Chapter 1
The Three Components of Stormwater Management

The most effective stormwater management plans include a comprehensive program of activities and controls, including prudent site design, aggressive pollution prevention, source control measures, and well-designed structural BMPs keyed to meeting a particular stormwater management standard, along with regular operation and maintenance of the BMPs. The best stormwater management plans are those that simulate natural hydrologic conditions, by gradually recharging groundwater and slowing runoff that flows to collection systems and receiving waters. To meet the Stormwater Management Standards, a project proponent needs to consider the following three stormwater management components in this order of priority:

- **Site Planning: Design the development using environmentally sensitive site design and low impact development techniques to preserve natural vegetation, minimize impervious surfaces, slow down times of concentration, and reduce runoff;**
- **Source Controls, Pollution Prevention, and Construction Period Erosion and Sediment Control:** Implement nonstructural measures to prevent pollution or control it at its source; and
- **Structural BMPs: Design, construct and maintain structural BMPs to attenuate peak flows, capture and treat runoff, and provide recharge to groundwater.**

Applicants select the best combination of control measures to meet the Stormwater Management Standards. The most cost-effective approach relies on the site planning and the nonstructural approaches discussed in this chapter. Maintaining pre-development hydrologic conditions through proper site planning and nonstructural approaches that preserve natural vegetation and prevent erosion and sedimentation is a highly effective pollution prevention strategy. By reducing or eliminating the need for structural BMPs, this approach results in a well-designed development with a stormwater management system that suits the land and minimizes costs.

A. Site Planning

Integrating comprehensive stormwater management into the site development process from the outset is the most effective approach for reducing and preventing potential pollution and flooding problems. Early stormwater management planning will generally minimize the size and cost of structural solutions. Stormwater management efforts which incorporate structural BMPs into the site design at the final stages frequently result in the construction of unnecessarily large and costly facilities, which may fail due to improper design, siting, engineering, operation or maintenance.

Who Does Site Planning for Stormwater?

Site planning is the responsibility of the project proponent. Certain components of site planning may require technical expertise (e.g., hydrology, engineering, landscaping), and in such cases, professional consultants and/or design engineers should do comprehensive site planning. Before and during the permit review process, collaborative efforts among various parties, including developers, consultants, technical staff, planning boards, and conservation commissions, frequently lead to final design plans that meet mutual goals.

Who Reviews Site Plans for Stormwater Management?
In most cases, site plan review, including review of the stormwater management system, is conducted at the local level by planning boards under the authority of the Subdivision Control Act or local regulations. Local zoning bylaws, for example, may establish special requirements for additional review through zoning districts or special permits that may require more stringent protection than the Stormwater Management Standards. If the project involves activity within a wetland resource area or associated Buffer Zone, the site design is subject to review by the conservation commission. If the Order of Conditions issued by the conservation commission is appealed, MassDEP reviews the project. The *Massachusetts Nonpoint Pollution Source Management Manual* (http://www.mass.gov/dep/water/resources/nonpoint.htm#megaman) published by MassDEP (2006) provides additional information on site plan review and stormwater planning.

Careful site designs minimize the size and related material, construction, and maintenance costs of structural stormwater controls. Site planning should include the preparation of accurate and complete site plan maps and narratives. Stormwater controls must be developed for both construction activities and post-construction conditions. If the project is subject to review under the Wetlands Protection Act, the construction and post-construction controls should be addressed separately in the plans and narrative descriptions provided with the Notice of Intent under the Wetlands Protection Act.

What is Environmentally Sensitive Site Design?
Conventional development strategies treat stormwater as a secondary component of site design, usually managed with "pipe-and-basin" systems that collect rainwater and discharge it off-site. In contrast, environmentally sensitive site design embraces hydrology as an integrating framework for site design, not a secondary consideration. Existing conditions influence the location of roadways, buildings, and parking areas, as well as the nature of the stormwater management system. Environmentally sensitive site design is a multi-step process that involves identifying important natural features, placing buildings and roadways in areas less sensitive to disturbance, and designing stormwater management systems that create relationships between development and natural hydrology. The attention to natural hydrology, stormwater "micromanagement," nonstructural approaches, and vegetation results in a more attractive, multifunctional landscape with development and maintenance costs comparable to or less than conventional strategies that rely on pipe-and-basin approaches.

Landscaping is an important component of environmentally sensitive site design. Ecological landscaping strategies seek to minimize the amount of lawn area and enhance the property with native, drought-resistant species; as a result, property owners use less water, pesticides, and fertilizers.[1] The maintenance of vegetated buffers along waterways can also enhance the site and help protect water quality.

What Types of Development Can Accommodate Environmentally Sensitive Site Design?
Environmentally sensitive site design can be applied to both residential and nonresidential developments as well as redevelopment projects. Environmentally sensitive site design begins with assessing the environmental and hydrologic conditions of a site and identifying important natural features such as streams and drainage ways, floodplains, wetlands, water supply protection areas, high-permeability soils, steep slopes, erosion-prone soils, woodland

[1] See More Than Just a Yard Ecological Landscape Tools for Massachusetts Homeowners. See http://www.mass.gov/envir/mwrc/pdf/More_Than_Just_Yard.pdf.

conservation areas, farmland, and meadows. This investigation helps to determine which "conservation areas" should be protected from development and construction impacts, and which site features (such as natural swales) should be incorporated into the stormwater management system.

The site analysis also identifies a "development envelope" where development can occur with minimal impact to hydrology and other ecologic, scenic, or historic features. In general, the development envelope includes upland areas, ridge lines and gently sloping hillsides, and slowly permeable soils outside of wetlands, leaving the remainder of the site in a natural undisturbed condition. It is important to protect mature trees and to limit clearing and grading to the minimum amount needed for buildings, access, and fire protection. Converting wooded areas to lawns increases the volume of runoff that must be managed.[2] The design should confine construction activity, including stockpiles and storage areas, to those areas that will be permanently altered, and clearly delineate the construction fingerprint.

What are the Most Common Environmentally Sensitive Site Design Techniques?
Specific environmentally sensitive site design techniques that minimize the creation of new runoff, enhance groundwater recharge, and remove suspended solids include minimizing impervious surfaces, fitting the development to the terrain, preserving and capitalizing on natural drainage systems, and reproducing pre-development hydrologic conditions. Each technique is discussed in detail below.

<u>Minimize Impervious Surfaces</u>
Replacing natural cover and soils with impervious surfaces leads to increased runoff volume and velocity, larger pollutant loads, and may adversely affect long-term hydrology and natural systems through flooding and channel erosion. Research demonstrates a marked drop in fish, amphibian, and insect species when the percent imperviousness within a watershed exceeds 15%.

Careful site planning can reduce the impervious area created by pavement and roofs and the volume of runoff and pollutant loading requiring control. Moreover, as the impervious surface area of a development increases, the size and expense of the stormwater control facilities also increase. Minimizing impervious surfaces mitigates this problem. Local zoning codes and development standards, such as those addressing road widths or cluster zoning, affect the amount of runoff generated by projects. Development practices that fail to minimize impervious surfaces rely on extensive conveyance networks to discharge stormwater runoff into receiving waters and adversely impact water quality.

[Note: To ensure a reliable source of safe drinking water, it is essential that impervious areas be minimized in certain recharge areas. To further that goal, the Massachusetts Drinking Water Regulations (310 CMR 22.00) require that municipalities proposing new groundwater sources for the public water system enact land use controls that prohibit land uses within the Zone II that render impervious more than 15% square feet of a lot, or 2,500 square feet, whichever is greater, unless a system for artificial recharge of precipitation is provided that will not result in the degradation of groundwater quality. The Drinking Water Regulations impose a similar requirement on municipalities proposing new surface water sources.]

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[2] Converting wooded areas to lawns increases the peak volume of runoff that must be attenuated in accordance with Standard 2. Standard 4 requires proponents that convert wooded areas to lawns to include proper management of fertilizers, herbicides, and pesticides in their pollution prevention plan. The EPA lists urban forestry as a stormwater management BMP. See http://cfpub1.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5

Common approaches that proponents can take to minimize impervious surfaces include:

- *Maintain as much of the pre-development vegetation as possible*, especially larger trees that may be on site. Vegetation absorbs water and reduces the amount of stormwater runoff. Proponents should locate structures to minimize shading effects on vegetation and roots and protect them from damage during the construction phase.
- *Maintain natural buffers and drainage ways.* Natural buffers located between development sites and wetlands infiltrate runoff, reduce runoff velocity, and remove some suspended solids. Natural depressions and channels act to slow and store water, promote sheet flow and infiltration, and filter pollutants.
- *Minimize the creation of steep slopes.* Steep slopes have significant potential for erosion and increase sediment loading. Avoid using slopes greater than 2:1.
- *Minimize placement of new structures or roads over porous or erodible soils:* Porous soils provide the best and most inexpensive mechanism for infiltrating stormwater, reducing runoff volume and peak discharges, and providing groundwater recharge and treatment by infiltration and adsorption through the soil strata. Proponents should avoid disturbing unstable soils that are likely to erode.
- *Reduce frontage and other setbacks.*
- *Modify Zoning to Allow Planned Unit Developments* that limit the density of development while maximizing the amount of undisturbed open space and *Cluster Developments* that cluster or group buildings closer together to maximize the amount of undisturbed open space.
- *Reduce the horizontal footprint of buildings and parking areas.* Footprint size can be reduced by constructing a taller building, including parking facilities within the building itself, while maintaining the same floor to area (FAR) ratio.
- *Reduce to one lane,* or eliminate if practical, on-street parking lanes on local access roads.
- *Limit sidewalks to one side*, or eliminate if practical, on local low-traffic roads.
- *Use shallow grass channels or water quality swales with check dams to manage runoff and snowmelt from roads and parking lots.* Guidelines for the use of grass channels and water quality swales are found in Chapter 2 of this Volume.
- *Use porous pavement* when possible for sidewalks, driveways, transition areas between pavement edge and swales, or overflow parking areas.

<u>Fit the Development to the Terrain</u>
Match road patterns to land forms. For example, in rolling terrain, local streets should branch from collector streets, ending in short loops or cul-de-sacs along ridgelines. Grids may be more appropriate in areas where the topography is characteristically flat. Preserve natural drainage ways by interrupting and bending the road grid around them. Grass channels or water quality swales can be constructed along street right-of-ways or on the back of lots to convey runoff without abrupt changes in the direction of flow.

<u>Preserve and Use Natural Drainage Systems</u>
The standard approach of using curbing on streets and parking areas impairs natural drainage systems. Curbs are widely held to be the signature of quality development; they provide a neat, "improved" appearance and also help delineate roadway edges. Because curb-and-gutter streets trap runoff in the roadbed, storm inlets and drains are logical solutions to providing good drainage for the roadbed.

Unfortunately, a requirement for curb-and-gutter streets can create significant stormwater management problems. Because storm drains operate on gravity flow, their efficiency is maximized if they are located in the lowest areas of the site. Storm drain pipes are usually located in valleys and low areas, destroying natural drainage ways. Natural filtration and infiltration capacities are lost in the most strategic locations.

Further, in most instances, storm drains are designed for short-duration, high-frequency storms (1-hour duration with 2, 5, or 10-year return periods) and not for flood flows (24-hour duration, 50 and 100-year return period), which are handled by street and gutter flows after the storm drain capacity is exceeded. The result is that the natural drainage ways are converted from slow moving, permeable, absorptive, vegetated waterways to fast moving, impervious, self-cleaning, paved waterways, thereby increasing hydraulic efficiency, peak discharges and flood volumes.

Natural waterways that are paved and specifically designed to be quickly drained by culverted stormwater management systems minimize channel storage times as well as reduce base flows and groundwater recharge. When examined in the context of environmentally sensitive site design, the net effect of the seemingly beneficial decision to use curbs can initiate a snowball effect that amplifies the extremes in the hydrologic cycle, increasing flood flows and reducing base flows.

Curb-and-gutter developments also affect water quality. Trace metals from automobile emissions and hydrocarbons from automobile crankcase oil and fuel spillage are directly deposited on paved surfaces. For the most frequent rainfalls, the first flush of stormwater runoff washes these deposits into the storm drain system, which is designed to keep in suspension the particles to which the pollutants adhere. The particles, together with their attached pollutants, are delivered via the runoff water to receiving waters where reductions in velocity permit them to settle out. Nutrient-rich runoff from surrounding lawns quickly moves through the paved system with no opportunity to come into contact with plant roots and soil surfaces. The result is rapid delivery of contaminants to lakes, streams, estuaries, and wetlands.

If natural vegetated drainage ways are preserved, flood volumes, peak discharges, and base flows can be maintained at pre-development levels. Trace metals, hydrocarbons, and other pollutants will bind to the underlying soils and organic matter. The infiltration process allows separation of the nutrients and other contaminants from the stormwater as it percolates through the subsurface soils.

Reproduce Pre-development Hydrologic Conditions

The goal of matching pre-development hydrologic conditions should be addressed at the site planning level. The full spectrum of hydrologic conditions, including peak discharge, runoff volume, infiltration capacity, base flow levels, groundwater recharge, and maintenance of water quality, can be examined through a comprehensive approach involving the entire site and even offsite areas contributing runoff to the site. Peak discharges, runoff volume, infiltration recharge, and water quality are directly related to the amount and location of impervious area required by development plans.

Past efforts focused on the reduction of the frequency and severity of flooding, primarily by lowering peak discharges to match pre-development levels with adequate storage (e.g., detention systems). Some waterways were deliberately designed to increase runoff removal with higher flow rates and smooth conveyances (e.g., storm drains, paved gutters, and waterways) so as to be self-cleaning, while ignoring infiltration and water quality issues. MassDEP does not recommend implementing these "solutions".

Standard 3 of the Stormwater Management Standards requires that proponents preserve infiltration at predevelopment levels in order to maintain base flow and groundwater recharge. Along with adequate pretreatment, infiltration of stormwater through the soil will generally remove pollutants and sediments and improve water quality.

Are there Limitations to Environmentally Sensitive Site Design?
Some environmentally sensitive site designs that seek to cluster development and reduce lot coverage may conflict with local land use regulations or public perceptions about what type of development is desirable.[3] For example, a compact multi-story building may be more visible than a single-story building with a larger footprint. To address this problem, developers, advocates and regulators who recognize the value of environmentally sensitive site design must educate the public.

Integrating Site Design, Pollution Prevention, and Structural BMPs
The time to integrate source controls and pollution prevention measures into the stormwater management system is during site design. During the planning process, a proponent should consider source control and pollution prevention measures, such as placing a roof over a fueling area or landscaping to minimize the need for fertilizers. These measures can reduce the requirements for stormwater control, prevent the discharge of pollutants to receiving waters, and result in substantial cost-savings.

During the site planning process, proponents should also consider the locations of structural BMPs and the need to provide ongoing access to those BMPs for maintenance. Some BMPs, such as infiltration basins, have specific site and construction requirements. The proponent should identify site constraints, such as depth to groundwater and nearby septic systems or wells, so the BMP will not fail or adversely affect on-site septic systems or wells.

Site planning can help identify the most appropriate points to direct discharges from BMPs. To avoid erosion and prevent system failure, proponents should locate discharge points on low slopes and stable soils away from the edges of wetlands. Where suitable, developers should use infiltration trenches for surface runoff and dry wells for uncontaminated runoff from non-metal roofs. The stormwater management system should be designed to separate the collection and treatment of contaminated and uncontaminated runoff.

The costs of rehabilitating or retrofitting failed stormwater management systems can be significant. These costs can be avoided by addressing stormwater runoff from the start. With careful planning, a proponent can design a stormwater management system that meets the Stormwater Management Standards, reduces the cost of stormwater management, facilitates long-term maintenance, and enhances the marketability and aesthetic qualities of the development.

Additional Resources and Links for Environmentally Sensitive Site Design:
Low Impact Development Design Strategies: An Integrated Design Approach; Prince George's County, Maryland, Department of Environmental Resources; June 1999. (available at http://www.epa.gov/owow/nps/lid/)

[3] The Metropolitan Area Planning Council has developed a checklist that allows local communities to determine whether their local bylaws and ordinances prevent the use of environmentally sensitive design. See http://www.mapc.org/regional_planning/LID/LID_codes.html

Better Site Design: A Handbook for Changing Development Rules in Your Community; Center for Watershed Protection; 1998. Site Planning for Urban Stream Protection; Thomas Schueler; Center for Watershed Protection; 1995.

Conservation Design for Subdivisions: A Practical Guide for Creating Open Space Networks; Randall Arendt; Island Press; 1996.

"Site Analysis." James A. LaGro, Jr.; John Wiley and Sons; 2001 *An Introduction to Better Site Design*; Article 45 from Watershed Protection Techniques; Center for Watershed Protection; 2000.

B. Nonstructural Approaches: Source Control and Pollution Prevention

Source controls can reduce the types and concentrations of contaminants in stormwater runoff and improve water quality. Source controls cover a wide range of practices including local bylaws and regulations, materials management at industrial sites, fertilizer and pest management in residential areas, reduced road salting in winter, erosion and sediment controls at construction sites, and comprehensive snow management.

Effective site planning is essential to source control and pollution prevention. Reducing impervious surfaces and runoff volumes prevents the transport of pollutants. The guiding principle for pollution prevention is to minimize the volume of runoff and the contact of stormwater with potential pollutants. Because nonstructural practices can reduce stormwater pollutant loads and quantities, the size and expense of structural BMPs (or in rare cases, even the need for structural BMPs) can be reduced, thereby affording substantial cost savings.

The *Massachusetts Nonpoint Pollution Source Management Manual* (http://www.mass.gov/dep/water/resources/nonpoint.htm#megaman) published by MassDEP (2006) provides a detailed summary of the pollutants associated with specific land use activities. These summaries can be used to identify the potential pollutants at a site, so that suitable controls can be implemented.

Street and Parking Lot Sweeping

One effective nonstructural source control is street and parking lot sweeping. Many municipalities and some private entities (e.g., commercial shopping areas or office parks) have street sweeping programs. Although intended to provide important nonpoint source pollution control, many street sweeping programs are not effective at capturing the peak sediment loads.

The NURP study (EPA, 1983) indicates that sweeping streets once a year using rotary brush sweepers resulted in no TSS removal. A study conducted by the USGS (Smith, 2002) along the Southeast Expressway in Boston indicates that sweeping yielded a net increase in sediment, because the road shoulder was not stabilized and contributed more sediment to the Southeast Expressway than the sweepers could remove.

There are many reasons that some street sweeping programs are not effective.

- The period immediately following winter snowmelt, when road sand and other accumulated sediment and debris is washed off, is frequently missed by street sweeping programs.
- Larger particles of street dirt may prevent smaller particles from being collected.
- The entire width of roadway may not be swept.
- Sweepers may be driven too quickly to achieve maximum efficiency.
- Land surfaces along the paved surfaces may not be entirely stabilized.

Other studies have shown that if done properly, street sweeping can be highly effective. Breault 2005 indicates that sweepers can achieve high removal efficiencies. That study assessed total solids removal, and included large particles. Zarriello 2002 verified the effectiveness of high efficiency sweepers.

There are three factors in particular that can have a major influence on the effectiveness of a street sweeping program: **access, the type of sweeper, and the frequency of sweeping**.

Effective sweeping requires access to the areas to be swept. Parked cars impede street sweeping. Studies have shown that up to 95% of the solids on a paved surface accumulate within 40 inches of the curb, regardless of land use. It is essential that applicants or those responsible for stormwater maintenance have the ability to impose parking regulations to facilitate proper sweeping, particularly in densely populated or heavily traveled areas, so that sweepers can get as close to curbs as possible.

A good street sweeping program requires an efficient sweeper. There are three types of sweepers: Mechanical, Regenerative Air, and Vacuum Filter. Each has a different ability to remove TSS.

- Mechanical: Mechanical sweepers use brooms or rotary brushes to scour the pavement. Although most of the sweepers currently in use in Massachusetts are mechanical sweepers, they are not effective at removing TSS (from 0% to 20% removal). Mechanical sweepers are especially ineffective at picking up fine particles ("fines") (less than 100 microns).
- Regenerative Air: These sweepers blow air onto the road or parking lot surface, causing fines to rise where they are vacuumed. Regenerative air sweepers may blow fines off the vacuumed portion of the roadway or parking lot, where they contaminate stormwater when it rains.
- Vacuum filter: These sweepers remove fines along roads. Two general types of vacuum filter sweepers are available - wet and dry. The dry type uses a broom in combination with the vacuum. The wet type uses water for dust suppression. Research indicates vacuum sweepers are highly effective in removing TSS. The best ones (in terms of pollutant removal efficiencies) typically cost about $240,000 to $310,000.

