being transported by stormwater runoff. For example, ask residents to bag leaves and store them in a designated area for collection, similar to municipal trash removal.
- Leaf collection programs can be coordinated with street sweeping activities for increased efficiency.
- Avoid disposing of leaves or grass clippings in or near storm drains, drainage channels, wetlands, or waterbodies.
- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.

Design Guidance

Leaf litter pickup is a major component of street sweeping. Pollutant removal efficiency will vary seasonally with increased leaf-fall and removal during the fall (September to December).

Current Pollutant Removal Credits

There is no specific pollutant removal credit that can currently be applied to street sweeping/ leaf collection under the AoT regulations. Under the 2017 New Hampshire MS4 General Permit, municipalities may earn Total Nitrogen or Total Phosphorus reduction credits through enhanced gathering, removal, and proper disposal of landscaping waste, organic debris, and leaf litter from impervious surfaces. For more information on current leaf litter collection credit calculations, refer to Appendix F of the New Hampshire MS4 General Permit.

Emerging Research for Pollutant Removal Credits

The current MS4 credits do not offer sufficient return on the investment required for such programs. There is emerging research on updating New Hampshire's current Enhanced Street/ Pavement Cleaning and Enhanced Organic Waste and Leaf Litter Collection Credits provided through NPDES permits (Great Bay Total Nitrogen General Permit and New Hampshire MS4 General Permit). One option for applying street cleaning/ leaf collection credits includes permittees measuring the amount of organic matter collected. Another option includes applying credits based on varied levels depending on the technology used and frequency of cleaning as outlined in the table below. Credits will also depend on the location and seasonality of sweeping/ collection to accommodate seasonal increases in Total Nitrogen and Total Phosphorus. For more information on how the credits can be calculated, refer to the Piscataqua Region Estuaries Partnership (PREP) and University of New Hampshire Stormwater Center (UNHSC) memo *Clean Sweep: Recommendations for New and Updated Credits for Street Cleaning in New Hampshire*. Additionally, the UNHSC has developed a Street Sweeping Credit Calculator tool to calculate annual removal of nitrogen and phosphorus from street sweeping activities and related credit under the upcoming MS4 General Permit.

Updated Design Parameters

Parameter	Minimum Effort	Medium Effort	Maximum Effort
Frequency	Up to two times annually in any season.	Every other week in the fall (September to December).	Monthly sweeping with weekly sweeping in the fall (September to December) and early spring. May be combined with other efforts.
Location and Seasonality	To accommodate seasonal increases in Total Nitrogen and Total Phosphorus and simplify the location parameter: 1. Use medium density residential IC land use, which integrates the majority of likely land uses. 2. For weekly fall sweeping in times of high organic material deposition, offer a 10 percent additional removal factor. This is a 5 percent increase over the enhanced leaf collection credit in the current model.		

Source: PREP and UNHSC, 2022

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement	Leaf Litter Pickup
Pollutant Removal (AoT 1507.03)	No
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	No

[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

[3] *See discussion on Emerging Research for Pollutant Removal Credits for street sweeping/ leaf collection above.*

References

City of Manchester, NH. *"Rake it or Leave it?" New Hampshire MS4 Guidance Sheet.* 2022. Available at: www.manchesternh.gov/Portals/2/Departments/environ_protec/stormwater/.

EPA. *2017 NH Small MS4 General Permit Appendix F: Requirements of Approved Total Maximum Daily Loads*. Original 2017. Modified 2020. Available at: *https://www3.epa.gov/region1/npdes/stormwater/nh/2017-appendix-f-sms4-nh-mod.pdf*.

PREP and UNHSC. *Clean Sweep: Recommendations for New and Updated Credits for Street Cleaning in New Hampshire*. Technical Memorandum. 2022. Available at: https://scholars.unh.edu/cgi/viewcontent.cgi?article=1459&context=prep.

Selbig, W.R. *Evaluation of leaf removal as a means to reduce nutrient concentrations and loads in urban stormwater*. Science of the Total Environment, Volume 571, pages 124-133. 2016. Available at: https://pubs.usgs.gov/publication/70175058.

USGS, Upper Midwest Water Science Center. *Using leaf collection and street cleaning to reduce nutrients in urban stormwater*. Webpage. 2019. Available at: https://www.usgs.gov/centers/upper-midwest-water-science-center/science/using-leaf-collection-and-street-cleaning-reduce.

Snow and Ice Management

Rising concentrations of chloride from salt applications/deicing chemicals have been identified in New Hampshire waters, similar to other colder regions of the United States and Canada. A 120 percent increase in the number of chloride contaminated wells in New Hampshire has occurred over the past 30 years. The majority of lakes and ponds that have active sampling programs display worsening trends for chloride concentrations.

To protect New Hampshire waters from chloride contamination, the New Hampshire Department of Environmental Services (NHDES), New Hampshire Department of Transportation, and the University of New Hampshire Technology Transfer Center, created the Green SnowPro Program for commercial salt applicators. This program offers snow and ice management training, proficiency testing, and certification in state-of-the-science salt reduction practices that prioritize public safety while mitigating salt usage. For additional incentive, commercial salt applicators certified by NHDES Green SnowPro under RSA 489-C, and property owners or managers who hire them, are granted limited liability protection against damages arising from snow and ice conditions under RSA 508:22. In addition, municipalities also have the opportunity to have their public works departments and snow and ice management crews certified as Green SnowPro under RSA-489-C. Municipalities that implement a comprehensive suite of snow and ice best practices achieve higher levels of Green SnowPro certification by NHDES. For additional information regarding road salt reduction and to become Green SnowPro certified or to engage with one for winter snow and ice property management in New Hampshire, refer to the NHDES Road Salt Reduction website.

NHDES also recommends the creation of a Road Salt and Deicing Minimization Plan when a development will create one acre or more of pavement, including parking lots and roadways. The plan should address the policies that the development will keep in place to minimize salt and other deicer use after the project has been completed. A component of the plan should include tracking the use of salt and other deicers for each storm event and compiling salt use data annually.

Design Considerations

- Property owners should hire New Hampshire Green SnowPro certified commercial applicators to maintain parking lots, driveway surfaces, and sidewalks or encourage existing maintenance companies to get certified. A list of certified Green SnowPro contractors can be found on the NHDES Road Salt Reduction website.
- As part of the annual reporting required by the Env-Wq 2200 Voluntary Certified Salt Applicator (Green SnowPro) Program, certified applicators must submit annual reports of salt use (i.e., amount of salt used, total area of paved surface maintained, and type and amount of each salt alternative used). See below for an example Annual Salt Accounting Report including the required Green SnowPro reporting elements.
- Anti-icing with salt brine before a storm is a proactive treatment to prevent snow and ice from bonding to the pavement so that it can be plowed away. For more information on anti-icing and brine making, refer to NHDES Technologies and Best Management Practices for Salt Reduction.
- Pre-wetting solid deicer chemicals improves the melting action of the material, reduces bounce and scatter of materials during spreading, and reduces the total amount of deicer needed to obtain the desired results. For more information on pre-wetting and deicing material housekeeping, refer to NHDES Technologies and Best Management Practices for Salt Reduction.
- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.

Design Guidance

- Snow disposal guidelines to minimize impact to the environment should include the following:
  - Snow should be stored near flowing surface waters, but at least 25 feet from the high-water mark of the surface water and/or top of stream bank. Upland sites further from surface waters are acceptable, provided they do not impact water supply sources as described below.
  - A silt fence or equivalent barrier should be securely placed between the snow storage area and the high-water mark and/or the top of stream bank.
  - Snow storage areas should be at least 75 feet from any private water supply wells, at least 200 feet from any community water supply wells, and at least 400 feet from any municipal wells. Snow storage is prohibited in wellhead protection areas.
  - All debris in the snow storage area should be cleared from the site prior to snow storage.
  - By May 15 each year, all debris from active snow storage areas should be cleared and properly disposed of.
  - Designated snow storage areas should not be located near any SCMs to ensure the SCMs continue to function as designed during melt events and to reduce the amount of debris flowing into SCMs, which can clog and flood drainage areas.
  - Snow storage site selection should consider the following:
    - How much snow disposal capacity is needed so an adequate number and size of sites can be selected and prepared.
    - Sites lacking mature tree growth are preferred because trees make collection of debris more difficult after the winter season.
    - Municipal open space, parks, recreation fields and parking areas should be considered for potential snow disposal sites. If there are no municipal sites available, securing permissions from landowners of non-municipally owned sites should be considered.
- Recommended deicing application rate guidelines are provided in the table below. An example form for tracking salt and other deicer usage is also provided.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Snow and Ice Management
Pollutant Removal (AoT 1507.03)	No
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	No

[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

References

EPA. *Snow Disposal Guidelines*. Environmental Fact Sheet. 2020. Available at: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/wmb-3.pdf.

Minnesota Snow and Ice Control Handbook, 2022. Available at: https://mdl.mndot.gov/_flysystem/fedora/2023-02/2022ric01.pdf

NHDES. *Road Salt Reduction*. Webpage. 2023. Available at: https://www.des.nh.gov/land/roads/road-salt-reduction.

Deicing Application Rate Guidelines

Deicing Application Rate Guidelines: 24 feet of pavement (typical two-lane road) These rates are not fixed values, but rather the middle of a range to be selected and adjusted according to local conditions and experience.						
			Pounds per two-lane mile			
Pavement Temp. (°F) and Trend (↑↓)	Weather Condition	Maintenance Actions	Salt Prewetted/ Pretreated with Salt Brine	Salt Prewetted/ Pretreated with Other Blends	Dry Salt*	Winter Sand (abrasives)
Greater than 30°	Snow	Plow, treat intersections only	100	100	100*	Not recommended
↑	Freezing Rain	Apply Chemical	100 - 160	100 - 140	100 - 200*	Not recommended
30°	Snow	Plow and apply chemical	100 - 160	100 - 140	100 - 200*	Not recommended
↓	Freezing Rain	Apply Chemical	150 - 200	130 - 180	180 - 240*	Not recommended
25° - 30°	Snow	Plow and apply chemical	120 - 160	100 - 140	150 - 200*	Not recommended
↑	Freezing Rain	Apply Chemical	150 - 200	130 - 180	180 - 240*	Not recommended
25° - 30°	Snow	Plow and apply chemical	120 - 160	100 - 140	150 - 200*	Not recommended
↓	Freezing Rain	Apply Chemical	160 - 240	140 - 210	200 - 300*	400
20° - 25° ↑	Snow or Freezing Rain	Plow and apply chemical	160 - 240	140 - 210	200 - 300*	400
20° - 25°	Snow	Plow and apply chemical	200 - 280	175 - 250	250 - 350*	Not recommended
↓	Freezing Rain	Apply Chemical	240 - 320	210 - 280	300 - 400*	400
15° - 20°	Snow	Plow and apply chemical	200 - 280	175 - 250	250 - 350*	Not recommended
↑	Freezing Rain	Apply Chemical	240 - 320	210 - 280	300 - 400*	400
15° - 20° ↓	Snow or Freezing Rain	Plow and apply chemical	240 - 320	210 - 280	300 - 400*	500 for freezing rain
0° - 15° ↑↓	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	300 - 400	Not recommended	500 - 750 spot treatment as needed
Less than 0°	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	400 - 600**	Not recommended	500 - 750 spot treatment as needed

* Dry salt is not recommended. It is likely to bounce, scatter, and/or blow off the road before it melts ice.
** A blend of 6 to 8 gallons per ton $MgCl_2$ or $CaCl_2$ added to NaCl can melt ice as low as -10°.

Source: Minnesota Snow and Ice Control Handbook, 2022

Example Documentation Form for Anti-icing

Anti-icing Route Data Form				
Truck Station:				
Date:				
Air Temperature	**Pavement Temperature**	**Relative Humidity**	**Dew Point**	**Sky**
Reason for applying:				
Route:				
Chemical:				
Application Time:				
Application Amount:				
Observation (first day):				
Observation (after event):				
Observation (before next application):				
Name:				

Source: Minnesota Snow and Ice Control Handbook, 2022

Example New Hampshire Green SnowPro Annual Salt Accounting Report

Annual Salt Accounting Report	
Name:	**Date:**
Certificate Number:	**Type of Certificate:** Master / Individual
Affiliated Business Name:	

Deicer Type and Amount

Complete the table below for each type of deicer used last winter including the unit reported. If you do not know the amount of deicer used by type, please report the total amount of all deicers used in the TOTAL row at the end of the table.

Type of Deicer Used	Solid Material Amount (indicate tons, pounds or yards)	Liquid Volume (gallons)
Salt, dry		
Salt, prewetted in the spreader		
Salt, prewetted in the pile		
Calcium chloride, dry		
Calcium chloride, liquid		
Calcium magnesium acetate, dry		
Calcium magnesium acetate, liquid		
Potassium acetate, dry		
Potassium acetate, liquid		
Sand		
Sand/ salt mix		
Liquid brine		
Other:		
Total deicer used last winter:		

Location and Area Treated

List the municipality and square feet of paved surface treated with salt/ deicer last winter in each municipality.

Municipality/ Municipalities	Square Feet of Paved Surface Treated

Subordinates

Master certificate holders are required to list all subordinates working and reporting under their certification.

Name

Source: NHDES Green SnowPro Certification website, Annual Salt Accounting Form, 2020.

Street Sweeping

Street sweeping is a pollution prevention practice that removes sediment, debris and trash that accumulates along streets and roads from winter sanding practices and everyday use. Street sweeping is often performed to improve aesthetics and to reduce the export of sand to the drainage network and receiving waters. In addition to sediment, debris and trash, other pollutants that may be minimized through street sweeping include some nutrients, oxygen-demanding substances and trace metals.

There are three types of commonly used street sweepers:

- **Mechanical sweepers** use rotating brooms to force debris from the street surface into a hopper by a conveyor system. Water is usually sprayed on the pavement surface to control dust. This type of sweeper typically removes only coarse particles and therefore is less effective at removing nutrients, oxygen-demanding materials, and toxic substances that are typically attached to fine particles.
- **Regenerative-air sweepers** combine the rotating brooms of mechanical sweepers with forced air to dislodge the remaining dirt and use a high-power vacuum to pick up the dislodged particles. This allows for greater removal of fine particles and the associated pollutants.
- **Vacuum-assisted sweepers** combine the rotating brooms of mechanical sweepers with a high-power vacuum. Some will spray water to control dust and others operate completely dry with a continuous filtration system.

Vacuum-assisted sweepers and regenerative-air sweepers are considered more effective than the mechanical sweeper at particulate pickup. However, it is understood that the overall effectiveness of street sweeping operations to remove pollutants from a given area will depend on a number of variables and may require a combination of technologies and operational efforts. Other variables include the season, the frequency and location of sweeping, the ability to sweep on heavily traveled roads, the number of passes made and the operation speed of the sweeper.

Design Considerations

- Identify areas of concern based on traffic volume, land use, field observations of sediment and trash accumulation and proximity to surface waters. Increase sweeping frequency in these areas to maximize pollutant removal benefits.
- Consider maintaining logs of the amount of waste collected by district, road, or area and use this information to develop/ amend a street sweeping plan that targets areas that accumulate greater amounts of material, along with the appropriate frequency to achieve the greatest removal.
- Consider instituting parking policies to restrict parking in problematic areas during periods of street sweeping.
- Street sweeping waste must be disposed of or reused in accordance with the New Hampshire Department of Environmental Services (NHDES) 2022 Solid Waste Management Plan. For more information on proper management of street sweeping waste materials, see the New Hampshire Department of Environmental Services (NHDES) Management of Municipal Roadway Soils fact sheet.

Design Guidance

As outlined under ‘Design Considerations’, street sweeping programs should be developed that accommodate areas of concern based on traffic volume, land use, field observations of sediment and trash accumulation and proximity to surface waters. At a minimum, street sweeping should be performed twice annually, preferably as soon as possible after the snow melts to reduce the amount of sand, grit, debris, and associated pollutants from entering surface waters.

Current Pollutant Removal Credits

There is no specific pollutant removal credit that can currently be applied to street sweeping under the AoT regulations. Under the 2017 New Hampshire Municipal Separate Storm Sewer System (MS4) General Permit, municipalities may earn Total Nitrogen or Total Phosphorus reduction credits through enhanced cleaning of impervious surfaces. For more information on current street sweeping credit calculations, refer to Appendix F of the New Hampshire MS4 General Permit.

Emerging Research for Pollutant Removal Credits

The current credits do not offer sufficient return on the investment required for such programs. There is emerging research on updating New Hampshire's current Enhanced Street/ Pavement Cleaning Credit provided through National Pollutant Discharge Elimination System (NPDES) permits (Great Bay Total Nitrogen General Permit and New Hampshire MS4 General Permit). One option for applying street cleaning credits includes permittees measuring the amount of organic matter collected. Another option includes applying credits based on varied levels depending on the technology used and frequency of cleaning as outlined in the table below. Credits will also depend on the location and seasonality of sweeping to accommodate seasonal increases in Total Nitrogen and Total Phosphorus. For more information on how the credits can be calculated, refer to the PREP and UNHSC memo *Clean Sweep: Recommendations for New and Updated Credits for Street Cleaning in New Hampshire*. Additionally, the UNHSC has developed a Street Sweeping Credit Calculator tool to calculate annual removal of nitrogen and phosphorus from street sweeping activities and related credit under the upcoming MS4 General Permit.

Updated Design Parameters

Parameter	Minimum Effort	Medium Effort	Maximum Effort
Frequency	Up to 2 times annually in any season.	Every other week in the fall (September to December).	Monthly sweeping with weekly sweeping in the fall (September to December) and early spring. May be combined with other efforts.
Location and Seasonality	To accommodate seasonal increases in Total Nitrogen and Total Phosphorus and simplify the location parameter: 1. Use medium density residential IC land use, which integrates the majority of likely land uses. 2. For weekly fall sweeping in times of high organic material deposition, offer a 10 percent additional removal factor. This is a 5 percent increase over the enhanced leaf collection credit in the current model.		

Source: PREP and UNHSC, 2022

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Inspect and maintain street sweeping equipment in accordance with manufacturer's recommendations.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement	Street Sweeping
Pollutant Removal (AoT 1507.03)[3]	No
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	No

[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

[3] *See discussion on Emerging Research for Pollutant Removal Credits for street sweeping above.*

References

Environmental Protection Agency. *Stormwater Best Management Practice: Parking Lot and Street Sweeping*. Fact Sheet. 2021. Available at: https://www.epa.gov/system/files/documents/2021-11/bmp-parking-lot-and-street-sweeping.pdf.

EPA. *2017 NH Small MS4 General Permit Appendix F: Requirements of Approved Total Maximum Daily Loads*. Original 2017. Modified 2020. Available at: *https://www3.epa.gov/region1/npdes/stormwater/nh/2017-appendix-f-sms4-nh-mod.pdf*.

NHDES. *Environmental Fact Sheet: Management of Municipal Roadway Soils*. SW-38. 2023. Available at: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/sw-38.pdf.

PREP and UNHSC. *Clean Sweep: Recommendations for New and Updated Credits for Street Cleaning in New Hampshire*. Technical Memorandum. 2022. Available at: https://scholars.unh.edu/cgi/viewcontent.cgi?article=1459&context=prep.

Selbig, W.R. *Evaluation of leaf removal as a means to reduce nutrient concentrations and loads in urban stormwater*. Science of the Total Environment, Volume 571, pages 124-133. 2016. Available at: https://pubs.usgs.gov/publication/70175058.

Zarriello, P.J., R.F. Breault and P.K. Weiskel. *Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, Massachusetts*. USGS Water Resources Investigations Report 02-4220. Northborough, MA. 2002. Available at: https://pubs.usgs.gov/wri/wri024220/pdfs/wrir024220.pdf.

Structural Pre-Treatment

Deep Sump Catch Basin

A deep sump catch basin consists of a utility access hole-type structure with an inlet grate, an outlet pipe connected to the piped drainage system, and a sump(s) with a depth several times the diameter of the outlet pipe. The inlet grate is located at the surface, and is sometimes combined with a vertical inlet integrated with a street or parking area curb. The sump's purpose is to capture coarse sediments and debris from the stormwater runoff intercepted by the structure. The outlet pipe can be fitted with a "hood" consisting of a cast metal or formed plastic fitting, designed to prevent floating materials from exiting the structure.

Deep sump catch basins used as pre-treatment are most effective if sited "off-line" since flow-through basins are more susceptible to sediment re-suspension. An outlet hood provides benefits for trapping floating trash, oil, and greases, as well as for short-term spill containment.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- "Boulanginator" media box filters.
- Inlet grate design considerations.
- MS4 Permit requirement that no catch basin at any time should be more than 1/2 full (target goal for unpermitted communities, see "Catch Basin Cleaning" fact sheet).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Media Box Filters (i.e., "Boulanginator")

Media box filters may replace deep sump catch basins to enhance water quality treatment. These filters provide additional filtration components connected to maintainable deep sump catch basins. The system may be expanded in the middle to increase filter media area and treat more impervious cover than typical deep sump catch basins. The depth of soil may vary from 6 to 12 inches as most filtration occurs at the surface. Filter media mixes can vary, but should be sandy soils with high conductivity. See example schematic below.

Design Considerations

- Deep sump catch basins used as pre-treatment devices must be located "off-line." "Off-line" systems only receive design flows. Excess flows must be bypassed or conveyed by an upstream diversion structure, rather than "in-line" systems which receive all flows for treatment before the treatment system outlets.
- Hoods may be susceptible to displacement or damage from cleaning activities. This should be considered in the configuration of the tops of structures (e.g., use of eccentric cones or flat tops with the inlet offset from alignment with the hood) to minimize risk of damage from cleaning equipment. However, the configuration should also permit access for repositioning or replacing the hood. Hoods should also be removed when pipes are cleaned.
- The inlet grate should be sized based on the contributing drainage area to ensure that the flow rate does not exceed the capacity of the grate. Inlet capacity should also consider surface slope. Grate types can be adjusted for higher flow velocities.

- Inlet grates designed with curb cuts should extend to the back of the curb cut to prevent flow bypass.
- To allow for easy maintenance access, the inlet grate shall not be welded to the frame.

Design Guidance

Design Parameters

Parameter	Criteria
Maximum Drainage Area	Less than or equal to 1/4 acre of impervious area
"Off-line" Configuration (no storm drain inlet pipes to the device)	Required.
Minimum Catch Basin Diameter	4 feet
Typical Depth from Outlet Invert to Sump Bottom	Greater than or equal to 4 times the diameter of the outlet pipe or at least 4 feet (required if used for pre-treatment).
Hooded Outlet	Required. Horizontal hood opening greater than or equal to 1 foot below outlet invert.
Inlet Grate Openings	Less than or equal to 4 square inches

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Sumps may require frequent maintenance. Depending on location, this may require several cleanings of the sumps each year. At a minimum, it is recommended that sumps be inspected at least once annually.
- Sediment should be removed when it approaches 1/2 the sump depth.
- If floating hydrocarbons are observed during an inspection, the material should be removed immediately by skimming, absorbent materials, or other method and disposed of in conformance with applicable state and federal regulations.
- Cleaning may require a vacuum truck instead of "clam-shell" to avoid damage to hood.
- Damaged hoods should be replaced when noted by inspection.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Deep Sump Catch Basin (Env-Wq 1508.16)
Pollutant Removal (AoT 1507.03)[3]	TSS Only
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	No

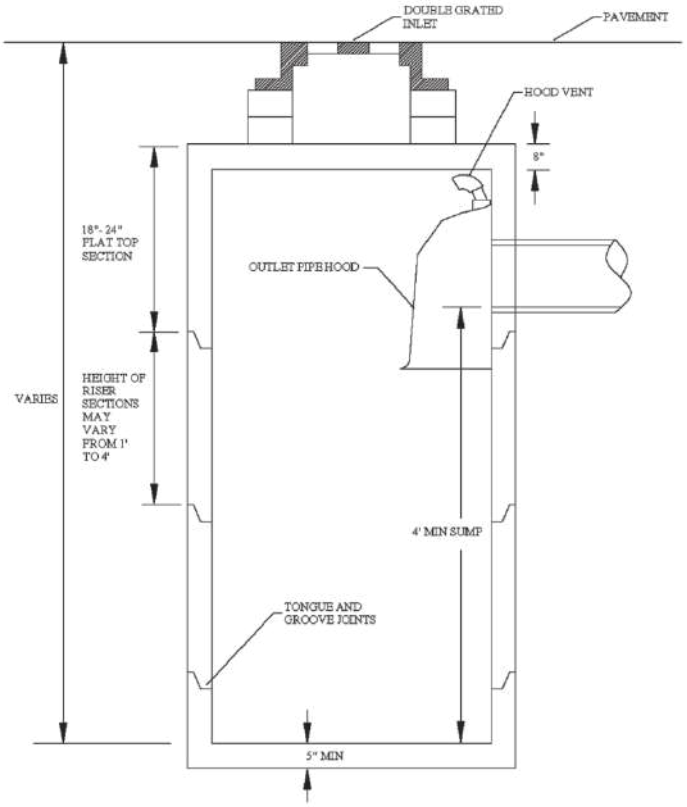
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

[3] *All pre-treatment SCMs can be used to meet the pre-treatment requirements for certain SCMs as outlined in Env-Wq 1500, but cannot be used to meet the required 1-inch water quality volume.*

Deep Sump Catch Basin

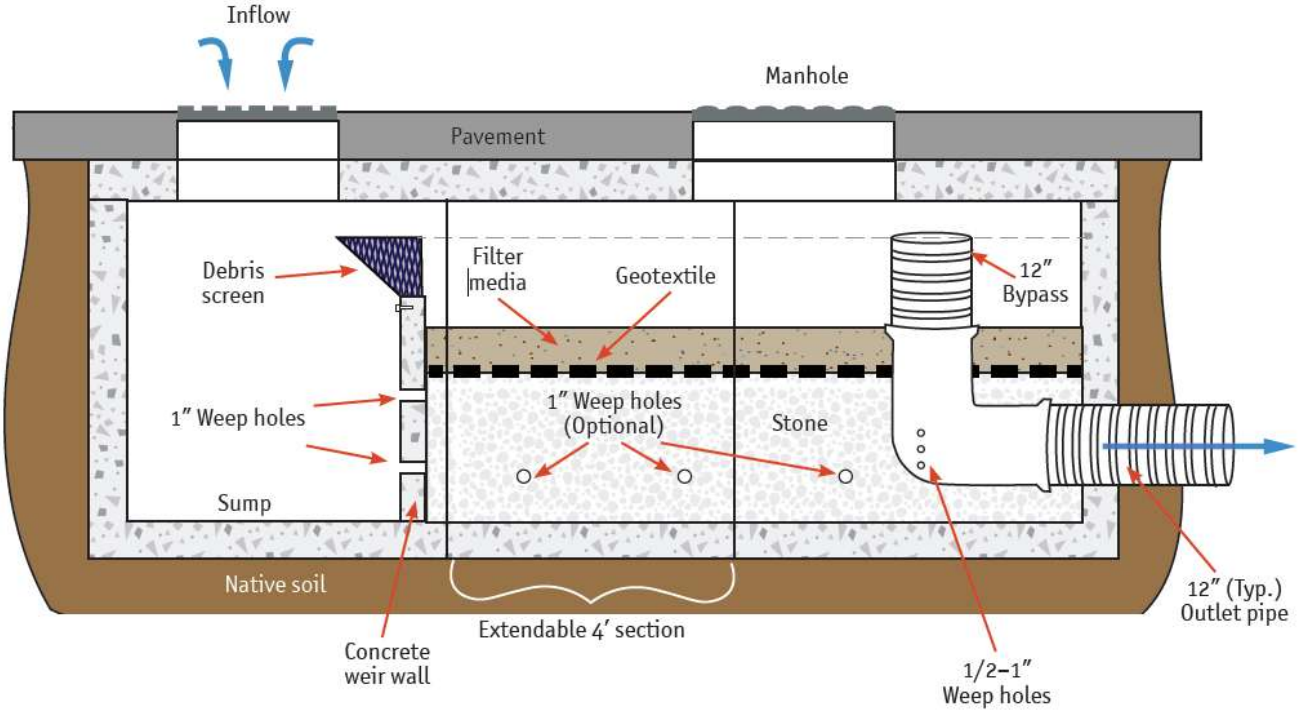
Profile



Adapted from ME DEP (2006)

Media Box Filter (i.e., "Boulanginator")

Design Detail



UNHSC, Generic Sectional Media Box Filter Design Detail

References

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Deep Sump Catch Basin*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Deep Sump Catch Basin*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

University of New Hampshire Stormwater Center (UNHSC). *Challenges and Practical Solutions to Managing Municipal Stormwater Systems*. Keynote presentation. 2018. Available at: https://scholars.unh.edu/cgi/viewcontent.cgi?article=1037&context=stormwater.

UNHSC. *Generic Sectional Media Box Filter Design Detail*. Available at: https://www.unh.edu/unhsc/sites/default/files/media/stormwater-sectional-media-box191219final.pdf.

Vermont Agency of Natural Resources. *Vermont Stormwater Management Manual Rule and Design Guidance.* 2017. Available at: https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/2017%20VSMM_Rule_and_Design_Guidance_04172017.pdf.

Pre-treatment Swale

Pre-treatment swales are shallow, vegetated, earthen channels designed to convey flows, while capturing a limited amount of sediment and associated pollutants. A pre-treatment swale differs from a treatment swale in that the grass swale is not designed for a specified hydraulic residence time. Therefore, pre-treatment swales do not necessarily provide sufficient time for the removal of pollutants other than those associated with larger sediment particles, and may only be used for pre-treatment.

The "**Flow-Through Treatment Swale**" is described in this manual under Treatment Practices, and provides enhanced pollutant removal through filtration, vegetation uptake, infiltration into underlying soils, and physical settling.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

General Requirements Applicable to Pre-treatment Swales

- Swales are prohibited in areas of RSA 482-A jurisdiction unless a wetlands permit has been issued.
- Swales are prohibited in groundwater protection areas receiving stormwater from a high-load area unless an impermeable liner is provided.
- Swale shape should be trapezoidal or parabolic.
- Bottom of swale should not be within the seasonal high-water table.
- Swale should be vegetated.

Design Considerations

- Pre-treatment swales must be designed so that the flow travels the full length (not including portions in a roadside ditch) to receive adequate pre-treatment. For this reason, flow must be directed to the inlet end of the swale, rather than the swale collecting water continuously along its length.
- Vegetation should be selected based on site soil conditions, anticipated mowing requirements (height, frequency), and design flow velocities. See "**Bioretention Systems**" for a planting guide of New England native species, including salt tolerant species.
- All channels should be designed for capacity and stability. A channel is designed for capacity when it can carry the maximum specified design flow within the design depth of the channel (allowing for recommended freeboard). A channel is designed for stability when the channel lining (e.g., vegetation) will not be eroded under design flow velocities. Analyses of these conditions must account for both the type of lining and its condition (e.g., capacity analysis for a grassed channel must consider the resistance of the maximum height of grass, while the stability analysis must consider the grass under its shortest, mowed condition).

Design Guidance

Design Parameters

Parameter	Criteria
Minimum Length	Greater than or equal to 50 feet (not including portions in a roadside ditch).
Bottom Width	4 to 8 feet.
Longitudinal Slope	0.5 percent to 2 percent without check dams. 2 percent to 5 percent with check dams.
Maximum Side Slopes	3h:1v.
Minimum Side Slopes	20h:1v.
Flow Depth	4 inches maximum at the Water Quality Flow.
Design Discharge Capacity	10-year, 24-hour storm with at least 1 foot of freeboard.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Inspect annually for erosion, sediment accumulation, vegetation loss, and presence of invasive species.
- Perform periodic mowing; frequency depends on location and type of grass. Avoid cutting shorter than Water Quality Flow (WQF) depth (minimum 4 inches).
- Remove debris and accumulated sediment, based on inspection.
- Repair eroded areas, remove invasive species, woody vegetation, and dead vegetation, and reseed with applicable grass mix as warranted by inspection.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,3]

AoT Requirement[2]	Pre-treatment Swale (Env-Wq 1508.14)
Pollutant Removal (AoT 1507.03)[3]	TSS Only
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	No

[1] *See **Chapter 4 (Design Criteria)** for more information.*

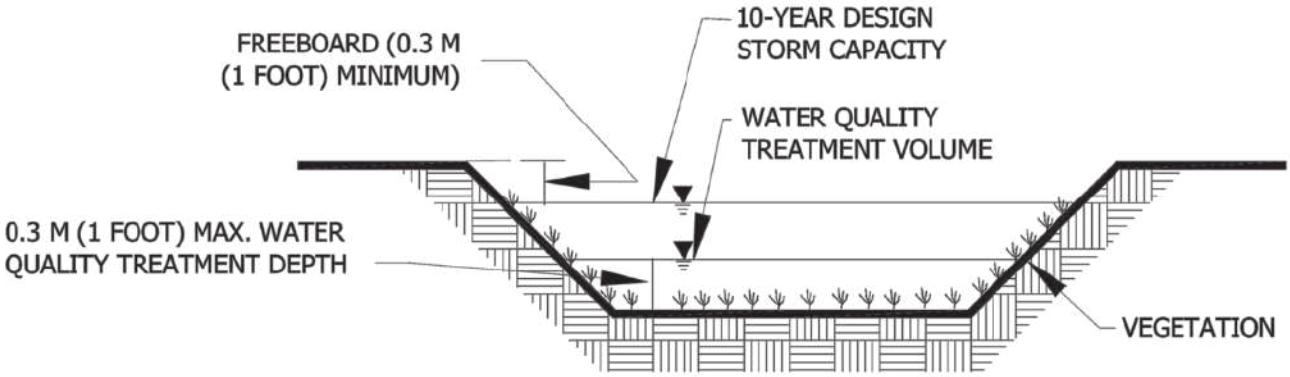
[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

[3] *All pre-treatment SCMs can be used to meet the pre-treatment requirements for certain SCMs as outlined in Env-Wq 1500, but cannot be used to meet the required 1-inch water quality volume.*

Example Design Schematic

Pre-treatment Swale

Profile



MassHighway (2004)

References

Environmental Protection Agency. Stormwater Technology Fact Sheets: Vegetated Swales. EPA 832-F-99-006. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/.

Maine Department of Environmental Protection. Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Vegetated Swale. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Environmental Protection (MassDEP). Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Grassed Channel. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

MassHighway. The MassHighway Storm Water Handbook For Highways and Bridges- Dry Swale, Wet Swale, Biofilter Swale. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Pennsylvania Department of Environmental Protection (PA DEP). Pennsylvania Stormwater Best Management Practices Manual- Vegetated Swale. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. Rhode Island Stormwater Design and Installation Standards Manual- Grass Channel. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Flow-Through Devices

Including Hydrodynamic Separators, Oil/ Particle Separators and Water Quality Inlets

Manufactured Separators

Several manufacturers offer a number of proprietary flow-through stormwater treatment devices. These devices are variously referred to as “oil/ particle separators,” “oil/ grit separator,” or “hydrodynamic separators.” Some of these devices use multiple chambers arranged horizontally or vertically to help trap and retain sediments and floating substances. Some use internal components to promote a swirling flow path to help enhance removal and retention of sediment.

These flow-through devices are normally sited close to the source of stormwater runoff, often receiving stormwater from relatively small areas that are mostly, if not entirely, impervious surface. They may only be used as pre-treatment of stormwater prior to discharge to other treatment SCMs.

Because stormwater runoff is detained briefly in conventional separators, only moderate removal of coarse sediments, oil and grease can be expected. Soluble pollutants, fine-grained sediment, and pollutants attached to the sediment such as trace metals or nutrients will likely pass through the separator.

With their comparatively small size and underground installation, they can be conveniently located to facilitate access for inspection and maintenance. However, given their limited capacity they require frequent maintenance. Also, because they are enclosed underground structures, selection, design, and installation should consider whether maintenance activities will be subject to confined-space safety procedures.

Water Quality Inlets

A water quality inlet is an underground storage structure with multiple chambers, designed to capture coarse sediments, floating debris, and some hydrocarbons from stormwater runoff. Such inlet devices are typically used for pre-treatment of stormwater runoff prior to discharge to another treatment practice.

The devices use baffles with weirs or orifices to control flow and help capture sediment, and inverted baffles or hooded outlets to help capture floating materials. Depending on the design of the unit and the magnitude of peak flow events, the captured sediments may be subject to re-suspension and flushing from the device. Floating hydrocarbons captured in the unit can be removed for disposal during maintenance operations by skimming or by use of sorbent materials. Note, however, that hydrocarbons carried by stormwater frequently are dispersed in suspension or adsorbed to fine-grained sediment particles or organic materials, and may not necessarily be captured in the unit.

To limit potential for re-suspension of captured materials, the device is usually designed as an “off-line” unit sized for the Water Quality Flow (WQF). “Off-line” systems only receive design flows. Excess flows must be bypassed or conveyed by an upstream diversion structure, rather than “in-line” systems which receive all flows for treatment before the treatment system outlets. Larger storm events would then bypass the unit.

Which Design Elements are “State-of-the-Practice”?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

General Requirements Applicable to Flow-Through Devices

- Design devices according to manufacturer's recommendations based on the WQF to achieve required removal rate. This flow-based sizing method may not be applicable to certain manufactured treatment devices (MTDs). Any proposed MTD may require additional verification and should be designed and verified in accordance with Env-Wq 1508.11 or other relevant regulations.
- Refer to the Washington State Technology Assessment Protocol (TAPE) for information on how MTDs are rigorously verified in other states – TAPE also includes a list of approved devices and their anticipated performance based on approved design parameters (e.g., loading rates).
- Document that devices remove a minimum of 80 percent of U.S. Silica grade OK-110 at the WQF.

Design Considerations

- Flow-through units must be installed as an "off-line" device.
- Inspection and maintenance may require "confined space" safety procedures.
- Limited capacity for removal of fine sediment and dissolved contaminants, together with potential for re-suspension, may result in limited overall pollutant removal capability. The devices may only be used for pre-treatment.
- Designs will vary based on the MTD and specific system design requirements.

Design Guidance

Design Parameters

Parameter	Criteria
Water Quality Inlets	
Minimum Sump Depth	4 feet.
Minimum Chamber Storage (First and Second Chambers)	Greater than or equal to 400 cubic feet per acre of contributing impervious area.
Utility Access Holes	Each chamber must be accessible by separate utility access hole.
Required Chamber Arrangement	3 chambers.
Oil/ Particle Separators	
Minimum Sump Depth	4 feet.
Minimum Permanent Pool Storage Volume	Greater than or equal to 400 cubic feet per acre of contributing impervious area.
Utility Access Holes	Each chamber must be accessible by separate utility access hole.
Maximum Contributing Impervious Drainage Area	Less than or equal to 1 acre.
"Off-line" Configuration	Required.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- All MTDs shall provide utility access.
- Follow specific MTD maintenance guidelines.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Flow-Through Devices (Env-Wq 1508.15)
Pollutant Removal (AoT 1507.03)[3]	TSS Only
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	No

[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

[3] *All pre-treatment SCMs can be used to meet the pre-treatment requirements for certain SCMs as outlined in Env-Wq 1500, but cannot be used to meet the required 1-inch water quality volume.*

References

Environmental Protection Agency. *Stormwater Technology Fact Sheets: Hydrodynamic Separators*. EPA 832-F-99-017. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/.

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Water Quality Inlet, Oil/Grit and Oil/Water Separator*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Oil/Grit Separators, Proprietary Separators*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Oil/Grit Separator*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

New Hampshire Department of Environmental Services (NHDES). *Innovative Stormwater Treatment Technologies Best Management Practices Manual*. May 2002. Available at: https://scholars.unh.edu/cgi/viewcontent.cgi?article=1314&context=prep.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Water Quality Filters & Hydrodynamic Devices*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual- Proprietary Devices*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Schueler, T. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1987.

Schueler, T., P. Kumble, and M. Heraty. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1992. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Sediment Forebay

A sediment forebay is an impoundment, basin, or other storage structure designed to dissipate the energy of incoming stormwater runoff and allow for initial settling of coarse sediments. Forebays are used for pre-treatment of stormwater runoff prior to discharge into the primary water quality treatment SCM. Forebays are generally integrated into the design of larger stormwater management structures.

Which Design Elements are "State-of-the-Practice"?

The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:



- Guidance from the Southeast New England Program (SNEP) 2022 New England Stormwater Retrofit Manual recommends providing pre-treatment to enhance operation and maintenance of downstream SCMs. When overcoming space constraints, consider simple measures (i.e., deep sump catch basins, vegetated filter strips) even if they do not meet standard requirements. The goal is a viable and accessible pre-treatment access point for more regular maintenance and cleaning.
- Inspection of SCMs is recommended at least once annually (or more frequently if specified in the Maintenance Requirements section below) and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance.

General Requirements Applicable to All Sediment Forebays

- Provide a fixed vertical sediment marker to measure depth of accumulated sediment.
- Re-stabilize all disturbed areas upon completion of maintenance in accordance with approved plans.

Design Considerations

- Maintenance access must be provided.
- Embankment design must be engineered to meet applicable safety standards (see description of "**Detention Basin**").
- Exposed earth slopes and bottom of basin should be stabilized using seed mixes appropriate for soils, mowing practices, and exposure to inundation.
- Exit velocities from the forebay should be non-erosive using a level spreader, spillway, check dam, or other appropriate dissipation techniques.
- The bottom floor may be designed with a concrete pad or hardened bottom to aid in removal of accumulated sediment during maintenance.
- As an alternative to an earthen basin, an underground structure may serve as a forebay. However, use of fully enclosed structures must consider accessibility for inspection and cleaning.
- For guidance on sizing of riprap, refer to the Federal Highway Administration's *Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance- Third Edition*, Volume I and II (FHWA-NHI-09-111 and FHWA-NHI-09-112, Hydraulic Engineering Circular 23, 2009).

Design Guidance

Design Parameters

Parameter	Criteria
Forebay Volume	Greater than or equal to 10 percent of the Water Quality Volume (WQV) (varies by SCM per Env-Wq 1500).
Minimum Depth	2 feet.
Maximum Depth	6 feet.
Maximum Side Slopes	3h:1v.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Forebays help reduce the sediment load to downstream SCMs, and will therefore require more frequent cleaning.
- Inspect quarterly for sedimentation, debris accumulation, erosion, and other issues.
- Conduct periodic mowing of embankments (generally 2 times per year) to control growth of woody vegetation on embankments.
- Replace displaced riprap on spillways/ check dams.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.
- The floor and sidewalls of the forebay must remain stabilized.
- Remove debris from outlet structures at least once annually.
- Remove and dispose of accumulated sediment based on inspection.
- Accumulated sediment or debris must be removed when it reaches approximately 40 percent of the depth capacity.
- Install and maintain a staff gage or other measuring device, to indicate depth of sediment accumulation and level at which clean-out is required.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement	Sediment Forebay (Env-Wq 1508.12)
Pollutant Removal (AoT 1507.03)[3]	TSS Only
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	No

[1] *See **Chapter 4 (Design Criteria)** for more information.*

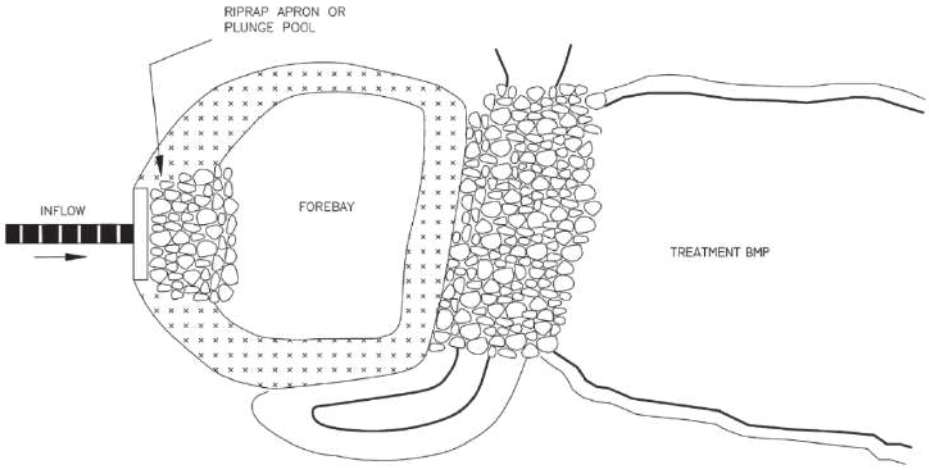
[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

[3] *All pre-treatment SCMs can be used to meet the pre-treatment requirements for certain SCMs as outlined in Env-Wq 1500, but cannot be used to meet the required 1-inch water quality volume.*

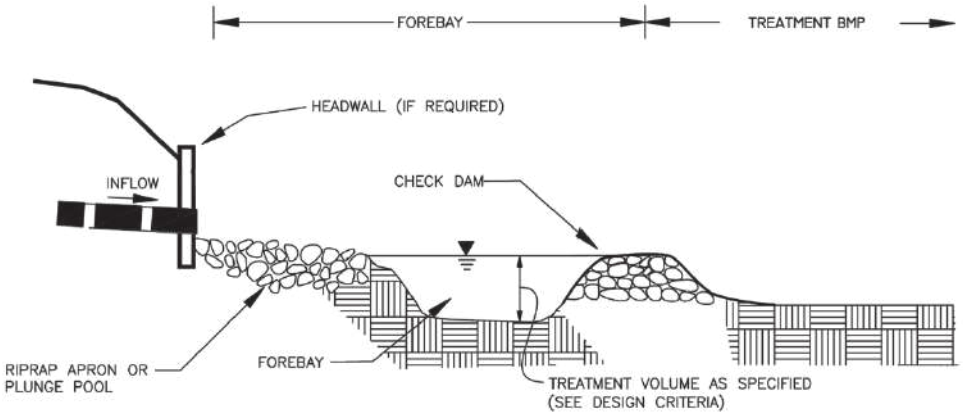
Example Design Schematic

Sediment Forebay

Plan



Profile



Adapted from MassHighway (2004)

References

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Sediment Forebay*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Sediment Forebay*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

MassHighway. *The MassHighway Storm Water Handbook For Highways and Bridges- Sediment Forebay, Outlet Sediment Trap*. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Schueler, T. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1987.

Schueler, T., P. Kumble, and M. Heraty. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1992. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Southeast New England Program (SNEP). *New England Stormwater Retrofit Manual*. VHB and UNHSC. 2022. Available at: https://snepnetwork.org/stormwater-retrofit-manual/.

Vegetated Filter Strip

Vegetated filter strips are gradually sloped areas of land with natural or established vegetation allowed to grow with minimal to no maintenance. They are designed to receive stormwater runoff as sheet flow. The vegetation slows stormwater runoff and allows water to infiltrate as sediments settle on the ground surface. A level spreader may be necessary to convert stormwater runoff to sheet flow as it enters the filter strip. Vegetation primarily consists of native grasses, but may be intermixed with shrubs or trees.

Vegetated filter strips may only be used as pre-treatment SCMs. See "Impervious Area Disconnection" fact sheet for information on vegetated buffers strips may be designed as a treatment SCM.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.
- Planting density guidelines.

General Requirements Applicable to Vegetated Filter Strips

- Vegetative cover type should be comprised primarily of native grasses, but may be intermixed with woody species (i.e., trees and shrubs). Vegetation planting density should be at least 80% to to increase infiltration and prevent soil erosion. See "Bioretention Systems" fact sheet for a planting guide of New England native species, including salt tolerant species.

Design Considerations

- Effectiveness of filter strips is dependent on shallow diffuse flow. Care is required to select or prepare the site, so that flow enters the filter strip as sheet flow and does not reconcentrate after entering the filter strip based on ground slope.
- The filter strip should be continuous for its entire length (flow path), not interrupted by other site features.
- Use salt tolerant vegetative cover that can withstand high flow velocities under wet weather conditions.

Design Guidance

Design Parameters

Parameter	Criteria
Maximum Length of Overland Flow to the Filter Strip	75 feet for impervious surfaces. 150 feet for pervious surfaces.
Maximum Longitudinal Slope	15 percent measured along flow path (*ideally no more than 6 percent*).
Minimum Longitudinal Slope	0.5 percent measured along flow path.
Minimum Filter Strip Length	25 feet measured along flow path.
Filter Strip Width	Equal to width of the area draining to the strip.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Inspect filter strip at least annually for signs of erosion, sediment buildup, or vegetation loss.
- Along the upper edge of the filter strip, the deposition of sediment may form a "berm" that obstructs flow into the filter area or concentrates flow. The filter strip and level spreader (if applicable) should be inspected at least annually to detect this condition, and accumulated sediment removed to restore sheet flow into the filter area.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.
- Provide periodic mowing as needed to maintain a healthy stand of herbaceous vegetation.
- Maintain trees in an undisturbed condition, unless erosion occurs.
- Fertilize only when necessary. Use fertilizers that do not contain phosphorus. In nitrogen impaired watersheds where a Total Maximum Daily Load (TMDL) has been established, use low nitrogen fertilizers (e.g., 5-0-5).
- If erosion occurs, eroded areas should be repaired and replanted with vegetation similar to the remaining buffer. Corrective action should include eliminating the source of the erosion problem, and may require retrofit with a level spreader.
- Remove debris and accumulated sediment based on inspection.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,3]

AoT Requirement[2]	Vegetated Filter Strips (Env-Wq 1508.13)
Pollutant Removal (AoT 1507.03)[3]	TSS Only
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	No

[1] *See **Chapter 4 (Design Criteria)** for more information.*

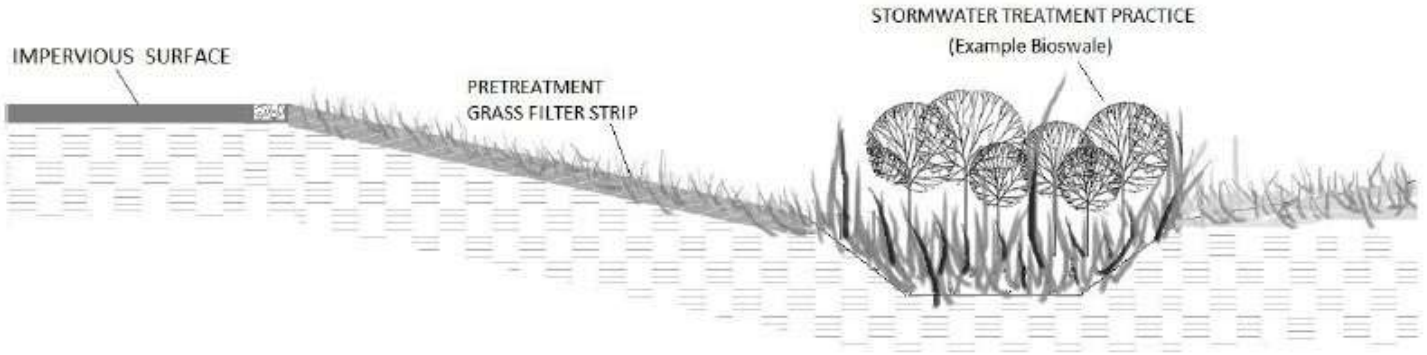
[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

[3] *All pre-treatment SCMs can be used to meet the pre-treatment requirements for certain SCMs as outlined in Env-Wq 1500, but cannot be used to meet the required 1-inch water quality volume.*

Example Design Schematic

Vegetated Filter Strip

Profile



VT ANR (2017)

References

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual.* Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Vegetated Filter Strips*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

MassHighway. *The MassHighway Storm Water Handbook For Highways and Bridges- Vegetated Filter Strip*. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual- Filter Strips*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Vermont Agency of Natural Resources (VT ANR). *Vermont Stormwater Management Manual Rule and Design Guidance. 2017*. Available at: https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/2017%20VSMM_Rule_and_Design_Guidance_04172017.pdf.

Structural Treatment

Bioretention Systems

Tier 1 Infiltrating Bioretention System and Infiltrating Bioretention System with Internal Storage Reservoir ("Hybrid" Bioretention System)

Tier 2 Filtering Bioretention System and Filtering Bioretention System with Internal Storage Reservoir

Bioretention systems collect stormwater runoff in a landscaped depression, where it ponds, filters through the engineered soil media, and infiltrates into the ground or is collected and discharged to the surface. Bioretention systems can reduce sediment, nutrients, oil and grease, and trace metals.

The major difference between bioretention systems and other filtration systems is the composition of the filter media and the use of vegetation. A typical surface sand filter is designed to be maintained with no vegetation, whereas a bioretention cell is planted with a variety of vegetation whose roots assist with pollutant uptake. The use of vegetation allows these systems to blend in with other landscaping features.

The primary types of bioretention systems are:

- **Infiltrating bioretention systems** have an elevated underdrain (or no underdrain) and are configured to infiltrate filtered stormwater runoff directly into the subsoil (preferred).
- **Filtering bioretention systems** have an underdrain that is installed in poor soils or is lined where infiltration is not desired (e.g., hot spot areas) such that limited or no infiltration is anticipated. The underdrain collects filtered stormwater runoff and conveys it to a discharge outlet.
- **Bioretention systems with internal storage reservoirs (ISR)** are designed to include a storage reservoir that remains in saturated conditions and creates an anoxic zone suitable for denitrification. Bioretention systems with ISR can be designed as infiltrating or filtering systems. Infiltrating bioretention systems with ISR are also called "hybrid" bioretention systems.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Elevated underdrains for infiltrating bioretention systems to enhance infiltration.
- 2021 UNHSC bioretention soil mix design specifications.
- May be used towards meeting the Watershed Protection Standard (see **Chapter 4.1**).
- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Bioretention areas are particularly adaptable to integration with site landscaping, and offer an aesthetically attractive opportunity to provide highly effective stormwater treatment.
- Bioretention areas can also be used to meet retention and recharge objectives to attain pre-development hydrological conditions.

- Avoid placing bioretention systems into service until it has been planted and its contributing areas have been fully stabilized.
- For bioretention systems with ISR, if a sediment forebay is used for pre-treatment, it should be designed to drain completely within 72 hours.
- Where ultimate discharge from the bioretention area is by infiltration into the subsoil, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
    - Avoid discharging sediment-laden waters from construction activities (stormwater runoff, water from excavations, etc.) to the bioretention area during any stage of construction.
    - Avoid driving on exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
- Key design parameters for bioretention systems such as soil media and plantings are an active area of research with the goal of optimizing for pollutant removal, infiltrating, and other functions.

Design Guidance

Design Parameters

Parameter	Criteria
Bioretention Volume	Size based on design criteria detailed in **Chapter 5**.
Watershed	Less than 5 acres of contributing drainage area.
Ponding Depth	Generally less than 12 inches, but should be designed for vegetation survival.
Depth of Bioretention Soil Mixture	Greater than or equal to 12 inches based on planned vegetation survival.
Bioretention Soil Mixture	UNHSC Design Specifications for soil mix (UNHSC, 2021).
Drain Time	Typically, less than 24 hours, but at least within 72 hours.
Underdrain (where required)	Greater than or equal to 8-inch diameter, perforated, elevated toward the top of the reservoir course to enhance infiltration.
Depth to Bedrock and Seasonal High-Water Table Elevation (SHWT)	Greater than or equal to 1 foot below the bottom of the system when a filter course is included. *Note*: More stringent separation requirements may apply within groundwater or water supply intake protection areas, areas with high pollutant loading, or other sensitive areas. Applicable regulations should be consulted.
Overflow Discharge Capacity	10-year, 24-hour storm.
Maximum Side Slopes	3h:1v.
Surface Covering	Minimum of 3 inches of organic material; covered in grasses or plantings.
Bioretention Systems with ISR	UNHSC Standard Detail, Bioretention ISR Stormwater System (UNHSC, 2020).
Planting Design	• Only native, non-invasive species. • Random and natural plant layout. • Vegetation should be drought tolerant. • Place trees or large shrubs along the perimeter to establish a perimeter tree canopy with an understory of shrubs and herbaceous plants. No woody vegetation should be used near inflow locations. • Vegetation over bioretention soil mixture should be able to withstand periodic inundation, as determined by a certified wetland scientist or landscape professional. • Additional planting resources are listed in the references below.

Hybrid Bioretention Soil Media Components[1]

Media Type	Percent of Mixture by Volume
Sand (0.5 to 2.0 millimeters) (See specs in table below)	60 - 85
Loam or Topsoil	15 - 25
Organic Matter	3 - 8
Water Treatment Residuals or Iron Filings[2]	0 - 5

[1] Alternatively, use media specified in the Alteration of Terrain Rules, Env-WQ 1508.08(k).

[2] This is an amendment used for enhanced phosphorus adsorption.

Source: UNHSC Hybrid Bioretention Detail, 2020

Acceptable Particle Size Distribution of Hybrid Bioretention Soil Mix

Media Type	Sieve Number	Size (inches)	Size (millimeters)	Percent Passing
Coarse Sand	4	0.187	4.76	100
Medium Sand	10	0.079	2.00	95
Fine Sand	40	0.017	0.42	40 - 15
Silts	200	0.003	0.075	10 - 20
Clays	< 200	Pan	Pan	0 - 5

Source: UNHSC Hybrid Bioretention Detail, 2020

Internal Storage Reservoir Notes:

- Bioretention systems which harbor an anaerobic internal storage reservoir (ISR) for nitrogen removal.
- The ISR is separated by an impermeable PVC liner between the pea gravel and crushed stone layers.
- The PVC liner slopes away from the outlet towards the inlet to maximize storage retention and provide extra treatment/ filter time via plug flow through crushed stone.
- Follow sizing design guidelines for the subsurface gravel wetland specifications (UNHSC, 2022), which identified that the water volume in the ISR be at least 0.10*WQV, or 10 percent of the WQV.
- PVC liner thickness of 40 to 60 mil, preferably seamless. If seams are unavoidable, the seams should be sealed.

Source: UNHSC Hybrid Bioretention Detail, 2020

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Special attention should be given to maintenance in the first two years of operation as vegetation is established.
- Systems should be inspected at least twice annually and following any rainfall event exceeding 2.5 inches in a 24-hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Pre-treatment measures should be inspected at least twice annually, and cleaned of accumulated sediment as warranted by inspection, but no less than once annually.
- Trash and debris should be removed at each inspection.
- At least once annually, system should be inspected for drawdown time. If bioretention system does not drain within 72 hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore filtration function or infiltration function (as applicable), including but not limited to removal of accumulated sediments or reconstruction of the bioretention soil mixture.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.
- Refer to UNHSC Maintenance Guidelines and Resources, “Checklist for Inspection of Bioretention Systems/ Tree Filters” for an example inspection checklist.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement[3]	Bioretention System (Infiltrating)	Bioretention System (Filtering)	"Hybrid" Bioretention System [Bioretention System with ISR (Infiltrating)] (Env-Wq 1508.06)	Bioretention System with ISR (Filtering) (Env-Wq 1508.06)
Pollutant Removal (AoT 1507.03)	Yes	Yes	Yes	Yes
Groundwater Recharge (AoT 1507.04)	Yes	No	Yes	No
Channel Protection (AoT 1507.05)	Yes	Yes	Yes	Yes
Peak Runoff Control (AoT 1507.06)	Yes	Yes	Yes	Yes

[1] *See **Chapter 4 (Design Criteria)** for more information on sizing calculations.*

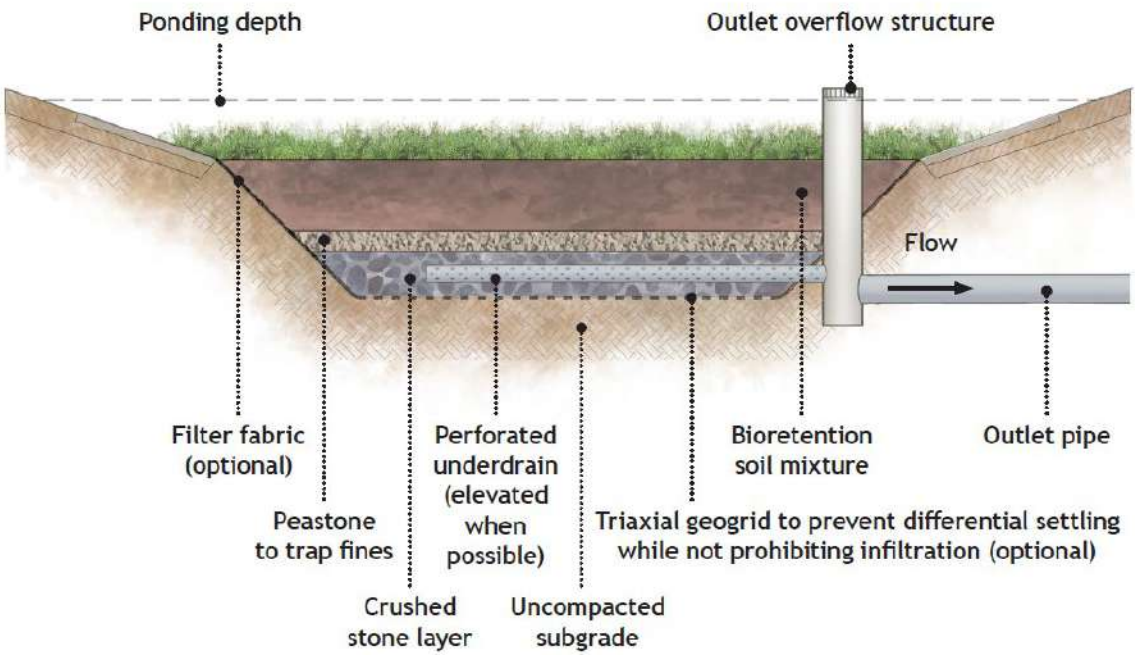
[2] *Refer to Env-Wq 1508.07 Infiltration Practices/ Env-Wq 1508.08 Filtering Practices for all SCM AoT requirements.*

[3] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematics

Bioretention System

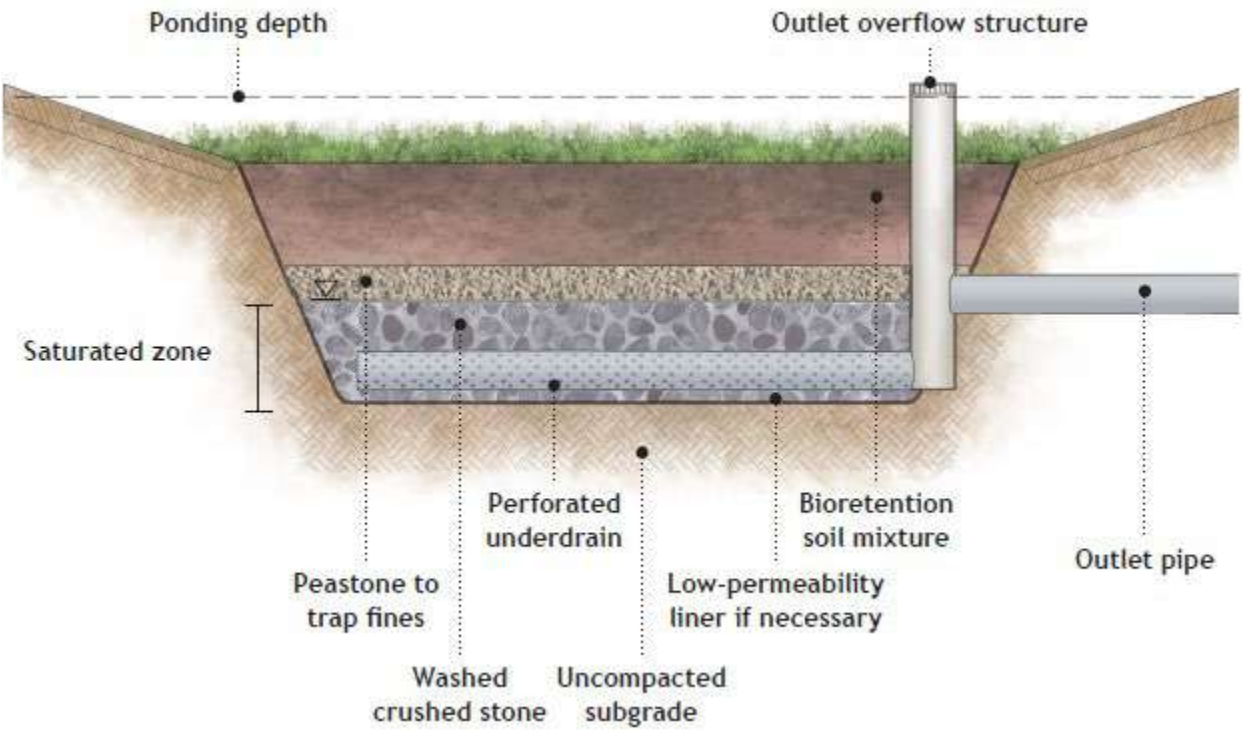
Profile



Reproduced from SNEP (2022) with permission

Bioretention System with ISR

Profile



Reproduced from SNEP (2022) with permission

Planting Guidance for Bioretention Areas

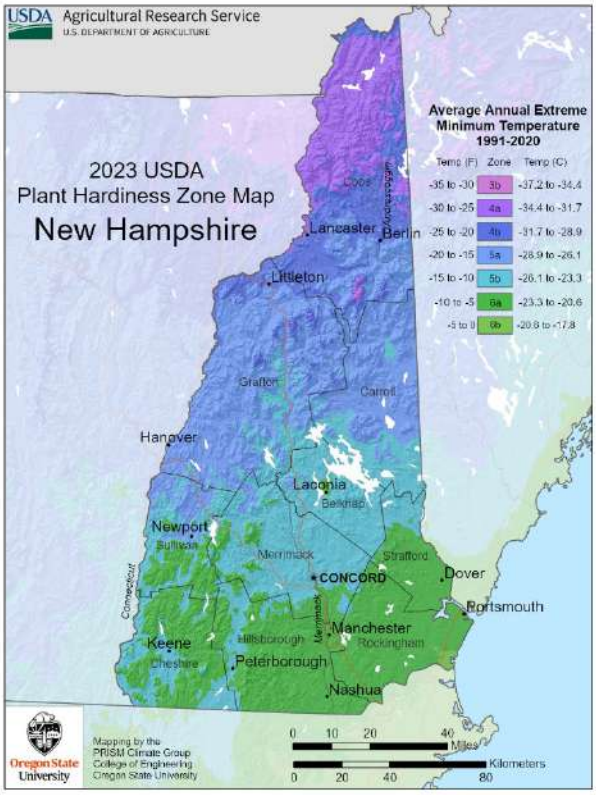
When selecting species for bioretention areas (and other SCMs that include plantings such as raingardens, buffer zones, etc.), general considerations include the following:

- It is important to select **species that are well-suited to the expected hydrology** of the site. For example, species planted in center of a bioretention area should be able to withstand periodic inundation, while those planted on the upper margins should be drought-tolerant.
- To **select native species** that are appropriate for the regional climate, check the USDA Plant Hardiness Zone Map to see what planting zone the site is in. The hardiness zones in New Hampshire range from 3b in the north country to 6b on in the southeast and on the coast.
- Consider using a **mix of species** with varied height, texture, and color to add visual interest.
- What is the desired **plant size at maturity**? Although some shrub and small tree species can be easily pruned to maintain a desired size, consider how frequently such maintenance will be performed, or if there are other aesthetic considerations (such as maintaining views).