Regardless of the type chosen, the efficiency of street sweeping is increased when sweepers are operated in tandem.

The frequency of sweeping is a major factor in determining efficiency. Unlike other stormwater treatment practices that function whenever it rains, street sweeping only picks up street dirt when streets and parking lots are actually swept. TSS removal efficiency is determined based on annual loading rates. If a road were swept only once a year with a sweeper that is 100% efficient, it would remove only a small fraction of the annual TSS load.

Street dirt accumulates on roads and parking lots and runs off in response to precipitation. The average interval between precipitation events in Massachusetts is approximately 3 days. Therefore, the hypothetical maximum effectiveness for street dirt removal requires sweeping at least once every 3 days, with a street sweeper with 100% efficiency at removing solids on paved surfaces before they become suspended. Modeling studies by Claytor (1999) in the Pacific Northwest suggest that optimum pollutant removal occurs when surfaces are swept every two weeks.

Because street sweeping may be an effective source reduction tool, a credit towards the 80% TSS removal standard *may* be available. ***At the discretion of the issuing authority****, a street sweeping program is eligible to receive credit towards the 80% TSS removal standard as set forth in the Table SS 1.*

TSS REMOVAL CREDITS FOR STREET SWEEPING

Table SS 1

TSS Removal Rate	High Efficiency Vacuum Sweeper – Frequency of Sweeping	Regenerative Air Sweeper – Frequency of Sweeping	Mechanical Sweeper (Rotary Broom)
10%	Monthly Average, with sweeping scheduled primarily in spring and fall.	Every 2 Weeks Average, with sweeping scheduled primarily in spring and fall.	Weekly Average, with sweeping scheduled primarily in spring and fall.
5%	Quarterly Average, with sweeping scheduled primarily in spring and fall.	Quarterly Average, with sweeping scheduled primarily in spring and fall.	Monthly Average, with sweeping scheduled primarily in spring and fall.
0%	Less than above	Less than above	Less than above

Street sweeping is not recommended as a practice to receive a TSS removal credit for post-construction period runoff, if the road or parking lot shoulders are not stabilized.

All TSS Removal Credits shown in Table SS 1 assume that the sweeping program gives special attention to sweeping paved surfaces in March/April before spring rains wash residual sand from winter applications into streams. If this assumption is not correct, the issuing authority should reduce the TSS removal credit by 50%.

Planning Considerations

In deciding whether street sweeping is an effective option, consider factors such as whether road and parking lot shoulders are stabilized, the speed at which the sweepers will need to be driven (safety factor such as along a highway), whether access is available to the curb (whether vehicles parked along the curb line will preclude sweeping of the curb line), the type of sweepers, and whether the sweepers will be operated in tandem. Municipalities or private developers that are planning to purchase a new street sweeper should consider vacuum sweepers, because they are most consistently effective.

Maintenance

Reuse and Disposal of Street Sweepings

Once removed from paved surfaces, the sweeping must be handled and disposed of properly. MassDEP's Bureau of Waste Prevention has issued a written policy regarding the reuse and disposal of street sweepings. These sweepings are regulated as a solid waste, and can be used in three ways:

- In one of the ways already approved by MassDEP (e.g., daily cover in a landfill, additive to compost, fill in a public way)
- If approved under a Beneficial Use Determination
- Disposed in a landfill

MassDEP provides guidance and standards for handling, reusing, and disposing of street sweepings. (For more information, go to: www.mass.gov/dep/recycle/laws/stsweep.htm)

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Additional research underway in Wisconsin by the USGS, anticipated to be published in 2008, should provide additional information regarding removal efficiencies.

Pollution Prevention Plans

One of the most important undertakings for identifying potential pollutant sources and associated control requirements at a site is to prepare the source control and pollution prevention plan required by Standard 4. It is important for businesses, industries and municipalities to take a fresh look at their current management practices to reduce pollution at its source and ensure that they are meeting their environmental legal obligations. Businesses and towns can save money by preventing pollution, rather than cleaning up after the fact.

Industrial dischargers that are covered by the NPDES Multi-Sector General Permit are required to prepare a Stormwater Pollution Prevention Plan (SWPPP). A SWPPP prepared in accordance with the requirements of the Multi-Sector General Permit can be used to fulfill the source control and pollution prevention plan requirements of Standards 4, 5, and 6.

Likewise, many state agencies and municipalities are covered by the NPDES General Permit for Municipal Separate Storm Sewer Systems (MS4 Permit) that requires the implementation of good housekeeping and pollution prevention. State and local agencies subject to the MS4 Permit may be able to develop one plan that fulfills the source control and pollution prevention requirements of the Stormwater Management Standards and the MS4 Permit.

The source control and pollution prevention plan required by Standard 4 is intended to:

- **Identify potential sources of pollution that may affect the quality of stormwater discharges, and**
- **Describe and ensure the implementation of practices to reduce the pollutants in stormwater discharges.**

A source control and pollution prevention plan must describe all potential sources of pollutants and identify methods to eliminate and reduce those sources, including minimizing the use of hazardous materials or oil including pesticides, herbicides, fertilizers, and deicing chemicals; diverting stormwater from potential pollutant sources; keeping all hazardous materials or oil inside or under cover; implementing good housekeeping, preventive maintenance, snow and snowmelt management; and spill prevention and response procedures.

Certain land uses with higher potential pollutant loads located within the Zone II of a public water supply area require additional pollution prevention measures. These land uses include:

- landfills and open dumps,
- landfills handling wastewater residuals and/or septage,
- automobile graveyards and junkyards,
- stockpiling and disposal of snow or ice removed from highways,
- petroleum fuel oil and heating oil bulk stations and terminals,
- wastewater treatment plants permitted pursuant to 314 CMR 5.00,
- hazardous waste facilities subject to regulation under 310 CMR 30.00,
- waste oil retention facilities,
- treatment works for the remediation of contaminated ground or surface waters,
- floor drainage systems,
- storage of any of the following materials: sludge, septage, sodium chloride, chemically treated abrasives or other chemicals used for the removal of ice or snow, chemical fertilizers, animal manures, liquid hazardous materials or petroleum products.

For all such land uses that commence or are expanded on or after January 2, 2008, the source control and pollution prevention plan must include measures to prevent the land use from coming into contact with rain, snow, snowmelt and runoff.

Construction Period Erosion and Sedimentation Control

Construction period erosion and sedimentation control is an essential component of pollution prevention and environmentally sensitive site design. Construction period activities increase the potential for erosion and sedimentation at a site. Erosion is the wearing away of the land surface by running water, wind, ice, or other causes. Soil erosion is usually caused by the force of water falling as raindrops and by the force of water flowing in rills and streams. Raindrops falling on bare or sparsely vegetated soil detach soil particles. Water running along the surface of the ground picks up these particles and carries them along as it flows downhill towards a stream system.

Sedimentation is the deposition of soil particles that have been transported by water and wind. The quantity and size of the material transported increases with the velocity. Sedimentation occurs when the medium, air or water, in which the soil particles are carried, is slowed long enough to allow particles to settle out. Heavier particles, such as gravel and sand, settle out sooner than finer particles, such as clay.

There are four principal factors that influence the potential for erosion: soil type, surface cover, topography, and climate. These factors are interrelated in their effect on erosion potential. Variability in terrain, soils, and vegetation makes erosion control unique to each development. Erosion and resulting sedimentation generally occur in Massachusetts only when the soil is disturbed. The seriousness of the problem is a function of the topography and size of the disturbed area, the characteristics of the soils, the climate, and the vegetative cover.

As a rule of thumb:

- The more fine-grained material there is in a soil, the greater the amount of material that will be picked up by water flowing across its surface;
- The steeper the slope, the faster the water will move, thus being able to carry more soil; and,
- The larger the unprotected surface, the larger the potential for problems.

Topographic features distinctly influence erosion potential. Watershed size and shape, for example, affect runoff rates and volumes. Slope length and steepness are key elements in determining the volume and velocity of runoff and erosion risks. As both slope length and gradient increase, the rate of runoff increases and the potential for erosion is magnified. Swales and channels concentrate surface flow, which results in higher velocities. Exposed south-facing soils are hotter and drier, which makes vegetation more difficult to establish.

Where storms are frequent, intense, or of long duration, erosion risks increase. The high erosion risk period of the year results from seasonal changes in temperature, as well as variations in rainfall. When precipitation falls as snow, no erosion will take place immediately. In the spring, however, the hazards will be high. Most plants are still dormant. The existing vegetative cover is less able to buffer the raindrops. The ground is still partially frozen, or else saturated from melting snow, and its absorptive capacity is reduced. That is why it is necessary to stabilize exposed areas in the fall, before the period of high erosion risk in the spring.

Assess the Site

The first step in controlling erosion and sedimentation is to assess the site for possible erosion and sediment problems. Erosion and sedimentation hazards associated with site development include increased water runoff, soil movement, sediment accumulation, and higher peak flows caused by:

- Removal of plant cover and a large increase in soil exposed to erosion by wind and water
- Changes in drainage areas caused by regrading the terrain, diversions or road construction
- A decrease in the area of soil which can absorb water because of construction of streets, building, sidewalks or parking lots
- Changes in volume and duration of water concentrations caused by altering steepness, distance and surface roughness
- Soil compaction by heavy equipment, which can reduce water intake of soils to 1/20 or less of the original rate
- Prolonged exposure of unprotected sites and service areas to poor weather conditions

- Altering the groundwater regime in a way that may adversely affect drainage systems, slope stability, survival of existing vegetation and establishment of new plants
- Exposing subsurface materials that are too rocky, too acidic or otherwise unfavorable for establishing plants
- Obstructing streamflow by new buildings, dikes and landfills
- Inappropriate timing and sequencing of construction and development activities
- Abandonment of sites before construction is completed

Develop an Erosion and Sediment Control Plan

After this assessment is complete, a construction period erosion and sedimentation control plan must be prepared as required by Standard 8. Construction sites that disturb at least one acre of land are required to obtain coverage under the NPDES Construction General Permit and prepare a SWPPP. A SWPPP prepared in accordance with the Construction General Permit satisfies the erosion and sedimentation control plan requirement of Standard 8.[4]

At a minimum, the construction period erosion and sedimentation control plan required by Standard 8 must be prepared in accordance with the *Erosion and Sedimentation Guidelines: A Guide for Planners, Designers, and Municipal Officials* and shall include the following items:

- **Brief narrative**
- **Vicinity map**
- **Site topography map**
- **Site development plan**
- **Erosion and sedimentation control plan drawing**
- **Detail drawings and specifications**
- **Vegetation planning**

The erosion and sedimentation control plan must identify the party(ies) responsible for implementing the erosion and sedimentation control plan or any component(s) thereof. The Conservation Commission's Order of Conditions should require the responsible parties to implement the erosion and sedimentation control plan as approved by the Conservation Commission during land disturbance activities. Land disturbance activities include demolition, construction, clearing, excavation, grading, filling, and reconstruction. The requirement to implement the erosion and sedimentation control plan should end with the final stabilization of the site and the removal of the temporary erosion and sedimentation controls.

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[4] For projects subject to jurisdiction under the Wetlands Protection Act, the construction period pollution prevention and erosion and sedimentation control plan should ordinarily be included in the Stormwater Report submitted with the Notice of Intent. For highly complex projects, where the proponent demonstrates that submission with the Notice of Intent is not possible, the issuing authority has the discretion to issue an Order of Conditions authorizing a project prior to submission of the construction period pollution prevention and erosion and sedimentation control plan. In any event, all Orders of Condition shall provide that no work, including site preparation and land disturbance, may commence unless and until a construction period pollution prevention plan that meets the requirements of Standard 8 as further elaborated by the Massachusetts Stormwater Handbook has been approved by the issuing authority.

Site Planning and Construction Sequencing

Because any modification of a site's drainage features or topography requires protection from erosion and sedimentation, the erosion and sedimentation control plan should include site planning and construction sequencing. Typically the staging of construction activities will depend upon these site factors:

- Existing soil limitations
- Existing slope and construction grading limitations
- Drainage problems
- Exposed soils during construction

The staging of construction activities to reduce sedimentation and the designation of areas to leave undisturbed during construction will reduce the size of construction BMPs, which reduces construction costs.

In developing a construction sequencing plan, the following factors should be considered:

- *Review and consider all existing conditions in the initial site selection for the project.* Select portions of the site that are suitable for the project rather than force the terrain to conform to development needs. Ensure that development features follow natural contours. Steep slopes, areas subject to flooding, and highly erodible soils severely limit a site's use, while level, well-drained areas offer few restrictions. Control seepage and high water table conditions. Any modification of a site's drainage features or topography requires protection from erosion and sedimentation.
- *Limit disturbance. Careful site selection will help on this point.* The site, or corridor, should be able to accommodate the development with a minimum of grading. The development plan should fit its topographic, soil, and vegetative characteristics with a minimum of clearing and grading. Natural cover should be retained and protected wherever possible. Critically erodible soil, steep slopes, stream banks, and drainage ways should be identified. The development can then be planned to disturb these vulnerable areas as little as possible.
- *Stabilize and Protect Disturbed Areas as Soon as Possible.* Two methods are available for stabilizing disturbed areas: mechanical (or structural) methods and vegetative methods. In some cases, both are combined in order to retard erosion.
- *Keep Stormwater Runoff Velocities Low.* The removal of existing vegetative cover during development and the resulting increase in impermeable surface area after development will increase both the volume and velocity of runoff. These increases must be taken into account when providing for erosion control.
- *Protect Disturbed Areas from Stormwater Runoff.* Best management practices can be utilized to prevent water from entering and running over the disturbed area. Diversions and other control practices intercept runoff from higher watershed areas, store or divert it away from vulnerable areas, and direct it toward stabilized outlets.
- *Retain Sediment within the Corridor or Site Area.* Sediment can be retained by two methods: filtering runoff as it flows and detaining sediment-laden runoff for a period of time so that the soil particles settle out. The best way to control sediment, however, is to prevent erosion.

Construction period erosion and sedimentation control and pollution prevention measures

In addition to construction sequencing, the erosion and sedimentation control plan must include source control and pollution prevention measures, construction period BMPs to address erosion and sedimentation, procedures for operating and maintaining the BMPs especially in response to wet weather events, actions to control mosquitoes during construction, and stabilization measures. Information on mosquito control is set forth in Chapter 5. Pollution prevention activities include storing construction materials away from wetland resource areas and catch basin inlets and preserving natural vegetation wherever possible.

The erosion and sedimentation control plan should specify the structural BMPs to be used during construction. The Massachusetts Erosion and Sediment Control Guidelines list 45 different kinds of Construction Period BMPs, from Brush Barriers, Check Dams and Dust Control to Inlet Protection, Outlet Protection and Stabilization to Sediment Fences. The BMPs selected for the project should reflect the needs identified in the project's erosion and sediment control plan. The erosion and sedimentation control plan must include design cross-sections and required freeboard for each construction period BMP. See Erosion and Sedimentation Guidelines, a Guide for Planners, Designers and Municipal Officials, http://www.mass.gov/dep/water/essec2.pdf - 62.[5]

When considering which control measures to use, always evaluate the consequences of a measure failing. Failure of a practice may be hazardous or damaging to both people and property. For example, a large sediment basin failure can have disastrous results; low points in dikes can allow them to overflow and cause major gullies. The BMPs used during construction must be distinct from the BMPs that will be used to handle stormwater after construction is completed and the site is stabilized. Many stormwater technologies (infiltration technologies) are not designed to handle the high concentrations of sediments typically found in construction runoff, and thus must be protected from construction-related sediment loadings. All construction period BMPs must be properly designed, and sediment traps or basins must be sized to provide adequate capacity and retention time to allow for proper settling of fine-grained soils.

Operation, Inspection, and Maintenance of Construction Period Best Management Practices.

The erosion and sedimentation control plan shall include a schedule for implementing the stormwater management activities during land disturbance and construction that establishes a sequence in which these activities will be implemented as the project proceeds. The plan should also state when temporary practices will be removed and how disturbed areas and any areas designated for waste disposal will be stabilized.

The erosion and sedimentation control plan should specify who is responsible for maintenance of construction period BMPs, and when maintenance will be provided. The maintenance schedule should be based on site conditions, design safeguards, construction sequence, and anticipated weather conditions. For each construction period BMP, the erosion and sedimentation control plan must specify the amount of allowable sediment accumulation, and detail what will be done with the sediment removed.

Inspections

The erosion and sedimentation control plan must also include a description of how the site will be inspected and maintained during land disturbance. Essential parts of the inspection program must include:

[5] The EPA has developed fact sheets for the BMPs that may be used to control erosion and sedimentation during construction. See http://cfpub1.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=4

- Inspection during or immediately following initial installation of sediment controls.
- Inspection following severe rainstorms to check for damage to controls.
- Inspection prior to seeding deadlines, particularly in the fall.
- Final inspection of projects nearing completion to ensure that temporary controls have been removed, stabilization is complete, drainage ways are in proper condition, and the final contours agree with the proposed contours on the approved plan.

The erosion and sedimentation control plan should call for interim inspections as manpower and workload permit, giving particular attention to the maintenance of installed controls. The erosion and sedimentation control plan should require that all inspections be documented in a written report or log. These reports should contain the date and time of inspections, dates when land-disturbing activities begin, comments concerning compliance or noncompliance, and notes on any verbal communications concerning the project.

Additional information on preparing and implementing pollution prevention plans is contained in *Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices* (EPA-832-R-92-006) or *Stormwater Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices* (EPA-832-R-92-005), available through Office of Water Resource Center at 202- 566-1729, NTIS at 800-553-6847, or the Educational Resources Information Center/Clearinghouse at 800-538-3742.

Snow and Snowmelt Management

Snow Disposal

A pollution prevention plan must provide for proper management of snow and deicing materials. The application and storage of deicing materials, most commonly salts such as sodium chloride, can lead to water quality problems for surrounding areas. Salts, gravel, sand, and other materials are applied to highways and roads to reduce the amount of ice or to provide added traction during winter storm events. Salts lower the melting point of ice, allowing roadways to stay free of ice buildup during cold winters. Sand and gravel increase traction on the road, making travel safer.

Finding a place to dispose of snow contaminated with deicing materials poses a challenge to municipalities and businesses as they clear roads, parking lots, bridges, and sidewalks. While we are all aware of the threats to public safety caused by snow, collected snow that is contaminated with road salt, sand, litter, and automotive pollutants such as oil also threatens public health and the environment.

As snow melts, road salt, sand, litter, and other pollutants are transported into surface water or through the soil where they may eventually reach the groundwater. Road salt and other pollutants can contaminate water supplies and may be toxic to aquatic life. Sand washed into waterbodies can create sand bars or fill in wetlands and ponds, impacting aquatic life, causing flooding, and affecting our use of these resources. To avoid these impacts, private and public entities must plan how they will manage snow before winter begins.

Deicing Materials

To prevent increased pollutant concentrations in stormwater discharges, the amount of road salt applied should be reduced. Calibration devices for spreaders in trucks aid maintenance workers in the proper application of road salts. Many drinking water supply watersheds in Massachusetts use lower amounts of road salt to protect the resource. Reduced salt areas should be designated next to roads and wetlands. The amount of salt applied should be varied to reflect site-specific characteristics, such as road width and design, traffic concentration, and proximity to surface waters. Alternative materials, such as sand or gravel, calcium chloride, and calcium magnesium acetate may be used in especially sensitive areas. MassHighway is developing a Generic Environmental Impact Report on Snow and Ice Control that evaluates options for reducing the impact of deicing materials on water resources. Information about road deicing materials can also be found at the American Association of State Highway and Transportation Officials web site at: http://www.transportation.org/

Proper Storage of Deicing Materials

Proper snow management involves the proper storage of deicing materials. Covering stored road salts may be costly; however, the benefits are greater than the perceived costs. Storing road salts correctly prevents the salt from lumping together, which makes it easier to load and apply. In addition, covering salt storage piles reduces salt loss from stormwater runoff and potential contamination to streams, aquifers, and estuarine areas. Salt storage piles should be located outside the 100-year floodplain for further protection against surface water contamination.

The Massachusetts General Laws, Chapter 85, Section 7A, forbid outside storage of salt in areas that would threaten groundwater and surface water sources for public water supplies or within 200 feet of an established river or estuary. Outside Zone IIs, Zone As and 200 feet of established rivers or estuaries, road salt and other deicing compounds must be stored on sheltered (protected from precipitation and wind), impervious pads. Internal flow within the shelter must be directed to a collection system and external flow directed around the shelter.

The Drinking Water Regulations require municipalities proposing new water sources to enact land use controls that prohibit the uncovered, uncontained storage of road deicing materials within:

- Wellhead Protection Areas (Zone I and Zone II) for public water supply wells and
- Zone A for both new public supply reservoirs

Road salt storage and loading areas are classified as Land Uses with Higher Potential Pollutant Loads. The pollution prevention plan for land uses involving the storage of deicing compounds should include plans to bring the storage into compliance with all applicable laws and regulations. Standard 5 of the Stormwater Management Standards provides that stormwater runoff from road salt storage areas requires the use of the specific structural BMPs determined to be suitable for runoff from land uses with higher potential pollutant loads, unless all salt storage areas are protected from exposure to rain, snow, snowmelt and runoff. MassDEP has issued Guidelines on Deicing Chemical (Road Salt) Storage (1997). See http://www.mass.gov/dep/water/laws/policies.htm#snowsalt

Snow Disposal Sites

In addition to limiting the use of deicing materials, proper management of snow and snowmelt requires selection of proper sites for snow disposal. MassDEP has developed a guidance document for communities regarding snow disposal, available on the web at: http://www.mass.gov/dep/water/laws/policies.htm#snowsalt. This guidance document recommends the following procedures.

Site Selection

The key to selecting effective snow disposal sites is to locate them adjacent to or on pervious surfaces in upland areas away from water resources and wells. At these locations, the snowmelt water can filter into the soil, leaving behind sand and debris that can be removed in the springtime. As more fully set forth below, the following areas should be avoided:

- Avoid dumping snow into any waterbody, including rivers, the ocean, reservoirs, ponds, or wetlands. In addition to water quality impacts and flooding, snow disposed of in open water can cause navigational hazards when it freezes into ice blocks.
- Do not dump snow within a Zone II or Interim Wellhead Protection Area (IWPA) of a public water supply well or within 75 feet of a private well, where road salt may contaminate water supplies.
- Avoid dumping snow on high and medium yield aquifers where it may contaminate groundwater.
- Avoid dumping snow in sanitary landfills and gravel pits. Snowmelt water will create more contaminated leachate in landfills posing a greater risk to groundwater. In gravel pits, there is little opportunity for pollutants to be filtered out of the melt water, because groundwater is close to the land surface.
- Avoid disposing of snow on top of storm-drain catch-basins or in stormwater drainage channels or ditches. Snow combined with sand and debris may block a storm drainage system, causing localized flooding. A high volume of sand, sediment, and litter released from melting snow may be quickly transported through the system into surface water.

Site Maintenance

In addition to carefully selecting disposal sites before the winter begins, it is important to prepare and maintain these sites to maximize their effectiveness. The following maintenance measures should be undertaken at all snow disposal sites:

- A silt fence or equivalent barrier should be placed securely on the downgradient side of the snow disposal site.
- To filter pollutants out of the melt water, a 50-foot vegetative buffer strip should be maintained during the growth season between the disposal site and adjacent water bodies.
- Debris should be cleared from the site prior to using the site for snow disposal.
- Debris should be cleared from the site and properly disposed at the end of the snow season and no later than May 15.

References

American Association of State Highway and Transportation Officials. 2000. AASHTO: Transportation Center of Excellence. http://www.transportation.org/

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Other Important Pollution Prevention and Source Control Measures

There are many other effective pollution control and source control measures that proponents, citizens and municipalities can undertake to reduce pollutant loads in stormwater, including the following[6]:

- ***Lawn and garden activities***, including application and disposal of lawn and garden care products, and proper disposal of leaves and yard trimmings. Effective measures include: applying pesticides and fertilizers properly, including: timing; application reduction; providing buffer areas (preferably natural vegetation) between surface waters and lawn and garden activities; limiting lawn watering and landscaping with climate-suitable vegetation; providing guidelines for what to expect from landscaping and lawn care professionals; and providing composting guidelines, if not covered elsewhere under solid waste efforts. <http://www.mass.gov/dep/water/resources/nonpoint.htm#megaman> See "More than Just a Yard: Ecological Landscaping Tools for Massachusetts Homeowners." http://www.mass.gov/envir/mwrc/pdf/More_Than_Just_Yard.pdf and Guide to Lawn and Landscape Water Conservation, http:www.mass.gov/envir/mwrc/pdf/LawnGuide.pdf.
- ***Turf management*** on golf courses, parks, and recreation areas. Many of the measures described above are applicable to turf management and need to be implemented by caretakers responsible for golf courses and parks and recreation areas (including municipal employees, in some cases).
- ***Pet waste management.*** Pooper-scooper laws for pets should be enacted and implemented. Public outreach is essential to the effectiveness of these laws. Priority resource areas, such as bathing beaches and shellfish growing areas, may need to exclude pets at least for the summer months or at other critical use times. Specific controls for horses and the control of manure may be needed. <http://www.mass.gov/dep/water/resources/nonpoint.htm#megaman>
- ***Integrated Pest Management*** **(IPM)** effectively prevents and controls pests (including weeds) in a way that maximizes environmental benefits at a reduced cost to growers. IPM involves applying an array of techniques and control strategies for pest management – with a focus on using them in the proper amounts and determining when they are most needed. By choosing from all possible pest control methods (e.g., biological controls and beneficial organisms) and rotating methods, resistance to repeated chemical controls can be delayed or prevented. <http://www.mass.gov/dep/water/resources/nonpoint.htm#megaman>
- ***Proper storage, use, and disposal of household hazardous chemicals***, including automobile fluids, pesticides, paints, and solvents. Information should be provided on chemicals of concern, proper use, and disposal options. Household hazardous waste

[6] Appendix A lists source control and pollution prevention measures for certain land uses .

collection days should be sponsored whenever feasible. Recycling programs for used motor oil, antifreeze, and other products should be developed and promoted.

- ***Storm drain stenciling*** involves labeling storm drain inlets with painted messages warning citizens not to dump pollutants into the drains. The stenciled messages are generally a simple phrase to remind passersby that the storm drains connect to local waterbodies and that dumping pollutes those waters. Some storm drain stencils specify which waterbody the inlet drains to or name the particular river, lake, or bay. Commonly stenciled messages include: "No Dumping. Drains to Water Source," "Drains to River," and "You Dump it, You Drink it. No Waste Here." Pictures can also be used to convey the message, including a shrimp, common game fish, or a graphic depiction of the path from drain to waterbody. Communities with a large Spanish-speaking population might wish to develop stencils in both English and Spanish, or use a graphic alone. <http://www.mass.gov/dep/water/resources/nonpoint.htm#megaman>
- ***Proper operation and maintenance of septic systems.*** Knowledge of proper operation and maintenance of septic systems should be promoted to avoid serious failures.
- *Car Washing*. This management measure involves educating the general public, businesses, municipal fleets (public works, school buses, fire, police, and parks) on the water quality impacts of the outdoor washing of automobiles and how to avoid allowing polluted runoff to enter the storm drain system. Outdoor car washing has the potential to result in high loads of nutrients, metals, and hydrocarbons during dry weather conditions in many watersheds, as the detergent-rich water used to wash the grime off our cars flows down streets and into storm drains. Commercial car wash facilities often recycle their water or are required to treat their wash-water discharge prior to release to the sanitary sewer system. As a result, most stormwater impacts from car washing are from residents, businesses, and charity car wash fundraisers that discharge polluted wash water to the storm drain system. <http://www.mass.gov/dep/water/resources/nonpoint.htm#megaman>
- ***Commercial operations and activities,*** including parking lots, gas stations, and other local businesses. Recycling, spill prevention and response plans, and proper material storage and disposal should be promoted. Using dry floor cleaners and absorbent materials and limiting the use of water to clean driveways and walkways should be encouraged. Care should be taken to avoid accidental disposal of hazardous materials down floor drains. Floor drains should be inventoried.
- ***Department of Public Works Facilities (DPWs).*** Because of the nature of the activities they perform, such as storing and managing sand, salt, and chemicals, and fueling and maintaining trucks and other equipment, DPWs are in a unique position to prevent a wide range of compounds from becoming stormwater pollutants. MassDEP has developed a Fact Sheet specifically for DPWs: <http://www.mass.gov/dep/water/resources/nonpoint.htm#megaman>
- **Other efforts, including water conservation and litter control, can be tied to nonpoint source pollution control.**

Local Bylaws and Regulations

Local bylaws, ordinances, and regulations are among the best mechanisms to institute many of the nonstructural controls described above, because they can cover a wide range of pollution prevention issues that fall below federal thresholds or for which no threshold exists. These bylaws are generally proposed by planning boards or conservation commissions, in consultation with other local officials. Stormwater bylaws and earth removal or sediment and erosion control bylaws are among the most common types of local initiatives. Stormwater bylaws establish requirements for site planning and pollution prevention plans in conjunction with design and construction activities. Earth removal or erosion and sediment control bylaws focus specifically on construction activities and controlling soil erosion problems. Many local boards of health have adopted pet waste control bylaws.

MassDEP's *Nonpoint Pollution Source Management Manual* (2006) provides several general suggestions for developing various types of bylaws for nonpoint pollution control, including controlling erosion and sediment, limiting impervious surfaces (or lot clearing), specifying nutrient loading standards, and enhancing site plan review, wetlands protection, and road salt management.

EEA's SmartGrowth Tool Kit (http://www.mass.gov/envir/smart_growth_toolkit/), the EPA website (http://www.epa.gov/owow/nps/ordinance/mol6.htm) and the Stormwater Managers Resource Center website (http://www.stormwatercenter.net) include model bylaws for LID development. See also http://www.mapc.org/regional_planning/Developing_Local_Bylaw.pdf. Technical assistance with the development of local bylaws is available from the Massachusetts Coastal Zone Management Office, or the NRCS Community Assistance Program. Other groups such as regional planning agencies or nonprofit groups such as Massachusetts Association of Conservation Commissions or the Massachusetts Audubon Society may be able to provide assistance with bylaw development.

C. Structural Best Management Practices

This section of Chapter 1 presents information about the structural Best Management Practices (BMPs) that may be used to manage stormwater runoff in accordance with the Stormwater Management Standards. Proponents should consult this section when selecting and evaluating BMPs for a given development or redevelopment. Conservation commissions and other issuing authorities should become familiar with the information presented here to learn whether a BMP is appropriate for a project site, if a drainage system meets the Stormwater Management Standards, and what actions are required to operate and maintain the BMP.

This section of Chapter 1 groups individual BMP technologies according to the principal methods of stormwater management: pretreatment, treatment, conveyance, and infiltration. *Some BMPs fall into several categories, because they serve several functions*. For example, some bioretention areas are designed to act as a filter (hereinafter "filtering bioretention areas"), and others are designed to infiltrate (hereinafter "exfiltrating bioretention areas"). The next section describes the basic issues to consider when choosing a BMP to meet a particular Stormwater Management Standard, including site suitability, design specifications, construction methods, and maintenance requirements.

Note that the BMPs described in this chapter address *post-construction* stormwater management. There are many other BMPs focused expressly on mitigating stormwater impacts *during* construction. Detailed descriptions of these construction-specific BMPs can be found in MassDEP's *Massachusetts Nonpoint Pollution Source Management Manual,* Chapter 6: "Erosion and Sediment Control." (2006), MassDEP's *Erosion and Sedimentation Control Guidelines: A Guide for Planners, Designers, and Municipal Officials* (May 2003), and MassHighway's *Stormwater Handbook for Highways and Bridges* (May 2004).

Chapter 2 contains detailed information on specific post-construction structural stormwater best management practices. For each BMP, there is a discussion of its purpose, advantages and disadvantages, applicability, expected range of pollutant removal effectiveness, planning considerations, design and construction issues and operation and maintenance requirements.

Volume 3 provides the basic calculations needed to design a BMP for conformance with each Standard, including how to determine:

- **The required water quality volume;**
- **The required recharge volume based on hydrologic soil classification; and**
- **The size of the BMP.**

Because increased awareness and attention to stormwater management have encouraged the research and development of new technologies for stormwater management, Chapter 4 provides additional information on innovative and emerging BMP technologies. Some of these technologies have been evaluated as part of EPA's Technology Acceptance Reciprocity Partnership (TARP) or Massachusetts' Strategic Envirotechnology Partnership (STEP). Chapter 4 provides information on the TARP and STEP programs.

The Classes of BMPs

MassDEP divides the stormwater BMPs into several basic classes as shown in Table 2-1. The table also lists manufactured BMPs such as proprietary separators. Each BMP varies to the extent that it conveys, treats, infiltrates, retains, attenuates, and stores stormwater runoff. *Note that some BMPs fit into more than one class because they serve more than one function.* The classes include:

Structural Pretreatment BMPs: **The first BMPs in a treatment train, these measures typically remove the coarse sediments that can clog other BMPs. The settling process generates sediment that must be routinely removed. Maintenance is especially critical for pretreatment BMPs, because they receive stormwater containing the greatest concentrations of suspended solids during the first flush. Some pretreatment devices such as the Oil Grit Separator are required to pretreat the runoff from certain land uses with higher potential pollutant loads, such as gas stations and high intensity use parking lots[7]. The most common pretreatment BMPs include:**

- **Deep Sump Catch Basins**
- **Oil Grit Separators**
- **Proprietary Separators**
- **Sediment Forebays**
- **Vegetated Filter Strips**

Pretreatment BMPs can be configured as on-line or off-line devices. On-line systems are designed to treat the entire water quality volume. Off-line practices are typically designed to receive a specified discharge rate or volume. A flow diversion structure or flow splitter is used to divert the design flow to the off-line practice. To receive TSS removal credit, oil grit separators and deep sump catch basins must be configured as off- line devices.

Treatment BMPs

[7] For such land uses, it may be possible to use a filtering bioretention area, or a sand filter in lieu of an oil grit separator.

There are three main types of Treatment BMPs:

- **Stormwater Treatment Basins**
- **Constructed Stormwater Wetlands**
- **Filtration BMPs**

They are more specifically described below.

Stormwater Treatment Basins: These BMPs provide peak rate attenuation by detaining stormwater and settling out suspended solids. The basins that are most effective at removing pollutants have either a permanent pool of water or a combination of a permanent pool and extended detention, and some elements of a shallow marsh. Stormwater basins include:

- **Extended Dry Detention Basins**
- **Wet Basins**

Constructed Wetlands: Constructed stormwater wetlands are designed to maximize the removal of pollutants from stormwater runoff through wetland vegetation uptake, retention and settling. Gravel wetlands remove pollutants by filtering stormwater through a gravel substrate.

- **Constructed Stormwater Wetland**
- **Gravel Wetland**

Filtration BMPs: Filtration systems use media to remove particulates from runoff. They are typically used when circumstances limit the use of other types of BMPs, such as where space is limited–particularly in a highly urbanized setting–or when it is necessary to capture particular industrial or commercial pollutants (e.g., hydrocarbons). In these circumstances, other BMPs might be cost-prohibitive or not as effective. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially exfiltrate into the soil. Filtration BMPs include:

- **Filtering Bioretention Areas and Rain Gardens**
- **Proprietary Media Filter**
- **Sand Filters/Organic Filters**
- **Treebox Filter**

Conveyance BMPs: These BMPs collect and transport stormwater to BMPs for treatment and/or infiltration. These practices may also treat runoff through infiltration, filtration, or temporary storage. A water quality swale usually functions as a runoff conveyance channel and a filtration practice. The vegetation or turf also prevents erosion, filters sediment, and provides some nutrient uptake benefits. Conveyance BMPs include:

- **Drainage Channels**
- **Grass Channels**
- **Water Quality Swales**
  - **Dry**
  - **Wet**

Infiltration BMPs: Infiltration systems are designed primarily to reduce the quantity of stormwater runoff from a particular site. Infiltration techniques reduce the amount of surface flow and direct the water back into the ground. Infiltration practices typically cannot provide channel protection and overbank or extreme flood detention storage. Infiltration BMPs include:

- **Exfiltrating Bioretention Areas and Rain Gardens**
- **Dry Wells**
- **Infiltration Basins**
- **Infiltration Trenches**
- **Leaching Catch Basins**
- **Subsurface Structures**

Other BMPs: Some BMPs do not fit into any of the categories set forth above. These BMPs include the following:

- **Dry Detention Basins**
- **Green Roofs**
- **Porous Pavement**
- **Rain Barrels and Cisterns**

Accessories: BMP accessories are devices that enable BMPs to operate as designed. BMP accessories include the following:

- **Check Dams**
- **Level Spreaders**
- **Outlet Structures**
- **Catch Basin Inserts**

Table 2.1		
BMPs for Controlling Stormwater Quantity		
	Pretreatment BMP	**BMP that requires pretreatment**
Pretreatment		
Deep Sump Catch Basin	**Yes**	**No**
Oil Grit Separators	**Yes**	**No**
Proprietary Separators	**Yes**	**No**
Sediment Forebays	**Yes**	**No**
Vegetated Filter Strips	**Yes**	**No**
Treatment		
Bioretention areas/rain gardens	**No**	**Yes**
Constructed stormwater wetlands	**No**	**Yes**
Extended Dry Detention Basins	**No**	**Yes**
Gravel Wetlands	**No**	**Yes**
Proprietary Media Filters	**No**	**Yes**
Sand/Organic Filters	**No**	**Yes**
Tree Box filters	**No**	**Yes**
Wet basins	**No**	**Yes**
Conveyance		
Grass Channels	**No**	**Yes**
Water Quality Swales – Dry	**No**	**Yes**
Water Quality Swales – wet	**No**	**Yes**
Infiltration BMPs		
Dry Wells	**No**	**No pretreatment required for runoff from non-metal roofs and metal roofs outside Zone II, IWPA and industrial site.**
Infiltration Basins	**No**	**Yes**
Infiltration Trenches	**No**	**Yes**
Leaching Catch Basins	**No**	**Yes**
Subsurface Structures	**No**	**Yes**
Other BMPs		
Dry Detention Basins	**No**	**No**
Green Roofs	**No**	**No**
Porous Pavements	**No**	**No**
Rain Barrels & Cisterns	**No**	**No**

The BMP Selection Process

Once site planning, pollution prevention, and source control measures have been implemented, applicants should integrate structural BMPs into the overall stormwater control system. For the most part, structural BMPs are engineered systems that are typically made of natural materials such as grass and plants, or manufactured materials like steel, fiberglass, and concrete. They act as the last line of defense in protecting the Commonwealth's waters from stormwater pollution. As such, these man-made structures can be highly effective in removing pollutants from stormwater if properly designed and maintained.

The following sections provide guidance for choosing the appropriate structural BMPs for a site by explaining the basic considerations for their use. Each BMP has certain limitations. When designing a stormwater management system for any site, the project proponent, working together with planners and design engineers, should ask the following questions:

- **How can the stormwater management system be designed to meet the standards for stormwater quantity and quality most effectively?**
- **What are the opportunities to meet the stormwater quality standards and the stormwater recharge and peak discharge standards simultaneously?**
- **What opportunities exist to use comprehensive site planning to minimize the need for structural controls?**
- **Are there Critical Areas on or adjacent to the project site?**
- **Does the project involve stormwater discharges from land uses with higher potential pollutant loads?**
- **What are the physical site constraints?**
- **Given the site conditions, which BMP types are most suitable?**
- **What type of development is being proposed and what pollutants does this land use typically generate?**
- **Is there an opportunity to receive the LID Site Design credits by incorporating environmentally sensitive design or low impact development techniques?**
- **Is the future maintenance reasonable and acceptable for this type of BMP?**
- **Has adequate access been provided for maintenance?**
- **Is the BMP option cost-effective?**
- **Does the stormwater discharge near or to an impaired surface water?**
- **Has a TMDL been developed?**
- **Are BMPs available to remove the pollutant of concern?**

The project proponent should consider whether a system of several BMPs is more appropriate for a site than a single BMP structure. Too often, stormwater controls are added to a site plan in its final stages. When planning for stormwater management is done as an afterthought, proponents are not likely to select the most environmentally appropriate and cost-effective practices for controlling runoff.

By engaging in early planning, the proponent can focus on the entire site and identify the best available locations for reducing, infiltrating and treating runoff. Early stormwater management planning can also allow the proponent to combine best management practices into treatment trains. With a treatment train, one or more of the measures can fail without undermining the integrity of the overall site control strategy.

Including stormwater management in the early stages of the planning process gives proponents the opportunity to consider whether a decentralized system comprised of BMPs scattered throughout the site may provide greater environmental benefits at less cost than a centralized system that transports all runoff to a single location for treatment and disposal. Through early planning, a proponent may discover that a decentralized system that uses dry wells for roof runoff, relies on water quality swales rather than curbs and gutters to convey street runoff to additional BMPs, and installs infiltration trenches in front of an extended dry detention basin, is the most cost-effective and environmentally protective approach to achieving compliance with the Stormwater Management Standards.