  Although larger trees may be suitable for some settings, make sure the site design (soil depth) can accommodate the full depth of the root zone at maturity, and that trees would not pose a potential risk to nearby structures, parking areas, etc.
- **Salt tolerance**: For bioretention areas that receive runoff from areas where salt is used for winter de-icing, special attention should be given to selecting salt-tolerant species. Look for the "salt-tolerant" icon in the table below.



- **Wildlife considerations**: In addition to their function within a bioretention area, plantings can benefit wildlife by providing food sources and habitat. However, it is also important to select species that will not be destroyed by wildlife and require replacement. For example, if deer are common in site vicinity, select deer-resistant species. For shoreline plantings in areas where beavers are present, avoid woody species that are preferred by beavers, such as birch, aspen, alder, and willows.
- To help **ensure plant survival**, water immediately after planting, and then water weekly (if there is no significant rainfall) or as needed based on weather conditions during the first growing season. More frequent watering may be needed during hot weather.



USDA Plant Hardiness Zone Map

Additional resources:

Native Plants for New England Rain Gardens

The Vermont Rain Garden Manual

The Native Plant Trust – Go Botany

USDA Plants Database

Notes:

This list is not comprehensive and was developed by reviewing plant characteristics through various resources.

Rain garden plants should be able to tolerate periods of inundation during storms and dry periods between storms.

Bioretention Planting List

The species list below is adapted primarily from Rain Gardens: A Way to Improve Water Quality (University of Massachusetts Extension) and Native Plants for New England Rain Gardens (University of New Hampshire Extension), with additional information from the USDA Plants Database and The Native Plant Trust - Go Botany. This list includes examples of native species that are recommended for use in bioretention areas in New Hampshire, but is not intended to be a comprehensive list of all suitable species.

Symbol Key			
			
Full Sun	Partial Sun	Shade	Salt Tolerant

Type	*Scientific Name* Common Name	Sun Exposure	Soil Moisture	Mature Height	USDA Hardiness Zone	Comments
Trees	***Acer rubrum*** red maple		dry to wet	40'-60'	3-9	Shallow root system; attractive red flowers and fruit; tolerates moist or dry sites; red/yellow/orange fall color.
	Betula nigra river birch		dry to wet	40'-70'	4-9	Adaptable to wide range of moisture conditions; beautiful peeling bark; yellow fall color.
	Carpinus caroliniana American hornbeam		moist	20'-30'	3-9	Tolerates sun if soil is moist; tolerates periodic flooding; unique fluted silver-gray bark; yellow, red, or orange fall color.
	Fraxinus pennsylvanica green ash		moist to wet	50'-70'	3-9	Fast-growing tall tree; tolerates a wide range of soil conditions and sun exposure; provides food and cover for various birds.
	Nyssa sylvatica tupelo/black gum		dry to wet	40'-70'	3-9	Tolerates seasonal flooding or dry, rocky uplands; blue-black berries eaten by birds; brilliant scarlet fall foliage.
Shrubs	***Amelanchier canadensis*** Canada serviceberry		dry to moist	15'-25'	4-7	Tall shrub (or small tree) with white flowers and reddish fruit in early summer; adaptable to many soil types and moisture conditions.
	Arctostaphylos uva-ursi bearberry		dry to moist	1'-2'	2-6	Low-growing evergreen, tolerant of variable moisture conditions; requires acidic soil; shiny leaves, red berries. Best suited for upper margin of bioretention areas.
	Aronia arbutifolia red chokeberry		dry to wet	6'-10'	4-9	White flowers in spring/summer; red fall foliage and bright red, edible berries in fall that persist into winter.
	Aronia melanocarpa black chokeberry		dry to wet	3'-6'	3-8	White flowers with red stamens; black berries persist in winter; dark purple-red fall color.

Type	*Scientific Name* Common Name	Sun Exposure	Soil Moisture	Mature Height	USDA Hardiness Zone	Comments
Shrubs	***Clethra alnifolia*** sweet pepperbush		dry to moist	6'-8'	4-9	Fragrant white flower spikes; yellow fall color; butterfly nectar plant; well-suited to lower planting zone for bioretention areas.
	Comptonia peregrina sweet fern		dry	2'-4'	2-6	Low-growing, deciduous shrub with sweet-scented, fern-like leaves; prefers acidic, sandy soil; best suited for upper margins/berms of bioretention areas.
	Hamamelis virginiana common witch hazel		dry to moist	15'-20'	3-8	Spice-scented yellow flowers begin blooming in fall; tolerates irregular flooding or dry sites; yellow fall color.
	Ilex glabra inkberry		dry to wet	6'-12'	5-9	Slow-growing evergreen; greenish-white flowers and black-blue fruits; tolerates wet soils; periodic pruning recommended.
	Ilex verticillata winterberry holly		moist to wet	6'-10'	3-9	White flowers; yellow fall color; both male and female needed for scarlet berries; tolerates wet soil; best suited for lowest/wettest portions of a bioretention area.
	Morella caroliniensis small bayberry		dry	5'-10'	2-9	Small, fragrant waxy berries.
	Physocarpus opulifolius common ninebark		dry to wet	5'-8'	2-8	Purple-leaved cultivars are popular; tolerates clay soils.
	Rhus aromatica fragrant sumac		moist	2'-6'	3-9	Use "Gro-lo" cultivars only, as others are too large; prefers acidic soils.
	Salix discolor pussy willow		moist to wet	20'-40'	3-8	White flowers; silky gray catkins; provide a critical source of pollen for native bees that emerge early in the season.
	Salix humilis small pussy willow		dry to moist	4'-8'	3-8	Vibrant green shrub with green catkins; deer resistant; attracts bees.
	Sambucus canadensis common elderberry		dry to wet	4'-12'	3-9	Large white flower clusters; purple berries eaten by a wide range of birds and mammals; fast-growing.
	Swida amomum silky dogwood		moist to wet	6'-12'	4-8	Clusters of blue berries in summer.
	Swida racemosa gray dogwood		moist to wet	10'-15'	4-8	Creamy, white flowers and berries in late summer.
	Swida sericea red osier dogwood		moist to wet	6'-10'	3-8	White flowers; blue or white berries; red/maroon fall color; scarlet twigs in winter; highly adaptable.

Type	*Scientific Name* Common Name	Sun Exposure	Soil Moisture	Mature Height	USDA Hardiness Zone	Comments
Shrubs	***Vaccinium angustifolium*** lowbush blueberry		dry to wet	6'-12'	2-5	Does well in acidic, poor soil; small edible blueberries; attractive bronze/red fall foliage.
	Vaccinium corymbosum highbush blueberry		wet	6'-12'	3-7	Prefers acidic soil; large blueberries and good fall color.
	Viburnum dentatum arrowwood		dry to moist	5'-10'	3-8	Creamy white flowers; blue berries; crimson fall color.
	Viburnum lentago nannyberry		dry to moist	14'-20'	2-8	Tall shrub with arching branches; white flowers in spring and black berries in late summer/ fall; attractive fall color.
	Viburnum opulus Cranberrybush		moist to wet	6'-10'	2-7	Densely branched shrub with creamy white flowers; edible red berries in fall that persist in winter; scarlet fall foliage.
Perennials / Grasses	***Actaea racemosa*** black cohosh/bugbane		moist	3'-6'	3-9	Flowers in large, white spikes; attracts pollinators.
	Ageratina altissima white snakeroot		moist to wet	2'-3'	4-9	Summer blooms of long lasting, fuzzy white flower clusters; attracts pollinators.
	Andropogon gerardii big bluestem		dry to moist	3'-5'	3-8	Clumping perennial grass with purplish, tassel-like flowers; tolerant of acid soil, sandy soil, flooding, and drought.
	Aquilegia canadensis red columbine		moist	1'-2'	3-9	Flowers attract bees, hummingbirds, and butterflies; red flowers in late spring/early summer.
	Asclepias incarnata swamp milkweed		moist to wet	2'-4'	3-9	Pink blooms in midsummer; butterfly nectar plant; monarch butterfly larval host plant.
	Asclepias tuberosa butterfly milkweed		moist to wet	2'-4'	3-9	Orange summer blooms; monarch butterfly larval host; plant on a dry berm or upper margins of bioretention area.
	Chelone glabra white turtlehead		moist to wet	2'-3'	3-9	White snapdragon type flowers; good fall bloomer; attracts butterflies and hummingbirds; best suited for lowest/wettest portions of a bioretention area.
	Dennstaedtia punctilobula hay-scented fern		dry to moist	1'-3'	3-8	Spreads rapidly; fragrant, light-green foliage turns yellow in fall.
	Dryopteris marginalis marginal wood fern		dry to moist	1'-3'	3-8	Fern with a leathery blue-green frond; spring fiddleheads are golden brown and furry.

Type	*Scientific Name* Common Name	Sun Exposure	Soil Moisture	Mature Height	USDA Hardiness Zone	Comments
Perennials / Grasses	***Eupatorium perfoliatum*** common boneset		moist to wet	2'-5'	3-8	Prefers soil with relatively high organic matter content; excellent for attracting pollinators; deer and rabbit resistant.
	Eurybia divaricata white wood aster		dry to moist	1'-3'	3-8	Good for dry shade or moist woods; white flowers attract butterflies.
	Eutrochium purpureum sweet Joe Pye weed		moist to wet	5'-8'	3-9	Huge, dusty-pink flowers attract bees, birds, and butterflies; good fall color.
	Gentiana clausa meadow bottle gentian		moist to wet	1'-3'	3-8	Bottle-shaped blue-purple flowers that never truly open; attracts bees and butterflies.
	Geranium maculatum wild geranium, cranesbill		dry to moist	1'-2'	4-8	Showy pink flowers; very adaptable; important pollinator for native bees.
	Helenium autumnale *common sneezeweed*		wet	2'-5'	3-8	Orange and red colored cultivars available.
	Iris versicolor blue flag		moist to wet	2'-3'	2-7	Deep blue flowers; can grow with roots in water; best suited for placing at bioretention low spots or near inlet/outlet.
	Lobelia cardinalis cardinal flower		moist to wet	2'-3'	3-9	Will grows in full sun if kept moist; red flowers attract hummingbirds; best suited for placing at bioretention low spots. or near inlet/outlet.
	Lobelia siphilitica great blue lobelia		moist	2'-3'	4-9	Bell-shaped blue flowers remain in bloom for 3 to 4 weeks.
	Monarda fistulosa beebalm, wild bergamont		dry to wet	4'-5'	3-8	Many attractive cultivars are available in a variety of colors.
	Matteuccia struthiopteris fiddlehead fern, ostrich fern		moist to wet	4'-5'	2-8	Plants form colonies by underground rhizomes; tall arching fronds; best suited for placing at bioretention low spots or near inlet/outlet.
	Osmunda cinnamomea cinnamon fern		moist to wet	2'-4'	3-10	Grows in clumps with cinnamon-colored fronds; needs constant moisture if in sun; best suited for placing at bioretention low spots or near inlet/outlet.
	Osmunda regalis royal fern		moist to wet	3'-6'	3-10	A tall, clump-forming fern producing a large rosette of bright green fronds; best planted in partial shade, but will grow in sun with ample moisture.
	Panicum virgatum switch grass		dry to moist	3'-6'	3-9	Attractive and adaptable grass; tolerates flooding; airy seed heads in summer.

Type	*Scientific Name* Common Name	Sun Exposure	Soil Moisture	Mature Height	USDA Hardiness Zone	Comments
Perennials / Grasses	***Penstemon digitalis*** Foxglove, beardtongue		moist to wet	1.5’	3-8	Reseeds freely.
	Rudbeckia laciniata cutleaf coneflower		moist to wet	3'-6'	3-9	Spreads vigorously from rhizomes.
	Schizachyrium scoparium little bluestem		dry to moist	3'-4'	3-9	Attractive native grass, blooms in August; dense root system; tolerant of poor soils.
	Solidago spp. goldenrod		dry to moist	18" – 6'	*Varies by species*	Over 20 *Solidago* species native to New England; yellow/golden late season color.
	Soreghastrum scoparium little bluestem		moist to wet	5’-7’	2-9	Caution, may spread by seed.
	Symphyotrichum laeve smooth aster		dry to moist	2'-4'	3-9	Pale blue flowers attract birds, bees, and butterflies.
	Symphyotrichum novae-angliae New England aster		moist to wet	2'-3'	4-8	Nectar source for butterflies; important pollinator plant in late fall.
	Symphyotrichum novi-belgii New York aster		moist to wet	3'	4-8	Purple flower with orange centers; attracts bees.
	Tiarella cordifolia foam flower		moist	1'	3-8	Attractive groundcover with spikes of foamy white flowers in spring.
	Verbena hastata blue vervain		moist to wet	3’-5’	3-9	Tall blue/purple flower spikes which bloom from summer through fall; attract birds, bees, and butterflies.
	Vernonia noveboracensis New York ironweed		moist to wet	4’-6’	5-8	Good nectar source for monarch butterflies; best suited for placing at bioretention low spots or near inlet/outlet.
	Zizia aurea Golden alexanders		moist to wet	1’-2’	4-9	Good choice for heavy, clay soils.

Planting Resources:

- Cornell University Woody Plants Database. https://woodyplants.cals.cornell.edu/plant/158
- Dirr, Michael. Various titles.
- Lady Bird Johnson Wildflower Center. https://www.wildflower.org/
- The Native Plant Trust. https://www.nativeplanttrust.org/
- University of New Hampshire Extension. Native Plants for New England Rain Gardens. https://extension.unh.edu/sites/default/files/migrated_unmanaged_files/Resource005899_Rep8265.pdf
- USDA PLANTS Database. http://plants.usda.gov.

References and Resources

Environmental Protection Agency. *Stormwater Technology Fact Sheets: Bioretention*. EPA 832-F-99-012. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Bioretention Filters*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Bioretention Areas & Rain Gardens*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Bioretention Area and Bioretention Linear Practice*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Minnesota Pollution Control Agency. *Minnesota plant lists*. 2024. Available at: https://stormwater.pca.state.mn.us/index.php/Minnesota_plant_lists

NHDES. *Soak Up the Rain New Hampshire: New Hampshire Homeowner's Guide to Stormwater Management*. 2019. Available at: https://www.soaknh.des.nh.gov/sites/g/files/ehbemt741/files/documents/homeowners-guide-to-stormwater-management.pdf.

Southeast New England Program (SNEP). *New England Stormwater Retrofit Manual*. VHB and UNHSC. 2022. Available at: https://snepnetwork.org/stormwater-retrofit-manual/.

University of New Hampshire Stormwater Center (UNHSC). *Hybrid Bioretention System*. Treatment Unit Fact Sheet. 2020. Available at: https://scholars.unh.edu/stormwater/73/

University of New Hampshire Stormwater Center (UNHSC). *Design Specifications for Bioretention Soil Mix.* 2021. Available at: https://scholars.unh.edu/stormwater/75/

University of New Hampshire Stormwater Center (UNHSC). *2009 Biannual Report*. Durham, NH. 2009. Available at: https://scholars.unh.edu/stormwater/76/

Rain Gardens: A Way to Improve Water Quality *(University of Massachusetts Extension)*

Native Plants for New England Rain Gardens *(University of New Hampshire Extension)*

USDA Plants Database

The Native Plant Trust – Go Botany

Infiltration Basin

Tier 1 Infiltration Basin and Subsurface Infiltration Chamber

Infiltration basins are impoundments designed to temporarily store stormwater runoff, allowing all or a portion of the water to infiltrate into the ground. An infiltration basin is designed to completely drain between storm events.

An infiltration basin is specifically designed to retain and infiltrate the entire Water Quality Volume. Some infiltration basins may infiltrate additional volumes during larger storm events, but many will be designed to release stormwater exceeding the water quality volume from the larger storms. In a properly sited and designed infiltration basin, water quality treatment is provided by stormwater runoff pollutants binding to soil particles beneath the basin as water percolates into the subsurface. Biological and chemical processes occurring in the soil also contribute to the breakdown of pollutants. Infiltrated water is used by plants to support growth, or it is recharged to the underlying groundwater.

As with all impoundment SCMs, surface infiltration basins should be designed with an outlet structure to pass peak flows during a range of storm events, as well as with an emergency spillway to pass peak flows around the embankment during extreme storm events that exceed the combined infiltration capacity and outlet structure capacity of the facility.

A subsurface infiltration chamber (i.e., basin) is specifically designed to retain and infiltrate the entire Water Quality Volume. Subsurface infiltration basins may comprise a subsurface reservoir and can include a distribution system with associated crushed stone storage bed, or specially designed chambers (with or without perforations) bedded in or above crushed stone.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- May be used towards meeting the Watershed Protection Standard (see **Chapter 4.1**).
- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Maintenance access must be provided.
- Pre-treatment is essential to the long-term function of infiltration systems.
- Avoid placing infiltration practices in locations that cause water intrusion problems for down-gradient structures.
- Additional requirements applicable to systems that infiltrate stormwater and that would contribute to groundwater recharge are listed in Env-Wq 1508.07.
- Proprietary subsurface infiltration chambers may be classified as Class V wells through the Safe Drinking Water Act Underground Injection Control (UIC) program and be subject to additional requirements (State: Env-Wq 404; Federal: 40 CFR 144-146).
- Filter fabric should be installed per manufacturer specifications.

- Preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Avoid discharging sediment-laden waters from construction activities (stormwater runoff, water from excavations) to permanent infiltration SCMs.
  - Avoid driving on exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
  - Avoid placing infiltration systems into service until the contributing areas have been fully stabilized.

Additional Considerations for Surface Infiltration Basins

- After the basin is excavated to the final design elevation, the basin floor should be assessed to match design expectations. If impacted, the subgrade can be scarified or deeply tilled with a rotary tiller or disc harrow to restore infiltration rates, followed by a pass with a leveling drag.
- Vegetation should be established immediately.

Design Guidance

Design Parameters

Parameter	Criteria
Surface and Subsurface Infiltration Basins	
Pre-treatment	Required unless receiving only roof runoff (see **Structural Pre-treatment**).
SCM Volume	Greater than or equal to the larger of WQV or GRV, depending on purpose of SCM excluding sediment forebay capacity, if present, and excluding infiltration occurring during the design event.
Slope of Basin Floor[1]	0 percent (flat).
Design Infiltration Rate	See **Chapter 4.4** for a discussion on selecting a design infiltration rate.
Drain Time	Less than 72 hours for complete drainage of the water quality volume.
Depth to Bedrock and to Seasonal High-Water Table Elevation	Greater than or equal to 3 feet from bottom of SCM, except: • Greater than or equal to 4 feet if within groundwater or water supply intake protection area. • Greater than or equal to 1 foot if stormwater runoff has been treated prior to entering the SCM.
Surface Infiltration Basins	
Layout	The pond perimeter should be curvilinear.
Maximum Side Slopes	3h:1v.
Minimum Side Slopes	20h:1v.
Infiltration Basin Floor Preparation	• 6-inch layer of coarse sand or 3/8-inch pea gravel, • Grass turf that can be inundated for at least 72 hours, or • Coarse organic material such as erosion control mix or composted mulch, that is tilled into the soil, soaked, and allowed to dry.
Design Discharge Capacity	50-year, 24-hour storm with adequate freeboard to avoid overtopping.
Subsurface Infiltration Basins	
Infiltration Media Material	Clean, washed, uniform (well-sorted) aggregate. Diameter 1.5 to 3 inches. Porosity equal to 40 percent.
Design Overflow Discharge Capacity	10-year, 24-hour storm.
Observation Well	Well or utility access hole structure required.

[1] Instances where the surface slope is not flat (0 percent), the subgrade can be stair stepped so that it is flat, or berms can be incorporated every 25 feet to 100 feet to interrupt flow along the confining layer.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Removal of debris from inlet and outlet structures.
- Removal of accumulated sediment.
- Inspection and repair of outlet structures and accessories.
- Inspection of infiltration components at least twice annually, and following any rainfall event exceeding 2.5 inches in a 24-hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Inspection of pre-treatment measures at least twice annually, and removal of accumulated sediment as warranted by inspection, but no less than once annually.
- If an infiltration system does not drain within 72 hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore infiltration function, including but not limited to removal of accumulated sediments or reconstruction of the infiltration basin.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.

Additional Requirements for Surface Infiltration Basins:

- Periodic mowing of embankments.
- Removal of woody vegetation from embankments.
- Inspection and repair of embankments and spillways.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement[3]	Infiltration Basin	Subsurface Infiltration Basin
Pollutant Removal (AoT 1507.03)	Yes	Yes
Groundwater Recharge (AoT 1507.04)	Yes	Yes
Channel Protection (AoT 1507.05)	Yes	Yes
Peak Runoff Control (AoT 1507.06)	Yes	Yes

[1] *See **Chapter 4 (Design Criteria)** for more information.*

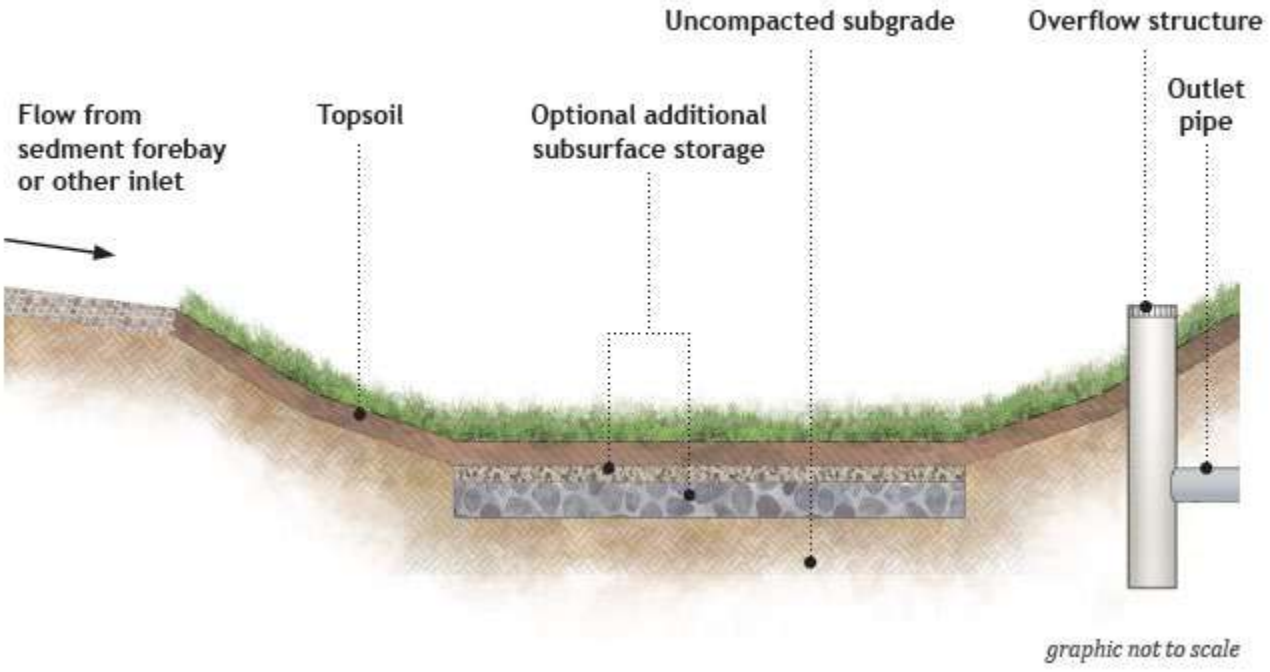
[2] *Refer to Env-Wq 1508.07 Infiltration Practices for all SCM AoT requirements.*

[3] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematics

Infiltration Basin

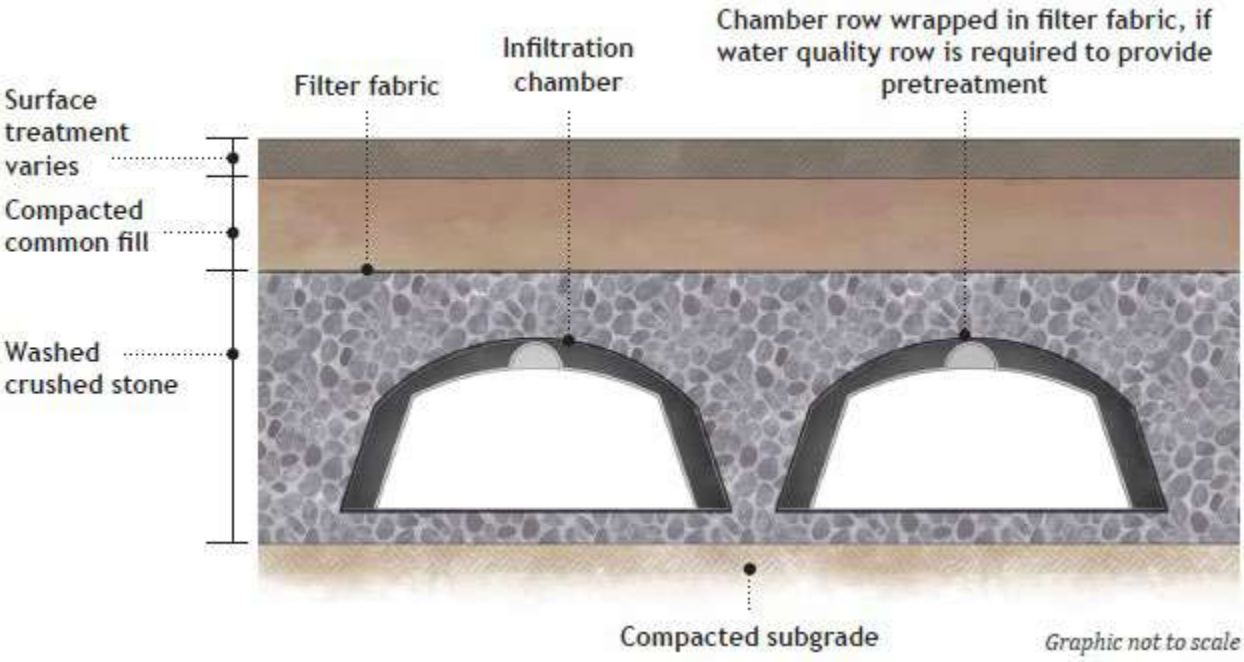
Profile



Reproduced from SNEP (2022) with permission

Subsurface Infiltration Chamber

Profile



Reproduced from SNEP (2022) with permission

References

Ferguson, B.K. *Stormwater Infiltration*. Lewis Publishers. Boca Raton, FL. 1994.

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Infiltration Basin*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Infiltration Basin and Infiltration Linear Practice/ Subsurface Infiltration System*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Infiltration Basin*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Infiltration Basin*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual- Stormwater Infiltration Practices*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Schueler, T. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1987.

Schueler, T., P. Kumble, and M. Heraty. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1992. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Southeast New England Program (SNEP). *New England Stormwater Retrofit Manual*. VHB and UNHSC. 2022. Available at: https://snepnetwork.org/stormwater-retrofit-manual/.

Vermont Agency of Natural Resources (VT ANR). *Vermont Stormwater Management Manual Rule and Design Guidance.* 2017. Available at: https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/2017%20VSMM_Rule_and_Design_Guidance_04172017.pdf

Infiltration Trench

Tier 1 Infiltration Trench

Tier 2 Roof Drip Edge (Infiltrating and Filtering)

An infiltration trench is a stone-filled excavation used to temporarily store stormwater runoff and allow it to infiltrate into surrounding, natural soil. Typically, stormwater runoff enters the trench as overland flow or piped inlet flow after designed pre-treatment. Installations around the perimeter of parking lots, between residential lots, and along roads are most common. Infiltration trenches can also be incorporated along the center of a vegetated swale to increase its infiltration ability. Infiltration trenches must have an observation well along the centerline for monitoring water levels and drawdown rates.

An infiltration drip edge is constructed like an infiltration trench, except that a drip edge intercepts only roof stormwater runoff, and does not require pre-treatment. Roof drip edges may be designed to act as a filtering practice or an infiltration practice as follows:

- **Filtering roof drip edges** do not infiltrate. They have an underdrain that captures and conveys stormwater runoff downstream. Filtering roof drip edges may be lined.
- **Infiltrating roof drip edges** are designed to provide infiltration.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Infiltration trenches may be used towards meeting the Watershed Protection Standard (see **Chapter 4.1**).
- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Maintenance access must be provided.
- Pre-treatment is essential to the long-term function of infiltration systems.
- Preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Avoid discharging sediment-laden waters from construction activities (stormwater runoff, water from excavations) to permanent infiltration SCMs.
  - Avoid driving upon exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
  - After the trench is excavated to the final design elevation, the floor should be deeply tilled with a rotary tiller or disc harrow to restore infiltration rates, followed by a pass with a leveling drag.

    - Avoid placing infiltration systems into service until the contributing areas have been fully stabilized.
- For aggregate, use clean, washed, well-sorted aggregate for infiltration media. The porosity of material provided for construction should be verified against the porosity specified by design.
- Infiltration trenches should have an emergency overflow channel to discharge stormwater runoff volume in excess of the design storm.
- Drip edges should extend the length of the building or area of roof.
- Drip edges are not recommended adjacent to buildings with foundation drains, as the intercepted stormwater runoff may adversely affect performance of the foundation drainage system. Also, if there is a foundation subdrain beneath the drip edge trench, the subdrain will likely prevent infiltration from occurring, by intercepting the flow and conveying it to discharge along with other foundation drainage.
- Drip edges require surface grading away from the foundation and robust waterproofing of basement walls to prevent the penetration of water into a basement.
- For more guidance on installing observation wells, see: Sprecher, S.W. 2008. Installing monitoring wells in soils (Version 1.0). National Soil Survey Center, NRCS, USDA, Lincoln, NE.
- Avoid placing infiltration practices in locations that cause water intrusion problems for down-gradient structures.
- Where infiltration is intended, filter fabric should be limited to the sides of the stone reservoir or be composed of a geotextile that will not prohibit infiltration. Where infiltration is not intended, a filter fabric or low-permeability liner can be provided below the filter media if necessary (SNEP, 2022).
- Additional requirements applicable to systems that infiltrate stormwater and that would contribute to groundwater recharge are listed in Env-Wq 1508.07.
- Infiltration trenches that are deeper than the widest surface dimension or that have a subsurface fluid distribution system may be classified as Class V wells through the Safe Drinking Water Act Underground Injection Control (UIC) program and be subject to additional requirements (State: Env-Wq 404; Federal: 40 CFR 144-146).

Design Guidance

Design Parameters

Parameter	Criteria
Pre-treatment	Required unless receiving only roof runoff (see **Structural Pre-treatment**).
Contributing Drainage Area	Less than 5 acres.
SCM Volume	Greater than or equal to the larger of Water Quality Volume (WQV) or Groundwater Recharge Volume (GRV), depending on purpose of SCM excluding sediment forebay capacity, if present, and excluding infiltration occurring during the design event.
Minimum Trench Depth	4 feet.
Maximum Trench Depth	10 feet.
Design Infiltration Rate	See **Chapter 4.4** for a discussion on selecting a design infiltration rate.
Drain Time	Infiltration trench: Less than 72 hours for complete drainage of the water quality volume. Roof drip edge: Storage volume needs to drain within 24 hours. An overflow should be provided.
Depth to Bedrock and Seasonal High-Water Table Elevation	Greater than or equal to 3 feet from bottom of SCM, except: • Greater than or equal to 4 feet if within groundwater or water supply intake protection area. • Greater than or equal to 1 foot if stormwater runoff has been treated prior to entering SCM.
Overflow Discharge Capacity	10-year, 24-hour storm.
Observation Well	Required along trench centerline.
Infiltration Material	Clean, washed, uniform (well-sorted) aggregate. Diameter 1.5 to 3 inches. Porosity equal to 40 percent.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5 inches in a 24-hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Pre-treatment measures should be inspected at least twice annually, and cleaned of accumulated sediment as warranted by inspection, but no less than once annually.
- If an infiltration system does not drain within 72 hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore infiltration function, including but not limited to removal of accumulated sediments or reconstruction of the infiltration trench.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement[3]	Infiltration Trench	Roof Drip Edge (Infiltrating)	Roof Drip Edge (Filtering)
Pollutant Removal (AoT 1507.03)	Yes	Yes	Yes
Groundwater Recharge (AoT 1507.04)	Yes	Yes	No
Channel Protection (AoT 1507.05)	Yes	No	No
Peak Runoff Control (AoT 1507.06)	Varies	Varies	Varies

[1] *See **Chapter 4 (Design Criteria)** for more information.*

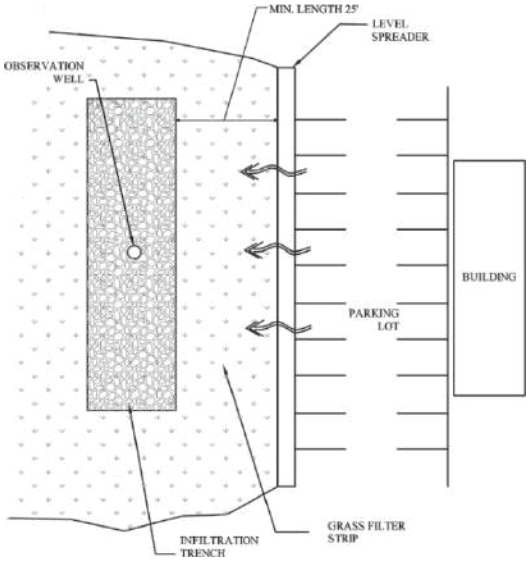
[2] *Refer to Env-Wq 1508.07 Infiltration Practices/ Env-Wq 1508.08 Filtering Practices for all SCM AoT requirements.*

[3] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

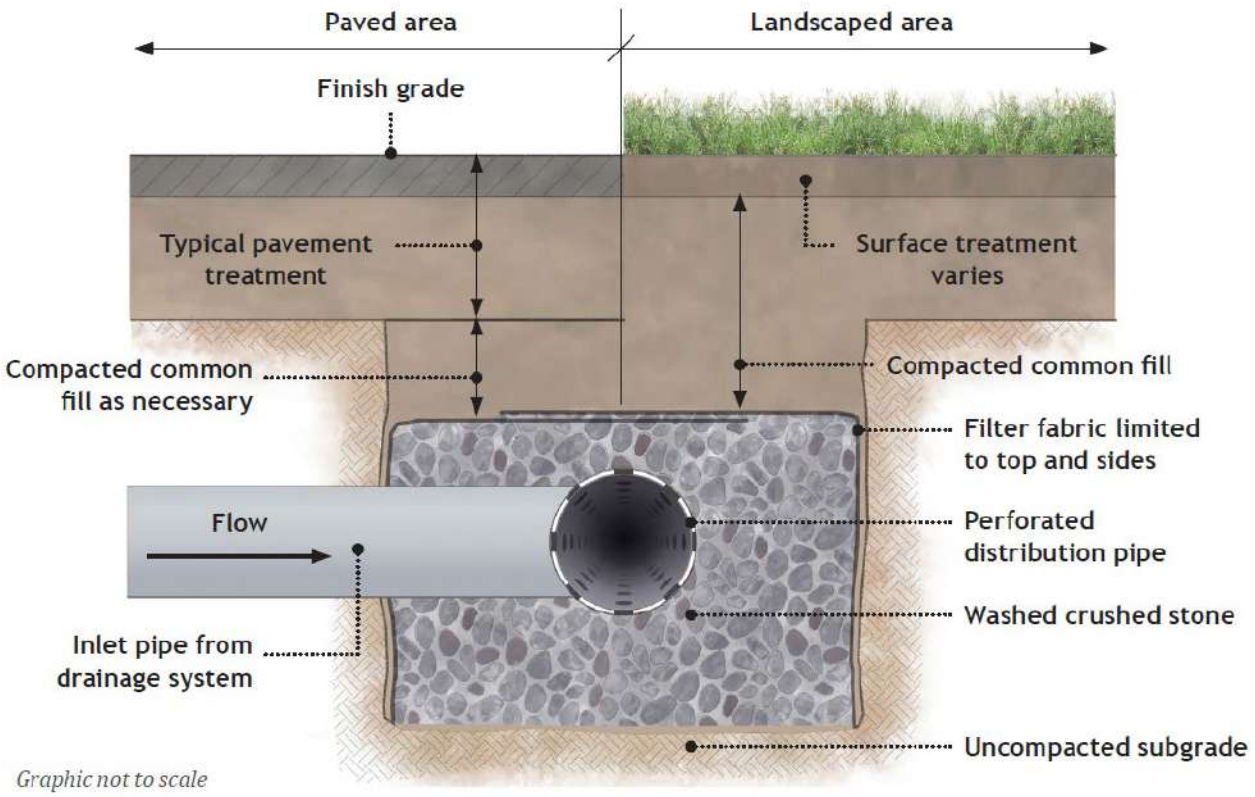
Infiltration Trench

Plan



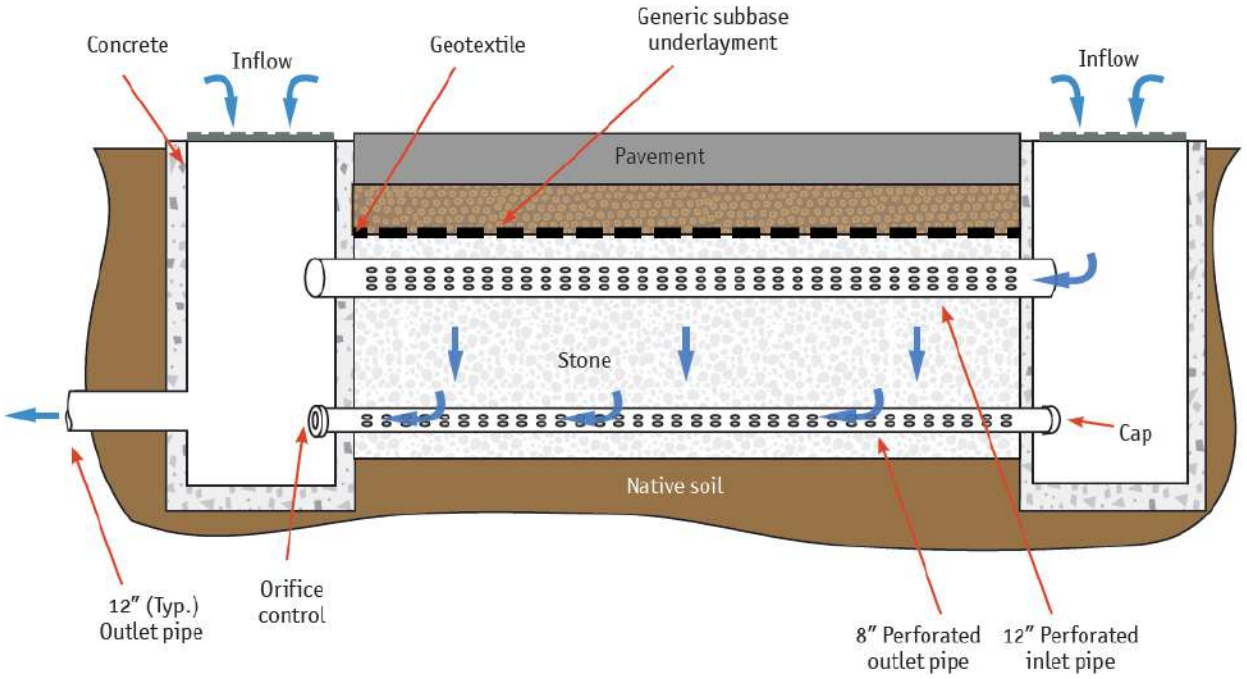
Adapted from ME DEP (2006)

Profile



Reproduced from SNEP (2022) with permission

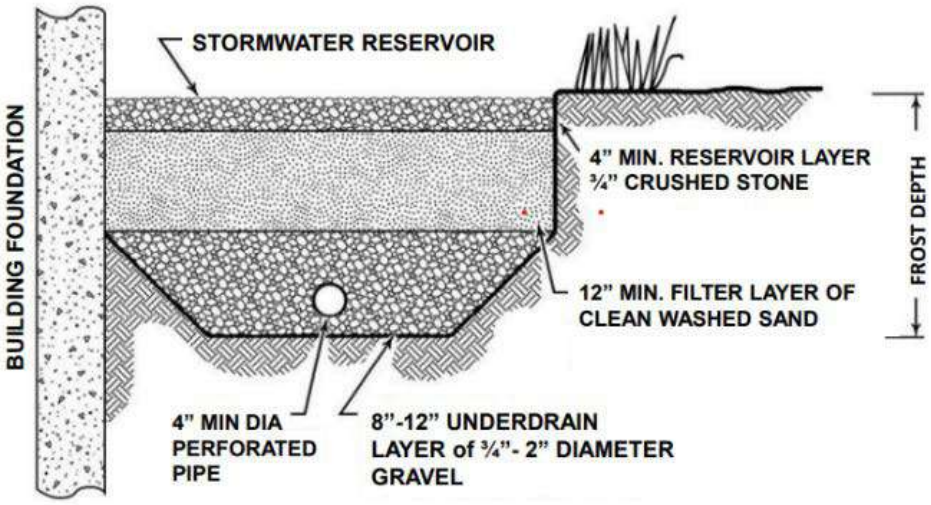
Design Detail



UNHSC, Generic Infiltration Trench Design Detail

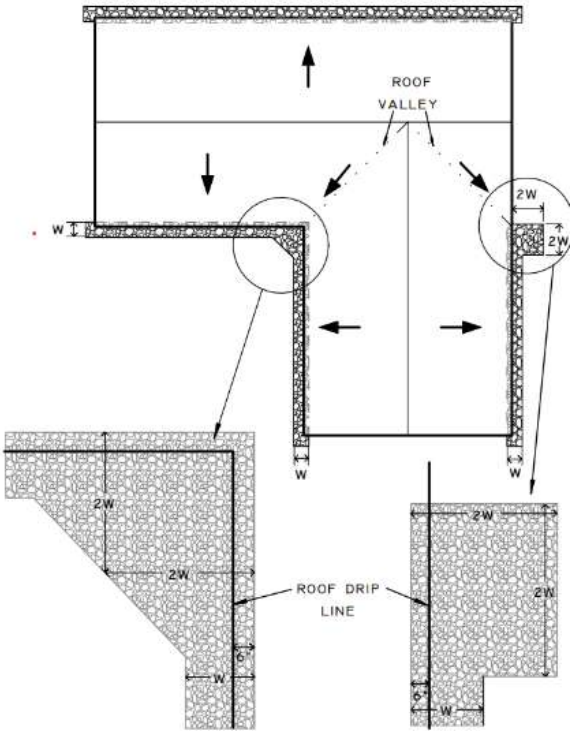
Roof Drip Edge

Profile



Adapted from Maine DEP (2016)

Example Dripline Filter



Adapted from Maine DEP (2016)

References

Ferguson, B.K. *Stormwater Infiltration*. Lewis Publishers. Boca Raton, FL. 1994.

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Infiltration Trench*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Infiltration Trench*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Infiltration Basin and Infiltration Linear Practice*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Infiltration Trench*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual- Stormwater Infiltration Practices*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Schueler, T. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1987.

Schueler, T., P. Kumble, and M. Heraty. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1992. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Southeast New England Program (SNEP). *New England Stormwater Retrofit Manual*. VHB and UNHSC. 2022. Available at: https://snepnetwork.org/stormwater-retrofit-manual/.

Sprecher, S.W. *Installing monitoring wells in soils (Version 1.0)*. NRCS, USDA, Lincoln, NE. 2008. Available at: https://forestrywebinars.net/webinars/planning-designing-and-installing-shallow-wells/Installing%20Monitoring%20Wells%20in%20Soils.pdf/at_download/file

UNHSC. *Generic Infiltration Trench Design Detail*. Available at: https://www.unh.edu/unhsc/sites/default/files/media/stormwater-infiltration-trench_200207.pdf.

Permeable Pavement

Tier 1 Infiltrating Permeable Pavement System

Tier 2 Filtering Permeable Pavement System

Permeable pavement consists of a permeable/pervious surface, base, and subbase materials which allow penetration of stormwater runoff into underlying soils. The surface materials for permeable pavement can consist of paving blocks or grids, porous asphalt, or pervious concrete. These materials are installed on a base which serves as a filter and or reservoir course between the pavement surface and the underlying subbase material. The subbase material typically comprises of a layer of crushed stone that not only supports the overlying pavement structure, but also serves as a reservoir to store stormwater runoff that penetrates the pavement surface until it can percolate into the ground.

Porous asphalt is very similar to conventional asphalt except that it is mixed without particles smaller than coarse sand. Without these smaller size particles, water can pass through the surface and into a crushed stone storage area. An advantage to the use of porous asphalt is the reduced need for stormwater conveyance systems and other additional SCMs.

Pervious concrete uses carefully controlled amounts of water and cementitious materials to create a thick coating around aggregate particles, but retaining significant void space in the placement of the mixture. A pervious concrete mixture contains little or no sand, creating this void content.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- 2016 UNHSC porous media design specifications.
- The recommended ratio of total contributing area to area of pervious surface is 1:1. For larger ratios, additional inspection and maintenance may be required to prevent clogging at areas of run on.
- To meet SCM Tier 1 and Watershed Protection Standard (see **Chapter 4.1**) criteria, permeable pavement must be infiltrating.
- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Frequently, permeable pavements filter only the stormwater runoff generated on the pavement surface itself. However, stormwater runoff from other areas can be directed to permeable pavement if properly designed. Stormwater runoff generated from adjacent areas of the site may require pre-treatment prior to discharge to the pavement surface, or require more frequent maintenance activities, to prevent clogging of the pavement structure and (where the pavement is used to infiltrate as well as filter the stormwater runoff) the underlying soils.
- Care must be taken during construction to assure preparation of subgrade, placement of aggregates, and installation of pavements meets design specifications.

- On sloping pervious pavement surfaces, stair stepping subgrade or including impermeable trench berms should be considered within the filter and reservoir courses to minimizing flow laterally within the pavement courses. The berm should be sized to a depth necessary to retain the stormwater for sufficient time to infiltrate and prevent raveling along the confining layer (typically every 25 feet to 100 feet).
- Where infiltration is provided by the design, the preservation of infiltration function by underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
    - Avoid discharging sediment-laden waters from construction activities (stormwater runoff, water from excavations) into areas designated for permeable pavement.
    - Prevent stormwater from other areas of the site from flowing onto the completed permeable pavement until those areas have been fully stabilized.

Design Guidance

Design Parameters

Parameter	Criteria
Maximum Ratio of Total Contributing Area to Area of Pervious Surface	5:1.
Porous Asphalt Design	University of New Hampshire Stormwater Center. *UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds*. Durham, NH. September 2016.
Pervious Concrete Design	American Concrete Institute, 522, 1-20, *Specification for Pervious Concrete Pavement*, 2020.
Pervious Concrete Installation	University of New Hampshire Stormwater Center. *UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds*. Durham, NH. September 2016.
Permeable Interlocking Paver Design	Interlocking Concrete Pavement Institute (2022) (icpi.org).
Filter Course Material	Bank run gravel, manufactured sand, or modified 304.1.
Filter Course Thickness	Varies based on pollutant removal. See EPA Performance Curve for Permeable Pavement.
Total Section Thickness	65 percent of the frost depth. Typically, the frost depth in New Hampshire is about 48 inches. Therefore, total section thickness (top of pervious pavement to the native ground) should be at least 32 inches.
Aggregate Storage Volume (Reservoir Course, Filter Blanket, Filter Course, Choker Course)	Greater than or equal to the larger of WQV or Recharge Volume, depending on purpose of SCM and excluding infiltration occurring during the design event.
Recommended Drain Time	24 to 48 hours.
Underdrain (where required)	8-inch minimum perforated HDPE or PVC, elevated in the reservoir as much as possible (minimum of 4 inches) from bottom.
Depth to Bedrock and Seasonal High-Water Table Elevation	Provide a minimum of 1 foot of separation between the bed bottom and the seasonal high groundwater elevation and bedrock if a filter layer is included, otherwise a 3-foot separation is required.
Overflow Discharge Capacity	10-year, 24-hour storm.
Overflow Outlet	Provide overflow from aggregate storage layer.
Observation Well(s)	Necessary to monitor conditions in reservoir course.

Gradations of choker, filter, and reservoir course materials

	Percent Passing			
US Standard Sieve Size (inches/ millimeters)	**Choker Course (AASHTO No. 57/ No. 67[1])**	**Filter Course (Manufactured Sand/ Modified NHDOT 304.1)**	**Reservoir Course (AASHTO No. 3)**	**Reservoir Course Alternative[2] (AASHTO No. 5)**
6/150	-	100	-	-
2.5/63	-	-	100	-
2/50	-	-	90 - 100	-
1.5/37.5	100	-	35 - 70	100
1/25	95 - 100	-	0 - 15	90 - 100
0.75/19	-	-	-	20 - 55
0.5/12.5	25 - 60	-	0 - 5	0 - 10
0.375/9.5	-	-	-	0 - 5
No. 4/4.75	0 - 10	70 - 100	-	-
No. 8/2.36	0 - 5	-	-	-
No. 200/0.075	-	0 - 6[3]	-	-

[1] Alternate gradations (e.g., AASHTO No. 67) may be accepted upon Engineer' approval.

[2] Alternate gradations (e.g., AASHTO No. 5) may be accepted upon Engineer's approval.

[3] Preferably less than 4 percent fines.

Source: UNHSC, 2016

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Provision of signs is recommended, to indicate locations of permeable pavements and the applicability of special maintenance measures.
- No winter sanding of permeable pavements is permitted.
- Minimize application of salt for ice control.
- Never reseal or repave with impermeable materials.
- Inspect annually for pavement deterioration or concrete spalling.
- Monitor periodically to ensure that the pavement surface drains effectively after storms.
- For permeable pavements, clean periodically (one to two times per year) using a vacuum sweeper. Note, permeable surface selection will likely lead to different maintenance sensitivities and approaches.
- For vegetated paver systems, periodically reseed grass pavers to fill in bare spots.
- Major clogging may necessitate restoration or replacement of pavement surface.
- Refer to UNHSC Maintenance Guidelines and Resources, "Checklist for Inspection of Permeable Pavement" for an example inspection checklist.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement[3]	Permeable Pavement (Infiltrating)	Permeable Pavement (Filtering)
Pollutant Removal (AoT 1507.03)	Yes	Yes
Groundwater Recharge (AoT 1507.04)	Yes	No
Channel Protection (AoT 1507.05)	Yes	Yes
Peak Runoff Control (AoT 1507.06)	Yes	Yes

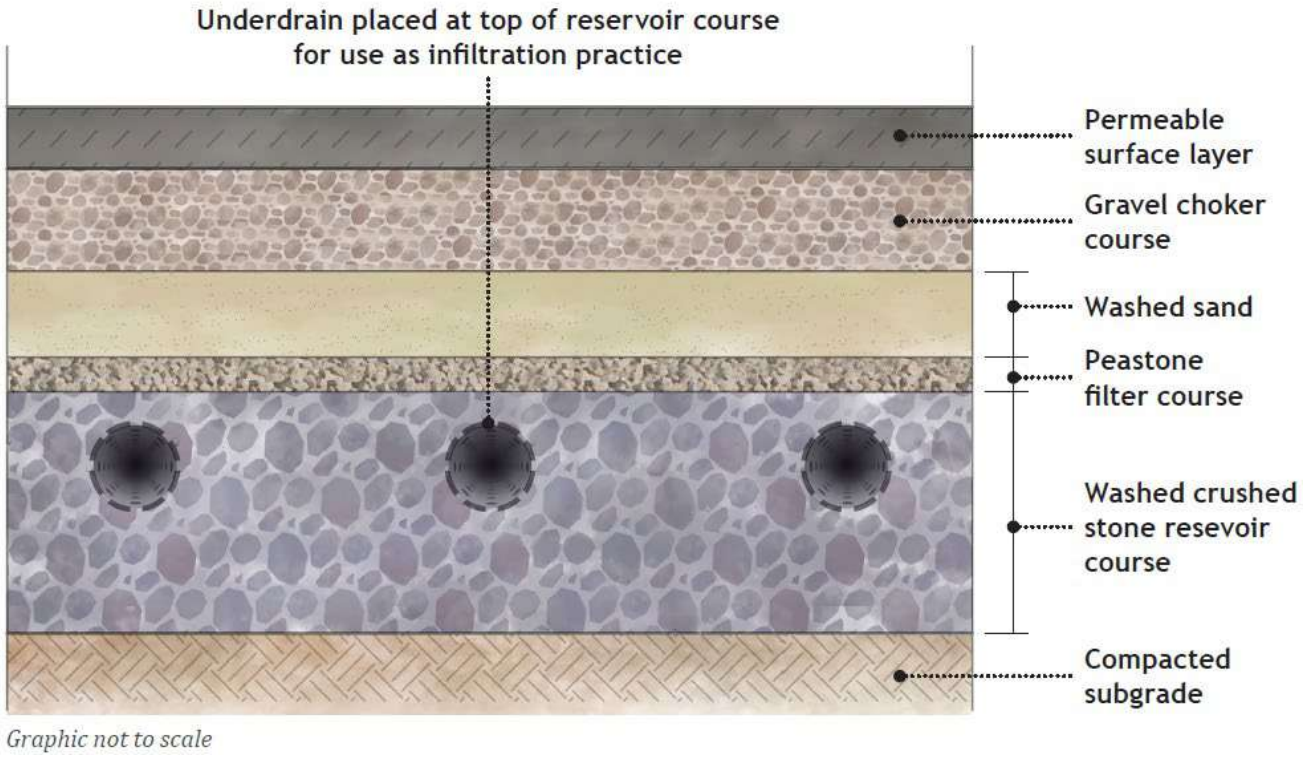
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *Refer to Env-Wq 1508.07 Infiltration Practices/ Env-Wq 1508.08 Filtering Practices for all SCM AoT requirements.*

[3] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

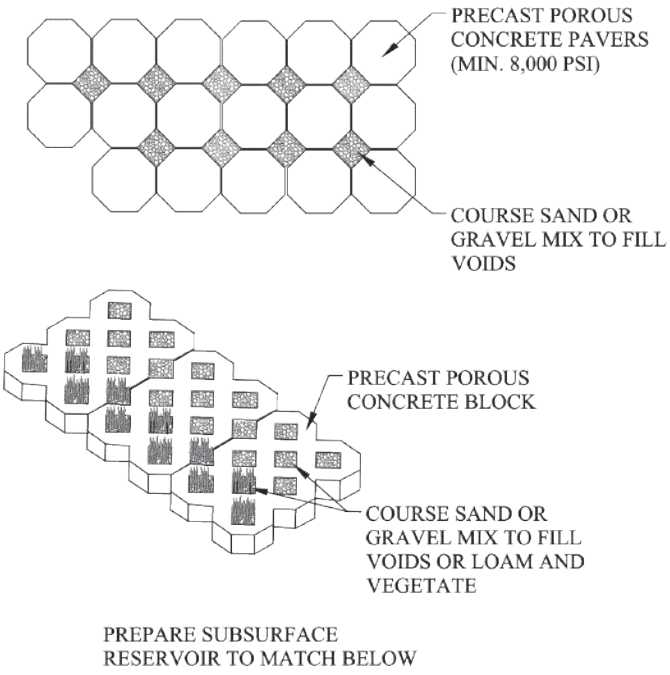
Permeable Pavement



Graphic not to scale

Reproduced from SNEP (2022) with permission

Permeable Concrete Pavers



Adapted from ME DEP (2006)

References

Maine Department of Environmental Protection (ME DEP). *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Manmade Pervious Surfaces*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Porous Pavement*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Pervious Pavement with Infiltration Bed*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Smith, D.R. *Permeable Interlocking Concrete Pavements (3rd ed.)*. Interlocking Concrete Pavement Institute. Washington, DC. 2006.

University of New Hampshire Stormwater Center. *UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds*. Durham, NH. September 2016. Available at: https://scholars.unh.edu/stormwater/13/

Dry Well and Leaching Basin

Tier 2

Dry wells consist of a small pit filled with stone, or a small structure surrounded by stone, used to temporarily store and infiltrate stormwater runoff from a limited contributing area. Stormwater runoff enters the structure through an inflow pipe, inlet grate, or through surface infiltration. The stormwater runoff is stored in the structure and/or void spaces in the stone fill. Properly sited and designed dry wells provide treatment of stormwater runoff as pollutants become bound to the soils under and adjacent to the well, as the water percolates into the ground. The infiltrated stormwater contributes to recharge of the groundwater table.

Dry wells are well-suited to receive roof runoff via building gutter and downspout systems. With the small size and manageable cost of these SCMs, they are particularly suited for use in subdivisions and for single family homes. When used for roof drainage, pre-treatment of stormwater runoff is not typically required.

Leaching basins are dry wells that allow for infiltration of stormwater runoff into the ground. The basin is set in an excavation lined with a geotextile and placed on a crushed stone pad. The excavation is back-filled with similar crushed stone. The base and barrel of the basin are perforated to allow for infiltration. They are used in well drained soils for the discharge of roadway or parking area stormwater runoff. Pre-treatment is required prior to discharge to the leaching basin. A typical arrangement is to use a deep sump, hooded catch basin in combination with a leaching basin. Leaching catch basins should be designed to be “off-line” because they are not meant to attenuate high inflows. “Off-line” systems only receive design flows, while excess flows must be bypassed and/ or conveyed by an upstream diversion structure to an SCM designed for peak rate control. “In-line” systems receive all flows for treatment before the treatment system outlets.

Dry wells, leaching basins, and similar devices should meet the design criteria applicable to subsurface infiltration basins.

Which Design Elements are “State-of-the-Practice”?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Design considerations for geotextiles and inlet grates.
- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Pre-treatment is essential to the long-term function of infiltration systems.
- Preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Avoid discharging sediment-laden waters from construction activities (stormwater runoff, water from excavations) to permanent infiltration SCMs.
  - Avoid driving upon exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
  - Avoid placing infiltration systems into service until the contributing areas have been fully stabilized.

- The stone surrounding the basin may need to be encapsulated by filter fabric designed to prevent migration of fine soil particles into void spaces in the stone (see fabric placement guidance for infiltration systems).
- The inlet grate shall be sized based on the contributing drainage area, to ensure that the flow rate does not exceed the capacity of the grate.
- Dry wells must be equipped with an overflow structure in compliance with Env-Wq 1507.02(d).
- Avoid placing infiltration practices in locations that cause water intrusion problems for down-gradient structures.
- Additional requirements applicable to systems that infiltrate stormwater and that would contribute to groundwater recharge are listed in Env-Wq 1508.07.
- Dry wells that are deeper than the widest surface dimension or that have a subsurface fluid distribution system may be classified as Class V wells through the Safe Drinking Water Act Underground Injection Control (UIC) program and be subject to additional requirements (State: Env-Wq 404; Federal: 40 CFR 144-146).