Stormwater Quantity Management

Approximating a site's pre-development hydrology, including the natural cover, is the primary goal of stormwater quantity management. A site's post-development hydrology can be controlled through a combination of stream bank/channel erosion control (2-year 24-hour storm events), flood control (10-year 24-hour and 100-year 24-hour storm events). Table 2-2 indicates the types of quantity controls provided by specific BMPs.

Table 2-2			
BMPs for Controlling Peak Discharge Rates			
	Peak Discharge Rate Control: 2-Yr. Storm	Peak Discharge Rate Control: 10-Yr. Storm	Peak Discharge Rate Control: 100-Yr. Storm
Pretreatment			
Deep sump catch basins	No	No	No
Oil grit separators	No	No	No
Proprietary separators	No	No	No
Sediment forebays	No	No	No
Vegetated filter strips	With careful design	No	No
Treatment			
Bioretention areas/rain gardens	No	No	No
Constructed stormwater wetlands	Yes	Yes	No
Extended dry detention basins	Yes	Yes	With careful design
Gravel wetlands	Yes	Yes	No
Proprietary media filters	No	No	No
Sand/Organic filters	No	No	No
Tree box filters	No	No	No
Wet Basins	Yes	Yes	With careful design
Conveyance			
Drainage channels	No	No	No
Grass Channels	No	No	No
Water Quality Swales	With careful design	With careful design	No
Infiltration BMPs			
Dry wells	No	No	No
Infiltration Basins	With careful design	With careful design for small sites	With careful design
Infiltration Trenches	Full exfiltration trench systems	Full exfiltration trench systems	Full exfiltration trench systems
Leaching catch basins	Only if sufficient leaching catch basins	Only if sufficient leaching catch basins	No
Subsurface structures	No	No	No
Other BMPs			
Dry detention basins	Yes	Yes	With careful design
Green Roofs	Yes with careful design	No	No
Porous Pavement	Yes with careful design	No	No
Rain barrels & Cisterns	Yes for cistern with careful design	No	No

Stormwater Quality Management

When designing stormwater management systems and screening BMP technologies to meet the water quality management standards, ask the following questions:

- **Does the project affect a sensitive resource?**
- **Based on existing and post-development conditions, what is the volume of stormwater to be treated for water quality?**
- **Is the water quality volume based on 0.5 inch or 1.0 inch of runoff times the impervious area?**
- **What is the best combination of BMP technologies and non-structural practices to achieve the 80% reduction of TSS loadings on an average annual basis?**
- **Does the stormwater discharge impact an impaired surface water? If so, what pollutants are the cause of that impairment? Which BMPs can remove that pollutant?**

Although the Stormwater Management Standards only require removal of TSS, a proponent must consider other pollutants, if the development or redevelopment will affect a surface water that is the subject of a Total Maximum Daily Load (TMDL) that indicates the concentrations of certain pollutants in stormwater runoff must be reduced. In that event, the proponents must design, construct, operate and maintain a stormwater management system that is consistent with the TMDL.

Stormwater Recharge

When designing stormwater management systems to meet the recharge standard, ask the following questions:

- **Based on existing and post-development conditions and soil types, what is the volume of stormwater to be recharged to groundwater?**
- **Will the infiltration BMP exfiltrate stormwater to the ground within a Zone II or Interim Wellhead Protection Area or an area with a rapid infiltration rate (greater than 2.4 inches per hour)?**
- **Is the infiltration BMP near a bathing beach, shellfish growing area, Outstanding Resource Area, Special Resource Area, or cold-water fishery?**
- **What pretreatment measures are needed to ensure that the infiltration BMP can continue to operate as designed?**

Site Suitability/BMP Suitability

In choosing an effective BMP system, it is necessary to determine the most suitable combinations of BMPs based on the characteristics of the site. The basic site requirements for each technology are included in Chapter 2. Site suitability is a major factor in choosing BMPs. Physical constraints at a site may include soil conditions, watershed size, depth to water table, depth to bedrock and slope. For redevelopment projects, physical constraints may include compacted soils or the presence of underground utilities. In some cases, a BMP may be eliminated as an option because of site constraints. Often, however, BMPs can be modified or combined with other BMPs and adapted to site conditions to create an efficient system capable of meeting the Stormwater Management Standards.

The following subsections briefly address the physical site conditions that affect BMP selection.

Soil Suitability
Generally, dry detention basins and extended dry detention basins are suitable in a broad range of soil conditions, but wet basins may have difficulty maintaining water levels in very sandy soils. Soil type is of particular importance to infiltration BMPs. Do not locate infiltration BMPs in areas with low permeability soils. (This would exclude "D" soil groups, as defined by the Natural Resources Conservation Service.) Where infiltration technologies are planned, confirm that the soils have adequate permeability.

Drainage Area/Watershed To Be Served
The size of the contributing area may be a limiting factor in selecting the appropriate BMP technology. Recommendations for appropriate contributing watershed areas are included in the discussion for each technology. Proper site planning can often overcome area constraints. Basins typically require large contributing drainage areas in order to function properly, while infiltration BMPs require smaller drainage areas. For technologies that require large contributing watersheds, additional offsite runoff may be routed to the BMP to increase flows. Conversely, portions of the total runoff can be routed to smaller individual BMPs to allow for the use of lower capacity BMPs. Keep in mind that some BMPs may have more rigorous maintenance and inspection requirements.

Depth to Water Table
Depth to the seasonal high groundwater table is an important factor for stormwater technologies, especially infiltration BMPs. If the seasonal high groundwater table extends to within two feet of the bottom of an infiltration BMP, the site is seldom considered suitable. The groundwater table acts as an effective barrier to exfiltration through the BMP media and soils below and can prevent an infiltration BMP from draining properly. Depending on soil conditions, depth to the groundwater table is also an important factor in reducing the risk of microbial contamination. For constructed stormwater wetlands and wet basins, a groundwater table at or near the surface is desirable. Areas with high groundwater tables are generally more conducive to siting these types of BMPs.

Depth to Bedrock
The depth to bedrock (or other impermeable layers) is a consideration for siting facilities that rely upon infiltration. Bedrock impedes the downward exfiltration of stormwater and prevents infiltration BMPs from draining properly. An area is generally not suitable for infiltration BMPs, if bedrock is within two feet of the bottom of the BMP. Similarly, stormwater basin BMPs are not feasible if shallow bedrock lies beneath the area to be excavated.

Slopes
Site slopes restrict the types of BMP that can be used. Water quality swales and infiltration trenches are not practical when slopes exceed 20%. To achieve water quality benefits and credit for TSS removal, proponents may not site water quality swales or grass channels on slopes greater than 5%. Where there are steeper slopes, the stormwater management system must be carefully designed to prevent stormwater runoff from bypassing the treatment BMPs and causing erosion and off-site flooding.

Thermal Enhancement
The water in wet basins and constructed stormwater wetlands warms up rapidly in summer. Warm water released from BMPs can be lethal to cold-water aquatic organisms. Do not use these BMPs in areas adjacent to designated cold-water streams.

Proximity to Critical Animal Habitats or Endangered Species

Some BMPs can be lethal traps for small animals such as frogs, salamanders, and turtles. Sediment forebays and dry detention basins with excessively steep or vertical side slopes (e.g., concrete steps) or improperly located catch basins can prevent a trapped animal from escaping. LID techniques may be more suitable for managing stormwater while at the same time, protecting indigenous animal populations as well as rare and endangered species.

Proximity to Septic Systems and Water Supplies

When evaluating the suitability of infiltration BMPs such as infiltration trenches, infiltration basins and dry wells, it is critical to consider setback requirements mandated under other state programs such as those addressing septic systems and drinking water supplies. Table 2.3 summarizes setback requirements for infiltration BMPs.

Table 2.3: Setbacks for Infiltration Structures
General Setback Requirements: **Soil Absorption Systems for Title 5 Systems:** 50ft. **Private wells**: 100 ft. **Public wells**: Outside Zone I **Public reservoir, surface water sources for public water systems and their tributaries**: Outside Zone A **Other surface waters**: 50 ft. **Property Line**: 10 feet **Building foundations**: >10 to 100 ft., depending on the specific type of infiltration BMP. See infiltration BMP for specific setback. **Specific BMPs have additional setback requirements**. See Chapter 2.

Proximity to Foundations

Infiltration of stormwater can cause seepage into foundations when BMPs are located too close to buildings; MassDEP requires a 10 to 100 foot setback depending on specific type of infiltration BMP.

Public Acceptance

Aesthetics are important in gaining acceptance of BMPs. BMPs can either enhance or degrade the amenities of the natural environment and the adjacent community. Careful planning, landscaping and maintenance can make a BMP an asset to a site. Frequently, ownership and maintenance responsibilities for BMPs in new developments fall on adjacent property owners. If adjacent residents will be expected to pay for maintenance, education and acceptance of the BMP are necessary.

BMP Treatment Trains

BMPs in series incorporate several stormwater treatment mechanisms in sequence to enhance the treatment of runoff. Known as "stormwater treatment trains," they consist of a combination of source control measures, natural features, and structural BMPs to maximize pollutant removal and subsurface recharge. Combining nonstructural and structural measures in series rather than using a single method of treatment improves the levels and reliability of pollutant removal. The effective life of a BMP can be extended by combining it with pretreatment BMPs, such as a vegetated filter strip or sediment forebay, to remove sediment prior to treatment in the downstream "units." Sequencing BMPs can also reduce the potential for re-suspension of settled sediments by reducing flow energy levels or providing longer flow paths for runoff.

The most suitable components for a treatment train depend on the pollutants to be removed. Pollutants in stormwater fall into two groups: suspended solids and dissolved pollutants. Particle sizes greater than 0.45 micron are considered suspended solids. Pretreatment BMPs (e.g. sediment forebay, oil grit separator) are ordinarily designed to remove suspended solids that have larger particle sizes than the dissolved solids removed by treatment practices that rely on settling (e.g. extended dry detention basins and wet basins s) or filtration (e.g. sand filters and filtering bioretention areas).

There are many combinations of BMPs that can be placed in a treatment train to maximize suspended solids removal. According to Minton (2006), some of the more common ones include:

- **A sediment forebay discharging to a wet basin flowing into a constructed stormwater wetland**
- **A water quality swale flowing into a wet basin or a constructed stormwater wetland**
- **An oil grit separator connected to a sand or organic filter**
- **A sediment forebay discharging to an extended dry detention basin connected to a sand filter**
- **A water quality swale discharging to a vegetated filter strip connected to an infiltration trench.**

BMPs by Land Use

Certain BMPs are more suitable for some land uses than others[8]. Some types of urban land uses contribute higher than normal pollutant loadings of solvents, oils, lubricants, fertilizers, grease, and/or bacteria. Table LUHPPL presents the applicability and use of various BMPs for various land uses with higher potential pollutant loads.

[8] The MassHighway Stormwater Handbook provides information on the information to consider when selecting BMPs for highway projects.

Table LUHPPL: Best Management Practices for Land Uses with Higher Potential Pollutant Loads

- Discharges from certain land uses with higher potential pollutant loads may be subject to additional requirements, including the need to obtain an individual or general discharge permit pursuant to the MA Clean Waters Act or Federal Clean Water Act.
- All proponents must implement source control and pollution prevention.
- All BMPs shall be designed in accordance with specifications and procedures in the Massachusetts Stormwater Handbook Volumes 2 and 3.
- The required water quality volume equals 1inch times the total impervious area of the post-development site.
- Many land uses have the potential to generate higher potential pollutant loads of oil and grease. These land uses include, without limitation, industrial machinery and equipment and railroad equipment maintenance, log storage and sorting yards, aircraft maintenance areas, railroad yards, fueling stations, vehicle maintenance and repair, construction businesses, paving, heavy equipment storage and/or maintenance, the storage of petroleum products, high-intensity-use parking lots, and fleet storage areas. To treat the runoff from such land uses, the following BMPs must be used to pretreat the runoff prior to discharge to an infiltration structure: an oil grit separator, a sand filter, organic filter, filtering bioretention area or equivalent.
- 44% TSS removal is required prior to discharge to an infiltration device.
- Until they complete the STEP or TARP verification process outlined in Volume 2, proprietary BMPs may not be used as a terminal treatment device for runoff from land uses with higher potential pollutant loads. For the purpose of this requirement, subsurface structures, even those that have a storage chamber that has been manufactured are not proprietary BMPs, since the pretreatment occurs in the soil below the structure, not in the structure itself.

Pretreatment	
	Deep Sump Catch Basin
	Oil Grit Separator
	Proprietary Separators - See Volume 2
	Sediment Forebays
	Vegetated Filter Strip (*must be lined*)
Treatment	
Sand Filters, Organic Filters, Proprietary Media Filters, Wet Basins, Filtering Bioretention Areas, and Extended Dry Detention Basins must be lined and sealed unless 44% of the TSS has been removed prior to discharge to the BMP.	Filtering Bioretention Areas including rain gardens
	Constructed Stormwater Wetlands
	Dry Water Quality Swales
	Extended Dry Detention Basins
	Gravel Wetlands
	Proprietary Media Filter. (Does not include catch basin inserts) (Proprietary Media Filters may be used for terminal treatment for runoff from land uses with higher potential pollutant loads, only if verified for such use by the TARP or STEP process. See Volume 2.)
	Sand /Organic Filters
	Wet Basins
Infiltration	
	Exfiltrating Bioretention Areas including rain gardens
	Infiltration Basins
	Infiltration Trenches
	Leaching Catch Basins
	Subsurface Structures.

Redevelopment Projects

There are fewer stormwater BMP options for heavily urbanized areas (often called *ultra-urban* areas) compared to less congested areas, because of the restrictions inherent in building in urbanized areas. The primary barrier is space, or more precisely, lack of space. This limitation eliminates many space-intensive options (e.g., extended dry detention basins) and makes BMPs that can be used on a micro-scale and that have smaller "footprints" more attractive. Other considerations that can take the shape of barriers include:

Engineering Concerns
If the discharge point of a BMP is to a storm drain or an underdrain connecting to a storm drain, proponents should avoid overloading the existing system. The BMP will not work if the discharge cannot be efficiently moved off-site or out of manufactured systems like proprietary separators or oil grit separators. BMP selection must include engineering considerations such as available head, hydraulic grade lines, and the presence of pipeline bottlenecks that may worsen flooding.

Underground Utilities
The presence of underground utilities, including gas and water mains, sewer pipes and electric cable conduits in urban areas, can greatly reduce the amount of land available for redevelopment BMPs. Utility conduits can limit the ability to excavate, making BMP siting and sizing difficult.

Given these constraints, the most suitable BMPs for redevelopment include:

- Bioretention Areas/Rain Gardens
- Grass Channels
- Green Roofs
- Subsurface Structures
- Leaching Catch Basins
- Porous Pavement
- Sand Filters/Organic Filters
- Water Quality Swales (Dry)
- Deep Sump Catch Basins
- Dry Wells
- Proprietary Separators
- Infiltration Trenches
- Other Proprietary Technologies
- Rain Barrels and Cisterns
- Vegetated Filter Strips

Table SSR summarizes the ability of each of these redevelopment BMPs to provide groundwater recharge, improve water quality, and attenuate peak flows. Redevelopment projects are required to meet Standard 2, Standard 3, and the structural best management practice requirements of Standards 4, 5 and 6 *to the maximum extent practicable*.

Redevelopment projects must meet all other requirements of the Stormwater Management Standards *and* improve existing conditions using one or more of the above techniques. Chapter 3 provides a detailed checklist to help conservation commissions and applicants determine which BMPs are most appropriate in each case and what types of improvements they provide.

Table SSR

Stormwater Standards and Redevelopment				
BMPs	**Standard 7: Is BMP Suitable for Redevelopment?**	**Standard 2: Does BMP Attenuate Peak Flows?**	**Standard 3: Does BMP Provide Recharge?**	**Standard 4: Does BMP Remove TSS?**
Pretreatment				
Deep sump catch basin	Yes	No	No	Yes
Oil grit separator	Yes	No	No	Yes
Proprietary separators	Yes	No	No	Yes
Sediment forebay	Yes	No	No	Yes
Vegetated filter strip	Yes	Some with careful design	No	Yes
Treatment				
Bioretention area/rain gardens	Yes	No	Depends on design	Yes
Constructed stormwater wetlands	As retrofit for dry detention basin	Yes	No	Yes
Extended dry detention basin	As retrofit for dry detention basin	Yes	No	Yes
Gravel wetlands	As retrofit for dry detention basin	Yes	No	Yes
Proprietary media filters	Yes	No	No	Yes
Sand/Organic filters	Yes	No	No	Yes
Tree box filters	Yes	No	No	Yes
Wet basins	As retrofit for dry detention basin	Yes	No	Yes
Conveyance				
Drainage channels	Yes	No	No	No
Grass channels	Yes	No	No	Yes
Water quality swale-dry	Yes	With careful design	No	Yes
Water quality swale-wet	May not be practicable because of site constraints	N/A	N/A	N/A
Infiltration				
Dry wells	Yes, runoff from nonmetal roofs and metal roofs outside Zone II, IWPA, and industrial sites	No	Yes	Yes
Infiltration basins	May not be practicable because of site constraints	N/A	N/A	N/A
Infiltration trenches	Yes, w/pretreatment	Yes Full Exfiltration System Trenches	Yes	Yes
Leaching catch basins	Yes, w/pretreatment	Yes if sufficient catch basins	Yes	Yes
Subsurface structures	Yes w/pretreatment	No	Yes	Yes
Other BMPs				
Dry detention basin	May not be practicable because of site constraints	N/A	N/A	N/A
Green roofs	Yes	Some with careful design	No	No
Porous pavement	Yes	Some with careful design	Yes	Yes
Rain barrels & cisterns	Yes	Some for cisterns with careful design	No	No

Additional references and links for Redevelopment Projects:
U.S. Department of Transportation, Federal Highway Administration
Stormwater BMPs in an Ultra-Urban Setting: Selection and Monitoring:
www.fhwa.dot.gov/environment/ultraurb/uubmp6p2.htm
California Stormwater Quality Association
www.cabmphandbooks.com/Development.asp
Center for Watershed Protection, Urban Stormwater Retrofit Manual
http://www.cwp.org/PublicationStore/USRM.htm#usrm3

Retrofitting Existing Stormwater Management Measures
MassDEP defines retrofitting as expanding, modifying, or otherwise upgrading existing stormwater management measures. As such, retrofitting stormwater management measures can reduce some of the adverse stormwater quantity and quality impacts caused by existing land developments. In many instances, existing stormwater management measures can be dramatically improved, and downstream water bodies protected, through effective retrofitting.

Beginning in the 1970s, many new developments were constructed with dry detention basins. Many of these facilities were built to attenuate the peak flow impacts of the 10-year, 25-year, and/or 100-year 24-hour storms. Because smaller storms are typically responsible for degrading water quality and eroding stream banks, it makes sense to retrofit such facilities to control these smaller storm events.

Another important benefit of retrofitting stormwater management facilities is the opportunity to correct site nuisances, maintenance problems, and aesthetic concerns. Retrofitting also allows a community to keep pace with new stormwater management regulations and objectives. It can help a community address a particular stormwater quantity or quality problem that has developed as a result of deficiencies in existing stormwater management facilities, or a basin-wide problem that has been identified in a TMDL. Constructing new stormwater management systems at future land development sites will not be sufficient to bring all the waters of the Commonwealth into compliance with the state's water quality standards. To assure that all the state's surface waters meet their existing and designated uses, previously constructed stormwater management facilities located at redeveloped sites must be retrofitted and improved.

In addition to such basic considerations as need and cost, two important factors must be considered when evaluating retrofit possibilities:

1. Health and safety; and
2. Effectiveness.

Review these factors thoroughly before undertaking a stormwater management measure retrofit to justify the cost and effort and ensure the retrofit's long-term success.

Health and Safety
A retrofit must not increase health and safety risks in any way. For example, the storage volume in an existing dry detention basin presently used for stormwater quantity control must not be reduced to provide new stormwater quality enhancement without ensuring that the lost quantity storage will not adversely increase peak basin outflows and cause downstream flooding or erosion.

Effectiveness
In many retrofit situations, it may not be possible to upgrade the stormwater management measure to meet all current groundwater recharge and stormwater quality and quantity standards. This means that relative performance improvements for a range of retrofits must be evaluated to determine which one represents the optimum combination of effectiveness, viability, and cost. As a result, the final retrofit selected for an existing stormwater measure will have to be based on its relative rather than absolute effectiveness. In such relative determinations, both the costs and benefits of the evaluated retrofits become more influential factors than when an absolute performance standard is used. Chapter 3 provides guidance on the BMPs most suitable for retrofitting.

Maintenance Requirements

Too often, BMPs are constructed without plans or obligations for long-term maintenance. Chapter 2 includes the basic maintenance requirements for each structural control. The maintenance requirements for BMPs must be considered during the selection process. Because maintenance is mandatory, it is logical that BMP selection should gravitate toward measures that are more easily maintained. In general, BMPs installed *above ground* are easier to maintain than ones placed *underground.* Further, BMPs that incorporate *natural vegetation* as part of the pollutant removal process, such as bioretention areas, require less maintenance than *engineered and pre-fabricated systems.*

For most BMPs, the maintenance requirements include visual inspections (e.g., inspection of sediment forebays) and physical upkeep (e.g., removing and disposing of sediment, and mowing water quality swales). Whatever the maintenance requirements, the Stormwater Management Standards mandate that all stormwater management facilities have an Operation and Maintenance Plan. The Operation and Maintenance Plan must clearly address the following BMP maintenance issues:

- How and when maintenance is to be performed,
- How and when inspections will be performed, and
- How these tasks will be financed.

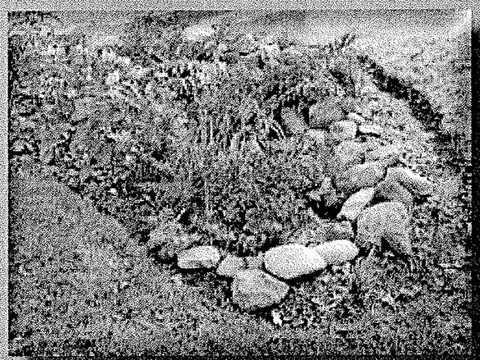
The Operations and Maintenance Plan must provide that best practical measures be implemented to conduct maintenance activities in a manner that avoids, minimizes and mitigates adverse impacts to wetland resource areas. BMPs should be designed to minimize maintenance needs wherever possible. Proponents should anticipate future maintenance problems and develop plans to alleviate them as much as possible. Preventative design measures, such as using forebays to trap incoming first-flush sediment, can reduce the future maintenance costs and requirements.

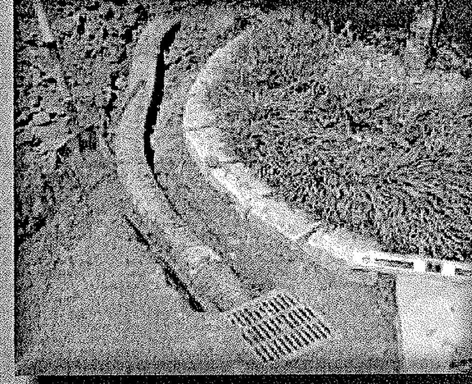
At a minimum, the Operation and Maintenance Plan must also identify:

(1) Stormwater management system owners
(2) The party or parties responsible for operation and maintenance
(3) The routine and non-routine maintenance tasks to be undertaken after construction is complete and a schedule for implementing those tasks
(4) Plan showing the location of all stormwater BMPs
(5) Description and delineation of public safety features
(6) Estimated operations and maintenance budget

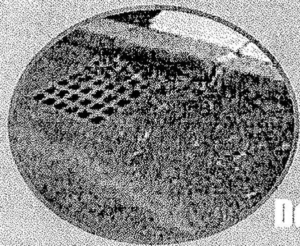
For the developer, the most difficult part of preparing a maintenance plan may be identifying the party that is responsible for performing and paying for the long-term maintenance of the BMP. The Order of Conditions should require the responsible party to: (1) implement the Operation and Maintenance Plan; (2) maintain a log of all operation and maintenance activities including without limitation inspections, repairs, replacement and disposal (for disposal, the log shall indicate the type of material and the disposal location); (3) make this log available to the MassDEP and the Conservation Commission; (4) allow the MassDEP and the Conservation Commission to inspect each BMP to determine whether the responsible party is implementing the Operation and Maintenance Plan; and (5) submit the O & M Compliance Statement when requesting a Certificate of Compliance.

Volume 2
Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook

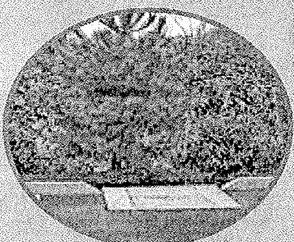



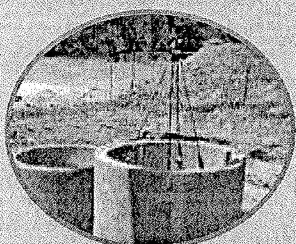

Structural Pretreatment BMPs



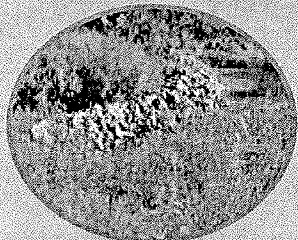
Deep Sump Catch Basin



Oil/Grit Separators



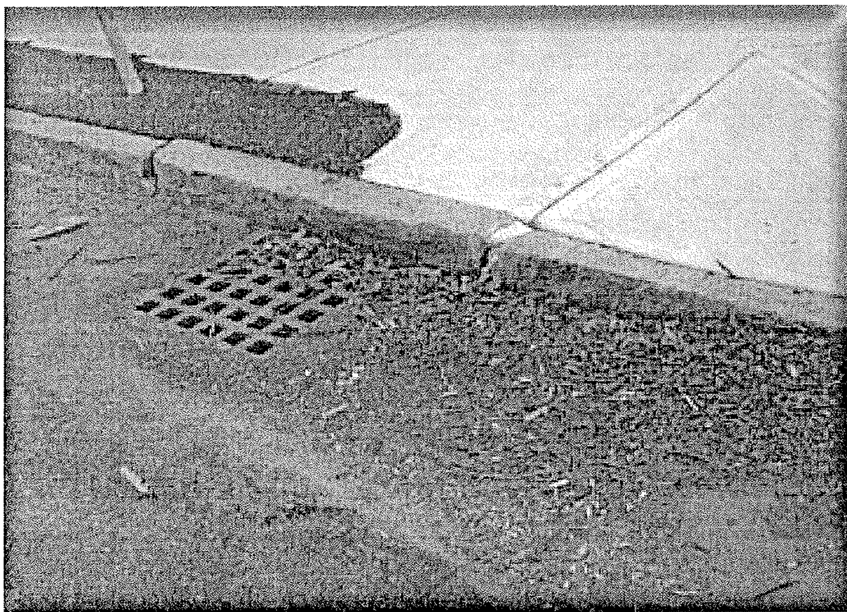
Proprietary Separators



Sediment Forebays

Vegetated Filter Strips

Deep Sump Catch Basin



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

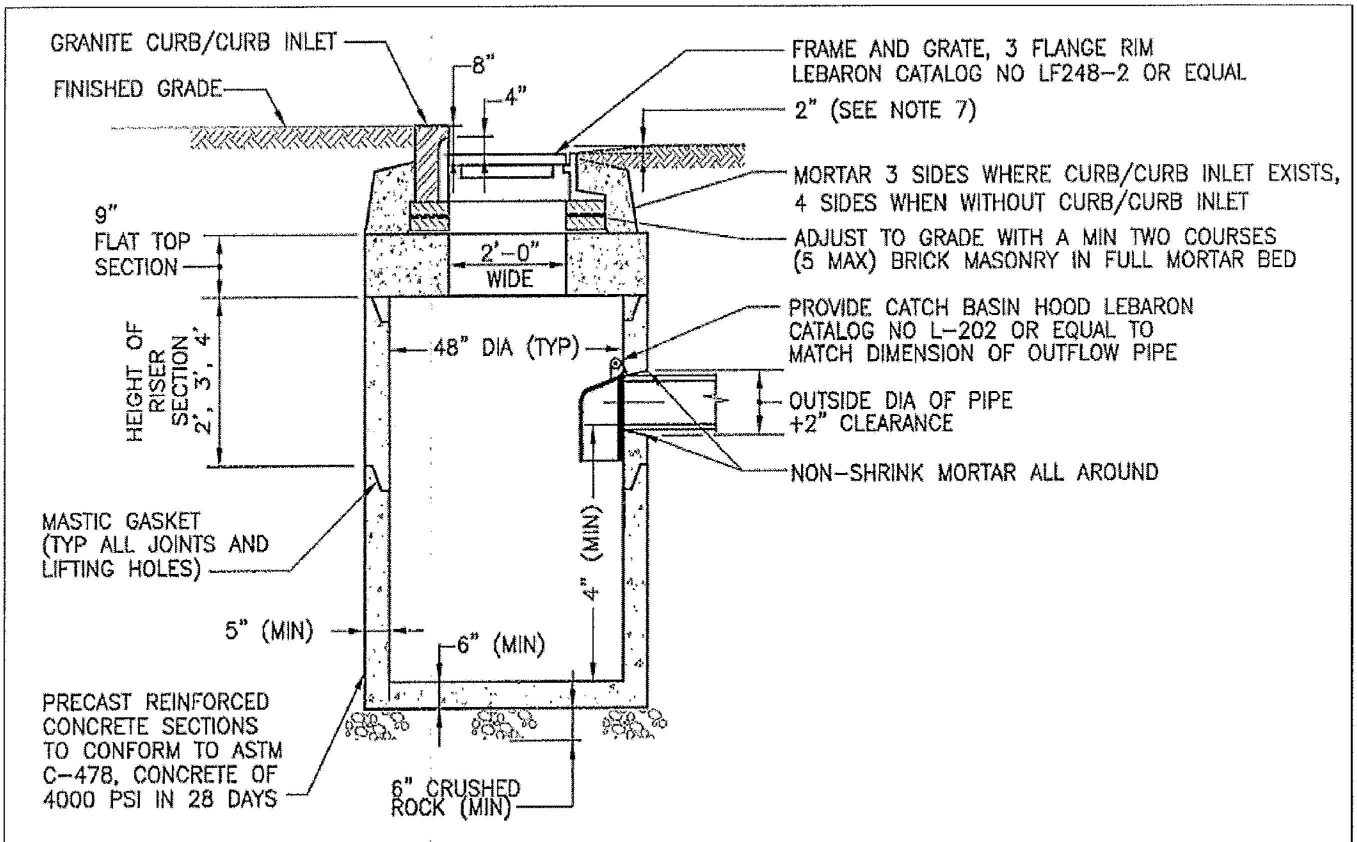
Ability to meet specific standards

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

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

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

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



adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Inspect units	Four times per year
Clean units	Four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin.

Special Features

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

LID Alternative

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

Deep Sump Catch Basin

Suitable Applications
- Pretreatment
- Residential subdivisions
- Office
- Retail

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

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

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

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

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

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

Site Constraints
A proponent may not be able to install a deep sump catch basin because of:
- Depth to bedrock;
- High groundwater;
- Presence of utilities; or
- Other site conditions that limit depth of excavation because of stability.

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

Inspect or clean deep sump basins at least four times per year and at the end of the foliage and snow-removal seasons. Sediments must also be removed four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. If handling runoff from land uses with higher potential pollutant loads or discharging runoff near or to a critical area, more frequent cleaning may be necessary.

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

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

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

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

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

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

Oil/Grit Separators

Description: Oil/grit separators are underground storage tanks with three chambers designed to remove heavy particulates, floating debris and hydrocarbons from stormwater.

Stormwater enters the first chamber where heavy sediments and solids drop out. The flow moves into the second chamber where oils and greases are removed and further settling of suspended solids takes place. Oil and grease are stored in this second chamber for future removal. After moving into the third outlet chamber, the clarified stormwater runoff is then discharged to a pipe and another BMP. There are other separators that may be used for spill control.

Advantages/Benefits:

- Located underground so limited lot size not a deterrent in urban areas with small lots
- Can be used for retrofits
- Can be installed in any soil or terrain.
- Public safety risks are low.

Disadvantages/Limitations:

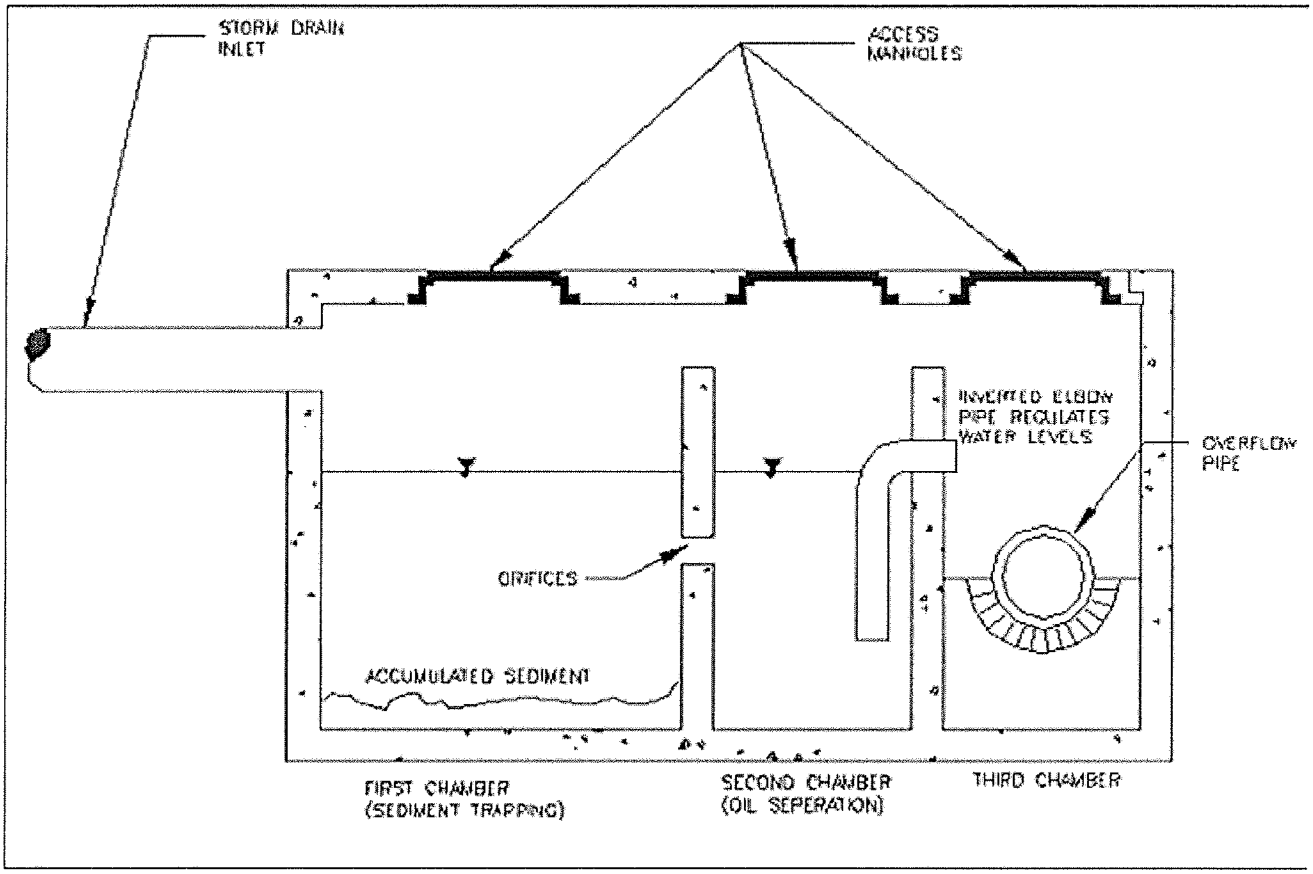
- Limited pollutant removal; cannot effectively remove soluble pollutants, fine particles, or bacteria
- Can become a source of pollutants due to resuspension of sediment unless properly maintained
- Susceptible to flushing during large storms
- Limited to relatively small contributing drainage areas
- Requires proper disposal of trapped sediments and oils
- May be expensive to construct and maintain
- Entrapment hazard for amphibians and other small animals

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) - 25% for oil grit separator, only when placed off-line and only when used for pretreatment
- Nutrients (Nitrogen, phosphorus) - Insufficient data
- Metals (copper, lead, zinc, cadmium) - Insufficient data
- Pathogens (coliform, e coli) - Insufficient data

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	25% TSS removal credit when used for pretreatment and placed off-line.
5 - Higher Pollutant Loading	MassDEP requires a pretreatment BMP, such as an oil/grit separator that is capable of removing oil and grease, for land uses with higher potential pollutant loads where there is a risk of petroleum spills such as: high intensity use parking lots, gas stations, fleet storage areas, vehicle and/or equipment maintenance and service areas.
6 - Discharges near or to Critical Areas	May be a pretreatment BMP when combined with other practices. May serve as a spill control device.
7 - Redevelopment	Highly suitable.



MassHighway 2004

Maintenance

Activity	Frequency
Inspect units	After every major storm but at least monthly
Clean units	Twice a year

Oil/Grit Separators

Applicability

Oil grit separators must be used to manage runoff from land uses with higher potential pollutant loads where there is a risk that the stormwater is contaminated with oil or grease. These uses include the following:

- High-Intensity-Use Parking Lots
- Gas Fueling Stations
- Vehicles (including boats, buses, cars, and trucks) and Equipment Service and Maintenance Areas
- Fleet Storage Areas

Design Considerations

- Dovetail design practices, source controls and pollution prevention measures with separator design.
- Place separators before all other structural stormwater treatment practices (except for structures associated with source control/ pollution prevention such as drip pans and structural treatment practices such as deep sump catch basins that double as inlets).
- Limit the contributing drainage area to the oil/grit separator to one acre or less of impervious cover.
- Use oil grit separators only in off-line configurations to treat the required water quality volume.
- Provide pool storage in the first chamber to accommodate the required water quality volume or 400 cubic feet per acre of impervious surface. Confirm that the oil/grit separator is designed to treat the required water quality volume.
- Make the permanent pool at least 4 feet deep.
- Design the device to pass the 2-year 24-hour storm without interference and provide a bypass for larger storms to prevent resuspension of solids.
- Make oil/grit separator units watertight to prevent possible groundwater contamination.
- Use a trash rack or screen to cover the discharge outlet and orifices between chambers.
- Provide each chamber with manholes and access stepladders to facilitate maintenance and allow cleaning without confined space entry.
- Seal potential mosquito entry points.
- Install any pump mechanism downstream of the separator to prevent oil emulsification.
- Locate an inverted elbow pipe between the second and third chambers and with the bottom of the elbow pipe at least 3 feet below the second chamber's permanent pool.
- Provide appropriate removal covers that allow access for observation and maintenance.
- Where the structure is located below the seasonal high groundwater table, design the structure to prevent flotation.
- For gas stations, automobile maintenance and service areas, and other areas where large volumes of petroleum and oil are handled, consider adding coalescing plates to increase the effectiveness of the device and reduce the size of the units. A series of coalescing plates constructed of oil-attracting materials such as polypropylene typically spaced one inch apart attracts small droplets of oil, which begin to concentrate until they are large enough to float to the surface.

Maintenance

Sediments and associated pollutants and trash are removed only when inlets or sumps are cleaned out, so regular maintenance is essential. Most studies have linked the failure of oil grit separators to the lack of regular maintenance. The more frequent the cleaning, the less likely sediments will be resuspended and subsequently discharged. In addition, frequent cleaning also makes more volume available for future storms and enhances overall performance. Cleaning includes removal of accumulated oil and grease and sediment using a vacuum truck or other ordinary catch basin cleaning device. In areas of high sediment loading, inspect and clean inlets after every major storm. At a minimum, inspect oil grit separators monthly, and clean them out at least twice per year. Polluted water or sediments removed from an oil grit separator should be disposed of in accordance with all applicable local, state and federal laws and regulations including M.G.L.c. 21C and 310 CMR 30.00.