Design Guidance

Design Parameters

Parameter	Criteria
Pre-treatment	Required unless receiving only roof runoff (see **Structural Pre-treatment**).
Contributing Drainage Area	Less than 1 acre. For roadways, the tributary area for each catch basin will be much less than this, based on typical spacing of basins along a roadway.
SCM Volume	Greater than or equal to the larger of WQV or GRV, depending on purpose of SCM and excluding infiltration occurring during the design event.
Design Infiltration Rate	See **Chapter 4.4** for a discussion on selecting a design infiltration rate.
Drain Time	Less than 72 hours for complete drainage of the WQV or GRV depending on purpose of SCM.
Depth to Bedrock and to Seasonal High-Water Table Elevation	Greater than or equal to 3 feet from bottom of SCM, except: • Greater than or equal to 4 feet if within groundwater or water supply intake protection area. • Greater than or equal to 1 foot if stormwater runoff has been treated prior to entering the SCM.
Infiltration Material	Clean, washed, uniform (well-sorted) aggregate. Diameter 0.75 to 3 inches. Porosity equal to 40 percent.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Removal of debris from inlet and outlet structures.
- Removal of accumulated sediment.
- Inspection and repair of outlet structures and accessories.
- Inspection of infiltration components at least twice annually, and following any rainfall event exceeding 2.5 inches in a 24-hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- If an infiltration system does not drain within 72 hours following a rainfall event, a qualified professional should assess the condition of the facility to determine measures required to restore infiltration function, including but not limited to removal of accumulated sediments or reconstruction of the system.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement[3]	Dry Well	Leaching Catch Basin
Pollutant Removal (AoT 1507.03)	Yes	Yes
Groundwater Recharge (AoT 1507.04)	Yes	Yes
Channel Protection (AoT 1507.05)	No	No
Peak Runoff Control (AoT 1507.06)	Varies	Varies

[1] *See **Chapter 4 (Design Criteria)** for more information.*

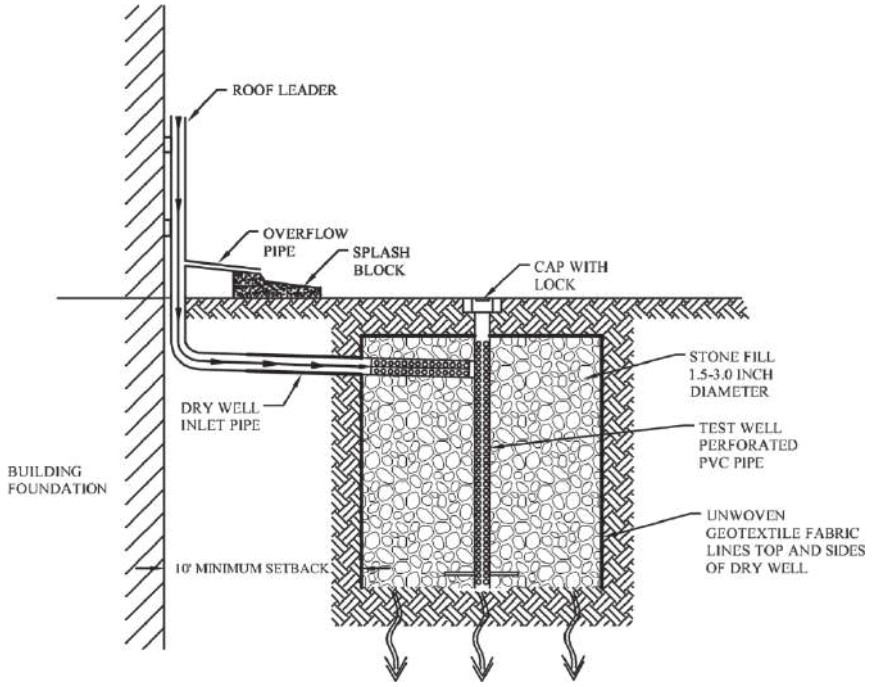
[2] *Refer to Env-Wq 1508.07 Infiltration Practices for all SCM AoT requirements.*

[3] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematics

Dry Well

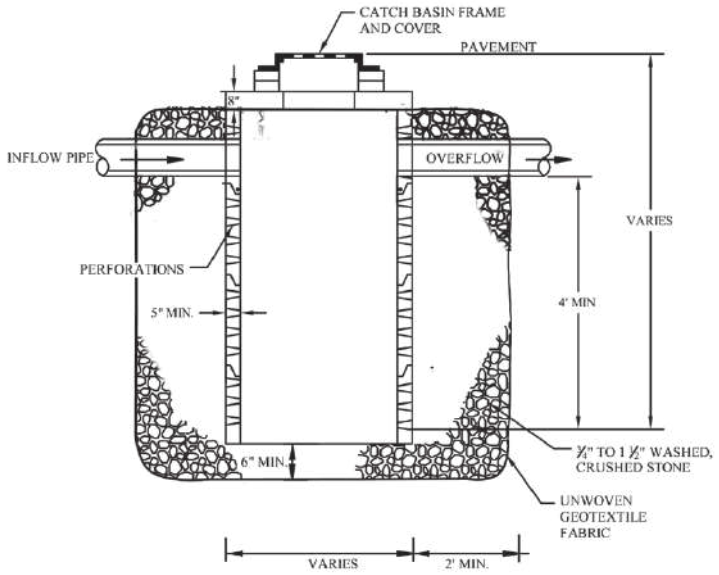
Profile (Residential)



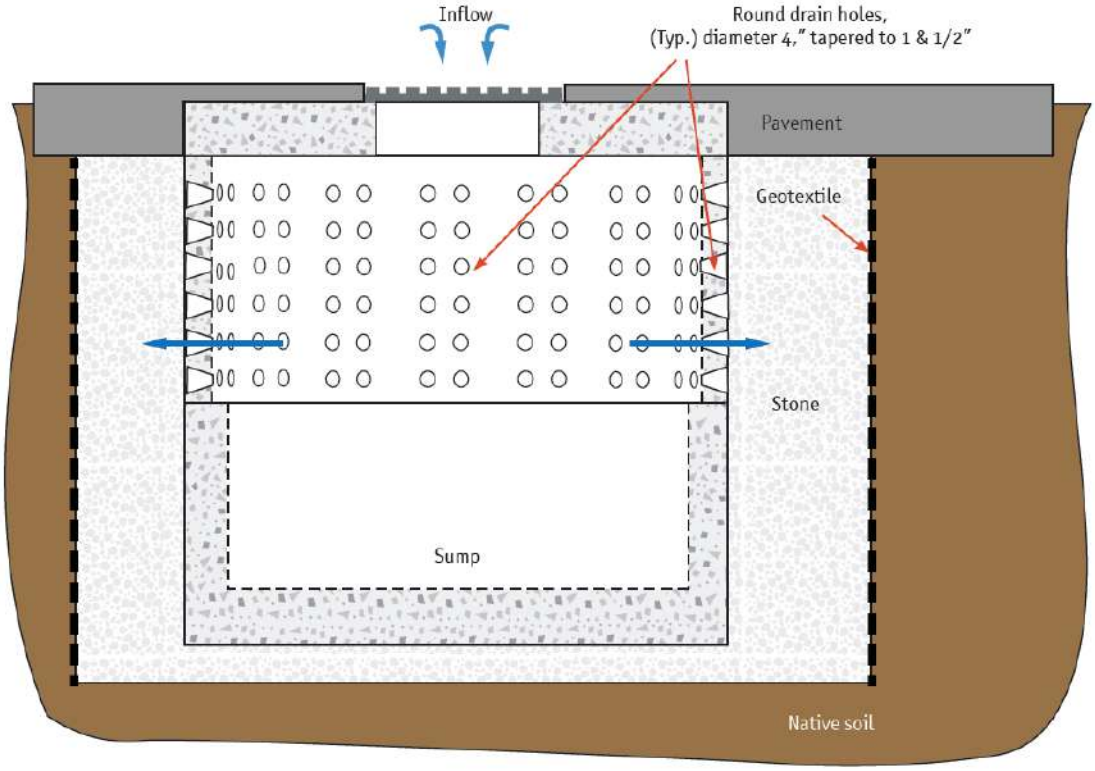
Adapted from RI DEM (1993)

Leaching Basin

Profile



Adapted from ME DEP (2006)



UNHSC, Generic Leaching Catch Basin Design Detail

References

Maine Department of Environmental Protection. *Maine Erosion and Sediment Control BMPs- Dry Well*. Publication No. DEPLW0588. Original print 2003. Revised March 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Dry Wells, Leaching Catch Basins*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Leaching Basin*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual- Stormwater Infiltration Practices*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

UNHSC. *Generic Leaching Catch Basin Design Detail*. Available at: https://www.unh.edu/unhsc/sites/default/files/media/stormwater-leaching-catchbasin191219final.pdf.

Gravel Wetland

Tier 2

The gravel wetland system consists of one or more flow-through constructed wetland cells, preceded by a pre-treatment structure. The cell(s) are filled with a gravel media, supporting an organic substrate that is planted with wetland vegetation. During low-flow storm events, the system is designed to promote subsurface horizontal flow through the gravel media, allowing contact with the root zone of the wetland vegetation. The gravel and planting media support a community of soil microorganisms. Water quality treatment occurs through microbial, chemical, and physical processes within this media. Treatment may also be enhanced by vegetative uptake and microbial activity.

To accommodate higher flows, the system is designed to permit ponding over the wetland surface, allowing the system to function similar to other constructed wetland or detention systems. Overflow from the wetland is provided by an outlet structure designed for this “extended detention” condition. Following such an event, remaining water on the surface of the wetland infiltrates through engineered inlets into the gravel media, and flows horizontally through the media as in the low-flow condition.

The wetland is designed to sustain a saturated zone, called the internal storage reservoir, that typically begins 4 inches below the treatment surface, consistent with the invert elevation of the primary system outlet. This design permits anaerobic denitrification treatment and wetland vegetation growth. The gravel media consists of either crushed rock or processed gravel. An organic soil layer is placed on top of this material, and wetland plants are rooted in the media where they directly take up pollutants.

The system can be designed to integrate some stormwater storage and extended detention but generally does not provide infiltration unless specifically designed (see "**Hybrid Bioretention Systems**”). With these features, the practice would not only remove pollutants, but also contribute to attenuation of peak rates through temporary storage with minimal reduction in stormwater runoff volume through evapotranspiration. For more information on gravel wetland design, see the UNHSC Subsurface Gravel Wetland Design Specifications.

Which Design Elements are “State-of-the-Practice”?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Design considerations and parameters are based on the 2022 UNHSC Specifications (linked above).
- Updated design recommendations for 8-inch underdrains and plumbing for maintenance access.
- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Maintenance access must be provided.
- The system should be planted to achieve a dense vegetated area with rigorous root mat.
- The bottom of each treatment cell should be lined with an impermeable liner if located in higher hydrologic conductive soils (see "Hybrid Bioretention Systems" for design alternatives to such conditions).
- Pre-treatment measures are essential to prevent clogging of the gravel media and the pipe manifold system.
- An optional high-capacity outlet at equal elevation or lower to the primary outlet may be installed for maintenance purposes.
- See "Bioretention Systems" for a planting guide of New England native species, including salt tolerant species.

Design Guidance

Design Parameters

Parameter	Criteria
Pre-treatment	Required, 10 percent of WQV; see criteria for "Sediment Forebay."
Maximum Side Slopes	3h:1v.
Permanent Pool + Extended Detention Volume	At a minimum: 10 percent of the WQV in the sediment forebay and 45 percent of the WQV in each treatment cell if a 2-cell system is used.
Extended Detention Volume	Less than or equal to 50 percent of WQV.
Extended Detention Drawdown	24 to 48 hours.
Length to Width Ratio	3:1 minimum, applicable to each pond cell.
Minimum Horizontal Travel Distance	15 feet within the gravel layer of each cell for a 2-cell system or 30 feet for a single cell system.
Maximum Temporary Pool Depth	Less than or equal to 4 feet above permanent pool.
Design Discharge Capacity	50-year, 24-hour storm without overtopping and at least 1 foot of freeboard should be provided.
Embankment Design	See criteria for "Detention Basin."
Perforated Riser Pipe	8-inch perforated riser pipe.
Underdrain	8-inch perforated underdrain.
Primary Outlet	6-inch minimum located 4-8 inches below the wetland soil surface, open or vented.
Materials Cross Section	8 inches wetland soil, 3 inches pea gravel, 24 inches of 3/4-inch stone, optional liner.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Removal of debris from inlet and outlet structures.
- Inspection and removal of sediment accumulation in the gravel bed.
- Depending on sediment accumulation, bed may require periodic replacement and replanting.
- Inspection and repair of containment structure (if applicable), inlet and outlet structures, and accessories.
- Wetland vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.
- Refer to UNHSC Maintenance Guidelines and Resources, "Checklist for Inspection of Subsurface Gravel Wetland Systems" for an example inspection checklist.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Gravel Wetland (Env-Wq 1508.05)
Pollutant Removal (AoT 1507.03)	Yes
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	Yes
Peak Runoff Control (AoT 1507.06)	Yes

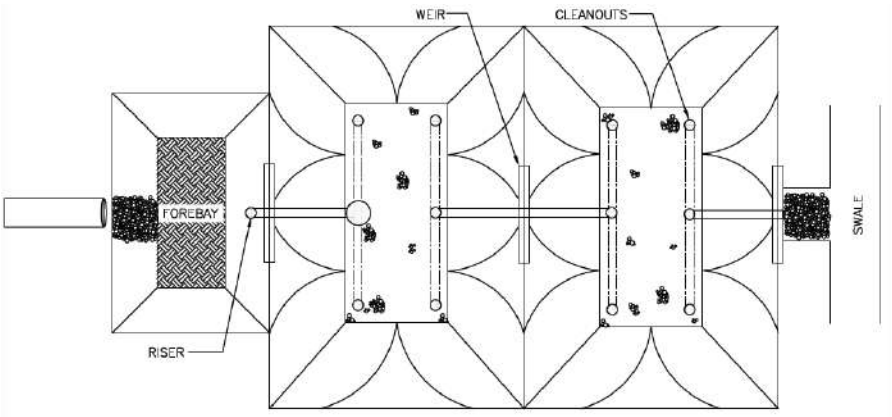
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

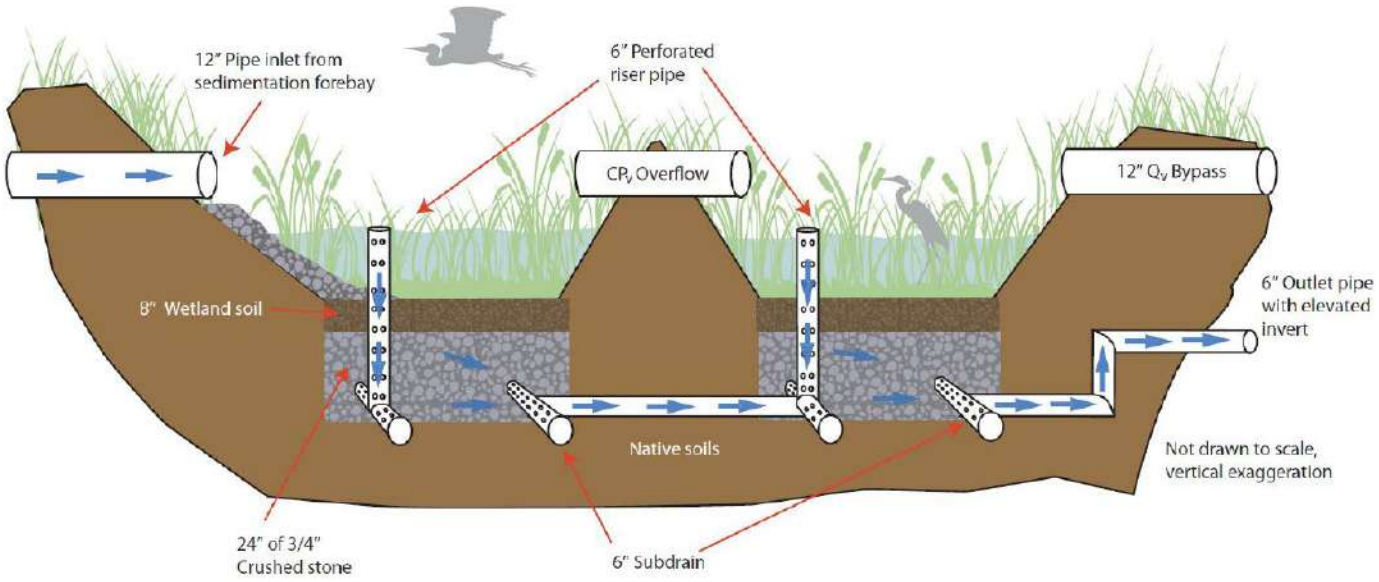
Gravel Wetland

Plan



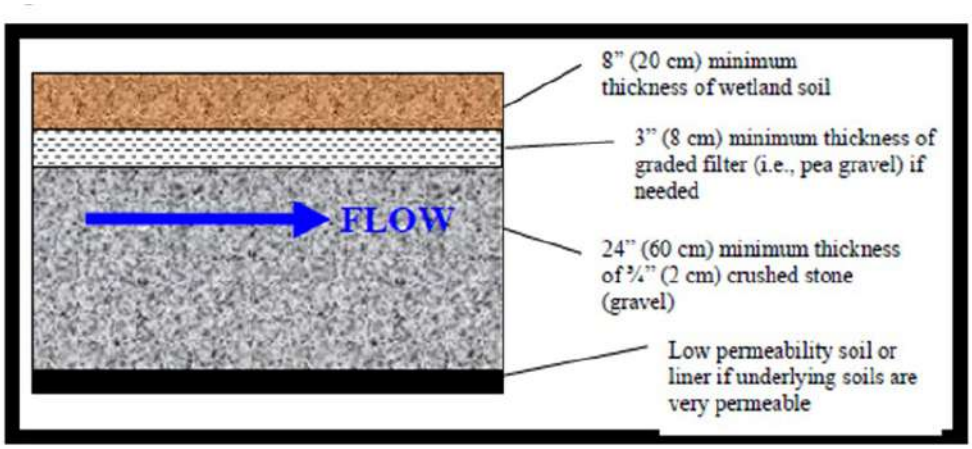
Adapted from UNHSC (2007)

Profile



Note: Updated design recommendations include 8-inch underdrains and plumbing for maintenance access.

Treatment Cell Profile



UNHSC (2022)

References

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Gravel Wetland*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

University of New Hampshire Stormwater Center. *Subsurface Gravel Wetland Design Specifications*. 2022. Available at: https://scholars.unh.edu/stormwater/74/

University of New Hampshire Stormwater Center. *Gravel Wetland*. Treatment Unit Fact Sheet. 2007.

Impervious Area Disconnection

Tier 2

Impervious area disconnection (also known as vegetated filter strips, vegetated buffers, residential and developed area buffers, and ditch turn-out buffers) involves changing flow patterns so that stormwater runoff that would otherwise discharge directly to the drainage system ("connected") will flow over pervious areas ("disconnected") providing infiltration and/ or treatment. Disconnection can be accomplished by removing excess impervious surfaces, directing runoff from impervious areas to flow over pervious areas (see discussion of vegetated buffers below), or storing runoff from impervious areas (see "**Rain Barrel/ Cistern**" fact sheet) and then slowly releasing it to pervious surfaces (also known as Impervious Area Disconnection through Storage). Impervious area disconnection can reduce surface discharge runoff volume and therefore, reduce associated pollutant loads to surface waters. Directing stormwater runoff from rooftops and impervious roads, driveways, and parking lots to pervious areas allows for additional pollutant reduction through either infiltration into the soil or filtration through vegetation and soils with sufficient time and reduced velocity. For more information on impervious area disconnection SCMs, refer to the SNEP 2022 New England Stormwater Retrofit Manual.

Which Design Elements are "State-of-the-Practice"?

The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:



- General guidance on impervious area disconnection beyond the use of vegetated buffers.
- Disconnection of impervious surfaces should be provided whenever possible.
- Use EPA Performance Curves to calculate pollutant removals based on the ratio of disconnected impervious area to the receiving pervious area (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.
- **Note**: There has been recent research on vegetated buffers and Impervious Area Disconnection, including recommended design characteristics and pollutant removal values. Examples include: SNEP 2022 New England Stormwater Retrofit Manual and https://bufferoptionsnh.org/.

General Requirements Applicable to Vegetated Buffers

- Buffers shall not be located in areas of RSA 482-A jurisdiction unless a wetlands permit has been issued.
- Buffers should not be interrupted by any intermittent or perennial stream channel or other drainage way.
- Project applicants should consider identifying buffers on plans and protected by deed restrictions, covenants, or both, to ensure the buffer remains in an unaltered state. If designed to meet AoT requirements, this must be done per Env-Wq 1508.10.
- For areas of higher impervious to pervious area ratios, additional structures such as level spreaders may need to be installed to ensure non-erosive sheet flow.
- All buffers should be vegetated with native or existing dense vegetation.

Design Considerations

- A soil evaluation must be performed to verify Hydrologic Soil Group (HSG) of the underlying soils in accordance with **Chapter 4** of this Manual. Ponding of water directed to a receiving pervious area must be avoided.
- The flow path through the receiving pervious area must comply with any applicable setbacks (e.g., Env-Wq 1508.02 and **Table 5-4** of this Manual).
- To prevent compaction of the soil in the receiving pervious area, construction vehicles should not be allowed to drive over the area. If it becomes compacted, the soil must be amended, tilled, and revegetated to restore its infiltrative capacity once construction is complete.
- Utilizing existing sites that already contain established vegetation can be advantageous.
- Ensure that flows for larger events exit the pervious area in a controlled manner.
- Identify limits of the receiving pervious area, including spatial limits, ownership, vegetated cover and soil types.
- Care is required to prepare the site so that flow enters the receiving pervious area as sheet flow and sheet flow is maintained through the pervious area. Use of grading, level spreaders, and erosion controls may be necessary. In general, sheet flow cannot be maintained for flow lengths greater than 300 feet (USDA, 1986).
- Proper grading of vegetated buffers is essential to establish the level spreader along the contour, so that the outlet of the device is level and distributes discharge as sheet flow over the width of the buffer.
- Soil stabilization measures should be implemented to prevent erosion and local rill and gulley formation until permanent vegetation is established within the receiving pervious area.
- Roadside buffers are not suited to steep terrain. The buffer slope should be planar or convex in shape; concave (or “dish-shaped”) slopes tend to concentrate stormwater runoff, increasing the potential for erosion and short-circuiting of stormwater runoff through the buffer.
- Additional requirements applicable to systems that infiltrate stormwater and that would contribute to groundwater recharge are listed in Env-Wq 1508.07.
- Additional requirements applicable to systems that filter stormwater are listed in Env-Wq 1508.08.

Design Guidance

- Sizing of buffer will be a function of:
    - The ratio of impervious area to pervious area.
    - Hydrologic soil group (i.e., using a weighted average based on percent of buffer in each soil type).
- Refer to the SNEP New England 2022 Retrofit Manual for Impervious Area Disconnection performance curves based on the ratio of impervious area to pervious area.
- Runoff shall enter the buffer uniformly across its entire length as sheet flow. If needed, use a level spreader to accomplish this.
- **Note:** If designed to meet AoT requirements, there are specific sizing requirements that must be followed (see Env-Wq 1508.02).

Guidance for Impervious Area Disconnection Using a Level Spreader Berm Length Per Acre of Impervious Area and Lawn Area Draining to the Buffer for a Given Buffer Length with 0 Percent to 8 Percent Buffer Slope

Hydrologic Soil Group of Soil in Buffer	Available Buffer Length (feet)	Level Spreader Berm Length to a Forest Buffer (feet)		Level Spreader Berm Length to a Meadow Buffer (feet)	
		Impervious Area	Lawn Area	Impervious Area	Lawn Area
A	75	75	25	125	35
	100	65	20	75	25
	150	50	15	60	20
B	75	100	30	150	45
	100	80	25	100	30
	150	65	20	75	25
C	75	125	35	150	45
	100	100	30	125	35
	150	75	25	100	30
D	150	150	45	200	60

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- The entirety of the pervious area receiving “disconnected” stormwater runoff should be inventoried, inspected, and maintained as any other SCM.
- Inspect receiving pervious areas at least annually to ensure no channelization or erosion has taken place, infiltration rates are maintained, and there is adequate vegetative coverage.
- Inspect flow controls (e.g., level spreaders) at least annually and maintain them to ensure runoff is transferred as sheet flow to the receiving area and excess runoff is safely exiting the area.
- Vegetation should be inspected at least annually, and maintained in healthy condition.
- If a meadow buffer, provide periodic mowing if needed to maintain a healthy stand of herbaceous vegetation.
- If a forest buffer, then the buffer should be maintained in an undisturbed condition, unless erosion occurs.
- If erosion occurs, eroded areas should be repaired and replanted with vegetation similar to the remaining buffer. Corrective action should include eliminating the source of the erosion problem, and may require retrofit with a level spreader.
- Remove debris and accumulated sediment, based on inspection.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Impervious Area Disconnection[3]
Pollutant Removal (AoT 1507.03)	Yes
Groundwater Recharge (AoT 1507.04)	Yes[4]
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	Varies[5]

[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

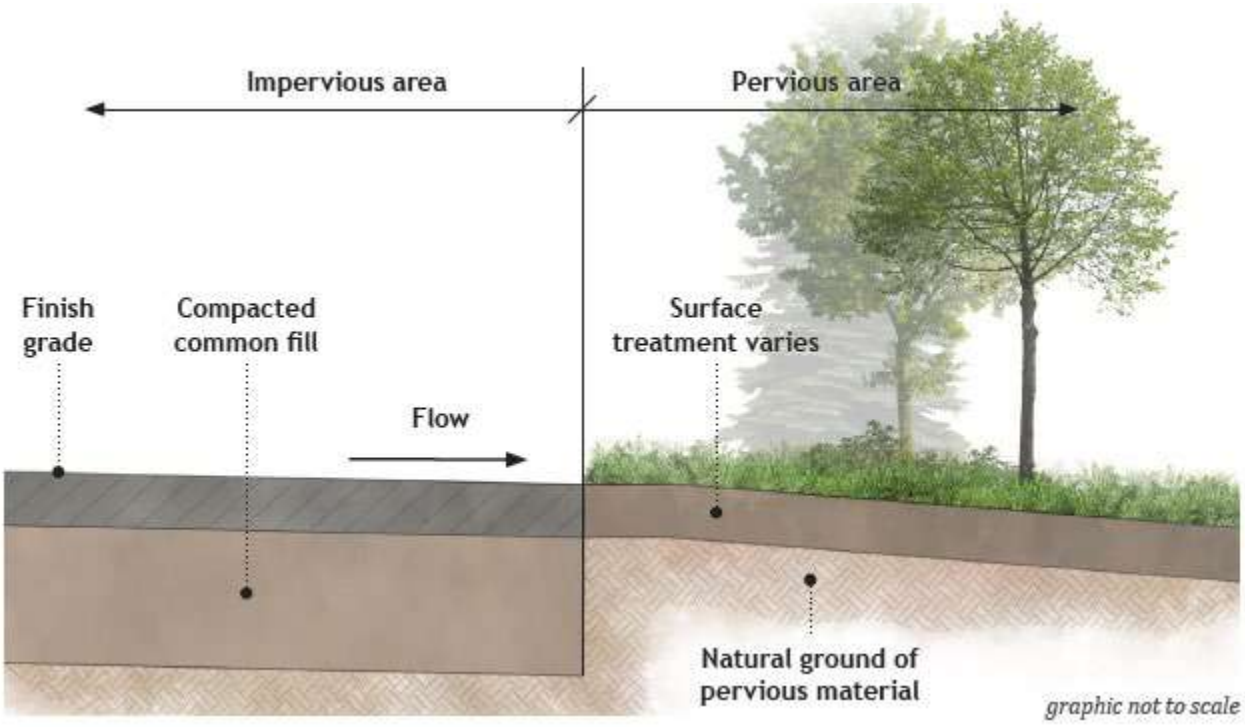
[3] *Refer to Env-Wq 1508.10 for all AoT requirements specific to Vegetated Buffers.*

[4] *Provides 1-inch of groundwater recharge credit for the portion of the site that drains to the buffer based on the ratio of impervious area to pervious area and the Hydrologic Soil Group as follows: HSG A (2:1 maximum); HSG B (1:1 maximum); HSG C (1:2 maximum); HSG D (1:4 maximum).*

[5] *Provides peak runoff control for smaller storms by reducing the Runoff Curve Number that is used for TR-55 peak runoff calculations.*

Example Design Schematics

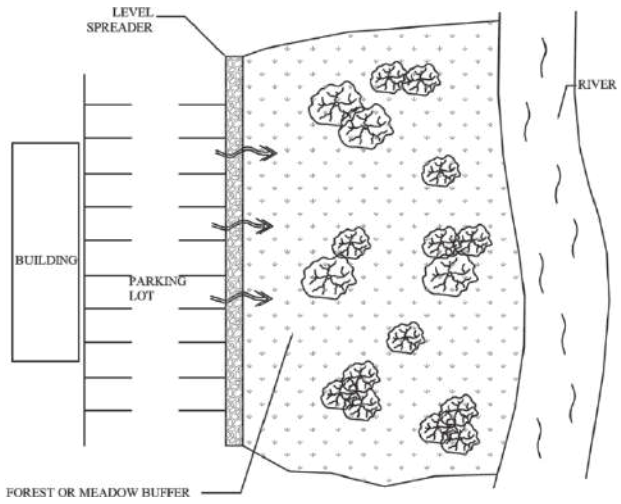
Impervious Area Disconnection



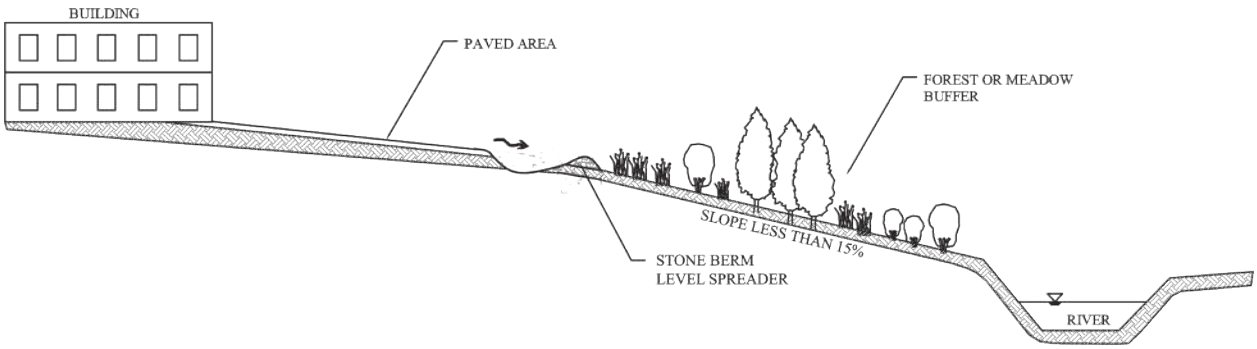
Reproduced from SNEP (2022) with permission

Developed Area Buffer

Plan



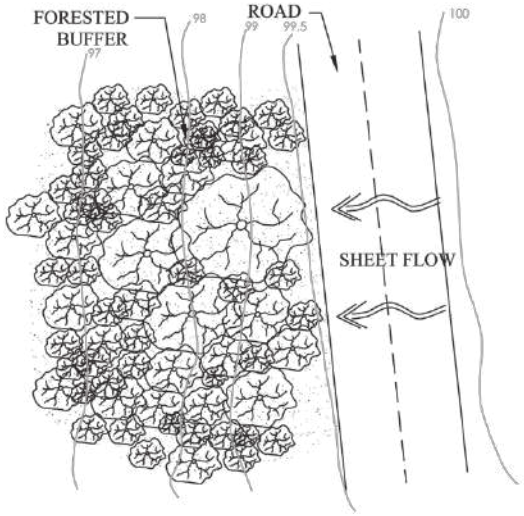
Profile



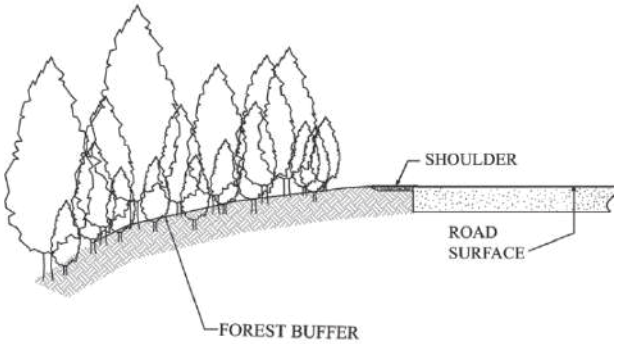
ME DEP (2006)

Roadway Buffer

Plan



Profile



ME DEP (2006)

References

Maine Department of Environmental Protection (ME DEP). *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Vegetated Buffers*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Massachusetts Stormwater Handbook Appendix A- SCM Specifications for the Massachusetts Stormwater Handbook, Disconnection of Impervious Surfaces*. Unpublished, 2025.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Pavement Disconnection*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Vegetated Filter Strip*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Southeast New England Program (SNEP). *New England Stormwater Retrofit Manual*. VHB and UNHSC. 2022. Available at: https://snepnetwork.org/stormwater-retrofit-manual/

USDA NRCS. *Urban Hydrology for Small Watersheds (TR 55).* 1986. Available at: https://www.nrc.gov/docs/ML1421/ML14219A437.pdf.

Stormwater Wetland

Tier 2

Stormwater wetlands are constructed depressions or impoundments designed to function similar to natural wetlands. However, unlike natural wetlands, stormwater wetlands are designed specifically to treat stormwater. Direct discharge of stormwater to natural wetlands is prohibited in New Hampshire due to critical impacts to wetland hydrology and potential habitat degradation.

Stormwater wetlands are like stormwater ponds (i.e., "Wet Ponds") in that the design includes a permanent pool of water. However, the retained pool is designed with varying depths to support a wetland plant community. In addition to the settling processes that occur in the permanent pool, stormwater wetlands provide pollutant removal/ uptake by vegetation and by other biological activity supported within the wetland environment. In some stormwater wetlands, such as "gravel wetlands," the systems provide filtration as well (discussed separately in the "Gravel Wetland" fact sheet).

Stormwater wetland designs can vary on the proportion of open water relative to marsh, and extended detention volume relative to permanent pool. The marsh areas typically include zones with the following depth ranges:

- **Deepwater** - From 18 inches deep, up to the design maximum depth.
- **Low Marsh** – From 6 inches to 18 inches below the normal pool elevation.
- **High Marsh** - From 6 inches below the normal pool elevation to the normal pool elevation.
- **Semi-wet** - Areas above the normal pool that are periodically inundated and expected to support wetland vegetation.

Water quality storage can be provided in multiple cells. Wetlands may be configured with a variety of low marsh and high marsh "cells" with sinuous channels to distribute flows to maximize retention time and contact area. The entire Water Quality Volume can be provided within the deepwater, low marsh, and high marsh zones. For designs including extended detention, part of the Water Quality Volume is stored above the level of the permanent pool.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

General Requirements Applicable to Stormwater Wetlands

- Maintenance access must be provided.
- The wetland perimeter must be curvilinear.
- Design must include a hydrologic budget to show sufficient water available to maintain permanent pool depth.
- Planting plan should not include any invasive species and should replicate the spatial and compositional diversity of a natural wetland, developed by an individual with knowledge of wetland plant species.
- Inlet and outlet should be located as far apart as possible.
- Provide a manually controlled drain, if elevations allow, to dewater ponds (if included in the design) over 24-hour period.
- Provide energy dissipation at inlet and outlet for scour prevention.
- Stormwater wetlands are prohibited in areas of RSA 482-A jurisdiction unless a wetlands permit has been issued.
- Provide small trash racks for outlets less than or equal to 6 inches in diameter or weirs less than or equal to 6 inches wide.

Design Considerations

- Requires sufficient contributing area and/or groundwater elevation to maintain permanent pool.
- Permanent pool elevation shall be based on an outlet control structure at an elevation 2 feet below the seasonal high- water table or preparation of a hydrologic budget.
- Basins should follow natural landforms to the greatest extent possible or be shaped to mimic a naturally formed depression.
- Use may be limited by depth to bedrock.
- May increase water temperature, which may affect use in watersheds of cold-water fisheries. For extended detention wetlands, because of the smaller area of permanent marsh, this effect may be more moderate than for a shallow wetland or pond/wetland system.
- May develop monoculture of invasive plant species over time.
- Effective wetland design displays “complex microtopography” to create both very shallow (less than 6 inches) and moderately shallow (less than 18 inches) water zones.
- Design of stormwater wetlands should include a water budget that demonstrates that a continuous supply of water is available to sustain the stormwater wetland.
- See “**Bioretention Systems**” for a planting guide of New England native species, including salt tolerant species.

Design Guidance

Design Parameters

Parameter	Criteria
Pre-treatment	10 percent of WQV; see criteria for "Sediment Forebay."
Maximum Side Slopes	3h:1v.
Minimum Side Slopes	20h:1v.
Permanent Pool + Extended Detention Volume	Greater than or equal to WQV (combined deep water, low marsh, high marsh and extended detention volume, if applicable).
Extended Detention Volume (if applicable)	Less than or equal to 50 percent of WQV.
Extended Detention Drawdown (if applicable)	24-hour minimum. Size extended detention volume outlet to discharge at a maximum flow rate as follows: Qmax ≤ 2*Qavg; Qavg = EDV/24 hours Where: EDV = the extended detention volume
Length to Width Ratio	3:1 minimum, applicable to each pond cell.
Permanent Pool Depth	Less than or equal to 8 feet. Greater than or equal to 35 percent of total surface area in permanent pool shall have depth of 6 inches or less, 65 percent of total permanent pool surface are shall be shallower than 18 inches.
Maximum Temporary Pool Depth	Less than or equal to 4 feet above permanent pool.
Design Discharge Capacity	50-year, 24-hour storm without overtopping and at least 1 foot of freeboard should be provided.
Embankment Design	See criteria for "Detention Basin."
Marsh/ Deepwater Ratios	Greater than or equal to 25 percent of WQV in "deep water zones" with depth greater than or equal to 4 feet. Remaining WQV in combination of shallow permanent pool with depth less than 4 feet and the EDV above the permanent pool, as applicable.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Periodic mowing of embankments.
- Removal of woody vegetation from embankments.
- Removal of invasive species from semi-wet, marsh, and deepwater areas.
- Monitoring and replanting, as warranted, of wetland vegetation.
- Removal of debris from outlet structures.
- Removal of accumulated sediment.
- Inspection and repair of embankments, inlet and outlet structures, and accessories.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Stormwater Wetland (Env-Wq 1508.04)
Pollutant Removal (AoT 1507.03)	Yes
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	Yes
Peak Runoff Control (AoT 1507.06)	Yes

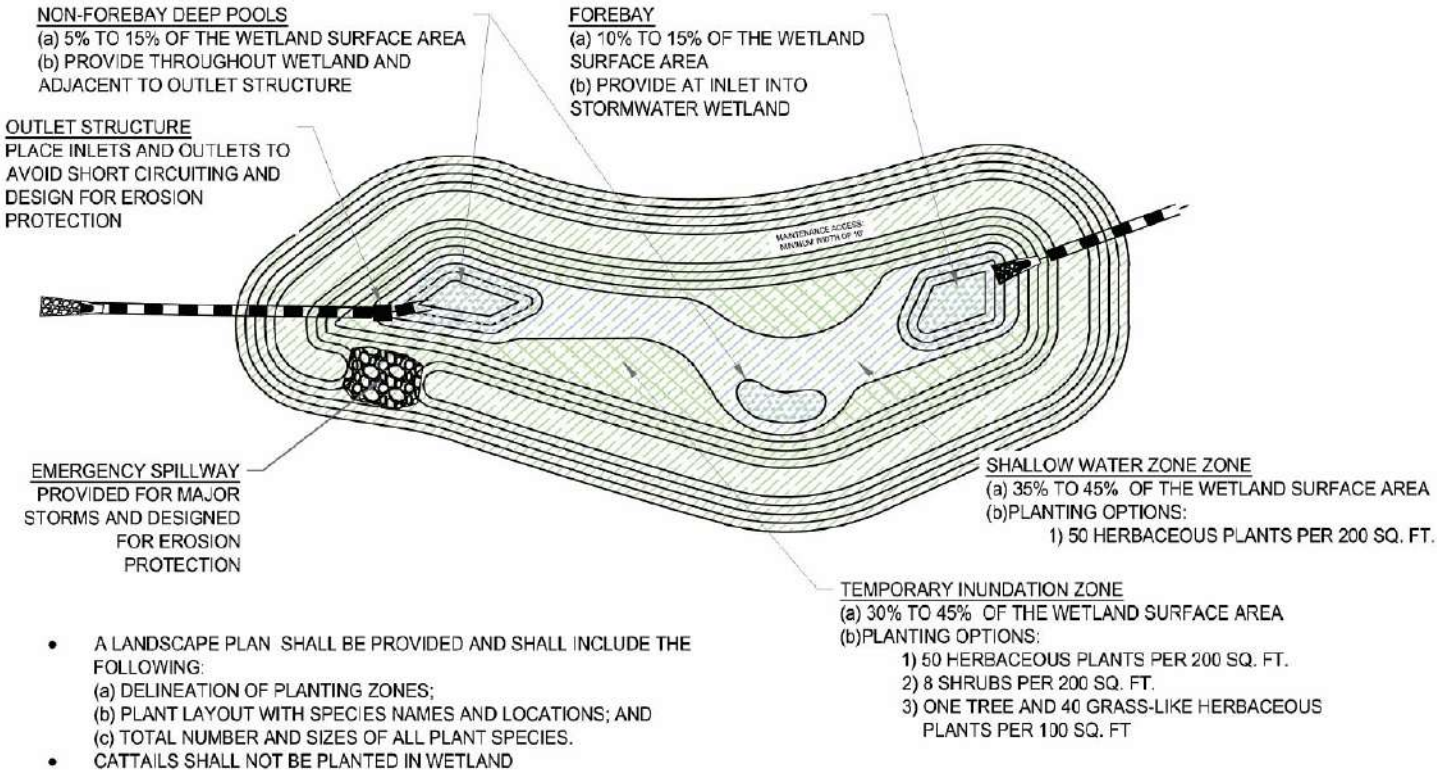
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

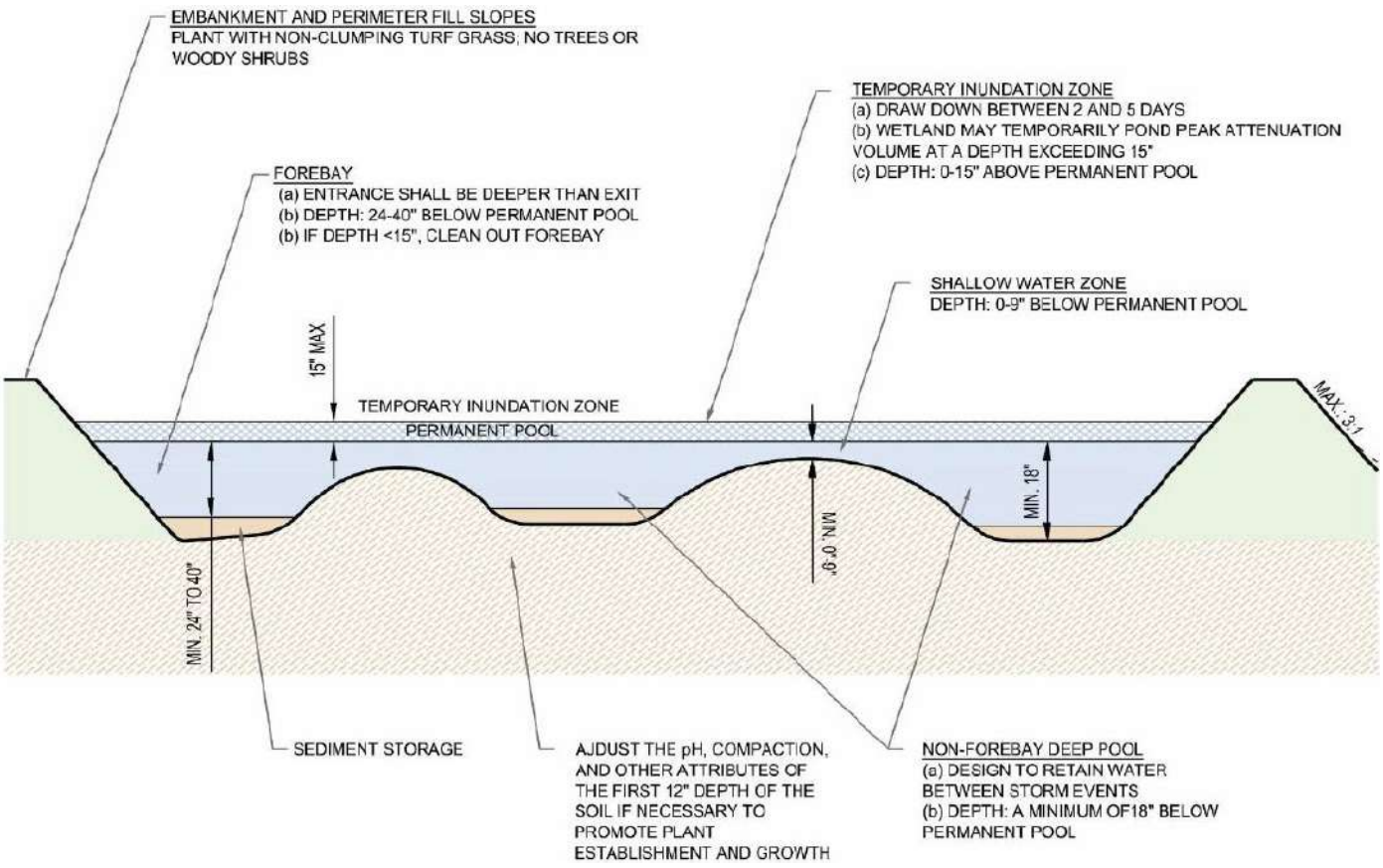
Stormwater Wetland

Plan



NCDEQ (2020)

Profile



NCDEQ (2020)

References

Cappiella, K., L. Fraley-McNeal, M. Novotney, and T. Schueler. *The Next Generation of Stormwater Wetlands. Wetlands & Watersheds Article #5*. Center for Watershed Protection, Ellicott City, MD. February 2008. Available at: https://owl.cwp.org/mdocs-posts/wetland-and-watershed-article-series-article-5/

EPA. *Stormwater Best Management Practice: Stormwater Wetland*. Fact Sheet. 2021. Available at: https://www.epa.gov/system/files/documents/2021-11/bmp-stormwater-wetland.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Constructed Stormwater Wetlands*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Constructed Stormwater Wetland*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

North Carolina Department of Environmental Quality (NCDEQ). *NCDEQ Stormwater Design Manual, Part C: Minimum Design Criteria and Recommendations for Stormwater Control Measures, C-4. Stormwater Wetland.* November 2020. Available at: https://www.deq.nc.gov/about/divisions/energy-mineral-and-land-resources/stormwater/stormwater-program/stormwater-design-manual.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Constructed Wetland*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Schueler, T. *Design of Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetlands in the Mid-Atlantic Region*. Metropolitan Washington Council of Governments. Washington, DC. 1992.

Tree Box Filter

Tier 2

The tree box filter is essentially a small bioretention system, combining the function of a curb-side drainage inlet with the water quality treatment functions of a vegetated soil media. It consists of an open bottom or closed bottom concrete box or barrel filled with a porous soil media. An underdrain system, consisting of a perforated pipe bedded in crushed gravel, is provided beneath the soil media. A tree is planted in the soil media. Stormwater is directed from surrounding impervious surfaces through the top of the soil media.

There are two types of tree box filters:

- **Infiltrating Systems**: If the device has an open bottom, the stormwater percolates through the media into the underlying ground. If the filtered stormwater exceeds the infiltration capacity of the underlying natural soil, the excess will be intercepted by the underdrain, where it may be directed to a storm drain, other device, or surface water discharge.
- **Filtering Systems**: Where a closed bottom box filter is used, such as where necessary to protect groundwater resources, stormwater that passes through the soil media filter is intercepted by the underdrain and conveyed to a suitable outlet.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Tree box filters should be carefully integrated into the design of parking areas and streets, to provide enough units in suitable locations for capturing the required Water Quality Flow. Generally, these systems are sized and spaced similarly to catch basin inlets.
- Tree box filters are particularly adaptable to integration with site landscaping, and offer an aesthetically attractive opportunity to provide highly effective stormwater treatment.
- Avoid using tree box filters to treat stormwater runoff from high-load areas (see the discussion of high-load areas in **Chapter 5.3** of this manual).
- Tree box filters can be used to meet recharge objectives, where underlying soils are suitable and where allowed by land use and receiving water characteristics.
- Avoid placing tree box filters into service until the SCM has been planted and its contributing areas have been fully stabilized.
- Where discharge from the tree box filter is by infiltration into the subsoil, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:

- Avoid discharging sediment-laden waters from construction activities (stormwater runoff, water from excavations) to the tree box filter during any stage of construction.
- Avoid trafficking or compacting exposed soil surface within the area of the filter with construction equipment. Perform excavation for the construction of this SCM with equipment positioned outside the limits of the system.

Design Guidance

Tree Box Filter Media

Component Material	Percent of Mixture by Volume	Required Material Characteristics
Sand	80	ASTM C-33 concrete sand.
Organic material, ***composted*** bark mulch recommended	20	Less than 5 percent passing No. 200 Sieve.
General requirements applicable to the mixture	• Soil mix should be uniform, free of stones, stumps, roots, or similar materials larger than 2 inches. • Soil pH should be between 5.5 and 6.5.	

Design Parameters

Parameter	Criteria
Pre-treatment	Pre-treatment not required. However, tree box filters should not be used for high-load areas.
Tree Box Filter Volume	Based on manufacturer recommendations or the WQF.
Depth of Filter Media	36 inches, minimum.
Tree Box Dimensions	Greater than or equal to 6 feet diameter. Greater than or equal to 4 feet depth.
Contributing Drainage Area	Less than 0.1 acres.
Filter Media	See Tree Box Filter Media table above.
Drain Time	Less than 72 hours for complete drainage.
Underdrain (where required)	Greater than or equal to 6-inch diameter perforated PVC or HDPE set in 1- to 2-inch diameter stone or gravel free of fines and organic material.
Depth to Bedrock and Seasonal High-Water Table Elevation (SHWT)	Greater than or equal to 1 foot below the bottom of the filter course material. *Note*: More stringent separation requirements may apply within groundwater or water supply intake protection areas, areas with high pollutant loading, or other sensitive areas. Applicable regulations should be consulted.
Overflow Discharge Capacity	10-year, 24-hour storm.
Planting Design	Vegetation selected for these systems should consist of native, drought-tolerant and salt-tolerant species. Plants with aggressive root growth may clog the subdrain, and therefore may not be suitable for this type of system.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5 inches in a 24-hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Trash and debris should be removed at each inspection.
- If inspection indicates that the system does not drain within 72 hours following a rainfall event, then a qualified professional should assess the condition of the tree box filter to determine measures required to restore filtration function or infiltration function (as applicable), including but not limited to removal of accumulated sediments or reconstruction of the filter media.
- The tree should be inspected at least annually, and maintained in healthy condition, including pruning. A dead or diseased tree, or a tree in stressed condition because of the constricted root space in the filter, should be removed and replaced. Filter media should be replaced when the tree is replaced.
- Refer to UNHSC Maintenance Guidelines and Resources, "Checklist for Inspection of Bioretention Systems/ Tree Filters" for an example inspection checklist.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement[3]	Tree Box System (Infiltrating)	Tree Box System (Filtering)
Pollutant Removal (AoT 1507.03)	Yes	Yes
Groundwater Recharge (AoT 1507.04)	Yes	No
Channel Protection (AoT 1507.05)	No	No
Peak Runoff Control (AoT 1507.06)	Varies	Varies

[1] *See **Chapter 4 (Design Criteria)** for more information.*

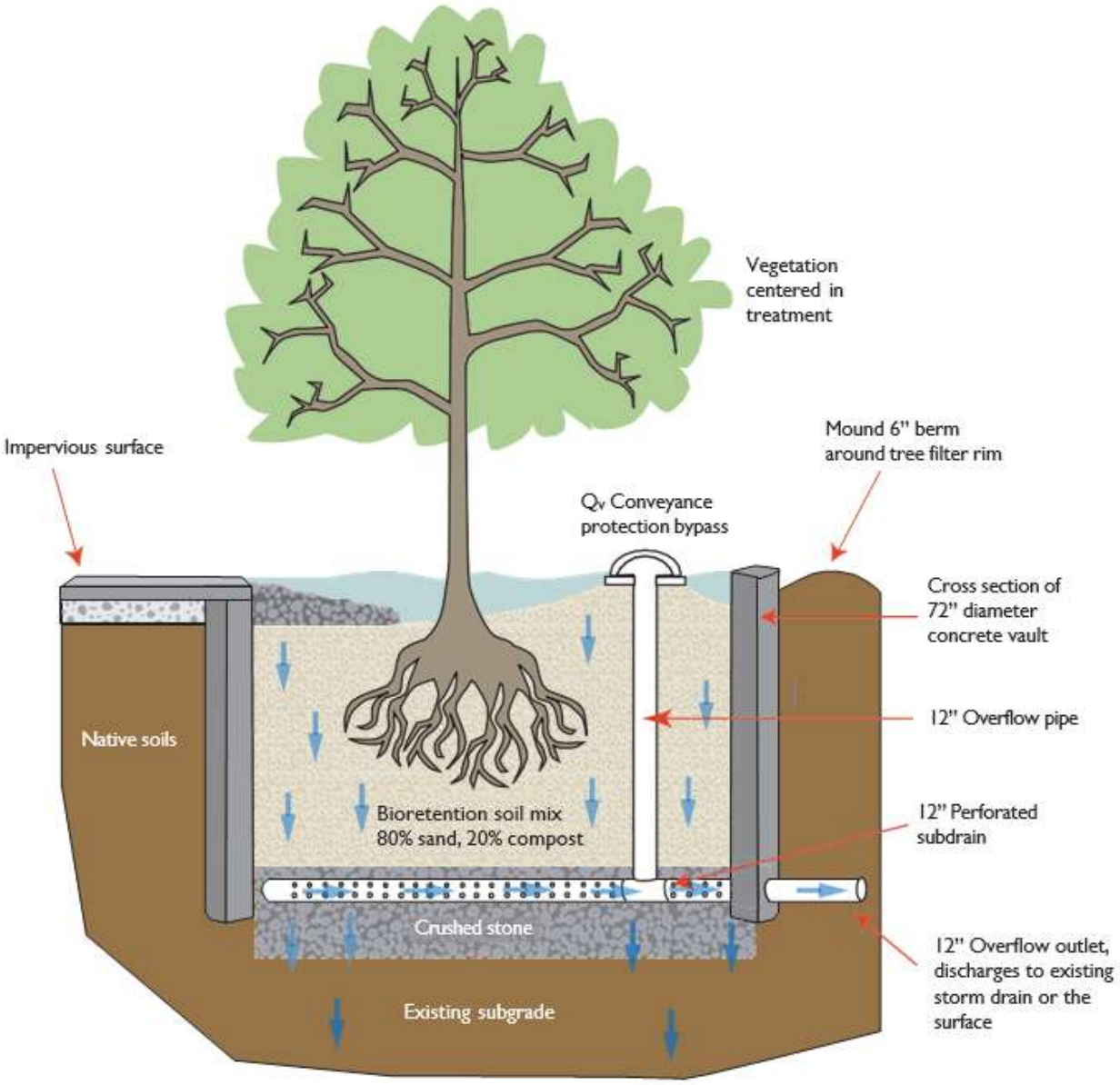
[2] *Refer to Env-Wq 1508.07 Infiltration Practices/ Env-Wq 1508.08 Filtering Practices for all SCM AoT requirements.*

[3] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

Tree Box Filter

Profile



UNHSC (2009)

References

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Bioretention SCMs*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Constructed Filter*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

University of New Hampshire Stormwater Center (UNHSC). *2009 Biannual Report*. Durham, NH. 2009. Available at: https://scholars.unh.edu/stormwater/76/ .

Extended Dry Detention Pond

Tier 3

Extended dry detention ponds are modified conventional dry detention basins designed to hold stormwater for an extended drawdown time of at least 24 hours. Extending the drawdown time allows solids, and associated pollutants, to settle and reduces local and downstream flooding. Extended dry detention ponds may be designed with either a fixed or adjustable outflow device.

Pre-treatment is a fundamental design component of an extended dry detention pond to ease maintenance and reduce the potential for filling and clogging. Other components such as a micropool or shallow marsh may be added to enhance pollutant removal. The micropool is typically provided near the outlet, to enhance pollutant removal and to help prevent resuspension of captured sediments. Except for the micropool, the pond is designed to be dry between storms, once the WQV has been discharged.

Which Design Elements are "State-of-the-Practice"?

The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:



- Additional design considerations.
  - Lengthen flow path to increase detention time.
  - Consider use of internal berms and other baffles.
  - Use of low-flow underdrains.
  - Establish wetland vegetation in a shallow marsh component.
- Additional design guidance for distinct stages.
- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Maintenance access must be provided.
- The pond perimeter should be curvilinear.
- Inlet and outlet should be located as far apart as possible to maximize detention time.
- To maximize sedimentation, design the extended dry detention pond to lengthen the flow path, thereby increasing detention time. Long, narrow configurations provide better removal efficiencies than small, deep ponds.
- Consider using internal berms and other baffles to minimize short-circuiting of flows and increase detention times.
- Provide a manually controlled drain, if elevations allow, to dewater pond over 24-hour period.
- Stormwater ponds are prohibited in areas of RSA 482-A jurisdiction unless a wetlands permit has been issued.

- Provide small trash racks for outlets less than or equal to 6 inches in diameter or weirs less than or equal to 6 inches wide.
- Use may be limited by depth to groundwater or bedrock.
- May increase water temperature, which may affect use in watersheds of cold-water fisheries.
- May have a greater risk of sediment re-suspension than wet ponds or stormwater wetlands.
- May not remove soluble pollutants as effectively as wet ponds or stormwater wetlands.
- Use low-flow underdrains connected to the principal outlet structure or other downstream discharge point to promote thorough drying of the channel and the pond bottom. Take into account the depth of the low-flow channel when preparing the final bottom grading plan.
- Planting plan should not include any invasive species and should replicate the spatial and compositional diversity of a natural wetland, developed by an individual with knowledge of wetland plant species.
- See "**Bioretention Systems**" for a planting guide of New England native species, including salt tolerant species.
- Establish wetland vegetation in a shallow marsh component or on an aquatic bench in the **lower stage** (see Design Guidance below) to enhance removal of soluble nutrients, increase sediment trapping, prevent sediment resuspension, and provide wildlife and waterfowl habitat.

Design Guidance

Design extended dry detention ponds with distinct stages:

- The upper stage(s) should have the capacity to regulate peak flow rates of large, infrequent storms (10-, 25-, or 50-year recurrence intervals).
- The middle stage is designed to regulate peak flow from the 2-year storm.
- Design the lowest stage of the basin to detain the water quality volume for at least 24 hours to remove pollutants from the stormwater runoff.

Design Parameters

Parameter	Criteria
Pre-treatment	10 percent of WQV; see criteria for "**Sediment Forebay**."
Maximum Side Slopes	3h:1v.
Minimum Side Slopes	20h:1v.
Extended Detention Volume	Extended detention volume less than or equal to 50 percent WQV.
Pool Depth	Average depth of 3 to 6 feet; no greater than 8 feet.
Extended Detention Drawdown	24-hour minimum. Size extended detention volume outlet to discharge at a maximum flow rate as follows: Qmax ≤ 2*Qavg; Qavg = EDV/24 hours Where: EDV = the extended detention volume
Length to Width Ratio	3:1 minimum.
Depth to Bedrock and Seasonal High- Water Table Elevation (SHWT)	Greater than or equal to 2 feet of separation between the bottom of the SCM to bedrock and SHWT.
Design Discharge Capacity	50-year, 24-hour storm without overtopping and at least 1 foot of freeboard should be provided.
Embankment Design	See criteria for "**Detention Basin**."
Micropool Volume (if applicable)	Approximately 10 percent of WQV.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Periodic mowing of embankments.
- Removal of woody vegetation from fill embankments.
- Removal of debris from outlet structures.
- Removal of accumulated sediment.
- Inspection and repair of side slopes, embankments, inlet and outlet structures, and accessories.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement[3]	Extended Dry Detention Pond
Pollutant Removal (AoT 1507.03)	Yes
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	Yes
Peak Runoff Control (AoT 1507.06)	Yes

[1] *See **Chapter 4 (Design Criteria)** for more information.*

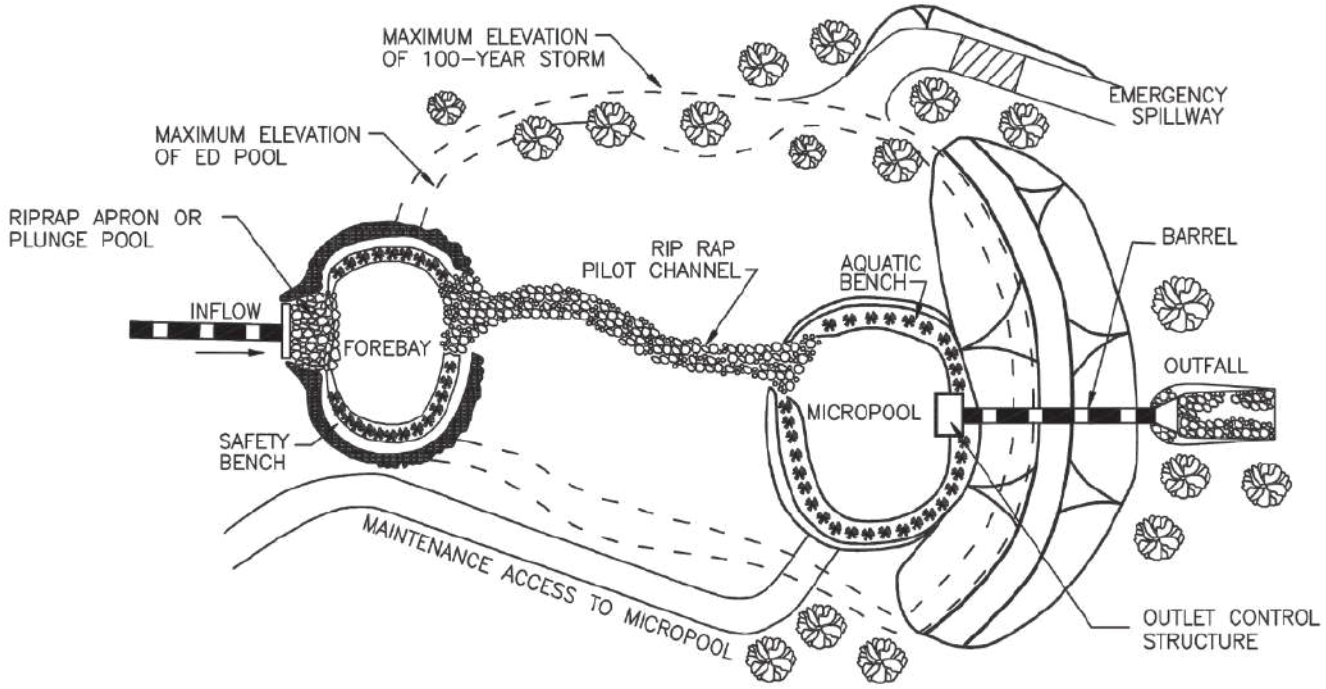
[2] *Refer to Env-Wq 1508.03 Stormwater Ponds for all SCM AoT requirements.*

[3] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

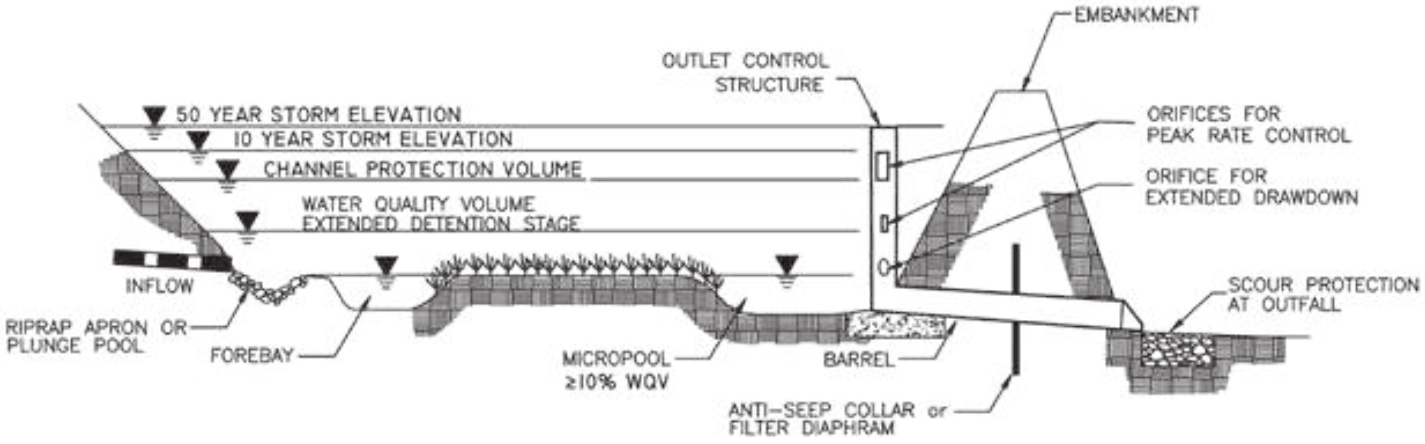
Example Design Schematic

Extended Dry Detention Pond with Micropool

Plan



Profile



Adapted from MDE (2000)

References

Maryland Department of the Environment (MDE). *Maryland Stormwater Design Manual, Volume I*. 2000. Available at: https://mde.maryland.gov/programs/water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/sedimentstormwater/MD%20SWM%20Volume%201.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Extended Dry Detention Basins*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Extended Dry Detention Basin*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Dry Extended Detention Basin*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual- Stormwater Basins*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Schueler, T. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1987.

Schueler, T., P. Kumble, and M. Heraty. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1992. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Flow-Through Treatment Swale

Tier 3

Unlike conventional grass channels and swales that are primarily designed for conveyance, treatment swales are designed to promote sedimentation by providing a minimum hydraulic residence time within the channel under design flow conditions (Water Quality Flow). This SCM may also provide some infiltration, vegetative filtration, and vegetative uptake. As a result, treatment swales provide higher pollutant removal efficiencies. Pollutants are removed through sedimentation, adsorption, biological uptake, and microbial breakdown.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

General Requirements Applicable to Treatment Swales

- Treatment swales are prohibited in areas of RSA 482-A jurisdiction unless a wetlands permit has been issued.
- Treatment swales are prohibited in groundwater protection areas receiving stormwater from a high-load area unless an impermeable liner is provided.
- Swale shape should be trapezoidal or parabolic.
- Swale must have greater than or equal to 85 percent vegetated growth prior to receiving stormwater runoff.
- Bottom of swale must be above seasonal high-water table.

Design Considerations

- Flow-through swales must be designed so that the flow travels the full length to receive adequate treatment. For this reason, flow must be directed to the inlet end of the swale, rather than the swale collecting water continuously along its length.
- All channels should be designed for *capacity* and *stability*. A channel is designed for *capacity* when it can carry the maximum specified design flow within the design depth of the channel (allowing for recommended freeboard). A channel is designed for *stability* when the channel lining (vegetation, riprap, or other material) will not be eroded under maximum design flow velocities. Analyses of these conditions must account for both the type of lining and its condition (e.g., capacity analysis for a grassed channel must consider the resistance of the maximum height of grass, while the stability analysis must consider the grass under its shortest, mowed condition).
- Vegetation should be selected based on site soils conditions, planned mowing requirements (height, frequency), and design flow velocities. See "Bioretention Systems" for a planting guide of New England native species, including salt tolerant species.
- The roughness coefficient, n, varies with the type of vegetative cover and flow depth. At very shallow depths, where the vegetation height is equal to or greater than the flow depth, the n value should be approximately 0.15.

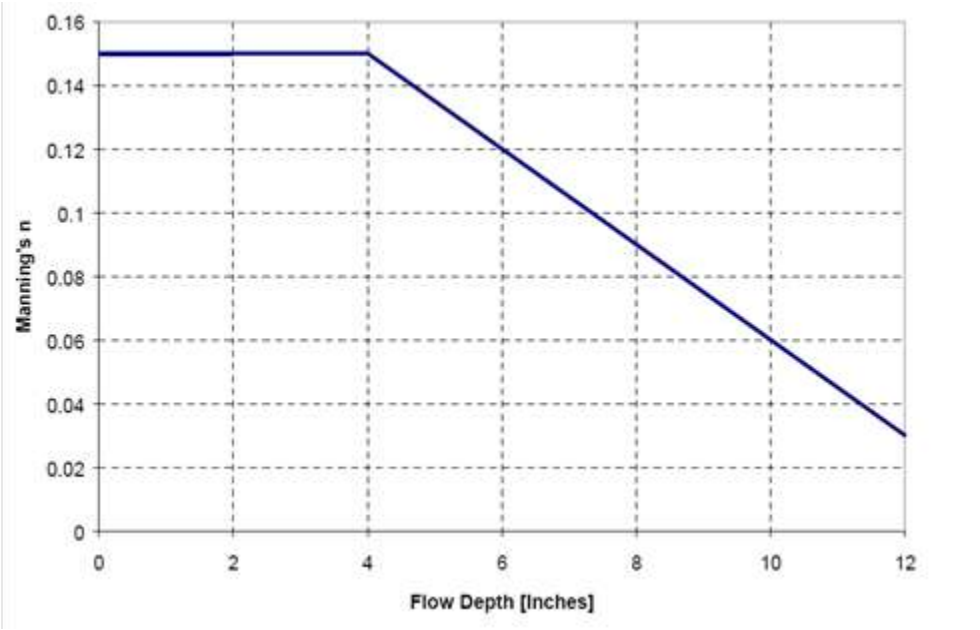
This value is appropriate for flow depths up to 4 inches typically. For higher flow rates and flow depths, the n value decreases to a minimum of 0.03 for grass channels at a depth of approximately 12 inches. The n value must be adjusted for varying flow depths between 4 inches and 12 inches (see chart below).

- Install check dams in drainage channels when necessary to achieve velocities of 5 feet per second or less. Avoid using earthen check dams because they tend to erode on the downstream side, and it is difficult to establish and maintain grass on the dams. The maximum ponding time behind the check dam should not exceed 24 hours.

Design Guidance

Design Parameters

Parameter	Criteria
Minimum Length	Greater than or equal to 100 feet (not including portions in a roadside ditch).
Bottom Width	4 to 8 feet (widths up to 16 feet are allowable with dividing berm/ structure such that neither channel width exceeds 8 feet).
Longitudinal Slope	0.5 percent to 2 percent without check dams. 2 percent to 5 percent with check dams.
Maximum Side Slopes	3h:1v.
Minimum Side Slopes	20h:1v.
Seasonal High-Water Table (SHWT)	Bottom of swale should not be within SHWT.
Flow Depth	4 inches maximum at the WQF. If a detention structure is used immediately upstream of swale, 4 inches maximum at the 2-year, 24-hour post development peak flow rate.
Hydraulic Residence Time	Greater than 10 minutes during the WQF or the 2-year, 24-hour post development peak flow rate routed through a detention structure.
Design Discharge Capacity	10-year, 24-hour storm without overtopping.



Manning's n Value with Varying Flow Depth
Source: Claytor and Schueler, 1996

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Inspect annually for erosion, sediment accumulation, vegetation loss, and presence of invasive species.
- Perform periodic mowing; frequency depends on location and type of grass. Avoid cutting shorter than Water Quality Flow depth (maximum 4 inches).
- Remove debris and accumulated sediment, based on inspection.
- Repair eroded areas, remove invasive species and dead vegetation, and reseed with applicable grass mix as warranted by inspection.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Flow-Through Treatment Swale (Env-Wq 1508.09)
Pollutant Removal (AoT 1507.03)	Yes
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	Yes
Peak Runoff Control (AoT 1507.06)	No

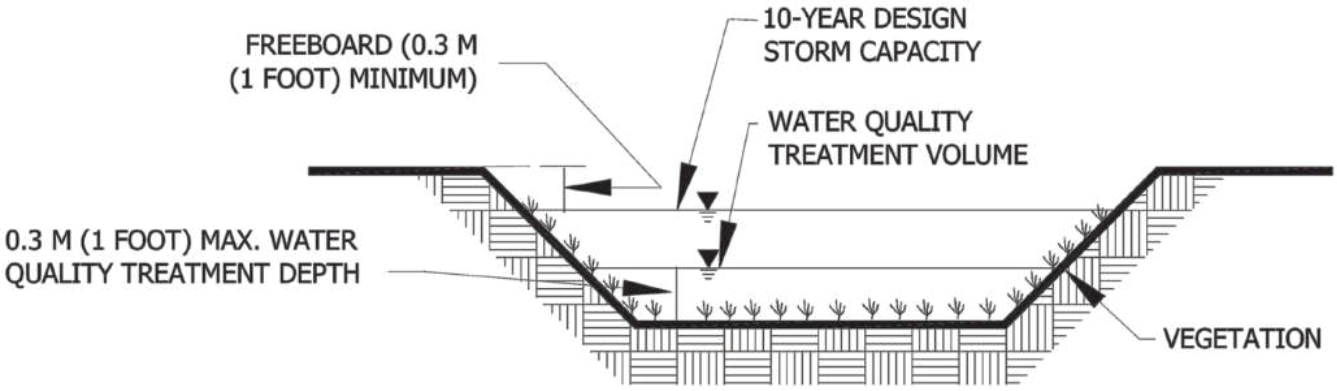
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

Flow-Through Treatment Swale

Profile



MassHighway (2004)

References

Claytor, Richard A. and Thomas R. Schueler. *Design of Stormwater Filtering Systems*. The Center for Watershed Protection, Ellicott City, MD. December 1996. Available at: https://owl.cwp.org/?mdocs-file=4553

MassHighway. *The MassHighway Storm Water Handbook For Highways and Bridges*. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Water Quality Swale*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Minton, Gary. 2005. *Stormwater Treatment*. Resource Planning Associates. Seattle, WA.

Green Roof

Tier 3

A green roof is a building roof that is partially or completely covered with vegetation and soil, or other type of growing medium. It can be applied to new construction or retrofitted to existing construction. A typical green roof includes vegetation planted in a substrate over a drainage layer and a root barrier membrane. Some green roofs are equipped with stormwater detention tanks with a recirculating system that allows for watering of the media during dry periods. There are generally two classes of green roofs:

- **Extensive green roofs** generally have only a few inches of growth media and are relatively lightweight in structure. They are designed to be low-maintenance and are not designed for public access. Vegetation is typically limited to various species of sedums or other similar arid plants.
- **Intensive green roofs** are designed to be used by the public or building inhabitants as a park or relaxation area. Intensive green roofs typically require more growth media, greater than 6 inches in depth, adding significant additional weight loading to the building. This requires greater capital and maintenance investments than extensive green roofs.

Green roofs can be constructed layer by layer or can be purchased as a system. Several vendors offer modular trays containing the green roof components.

Green roofs provide several benefits over conventional roofing, including:

- Reduction of stormwater runoff from buildings through absorption, storage and evapotranspiration. This reduces overall peak flow discharge to a storm sewer system and can result in less in-stream scouring, lower water temperatures and better water quality of receiving waters.
- Reduction of urban heat island effects with increased building thermal insulation and energy efficiency.
- Increased roof durability and lifespan.

Which Design Elements are "State-of-the-Practice"?

The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:



- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Green roofs can add significant weight load to a building. A structural engineer should be consulted to ensure the building can support the added weight at maximum water capacity or fully saturated conditions.
- On high pitched roofs, incorporate special design features, such as structural anti-shear protection, to prevent slumping and ensure plant survival.

- Although green roofs do not receive direct stormwater runoff from impervious areas, they technically meet antidegradation requirements until they discharge onto impervious cover. Green roofs have interception and retention capability, operating much like a lawn.

Design Guidance

Designers will need to work closely with building design professionals to identify applicable criteria, codes, and accepted standards of practice for the design of green roofs.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Immediately after construction, inspect green roofs regularly until the vegetation has established. Water as needed to establish vegetation.
- After vegetation has established, inspect, and fertilize extensive green roofs at least annually. Use fertilizers that do not contain phosphorus. In nitrogen impaired watersheds where a Total Maximum Daily Load (TMDL) has been established, use low nitrogen fertilizers (e.g., 5-0-5).
- Weed green roofs as needed.
- Water extensive green roofs as needed during exceptionally dry periods.
- Maintain intensive green roofs as any other landscaped area. This will involve mulching, weeding, irrigation, and the replacement of dead vegetation.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Green Roof
Pollutant Removal (AoT 1507.03)	No
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	Varies

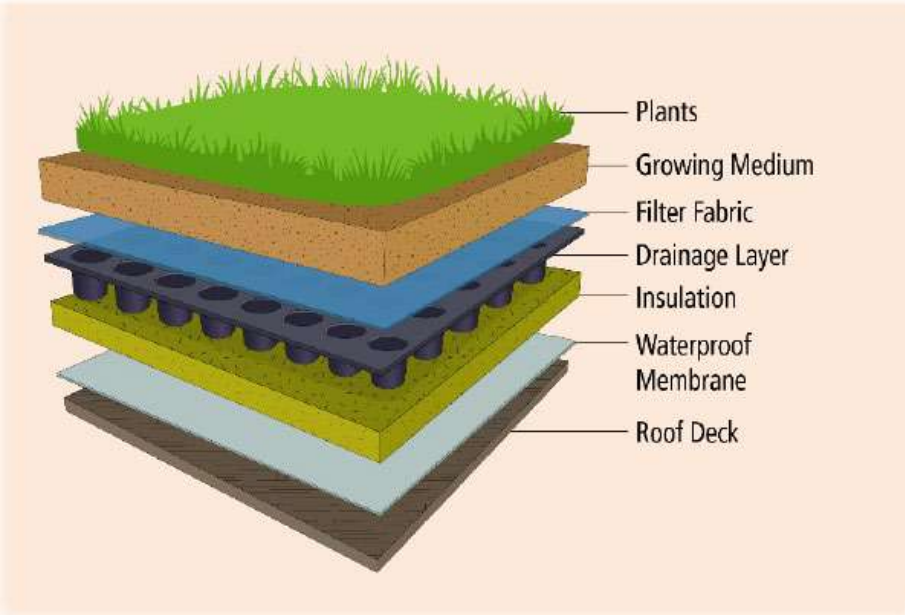
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

Green Roof

Profile



EPA (2021)

References

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Environmental Protection Agency. *Stormwater Best Management Practice: Green Roofs*. 2021. Available at: https://www.epa.gov/system/files/documents/2021-11/bmp-green-roofs.pdf

Rain Barrel/ Cistern (with reuse)

Tier 3

Rain barrels and cisterns are storage devices used to collect rainwater from roof downspouts for later reuse. They provide the benefit of reduced stormwater runoff and conservation of water supplies when the water is reused. Stormwater collected in rain barrels and cisterns can typically be reused for purposes such as irrigation of lawns and gardens, wash water and other non-potable or non-drinking water uses. Careful consideration should be made when reusing water from rain barrels as this water may contain pollutants from the roof that should not come into contact with vegetables or other edible crops.

Rain barrels are most used in residential applications to collect roof runoff for later watering of lawns, perennial gardens, and house plants. Rain barrels come in all shapes and sizes and can be purchased or made at home from existing materials. The low cost and maintenance associated with rain barrels makes them an attractive option for homeowners to manage rooftop runoff.

Cisterns are above or underground storage tanks used to collect roof runoff. While providing the same function as rain barrels, cisterns are generally larger and may include pumps and filtration devices to reuse the water. The larger storage capacity allows for greater reuse opportunities.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Design considerations follow recommendations from the SNEP 2022 New England Stormwater Retrofit Manual.
- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Rain barrels should hold a minimum of 55 gallons.
- Rain barrels can be connected in series to provide larger storage volumes.
- Size cisterns for the volume needed for the intended reuse of water.
- Design for retention time of 1 to 3 days to allow receiving pervious area time to dry between storms.
- Equip rain barrels with a drain spigot near the bottom of the barrel with garden hose threading to allow easy hook up and use for watering.
- Incorporate water pumps and filters into cisterns as needed for the intended reuse of the water.
- Provide an overflow pipe.
- Provide removable, child-resistant covers.
- Provide mosquito screening on water entry holes to prevent mosquito breeding in standing water.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Inspect rain barrel for potential leaks.
- Inspect overflow pipe and overflow area to ensure that overflow is draining in non-erosive manner.
- Inspect spigot to ensure it is functioning correctly.
- Inspect screen and cover to ensure they still function as anticipated and replace if needed.
- To prevent damage by freezing water, drain rain barrel and disconnect it from roof leader prior to winter; reconnect in spring.
- Inspect larger cisterns at least annually for accumulation of sediment and debris, and clean cistern as warranted by inspection. Cisterns may require servicing under the supervision of a qualified professional, including periodic disinfection to control bacteria growth, or application of larvicide to control mosquitoes.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Rain Barrels/ Cisterns
Pollutant Removal (AoT 1507.03)	Yes
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	No
Peak Runoff Control (AoT 1507.06)	Varies

[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

References

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

NHDES. *Soak Up the Rain New Hampshire: New Hampshire Homeowner's Guide to Stormwater Management*. 2019. Available at: https://www.soaknh.des.nh.gov/sites/g/files/ehbemt741/files/documents/homeowners-guide-to-stormwater-management.pdf.

Southeast New England Program (SNEP). *New England Stormwater Retrofit Manual*. VHB and UNHSC. 2022. Available at: https://snepnetwork.org/stormwater-retrofit-manual/.

Sand Filter

Tier 3 Surface Sand Filters and Underground Sand Filters

Sand filters consist of self-contained beds of filter media made of sand and organic materials. As stormwater runoff is filtered through the sand, pollutants are strained out or adsorbed to the filter media. Treated stormwater runoff is either discharged to a suitable outlet or infiltrated into the underlying native soil, depending on the design of the filter. Sand filters should be designed as "off-line" devices with the capacity to treat the WQV, with larger events diverted from the device. There are two types of sand filters covered by this fact sheet:

- **Surface sand filters** usually include a flow splitter, used to divert the first flush of stormwater runoff into a pre-treatment device, such as a sedimentation chamber (wet or dry) where coarse sediments settle out of the water (see "Sediment Forebay"). Pre-treated stormwater runoff then enters the sand filter, saturating the filter bed and filling temporary storage volume provided above the bed. The top surface of the sand filter is exposed to the elements, but is kept free of vegetation. If the filter is designed for infiltration, treated water is allowed to percolate into the underlying native soil. Alternatively, the filter can be designed with a perforated underdrain system to collect treated water at the bottom of the sand filter and direct it to a suitable outlet. If necessary, the underdrained sand filter can be designed with a liner to isolate it from adjacent soil material and prevent discharge of treated water to the groundwater table.
- **Underground sand filters** operate in a similar fashion to the surface sand filter, except that the system is enclosed in a below-grade structure. The structure may consist of a multi-chambered vault that accommodates pre-treatment, as well as the filtration component of the system. The structure is made accessible through utility access holes or grate openings. A typical structure incorporating pre-treatment will consist of a three-chambered vault, with the first chamber comprising a sedimentation chamber (see "Flow-Through Devices"), the second chamber consisting of the filter, and the final chamber serving as the outlet control for the system. The first chamber provides pre-treatment by settling coarse sediments and by trapping floating materials such as trash and oil. The pre-treated water then enters the sand filter. A permeable layer of gravel may be installed on top of the filter to help prevent clogging of the filter media. A perforated underdrain at the bottom of the filter directs treated water towards an outlet. Typical subsurface filter systems are fully enclosed in structures. However, some systems may be designed with an open bottom in contact with native soils, allowing for infiltration to occur. In these systems, the SCM needs to be designed to meet the requirements of subsurface infiltration systems, in addition to the requirements for the filter system.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Maintenance access must be provided.
- Sand and other media filters may be advantageous for specialized applications where specific target pollutants must be addressed.
- Sand and other media filters may be advantageous for sites with limited space.
- Pre-treatment is essential to the long-term function of surface sand filtration systems.
- The surface slope of filters should be level to promote even distribution of flow throughout the practice.
- Underdrain system is required if underlying native soil or fill soil has an infiltration rate less than 0.5 inches per hour.
- Filter beds should be extended below the frost line to prevent the filtering medium from freezing during the winter.
- Avoid placing filtration systems into service until the contributing areas have been fully stabilized.
- Where ultimate discharge from the filter is by infiltration into the subsoil, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
    - Avoid discharging sediment-laden waters from construction activities (stormwater runoff, water from excavations) to permanent filtration/infiltration SCMs.
    - Avoid driving upon exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
- Additional requirements applicable to systems that filter stormwater are listed in Env-Wq 1508.08.

Design Guidance

Filter Mixtures for Surface Sand Filters

Component Material	Percent of Mixture by Volume	Gradation of Material	
		Sieve No.	Percent by Weight Passing Standard Sieve
Filter Media Option A			
ASTM C-33 concrete sand	50 - 55		
Loamy sand topsoil, with fines as indicated	20 - 30	200	15 - 25
Moderately fine shredded bark or wood fiber mulch, with fines as indicated	20 - 30	200	Less than 5
Filter Media Option B			
Moderately fine shredded bark or wood fiber mulch, with fines as indicated	20 - 30	200	Less than 5
Loamy coarse sand	70 - 80	10	85 - 100
		20	70 - 100
		60	15 - 40
		200	8 - 15

Design Parameters

Parameter	Criteria
Pre-treatment	Required unless receiving only roof runoff (see **Structural Pre-treatment**).
Filter Volume	Greater than or equal to 75 percent WQV[1] (including storage area above filter, filter media voids, and pre-treatment area).
Watershed	Less than 10 acres of contributing drainage area.
Depth of Filter Media	18 to 24 inches.
Filter Media	See Filter Mixtures for Surface Sand Filters table above. Filter should not be covered with grass.
Filter Surface Area	Sized based on principles of Darcy's Law using a coefficient of permeability (k) of 3.5 feet per day. Filter bed area shall be computed using the following equation: $A_f = (T_v * d_f)/[k*(h_f+d_f)*t_f]$ Where: A_f= Surface area of filter bed (square feet) T_v= Treatment volume (cubic feet) d_f= Filter bed depth (feet) h_f= Average height of water above filter bed (feet) t_f= Design filter bed drain time (2 days recommended) *(VT ANR, 2017)*
Design Infiltration Rate	See **Chapter 4.4** for a discussion on selecting a design infiltration rate.
Filter Accessories	Must have access grate.
Drain Time	Less than 72 hours for complete drainage.
Underdrain (where required)	Surface: Greater than or equal to 6-inch diameter perforated PVC or HDPE set in 3/4 to 2-inch diameter stone or gravel free of fines and organic material. Underground: Greater than or equal to 6-inch diameter perforated PVC or HDPE set in 1- to 2-inch diameter stone or gravel free of fines and organic material.
Depth to Bedrock and Seasonal High-Water Table Elevation (SHWT)	If not providing an impermeable liner: • Greater than or equal to 1 foot below the bottom of the filter course material. If within groundwater or water supply intake protection area the practice should also have: • 24-inch depth of filter course. • Greater than or equal to 1 foot of separation between the bottom of the filter course material to bedrock and SHWT.
Overflow Discharge Capacity	10-year, 24-hour storm.

[1] *Storage volume must be at least 75 percent of WQV to capture the volume from high-intensity storms prior to filtration and to avoid premature bypass (VT ANR, 2017).*

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5 inches in a 24-hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Pre-treatment measures should be inspected at least twice annually, and cleaned of accumulated sediment as warranted by inspection, but no less than once annually.
- Trash and debris should be removed at each inspection.
- Manufactured filter media should be replaced periodically per manufacturer's specifications.
- At least once annually, system should be inspected for drawdown time. If a filtration system does not drain within 72 hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore filtration function, including but not limited to removal of accumulated sediments or reconstruction of the filter.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2]

AoT Requirement[3]	Surface Sand Filter	Subsurface Sand Filter
Pollutant Removal (AoT 1507.03)	Yes	Yes
Groundwater Recharge (AoT 1507.04)	No	No
Channel Protection (AoT 1507.05)	No	No
Peak Runoff Control (AoT 1507.06)	Varies	Varies

[1] *See **Chapter 4 (Design Criteria)** for more information.*

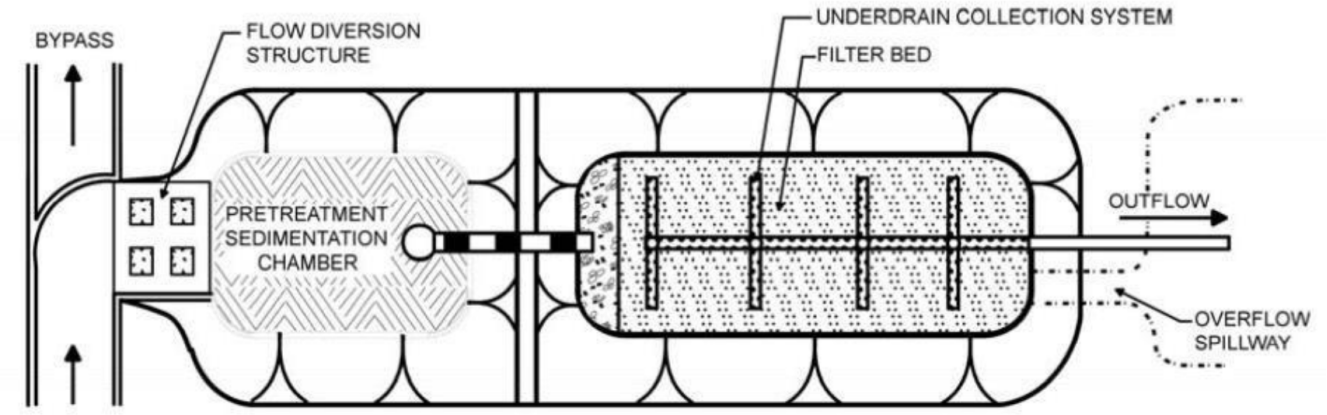
[2] *Refer to Env-Wq 1508.08 Filtering Practices for all SCM AoT requirements.*

[3] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

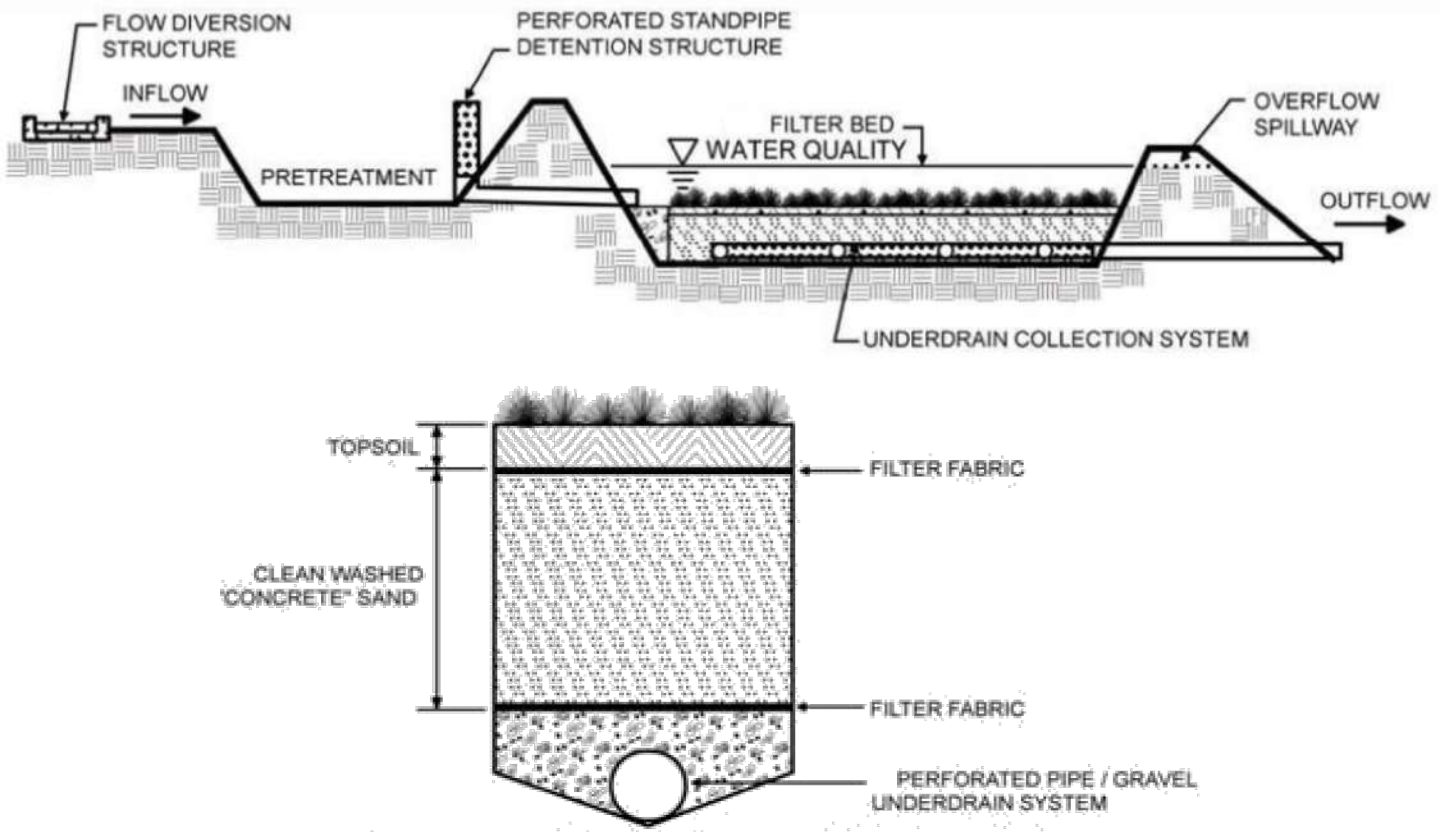
Example Design Schematic

Surface Sand Filter

Plan



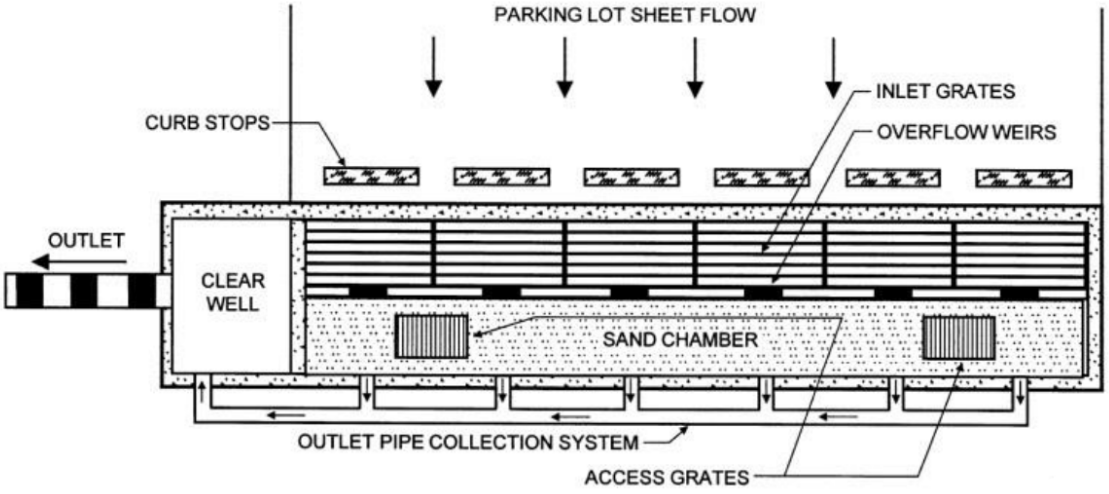
Profile



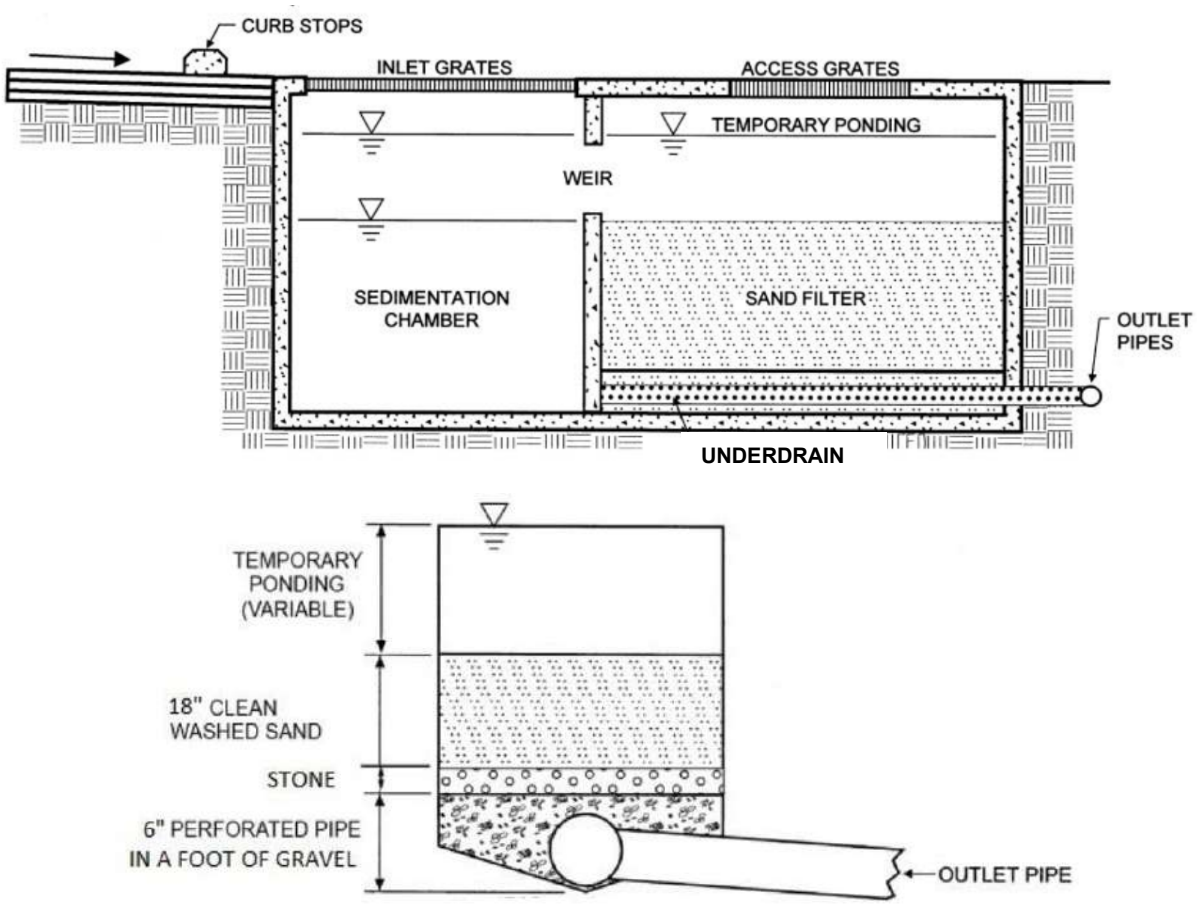
Adapted from VT ANR (2017)

Underground Sand Filter

Plan



Profile



VT ANR (2017)

Note: Graphics may represent outdated details that have since been modified such as all underdrains should be elevated to the maximum extent achievable within the reservoir course.

References

Claytor, Richard A. and Thomas R. Schueler. *Design of Stormwater Filtering Systems*. The Center for Watershed Protection, Ellicott City, MD. December 1996. Available at: https://owl.cwp.org/?mdocs-file=4553.

Environmental Protection Agency. *Stormwater Technology Fact Sheets: Sand Filters*. EPA 832-F-99-007. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Sand Filters*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

MassHighway. *The MassHighway Storm Water Handbook For Highways and Bridges- Sand Filter*. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Constructed Filter*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

University of New Hampshire Stormwater Center (UNHSC). *2005 Data Report: Surface Sand Filter Fact Sheet.* 2005. Available at: https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/annual_data_report_06.pdf.

Vermont Agency of Natural Resources (VT ANR). *Vermont Stormwater Management Manual Rule and Design Guidance*. 2017. Available at: https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/2017%20VSMM_Rule_and_Design_Guidance_04172017.pdf.

Wet Pond

Tier 3

Wet ponds are designed to maintain a permanent pool of water throughout the year. The pool, located below the outlet invert, allows for pollutant removal through settling and biological uptake or decomposition.

Wet ponds, if properly sized and maintained, can achieve high rates of removal for a number of urban pollutants, including sediment and its associated pollutants: trace metals, hydrocarbons, nutrients and pesticides. They also provide some treatment of dissolved nutrients through biological processes within the pond.

Where the temperature of receiving waters is a concern, the addition of an underdrained gravel trench in the bench area around the permanent pool allows for slow, extended release of stormwater, which minimizes the risk of the outlet structure clogging and provides effective cooling to avoid thermal impacts to receiving waters.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Use EPA Performance Curves to calculate pollutant removals (see **Chapter 4.2** for calculation guidance and **Table 5-1** for a crosswalk to identify the most applicable curve).
- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Maintenance access must be provided.
- The pond perimeter should be curvilinear.
- Design must include a hydrologic budget to show sufficient water available to maintain permanent pool depth.
- Planting plan should not include any invasive species and should replicate the spatial and compositional diversity of a natural wetland, developed by a professional with knowledge of wetland plant species.
- See "Bioretention Systems" for a planting guide of New England native species, including salt tolerant species.
- Inlet and outlet should be located as far apart as possible.
- Provide a manually controlled drain, if elevations allow, to dewater pond over 24-hour period.
- Provide energy dissipation at inlet and outlet for scour prevention.
- Stormwater ponds are prohibited in areas of RSA 482-A jurisdiction unless a wetlands permit has been issued.
- Provide small trash racks for outlets less than or equal to 6 inches in diameter or weirs less than or equal to 6 inches wide.
- Use may be limited by depth to bedrock.
- Use may be limited by soils permeability or groundwater levels, or require special design measures to control infiltration of retained water or inflow of groundwater.

- May increase water temperature, which may affect use in watersheds of cold-water fisheries.
- Safety issues must be addressed relative to establishing a permanent pool.

Design Guidance

Design Parameters

Parameter	Criteria
Pre-treatment	Greater than or equal to 10 percent of WQV; see criteria for "Sediment Forebay."
Maximum Side Slopes	3h:1v.
Minimum Side Slopes	20h:1v.
Permanent Pool Volume	Greater than WQV, but up to 2 to 4 times the WQV is recommended to enhance pollutant removal.
Permanent Pool Depth	Average depth of 3 to 6 feet; no greater than 8 feet.
Length to Width Ratio	3:1 minimum.
Design Discharge Capacity	50-year, 24-hour storm without overtopping and at least 1 foot of freeboard should be provided.
Embankment Design	See criteria for "Detention Basin."
Recommended Drainage Area	Greater than or equal to 10 acres unless groundwater conditions will sustain permanent pool.
Safety Bench	Recommended, greater than 10 feet width.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Periodic mowing of embankments.
- Removal of woody vegetation from fill embankments.
- Removal of debris from outlet structures.
- Removal of accumulated sediment.
- Inspection and repair of side slopes, embankments, inlet and outlet structures, and accessories.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1,2,3]

AoT Requirement[4]	Wet Pond
Pollutant Removal (AoT 1507.03)	Yes
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	Yes
Peak Runoff Control (AoT 1507.06)	Yes

[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *Refer to Env-Wq 1508.03 Stormwater Ponds for all SCM AoT requirements.*

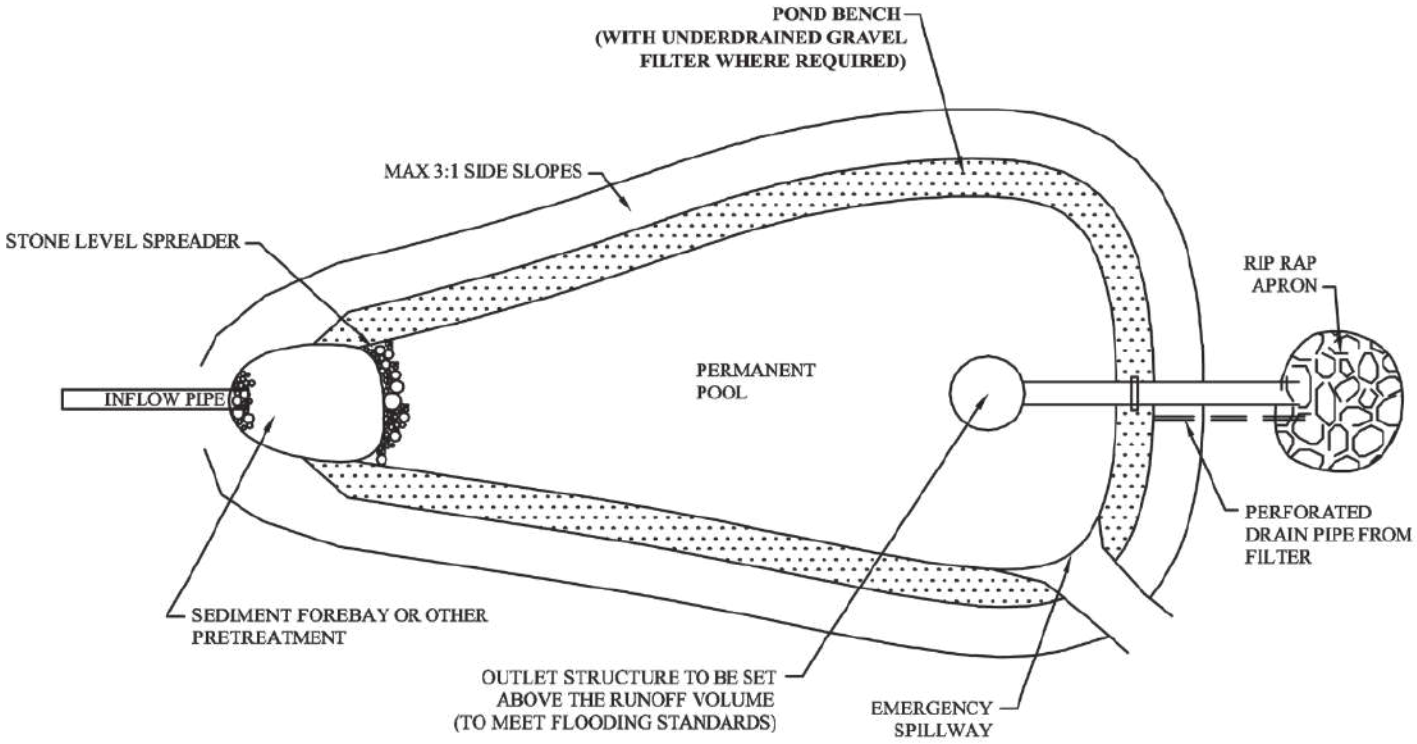
[3] *Wet ponds do not meet AoT requirements in impaired watershed areas.*

[4] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

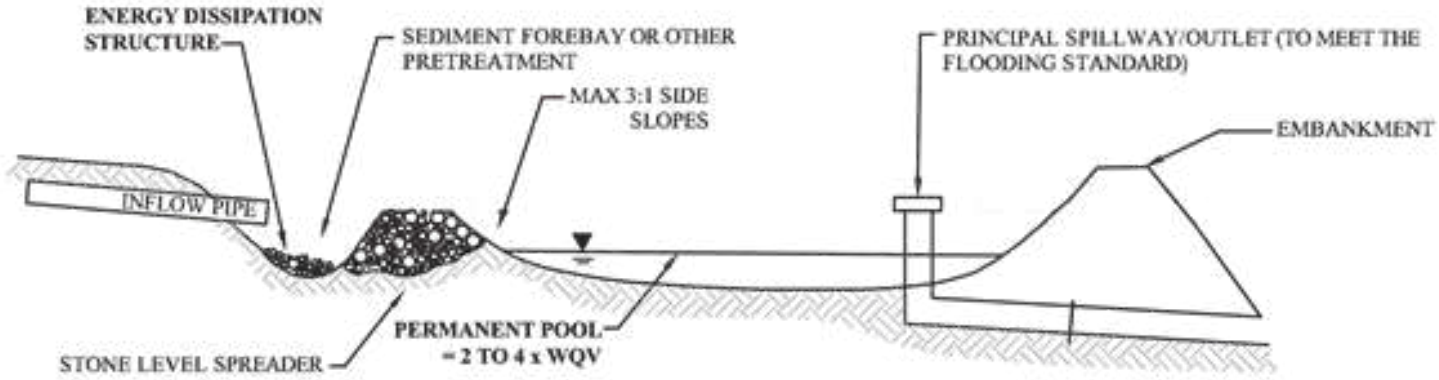
Example Design Schematic

Wet Pond

Plan



Profile



Adapted from Schueler (1987)

Note: Outlet control structure should be configured to accommodate multiple stages including the WQV (permanent pool), channel protection criteria (e.g., 2-year, 24-hour storm), and peak discharge criteria (e.g., 50-year, 24-hour storm).

References

Environmental Protection Agency. *Stormwater Technology Fact Sheets: Wet Detention Ponds.* EPA 832-F-99-048. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Wet Ponds*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Wet Basins*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide- Wet Basin and Wet Linear Practice*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Wet Pond/ Retention Basin*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual- Stormwater Basins*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Schueler, T. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1987.

Schueler, T., P. Kumble, and M. Heraty. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1992. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

University of New Hampshire Stormwater Center (UNHSC). *2009 Biannual Report- Retention Ponds*. Durham, NH. 2009. Available at: https://scholars.unh.edu/stormwater/76/

Structural Conveyance

Conveyance Swale

Conveyance swales are stabilized channels designed to convey stormwater runoff at non-erosive velocities. They may be stabilized using vegetation, riprap, or a combination, or with an alternative lining designed to accommodate design flows while protecting the integrity of the sides and bottom of the channel. Conveyance swales may provide incidental water quality benefits, but are not specifically designed to provide treatment. Conveyance swales are not considered a Treatment or Pre-treatment Practice under the AoT regulations, unless they are also designed to meet the requirements of an acceptable Treatment/ Pre-treatment Practice as described elsewhere in this Appendix.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Conveyance swales receiving stormwater from high-load areas must be lined (impermeable liner) to isolate the stormwater runoff from contact with underlying soil and groundwater.
- All swales should be designed for *capacity* and *stability*. A swale is designed for *capacity* when it can carry the maximum specified design flow within the design depth of the swale (allowing for recommended freeboard). A swale is designed for *stability* when the swale lining (vegetation, riprap, or other material) will not be eroded under maximum design flow velocities. Analyses of these conditions must account for both the type of lining and its condition (e.g., capacity analysis for a grassed swale must consider the resistance of the maximum height of grass, while the stability analysis must consider the grass under its shortest, mowed condition).
- Select vegetation based on soil conditions, growing conditions (sun exposure), anticipated mowing height and frequency, and design flow velocities. See "**Bioretention Systems**" for a planting guide of New England native species, including salt tolerant species.
- If swales must be lined with an impermeable liner, the design should take into consideration the effects of hydrostatic uplift by seasonal high-water table (if present).

Design Guidance

Design Parameters

Parameter	Criteria
Shape	Trapezoidal or parabolic.
Side Slopes	• 3h:1v or flatter (if not lined with riprap). • 2h:1v (if lined with riprap). • Alternative slopes may be possible with properly designed turf reinforcement. Such design should be documented.
Design Capacity	50-year, 24-hour storm.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Grassed swales should be inspected periodically (at least annually) for sediment accumulation, erosion, and condition of surface lining (vegetation or riprap). Repairs, including stone or vegetation replacement, should be made based on this inspection.
- Remove sediment, debris, and invasive species annually, or more frequently as warranted by inspection.
- Mow vegetated swales based on frequency specified by design. Mowing at least once per year is required to control establishment of woody vegetation. It is recommended to cut grass no shorter than 4 inches.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Conveyance Swale (Env-Wq 1508.20)
Pollutant Removal (AoT 1507.03)	No
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	Yes
Peak Runoff Control (AoT 1507.06)	No

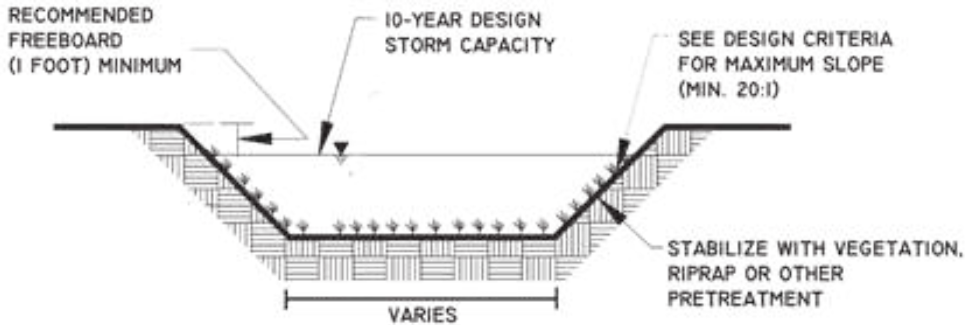
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

Conveyance Swale

Profile



Adapted from MassHighway (2004)

Note: Design storm capacity is 50-year, 24-hour storm based on requirements from Env-Wq 1508.20.

References

Environmental Protection Agency. *Stormwater Technology Fact Sheets: Vegetated Swales*. EPA 832-F-99-006. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Vegetated Swale*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Drainage Channels*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

MassHighway. *The MassHighway Storm Water Handbook For Highways and Bridges- Conventional Drainage Channel*. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Detention Basin

A detention basin is an impoundment designed to temporarily store stormwater runoff and release it at a controlled rate, reducing the intensity of peak flows during storm events. Conventional detention basins are typically designed to control peak stormwater runoff rates under a range of storm conditions, and can be used to control discharges as required under the AoT Regulations and other requirements, including, but not necessarily limited to:

- Storage and peak rate control to meet Channel Protection Requirements (see **Chapter 4.7**).
- Storage and peak rate control to meet Peak Runoff Control Requirements (see **Chapter 4.8**) (10-year and 50-year frequency, 24-hour storm events).
- Storage and peak rate control to prevent flood impacts within the 100-year flood plain.
- Storage and peak rate control to meet other regulatory requirements, including local permitting standards.

Detention basins may consist of surface basins (pond-type structures) or subsurface basins (enclosed structures located below ground). Surface basins should be designed with an emergency spillway or bypass meeting applicable dam safety standards (Env-Wr 100 - 700: Dam Safety Rules). Subsurface basins should also be designed to safely bypass flows exceeding the engineered capacity of the structure.

Detention basins may be combined with treatment SCMs discussed in this guidance document to provide for other stormwater management objectives. For example, a stormwater pond may be designed to provide treatment as well as detention. However, a detention basin is not by itself considered a “Treatment Practice” under the AoT Regulations.

Which Design Elements are “State-of-the-Practice”?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

General Requirements Applicable to Detention Basins

- Detention basins are prohibited in areas of RSA 482-A jurisdiction unless a wetlands permit has been issued.
- A dam permit may be needed prior to construction (RSA 482), and any criteria set by the NHDES Dam Bureau more stringent than those listed in this document or the AoT Regulations apply (Env-Wr 100 - 700: Dam Safety Rules).
- Detention basins receiving stormwater from high-load areas must be lined.
- Provide small trash racks for outlets less than or equal to 6 inches in diameter or weirs less than or equal to 6 inches wide.
- Provide energy dissipation at inlets and outlets to prevent scour.
- Provide vegetation suitable to the soil type, moisture content, sun exposure, and the level of inundation anticipated for all areas of the detention basin, including the basin floors, side slopes, berms, impoundment

structures, or other earthen structures. See "**Bioretention Systems**" for a planting guide of New England native species, including salt tolerant species.

- Underground detention basins must have utility access holes located upstream, downstream, and at intermediate locations for providing maintenance.
- The lowest orifice should be at least 6 inches above the basin floor.
- Outlet structures can be outfitted with various control outlets based on routing calculations.

Design Considerations

- Maintenance access should be provided.
- Although detention basins are effective at controlling peak discharge rates leaving a site, in some cases, the timing of the release of water from the basin may be such that the peak flow in receiving waters further downstream may actually increase. The design of detention basins should consider such potential effects. The engineer should carefully select analysis points and outlet routing to account for the impacts of detention on the local drainage system, and may need to analyze flows at selected downstream hydraulic structures, in addition to the flows at the property line of a project.
- The design and construction of basins and impoundment structures must consider depth to bedrock, depth to groundwater, existing soil conditions, foundation conditions for embankments and structures, and other factors. The design of these structures should only be completed by licensed Professional Engineers qualified in this area of practice.
- Detention basins constructed with impoundment structures may be considered as dams subject to regulation under applicable New Hampshire Reservoir and Dam Safety Standards (Env-Wr 100 - 700: Dam Safety Rules). Also, see discussion of embankment design in the Considerations for Small Impoundment Structures table below.
- Earth slopes and basin bottoms should be stabilized using seed mixes as recommended by the Natural Resources Conservation Service (NRCS).

Design Guidance

Design Parameters

Parameter	Criteria
Side Slopes	2h:1v or flatter (2.5h:1v or flatter recommended, see Note 1).
Minimum Crest Width	4 feet (6 feet recommended, see Note 2).
Design Discharge	50-year, 24-hour storm without overtopping embankment crest, 1 foot of freeboard required.
Emergency Spillway	Required for basins that impound water above existing ground elevation, see Note 3.

Notes:

1. Env-Wr 403.02 requires embankment slopes of dams subject to jurisdiction to be no steeper than 2.5 horizontal to 1 vertical unless a specific design for a steeper slope shows that the embankment is stable and capable of being safely maintained.
2. Env-Wr 403.02 requires embankment crests of dams subject to jurisdiction to be at least 6 feet in width.
3. Emergency spillways must be provided to protect against embankment failure when the primary outlet fails to function. Generally, emergency spillways should be constructed in existing ground, not in the embankment section. Freeboard from top of embankment to the design water surface in the spillway should meet the requirements of Env-Wr 403.02. If no freeboard is specified, use a minimum of 1 foot.

Considerations for Small Impoundment Structures

The design of stormwater management SCMs frequently involves the development of containment basins to store stormwater runoff from the contributing watershed. In some instances, these basins can be constructed by excavation. More frequently, the impoundments are created by earthen embankments, with ancillary discharge control structures.

These structures should be designed by Professional Engineers versed in the analysis and design of impoundments, and based on site specific information relative to watershed hydrology, site soils conditions, hydraulic behavior of receiving waters, hydraulic characteristics of inlet and outlet structures, and other parameters. In some instances, the design of the structures will be subject to regulatory review and licensing under governmental dam safety statutes, rules, and regulations, including, but not necessarily limited to the New Hampshire Reservoir and Dam Safety Standards (Env-Wr 100-700: Dam Safety Rules).

The following are some suggested general guidelines for parameters typically applied to the design of the relatively small impoundments used for stormwater management. However, this listing is not necessarily complete, and may not apply to particular site conditions. The design engineer on any particular project is responsible for research of applicable design standards, including regulatory requirements and codes, selection of methodologies, and performance of the analyses, calculations, and design procedures required to meet accepted engineering practice for the design of impoundments. Users of the following assume all risk associated with the application of this information to the design of impoundment structures.

Design References

Refer to New Hampshire Reservoir and Dam Safety Standards (Env-Wr 100 - 700: Dam Safety Rules), for design information and for information on accepted design references.

Embankment

- Top width per design reference guidelines for structural stability and access.
- Side slopes for surface and structural stability.
- Suitable foundation conditions.
- Freeboard capacity during maximum design flood.
- Construction materials for stability.
- Seepage control.
- Allowance for post-construction settlement.
- Surface stabilization (vegetation, armor, etc.).
- Provisions for controlling undesirable vegetation on embankment slopes.
- Where pipes or other conduits penetrate the embankment, provisions for “drainage diaphragm(s)” (specially designed layers of free-draining soil materials) or anti-seep collar(s) to prevent “piping” along exterior surface of conduit.

Principal Spillway (Outlet Structure)

- 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 and debris.
- Provisions for intercepting and managing floating pollutants.

- Accessibility for routine maintenance and emergency servicing.
- Provisions to prevent piping along exterior of conduit (see embankment guidelines).

Emergency Spillway

- Location to protect integrity of embankment (generally, the emergency spillway should not be located in the embankment, but in undisturbed original ground).
- Capacity to pass the routed design emergency storm (event based on applicable regulation); this emergency scenario may need to consider the primary outlet structure as non-functional during the event.
- Adequate freeboard above emergency impoundment stage.

Other

- Provisions for cleaning of forebays, cleaning and interior maintenance of basin.
- Provisions for lining if needed for maintaining permanent water levels, or preventing direct discharge of stored stormwater runoff into subsoils.
- Provisions for contingency response to spills of oil or hazardous materials, which may be discharged into the basin.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.
- Vegetated embankments that serve as “berms” or “dams” that impound water should be mowed on the bottoms, interior and exterior side slopes, and crest at least once annually to prevent establishment of woody vegetation.
- Embankments should be inspected at least annually by a qualified professional for settlement, erosion, seepage, animal burrows, woody vegetation, and other conditions that could degrade the embankment and reduce its stability. Immediate corrective action should be implemented if any such conditions are found in accordance with Dam Safety Regulations.
- Inlet and outlet pipes, inlet and outlet structures, energy dissipation structures or practices, and other structural accessories should be inspected at least annually by a qualified professional, and corrective action implemented (e.g., maintenance, repairs, or replacement) as indicated by such inspection.
- Trash and debris should be removed from basin and any inlet/outlet structures whenever observed by inspection.
- Accumulated sediment should be removed when it significantly affects basin capacity.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Detention Basin (Env-Wq 1508.18)
Pollutant Removal (AoT 1507.03)	No
Groundwater Recharge (AoT 1507.04)	No
Channel Protection (AoT 1507.05)	Yes
Peak Runoff Control (AoT 1507.06)	Yes

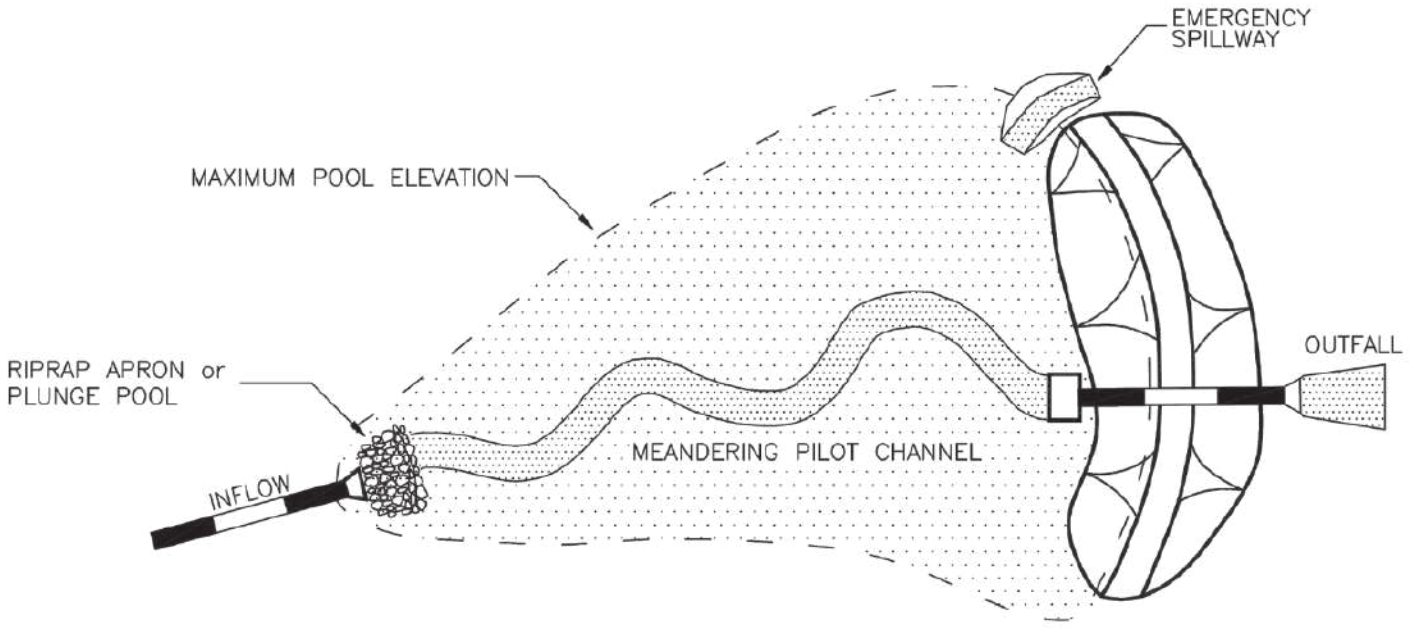
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

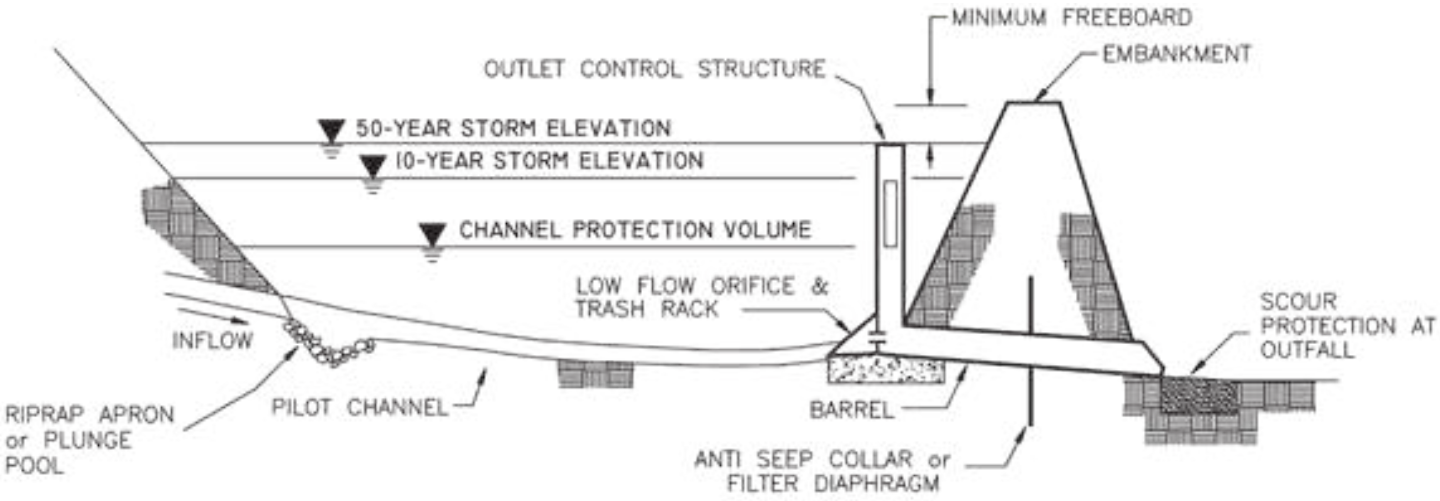
Example Design Schematic

Detention Basin

Plan



Profile



Adapted from MDE (2000)

References

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Detention Basins for Flooding Control*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

MassHighway. *The MassHighway Storm Water Handbook For Highways and Bridges- Detention Basin*. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Dry Detention Basin*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Maryland Department of the Environment (MDE). *Maryland Stormwater Design Manual, Volume I*. 2000. Available at: https://mde.maryland.gov/programs/water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/sedimentstormwater/MD%20SWM%20Volume%201.pdf.

NHDES Dam Bureau. *Dam Permit Guidance Documents*. Available at: https://www.des.nh.gov/resource-center/publications?keys=dampermit&purpose=&subcategory=Dams.

NHDES Dam Bureau. *Env-Wr 100-700*. Available at: https://www.des.nh.gov/rules-and-regulatory/administrative-rules?keys=envwr&purpose=&subcategory=.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual- Stormwater Basins*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Flow Splitters

A flow splitter is an engineered structure used to divide flow into two or more directions. The structure typically consists of a utility access hole, precast concrete vault, or other structure divided into chambers, with the chambers separated by hydraulic control elements. Various hydraulic devices (such as pipes, weirs, or orifices) can be used to control the direction and quantity of flow entering the structure. Generally, a flow splitter consists of a structure with one inlet and two outlets set at different elevations. One outlet conveys low flows, such as those during small storms or at the beginning of a large storm. The other outlet conveys high flows occurring later in the storm. The flows are conveyed in different directions for water quantity or quality control.

The flow splitter is typically used to direct base flows and smaller storm flows to an "off-line" water quality treatment or pre-treatment practice, with larger storms directed to an alternative outlet to bypass and thus prevent overloading of the treatment system. This simple type of device works on hydraulic principles and does not require mechanical components or instrumentation.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- Design must be compatible with the hydraulic capacities of the devices located downstream of the flow splitter outlets.
- Design requires careful evaluation of hydraulic performance of the system, and must account not only for inlet and outlet flow rates, but also for headwater and tailwater conditions, and head losses at transitions through the structure.
- Flow splitters should be accessible for maintenance, and sufficient utility access holes should be provided to enable inspection, cleaning, and repair of each chamber.