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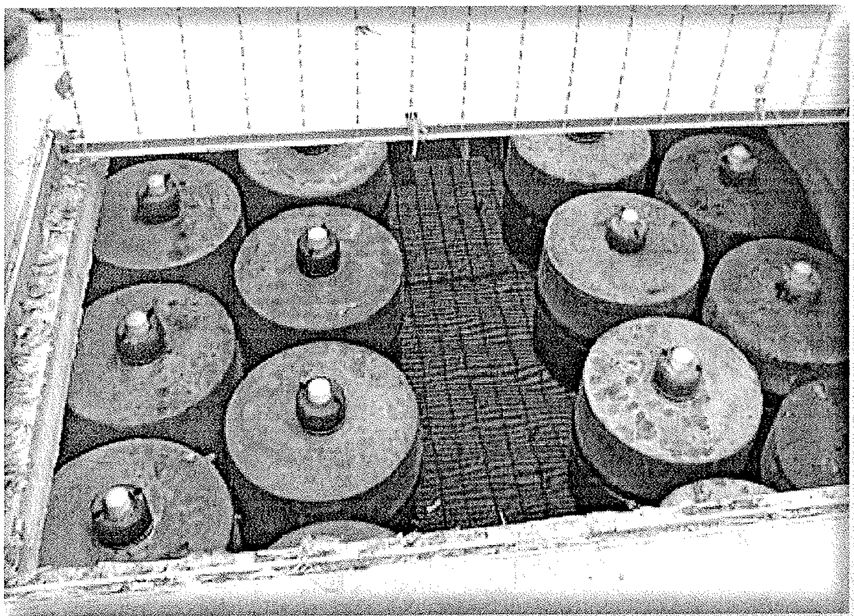
Proprietary Separators



Description: A proprietary separator is a flow-through structure with a settling or separation unit to remove sediments and other pollutants. They typically use the power of swirling or flowing water to separate floatables and coarser sediments, are typically designed and manufactured by private businesses, and come in different sizes to accommodate different design storms and flow conditions. Some rely solely on gravity separation and contain no swirl chamber. Since proprietary separators can be placed in almost any location on a site, they are particularly useful when either site constraints prevent the use of other stormwater techniques or as part of a larger treatment train. The effectiveness of proprietary separators varies greatly by size and design, so make sure that the units are sized correctly for the site's soil conditions and flow profiles, otherwise the unit will not work as designed.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	Varies by unit. Must be used for pretreatment and be placed first in the treatment train to receive TSS removal credit. Follow procedures described in Chapter 4 to determine TSS credit.
5 - Higher Pollutant Loading	Suitable as pretreatment device.
6 - Discharges near or to Critical Areas	Suitable as pretreatment device or potentially a spill control device
7 - Redevelopment	Suitable as pretreatment device or treatment device if it is not possible to provide other BMPs.

Advantages/Benefits:

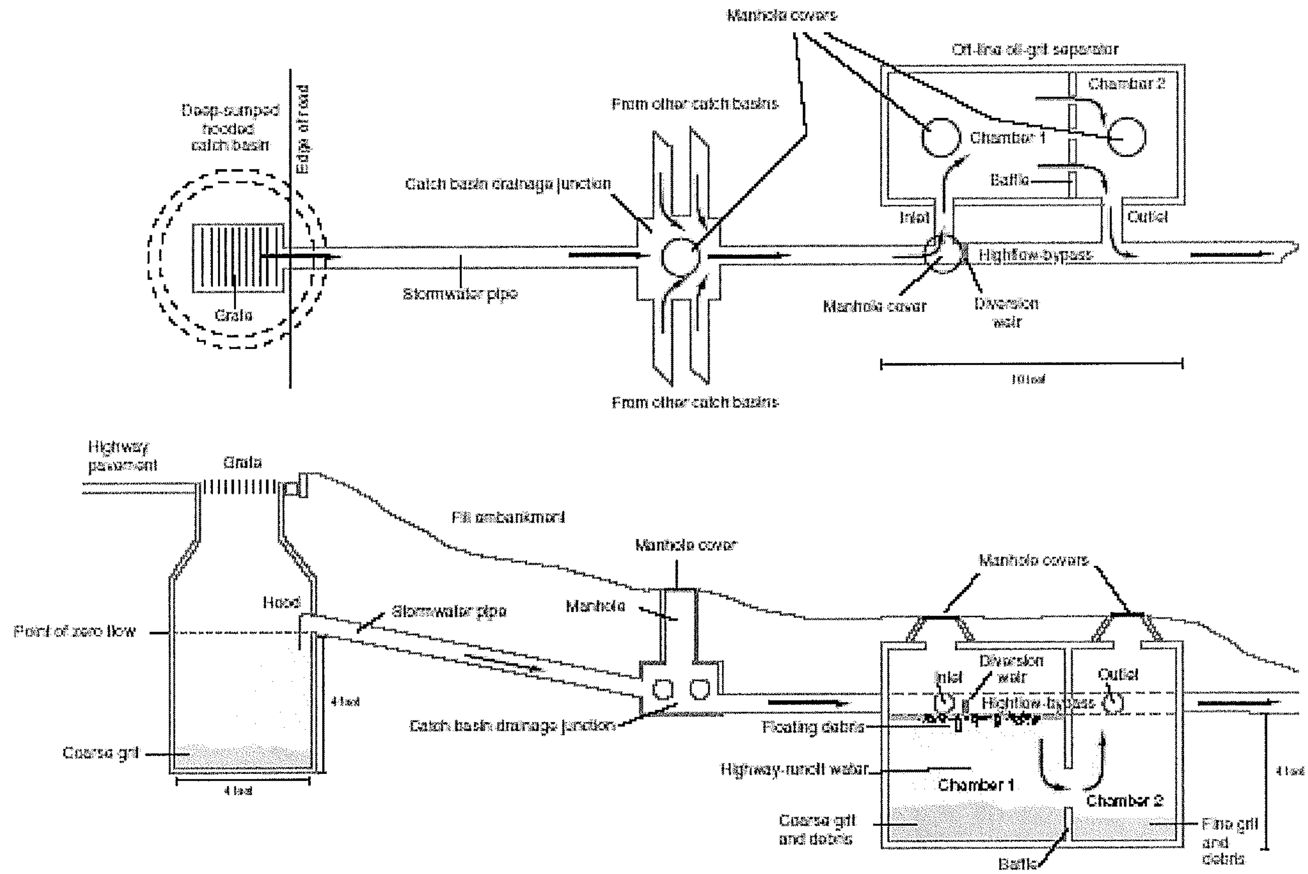
- Removes coarser sediment.
- Useful on constrained sites.
- Can be custom-designed to fit specific needs of a specific site.

Disadvantages/Limitations:

- Removes only coarse sediment fractions
- Provides no recharge to groundwater
- No control of the volume of runoff
- Frequent maintenance is essential

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) - Varies.
- Nutrients (Nitrogen, phosphorus) - Insufficient data
- Metals (copper, lead, zinc, cadmium) - Insufficient data
- Pathogens (coliform, e coli) - Insufficient data



Schematic section of a deep-sump hooded catch basin and a 1,500-gallon off-line water quality inlet.

adapted from the MassHighway Storm Water Handbook for Highways

Maintenance

Activity	Frequency
Inspect in accordance with manufacturer requirements, but no less than twice a year following installation, and no less than once a year thereafter.	See activity
Remove sediment and other trapped pollutants at frequency or level specified by manufacturer.	See manufacturer information

Special Features

Can be custom-designed to fit specific needs at a specific site.

LID Alternative

Reduce impervious surfaces

Disconnect runoff from non-metal roofs, roadways, and driveways

Proprietary Separators

Applicability
Because they have limited pollutant removal and storage capacity, proprietary separators must be used for pretreatment only. Because they are placed underground, proprietary separators may be the only structural pretreatment BMPs feasible on certain constrained redevelopment sites where space or storage is not available for more effective BMPs. They may be especially useful in ultra-urban settings such as Boston or Worcester. Some proprietary separators may be used for spill control.

Effectiveness
Proprietary separators have a wide range of TSS efficiencies. To assess the ability of proprietary separators to remove TSS and other pollutants, a proponent should follow the procedures set forth in Chapter 4. The specific units proposed for a particular project cannot be effective unless they are sized correctly. Proprietary separators are usually sized based on flow rate. A proprietary separator must be sized to treat the required water quality volume. To be effective at removing TSS and other pollutants the system must be designed, constructed, and maintained in accordance with the manufacturer's specifications and the specifications in this Handbook.

Planning Considerations
To receive TSS removal credit, proprietary separators must be used for pretreatment and placed at the beginning of a stormwater treatment train. They can be configured either in-line or if subject to higher flows, off-line to reduce scouring. They must be sized in accordance with the manufacturer's specifications and the specifications in this Handbook. Proprietary separators used as spill control devices may have to be sized differently than those used for TSS removal.

Design
The design of proprietary separators varies by manufacturer. Units are typically precast concrete, but larger systems may be cast in place. Units may have baffles or other devices to direct incoming water into and through a series of chambers, slowing the water down to allow sediment to drop out into internal storage areas, then directing this pre-treated water to exit to other treatment or infiltration devices. In some cases, flow will be introduced tangentially, to induce swirl or vortex. Units may include skirts or weirs, to keep trapped sediments from becoming re-entrained. Some units combine a catch basin with the treatment function, providing off-line rather than in-line treatment.

Generally they are placed below ground on a gravel or stone base. Make sure all units contain inspection and access ports so that they may be inspected and cleaned. During design, take care to place the inspection and access ports where they will be accessible. Do not place the ports in locations such as travel lanes of roadways/highways and parking stalls.

Construction
Install construction barriers around the excavation area to prevent access by pedestrians. Use diversions and other soil erosion practices up-slope of the proprietary separator to prevent runoff from entering the site before construction of the units is complete. Implement practices to prevent construction period runoff from being discharged to the units until construction is complete and the soil is stabilized. Stabilize all surrounding area and any established outlets. Remove temporary structures after vegetation is established.

Maintenance
Inspect and clean these units in strict accordance with manufacturers' recommendations and requirements. Clean the units using the method specified by the manufacturer. Vactor trucks are typically used to clean these units. Clamshell buckets typically used for cleaning catch basins are almost never allowed by manufacturers. Sometimes it will be necessary to remove sediment manually.

Adapted from:
MassHighway. Storm Water Handbook for Highways and Bridges. May 2004.

Sediment Forebays

Description: A sediment forebay is a post-construction practice consisting of an excavated pit, bermed area, or cast structure combined with a weir, designed to slow incoming stormwater runoff and facilitating the gravity separation of suspended solids. This practice is different from a sediment trap used as a construction period BMP.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	MassDEP requires a sediment forebay as pretreatment before stormwater is discharged to an extended dry detention basin, wet basin, constructed stormwater wetland or infiltration basin. No separate credit is given for the sediment forebay. For example, extended dry detention basins with sediment forebays receive a credit for 50% TSS removal. Wet basins and constructed stormwater wetlands with sediment forebays receive a credit for 80% TSS removal. When they provide pretreatment for other BMPs, sediment forebays receive a 25% TSS removal credit.
5 - Higher Pollutant Loading	Recommended as a pretreatment BMP
6 - Discharges near or to Critical Areas	Recommended as a pretreatment BMP
7 - Redevelopment	Usually not suitable due to land use constraints

Advantages/Benefits:

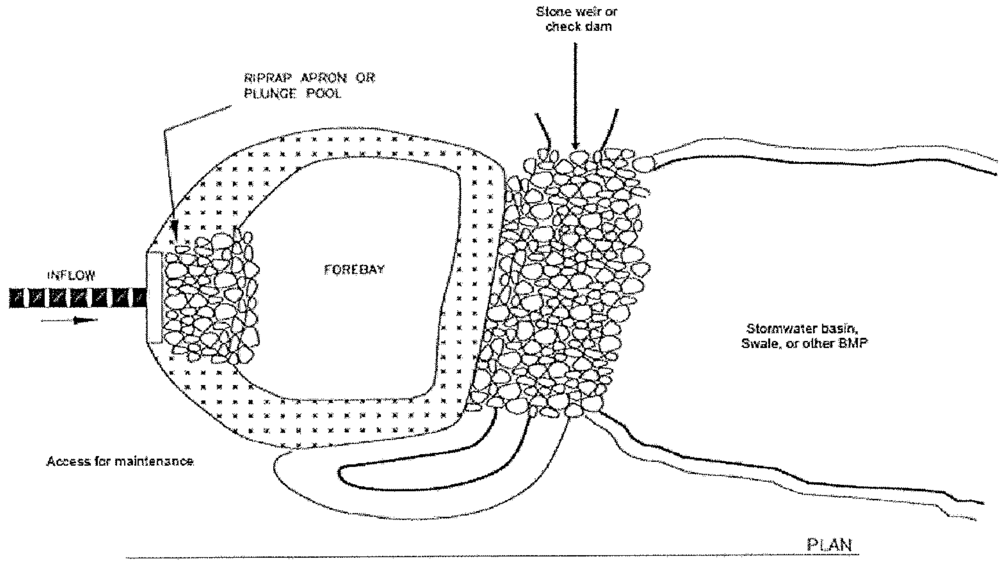
- Provides pretreatment of runoff before delivery to other BMPs.
- Slows velocities of incoming stormwater
- Easily accessed for sediment removal
- Longevity is high with proper maintenance
- Relatively inexpensive compared to other BMPs
- Greater detention time than proprietary separators

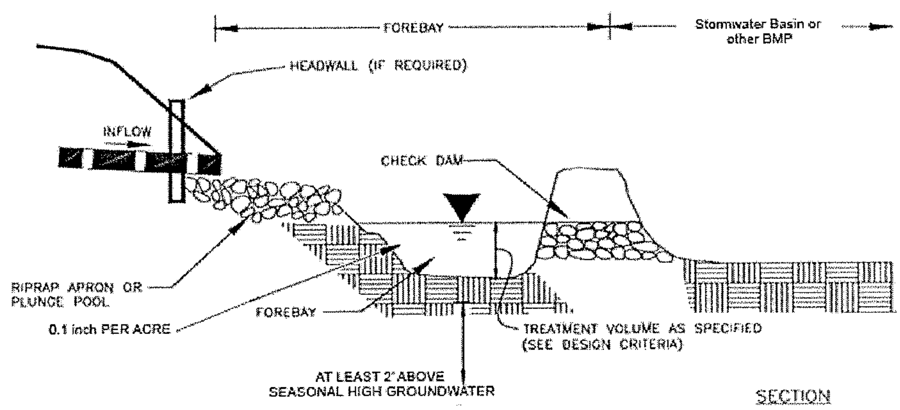
Disadvantages/Limitations:

- Removes only coarse sediment fractions
- No removal of soluble pollutants
- Provides no recharge to groundwater
- No control of the volume of runoff
- Frequent maintenance is essential

Pollutant Removal Efficiencies

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





adapted from the Vermont Stormwater Handbook

Maintenance

Activity	Frequency
Inspect sediment forebays	Monthly
Clean sediment forebays	Four times per year and when sediment depth is between 3 to 6 feet.

Special Features

MassDEP requires a sediment forebay as pretreatment before discharging to a dry extended detention basin, wet basin, constructed stormwater wetland, or infiltration basin.

MassDEP uses the term sediment forebay for BMPs used to pretreat stormwater after construction is complete and the site is stabilized. MassDEP uses the term sediment trap to refer to BMPs used for erosion and sedimentation control during construction. For information on the design and construction of sediment traps used during construction, consult the Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planners, Designers and Municipal Officials.

Sediment Forebays

Design

Sediment forebays are typically on-line units, designed to slow stormwater runoff and settle out sediment.

At a minimum, size the volume of the sediment forebay to hold 0.1-inch/impervious acre to pretreat the water quality volume.

When routing the 2-year and 10-year storms through the sediment forebay, design the forebay to withstand anticipated velocities without scouring.

A typical forebay is excavated below grade with earthen sides and a stone check dam.

Design elevated embankments to meet applicable safety standards.

Stabilize earth slopes and bottoms using grass seed mixes recommended by the NRCS and capable of resisting the anticipated shearing forces associated with velocities to be routed through the forebay. Use only grasses. Using other vegetation will reduce the storage volume in the forebay. Make sure that the selected grasses are able to withstand periodic inundation under water, and drought- tolerant during the summer. MassDEP recommends using a mix of grasses rather than relying upon a single grass species.

Alternatively, the bottom floor may be stabilized with concrete or stone to aid maintenance. Concrete floors or pads, or any hard bottom floor, greatly facilitate the removal of accumulated sediment.

When the bottom floor is vegetated, it may be necessary to remove accumulated sediment by hand, along with re-seeding or re-sodding grasses removed during maintenance.

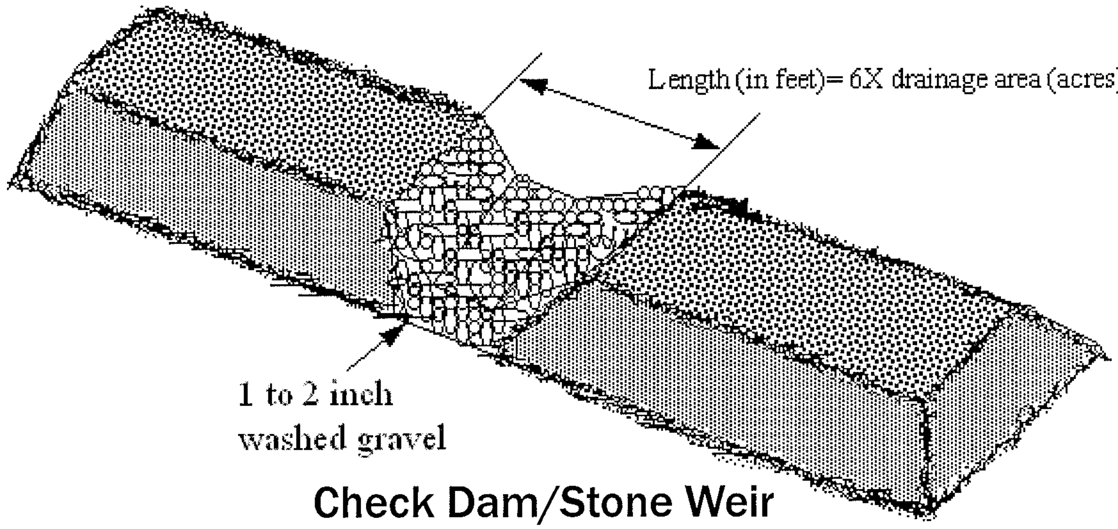
Design sediment forebays to make maintenance accessible and easy. If machinery is required to remove the sediment, carefully incorporate equipment access in the design. Sediment forebays may require excavation so concrete flooring may not always be appropriate.

Include sediment depth markers to simplify inspections. Sediment markers make it easy to determine when the sediment depth is between 3 and 6 feet and needs to be removed. Make the side slopes of sediment forebays no steeper than 3:1. Design the sediment forebay so that the discharge or outflow velocity can control the 2-year peak discharge without scour. Design the channel geometry to prevent erosion from the 2-year peak discharge.

Do not confuse post-construction sediment forebays with the sediment traps used as a construction-period control. Construction-period sediment control traps are sized larger than forebays, because there is a greater amount of suspended solids in construction period runoff. Construction-period sediment traps are sized based on drainage area and not impervious acre. Never use a construction-period sediment trap for post-construction drainage purposes unless it is first brought off-line, thoroughly cleaned (including check dam), and stabilized before being made re-operational.

Refer to the section of this chapter for information on the design of the check dam component of the sediment forebay. Set the minimum elevation of the check dam to hold a volume of 0.1-inch of runoff/ impervious acre. Check dam elevations may be uniform or they may contain a weir (e.g., when the top of the check dam is set to the 2-year or 10-year storm, and the bottom of the weir is set to the top of the 0.1-inch/impervious acre volume). When a weir is included in a stone berm, make sure that the weir is able to hold its shape. Fabric or wire may be required.

Unless part of a wet basin, post construction sediment forebays must be designed to dewater between storms. Set the bottom of the forebay at a minimum of 2 feet above seasonal high groundwater, and place pervious material on the bottom floor to facilitate dewatering between storms. For design purposes, use 72 hours to evaluate dewatering, using the storm that produces either the ½ inch or 1-inch of runoff (water quality volume) in a 24-hour period. A stone check dam can act as a filter berm, allowing water to percolate through the check dam. Depending on the head differential, a stone check dam may allow greater dewatering than an earthen berm.



Check Dam/Stone Weir

MassDEP Stormwater Handbook, 1996

Maintenance

Sediments and associated pollutants are removed only when sediment forebays are actually cleaned out, so regular maintenance is essential. Frequently removing accumulated sediments will make it less likely that sediments will be resuspended. At a minimum, inspect sediment forebays monthly and clean them out at least four times per year. Stabilize the floor and sidewalls of the sediment forebay before making it operational, otherwise the practice will discharge excess amounts of suspended sediments. When mowing grasses, keep the grass height no greater than 6 inches. Set mower blades no lower than 3 to 4 inches. Check for signs of rilling and gullying and repair as needed. After removing the sediment, replace any vegetation damaged during the clean-out by either reseeding or re-sodding. When reseeding, incorporate practices such as hydroseeding with a tackifier, blanket, or similar practice to ensure that no scour occurs in the forebay, while the seeds germinate and develop roots.

Vegetated Filter Strips

Description: Vegetated filter strips, also known as filter strips, grass buffer strips and grass filters, are uniformly graded vegetated surfaces (i.e., grass or close-growing native vegetation) that receive runoff from adjacent impervious areas. Vegetated filter strips typically treat sheet flow or small concentrated flows that can be distributed along the width of the strip using a level spreader. Vegetated filter strips are designed to slow runoff velocities, trap sediment, and promote infiltration, thereby reducing runoff volumes.