Design Guidance

- Engineers are responsible for developing hydraulic, structural, and other design criteria specific to the project site.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Flow splitters should be inspected concurrently with the conveyance and treatment practices served by the devices. It is recommended that the device be inspected and maintained at least once annually.
- Sediments and debris should be removed and disposed of as for other components of the drainage system.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Flow Splitters
Pollutant Removal (AoT 1507.03)	N/A
Groundwater Recharge (AoT 1507.04)	N/A
Channel Protection (AoT 1507.05)	N/A
Peak Runoff Control (AoT 1507.06)	N/A

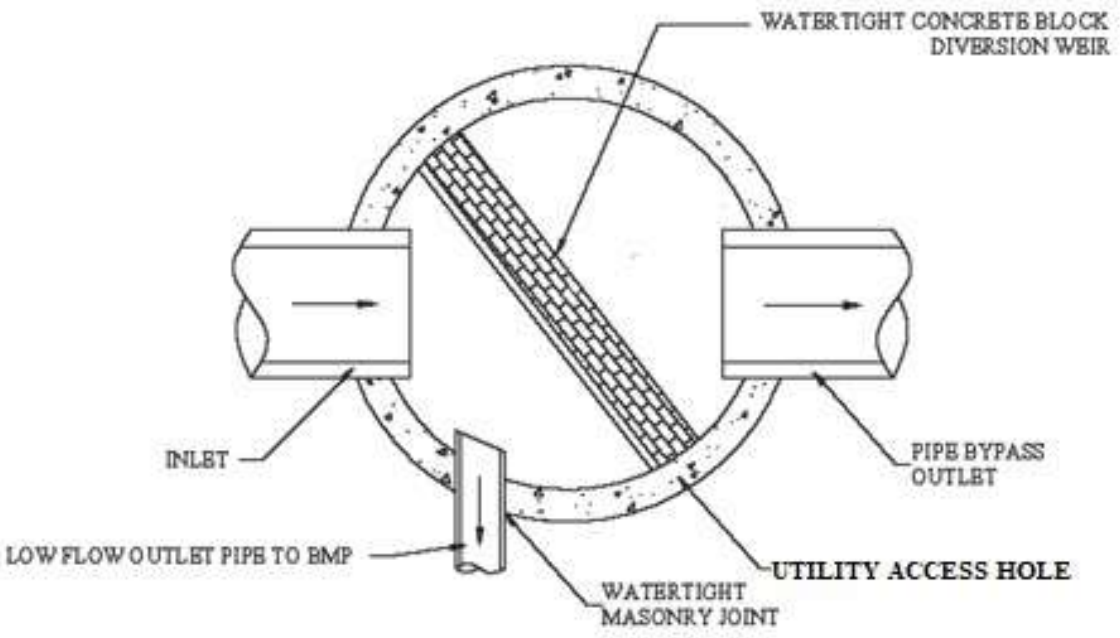
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematics

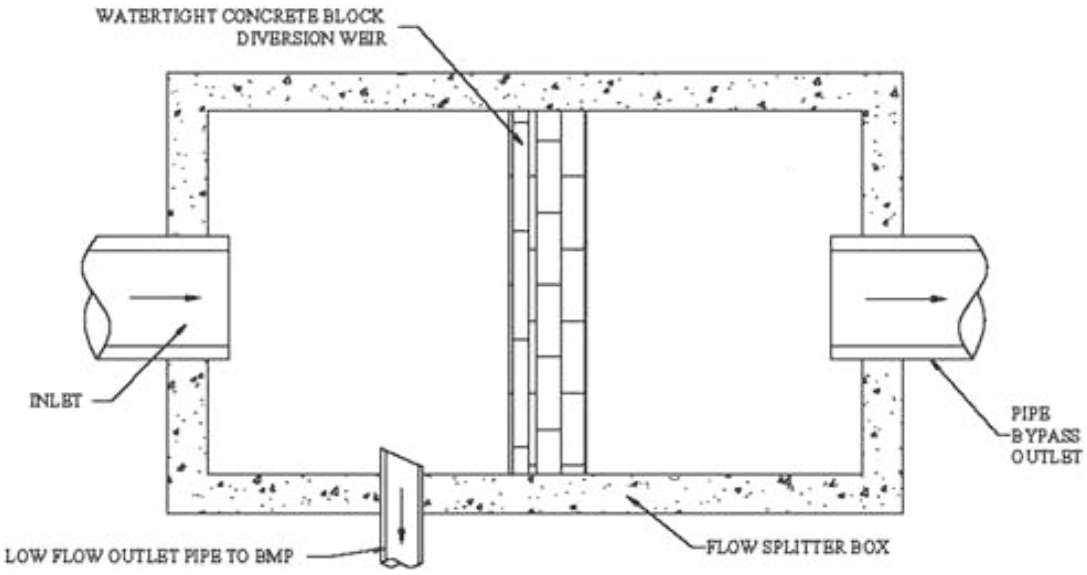
Utility Access Hole

Plan

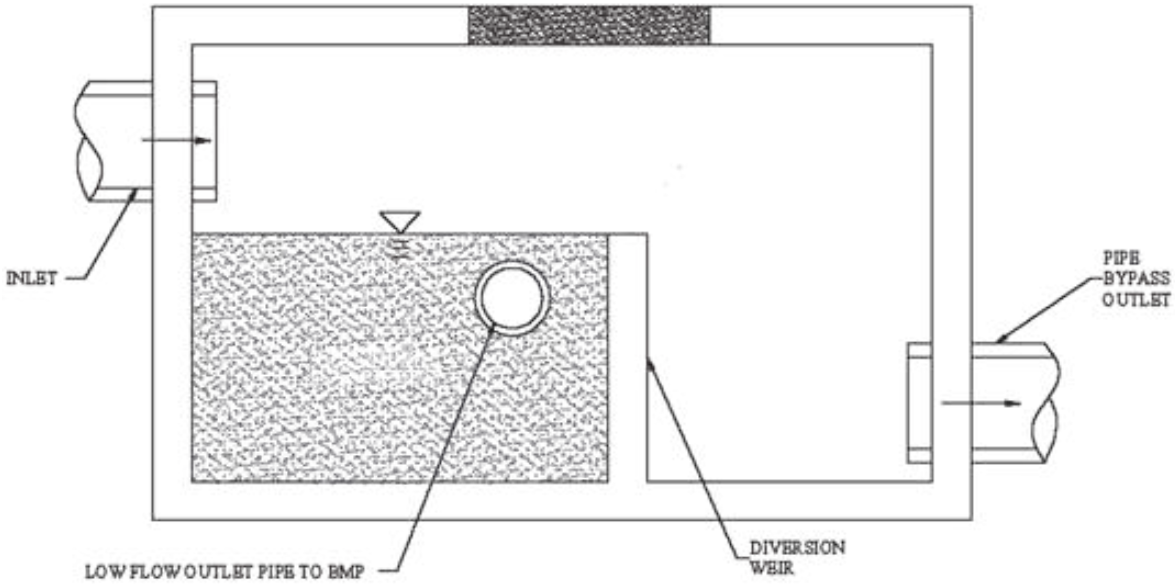


Flow Splitter Box

Plan



Profile



Adapted from ME DEP (2006)

References

Maine Department of Environmental Protection (ME DEP). *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Flow Splitter*. Publication No. DEPLW0738. January 2006. Revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

MassHighway. *The MassHighway Storm Water Handbook For Highways and Bridges- Flow Splitter*. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Permanent Outlet Protection

Outlet protection is typically provided at stormwater discharge conduits from structural SCMs to reduce the velocity of concentrated stormwater flows to prevent scour and minimize the potential for downstream erosion. Outlet protection is also provided where conduits discharge stormwater runoff into an inground stormwater management practice (e.g., pond or swale) to prevent scour where flow enters the SCM.

Standard engineering practices allow for many different types of outlet protection which provide energy dissipation. Common outlet protection measures include:

- Riprap aprons, the design of which is covered within this section.
- Riprap lined scour holes, stilling basins or plunge pools. Design references for stilling basins are provided under 'References'.

Other outlet protection practices may be used, if documented by applicable technical literature.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

Design Considerations

- The entire length of the flow path from the outlet of the conduit, channel, or structure to the point of entry into an existing stream or publicly maintained drainage system should be evaluated for the need for outlet protection.
- There should be no bends or curves at the intersection of the conduit and apron.
- There should be no overfall from the end of the apron to the receiving area.
- The design criteria presented below typically apply to pipes that are designed to be full at the 25-year storm. Where pipes do not flow full, designers should consult applicable design references for alternative apron sizing, particularly where the construction of the apron would disturb existing water resources. For example, wetland crossings should seek alternative apron sizing so as to not over design, thereby limiting the wetland impacts to only those that are necessary.

Design Guidance

Design Parameters

Parameter	Criteria
Apron Length	$L_a = 1.8Q/D_o1.5 + 7D_o$ (when $TW < D_o/2$) $L_a = 3.0Q/D_o1.5 + 7D_o$ (when $TW > D_o/2$) Where: L_a = length of the apron (feet) D_o = maximum inside width of outlet pipe or channel (feet) Q = outlet discharge (cubic feet per second) TW = tailwater elevation (feet)
Apron Width at the Outlet End of the Apron (when there is a well-defined channel downstream of the apron)	Bottom width of the apron should be greater than the bottom width of channel. The structural lining should extend at least 1 foot above the tailwater elevation but no lower than 2/3 of the vertical conduit dimension above the conduit invert.
Apron Width at the Outlet End of the Apron (when there is ***no*** well-defined channel downstream of the apron)	$W = 3D_o + L_a$ (when $TW < D_o/2$) $W = 3D_o + 0.4L_a$ (when $TW > D_o/2$) Where: W = width of the apron (feet) L_a = length of the apron (feet) D_o = maximum inside width of outlet pipe or channel (feet) TW = tailwater elevation (feet)
Apron Width at the Apron Inlet or Culvert Outlet	$W = 3D_o$
Side Slopes of Channel Bank Adjacent to Apron	2h:1v or flatter.
Bottom Grade	0 percent.
Riprap Diameter	$D_{50} = 0.02Q^{1.3}/(TW*D_o)$ Where: D_{50} = median stone diameter (feet) Q = outlet discharge (cubic feet per second) TW = tailwater elevation (feet) D_o = maximum inside width of outlet pipe or channel (feet) 50 percent of stone by weight should be smaller than D_{50}. The largest stone size should be 1.5 times D_{50}. Thickness should be at least 1.5 times the D_{50} . Gabions or precast cellular blocks may be substituted for riprap if the D_{50} size calculated above is less than or equal to the thickness of the gabions or concrete revetment blocks.
Preformed Scour Hole	If preformed scour hole is used instead of an apron, see *ASCE (1992)* in lieu of the above criteria.

Allowable Design Flow Velocities for Various Soils

Soil Texture	Allowable Velocity (feet per second)
Sand and sandy loam	2.5
Silt loam	3.0
Sandy clay loam	3.5
Clay loam	4.0
Clay, fine gravel, graded loam to gravel	5.0
Cobbles	5.5
Shale	6.0

Source: CT DEP, 2002

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Inspect the outlet protection annually for damage and deterioration. Repair damages immediately.
- Remove sediment, debris, and woody vegetation.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Outlet Protection
Pollutant Removal (AoT 1507.03)	N/A
Groundwater Recharge (AoT 1507.04)	N/A
Channel Protection (AoT 1507.05)	N/A
Peak Runoff Control (AoT 1507.06)	N/A

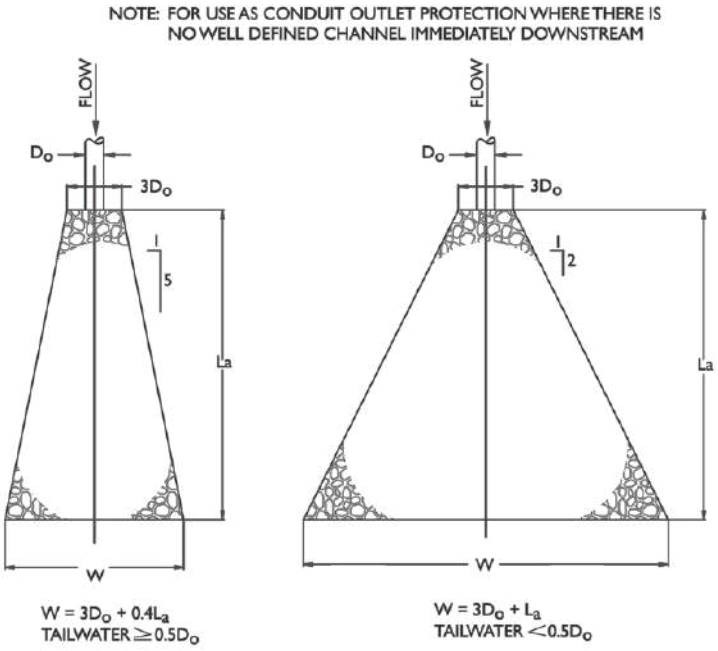
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

Apron

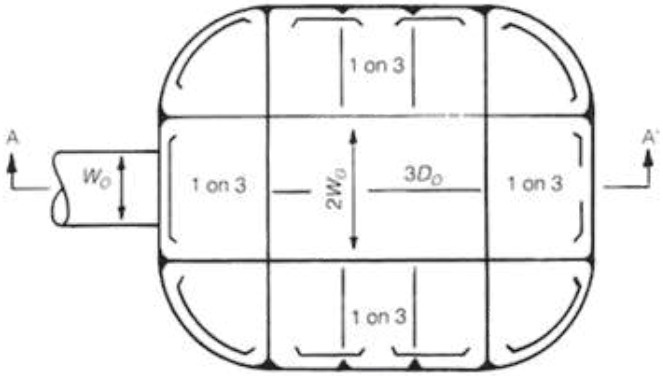
Plan



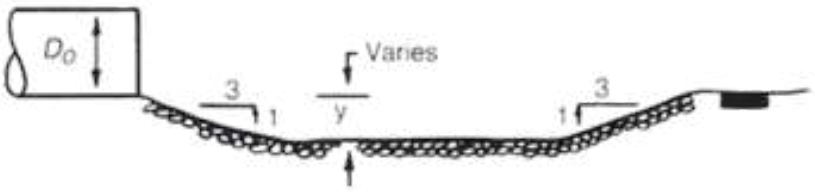
CT DEP (2002)

Preformed Scour Hole

Plan



Profile



ASCE (1992)

References

Agricultural Service Research Publication ARS-76. *Scour at Cantilevered Pipe Outlets – Plunge Pool Energy Dissipator Design Criteria*. 1989.

American Society of Agricultural Engineers. "Plunge Pool Design at Submerged Pipe Spillway Outlets." Volume 37(4):1167-1173. 1994. Available at: https://elibrary.asabe.org/abstract.asp?aid=28190&t=2&redir=&redirType=

American Society of Civil Engineers (ASCE). *Sedimentation Engineering*. Manuals and reports on engineering practice No. 54, ASCE, New York. 1975.

American Society of Civil Engineers and the Water Environment Federation. *Design and Construction of Urban Stormwater Management Systems*. Manual and Reports of Engineering Practice No. 77, and WEF Manual of Practice FD-20, ASCE, New York. 1992.

Connecticut Department of Environmental Protection (CT DEP). *Connecticut Guidelines for Soil Erosion and Sediment Control*. Hartford, CT. May 2002. Revised September 2023. Available at: https://portal.ct.gov/-/media/deep/water/water_quality_management/guidance/sescg_cleanfinal.pdf?rev=7a4cbf1406e841799148b1f8d4033f80&hash=679015A2EC8F068083F9F15B8A13AF90

Maine Department of Environmental Protection. *Maine Erosion and Sediment Control BMPs- Pipe Outlet Protection, Slope and Shoreline Stabilization*. Publication No. DEPLW0588. Original print 2003. Revised March 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

MassDOT. *MassDOT Project Development and Design Guide, Chapter 8 – Drainage and Erosion Control*. 2006. Available at: https://www.mass.gov/info-details/pddg-chapter-8-drainage-and-erosion-control

MassHighway. *The MassHighway Storm Water Handbook For Highways and Bridges- Outlet Sediment Trap*. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices- Outlet Structures*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

U.S. Department of the Interior, Bureau of Reclamation. *Hydraulic Design of Stilling Basins and Energy Dissipators*, Engineering Monograph No. 25. Available at: https://www.usbr.gov/tsc/techreferences/hydraulics_lab/pubs/EM/EM25.pdf

U.S. Department of Transportation, Federal Highway Administration. *Hydraulic Design of Energy Dissipators for Culverts and Channels*, Hydraulic Engineering Circular No. 14. December 1975. Revised July 2006. Available at: https://www.fhwa.dot.gov/engineering/hydraulics/pubs/06086/hec14.pdf

U.S. Environmental Protection Agency. "Erosion and sediment control, surface mining in the Eastern U.S." EPA-625/3-76-006, Washington, D.C. 1976. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Outlet Protection*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Stone Berm Level Spreader

A stone berm level spreader is an outlet structure constructed at zero percent grade across a slope used to convert concentrated flow to “sheet flow.” It disperses or “spreads” flow thinly over a receiving area, usually consisting of undisturbed, vegetated ground. The conversion of concentrated flow to shallow, sheet flow allows stormwater runoff to be discharged at non-erosive velocities onto natural ground. To stabilize the spreader outlet, a stone berm is provided to dissipate flow energy, and help disperse flows along the length of the spreader.

Level spreaders are not designed to remove pollutants from stormwater; however, some suspended sediment and associated phosphorus, nitrogen, metals and hydrocarbons will settle out of the stormwater runoff through settlement, filtration, infiltration, absorption, decomposition and volatilization.

Which Design Elements are “State-of-the-Practice”?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

General Requirements Applicable to Stone Berm Level Spreaders

- The spreader must discharge to a vegetated or other stable receiving area with capacity to convey the discharge without erosion.
- The receiving area must be stable prior to construction of level spreader.

Design Considerations

- It is critical to install level spreaders at a zero percent grade along the length of the discharge lip. Flow must discharge uniformly along the length of the spreader.
- Care must be exercised in siting the spreader, so that it discharges onto a gently sloping grade, where stormwater runoff exiting the spreader will not reconcentrate and cause erosion. A cross slope that is concave in shape (such as a shallow swale) is not suitable for receiving the discharge from a level spreader. Suitable cross slopes are planar or convex in shape, so that flow will continue as dispersed sheet flow across the site.
- It is essential to stabilize the outlet lip of the spreader, and to discharge onto a well stabilized receiving area (preferably undisturbed vegetation) to prevent erosion.

Design Guidance

Design Parameters

Parameter	Criteria
Slope of Receiving Area	Less than 15 percent (along flow path).
Level Spreader Grade	Bottom of spreader channel, and base and top of berm should be 0 percent grade.
Spreader Channel Cross Section	6-inch-deep trapezoidal trough.
Spreader Channel Bottom Width	Greater than or equal to 3 feet.
Side Slopes	2h:1v or flatter (level spreader channel and berm).
Berm Top Width	Greater than or equal to 2 feet.
Berm Height	Greater than or equal to 18 inches.
Stone Gradation	See Gradation of Stone for Level Spreader Berm table below.
Length of Spreader	When part of a Treatment Practice, the length should be as required for that practice or meet downstream grades to prevent erosion (topography). If not, the length should be no less than 5 feet.

Gradation of Stone for Level Spreader Berm

Sieve Designation	Percent by Weight Passing Square Mesh Sieve
12-inch	100
6-inch	84 - 100
3-inch	68 - 83
1-inch	42 - 55
No. 4	8 - 12

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Inspect at least once annually for accumulation of sediment and debris and for signs of erosion within approach channel, spreader channel or down-slope of the spreader.
- Remove debris whenever observed during inspection.
- Remove sediment when accumulation exceeds 25 percent of spreader channel depth.
- Remove woody vegetation.
- Snow should not be stored within or down-slope of the level spreader or its approach channel.
- Repair any erosion and re-grade or replace stone berm material, as warranted by inspection.
- Reconstruct the spreader if down-slope channelization indicates that the spreader is not level or that discharge has become concentrated, and corrections cannot be made through minor regrading.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Stone Berm Level Spreaders (Env-Wq 1508.19)
Pollutant Removal (AoT 1507.03)	N/A
Groundwater Recharge (AoT 1507.04)	N/A
Channel Protection (AoT 1507.05)	N/A
Peak Runoff Control (AoT 1507.06)	N/A

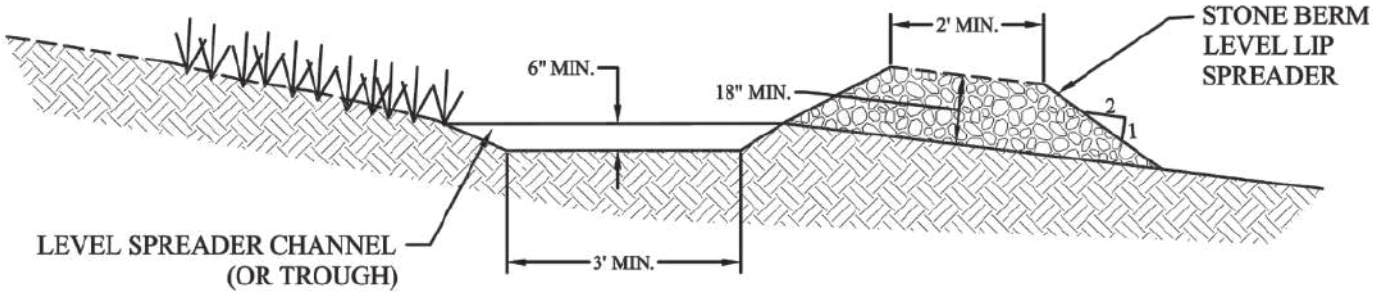
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

Stone Berm Level Spreader

Profile



Adapted from ME DEP (2006)

References

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual- Level Spreader*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Level Spreader*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual- Level Spreaders*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Level Spreader*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Terraced Slopes or Benching

The land grading practice of providing terraced slopes or benching consists of shaping disturbed land surfaces to control the length of flow down steep slopes. Intermediate terraces (or benches) are incorporated into slopes that exceed 4h:1v gradient. These terraces are then used to convey stormwater runoff laterally to a safe discharge (or to a constructed drainage system). The purpose of this practice is to provide for erosion control and vegetative establishment on those areas where the existing land surface is to be reshaped by grading.

Provisions should be made to safely convey surface stormwater runoff collected by the terraced slope to storm drains, stabilized channels, or other stable conveyance practices or water courses. Stormwater runoff should also be intercepted at the top of the slopes and directed to a stable outlet.

Which Design Elements are "State-of-the-Practice"?



The following design elements included in this fact sheet present the state-of-the-practice for stormwater management in New Hampshire and may exceed or differ from regulatory requirements:

- Inspection of SCMs is recommended at least once annually and after any storm event with greater than or equal to 1-inch of rain over 24 hours to inform the need for maintenance, unless specified differently in the Maintenance Requirements below.

General Requirements Applicable to Terraced Slopes or Benching

- Benches are required wherever the vertical height of a slope meets the conditions listed in the Design Parameters table. If diversion swales are incorporated to keep upstream drainage off a constructed slope, benches shall be provided wherever the vertical height between the top and bottom of the slope exceeds 40 feet.
- Benches, when required, must divide the slope face into equal parts.
- Benches must convey stormwater to a stable outlet.

Design Considerations

- Designs should address soil conditions, slope stability (friction angles), seeps, rock outcrops, the up-slope contributing drainage area, and other site conditions in the design of benches.
- All disturbed areas should be stabilized structurally or with vegetation.
- All graded or disturbed areas including slopes should be protected during clearing and construction in accordance with the approved erosion and sediment control plan until they are adequately stabilized.
- Surface water should generally be diverted away from the face of cut and/ or fill slopes by the use of diversions, channels and swales or conveyed downslope by the use of a designed structure, except where the face of the slope has been specifically engineered to receive such drainage, in which case:
    - The face of the slope must be stabilized with vegetation, riprap, or other stabilization measure and the face of all graded slopes will be protected from surface stormwater runoff until stabilized.
    - The face of the slope must not be subject to any concentrated flows of surface water such as from natural drainage ways, graded swales, roof drain outlets, drainage system outlets, and other sources.

Design Guidance

Design Parameters

Parameter	Criteria
Slopes Requiring Terracing/ Benching	Any 2h:1v slope with vertical height greater than or equal to 20 feet. Any 3h:1v slope with vertical height greater than or equal to 30 feet. Any 4h:1v slope with vertical height greater than or equal to 40 feet.
Bench Width	Greater than or equal to 6 feet.
Bench Reverse Slope	6h:1v or flatter (reverse slope from top of lower slope to toe of upper slope) and minimum 1 foot in depth.
Bench Gradient to Outlet	2 percent to 3 percent.
Flow Length Along Bench	Less than or equal to 800 feet.
Channel Gradient from Bench to Outlet	2 percent to 3 percent.

Maintenance Requirements

- Maintenance activities need to comply with laws that protect wildlife, including but not limited to RSA 209:8, RSA 209:9, RSA 209:10, and RSA 212-A:7.
- Grassed slopes should be mowed to grass height and frequency specified by design.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.
- Terraces and slopes should be inspected periodically for any sign of rill or gully erosion, and if such conditions are noted, the area should be immediately investigated and repaired as needed.

Ability to Meet AoT Requirements

Can SCM Meet AoT Requirements if Properly Designed?[1]

AoT Requirement[2]	Terraced Slopes or Benching (Env-Wq 1508.21)
Pollutant Removal (AoT 1507.03)	N/A
Groundwater Recharge (AoT 1507.04)	N/A
Channel Protection (AoT 1507.05)	N/A
Peak Runoff Control (AoT 1507.06)	N/A

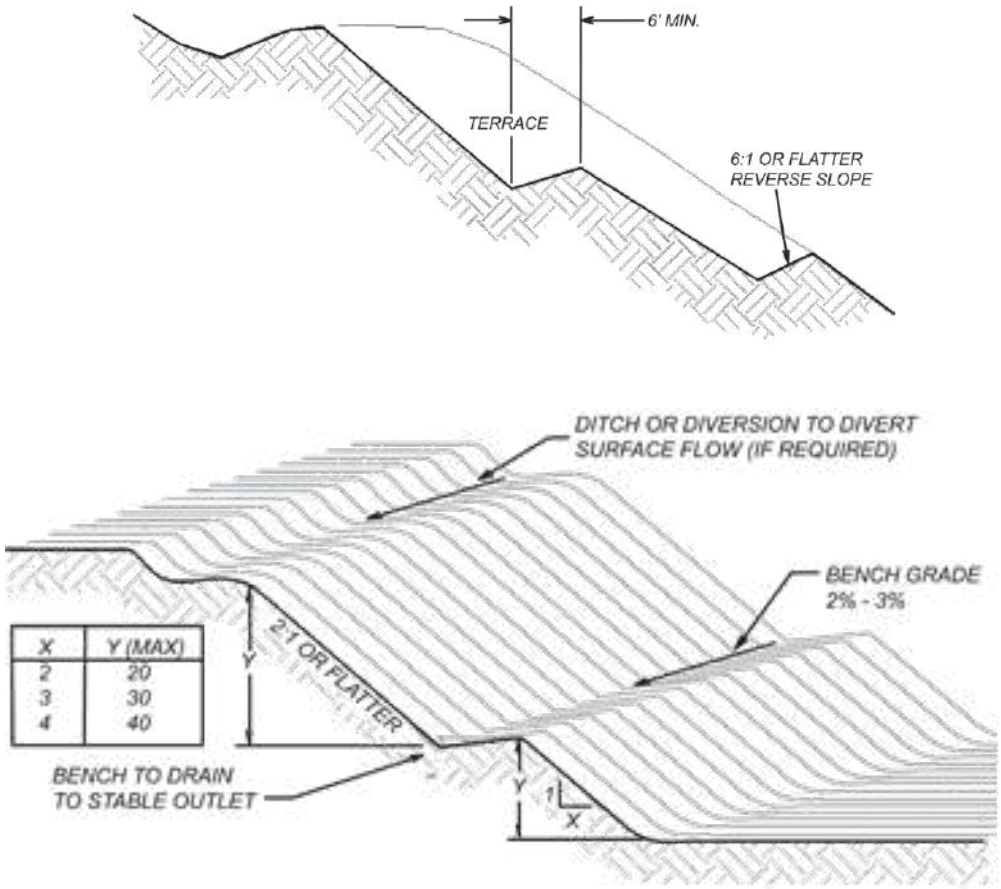
[1] *See **Chapter 4 (Design Criteria)** for more information.*

[2] *In accordance with Env-Wq 1507.07 Long-Term Maintenance, all SCMs should have a mechanism to provide on-going inspections and maintenance so long as the practices are expected to be used.*

Example Design Schematic

Terraced Slopes or Benching

Profile



Adapted from ME DEP (2003)

References

Connecticut Department of Environmental Protection. *2002 Connecticut Guidelines for Soil Erosion and Sediment Control*. Hartford, CT. May 2002. Revised September 2023. Available at: https://portal.ct.gov/-/media/deep/water/water_quality_management/guidance/sescg_cleanfinal.pdf?rev=7a4cbf1406e841799148b1f8d4033f80&hash=679015A2EC8F068083F9F15B8A13AF90

Maine Department of Environmental Protection. *Maine Erosion and Sediment Control BMPs- Slopes*. Publication No. DEPLW0588. Original print 2003. Revised March 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual- Infiltration Berm & Retentive Grading*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

References

Agricultural Service Research Publication ARS-76. *Scour at Cantilevered Pipe Outlets – Plunge Pool Energy Dissipator Design Criteria*. 1989.

American Society of Agricultural Engineers. "Plunge Pool Design at Submerged Pipe Spillway Outlets." Volume 37(4):1167-1173. 1994. Available at: https://elibrary.asabe.org/abstract.asp?aid=28190&t=2&redir=&redirType=

American Society of Civil Engineers (ASCE) and the Water Environment Federation. *Design and Construction of Urban Stormwater Management Systems*. Manual and Reports of Engineering Practice No. 77, and WEF Manual of Practice FD-20, ASCE, New York. 1992.

American Society of Civil Engineers. *Sedimentation Engineering*. Manuals and reports on engineering practice No. 54, ASCE, New York. 1975.

Brown, T. and D. Caraco. *Channel Protection*. Water Resources IMPACT. V3, n6, 16-19. November 2001. http://www.jstor.org/stable/wateresoimpa.3.6.0016.

Cappiella, K., L. Fraley-McNeal, M. Novotney, and T. Schueler. *The Next Generation of Stormwater Wetlands. Wetlands & Watersheds Article #5*. Center for Watershed Protection, Ellicott City, MD. February 2008. Available at: https://owl.cwp.org/mdocs-posts/wetland-and-watershed-article-series-article-5/

City of Manchester, NH. "Rake it or Leave it?" MS4 Guidance Sheet. 2022. Available at: www.manchesternh.gov/Portals/2/Departments/environ_protec/stormwater/.

Claytor, Richard A. and Thomas R. Schueler. *Design of Stormwater Filtering Systems*. The Center for Watershed Protection, Ellicott City, MD. December 1996. Available at: https://owl.cwp.org/?mdocs-file=4553.

Comprehensive Environmental Inc. *City of Nashua, New Hampshire Alternative Stormwater Management Methods Part 2. Designs & Specifications*. March 2003. Available at: https://www.nheconomy.com/getmedia/c0097d3d-fb0f-4de7-ae88-210dfaea2e6d/alternative-stormwater-management-methods-nashua-nh.pdf

Connecticut Department of Environmental Protection (CT DEP). *2002 Connecticut Guidelines for Soil Erosion and Sediment Control*. Hartford, CT. May 2002. Revised September 2023. Available at: https://portal.ct.gov/-/media/deep/water/water_quality_management/guidance/sescg_cleanfinal.pdf?rev=7a4cbf1406e841799148b1f8d4033f80&hash=679015A2EC8F068083F9F15B8A13AF90

Connecticut Department of Environmental Protection (CT DEP). *2004 Connecticut Stormwater Quality Manual*. Hartford, CT. 2004. https://portal.ct.gov/-/media/DEEP/water_regulating_and_discharges/stormwater/manual/StormwaterManualCompletepdf.pdf.

Environmental Protection Agency (EPA). *Storm Water O&M Fact Sheet: Catch Basin Cleaning.* EPA 832-F-99-011. 1999. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=200044BA.TXT

EPA. *Stormwater Best Management Practice: Green Roofs*. 2021. Available at: https://www.epa.gov/system/files/documents/2021-11/bmp-green-roofs.pdf

EPA. *Stormwater Best Management Practice: Parking Lot and Street Sweeping*. Fact Sheet. 2021. Available at: https://www.epa.gov/system/files/documents/2021-11/bmp-parking-lot-and-street-sweeping.pdf

EPA. *Stormwater Technology Fact Sheets: Hydrodynamic Separators*. EPA 832-F-99-017. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

EPA. *Stormwater Technology Fact Sheets: Bioretention*. EPA 832-F-99-012. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

EPA. *Stormwater Technology Fact Sheets: Sand Filters*. EPA 832-F-99-007. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

EPA. *Stormwater Technology Fact Sheets: Vegetated Swales*. EPA 832-F-99-006. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

EPA. *Stormwater Technology Fact Sheets: Wet Detention Ponds.* EPA 832-F-99-048. September 1999. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

EPA. *Snow Disposal Guidelines*. Environmental Fact Sheet. 2020. Available at: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/wmb-3.pdf.

EPA. *Stormwater Best Management Practice: Stormwater Wetland*. Fact Sheet. 2021. Available at: https://www.epa.gov/system/files/documents/2021-11/bmp-stormwater-wetland.pdf.

EPA. *2017 NH Small MS4 General Permit*. Original 2017. Modified 2020. Available at: https://www3.epa.gov/region1/npdes/stormwater/nh/2017-small-ms4-general-permit-nh-mod.pdf.

EPA. *2017 NH Small MS4 General Permit Appendix F: Requirements of Approved Total Maximum Daily Loads*. Original 2017. Modified 2020. Available at: https://www3.epa.gov/region1/npdes/stormwater/nh/2017-appendix-f-sms4-nh-mod.pdf.

Ferguson, B.K. *Stormwater Infiltration*. Lewis Publishers. Boca Raton, FL. 1994.

Interlocking Concrete Pavement Institute. *Permeable Interlocking Concrete Pavement: A Comparison Guide to Porous Asphalt and Pervious Concrete*. Washington, DC. February 2008. https://www.willowcreekpavingstones.com/resources/pdf/icpi-permeable-pavement-comparisons.pdf.

Maine Department of Environmental Protection. *Maine Erosion and Sediment Control BMPs*. Publication No. DEPLW0588. Original print 2003. Revised March 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Maine Department of Environmental Protection. *Stormwater Management for Maine: Vol. 3. BMPs Technical Design Manual*. Original print 2006, revised 2016. Available at: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/volume%20III%20May%202016.pdf.

Maryland Department of the Environment (MDE). *Maryland Stormwater Design Manual, Volume I*. 2000. Available at: https://mde.maryland.gov/programs/water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/sedimentstormwater/MD%20SWM%20Volume%201.pdf.

Massachusetts Department of Environmental Protection (MassDEP). *Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas.* Prepared by Franklin, Hampden, Hampshire Conservation Districts. Northampton, MA. Reprint May 2003. https://www.mass.gov/doc/complete-erosion-and-sedimentation-control-guidelines-a-guide-for-planners-designers-and/download.

Massachusetts Department of Environmental Protection. *Massachusetts Nonpoint Source Pollution Management Manual*. January 2006.

Massachusetts Department of Environmental Protection (MassDEP). *Massachusetts Stormwater Handbook*. Unpublished, 2025.

Massachusetts Department of Environmental Protection (MassDEP). *Stormwater Handbook Volume 2 Chapter 2: Stormwater Best Management Practices*. 2008. Available at: https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download.

Massachusetts Department of Transportation (MassDOT). *MassDOT Stormwater Design Guide*. 2023. Available at: https://www.mass.gov/doc/stormwater-design-guide/download.

MassDOT. *MassDOT Project Development and Design Guide, Chapter 8 – Drainage and Erosion Control*. 2006. Available at: https://www.mass.gov/info-details/pddg-chapter-8-drainage-and-erosion-control

MassHighway. *The MassHighway Storm Water Handbook For Highways and Bridges*. 2004. Available at: https://www.mass.gov/doc/storm-water-handbook-for-highways-and-bridges/download.

Minnesota Snow and Ice Control Handbook, 2022. Available at: https://mdl.mndot.gov/_flysystem/fedora/2023-02/2022ric01.pdf

Minton, Gary. 2005. *Stormwater Treatment*. Resource Planning Associates. Seattle, WA.

NAHM Research Center, Inc. *The Practice of Low Impact Development*. July 2003. Available at: https://www.huduser.gov/publications/pdf/practlowimpctdevel.pdf.

New Hampshire Department of Environmental Services (NHDES) Dam Bureau. *Dam Permit Guidance Documents*. Available at: https://www.des.nh.gov/resource-center/publications?keys=dampermit&purpose=&subcategory=Dams.

NHDES Dam Bureau. *Env-Wr 100-700*. Available at: https://www.des.nh.gov/rules-and-regulatory/administrative-rules?keys=envwr&purpose=&subcategory=.

NHDES. *Environmental Fact Sheet: Management of Municipal Roadway Soils*. SW-38. 2023. Available at: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/sw-38.pdf.

NHDES. *Innovative Stormwater Treatment Technologies Best Management Practices Manual*. May 2002. Available at: https://scholars.unh.edu/cgi/viewcontent.cgi?article=1314&context=prep.

NHDES. *Road Salt Reduction*. Webpage. 2023. Available at: https://www.des.nh.gov/land/roads/road-salt-reduction.

NHDES. *Soak Up the Rain New Hampshire: New Hampshire Homeowner's Guide to Stormwater Management*. 2019. Available at: https://www.soaknh.des.nh.gov/sites/g/files/ehbemt741/files/documents/homeowners-guide-to-stormwater-management.pdf.

North Carolina Department of Environmental Quality (NCDEQ). *NCDEQ Stormwater Design Manual, Part C: Minimum Design Criteria and Recommendations for Stormwater Control Measures.* November 2020. Available at: https://www.deq.nc.gov/about/divisions/energy-mineral-and-land-resources/stormwater/stormwater-program/stormwater-design-manual.

Pennsylvania Department of Environmental Protection (PA DEP). *Pennsylvania Stormwater Best Management Practices Manual*. Document number 363-0300-002. December 2006. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4673.

PREP and UNHSC. *Clean Sweep: Recommendations for New and Updated Credits for Street Cleaning in New Hampshire*. Technical Memorandum. 2022. Available at: https://scholars.unh.edu/cgi/viewcontent.cgi?article=1459&context=prep

Prince George's County, Maryland Department of Environmental Resources, Programs and Planning Division. *Low Impact Design Strategies: An Integrated Design Approach*. January 2000. https://nepis.epa.gov/Exe/ZyNET.exe/.

Rhode Island Department of Environmental Management (RI DEM) and Coastal Resources Management Council. *Rhode Island Stormwater Design and Installation Standards Manual*. Original print 1993. Revised 2015. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/pubs/regs/regs/water/swmanual15.pdf.

Rockingham County Conservation District. *Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire*. Prepared for New Hampshire Department of Environmental Services. Exeter, NH. August 1992.

Schueler, T. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1987.

Schueler, T. *Design of Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetlands in the Mid-Atlantic Region*. Metropolitan Washington Council of Governments. Washington, DC. 1992.

Schueler, T., D. Hirschman, M. Novotney, and J. Zielinski, P.E. *Urban Stormwater Retrofit Practices. Urban Subwatershed Restoration Manual No. 3*. Center for Watershed Protection, Ellicott City, MD. July 2007. https://owl.cwp.org/mdocs-posts/urban-subwatershed-restoration-manual-series-manual-3/.

Schueler, T., P. Kumble, and M. Heraty. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC. 1992. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

Smith, D.R. *Permeable Interlocking Concrete Pavements (3rd ed*.). Interlocking Concrete Pavement Institute. Washington, DC. 2006.

Southeast New England Program (SNEP). *New England Stormwater Retrofit Manual*. VHB and UNHSC. 2022. Available at: https://snepnetwork.org/stormwater-retrofit-manual/.

Sprecher, S.W. *Installing monitoring wells in soils (Version 1.0)*. National Soil Survey Center, NRCS, USDA, Lincoln, NE. 2008. Available at: https://forestrywebinars.net/webinars/planning-designing-and-installing-shallow-wells/Installing%20Monitoring%20Wells%20in%20Soils.pdf/at_download/file

U.S. Department of the Interior, Bureau of Reclamation. *Hydraulic Design of Stilling Basins and Energy Dissipators*, Engineering Monograph No. 25. Available at: https://www.usbr.gov/tsc/techreferences/hydraulics_lab/pubs/EM/EM25.pdf

U.S. Department of Transportation, Federal Highway Administration. *Hydraulic Design of Energy Dissipators for Culverts and Channels*, Hydraulic Engineering Circular No. 14. December 1975. Revised July 2006. Available at: https://www.fhwa.dot.gov/engineering/hydraulics/pubs/06086/hec14.pdf

U.S. Environmental Protection Agency. “Erosion and sediment control, surface mining in the Eastern U.S.” EPA-625/3-76-006, Washington, D.C. 1976. Available at: https://nepis.epa.gov/Exe/ZyNET.exe/

UNHSC. *Challenges and Practical Solutions to Managing Municipal Stormwater Systems*. Keynote presentation. 2018. Available at: https://scholars.unh.edu/cgi/viewcontent.cgi?article=1037&context=stormwater.

UNHSC. *Generic Infiltration Trench Design Detail*. Available at: https://www.unh.edu/unhsc/sites/default/files/media/stormwater-infiltration-trench_200207.pdf.

UNHSC. *Generic Leaching Catch Basin Design Detail*. Available at: https://www.unh.edu/unhsc/sites/default/files/media/stormwater-leaching-catchbasin191219final.pdf

UNHSC. *Generic Sectional Media Box Filter Design Detail*. Available at: https://www.unh.edu/unhsc/sites/default/files/media/stormwater-sectional-media-box191219final.pdf.

United States Environmental Protection Agency. “National Pollutant Discharge System Menu of BMPs.” September 2022. https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater

University of New Hampshire Stormwater Center (UNHSC). *2005 Data Report.* 2005. Available at: https://scholars.unh.edu/stormwater/84/

University of New Hampshire Stormwater Center (UNHSC). *2009 Biannual Report*. Durham, NH. 2009. Available at: https://scholars.unh.edu/stormwater/76/

University of New Hampshire Stormwater Center (UNHSC). *Design Specifications for Bioretention Soil Mix.* 2021. Available at: https://scholars.unh.edu/stormwater/75/

University of New Hampshire Stormwater Center (UNHSC). *Hybrid Bioretention System*. Treatment Unit Fact Sheet. 2020. Available at: https://scholars.unh.edu/stormwater/73/

University of New Hampshire Stormwater Center. *Gravel Wetland*. Treatment Unit Fact Sheet. 2007.

University of New Hampshire Stormwater Center. *Subsurface Gravel Wetland Design Specifications*. 2022. Available at: https://scholars.unh.edu/stormwater/74/

University of New Hampshire Stormwater Center. *UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds*. Durham, NH. September 2016. Available at: https://scholars.unh.edu/stormwater/13/

USDA NRCS. *Earth Dams and Reservoirs. Technical Release No. 60*. U.S. Department of Agriculture, Natural Resources Conservation Service, Conservation Engineering Division. July 2005. https://www.nrcs.usda.gov/sites/default/files/2024-10/TR-210-60%2C%20Earth%20Dams%20and%20Reservoirs.pdf.

USDA NRCS. *Urban Hydrology for Small Watersheds (TR 55*). 1986. Available at: https://www.nrc.gov/docs/ML1421/ML14219A437.pdf.

USGS, Upper Midwest Water Science Center. *Using leaf collection and street cleaning to reduce nutrients in urban stormwater*. Webpage. 2019. https://www.usgs.gov/centers/upper-midwest-water-science-center/science/using-leaf-collection-and-street-cleaning-reduce.

Vermont Agency of Natural Resources (VT ANR). *Vermont Stormwater Management Manual Rule and Design Guidance.* 2017. Available at: https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/2017%20VSMM_Rule_and_Design_Guidance_04172017.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Level Spreader*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Zarriello, P.J., R.F. Breault and P.K. Weiskel. *Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, Massachusetts*. USGS Water Resources Investigations Report 02-4220. Northborough, MA. 2002. Available at: https://pubs.usgs.gov/wri/wri024220/pdfs/wrir024220.pdf.

Appendix B:

Erosion and Sediment Control Fact Sheets

B. Erosion and Sediment Control Fact Sheets

This Appendix presents fact sheets for a selection of construction phase **Erosion and Sediment Control (E&SC) measures** that may be used for projects in New Hampshire. Fact sheets for structural and non-structural Stormwater Control Measures (SCMs) are provided separately in **Appendix A**. Fact sheets are grouped according to the following categories:

- Erosion control.
- Sediment control.
- Winter weather stabilization.

Extensive literature exists that describes the E&SC measures listed in this Manual, with many references on their selection, siting, design, and operational characteristics. Consulting professionals, engineers, and persons performing technical reviews are expected to consult the design reference literature currently considered as accepted practice. If there is any discrepancy between the information presented here and applicable regulations such as the Alteration of Terrain (AoT) regulations, the regulations take precedence. Project applicants are responsible for designing projects in compliance with these (and other local, state, and federal) regulations and should refer to them directly to verify applicable criteria.

Where Can I Find More Information on Construction-Phase Erosion and Sediment Control Measures?

Chapter 6 provides detailed information on erosion and sediment control strategies, including but not limited to:

- Design and planning considerations, including preparation of required plans.
- Selection of E&SC measures.
- Monitoring, inspection, and maintenance.

A list of E&SC measure fact sheets and accompanying links is provided in the table below.

Table of Erosion and Sediment Control Measure Fact Sheets

Description	NHDES AoT Reference *(Env-Wq 1500)*
Erosion Control	
Construction Phasing	Env-Wq. 1505.03 - 1505.04
Diversion Ditch/ Berm	Env-Wq 1506.12
Dust Control	--
Slope Drain	--
Soil Stockpile Protection Practices	--
Surface Roughening	--
Temporary and Permanent Mulching	Env-Wq. 1506.01
Temporary and Permanent Vegetation	Env-Wq 1506.02
Temporary Erosion Control Blanket and Matting	Env-Wq 1506.03
Tree Preservation and Protection	--
Sediment Control	
Construction Dewatering	Env-Wq 1506.11
Erosion Control Mix Berm	Env-Wq 1506.05
Filter Sock	--
Flocculants	Env-Wq 1506.13
Silt Fence	Env-Wq 1506.04
Straw or Hay Bale Barrier	Env-Wq 1506.06
Temporary Check Dam	Env-Wq 1506.07
Temporary Construction Exit	Env-Wq 1506.09
Temporary Sediment Basin	Env-Wq 1506.12
Temporary Sediment Trap	Env-Wq 1506.10
Temporary Storm Drain Inlet Protection	Env-Wq 1506.08
Turbidity Curtain	--
Winter Weather Stabilization	
Winter Weather Stabilization	Env-Wq 1505.06

Construction Phasing

General Description

Land grading activities are an essential component of site development and construction and are also often required for redevelopment construction. Land grading is often necessary to shape the existing land surface in accordance with a plan determined by engineering surveys and layout. The sequencing or phasing of land grading activities is essential to minimize the potential for erosion. Typically, a contractor will complete subgrade land grading activities and base course paving to prepare the site for the construction of buildings and other structures.

Proper construction phasing reduces the exposure of bare slopes to stormwater runoff and potential erosion, provides for stable temporary or permanent slopes, and facilitates establishment of vegetation. When developing construction-phasing activities, the contractor should anticipate potential delays in the schedule and be prepared to adjust activities to meet both project goals and E&SC goals.

Considerations

Construction phasing of land grading activities must be carefully planned and carried out to prevent erosion and sedimentation. Construction plans with separate sheets for the phasing of the project is a requirement of an Alternation of Terrain (AoT) Erosion and Sediment Control (E&SC) Plan. Detailed construction phasing and sequencing plans also must be documented in the Stormwater Pollution Prevention Plan (SWPPP) as required by National Pollutant Discharge Elimination System (NPDES) permits. Refer to **Chapter 6** of this Manual for all E&SC Plan and SWPPP requirements.

The following are important considerations when phasing a project:

- Plan earth disturbance and grading activities to minimize the area of soil exposed at one time, as well as the length of time between initial soil exposure and final grading.
- Protect the existing vegetation and natural forest cover designated to remain on site.
- Preserve and maintain buffer strips of undisturbed vegetation between construction areas and environmentally vulnerable areas such as watercourses, ponds, and wetlands.
- Divert stormwater runoff from upgradient, undisturbed areas away from the immediate construction area to reduce the threat of erosion.
- Disperse stormwater to undisturbed, vegetated, flat or moderate-sloped surfaces wherever possible, rather than concentrate it into channels.
- Fall and winter erosion control measures must be upgraded and refined to protect the site from spring stormwater runoff and snowmelt.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Any sign of rill or gully erosion should be immediately investigated and repaired as needed.
- Inspections should be documented in a report. Reports should include the following:
  - The inspection dates.
  - Names, titles, and qualifications of personnel making the inspection.
  - Weather information and a description of any discharges occurring at the time of the inspection.
  - Location(s) of discharges of sediment or other pollutants from the site.
  - Location(s) of E&SC measures that need to be maintained.
  - Location(s) of E&SC measures that failed to operate as designed or proved inadequate for a particular location.
  - Location(s) where additional E&SC measures are needed that did not exist at the time of inspection.
  - Corrective action required including implementation dates.
- See **Chapter 6** for general information on inspection and maintenance of E&SC measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

- **Temporary Stabilization:** All areas of exposed or disturbed soil should be temporarily stabilized as soon as practicable but no later than 45 days from the time of initial disturbance, unless a shorter time is specified by local authorities or permit conditions, the construction sequence approved as part of the issued permit, or an independent monitor. Some permits such as the Environmental Protection Agency (EPA) Construction General Permit require temporary stabilization of disturbed areas that have been inactive for 14 days.
- **Permanent Stabilization:** All areas of exposed or disturbed soil should be permanently stabilized as soon as practicable but no later than 3 days following final grading.

Stabilization

A site is deemed to be stabilized when it is in a condition in which the soils on the site will not experience accelerated or unnatural erosion under the conditions of a 10-year storm, such as but not limited to:

- In areas that will not be paved, a minimum of 85 percent vegetative cover has been established, a minimum of 3 inches of non-erosive material such as stone or riprap has been installed, or an erosion control blanket has been installed in accordance with Env-Wq 1506.03.
- In areas to be paved, base course gravels meeting the gradation requirements of New Hampshire Department of Transportation (NHDOT) Standard Specification for Road and Bridge Construction (2016), Table 304-1, Item No. 304.1, 304.2, or 304.3 have been installed.

Refer to the "**Temporary and Permanent Mulching**" and "**Temporary and Permanent Vegetation**" fact sheets in this Appendix for recommended stabilization measures.

- **Maximum Area of Disturbance**: The area of unstabilized soil should not exceed 5 acres at any time unless project permits specifically provide for a greater area of disturbance. Any such greater area of disturbance requires, as part of the permitting process:

- Documentation that the required areas of earth cuts and fills are such that an area of disturbance of 5 acres or less would unreasonably limit the construction schedule.
- An approved construction sequence plan, developed by a Professional Engineer licensed to practice in the state of New Hampshire or a Certified Professional in Erosion and Sediment Control (CPESC) as certified by the CPESC Council of EnviroCert International, Inc.
- Employment or retainment of a Professional Engineer licensed to practice in the state of New Hampshire or a Certified Professional in Erosion and Sediment Control as certified by the CPESC Council of EnviroCert International, Inc. to serve as an environmental monitor during construction.

- Only disturb, clear, or grade areas necessary for construction. Flag or otherwise delineate areas not to be disturbed. Exclude vehicles and construction equipment from these areas to preserve natural vegetation.
- All graded or disturbed areas including slopes should be protected during clearing and construction in accordance with an approved erosion and sediment control plan until they are permanently stabilized.
- All erosion and sediment control practices and measures should be constructed, applied, and maintained in accordance with the approved erosion and sediment control plan.
- Topsoil required for the establishment of vegetation should be stockpiled in the amount necessary to complete finished grading and be protected from erosion.
- Stockpiles, borrow areas, and spoils should be stabilized as described under "**Soil Stockpile Protection Practices**."
- Slopes should not be created so close to property lines as to endanger adjoining properties without adequate protection against sedimentation, erosion, slippage, settlement, subsidence, or other related damages as determined by a Professional Engineer.
- Areas to be filled should be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other objectionable materials.
- Areas should be scarified to a minimum depth of 3 inches prior to placement of topsoil to a minimum thickness of 4 inches. Topsoil should be placed without significant compaction to provide a loose bedding for placement of seed.
- All fills should be compacted in accordance with project specifications to reduce erosion, slippage, settlement, subsidence, or other related problems. Fill intended to support buildings, structures, site utilities, conduits, and other facilities, should be compacted in accordance with local requirements or codes.
- In general, fills should be placed and compacted in layers ranging from 6 to 24 inches in thickness. The contractor should review the project geotechnical report for specific guidance. Fill material should be free of brush, rubbish, rocks, logs, stumps, building debris, frozen material, organics, and other objectionable materials.
- Frozen material or soft, mucky, or highly compressible materials are susceptible to accelerated settlement and potential accelerated erosion. Work in these materials should be performed under the direction of a Professional Engineer.
- The outer face of the fill slope should be allowed to stay loose, not rolled, compacted, or bladed smooth. A bulldozer may run up and down the fill slope so the bulldozer treads (cleat tracks) create grooves perpendicular to the slope. If the soil is not too moist, excessive compaction will not occur. See the "**Surface Roughening**" fact sheet in this Appendix.
- Roughen the surface of all slopes during the construction operation to retain water, increase infiltration, and facilitate vegetation establishment.

- Use slope breaks, such as diversions, benches, or contour furrows as appropriate, to reduce the length of cut-and-fill slopes to limit sheet and rill erosion and prevent gully erosion. All benches should be kept free of sediment during all phases of development.
- Seeps or springs encountered during construction should be evaluated by a Professional Engineer to determine if the proposed design should be revised to properly manage the condition.
- Stabilize all graded areas with vegetation, crushed stone, compost blanket, or other ground cover as soon as grading is completed or if work is interrupted for 21 working days or more. Use anchored mulch or other approved methods to stabilize areas temporarily where final grading must be delayed.
- All graded areas should be permanently stabilized immediately following finished grading.

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Land Grading and Slope Protection*. March 2003.

Diversion Ditch/ Berm

General Description

A diversion is a temporary channel constructed across the slope to intercept stormwater runoff and direct it to a stable outlet or sediment trapping structures. The channel may be formed by excavation, placement of a berm (or dike), or a combination of these measures. This temporary measure is used immediately above a new cut or soil fill slope or around the perimeter of a disturbed area. Diversions can be used as follows:

- To divert stormwater runoff from upslope drainage areas away from unprotected disturbed areas and slopes to a stabilized outlet. In this case, the diversion is placed upslope of the construction area.
- To divert sediment-laden stormwater runoff from a disturbed area to a sediment-trapping structure such as a sediment trap or sediment basin. In this case, the diversion is placed below the disturbed area, to assure that sediment-laden stormwater runoff will not leave the site without treatment.

Diversions are intended to facilitate management of the site during construction, and should not be substituted for terracing, vegetated waterways, permanent land grading practices, and other permanent measures for providing long-term erosion control.

Considerations

- If erosion of the temporary diversion measure occurs during construction, the basin, channel, and berm must be stabilized.
- The gradient along the flow path must have a positive grade to assure drainage, but should not be so steep as to result in erosion due to high velocity channel flow. If such erosion occurs during construction, corrective action should be taken to stabilize the channel and berm, flatten the gradient of the channel, or otherwise eliminate the cause of erosion. Channel slopes greater than 2 percent require stabilization.
- Diversions are typically installed using material available on the site and can usually be constructed with equipment needed for site grading. The useful life of the measure can be extended by stabilizing the berm with vegetation.
- Temporary diversion berms are often used as a perimeter control in association with a sediment trap or a sediment basin, or a series of sediment-trapping facilities, on moderate to large construction sites. If installed properly and in the first phase of grading, maintenance costs are very low.
- Diversions upslope of a construction area should not be located below high sediment-producing areas unless land treatment practices or structural measures designed to prevent damaging accumulations of sediment in the channels are installed with or before the diversions. (The exception is where the diversion is used to divert sediment-laden water to a sedimentation facility.)
- Where diversions carry concentrated flows, their outlets require treatment or structures to dissipate energy and re-disperse flow or re-create sheet flow into undisturbed upland areas, where stormwater runoff can be absorbed. Untreated, sediment-laden stormwater runoff should not be discharged to undisturbed areas.
- Temporary vegetative stabilization of slopes should be conducted on slopes that are not in the final configuration and will have no work for an extended time period, but will have more work in the future.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Diversion berms used to trap sediment should be inspected and cleaned out after every significant storm.
- Diversion ditches must be cleared of sediment whenever sediment accumulates.
- Damages caused by construction traffic or other activity must be repaired before the end of each working day.
- If inspection indicates vegetation has not been established or has been damaged, the affected areas must be reseeded immediately.
- Once diversions have been stabilized, they should be mowed periodically to maintain a healthy vegetative cover, but the grass should not be cut shorter than 4 inches. Diversion ridges can be hazardous to mow, and equipment operators should be made aware of this potential hazard.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

Design Specifications:

Diversions should be designed to meet the criteria in the following table:

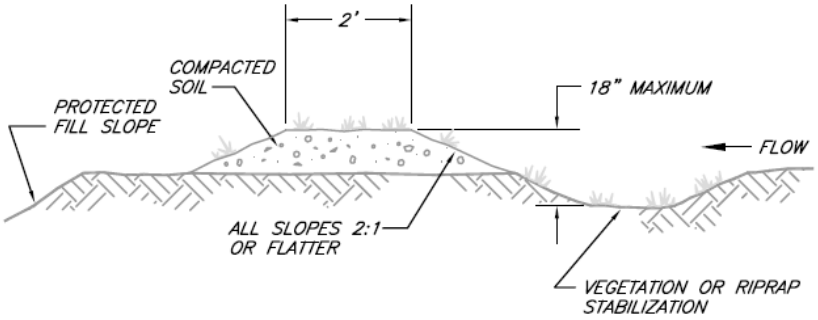
Design Parameter	Criteria
Location	The condition of the outlet area, site topography, ground cover, soil type, and length of slope should determine the location of the diversion.
Drainage Area	Less than 5 acres.
Capacity	2-year, 24-hour design storm conveyance capacity without overtopping the banks.
Design Velocity	2.5 to 4.5 feet per second, depending on channel lining.
Berm or Channel Side Slope	2h:1v or flatter.
Berm Top Width	2 feet, minimum.
Total Depth, Top of Berm to Bottom of Channel	1.5 feet maximum, except for berm of approximately 10 percent of berm height to allow for settlement.
Freeboard	0.5 feet minimum.
Channel Shape	Parabolic or trapezoidal.
Stabilization	Vegetation or riprap.
Gradient (Along Flow Path)	Positive grade to outlet. Channels less than 2 percent do not require stabilization unless excessive erosion is observed during routine inspection. Channels greater than 2 percent should be stabilized.
Outlet	Sediment-laden water must be diverted into sediment trap or sediment basin. Stormwater runoff from undisturbed areas must discharge at either a naturally stable outlet, or a stabilized level spreader, apron, or other suitable structure.

Construction Specifications

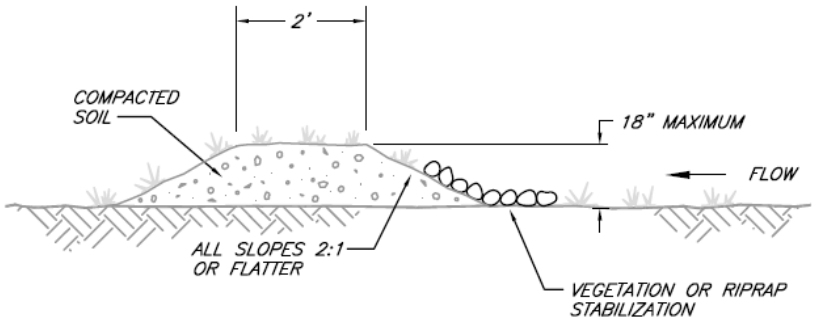
- Temporary diversion berms should be installed as an initial step in the land-disturbing activity. They must be functional prior to exposure of soils in the area being served by the diversion.
- Ditches or gullies within the limits of the diversion should be filled, and trees and other obstructions should be removed before or as part of construction.
- Berms should be located to minimize damages by construction operations and traffic.
- Where the diversion crosses an underground utility or other structure, measures should be employed to prevent damage to the utility, and to prevent settlement or displacement of trench backfill resulting from placement of the diversion.
- Once soil is exposed for a diversion channel, it should be immediately shaped, graded, and stabilized. Berms should be adequately compacted to prevent failure.
- Diversions must be completely stabilized prior to directing stormwater runoff to them.
- Where vegetation is used for stabilization, disturbed areas should be established to grass immediately after construction. Seedbed preparation, seeding, fertilizing, and mulching should comply with "**Temporary and Permanent Vegetation**" measures described in this Appendix.
- Temporary or permanent seeding and mulch should be applied to the berm immediately following its construction.
- If the soils or winter conditions preclude the use of vegetation and protection is needed, nonvegetative means, such as erosion control mats or an armor stone lining may be used.
- Each diversion must have an adequate outlet. The outlet must convey stormwater runoff to a point where outflow will not cause damage. The outlet should be installed and stabilized before the construction of the diversion.

Example Design Schematic

Temporary Diversion



TYPICAL FILL DIVERSION



TYPICAL TEMPORARY DIVERSION DIKE

NOTES:
1. THE CHANNEL BEHIND THE DIKE SHALL HAVE POSITIVE GRADE TO A STABILIZED OUTLET.
2. THE DIKE SHALL BE ADEQUATELY COMPACTED TO PREVENT FAILURE.
3. THE DIKE SHALL BE STABILIZED WITH TEMPORARY OR PERMANENT SEEDING OR RIPRAP.

Adapted from McCullah (1994)

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Temporary Stream Diversion, Water Diversion*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Diversion*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Diversion, Temporary Diversion Dike, Temporary Fill Diversion, Temporary Right-of-Way Diversion*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Dust Control

General Description

Dust control consists of applying various measures to prevent blowing and movement of dust from exposed soil surfaces. This measure is applicable to areas subject to dust blowing and soil movement where on-site and off-site damage is likely to occur if preventive measures are not taken. Typical dust control measures include traffic control, construction phasing, and maintenance of existing vegetation to limit exposure of soils and prevent conditions that result in dry soils and dust; application of water, calcium chloride, and temporary stabilization measures to control mobilization of dust by equipment operation or wind; and pavement sweeping to prevent accumulation of dust-producing sediment.

Dusty conditions occur when a disturbed site, soil stockpiles, or unpaved road surfaces dry out. Soil fines can shrink due to moisture loss that, in turn, loosens and weakens the soil surface. The dust becomes mobilized by equipment trafficking or by wind action. Dust can also become mobilized from construction equipment spilling or tracking soil materials onto paved surfaces, as well as from the operation of stationary equipment such as rock crushers. Dust can cause off-site damage, be a health hazard or nuisance to humans, wildlife, and plant life, or become a traffic safety hazard.

Considerations

Phase construction and sequence earth disturbance activities to reduce the area of land disturbed at any one time.

- Maintain as much natural vegetation as practicable.
- Use traffic control to restrict traffic to predetermined routes.
- Use temporary mulching, permanent mulching, temporary vegetative cover, permanent vegetative cover, or sodding to reduce the need for dust control.
- Use mechanical sweepers on paved surfaces where necessary to prevent dust buildup. Stationary sources of dust (i.e., rock crushers) should utilize fine water sprays to control dust.
- Apply water, or other dust inhibiting agents or tackifiers, as approved by the New Hampshire Department of Environmental Services (NHDES).

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- When temporary dust control measures are used, repetitive treatment should be applied as needed to accomplish control. Inspection and monitoring of dust is needed to determine when and how often treatment is needed.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

Water Application:

- Periodically moisten exposed soil surfaces with adequate water to control dust.
- Avoid excessive application of water that would result in mobilizing sediment and subsequent deposition in natural waterbodies.

Stone Application:

- Cover surface with crushed stone or coarse gravel.
- In areas adjacent to waterways, use only chemically stable or washed aggregate.

Commercial Products:

- The use of other commercial products (i.e., tackifiers) to stabilize exposed surfaces or stockpiles for dust control will be subject to acceptance by NHDES on a project-specific basis.

Other Measures:

- Apply other temporary and permanent stabilization measures as specified in this Appendix.
- Calcium chloride cannot be applied in watersheds with chloride-impaired waterbodies. Elsewhere, it should only be used when other methods are not practical, and following these guidelines:
    - For dry application, use a commercial chemical product that is either loose dry granules or flakes, fine enough to feed through a spreader at a rate that will keep the surface moist but not cause pollution or plant damage.
    - For liquid applications, the application rate will vary depending on the relative quality of materials in a given road surface. Some calcium chloride suppliers may require a road sample before recommending an application rate. Typically, 30 percent calcium chloride is recommended for most gravel roads.

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Dust Control*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Dust Control*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Dust Control*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Slope Drain

General Description

A slope drain is a pipe, flexible tubing, or other conduit that extends from the top to the bottom of a cut or fill slope. Cut and fill slopes are vulnerable to erosion between the time they are graded and permanently stabilized. Temporary slope drains can safely convey stormwater runoff down the disturbed face of an embankment without causing erosion. The measure is maintained until the slope has been sufficiently stabilized to enable it to convey stormwater runoff by sheet flow or until another measure has been installed to convey concentrated stormwater runoff from the top of slope to a safe outlet.

Considerations

- Slope drains must be sized, installed, and maintained properly, because failure will result in severe erosion of the slope. Care must be taken to size, install, and maintain the conduit inlet and contributing diversion channel to prevent failure from overtopping due to inadequate inlet capacity, lack of maintenance of diversion channel capacity and ridge height.
- Slope drains should not be used to transfer construction stormwater off-site with no treatment.
- The entrance section to the drain should be well-entrenched and stable so that surface water can enter freely. The drain should extend downslope beyond the toe of the slope to a stable area or appropriately stabilized outlet.
- The maximum drainage area per drain should be less than 5 acres as summarized in the below table.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- The entrance and outlet should be kept clear of sediment and debris. Any scour at the outlet should be repaired immediately, and the outlet stabilized against further erosion.
- The contractor should prevent construction traffic over the slope drain.
- The contractor should avoid the placement of any material on the drain conduit, other than material used to anchor it in place.
- Upon stabilization of the slope, the slope drain should be removed, materials properly disposed of, and disturbed areas stabilized.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

Site Preparation:

- The slope drain should consist of heavy-duty flexible material designed for this purpose. The segment of drain located on the slope may consist of a sewn geotextile “sock” fabricated for this purpose, or sections of corrugated plastic or corrugated metal pipe.
- The diameter of the slope drain should be the same over its entire length.

- For sewn geotextile “sock” or open-top chutes, install reinforced, hold-down grommets or stakes to anchor the conduit at intervals not to exceed 10 feet, with the outlet end securely fastened in place.
- Corrugated metal pipe or corrugated plastic pipe must have at least 1 anchor assembly for every 20 feet of slope drain.
- The conduit must extend beyond the toe of the slope.
- Slope drains should be sized according to the following table:

Drainage Area (acres)	Pipe Diameter, D (inches)
0.5	12
1.5	18
2.5	21
3.5	24
5.0	30

- The entrance to the slope drain should consist of a standard NHDOT Flared End-Section for Metal Pipe Culverts. A standard T-section fitting may also be used at the inlet, as indicated in the example drawing. An open top flared inlet for overside drain may also be used.
- Extension collars should consist of 12-inch-long corrugated metal or corrugated plastic pipe, as required by the type of pipe used on the project. Watertight fittings should be provided.
- An earthen berm should be used to direct stormwater runoff into the temporary slope drain and should be constructed according to the “**Diversion Ditch/ Berm**” fact sheet in this Appendix.
- The height of the berm at the centerline of the inlet should be equal to the diameter of the pipe (D) plus 12 inches or the height of the diversion berm, whichever is greater. Where the inlet berm height is greater than 18 inches, it should be sloped at the rate of 3h:1v or flatter to connect with the adjacent diversion berm.
- The outlet of the slope drain should be protected from erosion by a riprap apron or other accepted practice for energy dissipation and scour protection.

Construction Specifications:

Slope drain failure is frequently caused by water saturating the soil at the inlet and pipe joints, and then seeping along the outside of the pipe. Proper backfill and compaction at the inlet and around and under pipe haunches with stable soil material is essential to prevent this type of failure.

Construction of slope drains should follow the specifications below:

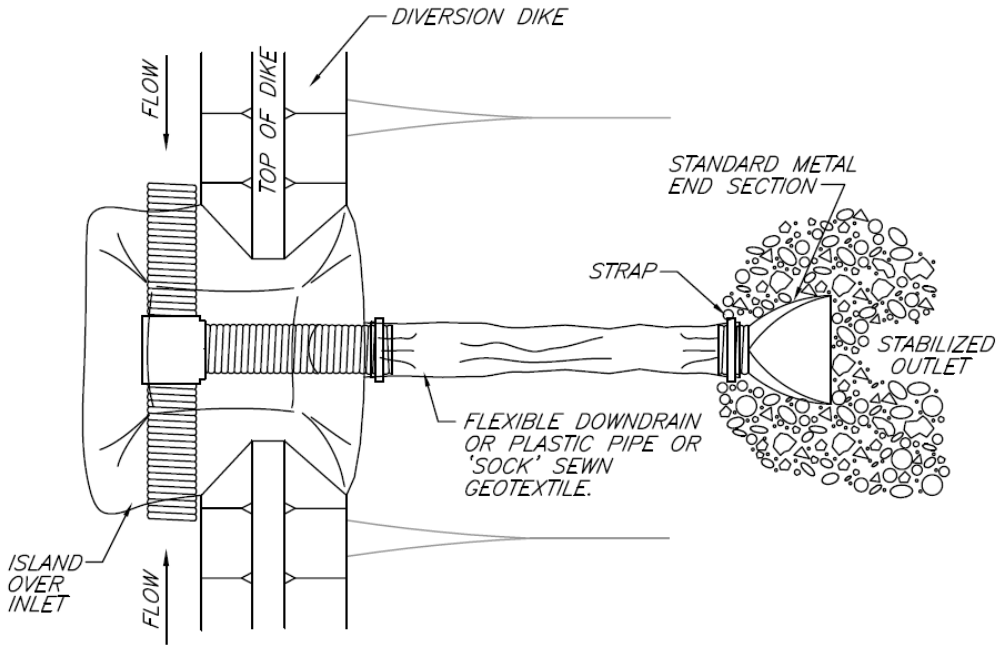
- Place slope drains on undisturbed soil or well-compacted fill at locations and elevations shown on the plans.
- The temporary slope drain should be placed on undisturbed soil or well-compacted fill.
- The entrance section should slope toward the slope drain at the minimum gradient of 1/2-inch per foot.
- The slope of down drain should be at least 5 percent to minimize sediment deposition within the conduit.
- The maximum slope of down drain should be 1.5h:1v.
- The soil around and under the entrance section should be hand-tamped in 8-inch lifts to the top of the berm to prevent seepage failure around the inlet.
- Ensure that fill over the drain at the top of the slope has a minimum depth of 12 inches above top of pipe, and a minimum top width of 4 feet. The sides should have a 3h:1v slope.
- The slope drain sections should be securely fastened together with grommets or stakes spaced at specified intervals and have watertight fittings.

- Extend the drain beyond the toe of slope and adequately protect the outlet from erosion.
- Installation of temporary slope drains should be completed and their outlets protected before stormwater runoff is diverted to them.
- Immediately stabilize all disturbed areas following construction of the slope drain.

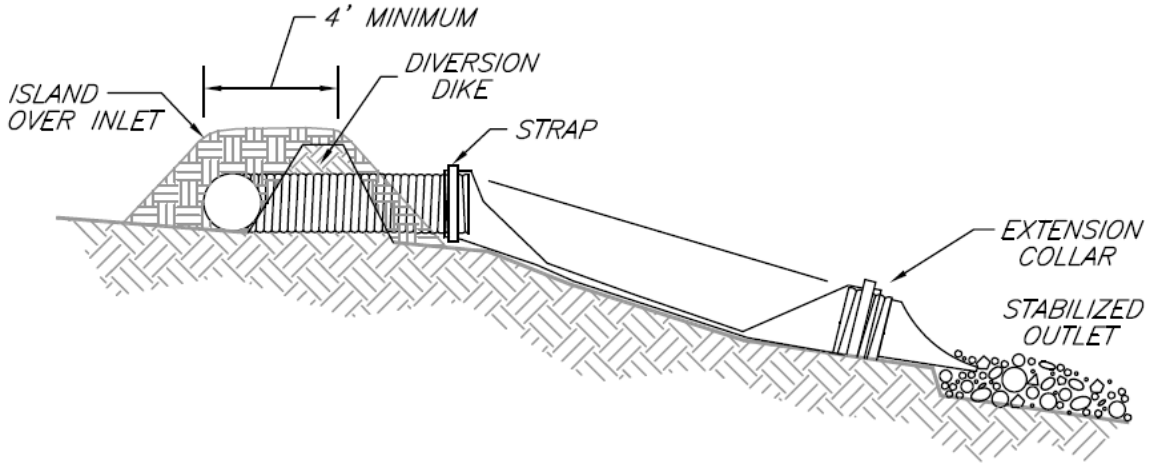
Example Design Schematic

Slope Drain

Plan



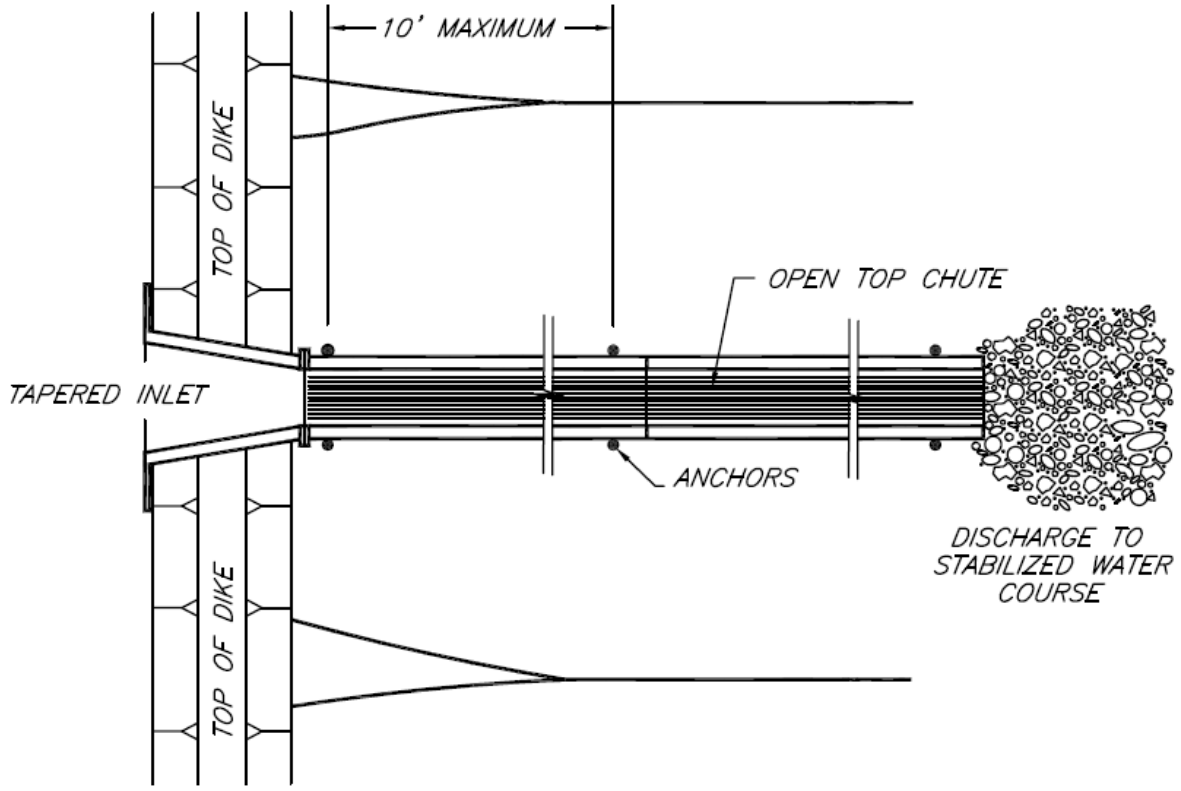
Profile



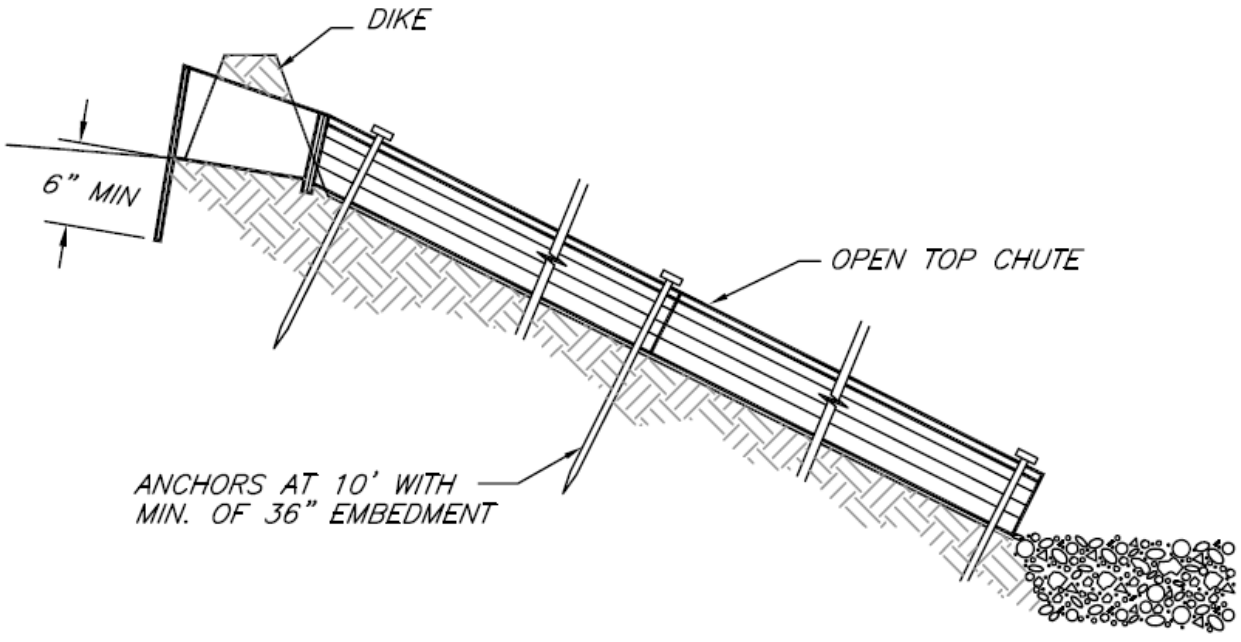
Adapted from McCullah (1994)

Overside Drain

Plan



Profile



Adapted from McCullah (1994)

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). Maine Erosion and Sediment Control BMPs- Slope Drains. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Slope Protection*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Paved Flume, Temporary Slope Drain*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Soil Stockpile Protection Practices

General Description

Soil stockpile protection practices include measures to locate, manage, and protect stockpiled earth materials, to reduce or eliminate wind and water erosion, and prevent resulting air and water pollution from displaced sediment. Stockpile practices apply to topsoil, excavated materials, borrow materials imported to the site, and construction aggregates and paving materials that are placed on site prior to construction.

Considerations

- Soil stockpiles should be sited in compliance with permit conditions governing setbacks from adjacent property lines and water resources (including wetlands).
- The EPA Construction General Permit requires any area that is inactive for 14 days to be temporarily stabilized.
- Soil and erosion control practices at stockpiles should be regularly inspected and adjusted immediately to respond to ongoing construction operations. Delivery of new materials or removal of materials may require modification and updates to protective measures.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

General:

- Locate stockpiles a minimum of 50 feet away from concentrated flows of stormwater, drainage courses, and inlets.
- Protect stockpiles from stormwater run-on using temporary perimeter measures such as diversions, berms, sandbags, or other approved practice.
- Stockpiles should be surrounded by sediment barriers (i.e., perimeter controls) as described in this manual, to prevent migration of material beyond the immediate confines of the stockpiles.
- Implement wind erosion control practices as appropriate on stockpiled material (see "Dust Control" fact sheet).
- Place bagged materials on pallets and under cover.

Protection of Inactive Stockpiles:

- Inactive soil stockpiles should be covered with anchored tarps or protected with soil stabilization measures (temporary seed and mulch or other temporary stabilization practice) and temporary perimeter sediment barriers at all times.
- Inactive stockpiles of concrete rubble, asphalt concrete rubble, aggregate materials, and other similar materials should be protected with temporary sediment perimeter barriers at all times. If the materials are a source of dust, they should also be covered.

Protection of Active Stockpiles:

- Stockpiles should be surrounded with temporary linear sediment barriers prior to the onset of precipitation. Perimeter barriers should be maintained at all times and adjusted as needed to accommodate delivery and removal of materials from the stockpile. The integrity of the barrier should be inspected at the end of each working day.
- When a storm event is predicted, stockpiles should be protected with an anchored protective covering.

References

California Stormwater Quality Association (CASQA). *Stormwater Best Management Practice Handbook- Stockpile Management*. Original print 2003, revised 2009. Available at: https://planning.lacity.org/eir/conventioncntr/DEIR/files/references/Stormwater%20BMP%20Handbook%20-%20Construction%20-%20CASQA.pdf.

Idaho Department of Environmental Quality (IDEQ). *Storm Water Best Management Practices Catalog- Stockpile Management*. Original print 2005, revised 2015. Available at: https://www2.deq.idaho.gov/admin/LEIA/api/document/download/14968.

Surface Roughening

General Description

Surface roughening is a technique for creating furrows in a bare soil surface, by tracking the slope with construction equipment. The purpose of surface roughening is to aid the establishment of vegetative cover from seed, to reduce stormwater runoff velocity and increase infiltration, and to reduce erosion and provide for sediment trapping.

This measure applies to all construction slopes to facilitate long-term stabilization with vegetation, and particularly slopes steeper than 3h:1v.

Considerations

Graded areas with smooth, hard surfaces may be initially attractive, but such surfaces increase the potential for erosion. A rough, loose soil surface gives a mulching effect that provides more favorable moisture conditions than hard, smooth surfaces; this aids seed germination.

Methods for achieving a roughened soil surface on a slope include tracking, furrowing, and serrating (or grooving). Selection of the method is based on slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Any sign of rill or gully erosion should be immediately investigated and repaired as needed.
- Periodically inspect seeded slopes for rills or other signs of erosion. Fill these areas slightly above the original grade, reseed, and mulch as soon as possible, but no more than 3 days following inspection.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

Cut Slope Roughening:

- Groove the slope using machinery to create a series of ridges and depressions that run across the slope, on the contour.

Fill Slope Roughening:

- In general, fill slopes with a gradient steeper than 3h:1v should be constructed in lifts not to exceed 12 inches, compacting each lift. The contractor should refer to the project geotechnical report for specific guidance.
- The face of the slope should consist of loose, uncompacted fill 4 to 6 inches deep.
- Use grooving or tracking to roughen the face of the slopes, if necessary.
- Apply seed, fertilizer, and straw mulch, and then track or punch in the mulch with the bulldozer.
- Avoid blading or scraping the final slope face.

Cuts, Fills, and Graded Areas:

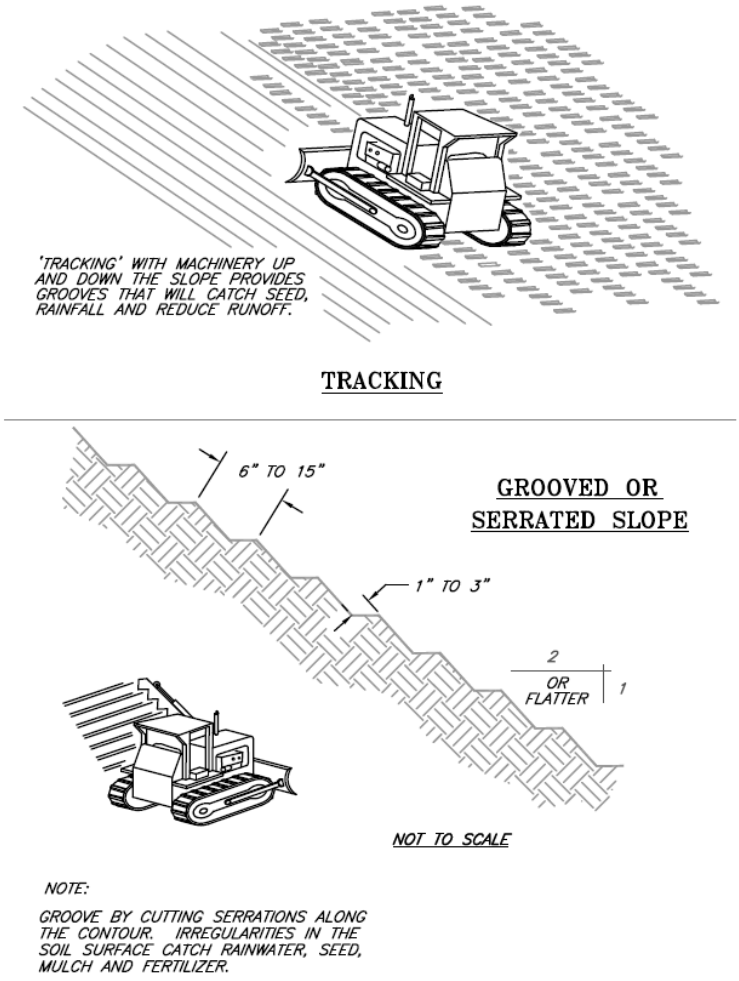
- Make mowed slopes no steeper than 3h:1v.
- Roughen these areas to shallow grooves by normal tilling, disking, or harrowing. The final pass of any such tillage should be on the contour.
- Make grooves formed by such implements close together (less than 10 inches), and not less than 1-inch deep.
- Excessive roughness is undesirable where mowing is planned.

Roughening With Tracked Machinery:

- Limit roughening with tracked machinery to soils with a sandy textural component to avoid undue compaction of the soil surface.
- Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Avoid back-blading during the final grading operation.
- Immediately seed and mulch roughened areas to obtain optimum seed germination and growth.

Example Design Schematic

Surface Roughening



Adapted from McCullah (1994)

References

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Surface Roughening*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Temporary and Permanent Mulching

General Description

Temporary mulching consists of the application of plant residues or other suitable materials to the soil surface. Mulching reduces erosion potential by protecting the exposed soil surface from direct impact by rainfall. It also aids in the growth of vegetation by conserving available moisture, controlling weeds, and providing protection against extreme heat and cold. Mulches can also protect the infiltration rate of the soil, prevent soil compaction, and provide a suitable microclimate for seed germination. This is the quickest and most cost-effective method of preventing erosion on disturbed soils and its value should not be underestimated.

Permanent mulching consists of the application of long-term surface cover such as bark, wood chips, or erosion control mix. Permanent mulch can be used as a permanent ground cover, as an overwinter stabilization mulch, or left to naturalize. It is not designed to support grass vegetation, but legumes or woody vegetation may be established for additional stability. Permanent mulch must not be used in areas of concentrated water flows. Slopes with evidence of groundwater seepage may require the use of other treatments such as riprap.

The composition of "erosion control mix" is further described in the "Erosion Control Mix Berm" fact sheet. In addition to its use for the temporary or semi-permanent stabilization of slopes, it can be applied to protect areas from erosion during spring thaw. It can also be used in construction yards to mitigate muddy conditions. In these applications, the erosion control mix application rate will need to be adjusted for site conditions, use, and long-term effectiveness. With time, the organic component of the erosion control mix will decompose and become ineffective. Any required repairs should be made immediately, with additional erosion control mix placed on top to reach the desired thickness.

Timing of Temporary versus Permanent Stabilization

All areas of exposed or disturbed soil should be **temporarily stabilized** as soon as practicable but no later than 45 days from the time of initial disturbance unless a shorter time is specified by local authorities, the construction sequence approved as part of the issued permit, or an independent monitor. **Permanent stabilization** must be completed as soon as practicable but no later than 3 days following final grading (Env-Wq 1505.03).

The EPA Construction General Permit also requires any area that is inactive for 14 days to be temporarily stabilized; however, it is generally good practice to stabilize any area that will be inactive for 7 days.

Considerations

- Within 100 feet of rivers, streams, wetlands and in lake and pond watersheds, temporary mulch should be applied **within 7 days of exposing soil or prior to any storm event**.
- Areas that have been temporarily or permanently seeded should be mulched immediately following seeding.
- Areas that cannot be seeded within the growing season should be mulched for over-winter protection. The area should be seeded at the beginning of the next growing season.
- Mulch anchoring (or mats/ netting) should be used on slopes with gradients greater than 5 percent in late fall (past September 15), and over winter (September 15 through May 15).
- Permanent mulch can be used in conjunction with tree, shrub, vine, and ground cover plantings.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- If less than 90 percent of the soil surface is covered by mulch, additional mulch should be immediately applied. Anchor nets must be inspected after rain events for dislocation or failure. If washouts or breakages occur, repair any damage to the slope and re-install or replace netting as necessary. Inspections should take place until grasses are firmly established (85 percent soil surface uniformly covered with healthy stand of grass).
- Erosion control mix mulch used for temporary stabilization should be left in place and incorporated into any permanent mulching or final stabilization phase. Vegetation adds stability and should be promoted.
- Where permanent mulch is used in conjunction with ornamental plantings, inspect periodically throughout the year to determine if mulch is maintaining coverage of the soil surface. Repair as needed.
- Permanently mulched areas should be inspected at least annually, and after each large rainfall (2.5 inches or more in a 24-hour period). Any repairs required to restore erosion control functionality should be made immediately. Where erosion control mix has been used, place additional mix on top of the mulch to maintain recommended thickness. When the mulch is decomposed, clogged with sediment, eroded or ineffective, it must be replaced or repaired.
- If the mulch needs to be removed, spread it out into the landscape if feasible.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

General:

- Apply mulch prior to a storm event. This is especially applicable in extremely sensitive areas such as within 100 feet of lakes, ponds, rivers, streams, and wetlands. It will be necessary to closely monitor weather predictions to have adequate warning of significant storms.
- Mulching should be completed within the following specified time periods from original soil exposure:
    - Within 100 feet of rivers, streams, wetlands, and in lake and pond watersheds, the time period should be no greater than 7 days. This 7-day limit should be reduced further during wet weather periods.
    - In other areas, the time period can range from 14 to 30 days, the length of time varying with site conditions (soil erodibility, season of year, extent of disturbance, proximity to sensitive resources) and the potential impact of erosion on adjacent areas. Other state or local restrictions may also apply.
- The choice of mulch material should be based on site conditions, soils, slope, flow conditions, and time of year.
- Jute and fibrous mats and wood excelsior should be installed according to the applicable manufacturer's instructions.

Hay or Straw Mulches:

- Organic mulches including hay and straw should be air-dried, free of undesirable seeds and coarse materials.
- Application rate should be 2 bales (70 to 90 pounds) per 1000 square feet or 1.5 to 2 tons (90 to 100 bales) per acre to cover 75 to 90 percent of the ground surface.

- Hay or straw mulch should be anchored to prevent displacement by wind or flowing water, using one of the following methods:
    - Netting: Install jute, wood fiber, or other biodegradable netting over hay or straw to anchor it to the soil surface. Install netting material according to manufacturer's recommendation. Netting should be used sensibly, as wildlife can become entangled in the materials. Use of plastic netting should be avoided as indicated in Env-Wt 104.64.
    - Tackifier: Apply polymer or organic tackifier to anchor hay or straw mulch. Application rates vary by manufacturer: typically, 40 to 60 pounds per acre for polymer material, and 80 to 120 pounds per acre for organic material. Liquid mulch binders are also typically applied heavier at edges, in valleys, and at crests than other areas.
- When mulch is applied to provide protection over winter (past the growing season), it should be applied to a depth of 4 inches (150 to 200 pounds of hay or straw per 1,000 square feet, or double standard application rate). Seeding cannot generally be expected to grow up through this depth of mulch and will be smothered. If vegetation is desired, the mulch will need to be removed in the springtime and the area seeded and mulched.

Wood Chips or Bark:

- Wood chips or ground bark should be applied to a thickness of 2 to 6 inches.
- Wood chips or ground bark should be applied at a rate of 10 to 20 tons per acre or 460 to 920 pounds per 1,000 square feet.

Erosion Control Mix:

Erosion control mix can be manufactured on or off the project site. It must consist primarily of organic material, separated at the point of generation, and may include shredded bark, stump grindings, composted bark, or acceptable manufactured products. Wood and bark chips, ground construction debris or reprocessed wood products will not be acceptable as the organic component of the mix. Erosion control mix must be placed at a thickness of 2 inches or more. See the "**Erosion Control Mix Berm**" fact sheet for detailed erosion control mix requirements.

Erosion Control Blankets and Mats:

Mats are manufactured combinations of mulch and netting designed to protect against erosion and to retain soil moisture and modify soil temperature. See specifications on "**Temporary Erosion Control Blanket and Matting**" fact sheet.

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Mulching*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Mulching*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Mulching*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Temporary and Permanent Vegetation

General Description

Temporary vegetation consists of the establishment of a grass and legume cover on exposed soils for periods of up to 12 months. The purpose is to reduce erosion and sedimentation by stabilizing disturbed areas that will not be brought to final grade for a year or less and to reduce problems associated with mud and dust production from exposed soil surfaces during construction. Temporary seeding is also essential to preserve the integrity of earthen structures used to control sediment, such as diversions and embankments of sediment basins.

Temporary vegetative cover should be applied where exposed soil surfaces will not be final graded within 45 days from initial disturbance. Such areas include excavated areas, soil stockpiles, berms, embankments and sides of sediment basins, temporary road banks, and other earthworks. Annual plants that sprout rapidly and survive for only one growing season are suitable temporary vegetative cover.

Permanent vegetation should be established on disturbed areas where permanent, long-lived vegetative cover is needed to stabilize soil, reduce damages from sediment and stormwater runoff, and enhance the environment. A site is considered stable when it has a minimum of 85% vegetative cover.

Stormwater runoff and sheet erosion caused by splash erosion (raindrop impact on bare soil) is the source of most fine particles in sediment. To reduce sediment load in stormwater runoff, the soil surface itself should be protected. The most effective and economical means of controlling sheet and rill erosion is to establish a vegetative cover.

Timing of Temporary versus Permanent Stabilization

All areas of exposed or disturbed soil should be **temporarily stabilized** as soon as practicable but no later than 45 days from the time of initial disturbance, unless a shorter time is specified by local authorities, the construction sequence approved as part of the issued permit, or an independent monitor. **Permanent stabilization** must be completed as soon as practicable but no later than 3 days following final grading (Env-Wq 1505.03).

The EPA Construction General Permit also requires any area that is inactive for 14 days to be temporarily stabilized; however, it is generally good practice to stabilize any area that will be inactive for 7 days.

Considerations

- Proper seedbed preparation and the use of quality seed are important in this practice. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.
- Nutrients and pesticides used to establish and maintain vegetation must be managed to protect surface water and groundwater quality.
- Temporary seeding should be used extensively in sensitive areas (e.g., pond and lake watersheds, steep slopes, streambanks).
- Late fall seeding may fail, resulting in inadequate overwinter erosion protection, as well as potential surface stability problems associated with spring thaw and spring stormwater runoff events. If full stabilization is not achieved by late fall, other stabilization measures such as mulching should be implemented.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Temporary seeding should also be inspected just prior to September 15, to ascertain whether additional seeding is required to provide stabilization over the winter period.
- Permanent seeded areas should be inspected at least monthly during the course of construction. Inspections, maintenance, and corrective actions should continue until the owner assumes permanent operation of the site.
- Based on inspection, areas should be reseeded to achieve full stabilization of exposed soils. If it is too late in the planting season to apply additional seed, then other temporary stabilization measures should be implemented.
- At a minimum, 85 percent of the soil surface should be covered by vegetation. Reseeding may be required to achieve or retain 85 percent vegetative cover.
- Seeded areas should be mowed as required to maintain a healthy stand of vegetation, with mowing height and frequency dependent on type of grass cover.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal, and replacement of dead or diseased vegetation, and removal of invasive species.
- If any evidence of erosion or sedimentation is apparent, repairs should be made and areas should be reseeded, with other temporary measures (e.g., mulch) used to provide erosion protection during the period of vegetation establishment.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

Site Preparation:

- Install erosion and sediment control measures such as siltation barriers, diversions, and sediment traps as needed.
- Grade as needed for the access of equipment for seedbed preparation, seeding, mulch application, and mulch anchoring.
- Stormwater runoff should be diverted from the seeded area.
- On slopes 4h:1v or steeper, the final preparation should include creating horizontal grooves perpendicular to the direction of the slope to catch seed and reduce stormwater runoff.

Seedbed Preparation:

- Remove all stones 2 inches or larger in any dimension from the surface. Remove all other debris such as wire, cable, tree roots, concrete, clods, lumps, trash, or other unsuitable material.
- Where the soil has been compacted by construction operations, loosen soil to a depth of 2 inches before applying fertilizer, limestone, and seed.
- If needed to ensure growth, fertilizer and organic soil amendments should be applied during the growing season.
    - Apply limestone and fertilizer according to soil test recommendations. If soil testing is not feasible on small or variable sites, or where timing is critical, fertilizer may be applied at the rate of 600 pounds per acre or 13.8 pounds per 1,000 square feet of low phosphate fertilizer[1] (N-P2O5-K2O) or equivalent. Apply limestone (equivalent to 50 percent calcium plus magnesium oxide) at a rate of 3 tons per acre (138 pounds per 1,000 square feet).

- Fertilizer should be restricted to a low phosphate, slow-release[2] nitrogen fertilizer when applied to areas between 25 feet and 250 feet from a surface water body. No fertilizer except limestone should be applied within 25 feet of a surface water body. **These limitations are requirements for any water body protected by the Shoreland Water Quality Protection Act** (RSA 483-B; Env-Wq 1400)**.**

Additional Requirements for Permanent Seedbed Preparation:

- Inspect seedbed just before seeding. If traffic has compacted the soil, the area must be tilled and firmed as above.
- Work limestone and fertilizer into the soil as practical to a depth of 4 inches with a disc, spring tooth harrow or other suitable equipment. The final harrowing operation should be on the general contour. Continue tillage until a reasonably uniform, fine seedbed is prepared. All but clay or silty soils and coarse sands should be rolled to firm the seedbed wherever feasible.

Seeding:

- For temporary vegetation, select seed from recommendations in the "Seeding Recommendations for Temporary Vegetation" table below.
- For permanent vegetation, select a seed mixture in Seed Mixture Selection Based on Soil Type table that is appropriate for the soil type and moisture content as found at the site, the amount of sun exposure and for level of use. Select seed from recommendations in Seed Mixtures for Permanent Vegetation.
- Apply seed uniformly by hand, cyclone seeder, drill, cultipacker type seeder or hydroseeder (slurry including seed and fertilizer). Normal seeding depth is from 1/4- to 1/2-inch. Hydroseeding that includes mulch may be left on soil surface. Seeding operations should be on the contour.
- Spring seeding usually gives the best results for all seed mixes or with legumes. Permanent seeding should be completed 45 days prior to the first killing frost. When crown vetch is seeded in later summer, at least 35 percent of the seed should be hard seed (unscarified). If seeding cannot be done within the specified seeding dates, mulch according to the "**Temporary and Permanent Mulching**" fact sheet and delay seeding until the next recommended seeding period.
    - Temporary seeding should typically occur prior to September 15 of the year in which the area being seeded was disturbed.
    - Areas seeded between May 15 and August 15 should be covered with hay or straw mulch, according to the "**Temporary and Permanent Mulching**" fact sheet.
- Vegetated growth covering at least 85 percent of the disturbed area should be achieved prior to October 15. If this condition is not achieved, implement other temporary stabilization measures for overwinter protection, and if applicable, complete permanent seed stabilization during the next growing season.
- Inoculate all legume seed with the correct type and amount of inoculant.
- For permanent seeding, except where either a cultipacker type seeder or hydroseeder is used, the seedbed should be firmed following seeding operations with a roller, or light drag.

Seeding Notes:

[1] Low phosphorus fertilizer is defined by the **Shoreland Water Quality Protection Act** as less than 2 percent phosphorus. The University of New Hampshire (UNH) Cooperative Extension has found through soil tests that New Hampshire's soils have ample phosphorus and recommend low phosphorus fertilizers with 0 percent to 1 percent phosphorus such as 3:1:3 or 10:0:10 N:P:K. They discourage the use of imbalanced fertilizers.

[2] Slow-release fertilizers must be at least 50 percent slow-release nitrogen component, which means that half of the nitrogen will not be immediately available. Typically, it takes 2 to 24 weeks for all slow-release nitrogen to become available. Slow-release fertilizers do not necessarily reduce nitrogen loading. Nitrogen fertilizers are necessary for grass lawns, however, according to the UNH Cooperative Extension, nitrogen fertilizers for lawns that consist of legume and clover are not necessary.

Hydroseeding:

- When hydroseeding (hydraulic application), prepare the seedbed as specified above or by hand raking to loosen and smooth the soil and remove surface stones larger than 2 inches in diameter.
- Slopes must be no steeper than 2h:1v.
- Lime and fertilizer may be applied simultaneously with the seed. The use of fiber mulch on critical areas is not recommended (unless it is used to hold straw or hay). Better protection is gained by using straw mulch and holding it with adhesive materials or 500 pounds per acre of wood fiber mulch.
- Seeding rates must be increased 10 percent when hydroseeding.

Seeding Recommendations for Temporary Vegetation

Species	Per Acre Bushels (BU) or Pounds (lbs)	Per 1,000 Square Feet	Remarks
Winter Rye	2 BU or 112 lbs	2.5 lbs	Best for fall seeding. Seed from August 15 for best cover. Seed to a depth of 1-inch.
Oats	2.5 BU or 80 lbs	2 lbs	Best for spring seedings. Seed no later than May 15 for summer protection. Seed to a depth of 1-inch.
Annual Ryegrass	40 lbs	1 lb	Grows quickly but is of short duration. Use where appearances are important. Seed early spring and/ or between August 15 and September 15. Cover the seed with no more than 1/4-inch of soil.
Perennial Ryegrass	30 lbs	0.7 lb	Good cover which is longer lasting than annual ryegrass. Seed between April 1 and June 1 and/ or between August 15 and September 15. Mulching will allow seeding throughout the growing season. Seed to a depth of approximately 1/2-inch.

Source: Minnick, E.L. and H.T. Marshall, 1992

Seed Mixture Selection Based on Soil Type

Use	Seed Mixture (see table below)	Soil Drainage: Droughty	Soil Drainage: Well Drained	Soil Drainage: Moderately Well Drained	Soil Drainage: Poorly Drained
Steep cuts and fills, borrow and disposal areas	A B C D E	Fair Poor Poor Fair Fair	Good Good Good Fair Excellent	Good Fair Excellent Good Excellent	Fair Fair Good Excellent Poor
Waterways, emergency spillways, and other channels with flowing water	A C D	Good Good Good	Good Excellent Excellent	Good Excellent Excellent	Fair Fair Fair
Lightly used parking lots, unused lands, and low intensity use recreation sites	A B C D	Good Good Good Fair	Good Good Excellent Good	Good Fair Excellent Good	Fair Poor Fair Excellent
Play areas and athletic fields. (Topsoil is essential for good turf.)	F G	Fair Fair	Excellent Excellent	Excellent Excellent	See Note See Note
Gravel pit	Consult with USDA Natural Resource Conservation Service.				

Note: Poorly drained soils are not desirable for use as playing areas and athletic fields.

Source: Minnick, E.L. and H.T. Marshall, 1992

Seed Mixtures for Permanent Vegetation

Mixture	Species	Pounds Per Acre	Pounds Per 1,000 Square Feet
A	Tall fescue Creeping red fescue Redtop *Total*	20 20 2 42	0.45 0.45 0.05 0.95
B[3]	Tall fescue Creeping red fescue Crown vetch Or Flatpea *Total*	15 10 15 - 30 40 or 55	0.35 0.25 0.35 - 0.75 0.95 or 1.35
C[3]	Tall fescue Creeping red fescue Birdsfoot trefoil *Total*	20 20 8 48	0.45 0.45 .20 1.10
D[3]	Birdsfoot trefoil Redtop Reed canary grass *Total*	10 5 15 30	0.25 0.10 0.35 0.70
E	Tall fescue Flatpea *Total*	20 30 50	0.45 0.75 1.20
F	Creeping red fescue[2] Kentucky bluegrass[2] *Total*	50 50 100	1.15 1.15 2.30
G	Tall fescue[2]	150	3.60

Notes:

1. Reed canary grass is on the invasive species watch list due to its rapid, aggressive growth and its ability to move into wetlands and out-compete other desirable wetland plants. Caution should be used when planted near wetlands.
2. For heavy use athletic fields, consult the University of New Hampshire Cooperative Extension Turf Specialist for current varieties and seeding rates.
3. The University of New Hampshire Cooperative Extension recommends red clover to substitute for crown vetch or birdsfoot trefoil if they are going to be mowed to a height of 4 inches or less. Red clover (Alsike variety) should be seeded at a rate of 20 pounds per acre.

Source: Minnick, E.L. and H.T. Marshall, 1992

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Vegetation*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Minnick, E.L. and H.T. Marshall. Rockingham County Conservation District. *Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire.* August 1992.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Soil Preparation and Topsoiling, Seeding for Temporary and Permanent Vegetative Cover*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Temporary Seeding, Permanent Seeding, Topsoiling*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Temporary Erosion Control Blanket and Matting

General Description

Erosion control blankets or mats consist of protective manufactured mulch blankets installed on prepared soil surfaces to provide erosion protection and surface stability on steep slopes, vegetated channels, or shorelines during vegetation establishment.

Erosion control blankets temporarily stabilize and protect disturbed soil from raindrop impact and surface erosion. Like other types of mulch, the blankets help increase infiltration, decrease compaction, and soil crusting, and conserve soil moisture. Erosion control blankets increase germination rates for grasses and legumes and promote vegetation establishment. Erosion control blankets also protect seeds from predators and reduce desiccation and evaporation by insulating the soil and seed environment.

Erosion control blankets generally consist of machine-made mats made of organic, biodegradable mulch such as straw, curled wood fiber (excelsior), coconut fiber or a combination thereof, evenly distributed on or between netting. Netting should be wildlife friendly (see wildlife friendly considerations below) and composed of biodegradable natural fiber. The blankets are provided in rolls for ease of handling and installation.

Note: This erosion control measure as described in this manual does not cover the selection and installation of turf reinforcement products. If such products are used on-site, they must be included in the project plans, designed by a Professional Engineer registered in New Hampshire, and included in permit approvals.

Considerations

Erosion control blankets can be applied to steep slopes, vegetated waterways, and other areas sensitive to erosion, to supplement vegetation during initial establishment and help provide for safe conveyance of stormwater runoff over the protected surface.

The following considerations are important for proper use of erosion control blankets and matting:

- During the growing season (April 15 – September 15) use mats (or mulch and netting) on:
  - The base of grassed waterways.
  - Steep slopes (15 percent or greater).
  - Any disturbed soil within 100 feet of lakes, ponds, rivers, streams, and wetlands.
- During late fall and winter (September 15 – April 15) use heavy grade mats on all areas noted above plus use lighter grade mats (or mulch and netting) on:
  - Side slopes of grassed waterways.
  - Moderate slopes (greater than 8 percent). There may be cases where mats will be needed on slopes flatter than 8 percent, depending on site conditions and length of the slope.
- The most critical aspect of installing mats is obtaining firm continuous contact between the mat and the soil. Without such contact, erosion will occur underneath the mat.
- Install mats and staple in accordance with the manufacturer's recommendations.
- The designer must exercise care to choose the type of blanket or matting which is appropriate for the specific objectives and site conditions of the project. There are many soil stabilization products available, and a thorough

review by an engineer or erosion control professional is necessary to evaluate the advantages, disadvantages, and construction requirements of the manufactured products, and to select and specify a product for a particular application.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Any failure should be repaired immediately. If washout of the slope, displacement of the mat, or damage to the mat occurs, the affected slope shall be repaired and reseeded, and the affected area of mat shall be re-installed or replaced.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Design Erosion Control Blankets and Matting to be Wildlife Friendly

Blankets and matting should be designed to minimize potential harm to wildlife. Wildlife friendly considerations based on the United States Fish and Wildlife Service (USFWS, 2023) include:

- Use of natural fiber, loose weave netting or no netting. Avoid plastic netting of any type- including "photodegradable" netting.
- Use of 100 percent biodegradable materials.
- Rectangle (elongated) mesh is better than square.
- All edges of blankets and mats should be secured with wooden stakes and buried.
- Remove blankets and mats as soon as they are no longer needed for erosion control.

Specifications

Site Preparation:

Proper site preparation is essential to ensure complete contact of the protection matting with the soil. Site preparation should include the following specifications:

- Grade and shape area of installation.
- Remove all rocks, clods, trash, vegetation, or other obstructions so that the installed blankets will have direct contact with the soil.
- Prepare seedbed by loosening 2 to 3 inches of topsoil above final grade.
- Incorporate amendments, such as lime and fertilizer, into the soil according to soil test and the seeding plan.

Seeding:

- Seed area before blanket installation for erosion control and re-vegetation. Seeding and top soil layering after mat installation is often specified for turf reinforcement application. When seeding prior to blanket installation, all check slots and other areas disturbed during installation must be reseeded.
- Where soil filling is specified, seed the matting and the entire disturbed area after installation and prior to filling the mat with soil.

Installing and Anchoring Blankets:

- Blankets shall be installed and anchored per the manufacturer's specifications. If the manufacturer's instructions differ from those listed below, the manufacturer's instructions should be followed.
- Blankets shall be placed within 24 hours after sowing seed in that area.
- Lay blankets loosely and maintain direct contact with the soil – avoid stretching.
- U-shaped wire staples, metal geotextile stake pins, or triangular wooden stakes can be used to anchor mats to the ground surface. Biodegradable anchors are preferred.
    - Wire staples should be a minimum gauge as specified by the manufacturer.
    - Metal stake pins should be 3/16-inch diameter steel with a 1.5-inch steel washer at the head of the pin, or as specified by the manufacturer.
- Wire staples and wood or metal stakes should be driven flush to the soil surface. All anchors should have sufficient ground penetration to resist pullout. Longer anchors may be required for loose soils.

Installation on Slopes:

- Blankets shall be installed on slopes per the manufacturer's specifications. If the manufacturer's instructions differ from those listed below, the manufacturer's instructions should be followed.
- Blankets shall be laid loosely over the soils, maintaining contact with the soil, and not stretched.
- Blankets shall be anchored at the top of the slope in a trench to prevent stormwater runoff from undermining the mat. Subsequent mats should be overlapped by the upslope mat. Backfill trench and tamp earth firmly.
- Blankets should be placed starting at the bottom (downslope) so proper overlap is achieved.
- Blankets shall be unrolled in the direction of the water flow, overlapping the edges by a minimum of 4 inches and stapling the edges, as directed by the manufacturer.
- When blankets must be spliced, they shall be placed end over end (shingle style) with 6-inch minimum overlap. Staple through overlapped area, approximately 12 inches apart, or as specified by manufacturer.
- Blankets shall be stapled sufficiently to anchor blanket and maintain contact with the soil. Staples shall be placed down the center and staggered with the staples placed along the edges. Stapling pattern and number of staples will depend on steepness of slope and manufacturer's anchoring methods; follow manufacturer's instructions.

Installation in Channels:

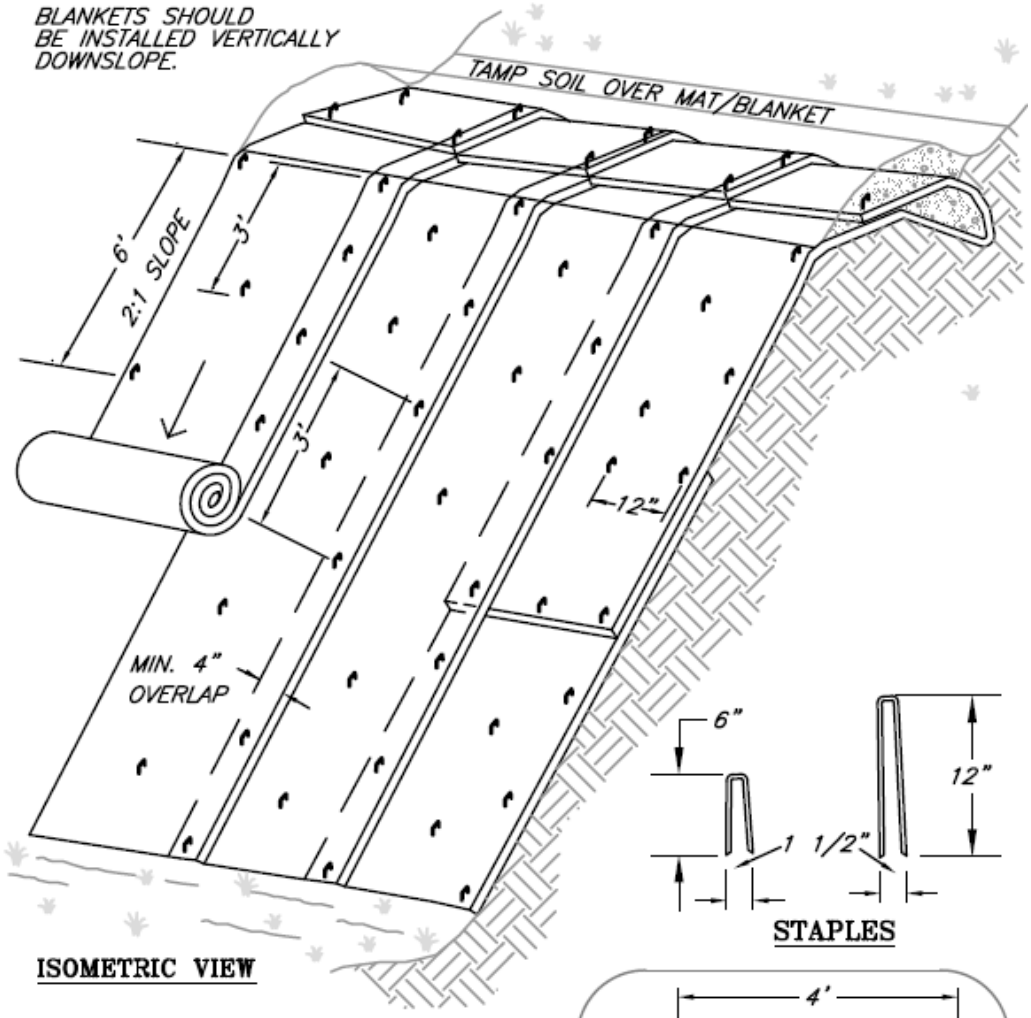
- Blankets shall be installed in channels per the manufacturer's specifications. If the manufacturer's instructions differ from those listed below, the manufacturer's instructions should be followed.
- Dig initial anchor trench across the channel at the lower end of the project area.
- Excavate intermittent check slots, across the channel at 25- to 30-foot intervals along the channel, or as specified by manufacturer.
- Cut longitudinal channel anchor slots along each side of the installation to bury edges of matting. Whenever possible extend matting 2 to 3 inches above the crest of channel side slopes.

- Beginning at the downstream end and in the center of the channel, place the initial end of the first roll in the anchor trench and secure with fastening devices, as directed by the manufacturer. Note: matting will initially be upside down in anchor trench.
- In the same manner, position adjacent rolls in anchor trench, overlapping the preceding roll a minimum of 3 inches.
- Secure these initial ends of mats with anchors at manufacturer's specified intervals, backfill and compact soil.
- Unroll center strip of matting upstream. Stop at next check slot or terminal anchor trench.
- Unroll adjacent mats upstream in similar fashion, maintaining a 3-inch minimum overlap.
- Fold and secure all rolls of matting snugly into all transverse check slots. Lay mat in the bottom of the slot then fold back against itself. Anchor through both layers of mat at manufacturer's specified intervals, then backfill and compact soil. Continue rolling all mat widths upstream to the next check slot or terminal anchor trench.
- Alternative method for noncritical installations: place two rows of anchors on 6-inch centers at 25 to 30 feet intervals in lieu of excavated check slots.
- Shingle-lap spliced ends by a minimum of 1-foot with upstream mat on top to prevent uplifting by water or begin new rolls in a check slot. Anchor overlapped area by placing two rows of anchors, 1-foot apart on 1-foot intervals.
- Place edges of outside mats in previously excavated longitudinal slots, anchor using prescribed staple pattern, backfill and compact soil.
- Anchor, fill, and compact upstream end of mat in a terminal trench, as directed by manufacturer.
- Secure mat to ground surface using U-shaped wire staples, geotextile pins, wooden stakes, or other anchors as recommended by the manufacturer.

Example Design Schematic

Erosion Blankets

Slope Installation



TYPICAL SLOPE
SOIL STABILIZATION

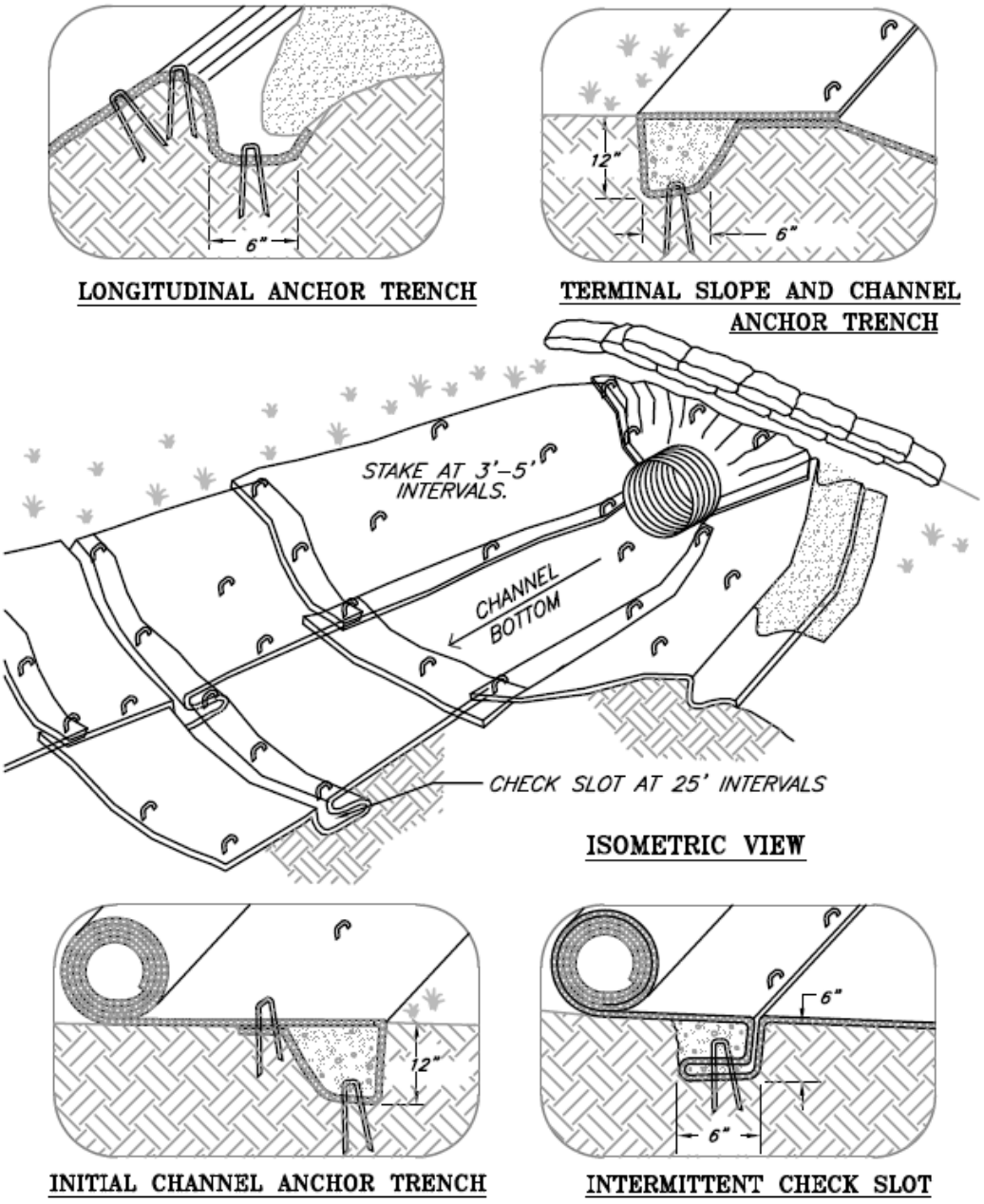
NOTES:

1. DIMENSIONS GIVEN IN THE DRAWINGS ARE EXAMPLES; DEVICE SHOULD BE INSTALLED PER MANUFACTURER'S SPECIFICATIONS.
2. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/ BLANKETS SHALL HAVE GOOD SOIL CONTACT.
3. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.
4. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

NOT TO SCALE

Adapted from McCullah (1994)

Channel Installation



NOTES:

1. DIMENSIONS GIVEN IN THE DRAWINGS ARE EXAMPLES; DEVICE SHOULD BE INSTALLED PER MANUFACTURER'S SPECIFICATIONS.
2. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURER'S SPECIFICATIONS.
3. STAKING OR STAPLING LAYOUT PER MANUFACTURER'S SPECIFICATIONS.

Adapted from McCullah (1994)

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Geotextiles (2003), Erosion Control Blankets (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

U.S. Fish & Wildlife Service (USFWS). *Make the Change to Wildlife-Friendly Erosion Control Products!* Webpage. Accessed February 2023. https://www.fws.gov/initiative/protecting-wildlife/make-change-wildlife-friendly-erosion-control-products.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Soil Stabilization Blankets & Matting*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Tree Preservation and Protection

General Description

Natural vegetation should be preserved wherever possible to minimize exposed soils and consequent erosion. This is especially true for sites on steep slopes, near perennial and intermittent watercourses or swales, and in wooded areas. Preserving trees is particularly important because it takes 20 to 30 years for newly planted trees to provide the benefits for which we value trees so highly such as erosion and sediment control, watershed protection, landscape beautification, dust and pollution control, noise reduction, shade, and other environmental benefits.

Considerations

- Clearing should be limited to only where construction will occur/ only where necessary. Refer to the Shoreland Protection regulations (Env-Wq 1400) for tree removal requirements.
- Local governments may have ordinances to save natural vegetation and trees.
- To increase the chance of survival, it is best to limit grade changes and other soil disturbances to areas at least as far out as the tree dripline.
- Few trees can survive with more than 6 inches of earth fill over the roots. Construction of a dry well and drain system around the tree trunk can provide some air circulation. Four-inch drainpipe can be placed in a spoke-like fashion to drain water away from the tree before filling takes place. Dry wells should be built with stones, brick, tile, or concrete blocks at least 12 to 18 inches from the trunk of a large, slow-growing tree and up to 36 inches from younger, faster growing trees.
- When possible, excavation trenches should be routed around trees. If this is not possible, it is best to tunnel under them using hand tools or power augers as close to the center of the trunk as possible, cutting as few roots as possible, and backfilling the trench as soon as possible. An arborist should be consulted for branch and root trimming to meet construction needs.

Special Considerations

- Maple, Dogwood, Eastern hemlock, Eastern red cedar, and Douglas fir do not readily adjust to changes in the environment and require special care for protection.
- Maples and willows have water-seeking roots which can cause trouble with sewer lines and filter fields but can thrive in high moisture conditions that other trees may succumb to.
- Disease in trees can become established through damaged limbs, trunks, roots, and freshly cut stumps. Diseased and weakened trees are also susceptible to insect attack.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Marked trees should be regularly inspected to make sure flagging has not been removed and tree roots have not been exposed or injured. If needed, re-cover and/ or seal the roots.
- Trees that are to be saved should be marked by either:
    - Placing a barrier around the trees where possible, i.e., place a simple wooden fence around the tree. Erect the barrier before the heavy construction equipment arrives and leave it up until the last piece of equipment has left the area. Silt fences can be used as barriers around groups of trees for protection (see "**Silt Fence**" fact sheet).
    - Marking the tree if erecting a barrier is not practical. Trees should be marked with a bright colored band of cloth, ribbon, or tape that can be seen from a distance and from all angles. It is important that everyone on site is informed of the meaning of the marking.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

In the selection of which trees should be saved, the factors that should be considered include:

- Healthiness of the tree: Retained trees should have full green crowns without many dead branches or scars.
- Location of the tree: Retained trees should not interfere with the installation and maintenance of utilities.
- Age and size of the tree: It is usually best to save trees which are less than 40 years old. After maturity, trees decline rapidly in vigor.
- Trees with unique or unusual form.
- Trees which may be uncommon to the area.
- Desirable shade trees.
- Trees for screening purposes.

References

Georgia Soil & Water Conservation Commission (GSWCC). *Field Manual for Erosion & Sediment Control in Georgia-Tree Protection.* 2016. Available at: https://gaswcc.georgia.gov/sites/gaswcc.georgia.gov/files/imported/SWCC/Files/2016%20Field%20Manual%20for%20Erosion%20%26%20Sediment%20Control.pdf.

Adapted from: MassDEP. *Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas-Preserving Natural Vegetation*. 2003. Available at: https://www.mass.gov/doc/complete-erosion-and-sedimentation-control-guidelines-a-guide-for-planners-designers-and/download.

Construction Dewatering

General Description

This construction dewatering measure is intended to prevent sedimentation associated with the management of water removed during construction from excavations, cofferdams, and other work areas that trap stormwater and groundwater. Dewatering activities must meet state surface water quality standards.

Construction sites in New Hampshire typically require construction dewatering operations. For example, excavations within the work area can trap rainwater or groundwater. This water needs to be removed before certain operations can be performed or to keep work conditions safe. Dewatering may also be required for water from cofferdams and when bypassing stream flows (both of which would require a permit from the Wetlands Bureau). Contractors typically use ditch pumps to dewater these enclosed areas. If care is not taken to select the point of discharge and provide adequate treatment, the pumped water may discharge to down-gradient natural resources such as lakes, ponds, rivers, streams, or wetlands with subsequent sedimentation of those waterbodies.

Construction dewatering activities must be conducted in a proper manner to:

- Prevent the discharged water from eroding soil on the site.
- Remove sediment from the collected water.
- Preserve down-gradient natural resources and property.

Considerations

- Choose the best location for discharge to meet the above objectives. The discharge areas should be chosen with careful consideration to the down-gradient water resources and the existing landscape's ability to treat water flows from the dewatering process. Wooded buffers and flat to moderate slopes provide the best opportunity for filtration and absorption of such discharges.
- Care must be exercised to prevent contact of water from construction dewatering with oil, grease, other petroleum products, or toxic and hazardous materials. Contaminated stormwater runoff must be contained, treated, and discharged or removed in accordance with NHDES requirements.
- All requirements of state law and permit requirements of local, state, and federal agencies must be met, including the Dewatering and Remediation General Permit for projects that propose to discharge construction dewatering water to surface waters such as lakes, ponds, rivers, streams, and wetlands.
- The discharge should be stopped immediately if the receiving area shows any sign of instability or erosion.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- During the active dewatering process, inspection of the dewatering facility should be reviewed at least daily, with more frequent or continuous supervision as warranted by site conditions.
- Special attention should be paid to the buffer area for any sign of erosion or concentration of flow that may damage the buffer's vegetation or underlying soil.

- The visual quality of the effluent should be monitored to assess whether additional treatment can be provided to prevent sedimentation of downstream receiving waters.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

Dewatering excavated areas is conducted in three distinct operations: the removal of the collected water within the excavation, the treatment of the collected water, and the controlled discharge of water in a non-erosive manner.

Water Removal:

- Install diversion ditches or berms to minimize the amount of clean stormwater runoff allowed into the excavated area.
- For trench excavation, limit the trench length to 500 feet and place the excavated material on the upgradient side of the trench.
- The removal of water from the excavated area can be accomplished by numerous methods, including but not limited to gravity drainage through channels, mechanical pumping, siphoning, and using the bucket of construction equipment to scoop and dump water from the excavation. Water may also be withdrawn from the ground adjacent to an excavation by pumping of well points.
- All channels, swales, and ditches dug for discharging water from the excavated area should be stable prior to directing discharge to them. If flow velocities cause erosion within these channels, then the channel should be re-stabilized; if necessary, a stone lining or other stabilizing measure should be used.
- Bucketed water should be discharged in a stable manner to the sediment removal area. A splash pad of riprap underlain with geotextile may be necessary to prevent scouring of the soil in the basin.
- Dewatering during periods of intense, heavy rain should be avoided.

Sediment Removal:

- There are several methods for settling or filtering sediment that a contractor may use. Typical measures include temporary basins or sediment traps, sedimentation tanks, and manufactured fabric bags designed for filtering pumped discharges.
- Flow to the sediment removal structure must not exceed the structure's capacity to settle or filter the receiving flow.
- Sediment removal structures should discharge wherever possible to a well-vegetated buffer through sheet flow and should maximize the distance to the nearest water resources and minimizing the slope of the buffer area.

Temporary Basin Designs:

Temporary basin designs include but are not limited to:

- An enclosure of Jersey Barriers lined with geotextile fabric.
- A temporary enclosure constructed with hay bales, silt fence, or both. Erosion control mix also may be incorporated with silt fence or hay bales. A silt fence must be supported to prevent it from collapsing under the weight of impounded water.
- Chambered settling system fabricated of concrete or steel and designed for sediment removal.
- Excavated or bermed sedimentation trap. See the description of "**Temporary Sediment Trap**" in this Appendix.
- A sediment basin (including temporarily modified stormwater detention ponds), if designed in accordance with the description of "**Temporary Sediment Basin**" in this Appendix.

Frac Tanks:

- Frac tanks can provide storage for large volumes of water during construction dewatering measures. As water is held in the frac tank, sediment in the water will settle to the bottom of the tank.
- Frac tanks are commonly used with a flocculant (see "**Flocculants**") to increase sediment removal effectiveness.
- Frac tanks are commonly deployed in constrained construction sites.
- Frac tanks must be carefully sized in accordance with manufacturer instructions and based on the anticipated amount of dewatering volume needed.