Ability to meet specific standards

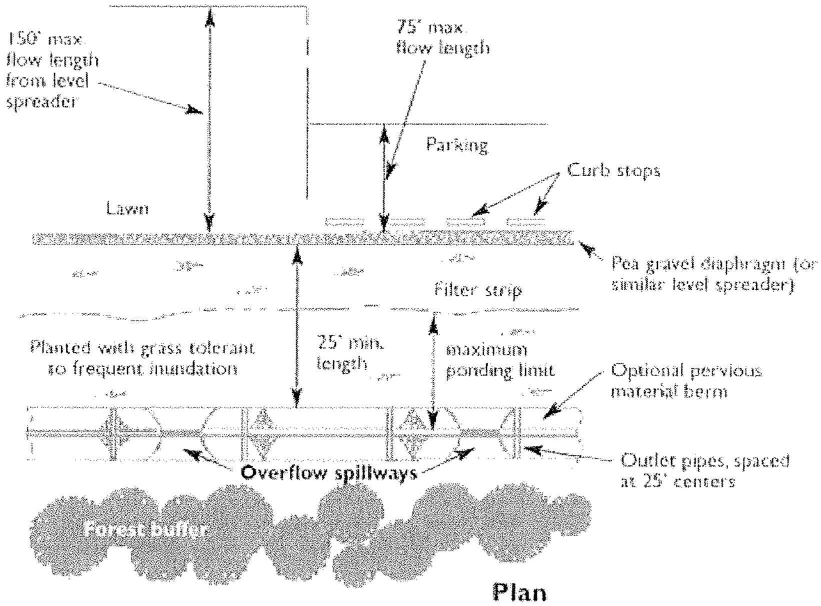
Standard	Description
2 - Peak Flow	Provides some peak flow attenuation but usually not enough to achieve compliance with Standard 2
3 - Recharge	No recharge credit
4 - TSS Removal	If greater than or equal to 25' and less than 50' wide, 10% TSS removal. If greater than or equal to 50' wide, 45% TSS removal.
5 - Higher Pollutant Loading	May be used as part of a pretreatment train if lined
6 - Discharges near or to Critical Areas	May be used as part of a pretreatment train if lined. May be used near cold-water fisheries.
7 - Redevelopment	Suitable for pretreatment or as a stand-alone practice if sufficient land is available.

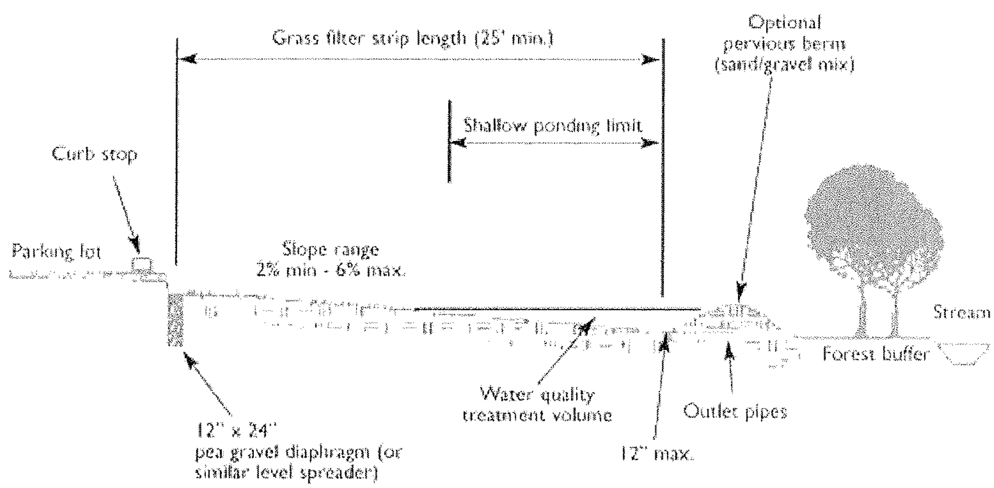
Advantages/Benefits:
- Reduces runoff volumes and peak flows.
- Slows runoff velocities and removes sediment.
- Low maintenance requirements.
- Serves as an effective pretreatment for bioretention cells
- Can mimic natural hydrology
- Small filter strips may be used in certain urban settings.
- Ideal for residential settings and to treat runoff from small parking lots and roads.
- Can be used as part of runoff conveyance system in combination with other BMPs
- Little or no entrapment hazard for amphibians or other small creatures

Disadvantages/Limitations:
- Variability in removal efficiencies, depending on design
- Little or no treatment is provided if the filter strip is short-circuited by concentrated flows.
- Often a poor retrofit option due to large land requirements.
- Effective only on drainage areas with gentle slopes (less than 6 percent).
- Improper grading can greatly diminish pollutant removal.

Pollutant Removal Efficiencies

• TSS (if filter strip is 25 feet wide)	10% assumed (Regulatory)
• TSS (if filter strip is 50 feet wide)	45% assumed (Regulatory)
• Nutrients (Nitrogen, phosphorus)	Insufficient data
• Metals (copper, lead, zinc, cadmium)	Insufficient data
• Pathogens (coliform, e coli)	Insufficient data





adapted from the "Design of Stormwater Systems" 1996

Maintenance

Activity	Frequency
Inspect the level spreader for sediment buildup and the vegetation for signs of erosion, bare spots, and overall health.	Every six months during the first year. Annually thereafter.
Regularly mow the grass.	As needed
Remove sediment from the toe of slope or level spreader and reseed bare spots.	As needed

Special Features

Include an impermeable liner and underdrain for discharges from Land Use with Higher Potential Pollutant Loads and for discharges within Zone IIs and Interim Wellhead Protection Areas; for discharges near or to other critical areas or in soils with rapid infiltration rates greater than 2.4 inches per hour.

Vegetated Filter Strips

Applicability

Vegetated filter strips are used to pretreat sheet flow from roads, highways, and small parking lots. In residential settings, they are useful in pretreating sheet flow from driveways. They provide effective pretreatment, especially when combined with bioretention areas and stream buffers. Urban areas can sometimes accommodate small filter strips depending on available land area, making them potential retrofit options in certain urban settings. Vegetated filter strips can also be used as side slopes of grass channels or water quality swales to enhance infiltration and remove sediment.

Effectiveness

Variable TSS removal efficiencies have been reported for filter strips, depending on the size of the contributing drainage area, the width of the filter strip, the underlying parent soil, the land slope, the type of vegetation, how well the vegetation is established, and maintenance practices. Vegetated filter strips may remove nutrients and metals depending on the length and slope of the filter, soil permeability, size and characteristics of the drainage area, type of vegetative cover, and runoff velocity.

Planning Considerations

Vegetated filter strips may be used as a stand-alone practice for redevelopments, only where other practices are not feasible. Vegetated filter strips can be designed to fit within the open space and rights of way that are available along roads and highways. Do not design vegetated filter strips to accept runoff from land uses with higher potential pollutant loads (LUHHPL) without a liner. Vegetated filter strips function best for drainage areas of one acre or less with gentle slopes.

Design

Do not locate vegetated filter strips in soils with high clay content that have limited infiltration or in soils that cannot sustain grass cover.

The filter strip cannot extend more than 50 feet into a Buffer Zone to a wetland resource area.

The contributing drainage area to a vegetated filter strip is limited to one acre of less.

Design vegetated filter strips with slopes between 2 and 6 percent. Steeper slopes tend to create concentrated flows. Flatter slopes can cause ponding and create mosquito-breeding habitat.

Design the top and toe of the slope to be as flat as possible. Use a level spreader at the top of the slope to evenly distribute overland flows or concentrated runoff across the entire length of the filter strip. Many variations of level spreader designs may be used including level trenches, curbing and concrete weirs. The key to any level spreader design is creating a continuous overflow elevation along the entire width of the filter strip.

Velocity dissipation (e.g. by using riprap) may be required for concentrated flows.

Design the filter strip to drain within 24 hours after a storm. The design flow depth must not exceed 0.5 inches.

To recieve TSS removal credit, make the filter strip at least 25 feet long and generally as wide as the area draining to the strip. To prevent high-velocity concentrated flows, the length of the flow path must be limited to 75 feet if the filter strip handles runoff from impervious surfaces, and 150 feet if the filter strip handles runoff from pervious surfaces. The minimum width of the filter strip must be 20% of the length of the flow path or 8 feet, whichever is greater.

To prevent groundwater contamination, the filter strip must be constructed at least 2 feet above seasonal high groundwater and 2 to 4 feet above bedrock.

The filter strip must be planted with grasses that are relatively salt-tolerant. Select grasses to withstand high flow velocities under wet weather conditions.

A vegetated filter strip may be used as a qualifying pervious area for purposes of the LID Site Design Credits for disconnecting rooftop and nonroof top runoff.

Construction

Proper grading is essential to establish sheet flow from the level spreader and throughout the filter strip.

Implement soil stabilization measures until permanent vegetation is established.

Protect the area to be used for the filter strip by using upstream sediment traps.

Use as much of the existing topsoil on the site as possible to enhance plant growth.

Maintenance

Regular maintenance is critical for filter strips to be effective and to ensure that flow does not short-circuit the system. Conduct semi-annual inspections during the first year (and annually thereafter). Inspect the level spreader for sediment buildup and the vegetation for signs of erosion, bare spots, and overall health. Regular, frequent mowing of the grass is required. Remove sediment from the toe of slope or level spreader, and reseed bare spots as necessary. Periodically, remove sediment that accumulates near the top of the strip to maintain the appropriate slope and prevent formation of a "berm" that could impede the distribution of runoff as sheet flow.

When the filter strip is located in the buffer zone to a wetland resource area, the operation and maintenance plan must include strict measures to ensure that maintenance operations do not alter the wetland resource areas. Please note, filter strips are restricted to the outer 50 feet of the buffer zone.

Cold Climate Considerations

In cold climates such as Massachusetts, the depth of soil media that serves as the planting bed must extend below the frost line to minimize the effects of freezing. Avoid using peat and compost media, which retain water and freeze during the winter, and become impermeable and ineffective.

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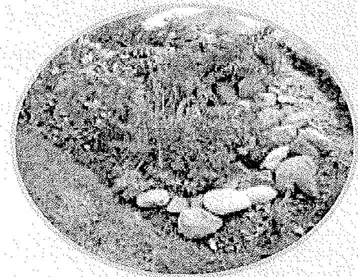
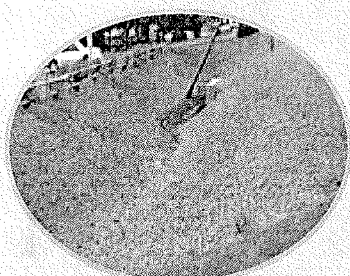
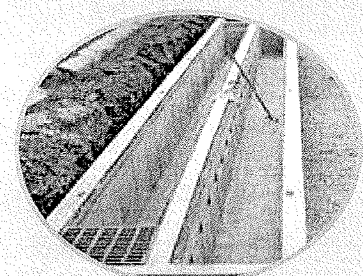
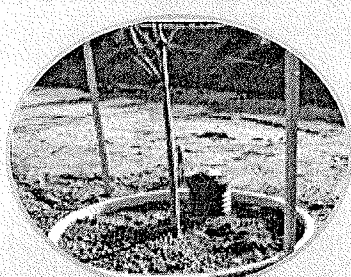
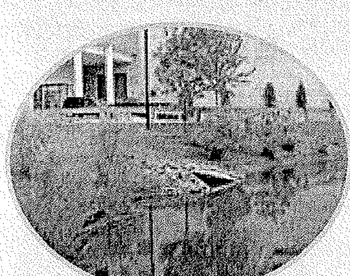










Bioretention Areas & Rain Gardens

Description: Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with dense native vegetation. Stormwater runoff is directed into the cell via piped or sheet flow. The runoff percolates through the soil media that acts as a filter.

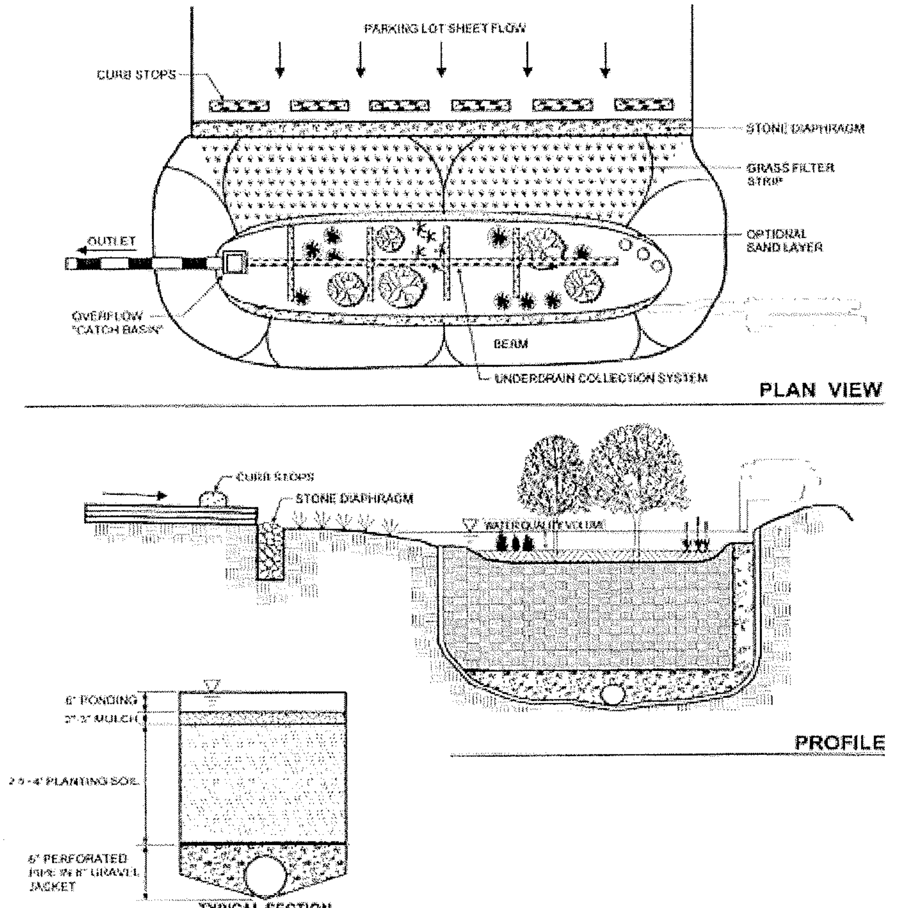
There are two types of bioretention cells: those that are designed solely as an organic filter filtering bioretention areas and those configured to recharge groundwater in addition to acting as a filter exfiltrating bioretention areas. A filtering bioretention area includes an impermeable liner and underdrain that intercepts the runoff before it reaches the water table so that it may be conveyed to a discharge outlet, other best management practices, or the municipal storm drain system. An exfiltrating bioretention area has an underdrain that is designed to enhance exfiltration of runoff into the groundwater.

Ability to meet specific standards

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

Pollutant Removal Efficiencies

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



EXAMPLE OF BIORETENTION *adapted from the Vermont Stormwater Manual*

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

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

Disadvantages/Limitations:
- Requires careful landscaping and maintenance
- Not suitable for large drainage areas

Maintenance

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

Bioretention Areas & Rain Gardens

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

Applicability

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

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

Effectiveness

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

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

Planning Considerations

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

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

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

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

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

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

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

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

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

Design

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

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

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

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

Engineered Soil Mix for Bioretention Systems Designed to Exfiltrate

- The soil mix for bioretention areas should be a mixture of sand compost and soil.
  - o 40 % sand,
  - o 20-30% topsoil, and
  - o 30-40% compost.
- The soil mix must be uniform, free of stones, stumps, roots or similar objects larger than 2 inches. Clay content should not exceed 5%.
- Soil pH should generally be between 5.5-6.5, a range that is optimal for microbial activity and adsorption of nitrogen, phosphorus, and other pollutants.
- Use soils with 1.5% to 3% organic content and maximum 500-ppm soluble salts.
- The sand component should be gravelly sand that meets ASTM D 422.

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

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

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

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

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

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

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

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

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

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

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

Construction

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

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

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

Maintenance

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

Bioretention Maintenance Schedule

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

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

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

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

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

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

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

Cold Climate Considerations

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

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Plant Species Suitable for Use in Bioretention - Herbaceous Species

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

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

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

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Itea virginica tassel-white, Virginia sweetspire	OBL	Mesic	1-2	M	–	–	M	Sun or shade	Broad-leaved, deciduous shrub	6-12'	–	Yes	Low	–
Juniperus communis 'compressa' common juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Mounded shrub	3-6'	Deep taproot	No	High	Evergreen
Juniperus horizontalis 'Bar Harbor' creeping juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Matted shrub	0-3'	Deep taproot	No	High	Evergreen
Lindera benzoin spicebush	FACW	Mesic to wet Mesic	2-4	H	–	–	H	Sun	Upright shrub	6-12'	Deep	Yes	High	–
Myrica pennsylvanica bayberry	FAC	Mesic	2-4	H	M	M	H	Sun to partial sun	Rounded, compact shrub	6-8'	Shallow	Yes	High	Coastal plain species.
Physocarpus opulifolius ninebark	FAC	Dry Mesic to wet Mesic	2-4	M	–	–	H	Sun	Upright shrub	6-12'	Shallow	Yes	Med	May be difficult to locate
Viburnum cassinoides northern wild raisin	FACW	Mesic	2-4	H	H	H	H	Sun to partial sun	Rounded, compacted shrub	6-8'	Shallow	Yes	High	–
Viburnum dentatum arrow-wood	FAC	Mesic to wet	2-4	H	H	H	H	Sun to partial sun	Upright, multi-stemmed shrub	8-10'	Shallow	Yes	High	–
Viburnum lentago nannyberry	FAC	Mesic	2-4	H	H	H	H	Sun to partial sun	Upright, mlti-stemmed shrub	8-10'	Shallow	Yes	High	–

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Acer rubrum red maple	FAC	Mesic-Hydric	4-6	H	H	H	H	Partial sun	Single to multi-stem tree	50-70'	Shallow	Yes	High	-
Amelanchier canadensis shadbush	FAC	Mesic	2-4	H	M	-	H	Partial sun	Single to multi-stem tree	35-50'	Shallow	Yes	High	Not recommended for full sun.
Betula nigra river birch	FACW	Mesic-Hydric	4-6	-	M	M	H	Partial sun	Single to multi-stem tree	50-75'	Shallow	Yes	High	Not susceptible to bronze birch borer.
Betula populifolia gray birch	FAC	Xeric-Hydric	4-6	H	H	M	H	Partial sun	Single to multi-stem tree	35-50'	Shallow to deep	No	High	Native to New England area.
Fraxinus americana white ash	FAC	Mesic	2-4	M	H	H	H	Sun	Large tree	50-80'	Deep	Yes	Low	-
Fraxinus Pennsylvanica green ash	FACW	Mesic	4-6	M	H	H	H	Partial sun	Large tree	40-65'	Shallow to deep	Yes	Low	-
Ginko biloba Maidenhair tree	FAC	Mesic	2-4	H	H	H	H	Sun	Large tree	50-80'	Shallow to deep	No	Low	Avoid female species-offensive odor from fruit.
Gleditsia triacanthos honeylocust	FAC	Mesic	2-4	H	M	-	M	Sun	Small caopied large tree	50-75'	Shallow to deep variable taproot	Yes	Low	Select thornless variety.
Juniperus virginiana eastern red cedar	FACU	Mesic-Xeric	2-4	H	H	-	H	Sun	Dense single stem tree	50-75'	Taproot	Yes	Very high	Evergreen
Liquidambar styraciflua sweet gum	FAC	Mesic	4-6	H	H	H	M	Sun	Large tree	50-70'	Deep taproot	Yes	High	Edge and perimeter, fruit is a maintenance problem.
Nyssa sylvatica black gum	FACW	Mesic-Hydric	4-6	H	H	H	H	Sun	Large tree	40-70'	Shallow to deep taproot	Yes	High	-

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

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Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name **Common Name**	**Indicator Status**	**Habitat**	**Ponding (days)**	**Salt**	**Oil/ Grease**	**Metals**	**Insects/ Disease**	**Exposure**	**Form**	**Height**	**Root System**	**Native**	**Wildlife**	
Sophora japonica Japanese pagoda tree	FAC	Mesic	1-2	M	M	_	M	Sun	Shade tree	40-70'	Shallow	No	Low	Fruit stains sidewalk
Taxodium distichum bald cypress	FACW	Mesic-Hydric	4-6	_	_	M	H	Sun to partial sun	Typically single stem tree	75-100'	Shallow	Yes	Low	Not well documented for planting in urban areas.
Thuja occidentalis arborvitae	FACW	Mesic to wet Mesic	2-4	M	M	M	H	Sun to partial sun	Dense single stem tree	50-75'	Shallow	No	Low	Evergreen
Zelkova serrata Japanese zelkova	FACU	Mesic	1-2	M	M	_	H	Sun	Dense shade tree	60-70'	Shallow	No	Low	Branches can split easily in storms.