Manufactured Filter Bags:

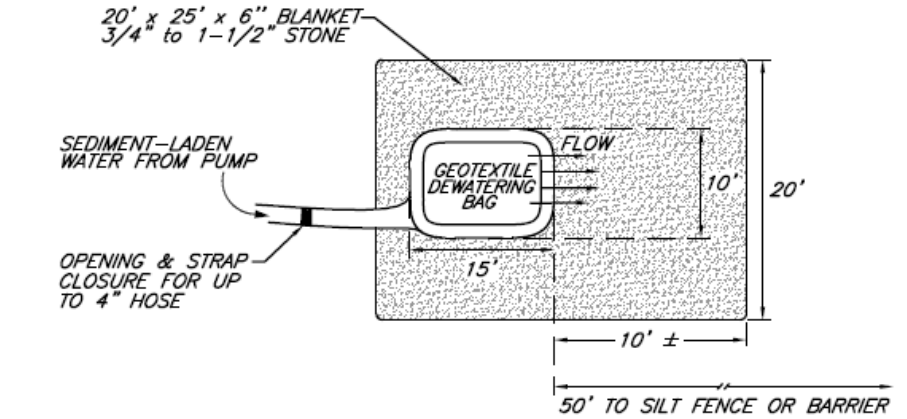
- Water from construction operations may be discharged to a manufactured filter structure specifically designed for sediment removal, such as a manufactured silt "bag" or other similar product.
- The filter bag should be used in accordance with the manufacturer's recommended guidelines.
- The type of fabric should be based on the size of the soil particles to be trapped (i.e., woven material for coarse particles and nonwoven material for fine particles).
- Filter bags have finite capacity. Avoid over-pressurizing the bag and routinely inspect for tears or other malfunctions.

Discharges:

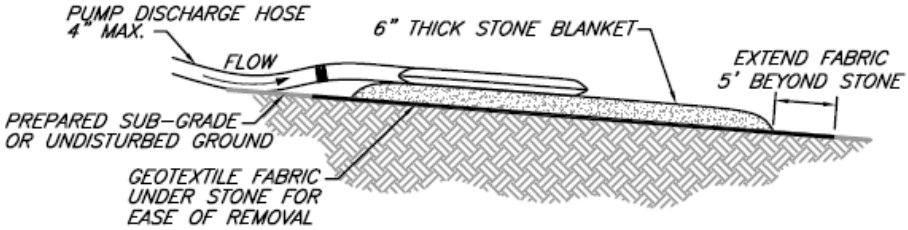
- Water that is visibly clear of sediment, and has not come into contact with other contaminants, may be directly discharged into well-vegetated buffered areas with less than 2 percent slope, as long as a method is used to spread flow into sheet flow as it enters the buffer.
- Never discharge to areas that are bare or newly vegetated.
- The discharge should be stopped immediately if the receiving area is showing any sign of instability or erosion.
- Stilling basins may require a properly sized and stabilized spillway for discharge.

Example Design Schematic

Geotextile Dewatering Bag



PLAN VIEW



PROFILE

NOTES:

1. GEOTEXTILE BAG MATERIAL BASED ON PARTICLE SIZE IN PUMPED WATER, I.E., FOR COARSE PARTICLES A WOVEN MATERIAL; FOR SILTS/CLAYS A NON-WOVEN MATERIAL.
2. DO NOT OVER PRESSURIZE BAG OR USE BEYOND CAPACITY.
3. LOCATE DISCHARGE SITE ON FLAT UPLAND AREAS AS FAR AWAY AS POSSIBLE FROM STREAMS, WETLANDS, OTHER RESOURCES AND POINTS OF CONCENTRATED FLOW.
4. DOWNGRADIENT FROM RECEIVING AREA MUST BE WELL VEGETATED OR OTHERWISE STABLE FROM EROSION, E.G., FOREST FLOOR OR COARSE GRAVEL/STONE.
5. DISCHARGE LOCATION SHALL MEET ALL REGULATORY SETBACKS FROM WETLANDS AND OTHER WATER COURSES.

Adapted from ME DEP (2003)

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Construction Dewatering (2003), Excavation Dewatering, Sediment Containment (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Dewatering Structure*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Erosion Control Mix Berm

General Description

An erosion control mix berm is a type of sediment barrier with trapezoidal berm in shape that intercepts sheet flow and ponds stormwater runoff, allowing sediment to settle, and filtering runoff through sediment as well. They are an environmentally sensitive and cost-effective alternative to silt fence. An alternative to a simple erosion control mix berm is a "continuous contained berm." consisting of erosion control mix compost encapsulated in a mesh fabric (or "filter sock"). Refer to the "Filter Sock" fact sheet in this Appendix for specifications.

This barrier is installed across or at the toe of a slope, to intercept and retain small amounts of sediment from disturbed or unprotected areas.

Erosion control mix berms and socks sometimes offer a better solution than silt fence and other sediment control methods, because the organic material does not require any special trenching, construction, or removal, unlike straw bales, silt fence or coir rolls. This makes the technique very cost-effective. Silt fence must be disposed of as a solid waste.

The erosion control mix is organic, biodegradable, renewable, and can be left onsite. This is particularly important below embankments near streams, as re-entry to remove or maintain a synthetic barrier can cause additional disturbance.

Erosion control mix berms can be easily and quickly fixed if they are disturbed during construction activity.

Considerations

The erosion control mix berm is used where:

- Erosion will occur in the form of sheet erosion only and there is no concentration of water in a channel or other drainage way above the berm.
- The area upslope of the berm has a slope of less than 5 percent.
- Sedimentation can pollute or degrade adjacent wetland and/ or watercourses.
- Sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas.
- The contributing drainage area is less than 1/4 acre per 100 feet of barrier length, the maximum length of slope above the barrier is 100 feet, and the maximum gradient behind the barrier is 5 percent. If the slope length is greater, other measures such as diversions may be necessary to reduce the slope length.
- Sediment barriers should not be used in areas of concentrated flows. Under no circumstances should erosion control mix barriers be constructed in live streams or in swales where there is the possibility of a washout.
- Sediment barriers are effective only if installed and maintained properly.
- Sediment barriers should be installed prior to any soil disturbance of the contributing drainage area above them.
- Frozen ground, outcrops of bedrock and very rooted forested areas are locations where berms of erosion control mix are most practical and effective.
- Other Erosion and Sediment Control (E&SC) measures should be used at low points of concentrated stormwater runoff, below culvert outlet aprons, around catch basins and closed storm systems, and at bottom of steep perimeter slopes.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Filter berms should be inspected at least daily during prolonged rainfall. They should be repaired immediately if there are any signs of erosion or sedimentation below them. If there are signs of breaching of the barrier, or impounding of large volumes of water behind them, then they should be replaced with other measures to intercept and trap sediment (such as a diversion berm directing stormwater runoff to a sediment trap or basin).
- Sediment deposits should be removed after each storm event. They must be removed when deposits reach approximately 1/3 of the height of the barrier.
- Filter berms should be reshaped or reapplied as needed.
- Any sediment deposits remaining in place after the barrier is no longer required should be dressed to conform to the existing grade, prepared and seeded.
- See **Chapter 6** for general information on inspection and maintenance of E&SC measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

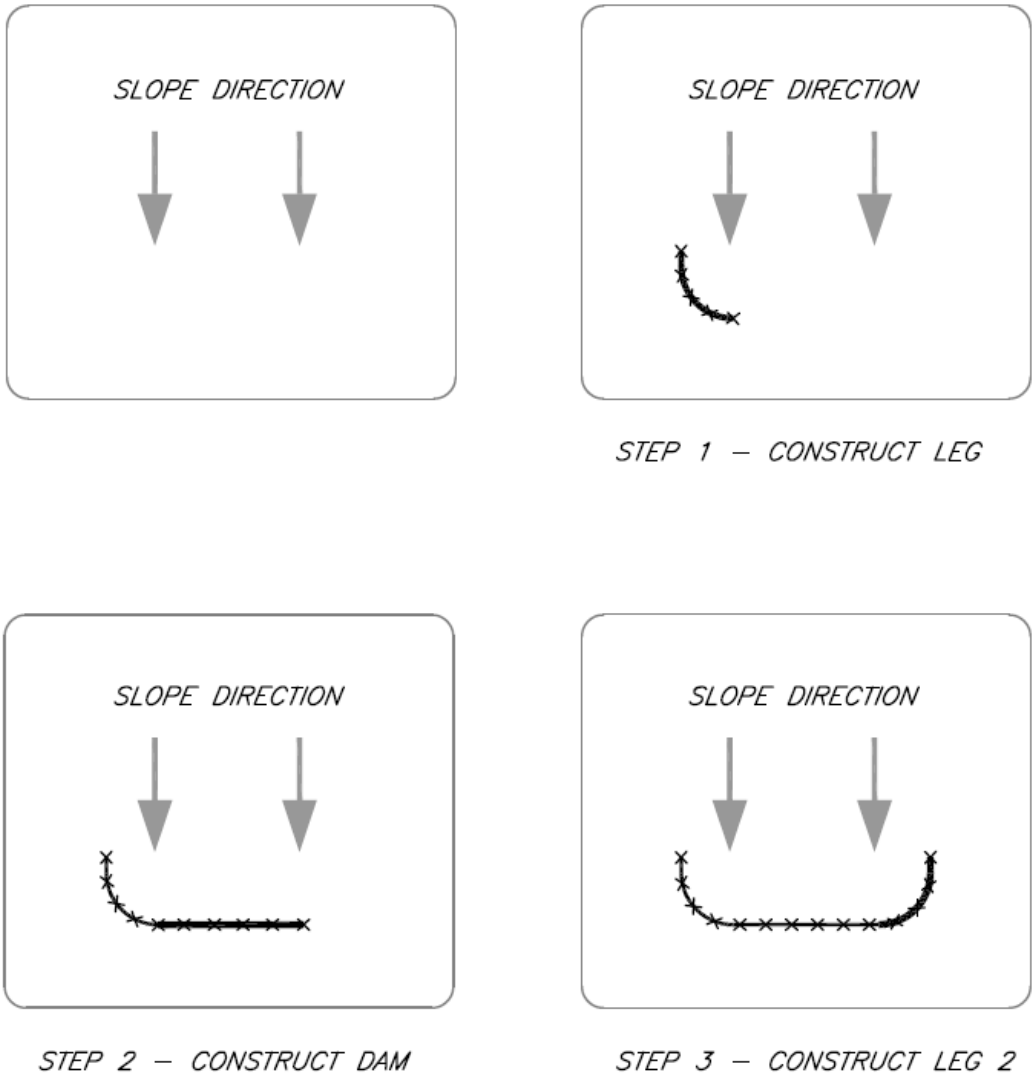
Erosion control mix can be manufactured on or off the project site. It must consist primarily of organic material, separated at the point of generation, and may include shredded bark, stump grindings, composted bark, or acceptable manufactured products. Wood and bark chips, ground construction debris or reprocessed wood products will not be acceptable as the organic component of the mix.

Specifications for erosion control mix berms include:

- Composition of the erosion control mix should be as follows:
    - Erosion control mix should contain a well-graded mixture of particle sizes and may contain rocks less than 4 inches in diameter. Erosion control mix must be free of refuse, physical contaminants, and material toxic to plant growth.
    - The mix composition should meet the following standards:
        - The organic matter content should be between 25 and 65 percent, dry weight basis.
        - Particle size by weight should be 100 percent passing a 3-inch screen, 90 percent to 100 percent passing a 1-inch screen, 70 percent to 100 percent passing a 0.75-inch screen, and a maximum of 30 percent to 75 percent, passing a 0.25-inch screen.
        - The organic portion needs to be fibrous and elongated.
        - The mix should not contain silts, clays, or fine sands.
        - Soluble salts content should be less than 4.0 millimhos per centimeter.
        - The pH should be between 5.0 and 8.0.
- The barrier must be placed along a relatively level contour and follow the contour of the land as closely as possible. It may be necessary to cut tall grasses or woody vegetation to avoid creating voids and bridges that would enable fines to wash under the barrier through the grass blades or plant stems.
- The barrier must be a minimum of 12 inches high, as measured on the uphill side of the barrier, and a minimum of 2 feet wide.

Example Design Schematic

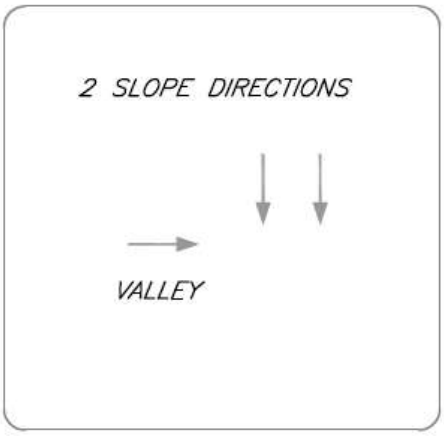
Erosion Control Mix Berm Typical Placement - One Slope

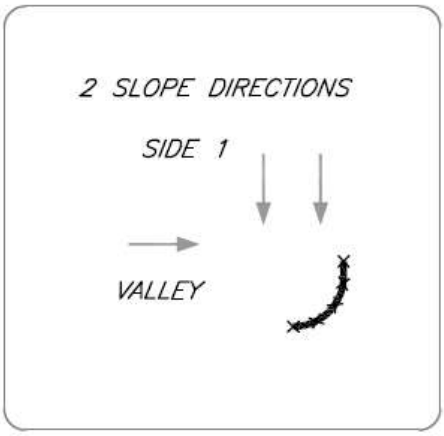


INSTALLATION WITH J–HOOKS OR 'SMILES'
INCREASES EROSION CONTROL MIX BERM EFFICIENCY.

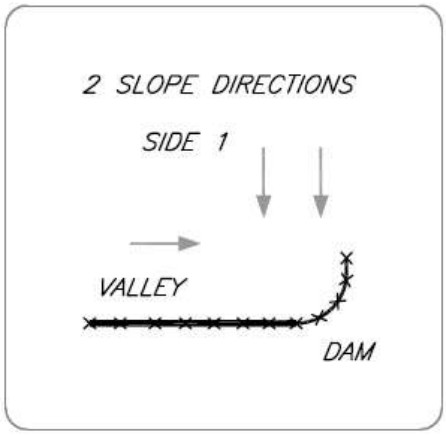
Adapted from McCullah (2002)

Erosion Control Mix Berm Typical Placement - Two Slopes

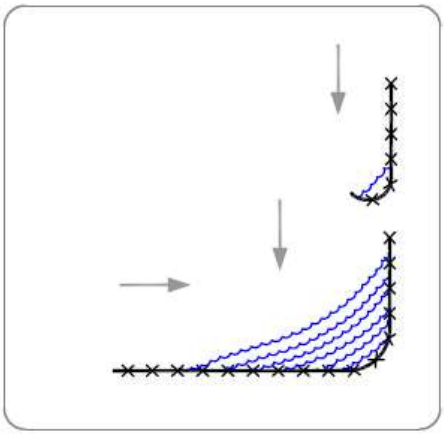




STEP 1 – CONSTRUCT A DAM



STEP 2 – CONSTRUCT SIDE 2

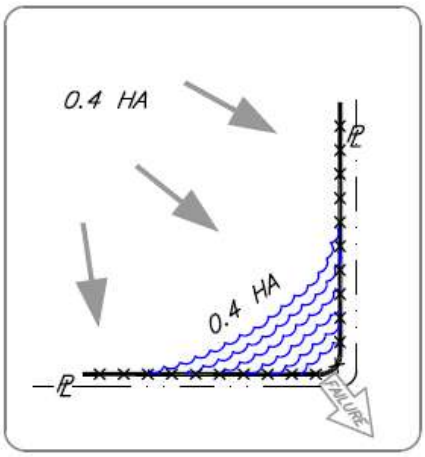


STEP 3 – CONSTRUCT J–HOOKS AS NEEDED

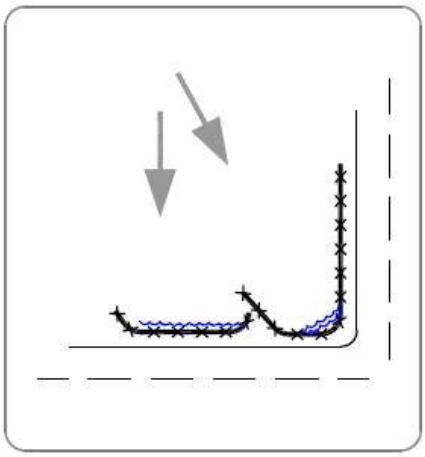
INSTALLATION WITH J–HOOKS WILL INCREASE EROSION CONTROL MIX BERM EFFICIENCY AND REDUCE EROSION–CAUSING FAILURES.

Adapted from McCullah (2002)

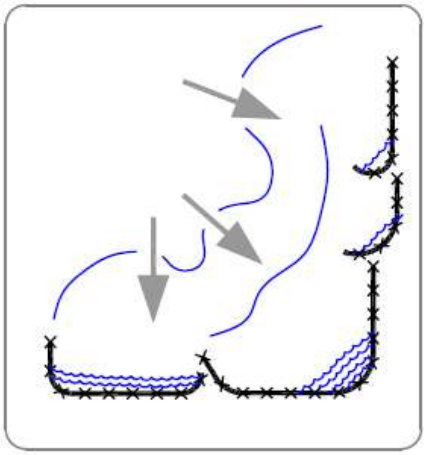
Erosion Control Mix Berm Placement for Perimeter Control

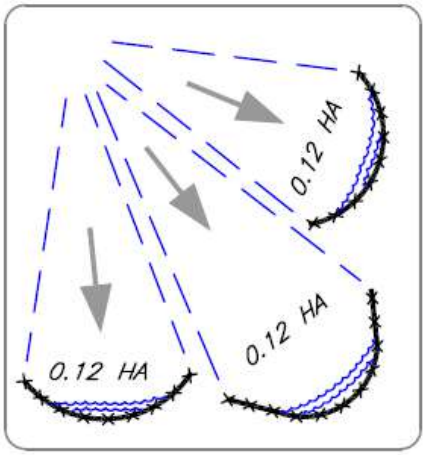


Incorrect – Do Not layout "perimeter control" erosion control mix berms along property lines. All sediment laden runoff will concentrate and overwhelm the system.



Correct – Install J–hooks





Discreet segments of compost berms, installed with J–hooks or 'smiles' will be much more effective.

Adapted from McCullah (2002)

References

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Sediment Barriers (2003), Sediment Controls (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Filter Sock

General Description

Filter socks, also known as "continuous contained berms" or "straw wattles" are an alternative to simple erosion control mix berms that add containment and stability. Filter socks consist of stump grindings or erosion control mix compost encapsulated in mesh fabric. A straw wattle consists of straw encapsulated in mesh fabric. These controls are a type of temporary sediment barrier installed across or at the toe of a slope to intercept and retain small amounts of sediment from disturbed or unprotected areas. The primary function of filter socks is to slow and pond the water, allowing soil particles to settle.

Considerations

- Filter socks are not for use across streams or channels. They should be located only where shallow pools can form and where areas only contribute sheet flow to the device.
- Filter socks should be used for small, disturbed areas such as for providing protection around a soil stockpile.
- Filter socks, similar to other sediment barriers, should be designed for a contributing drainage area of less than 1/4 acre per 100 feet of barrier or with a drainage distance of 100 feet or less.
- Filter socks should only receive sheet flow from upgradient areas.
- Filter socks work especially well in areas where trenching is not feasible such as over frozen ground, over pavement, or over ledge areas.
- Filter socks are especially useful on steep slopes if sufficient anchoring and preparation is made (i.e., remove heavy vegetation) to ensure good contact of sock and underlying soil along its entire length. Maximum gradient behind the barrier is 2h:1v (50 percent).
- Filter socks must be used in conjunction with other measures that prevent or control erosion, as this control measure is for sediment only. Improperly applied or installed sediment barriers may increase erosion.
- Filter socks and straw wattle barriers may also be used for check dams where installation access or other conditions prevent the use of materials such as stone.
- Mesh materials should be 100 percent biodegradable where feasible. The opening size should be less than or equal to 1/8 inches as required by Env-Wq 1506.15. Non-biodegradable mesh encapsulation materials should be removed from the site following 85 percent vegetative site stabilization.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Filter socks should be inspected at least daily during prolonged rainfall.
- At a minimum, sediment deposition should be removed when the silt deposition accumulates to one-half the height of the berm.
- These barriers can be entirely removed as a unit from the site following site stabilization.
- Biodegradable filter socks should last 6 months and may need to be replaced if disturbances are anticipated to last longer.

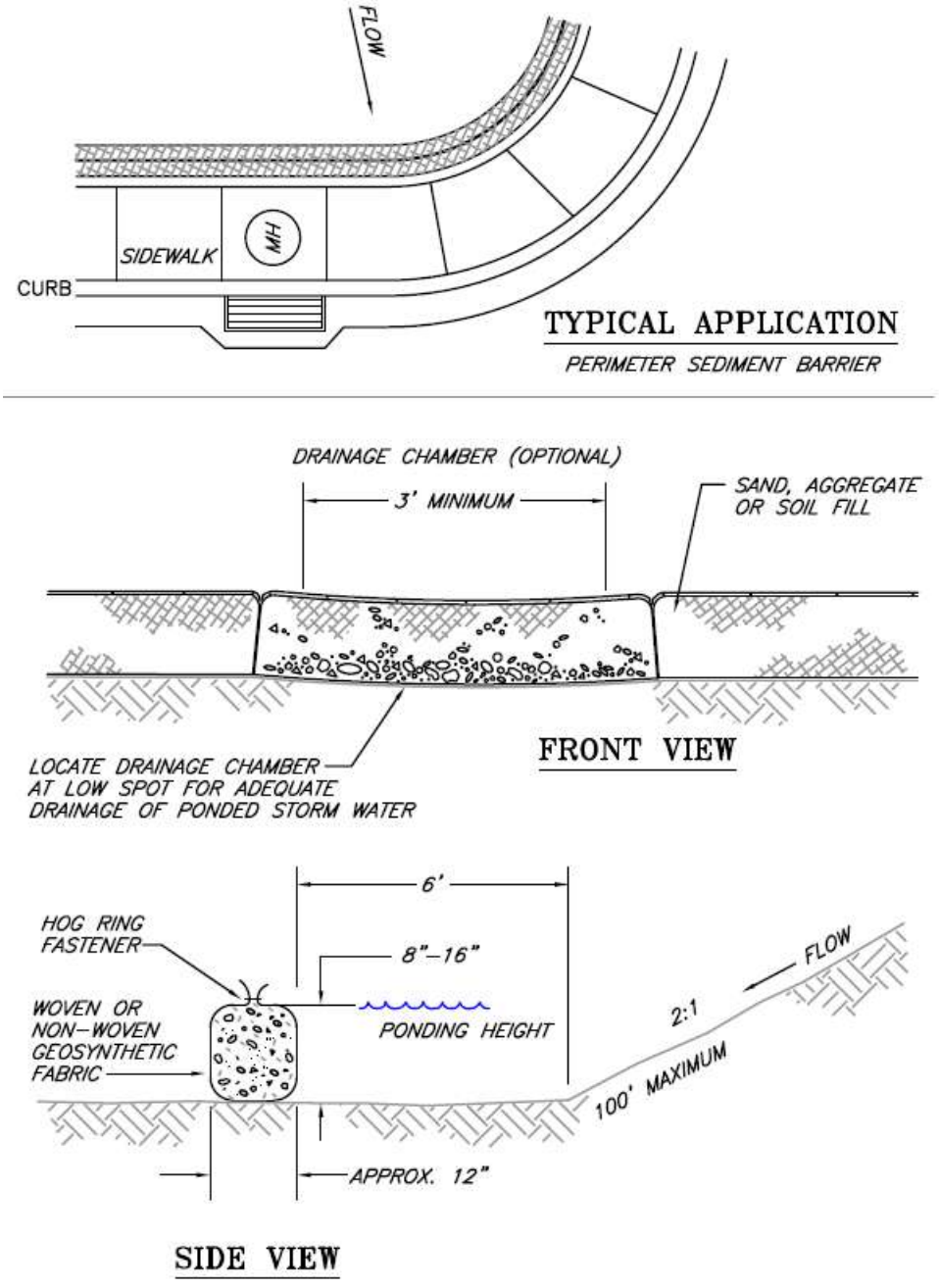
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

- Filter socks can be manufactured on or off the project site.
- Filter socks can range in diameter from 8 inches to 32 inches. Socks with diameters less than 12 inches should only be used for residential projects disturbing a quarter acre or less.
- Filter socks should be staked using 2-inch by 2-inch wooden stakes placed at 10-foot lineal spacing to a depth of 12 inches, or staked per manufacturer specifications. Socks placed on slopes should be anchored with stakes driven through the center of the sock or immediately downslope of the sock.
- The barrier should be installed to maintain surface contact and avoid potential creation of voids that would allow fines to flow under the barrier (i.e., full contact with the ground is critical for filter socks to properly function). It may be necessary to cut tall grasses or woody vegetation.
- Filter socks must consist of primarily organic material including shredded bark, stump grindings, composted bark, or acceptable manufactured products. Unacceptable materials include wood and bark chips, ground construction debris or reprocessed wood projects.
- Seeds may be added to the organic filler material, which can permanently stabilize the shallow slope. The seed mix must not contain non-native or nuisance species seed sources.
- Installation with J-hooks or “smiles” will increase berm efficiency and reduce erosion-causing failures.

Example Design Schematic

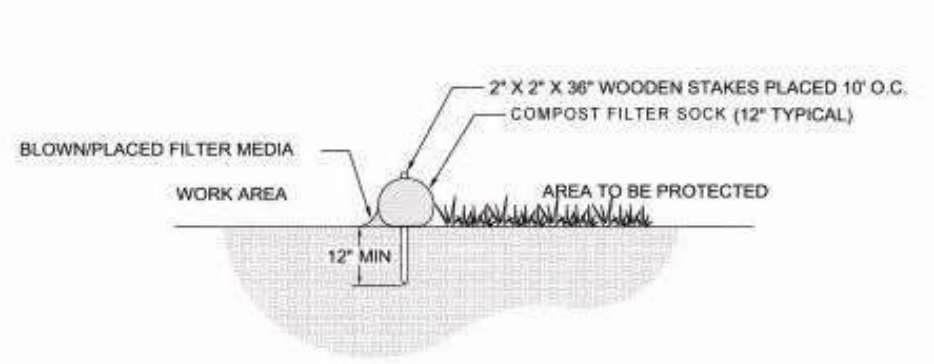
Continuous Contained Berm



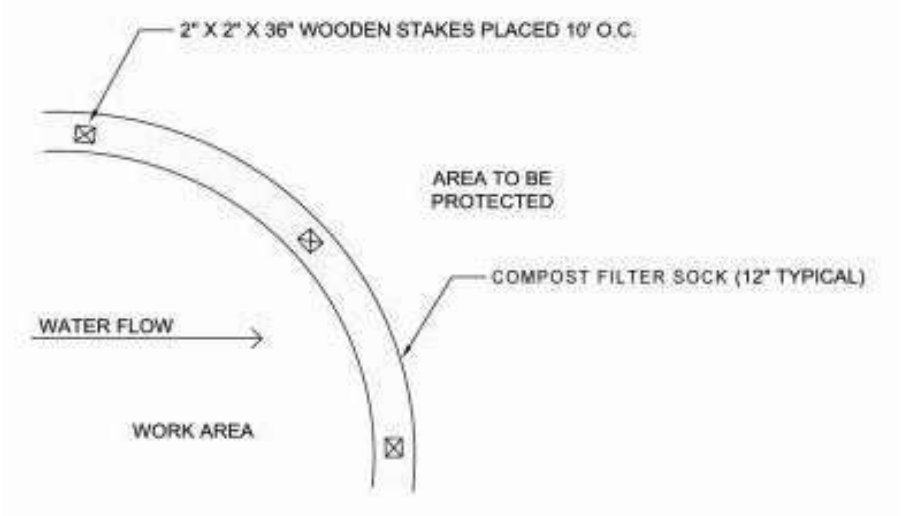
Adapted from McCullah (1996)

Compost Filter Sock

Profile



Plan



NHDOT (2019)

*Refer to "**Erosion Control Mix Berm**" fact sheet for "placement" schematics.*

References

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Sediment Barriers (2003), Sediment Controls (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

New Hampshire Department of Natural and Cultural Resources (NH DNCR). *Best Management Practices Manual Utility Maintenance in and Adjacent to Wetlands and Waterbodies in New Hampshire*. 2019. Available at: https://www.nheconomy.com/getmedia/1b6415ea-f02b-4337-b061-ca30ed1c83d4/dncr-utility-bmps-2019.pdf.

New Hampshire Department of Transportation (NHDOT). *Best Management Practices for Routine Roadway Maintenance Activities in New Hampshire*. 2019. Available at: https://mm.nh.gov/files/uploads/dot/remote-docs/bmp-road-maint-activities-3-14-19.pdf.

Pennsylvania Department of Environmental Protection (PA DEP). *Erosion and Sediment Pollution Control Program Manual*. Technical Guidance 363-2134-008. March 2012. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4680.

Flocculants

General Description

Flocculants (or coagulants) are natural materials or chemicals that cause colloidal particles (silt or clay) to coagulate. The coagulated particles group together to form flocs, which settle out of detained stormwater.

Flocculants can be used in conjunction with sediment basins and sediment traps to remove suspended clay and fine silt particles from stormwater runoff prior to discharge. Use of flocculants improves the ability of these settling facilities to remove finer particles than would be removed otherwise and can increase the percentage of fines removed during the detention period.

Flocculants should only be used upon approval by NHDES.

Considerations

Fine silts and clays are difficult to remove with conventional settling techniques such as sediment traps or basins. Colloidal particles can remain in suspension indefinitely. When these soil materials are present in significant quantities, flocculants may need to be considered to prevent impacts to receiving waters.

If a construction site is characterized by soils with significant amounts of fine silts and clays, it is particularly critical to prevent erosion of these soils in the first place, because of the difficulty in removing fine and colloidal particles from suspension.

There is a variety of flocculant materials available. Any product selected for use must be non-toxic and safe for both human and aquatic life and should not increase Biochemical Oxygen Demand (BOD) in the downstream receiving waters.

The use of flocculants must consider the following:

- Selection of an appropriate flocculant is highly dependent on the soil particle type and concentration.
- Flocculants require specific dosing rates that must be developed on a site-specific basis.
- Flocculants must be thoroughly mixed with the stormwater being treated.
- Settling basins must have sufficient volume and flow capacity to provide the necessary detention time for settling.
- Flocculated material must be periodically removed to maintain system capacity, and upon completion of the project unless otherwise approved by NHDES. Specific disposal requirements may apply.

For these reasons, flocculants are typically only used in special circumstances, and should be used under the direction of qualified professionals, and according to NHDES regulations.

Maintenance Requirements

- Site-specific maintenance requirements applicable to the use of flocculants should be determined in coordination with NHDES staff at the time that flocculants are reviewed and approved for use on a project.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

- Sites should be stabilized as soon as possible using conventional measures to minimize the need to use flocculants.
- Flocculants should not be applied directly to or within 100 feet of any surface water unless specifically approved by the NHDES in writing.
- Flocculants should not be used unless the person requesting approval of such use demonstrates that due to the presence of on-site clay colloidal particles, other erosion control measures, alone or in combination, will not be sufficient to prevent turbidity violations and sedimentation in downstream receiving waters. Turbidity violations are described in Env-Wq 1703.11.
- Flocculants should only be used in strict accordance with the procedures and materials specifications outlined in the New Hampshire Alteration of Terrain (AoT) regulations (Env-Wq 1506.13).

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Flocculants (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Iowa State University, Center for Transportation Research and Education. *Iowa Statewide Urban Design Standards Manual*. Original reference 2007, revised 2023. Available at: https://iowasudas.org/manuals/design-manual/.

Silt Fence

General Description

Silt fences are temporary sediment barriers consisting of filter fabric attached to supporting posts and entrenched into the soil. This barrier is installed across or at the toe of a slope, to intercept and retain small amounts of sediment from disturbed or unprotected areas.

Silt fences have a useful life of one season. They function primarily to slow and pond the water and allow soil particles to settle. Silt fences are not designed to withstand high heads of water, and therefore should be located where only shallow pools can form. Their use is limited to areas where overland sheet flows are expected.

Silt fence is a sediment control measure, not an erosion control measure. It is intended to be used in conjunction with other measures that do prevent or control erosion. Improperly applied or installed silt fence will increase erosion.

Silt fences should not be used across streams, channels, swales, ditches, or other drainage ways. Silt fences are not capable of effectively filtering the high rates and volumes of water associated with channelized flow. Silt fences should not be designed to impound sediment or water more than 18 inches high. Silt fences installed across a concentrated flow path are subject to undercutting, end cutting, and overtopping. This frequently not only results in the bypass of sediment-laden water, but also in the complete failure of the fence. Such failures typically release sediment accumulated on the upgradient side of the fence, and result in severe erosion of the channel both upstream and downstream of the fence.

Considerations

- Silt fence barriers are used where:
  - Erosion will occur only as of the result from sheet flow (flow depth of less than 0.1 feet) and there is no concentration of water in a channel or other drainage way above the fence.
  - Sedimentation can pollute or degrade adjacent wetlands or watercourses.
  - Sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas.
  - The contributing drainage area is less than 1/4 acre per 100 feet of barrier length, the maximum length of slope above the barrier is 100 feet, and the maximum gradient behind the barrier is 50 percent (2h:1v). If any of these conditions are exceeded, other measures may be necessary to control erosion and to intercept and treat the sediment load.
  - Sediment barriers should not be used in areas of concentrated flows. Under no circumstances should silt fences be constructed in streams or in swales where there is the possibility of a washout.
- Silt fences can be used for 60 days or longer depending on ultraviolet stability and manufacturer's recommendations. However, silt fences generally have a useful life of one season, and should be periodically replaced on longer duration construction projects.
- Avoid reinforcing silt fences with metal mesh or plastic mesh, which could potentially entangle and harm wildlife (USFWS, 2023).
- Silt fencing generally is a better sediment barrier than hay bale barriers.
- Potential causes of silt fence failure include:
  - Improper placement on the site.
  - Allowing excessive drainage area to the silt fence structure.

- Inadequate trenching depth and improper backfill and compaction of the bottom of the silt fence fabric.
- Improper attachment to posts.
- Inadequate maintenance of the silt fence after installation.
- Installing silt fence with a descending grade along the fence alignment, resulting in the diversion or concentration of stormwater runoff.
- Placement of fence at mid-slope of a cut or fill embankment. Because a silt fence works by impounding water, it should be placed at the toe of such slopes, to allow for this function, and to avoid potential diversion or concentration of flows.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Fences should be inspected and maintained at least daily during prolonged rainfall.
- Sediment deposition should be removed, at a minimum, when deposition accumulates to 1/3 the height of the fence, and moved to an appropriate location so the sediment is not readily transported back toward the silt fence.
- Silt fences should be repaired immediately if there are any signs of erosion or sedimentation below them. If there are signs of undercutting at the center or the edges of the barrier, or impounding of large volumes of water behind them, sediment barriers should be replaced with a temporary check dam.
- Should the fabric on a silt fence decompose or become ineffective prior to the end of the expected usable life and the barrier still is necessary, the fabric should be replaced promptly.
- Any sediment deposits remaining in place after the silt fence is no longer required should be dressed to conform to the existing grade, prepared and seeded.
- If there is evidence of end flow on properly installed barriers, extend barriers uphill or consider replacing them with other measures, such as temporary diversions and sediment traps.
- Silt fences have a useful life of one season. On longer construction projects, silt fence should be replaced periodically as required to maintain effectiveness.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

Fences should be used in areas where erosion will occur only in the form of sheet erosion and there is no concentration of water in a channel or drainage way above the fence. Sediment barriers should be installed prior to any soil disturbance of the contributing drainage area above them.

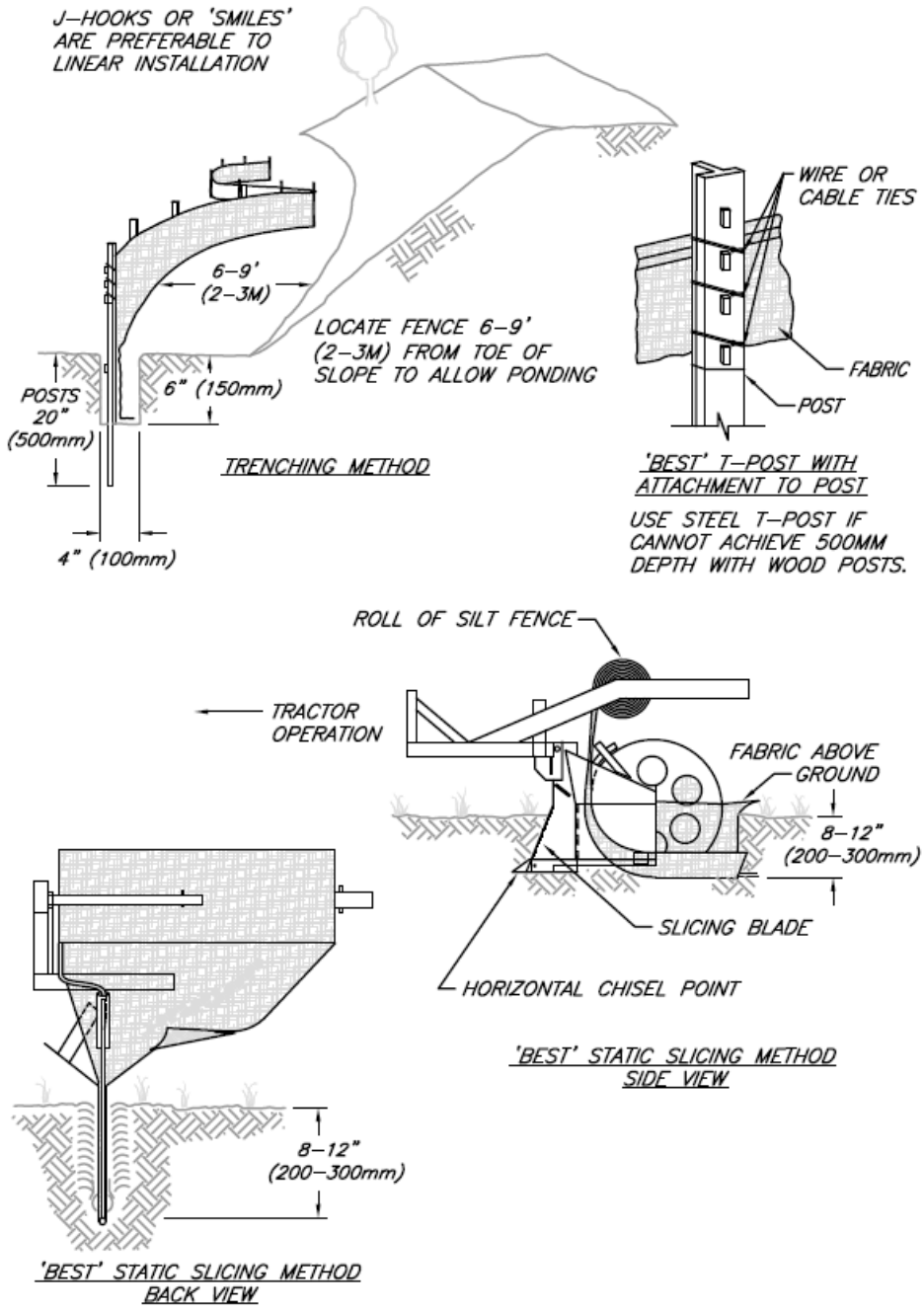
Specifications for use of silt fences are as follows:

- The maximum contributing drainage area above the fence should be less than 1/4 acre per 100 linear feet of fence.
- The maximum length of slope above the fence should be 100 feet.
- The maximum slope above the fence should be 2h:1v.
- Fences should be installed following the contour of the land as closely as possible, and
- The ends of the fence should be flared upslope.

- The fabric should be embedded a minimum of 4 inches in depth and 4 inches in width in a trench excavated into the ground, or if site conditions include frozen ground, ledge, or the presence of heavy roots, the base of the fabric should be backfilled with a minimum thickness of 8 inches of 3/4-inch stone.
- The soil should be compacted over the embedded fabric.
- Adjoining sections of the fence should be overlapped by a minimum of 6 inches (24 inches is preferred), folded and stapled to a support post. If metal posts are used, fabric should be wire-tied directly to the posts with three diagonal ties.
- Silt fencing should not be stapled or nailed to trees.
- The height of a silt fence should not exceed 36 inches as higher fences may impound volumes of water sufficient to cause failure of the structure.
- The filter fabric should be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are necessary, filter cloth should be spliced together only at support post, with a minimum 6-inch overlap, and securely sealed.
- A manufactured silt fence system with integral posts may be used.
- A trench should be excavated approximately 4 inches wide and 4 inches deep along the line of posts and upgradient from the barrier. Post spacing should not exceed 6 feet. The trench should be backfilled and the soil compacted over the filter fabric.
- The filter fabric should be stapled or wired to the post, and 8 inches of the fabric should be extended into the trench. The fabric should not extend more than 36 inches above the original ground surface.
- Silt fence may be installed by “slicing” using mechanical equipment specifically designed for this procedure. The slicing method uses an implement towed behind a tractor to “plow” or slice the silt fence material into the soil. The slicing method minimally disrupts the soil upward and slightly displaces the soil, maintaining the soil’s profile and creating an optimal condition for subsequent mechanical compaction.
- Silt fences should be installed with “smiles” or “J-hooks” to reduce the drainage area that any segment will impound (see diagrams). The ends of the fence should be turned uphill.
- Silt fences placed at the toe of a slope should be set at least 6 feet downgradient from the toe to allow space for shallow ponding and to allow for maintenance access without disturbing the slope.
- Silt fences should be removed when they have served their useful purpose, but not before the upslope areas have been permanently stabilized.

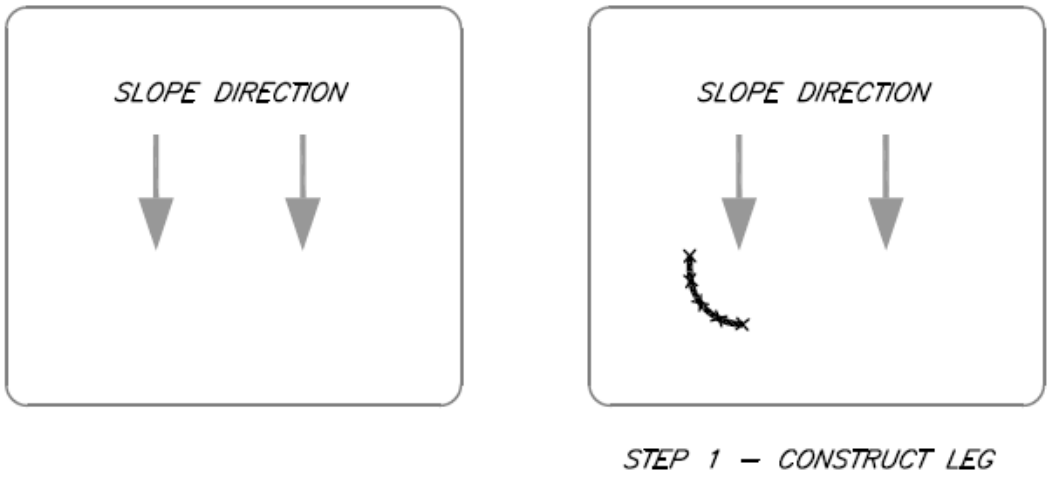
Example Design Schematic

Silt Fence Installation



McCullah (2001)

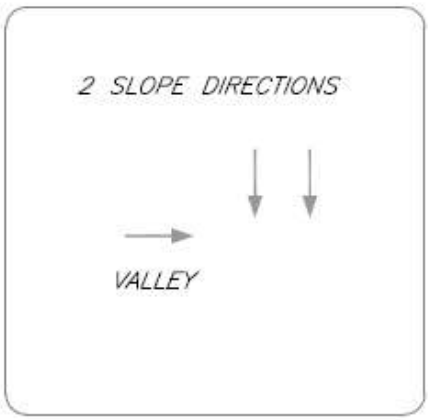
Silt Fence Typical Placement - One Slope

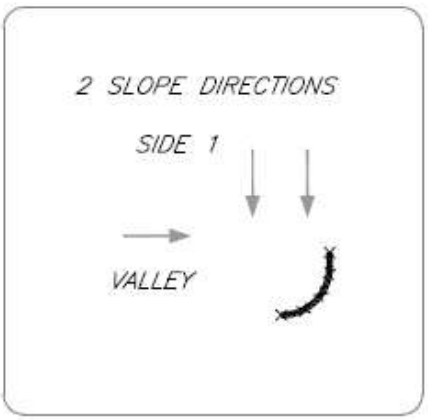


INSTALLATION WITH J–HOOKS OR 'SMILES' INCREASE SILT FENCE EFFICIENCY.

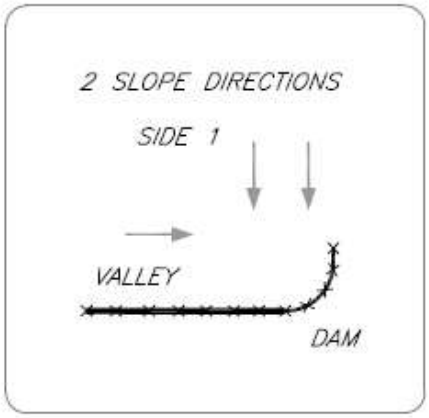
McCullah (2001)

Silt Fence Typical Placement - Two Slopes

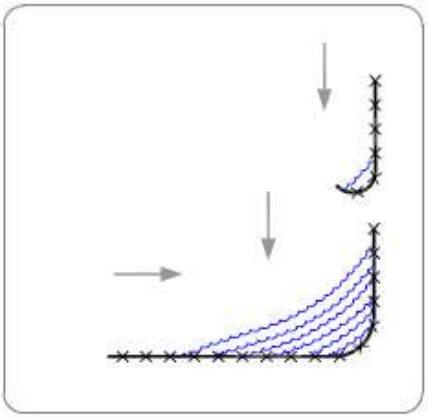




STEP 1 – CONSTRUCT A DAM



STEP 2 – CONSTRUCT SIDE 2

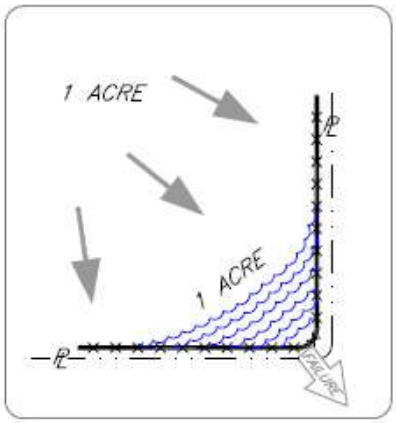


STEP 3 – CONSTRUCT J–HOOKS AS NEEDED

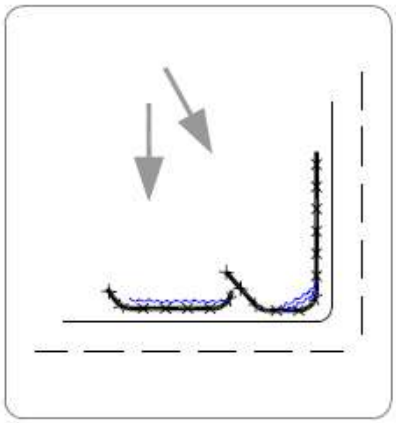
INSTALLATION WITH J–HOOKS WILL INCREASE SILT FENCE EFFICIENCY AND REDUCE EROSION–CAUSING FAILURES.

McCullah (2001)

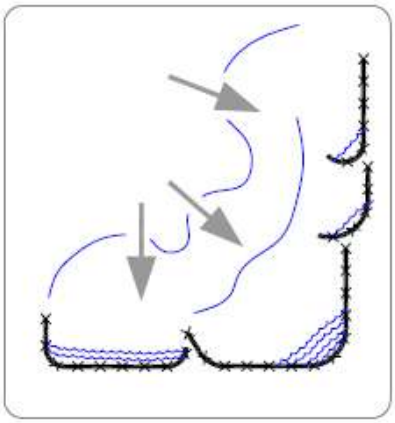
Silt Fence Placement for Perimeter Control

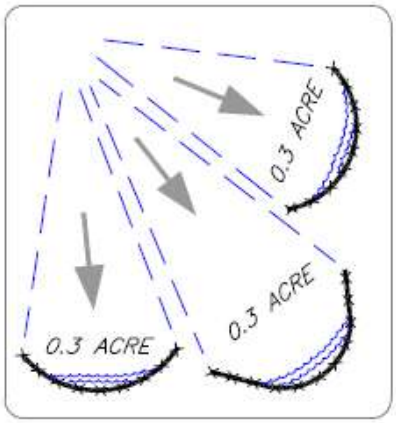


Incorrect – Do Not layout "perimeter control" silt fences along property lines. All sediment laden runoff will concentrate and overwhelm the system.



Correct – Install J–hooks





Discreet segments of silt fence, installed with J–hooks or 'smiles' will be much more effective.

McCullah (2001)

References

Connecticut Department of Environmental, Protection Rothchild, J.A. (Eds.). *Connecticut Guidelines for Soil Erosion and Sediment Control- Silt Fence.* 2002. Available at: https://portal.ct.gov/DEEP/Water/Soil-Erosion-and-Sediment-Control-Guidelines/Guidelines-for-Soil-Erosion-and-Sediment-Control.

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

U.S. Fish & Wildlife Service (USFWS). *Make the Change to Wildlife-Friendly Erosion Control Products!* Webpage. Accessed February 2023. https://www.fws.gov/initiative/protecting-wildlife/make-change-wildlife-friendly-erosion-control-products.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Silt Fence.* 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Straw or Hay Bale Barrier

General Description

Straw and hay bale barriers are a type of temporary sediment barrier installed across or at the toe of a slope, to intercept and retain small amounts of sediment from disturbed or unprotected areas.

Straw or hay bale barriers have a useful life of less than six months. They function primarily to slow and pond the water and allow soil particles to settle. They are not designed to withstand high heads of water, and therefore should be located where only shallow pools can form. Their use is limited to areas that only contribute sheet flow to the device.

Straw or hay bale barriers constitute a sediment control measure, not an erosion control measure. They must be used in conjunction with other measures that prevent or control erosion. Improperly applied or installed sediment barriers will increase erosion.

Straw or hay bale barriers should generally not be used across streams, channels, swales, ditches, or other drainage ways or areas with concentrated flows. Such barriers are not capable of effectively filtering the high rates and volumes of water associated with channelized flow. However, they may be used for check dams in applications where installation access or other conditions prevent the use of preferred materials such as stone; in such cases, installation must provide proper embedment of the straw or hay bale barrier, limit contributing drainage area to less than an acre, and provide for frequent monitoring of the barrier. Straw or hay bale barriers installed across a concentrated flow path are subject to undercutting, end cutting, and overtopping. This can frequently result in the bypass of sediment-laden water, but also in the complete failure of the barrier. Such failures typically release the sediment accumulated on the upgradient side of the barrier, and severe erosion of the channel both upstream and downstream of the device.

Hay Bale Alternatives

Construction sites have historically used straw or hay bales for erosion and sediment control as check dams, inlet protection, outlet protection and perimeter control. **Many applications of straw hale bales for erosion and sediment control are ineffective** due to their composition, inappropriate placement, inadequate installation, lack of maintenance, or a combination of these factors. Some local regulations limit the use of hay bales. For these reasons, the **United States Environmental Protection Agency (EPA) recommends carefully considering other E&SC measure first**. For example, consider silt fence for perimeter controls, stone check dams for diversion channels, erosion control blanket and matting for slope protection, filter sacks for inlet protection, and prefabricated washout containers for concrete washout structures. Refer to the U.S. EPA Fact Sheet for Straw or Hay Bales for more information.

Considerations

- Straw or hay bale barriers principally trap sediment by temporarily ponding water, allowing particles to settle. These barriers are not designed to withstand high heads of water; therefore, they should be located where only shallow pools can form.
- Straw or hay bale barriers are used where:
  - Erosion will occur only in the form of sheet erosion and there is no concentration of water in a channel or other drainage way above the barrier.
  - Sedimentation can pollute or degrade adjacent wetlands or watercourses.
  - Sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas.

- The contributing drainage area is less than 1/4 acre per 100 feet of barrier length, the maximum length of slope above the barrier is 100 feet, and the maximum gradient behind the barrier is 50 percent (2h:1v). If any of these conditions are exceeded, other measures may be necessary to control erosion and to intercept and treat the sediment load.
- Sediment barriers should not be used in areas of concentrated flows. However, they may be used for check dams in applications where installation access or other conditions prevent the use of preferred materials such as stone; in such cases, installation must provide proper embedment of the straw or hay bale barrier, limit contributing drainage area to less than one acre, and provide for frequent monitoring of the barrier. Under no circumstances should sediment barriers be constructed in live streams or in swales where there is the possibility of a washout.

- Straw or hay bales should only be used as a temporary barrier for no longer than 60 days.
- Potential causes of straw or hay bale barrier failure include:
  - Improper placement on the site.
  - Allowing excessive drainage area to the barrier.
  - Inadequate keying of the bales into the ground surface.
  - Inadequate maintenance after installation.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Hay bale barriers should be inspected at least daily during prolonged rainfall.
- Barriers should be repaired immediately if there are any signs of erosion or sedimentation below them. If there are signs of undercutting at the center or the edges of the barrier or impounding of large volumes of water behind the barrier, the barrier should be replaced with an alternative measure to intercept and capture sediment (e.g., a diversion berm directing sediment-laden stormwater runoff to a sediment trap or basin).
- Damaged or decomposed bales should be replaced promptly.
- Sediment deposits should be removed after each storm event. They must be removed when deposits reach approximately 1/3 the height of the barrier.
- Any sediment deposits remaining in place after the filter barrier is no longer required should be dressed to conform to the existing grade, prepared and seeded.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

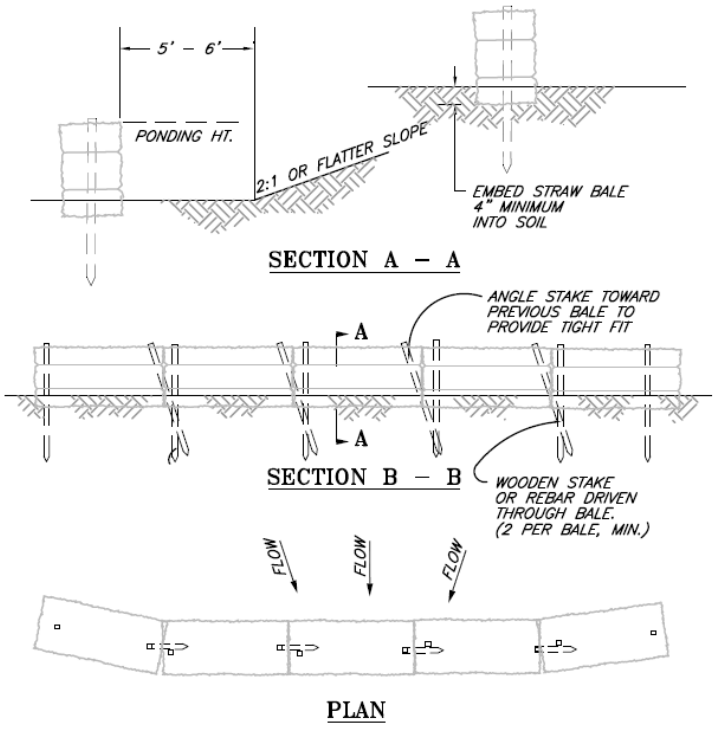
Specifications

- Sediment barriers should be installed prior to any soil disturbance of the contributing drainage area above them.
- Bales should be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another. The ends of the barrier should be flared up slope. Barriers should follow the contour or run parallel across slopes of the land as closely as possible.
- Barriers should not be constructed more than 1 bale high.
- All bales should be either wire-bound or string-tied. Bales should be installed so that bindings are oriented around the sides, parallel to the ground surface to prevent deterioration of the bindings.

- The barrier should be entrenched and backfilled. A trench should be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches.
- After the bales are staked and chinked, the excavated soil should be backfilled against the barrier. Backfill soil should conform to the ground level on the downhill side and should be built up 4 inches against the uphill side of the barrier. Ideally, bales should be placed 10 feet downgradient from the toe of slope.
- At least two stakes driven through the bale and penetrating at least 18 inches into the ground, should securely anchor each bale. The first stake in each bale should be driven toward the previously laid bale to force the bales together.
- The gaps between bales should be chinked (filled by wedging) with hay or straw to prevent water from escaping between the bales.
- Inspection should be frequent, and repair or replacement should be made promptly as needed. Bale barriers should be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

Example Design Schematic

Straw Bale Barrier



NOTES:

1. THE BALES SHALL BE PLACED ON SLOPE CONTOUR.
2. BALES TO BE PLACED IN A ROW WITH THE ENDS TIGHTLY ABUTTING.
3. KEY IN BALES TO PREVENT EROSION OR FLOW UNDER BALES.
4. REFER TO DESCRIPTION OF "SILT FENCE" FOR DIAGRAMS ILLUSTRATING PLACEMENT OF BARRIERS FOR EFFECTIVE SEDIMENT CONTROL.

Adapted from McCullah (1994)

References

Connecticut Department of Environmental, Protection Rothchild, J.A. (Eds.). *Connecticut Guidelines for Soil Erosion and Sediment Control- Hay Bale Barrier.* 2002. Available at: https://portal.ct.gov/DEEP/Water/Soil-Erosion-and-Sediment-Control-Guidelines/Guidelines-for-Soil-Erosion-and-Sediment-Control.

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Sediment Barriers (2003), Sediment Controls (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Perimeter Sediment Barriers (1989), Straw Bale (2016)*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Straw Bale Barrier.* 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Temporary Check Dam

General Description

Temporary check dams are small temporary dams constructed across a swale, channel, or drainage ditch. Check dams are used to reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale, channel, or ditch.

Check dams may also trap small amounts of sediment generated in the swale, channel, or ditch itself. However, the check dam is not a sediment trapping measure and should not be used as such.

The measure is limited to use in small open channels that drain one acre or less. It should **not** be used in either perennially flowing streams or intermittent stream channels.

Check dams can be constructed of stone. In locations where stone is not available, timber check dams may be considered. Typical applications include temporary or permanent ditches, channels, or swales, which need protection during the establishment of grass linings.

Hay or straw bales should generally not be used as check dams, or in any location where there is concentrated flow. However, they may be used for check dams in applications where installation access or other conditions prevent the use of preferred materials such as stone; in such cases, installation must provide proper embedment of the straw or hay bale barrier, limit contributing drainage area to less than one acre, and provide for frequent monitoring of the barrier.

Considerations

- This measure is intended for use in areas of concentrated flow, but must not be used in stream channels (whether perennial or intermittent).
- The check dam may be left in place permanently to avoid unnecessary disturbance of the soil on removal, but only if the project design has accounted for their hydraulic performance and construction plans call for them to be retained.
- If it is necessary to remove a stone check dam from a grass-lined channel that will be mowed, care should be taken to ensure that all stones are removed, including stones that have washed downstream.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Check dams should be inspected at least daily during prolonged rainfall.
- Inspections should verify that the center of the dam is lower than the edges.
- Erosion caused by high flows around the edges of the dam must be corrected immediately.
- If evidence of siltation in the water is apparent downstream from the check dam, the check dam should be inspected and adjusted immediately.
- Check dams should be checked for sediment accumulation after each significant rainfall. Sediment should be removed routinely and when it reaches a maximum depth of 1/2 of the original height.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

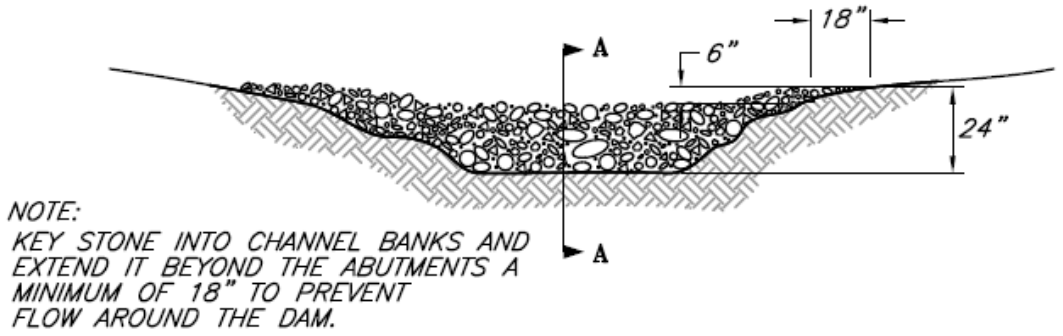
Specifications

Temporary check dams should conform to the following requirements:

- Check dams should be installed before stormwater runoff is directed to the swale, channel, or drainage ditch.
- The maximum contributing drainage area to the dam should be less than one acre.
- The maximum height of the dam should be 2 feet.
- The center of the dam should be at least 6 inches lower than the outer edges.
- The maximum spacing between the dams should be such that the toe of the upstream dam is at the same elevation as the overflow elevation of the downstream dam.
- The check dam should not be used in a flowing stream.
- Hay bale check dams should be embedded into the ground at least 4 inches but no more than 6 inches.
- Stone check dams should be constructed of a well-graded angular 2-inch to 3-inch stone. 3/4-inch stone on the upgradient face is recommended for better filtering, with larger stone on the down-gradient face to provide stability.
- The stone should be keyed into swale/ channel/ ditch side slopes and extended by a minimum of 18 inches to prevent bypass or washout.
- If carefully installed and monitored, timber check dams may be used, and should be constructed of 4-inch to 6-inch logs embedded at least 18 inches deep into the soil. However, stone check dams are generally preferred. The stone has the ability to conform to the channel and settle if scour occurs, rendering stone check dams less susceptible to scour around the ends and downstream of the devices.
- If provided by design and construction plans, leave the dam in place permanently.
- Temporary structures should be removed once the swale, channel, or ditch has been stabilized:
    - In temporary ditches, channels, and swales, check dams should be removed, and the ditch/ channel/ swale filled in when it is no longer needed.
    - In permanent structures, check dams should be removed when a permanent lining has been established. If the permanent lining is vegetation, then the check dam should be retained until the grass has matured to protect the ditch, channel, or swale. The area beneath the check dam must be seeded and mulched immediately after removal.

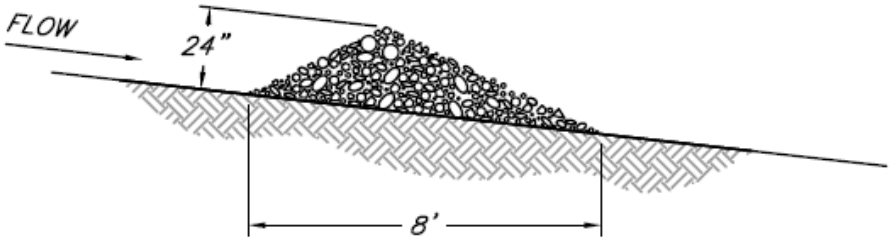
Example Design Schematic

Stone Check Dam



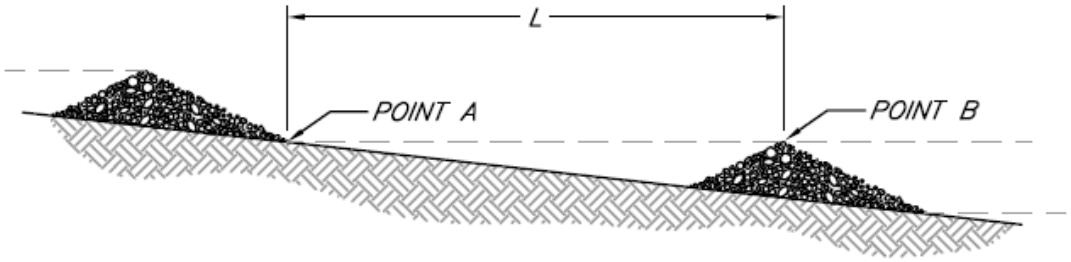
NOTE:
KEY STONE INTO CHANNEL BANKS AND EXTEND IT BEYOND THE ABUTMENTS A MINIMUM OF 18" TO PREVENT FLOW AROUND THE DAM.

VIEW LOOKING UPSTREAM



SECTION A – A

L = THE DISTANCE SUCH THAT POINTS A AND B ARE OF EQUAL ELEVATION



SPACING BETWEEN CHECK DAMS

NOT TO SCALE

Adapted from ME DEP (2003)

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Temporary Check Dams (2003), Stone Check Dams (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Check Dams*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Rock Check Dams.* 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Temporary Construction Exit

General Description

A stabilized construction exit consists of a pad of stone aggregate placed on a geotextile filter fabric, located at any point where traffic will be leaving a construction site to an existing access roadway or other paved surface. Its purpose is to reduce or eliminate the tracking of sediment onto public roads by construction vehicles. This helps protect receiving waters from sediment carried by stormwater runoff from public roads.

Considerations

- Only construction traffic ***leaving*** the site is required to use the temporary stabilized exit. Consider providing a separate, unprotected, entrance for traffic entering the site. This will increase the longevity of the stabilized exit by eliminating heavy loads entering the site and reducing the total traffic over the device.
- Locate construction exits to limit sediment leaving the site and to provide for maximum utility by all construction vehicles. Avoid entrances that have steep grades and entrances at curves in public roads to minimize sight distance issues.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- The exit should be maintained in a condition that will prevent tracking of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand, and repair and/ or maintenance of any measures used to trap sediment.
- When the control pad becomes ineffective, the stone should be removed along with the collected soil material, regraded on site, and stabilized. The entrance should then be reconstructed.
- The contractor should sweep the pavement at exits whenever soil materials are tracked onto the adjacent pavement or traveled way.
- When wheel washing is required, it should be conducted on an area stabilized with aggregate, which drains into an approved sediment-trapping device. All sediment should be prevented from entering storm drains, channels/ swales, or waterways.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

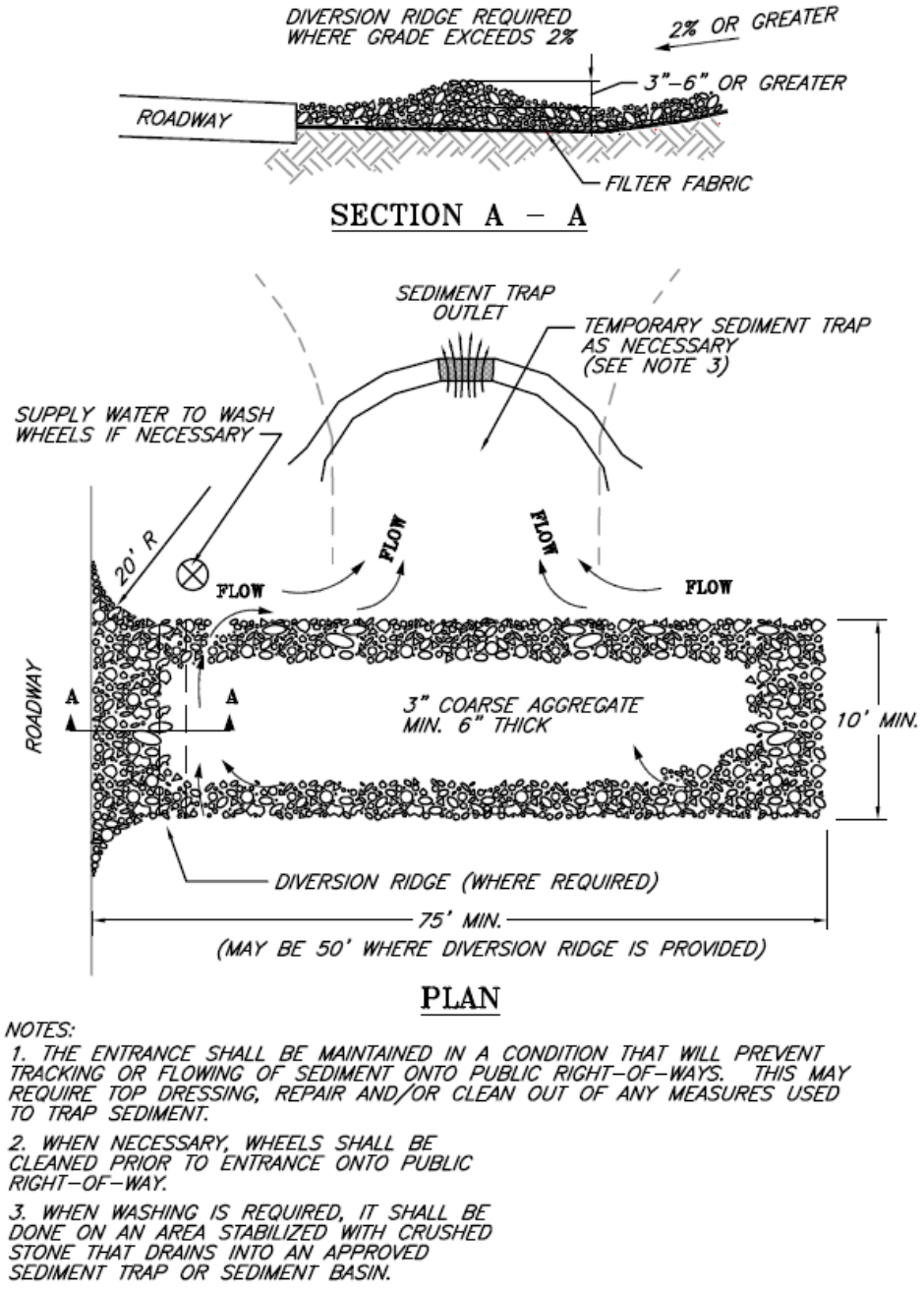
Temporary construction exits should meet the following requirements:

- The stone should be 3-inch crushed stone (NHDOT Item No. 304.5).
- The minimum length of the pad should be 75 feet, except that the minimum length may be reduced to 50 feet if a 3-inch to 6-inch-high berm is installed at the entrance of the project site.
- The pad should extend the full width of the construction access road or 10 feet, whichever is greater.
- The pad should slope away from the existing roadway.

- The pad should be at least 6 inches thick.
- A geotextile filter fabric should be placed between the stone pad and the earth surface below the pad.
- The pad should be maintained or replaced when mud and soil particles clog the voids in the stone such that mud and soil particles are tracked off-site.
- Natural drainage that crosses the location of the stone pad should be intercepted and piped beneath the pad, as necessary, with suitable outlet protection.

Example Design Schematic

Temporary Gravel Construction Exit



NOTES:

1. THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION THAT WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHT–OF–WAYS. THIS MAY REQUIRE TOP DRESSING, REPAIR AND/OR CLEAN OUT OF ANY MEASURES USED TO TRAP SEDIMENT.
2. WHEN NECESSARY, WHEELS SHALL BE CLEANED PRIOR TO ENTRANCE ONTO PUBLIC RIGHT–OF–WAY.
3. WHEN WASHING IS REQUIRED, IT SHALL BE DONE ON AN AREA STABILIZED WITH CRUSHED STONE THAT DRAINS INTO AN APPROVED SEDIMENT TRAP OR SEDIMENT BASIN.

Adapted from McCullah (1994)

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Stabilized Construction Exit (2003), Construction Entrance/ Exit (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Construction Entrances*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Temporary Stone Construction Entrance*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Temporary Sediment Basin

General Description

A sediment basin is a water impoundment constructed to capture and store sediment and/ or debris. Sediment is removed by temporarily detaining sediment-laden stormwater runoff, allowing time for the sediment particles to settle. In some instances, settling may be enhanced by the introduction of flocculants (see separate "**Flocculants**" fact sheet in this Appendix). Flocculants should only be used upon approval by NHDES. Sediment basins may be made by constructing a dam or embankment or by excavating a depression. Sediment basins differ from sediment traps, in that basins are engineered impoundment structures, and may serve larger areas than sediment traps.

The sediment basin is designed to:

- Detain stormwater volume and slowly release it to the downstream waterways (if surface water quality standards can be met at discharge point).
- Trap sediment originating from construction site and prevent subsequent deposition in downstream drainage waterways.
- Provide storage of the trapped sediment and debris.

Considerations

- Sediment basins should only be used where the following conditions exist:
  - Failure of the embankment or impoundment will not result in loss of life; damage to homes, commercial or industrial buildings, main highways, or railroads; or interruption of the use or service of public utilities.
  - The basin is designed by a Professional Engineer licensed in New Hampshire.
  - The basin is designed in accordance with the measures applicable to impoundment embankments, as identified in the **Appendix A** "**Detention Basin**" fact sheet.
- Sediment basins must meet all applicable requirements if they meet New Hampshire's definition of a "dam" (https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/dam-definiton.pdf). Applicable requirements may be accessed at the NHDES Dam Bureau web page at https://www.des.nh.gov/water/dam-maintenance-and-management.
- It is possible to use a basin that is designed for eventual permanent use as a detention basin or water quality treatment facility for the final constructed project. However, this measure should not be undertaken unless specifically provided in the design of the project, and authorized by the design engineer. In some cases, the long-term operating integrity of a basin can be adversely affected by temporary use as a sediment basin (such as potential clogging of soils intended to provide future infiltration function).
- A sediment basin should be installed as close as possible to the disturbed area or sediment source.
- Sediment basins should be installed where stormwater runoff from undisturbed areas can be excluded from the drainage area to the basin and should be placed in compliance with the Construction General Permit Appendix F, which requires a 50 foot vegetative natural buffer from wetlands, streams, and other jurisdictional areas.
- Sediment basins mostly trap coarse-grained sediments. Fine-grained sediments such as silts and clays will remain suspended in the water and will travel off-site unless the water is detained for an extended period of time, or unless other treatment measures (such as use of flocculants or downstream filters) are implemented to enhance settling of these materials.

- Sediment basins, like detention basins, can result in warmer water temperatures than the natural condition (i.e., above ambient). Care must be exercised to not locate discharges from sediment basins near to cold-water streams.
- Basin locations and construction activities may affect downstream water quality, wetlands, and water-related wildlife habitats. These conditions must be considered in the design.
- Overall planning and design should be carefully considered to minimize the number of sediment basins required.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Sediment basin installations need to be regularly inspected during their installation. If there is any evidence of siltation downstream of the basin, corrective measures need to be implemented to keep sediment from entering downstream areas.
- Sediment basins should be inspected at least daily during prolonged rainfall.
- Outlet structures and emergency spillways should be examined at the time of inspection for any damage, and repaired immediately if any such damage is observed.
- Side slopes and embankments should be examined at the time of inspection to ensure that they are structurally sound, are not showing signs of seepage, and are not damaged by erosion or by construction activities.
- The water discharged from sediment basins should be monitored during storm events to determine how well they are functioning and if sedimentation is apparent, additional erosion control measures should be applied to eliminate the source of sedimentation.
- Geotextile fabric or stone used around a pipe-outlet riser should be checked periodically and replaced when the material has become clogged with sediment.
- Sediment should be removed, and the trap restored to original capacity when sediment has accumulated to the original design sediment storage volume.
- The materials removed from the basin should be properly disposed of and stabilized.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

Sediment basins must meet the following requirements:

- Basins must be constructed and stabilized prior to disturbing the watershed above them. If sediment basins will be stabilized with vegetation, they must be installed early in the growing season.
- Erosion and Sediment Control (E&SC) measures should be employed during the construction of the sediment basin until stabilized to protect downstream waterbodies from sedimentation due to the construction disturbance required to install this E&SC measure.
- An outlet structure should be provided adequate to handle the 10-year frequency discharge without failure or significant erosion.
    - The outlet should be designed, constructed, and maintained in such a manner that sediment does not leave the trap and that erosion at or below the outlet does not occur.
    - Outlets should be designed so that the top of the embankment provides the minimum freeboard specified in **Appendix A** "**Detention Basin**" fact sheet.

- The outlet should discharge to a stabilized area. The outlets must empty onto undisturbed or stabilized ground, into a watercourse, stabilized channel, or a storm sewer system. Any discharges must meet surface water quality standards. Outlet protection should be provided (see **Appendix A** "**Permanent Outlet Protection**" fact sheet) or control valves on outlet structures should be provided to hold or reduce discharge volume.

- The minimum sediment storage volume of the basin should be 3,600 cubic feet of storage for each acre of drainage area, or the calculated stormwater runoff volume from a 2-year, 24-hour storm. The capacity of the sediment basin should be equal to the stormwater volume to be detained plus the volume of sediment expected to be trapped. Periodic removal of sediment will be necessary to maintain the basin's capacity.
- The side slopes of the basin should be 3h:1v or flatter, and should be stabilized immediately after their construction.
- Embankments should be designed to meet applicable regulations, and should meet the design requirements identified in **Appendix A** "**Detention Basin**" fact sheet for embankment construction.
- The drainage area contributing to the basin must be protected against erosion so that expected sedimentation will not shorten the planned effective life of the structure.
- Basins must be designed to be drained within 72 hours or less.
- An emergency spillway should be provided to safely pass the 50-year design storm without damage to the embankment, assuming that the basin is full to design depth at the beginning of the storm. The emergency spillway should not be installed in filled embankments.
- All areas disturbed during construction should be stabilized within 7 calendar days of that disturbance in accordance with the Permanent Vegetation E&SC measure, Temporary Mulching E&SC measure, or other appropriate structural E&SC measure. All construction of sediment basins must be completed and seeded by September 15 if vegetative measures will be used for final stabilization. Otherwise, side slopes must be stabilized with an alternative approved long-term stabilization measure. If structural measures such as riprap will be used for final stabilization, this time limit will not apply. Water should not be directed to the sediment basin until the basin is stabilized with vegetative or other measures.
- A sediment basin with a pipe outlet structure should be fitted with a perforated riser surrounded by a gravel cone. This will serve to filter fine particulate material. A geotextile filter should be installed around the riser prior to the placement of the gravel.

Additional Outlet Protection Considerations:

- Note that sediment basins are vulnerable to discharging sediment-laden water and may require additional protection at the outlet, particularly when construction sediment is fine (i.e., comprised mostly of fine silts or clays).
- Additional measures may include, but are not limited to stone filter rings, porous, baffling systems, and sediment skimmers as pictured below.

Stone Filter Ring

(Example Photo)



SC DHEC (2014)

Porous Baffles

(Example Photo)



SC DHEC (2014)

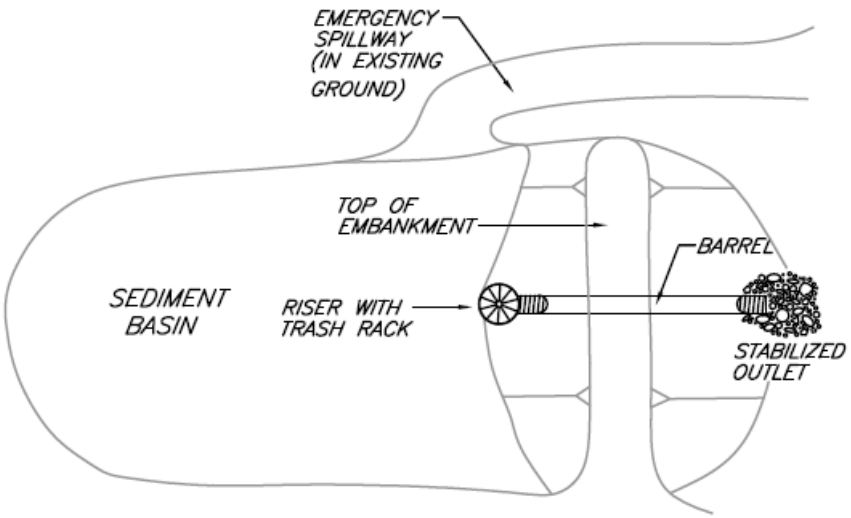
Sediment Skimmer

(Example Photo)

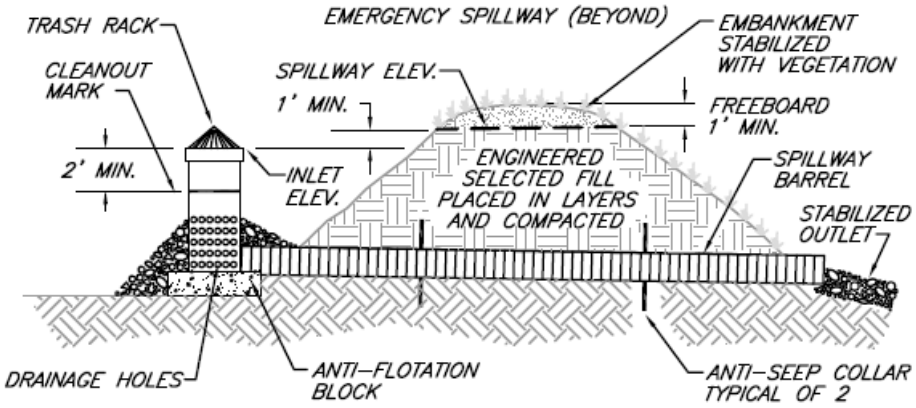


SC DHEC (2014)

Temporary Sediment Basin



PLAN



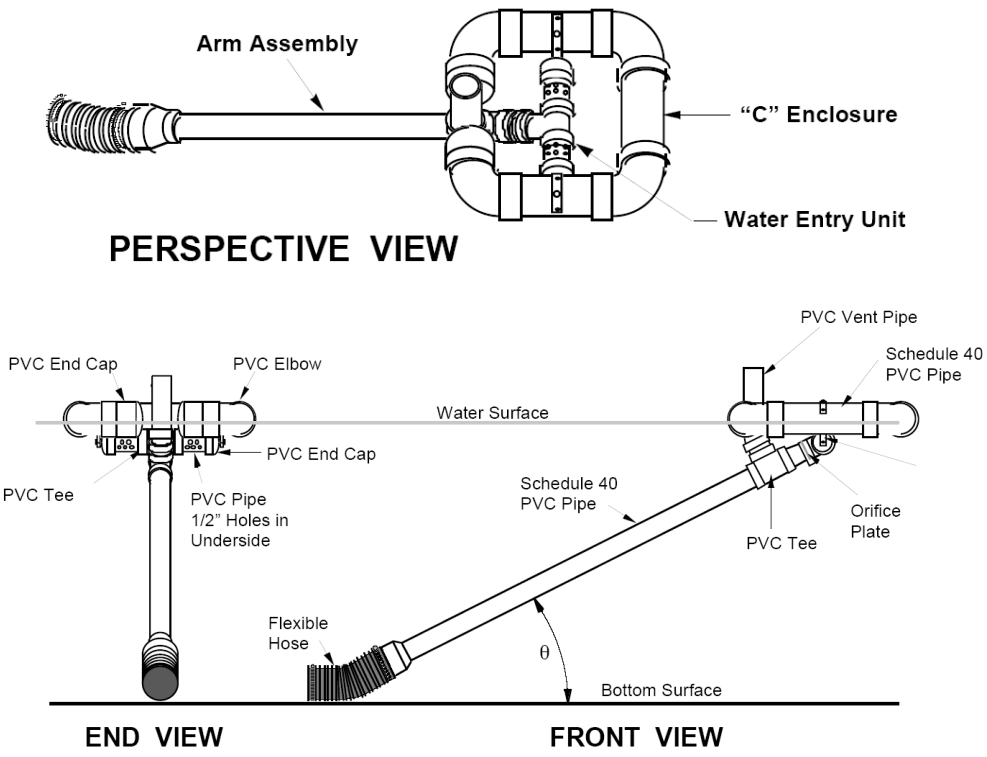
SECTION

NOTES:

1. THE TEMPORARY SEDIMENT BASIN, DESIGNED BY A QUALIFIED PROFESSIONAL, IS REQUIRED FOR DISTURBED AREAS GREATER THAN 5 ACRES WITHIN A DRAINAGE AREA LESS THAN 100 ACRES.
2. THE SEDIMENT BASIN WILL BE REMOVED WITHIN 3 YEARS.

Adapted from McCullah (1994)

Sediment Skimmer



Iowa SUDAS (2018)

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Sediment Pond Construction (2003), Sediment Basins (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Iowa Statewide Urban Design and Specifications (SUDAS). *Iowa Statewide Urban Design Standards Manual (7E-12: Sediment Basin)*. Revised 2018 edition. Available at: https://intrans.iastate.edu/app/uploads/sites/15/2020/03/7E-12.pdf.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Sediment Basin (1989), Temporary Sediment Basins (2016)*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

South Carolina Department of Health and Environmental Control (SC DHEC). *Stormwater BMP Handbook, Sediment Control BMPs- Sediment Basins*. March 2014. Available at: https://scdhec.gov/sites/default/files/docs/Environment/docs/sedim-Basin.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Temporary Sediment Basin*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Temporary Sediment Trap

General Description

A sediment trap is a small, temporary ponding area to intercept sediment-laden stormwater runoff from small, disturbed areas. Intercepted stormwater runoff is retained long enough to allow for settling of the coarser sediment particles. Sediment traps are usually installed at the outlet of stormwater diversion structures, channels, slope drains, construction exit wash areas, or other points of discharge from disturbed area.

Considerations

- A sediment trap should be installed as close as possible to the disturbed area or sediment source.
- Sediment traps should be used in drainage ways with small watersheds (contributing drainage area less than 5 acres, but usually significantly smaller than this). For larger contributing areas, engineered sediment basins should be used instead.
- Sediment traps should be installed where stormwater runoff from undisturbed areas can be excluded from the trap.
- Traps should be located to obtain maximum storage benefit from the terrain, as well as for ease of removal and disposal of accumulated sediment.
- Sediment trap discharge should meet NH surface water quality standards at discharges to streams, rivers, or other waterbodies.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Sediment traps should be inspected at least daily during prolonged rainfall.
- Sediment should be removed, and the trap restored to original capacity when sediment has accumulated to 50 percent of the original volume.
- The materials removed from the trap should be properly disposed of and stabilized.
- Sediment trap outlets should be examined at the time of inspection for any damage, and repaired immediately if any such damage is observed.
- Geotextile fabric or stone used around a pipe-outlet riser should be checked periodically and replaced when the material has become clogged with sediment.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

Temporary sediment traps should meet the following requirements:

- Sediment traps should be located so that they can be installed prior to disturbing the area they are to protect.
- The trap should be installed as close to the disturbed area or source of sediment as possible.

- The maximum contributing drainage area to the trap should be less than 5 acres.
- The minimum volume of the trap should be 3,600 cubic feet of storage for each acre of drainage area.
- The side slopes of the trap should be 3h:1v or flatter, and should be stabilized immediately after their construction.

Embankments:

- The maximum height of the sediment trap embankment should be 4 feet when measured from the lowest point of natural ground on the downstream side of the embankment.
- The minimum top width of the embankment should be 6 feet.

Outlets (General Requirements):

- The outlet should be designed, constructed, and maintained in such a manner that sediment does not leave the trap and that erosion at or below the outlet does not occur.
- Outlets should be designed so that the top of the embankment is a minimum of 1 foot above the crest elevation of the outlet.
- The outlet should discharge to a stabilized area (see "**Temporary and Permanent Mulching**," "**Temporary Erosion Control Blanket**," or "**Temporary Vegetation**").
- Outlets may be constructed as earth spillways, stone outlets, or pipe outlets.

Earth Outlets:

- An earth outlet sediment trap has a discharge point that is located either over natural ground or cut into natural ground.
- The outlet width should be equal to 6 times the drainage area in acres.
- The embankment and outlet should be vegetated within 3 days of construction.

Stone Outlets:

- A stone outlet sediment trap has an outlet consisting of a crushed stone section in the embankment.
- The stone section should be located at the low point of the natural ground, as determined at the downstream side of the embankment.
- The outlet should be constructed of minimum size 1.5-inch crushed stone.

Pipe Outlets:

- A pipe outlet sediment trap has a pipe through the embankment, with an inlet consisting of a perforated riser.
- The pipe and riser should be constructed of corrugated metal. Plastic pipe (polyvinyl chloride or high-density polyethylene) may be considered, if the piping is located where it will not be subject to damage from vehicle traffic or from ice and frost conditions.
- The top 2/3 of the riser should be perforated with 1-inch diameter holes spaced 8 inches vertically and 10 to 12 inches horizontally around the pipe.
- Anchoring Weight: The riser should have a base with sufficient weight to prevent flotation of the riser. Two approved bases are: (1) A concrete base 12 inches thick with the riser embedded 9 inches into the concrete base, or (2) 1/4-inch minimum thickness steel plate attached to the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate should be backfilled with a minimum of 2.5 feet of stone, gravel, or earth to prevent flotation. In either case, each side of the square base measurement should be the riser diameter plus 24 inches.

- To increase the efficiency of the trap, the riser can be wrapped with a geotextile fabric held in place by woven wire and secured by strapping. The cloth should cover an area at least 6 inches above the highest hole and 6 inches below the lowest hole. The top of the riser pipe should not be covered with filter cloth.
- Crushed stone can also be used around the riser to increase trap efficiency.
- The minimum pipe sizes should be determined as provided in the following table:

Maximum Drainage Area (acres)	Minimum Barrel Diameter (inches)	Minimum Riser Diameter (inches)
1	15	21
2	18	24
3	21	30
4	24	30
5	30	36

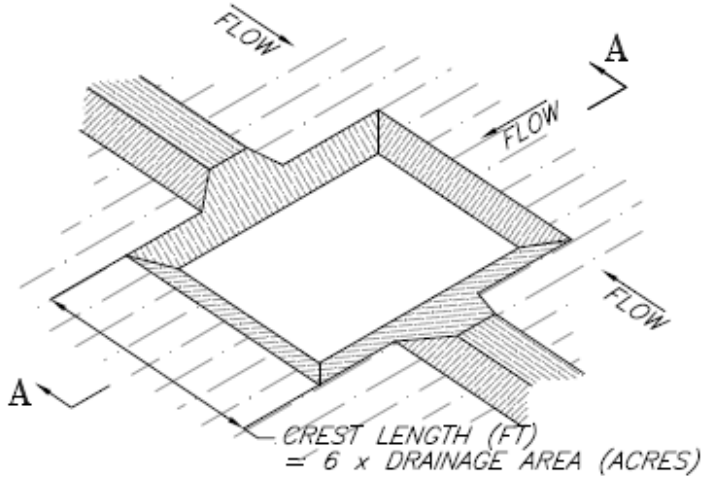
Combination of Earth, Stone, or Pipe Outlets:

- A temporary sediment trap may have a combination of outlets. For instance, an 18-foot earth spillway outlet (adequate for 3 acres) and a pipe outlet with an 18-inch CMP barrel with a 24-inch CMP riser (adequate for 2 acres) could be used for the maximum drainage area of 5 acres.

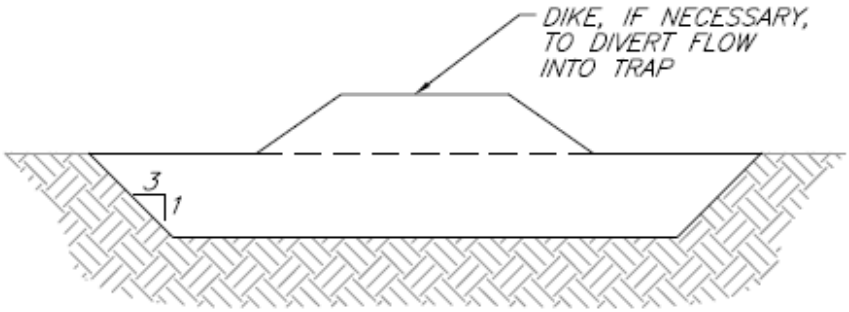
Vegetation:

- All embankments, earth spillways, and disturbed areas below the structure should be vegetated within 72 hours of completion of the construction of the structure.
- If the structure is not planned for more than one vegetative growing season, the structure may be vegetated using the recommendation for "**Temporary Vegetation**" described in this Appendix.
- Basins that will be carried over the winter and into the next vegetative growing season should be vegetated using the recommendations for "**Permanent Vegetation**" described in this Appendix.

Excavated Earth Outlet Sediment Trap



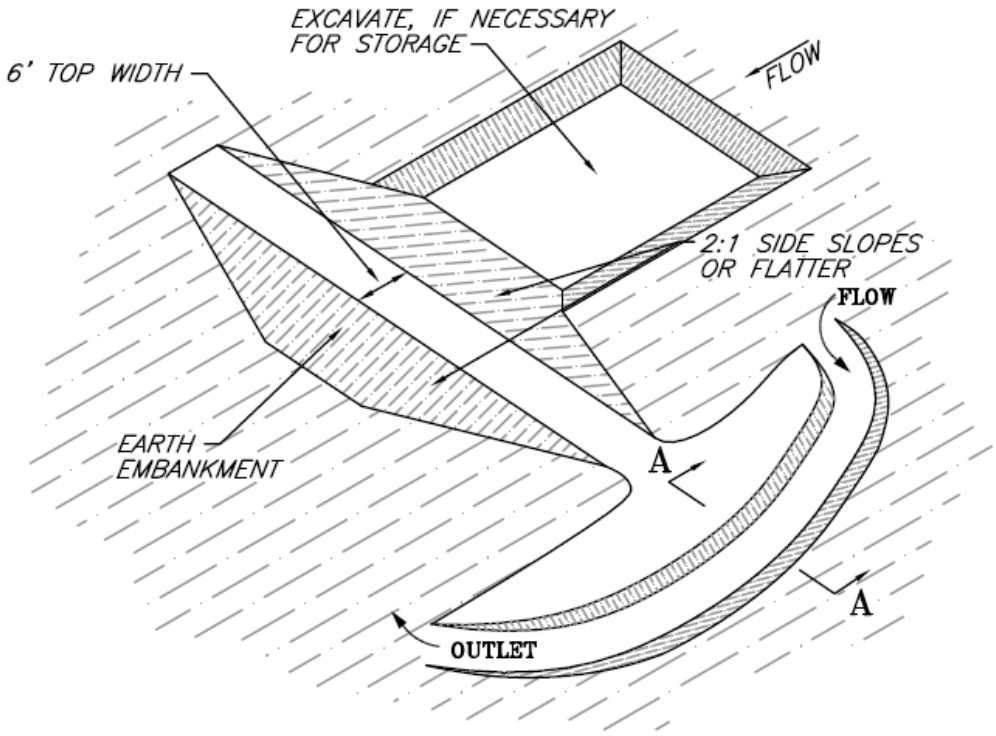
ISOMETRIC VIEW



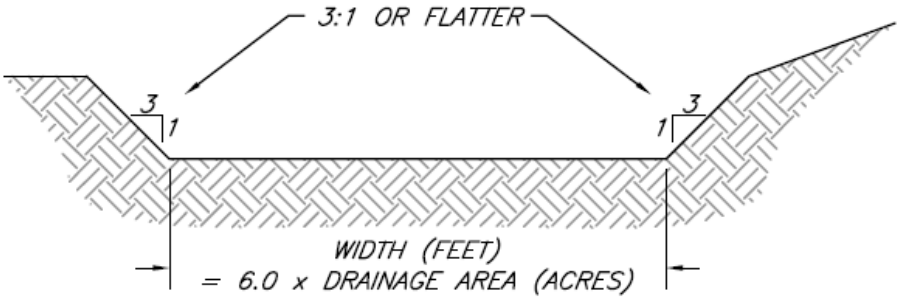
SECTION A–A

Adapted from Minnick & Marshall (1992)

Embankment Earth Outlet Sediment Trap



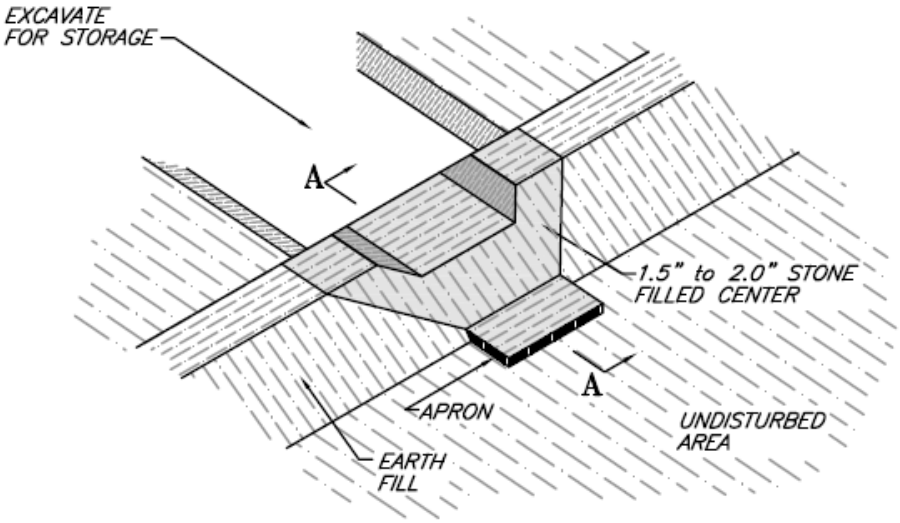
ISOMETRIC VIEW



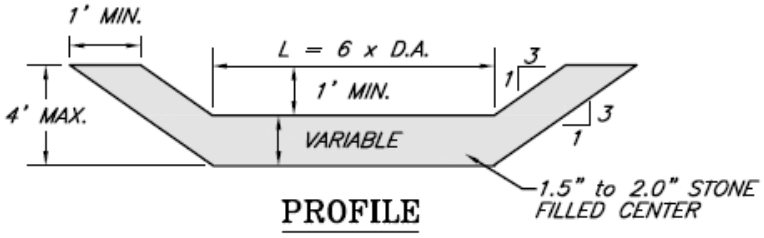
SECTION A–A

Adapted from Minnick & Marshall (1992)

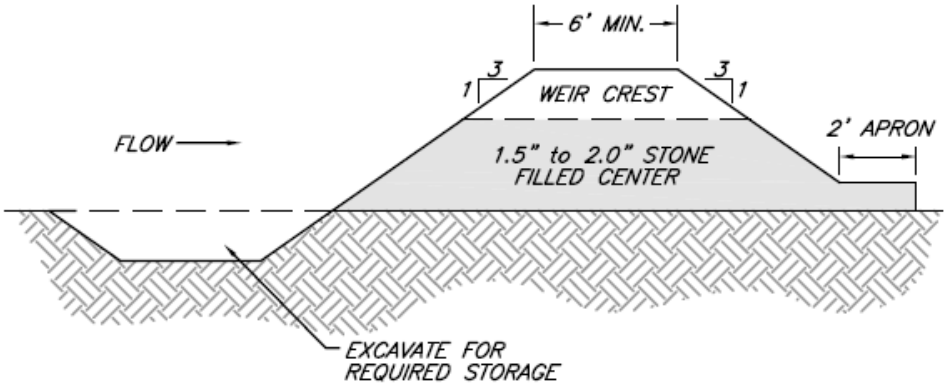
Stone Outlet Sediment Trap



ISOMETRIC VIEW



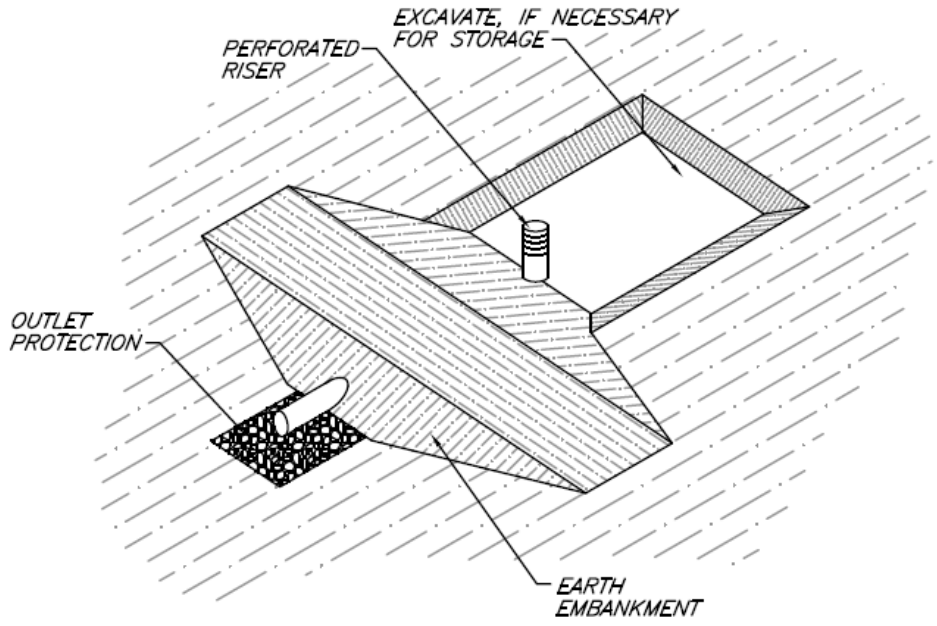
PROFILE



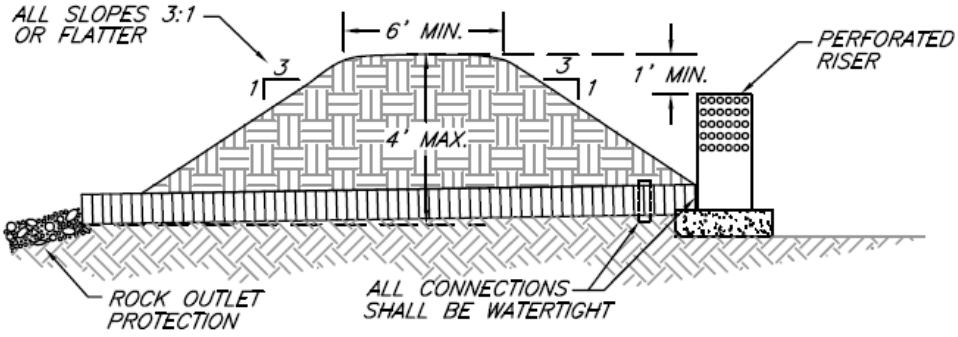
SECTION A–A

Adapted from Minnick & Marshall (1992)

Pipe Outlet Sediment Trap



ISOMETRIC VIEW



EMBANKMENT SECTION THROUGH BARREL & RISER

Adapted from Minnick & Marshall (1992)

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Sediment Traps*. March 2003.

Minnick, E.L. and H.T. Marshall. Rockingham County Conservation District. *Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire.* August 1992.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Temporary Sediment Trap*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Temporary Storm Drain Inlet Protection

General Description

Storm drain inlet protection is a sediment barrier installed around a drop inlet or curb inlet to reduce sediment discharge. There are several types of inlet protection including, but not limited to, the following:

- Gravel and wire mesh inlet barriers.
- Concrete block and gravel inlet barriers.
- Catch basin inserts (e.g., filter sacks).

Sediment removal is accomplished by shallow ponding adjacent to the barrier and resulting settling of the sediment particles. Temporary storm drain inlet protection using stone and wire will not prevent fine sediment from entering a storm drain. This control will only trap the coarser particles. If turbid water is being directed to the storm drain inlet protection as described and that water does not continue to a sediment trap or basin, alternative solutions for treating the water should be evaluated upslope of the catch basin.

The purpose of storm drain inlet protection is to prevent sediment from entering a storm drainage system prior to permanent stabilization of the contributing disturbed area. Storm drains made operational before their drainage areas are stabilized can convey large amounts of sediment to storm sewer systems or natural drainage ways. In some cases, the storm drain itself may accumulate sufficient sediment to significantly reduce or eliminate its conveyance capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

Considerations

- This measure applies primarily to closed drainage systems.
- This measure includes several types of inlet barriers, the use of which may depend on site conditions and the type of inlet. Other techniques for accomplishing the same purpose may be used, but they should be installed only after careful study of their effectiveness.
- This measure is effective in reducing coarse grained suspended particles from stormwater runoff. Silt and clay particles will not be treated by the inlet protection and can sometimes block the inlet (filter sack).
- Stormwater runoff from large, disturbed areas should be routed through a sediment trap or sediment basin.
- The best way to prevent sediment from entering the storm sewer system is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Sediment should be removed from inlet barriers, and the barrier restored to its original dimensions when the sediment has accumulated to 1/2 the design depth of the barrier. Removed sediment should be deposited in a suitable area and in such a manner that it will not erode.
- Inlet barriers should be removed, and the area stabilized when the contributing drainage area has been properly stabilized.

- All catch basins and storm drain inlets must be cleaned at the end of construction and after the site has been fully stabilized.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

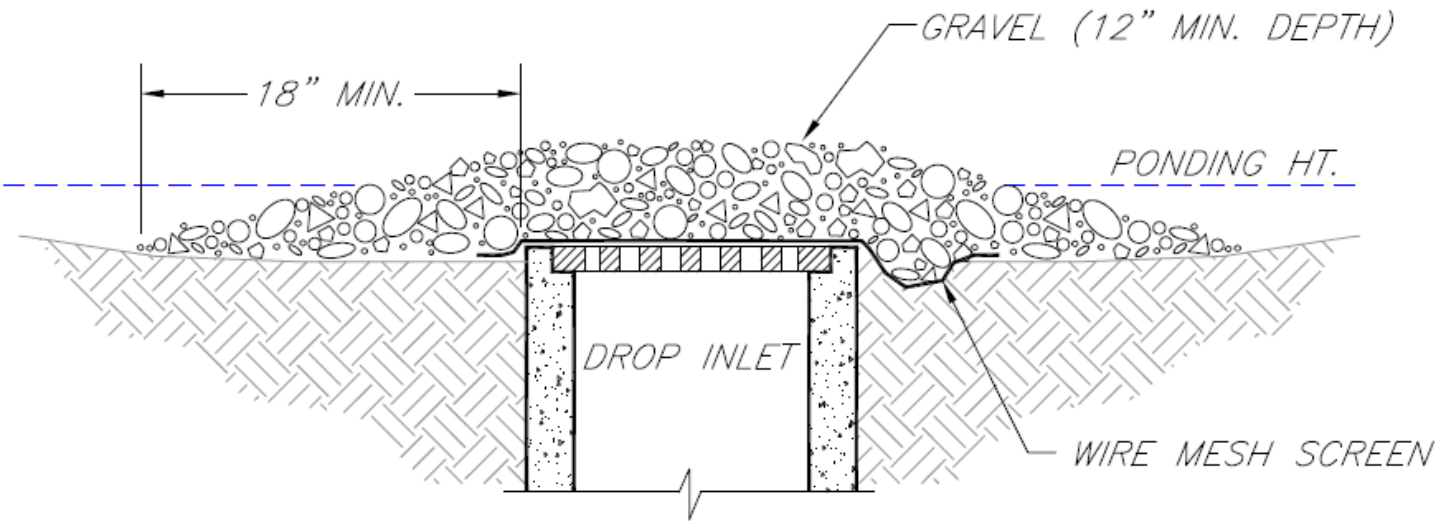
- The maximum contributing drainage area to the trap should be less than one acre.
- The inlet protection device should be constructed in a manner that will facilitate clean-out and disposal of trapped sediments and minimize interference with construction activities.
- Any resultant ponding of stormwater must not cause excessive inconvenience or damage to adjacent areas or structures.
- **Gravel and wire mesh inlet barriers** should meet the following additional requirements:
    - This type of barrier has no overflow provision; therefore, ponding at the inlet may be significantly greater in depth than with other barriers, especially if sediment is not removed regularly. This type of barrier should not be used where overflow may endanger an exposed fill slope or cause excessive flooding. Consideration should also be given to the possible effects of ponding on traffic movement, nearby structures, working areas, and adjacent property.
    - The wire mesh should be placed over the drop inlet so that the entire opening and a minimum of 12 inches around the opening are covered by the mesh.
    - The wire mesh should be hardware cloth or wire with openings up to 1/2-inch.
    - The gravel filter should be clean coarse aggregate.
    - The gravel should extend at least 18 inches beyond on all sides of the drain opening.
    - The gravel should be at least 12 inches in depth.
    - If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stones must be pulled away from the inlet, cleaned and replaced.
- **Concrete block and gravel inlet barriers** should meet the following additional requirements:
    - The blocks should be placed lengthwise in a single row around the perimeter of the inlet.
    - The block ends should abut one another.
    - The height of the barrier can vary, depending on design needs, by stacking combinations of 4-inch, 8-inch and 12-inch-wide blocks. The barrier of blocks and gravel filter should be a minimum of 12 inches high and no more than 24 inches high.
    - A hardware cloth or wire mesh should be placed over the openings of the concrete blocks and extend at least 12 inches around the opening to prevent aggregate from being transported through the openings in the blocks. Hardware cloth or comparable wire mesh with 1/2-inch openings should be used.
    - The gravel filter should be clean coarse aggregate.
    - The gravel should be placed against the wire and along the outside edges of the blocks to the top of the block barrier.
    - If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and replaced.
- **Manufactured catch basin sediment barriers (e.g., filter sacks)** are now available that could be functionally equivalent to the barriers listed above in certain situations. These measures are acceptable as long as they are installed, used, and maintained as specified by the vendor or manufacturer, and prevent sediment from entering

the storm drain system. If such products fail to perform the required sediment trapping function, they should be removed and replaced with an effective alternative barrier. Filter sacks should not be used protect a catch basin that is surrounded by disturbed soil. Filter sacks are most effective when installed on pavements to capture sediment track out from construction vehicles.

Example Design Schematics

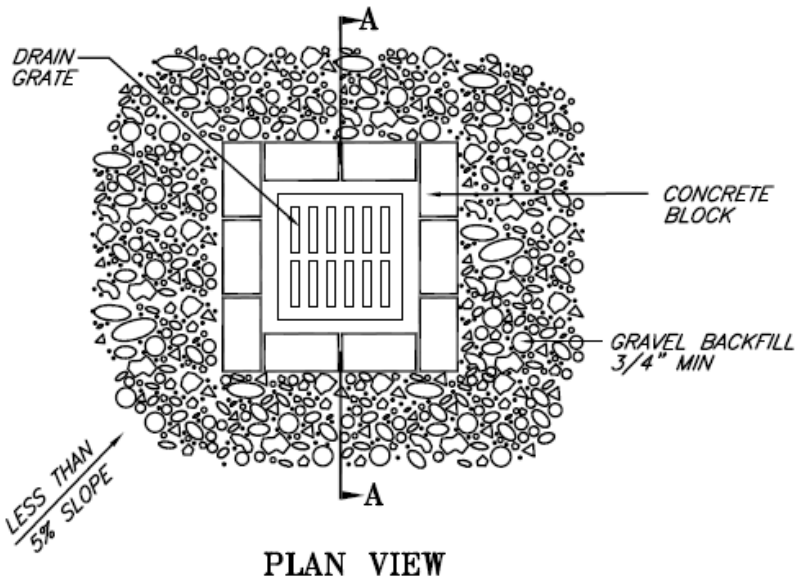
Gravel and Wire Mesh Drop Inlet Sediment Barrier

Profile

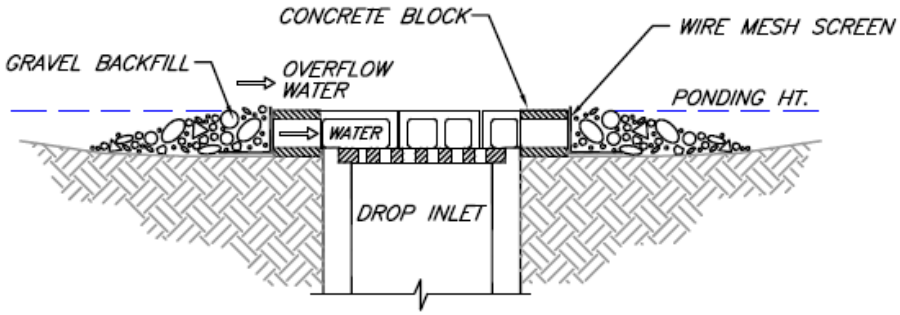


Adapted from Minnick & Marshall (1992)

Concrete Block and Gravel Drop Inlet Sediment Barrier



PLAN VIEW



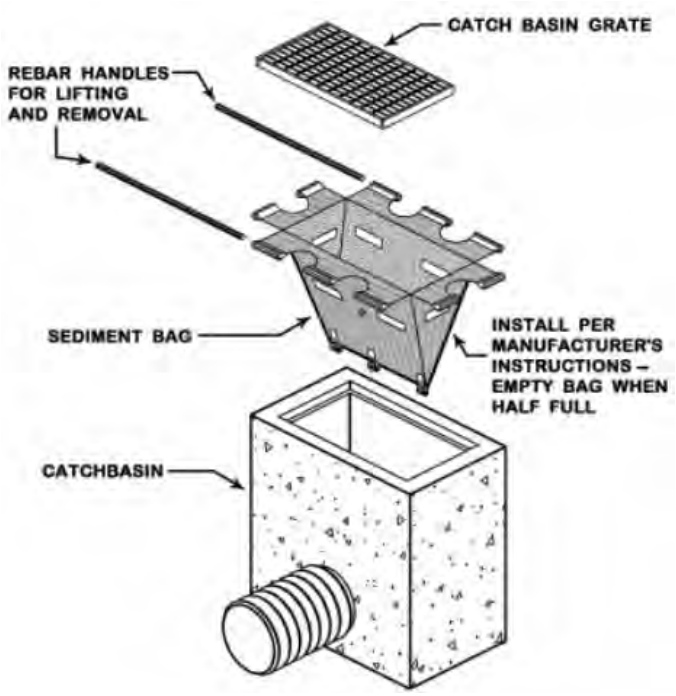
SECTION A – A

NOTES:

1. DROP INLET SEDIMENT BARRIERS ARE TO BE USED FOR SMALL, NEARLY LEVEL DRAINAGE AREAS. (LESS THAN 5%)
2. EXCAVATE A BASIN OF SUFFICIENT SIZE ADJACENT TO THE DROP INLET.
3. THE TOP OF THE STRUCTURE (PONDING HEIGHT) MUST BE WELL BELOW THE GROUND ELEVATION DOWNSLOPE TO PREVENT RUNOFF FROM BYPASSING THE INLET. A TEMPORARY DIKE MAY BE NECESSARY ON THE DOWNSLOPE SIDE OF THE STRUCTURE.

Adapted from McCullah (1994)

Catch Basin Insert (Filter Sack)



ME DEP (2016)

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Storm Drain Inlet Protection (2003), Storm Drain Inlet Protection (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

Minnick, E.L. and H.T. Marshall. Rockingham County Conservation District. *Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire.* August 1992.

J. McCullah, Salix, Applied Earthcare. Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook- Inlet Protection*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook- Storm Drain Inlet Protection*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.

Turbidity Curtain

General Description

Turbidity curtains are used along the banks in streams or lakes where sediment could pollute or degrade the waterbody. Turbidity curtains are primarily used for dredging or work within a waterbody. These barriers consist of silt fence attached to a floating boom. The boom remains floating on top of the water, while the filtration mechanism is anchored to the bed, suspended vertically, retaining the suspended sediments in the work area. With proper design and consideration, turbidity curtains can effectively reduce or eliminate sediment transport from a disturbed area adjacent to or within a body of water.

Considerations

- For use when working adjacent to or within a waterbody or when dewatering discharge has the potential to enter directly into a waterbody.
- Turbidity curtains are not for use in shallow or flowing streams where the velocity of the water may be too substantial for installation or functionality (i.e., velocity must not be so great as to allow particle migration beyond the barrier before settling can occur).
- Turbidity curtains can, and sometimes should, be used in conjunction with other Erosion and Sediment Control (E&SC) measures depending on the proposed work.
- Turbidity curtains are commonly installed immediately down-gradient of a construction site's discharge point (i.e., outfall) as a last line of defense.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Installation and maintenance of turbidity curtains should be limited to periods of low flow.
- Turbidity curtains should be designed to be removed during periods of high flow and periods of non-instream construction.
- Accumulated sediment must be removed periodically.
- Monitor turbidity in waterbody downstream of curtain. Any damage must be repaired immediately.
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

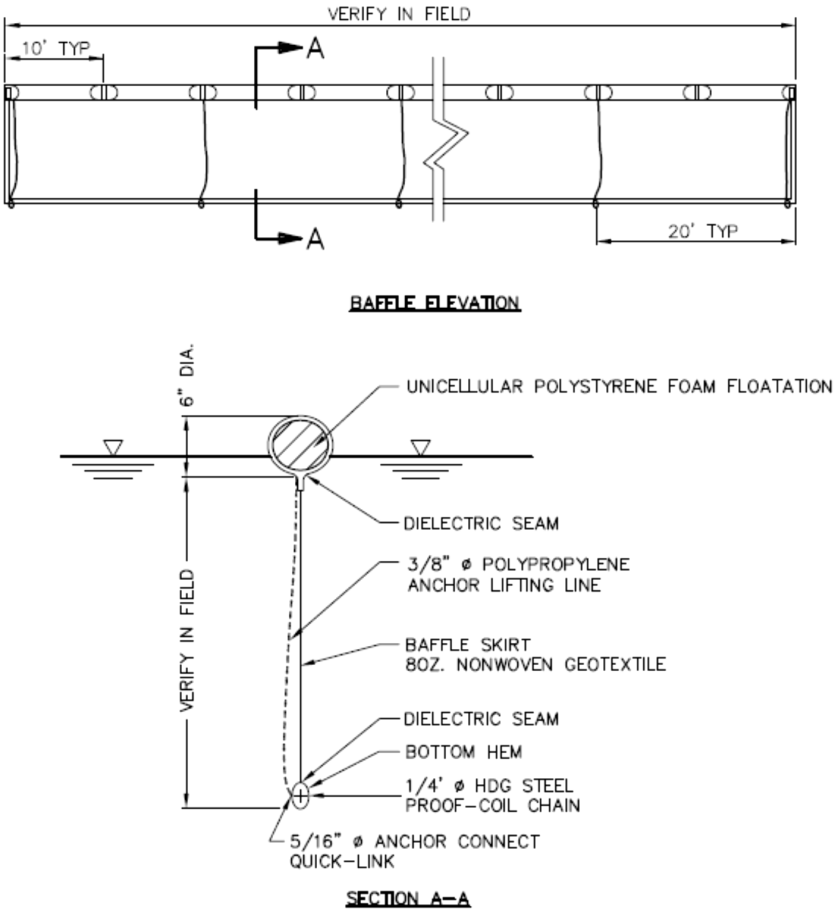
- Turbidity curtains should be installed:
  - In quiet water.
  - As close as possible to the construction area and within the limit of work.
  - To avoid bypass or turbid water around or under the curtain, anchored to the stream bed and securely fastened to the bank.
  - Parallel or perpendicular to the direction of flow.

- To contain sedimentation in the retention area long enough to allow it to settle out of suspension.

- Curtains should be of a highly visible color for the purpose of water travel safety.
- Variables that influence the distance to the barrier from shore or bank include water velocity, barrier depth, and particle size of sediment.

Example Design Schematic

Turbidity Curtain



NH DNCR (2019)

References

New Hampshire Department of Natural and Cultural Resources (NH DNCR). *Best Management Practices Manual Utility Maintenance in and Adjacent to Wetlands and Waterbodies in New Hampshire*. 2019. Available at: https://www.nheconomy.com/getmedia/1b6415ea-f02b-4337-b061-ca30ed1c83d4/dncr-utility-bmps-2019.pdf.

New Hampshire Department of Transportation (NHDOT). *Best Management Practices for Routine Roadway Maintenance Activities in New Hampshire*. 2019. Available at: https://mm.nh.gov/files/uploads/dot/remote-docs/bmp-road-maint-activities-3-14-19.pdf.

MassDEP. *Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas*. 2003. Available at: https://www.mass.gov/doc/complete-erosion-and-sedimentation-control-guidelines-a-guide-for-planners-designers-and/download.

Winter Weather Stabilization

General Description

A project involving construction activity extending beyond one construction season will require measures to stabilize the site for the over-winter period. If a construction site is not stabilized with pavement, a road gravel base, 85 percent mature vegetation cover, or riprap by October 15, then the site must be protected with over-winter stabilization. The winter construction period is from October 15 through May 1.

Considerations

Winter excavation and earthwork activities need to be limited in extent and duration, to minimize potential erosion and sedimentation impacts.

The following considerations are important for winter weather stabilization:

- No more than one acre of the site should be exposed (without stabilization) at any one time. Generally, the exposed area should be limited to only those areas in which work will occur during the following 15 days and that can be mulched in one day prior to any snow or rainfall event.
- Subsequent work areas should not be exposed until the previously exposed work area has been fully stabilized.
- An area is considered “exposed” until stabilized with pavement, vegetation, mulching, erosion control mix, erosion control mats, or riprap (or gravel base on a road or parking area).
- All erosion and sediment control measures installed for the project should have routine maintenance and cleaning completed prior to winter work by October 15. These should be inspected and repaired as needed in preparation for the winter season. Temporary embankments should be fully vegetated or otherwise stabilized by accepted methods.

Maintenance Requirements

- All E&SC measures should be inspected at least once per week and within 24 hours of any storm event exceeding 1/4-inch in a 24-hour period, or as stipulated by the applicable permits. Repairs should be made as necessary.
- Inspection and maintenance measures should continue as needed throughout construction, including the over-winter period, after each snowstorm or period of thawing and stormwater runoff.
- For any area stabilized by temporary or permanent seeding prior to the onset of the winter season, the contractor should conduct an inspection in the spring to ascertain the condition of vegetation cover, and repair any damage areas or bare spots and reseed as required to achieve an established vegetative cover (at least 85 percent of area vegetated with healthy, vigorous growth).
- See **Chapter 6** for general information on inspection and maintenance of Erosion and Sediment Control (E&SC) measures (e.g., inspection frequency, corrective actions, documentation requirements, etc.).

Specifications

To adequately protect water quality during cold weather and during spring stormwater runoff, the following stabilization techniques should be employed during the period from October 15 through May 1:

- Before winter:
  - Stabilization as follows should be completed within a day of establishing the grade that is final or that otherwise will exist for more than 5 days:
    - All proposed vegetated areas having a slope of less than 15 percent which do not exhibit a minimum of 85 percent vegetative growth by October 15, or which are disturbed after October 15, should be seeded and covered with 3 to 4 tons of hay or straw mulch per acre secured with anchored netting, or 2 inches of erosion control mix (see "**Erosion Control Mix Berm**" fact sheet for material specifications).
    - All proposed vegetated areas having a slope of greater than 15 percent which do not exhibit a minimum of 85 percent vegetative growth by October 15, or which are disturbed after October 15, should be seeded and covered with a properly installed and anchored erosion control blanket or with a minimum 4-inch thickness of erosion control mix, unless otherwise specified by the manufacturer. Note that erosion control blankets, with compost, should not exceed 2 inches in thickness or they may overheat.
  - All stone-covered slopes must be constructed and stabilized by October 15.
  - Stockpiles of soil materials should be mulched for over winter protection with hay or straw at twice the normal rate or with a 4-inch layer of erosion control mix. Mulching should be done within 24 hours of stocking, and re-established prior to any rainfall or snowfall. No soil stockpile should be placed (even covered with mulch) within 100 feet from any wetland or other water resource area.
  - Installation of erosion control blankets should not occur over snow of greater than 1-inch in depth or on frozen ground.
  - All grass-lined ditches, swales, and channels should be constructed and stabilized by September 1. All ditches, swales, or channels which do not exhibit a minimum of 85 percent vegetative growth by October 15, or which are disturbed after October 15, should be stabilized temporarily with stone or erosion control blankets appropriate for the design flow conditions, as determined by a qualified Professional Engineer or a Certified Professional in Erosion and Sediment Control as certified by the CSPESC Council of EnviroCert International, Inc. If a stone lining is necessary, the contractor may need to re-grade the ditch, swale, or channel as required to provide adequate cross-section after allowing for placement of the stone.
  - All stone-lined ditches, swales, and channels must be constructed and stabilized by October 15.
- During winter:
  - The area of exposed, unstabilized soil should be limited to one acre and should be protected against erosion by the methods described in this section prior to any thaw or spring melt event. Subject to applicable regulations, the allowable area of exposed soil may be increased if activities are conducted according to a winter construction plan, developed by a Professional Engineer licensed to practice in the state of New Hampshire or a Certified Professional in Erosion and Sediment Control as certified by the CSPESC Council of EnviroCert International, Inc.
  - Installation of anchored hay mulch or erosion control mix should not occur over snow of greater than 1-inch in depth or on frozen ground.
  - All mulch applied during winter should be anchored (e.g., by netting, tracking, wood cellulose fiber).
  - Frozen materials, (e.g., frost layer that is removed during winter construction), should be stockpiled separately and in a location that is away from any area needing to be protected. Stockpiles of frozen material can melt in the spring and become unworkable and difficult to transport due to the high moisture content in the soil.
  - After October 15, incomplete road or parking areas where active construction of the road or parking area has stopped for the winter season should be protected with a minimum 3-inch layer of base course gravels

meeting the graduation requirements of NHDOT Standard Specification for Road and Bridge Construction Table 304-1, Item No. 304.1, 304.2, or 304.3.

- Sediment barriers that are installed during frozen conditions should consist of erosion control mix berms, or continuous contained berms. Silt fences and hay bales should not be installed when frozen conditions prevent proper embedment of these barriers.

References

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs- Overwinter Construction and Stabilization (2003), Overwinter Construction (2016)*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

References

California Stormwater Quality Association (CASQA). *Stormwater Best Management Practice Handbook*. Original print 2003, revised 2009. Available at: https://planning.lacity.org/eir/conventioncntr/DEIR/files/references/Stormwater%20BMP%20Handbook%20-%20Construction%20-%20CASQA.pdf.

Connecticut Department of Environmental, Protection Rothchild, J.A. (Eds.). *Connecticut Guidelines for Soil Erosion and Sediment Control.* 2002. Available at: https://portal.ct.gov/DEEP/Water/Soil-Erosion-and-Sediment-Control-Guidelines/Guidelines-for-Soil-Erosion-and-Sediment-Control.

Georgia Soil & Water Conservation Commission (GSWCC). *Field Manual for Erosion & Sediment Control in Georgia.* 2016. Available at: https://gaswcc.georgia.gov/sites/gaswcc.georgia.gov/files/imported/SWCC/Files/2016%20Field%20Manual%20for%20Erosion%20%26%20Sediment%20Control.pdf.

Idaho Department of Environmental Quality (IDEQ). *Storm Water Best Management Practices Catalog*. Original print 2005, revised 2015. Available at: https://www2.deq.idaho.gov/admin/LEIA/api/document/download/14968.

Iowa State University, Center for Transportation Research and Education. *Iowa Statewide Urban Design Standards Manual*. Original reference 2007, revised 2023. Available at: https://iowasudas.org/manuals/design-manual/.

J. McCullah, Salix, Applied Earthcare. (2004). Erosion Draw 5.0: Erosion Control Standards and Construction Drawings. Redding, CA: Salix, Applied Earthcare.

Maine Department of Environmental Protection (ME DEP), Bureau of Land and Water Quality, Hubert, M (Eds.). *Maine Erosion and Sediment Control BMPs*. Original print March 2003, revised October 2016. Available at: https://www.maine.gov/dep/land/erosion/escbmps/esc_bmp_engineers.pdf.

MassDEP. *Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas*. 2003. Available at: https://www.mass.gov/doc/complete-erosion-and-sedimentation-control-guidelines-a-guide-for-planners-designers-and/download.

Minnick, E.L. and H.T. Marshall. Rockingham County Conservation District. *Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire.* August 1992.

New Hampshire Department of Natural and Cultural Resources (NH DNCR). *Best Management Practices Manual Utility Maintenance in and Adjacent to Wetlands and Waterbodies in New Hampshire*. 2019. Available at: https://www.nheconomy.com/getmedia/1b6415ea-f02b-4337-b061-ca30ed1c83d4/dncr-utility-bmps-2019.pdf.

New Hampshire Department of Transportation (NHDOT). *Best Management Practices for Routine Roadway Maintenance Activities in New Hampshire*. 2019. Available at: https://mm.nh.gov/files/uploads/dot/remote-docs/bmp-road-maint-activities-3-14-19.pdf.

Pennsylvania Department of Environmental Protection (PA DEP). *Erosion and Sediment Pollution Control Program Manual*. Technical Guidance 363-2134-008. March 2012. Available at: http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4680.

Rhode Island Department of Environmental Management (RI DEM), U.S. Department of Agriculture Soil Conservation Service and Rhode Island State Conservation Committee. *Rhode Island Soil Erosion and Sediment Control Handbook*. Providence, RI. Issued 1989, revised 2016. Available at: https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/bnatres/water/pdf/riesc-handbook16.pdf.

South Carolina Department of Health and Environmental Control (SC DHEC). *Stormwater BMP Handbook, Sediment Control BMPs*. March 2014. Available at: https://scdhec.gov/sites/default/files/docs/Environment/docs/sedim-Basin.pdf.

U.S. EPA. *EPA Construction General Permit*. 2022. Available at: https://www.epa.gov/npdes/2022-construction-general-permit-cgp#2022cgp.

U.S. Fish & Wildlife Service (USFWS). *Make the Change to Wildlife-Friendly Erosion Control Products!* Webpage. Accessed February 2023. https://www.fws.gov/initiative/protecting-wildlife/make-change-wildlife-friendly-erosion-control-products.

Virginia Department of Conservation and Recreation (VA DCR), Division of Soil and Water Conservation. *Virginia Erosion and Sediment Control Handbook*. 1992. Available at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/handbooks.