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Description: Constructed stormwater wetlands are stormwater wetland systems that maximize the removal of pollutants from stormwater runoff through wetland vegetation uptake, retention and settling. Constructed stormwater wetlands temporarily store runoff in shallow pools that support conditions suitable for the growth of wetland plants. Like extended dry detention basins and wet basins, constructed stormwater wetlands must be used with other BMPs, such as sediment forebays. There is also an innovative constructed wetland—the gravel wetland—that acts as a filter. Information on the gravel wetland is presented at the end of this section.

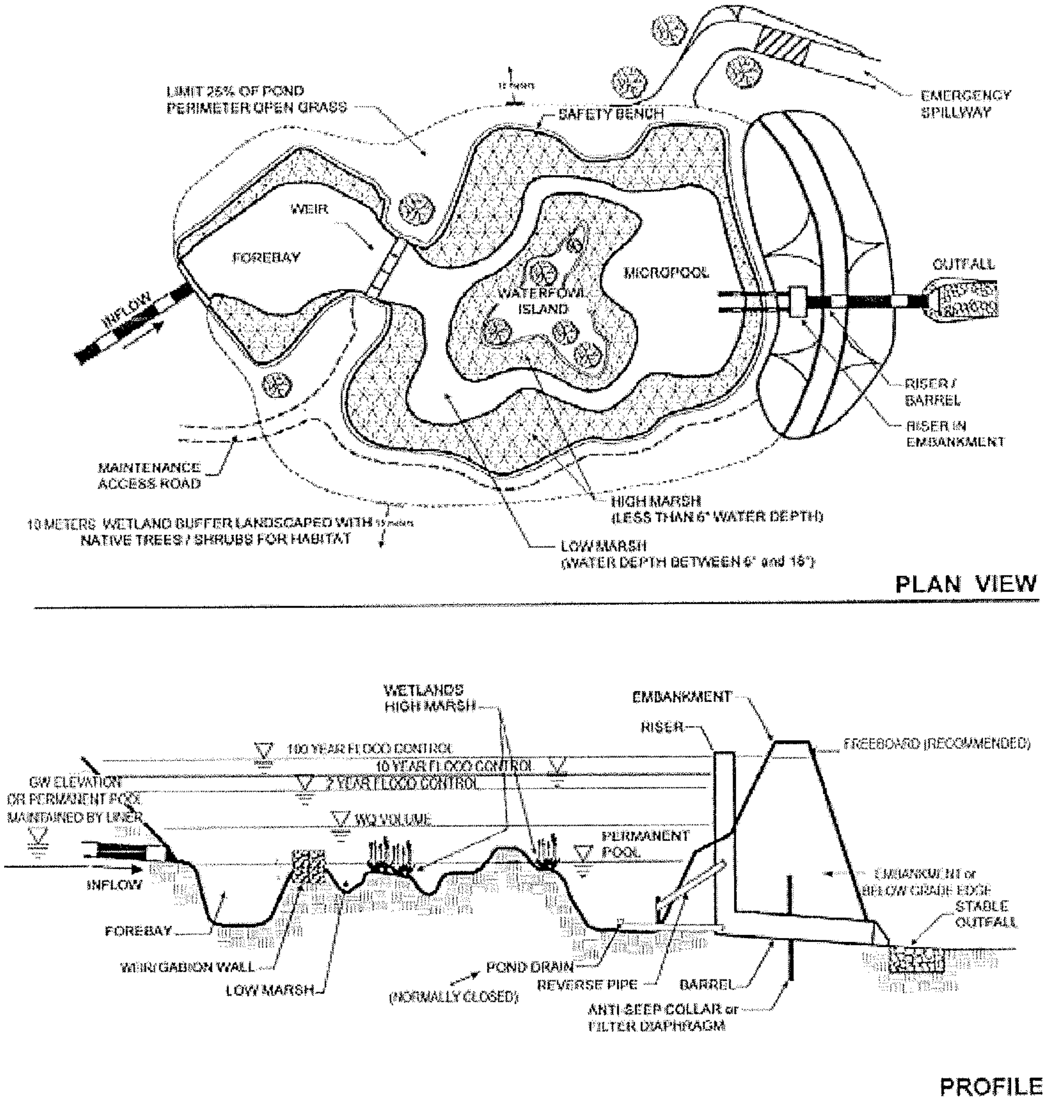
Ability to meet specific standards

Standard	Description
2 - Peak Flow	If properly designed, can provide peak flow attenuation.
3 - Recharge	Provides no groundwater recharge.
4 - TSS Removal	Provides 80% TSS removal when combined with sediment forebay for pretreatment
5 - Higher Pollutant Loading	May be used as treatment BMP provided basin bottom is lined and sealed
6 - Discharges near or to Critical Areas	Do not use near cold-water fisheries. Highly recommended for use near other critical areas.
7 - Redevelopment	Suitable if sufficient space is available.

Pollutant Removal Efficiencies
- Total Suspended Solids (TSS) - 80% with pretreatment
- Total Nitrogen - 20% to 55%
- Total Phosphorus - 40% to 60%
- Metals (copper, lead, zinc, cadmium) - 20% to 85%
- Pathogens (coliform, e coli) - Up to 75%

Advantages/Benefits:
- Relatively low maintenance costs.
- High pollutant removal efficiencies for soluble pollutants and particulates.
- Removes nitrogen, phosphorus, oil and grease
- Enhances the aesthetics of a site and provides recreational benefits.
- Provides wildlife habitat.

Disadvantages/Limitations:
- Depending upon design, more land requirements than other BMPs.
- Until vegetation is well established, pollutant removal efficiencies may be lower than anticipated.
- Relatively high construction costs compared to other BMPs.
- May be difficult to maintain during extended dry periods
- Does not provide recharge
- Creates potential breeding habitat for mosquitoes
- May present a safety issue for nearby pedestrians
- Can serve as decoy wetlands, intercepting breeding amphibians moving toward vernal pools.



Example of Constructed Wetland: Shallow Marsh Type

adapted from Schueler 1992

Maintenance

Activity	Frequency
Inspect wetland during both the growing and non-growing seasons	Twice a year for the first three years of construction,
Clean out forebays	Once a year
Clean out sediment in basin/wetland systems	Once every 10 years

Special Features

There are five basic types of constructed stormwater wetlands: shallow marsh systems, basin/wetland systems, extended detention wetlands, pocket wetlands, and gravel wetlands.

Like other stormwater BMPs, constructed stormwater wetlands may not be located within natural wetland areas other than riverfront area, land subject to coastal storm flowage, isolated land subject to flooding or bordering land subject to flooding.

The Operation and Maintenance Plan for constructed stormwater wetlands must include measures for monitoring and preventing the spread of invasive species.

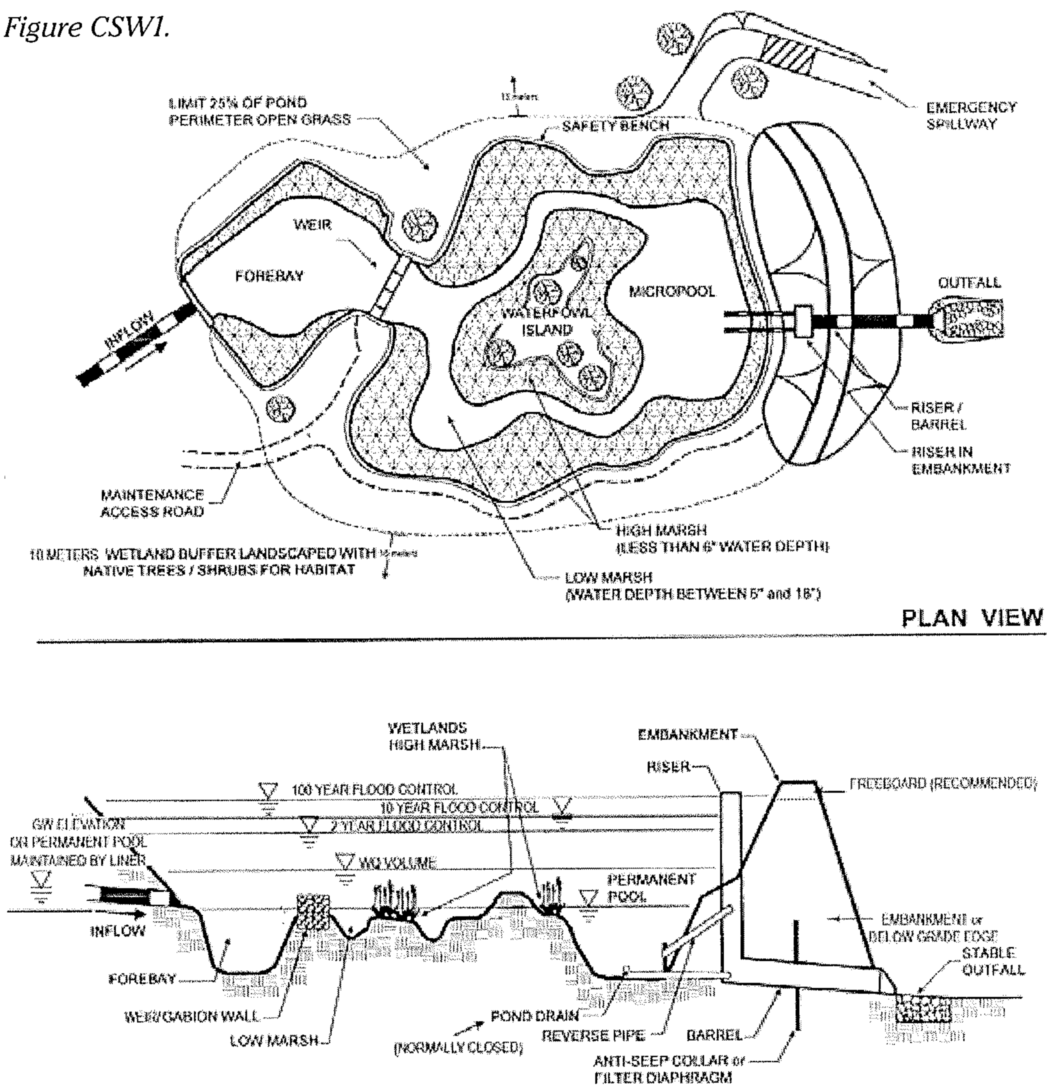
The Five Basic Types of Constructed Stormwater Wetlands

Like wet basins, most constructed stormwater wetlands require relatively large contributing drainage areas and dry weather base flows. Ten acres is the minimum contributing drainage area, although pocket type wetlands may be appropriate for smaller sites, if sufficient groundwater flow is available. There are five basic constructed wetland designs: 1) Shallow Marsh, 2) Basin/Wetland (formerly Pond/Wetland) 3)Extended Detention (ED) Wetland, 4) Pocket Wetland, and 5) Gravel Wetlands. In addition to these designs, there is a sixth type known as a subsurface gravel wetland. However, due to the lack of performance data, MA currently does not recognize subsurface gravel wetlands as having a presumed TSS removal credit.

Shallow marsh systems

Most shallow marsh systems consist of pools ranging from 6 to 18 inches deep during normal conditions. Shallow marshes may be configured with different low marsh and high marsh areas, which are referred to as cells. Shallow marshes are designed with sinuous pathways to increase retention time and contact area. Shallow marshes may require larger contributing drainage areas than other systems, as runoff volumes are stored primarily within the marshes, not in deeper pools where flow may be regulated and controlled over longer periods of time.

Figure CSW1.

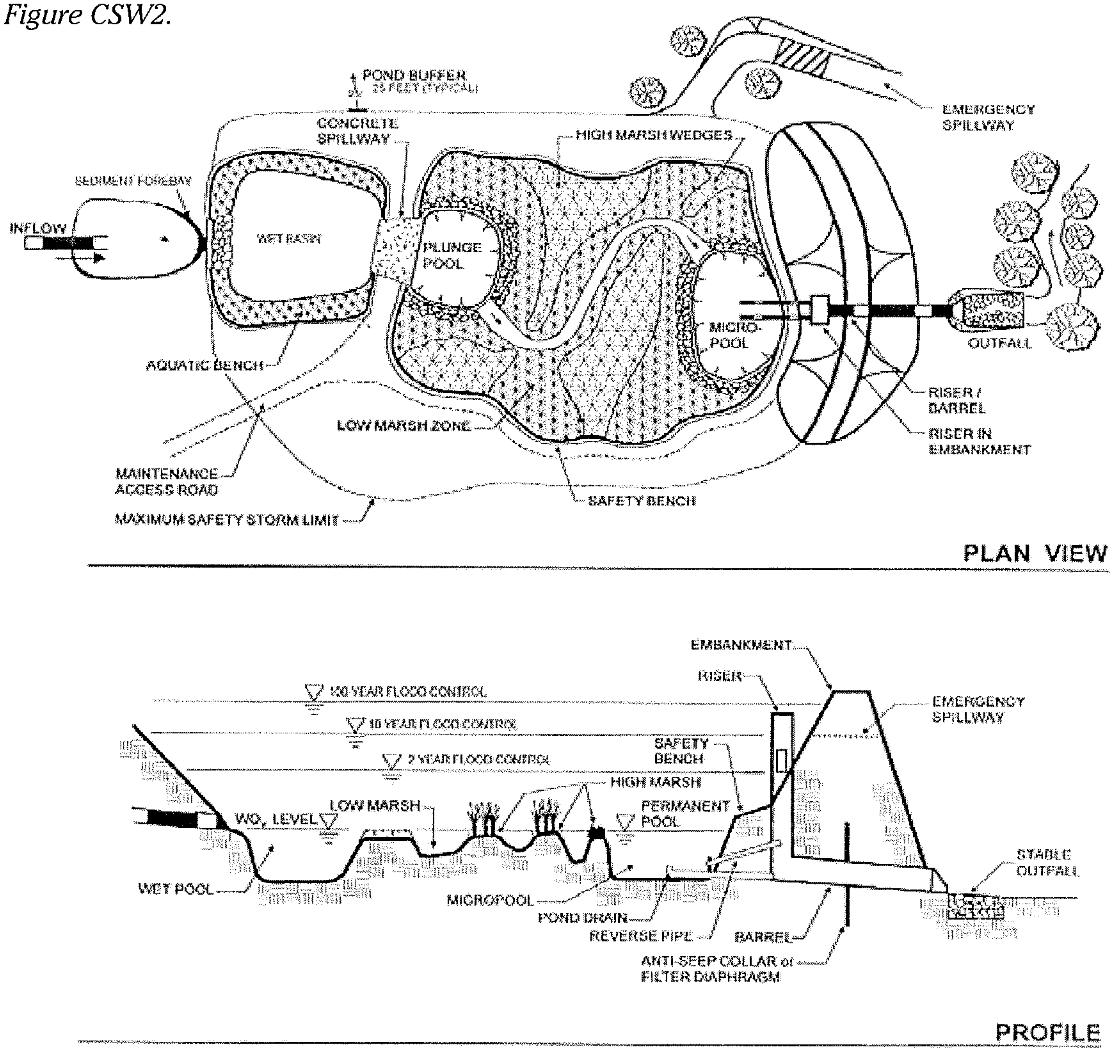


Shallow Marsh Constructed Stormwater Wetland adapted from Schueler 1992

Basin/wetland systems (formerly pond/wetland system)

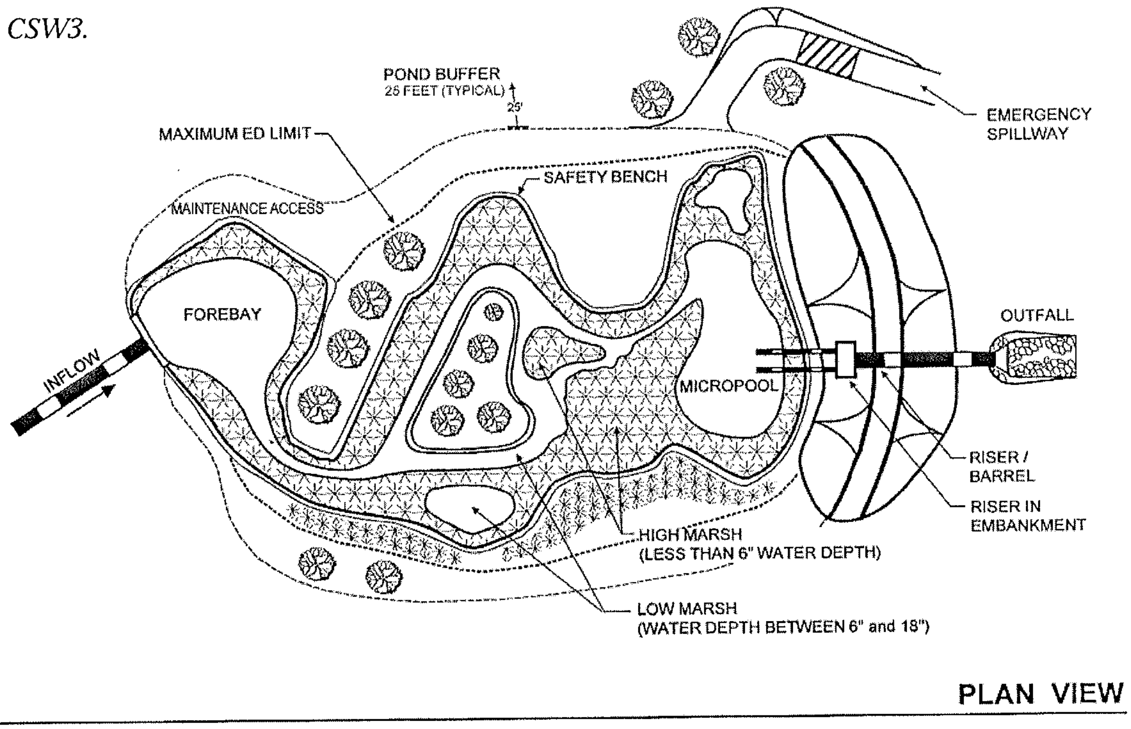
Multiple cell systems, such as basin/wetland systems, use at least one wet basin along with a shallow marsh component. The first cell is a sediment forebay that outlets to a wet basin, which removes particulate pollutants. The wet basin also reduces the velocity of the runoff entering the system. Stormwater then travels to the next cell, which contains a plunge pool. The plunge pool acts as an energy dissipator. Shallow marshes provide additional treatment of runoff, particularly for dissolved pollutants. These systems require less space than the shallow marsh systems and generally achieve a higher pollutant removal rate than other stormwater wetland systems.

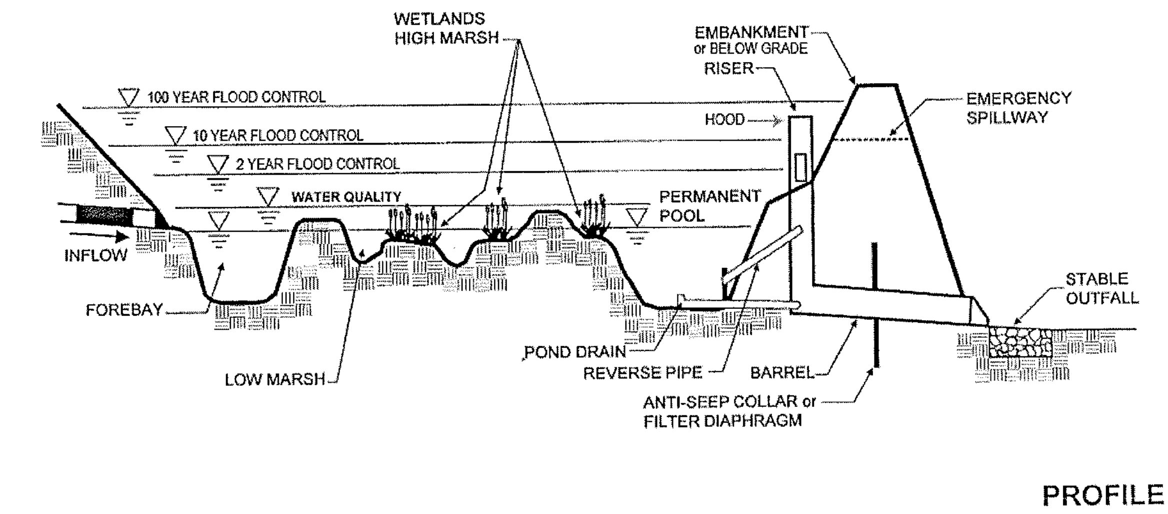
Figure CSW2.



Basin/Wetland Constructed Stormwater Wetland adapted from Schueler 1992

Figure CSW3.



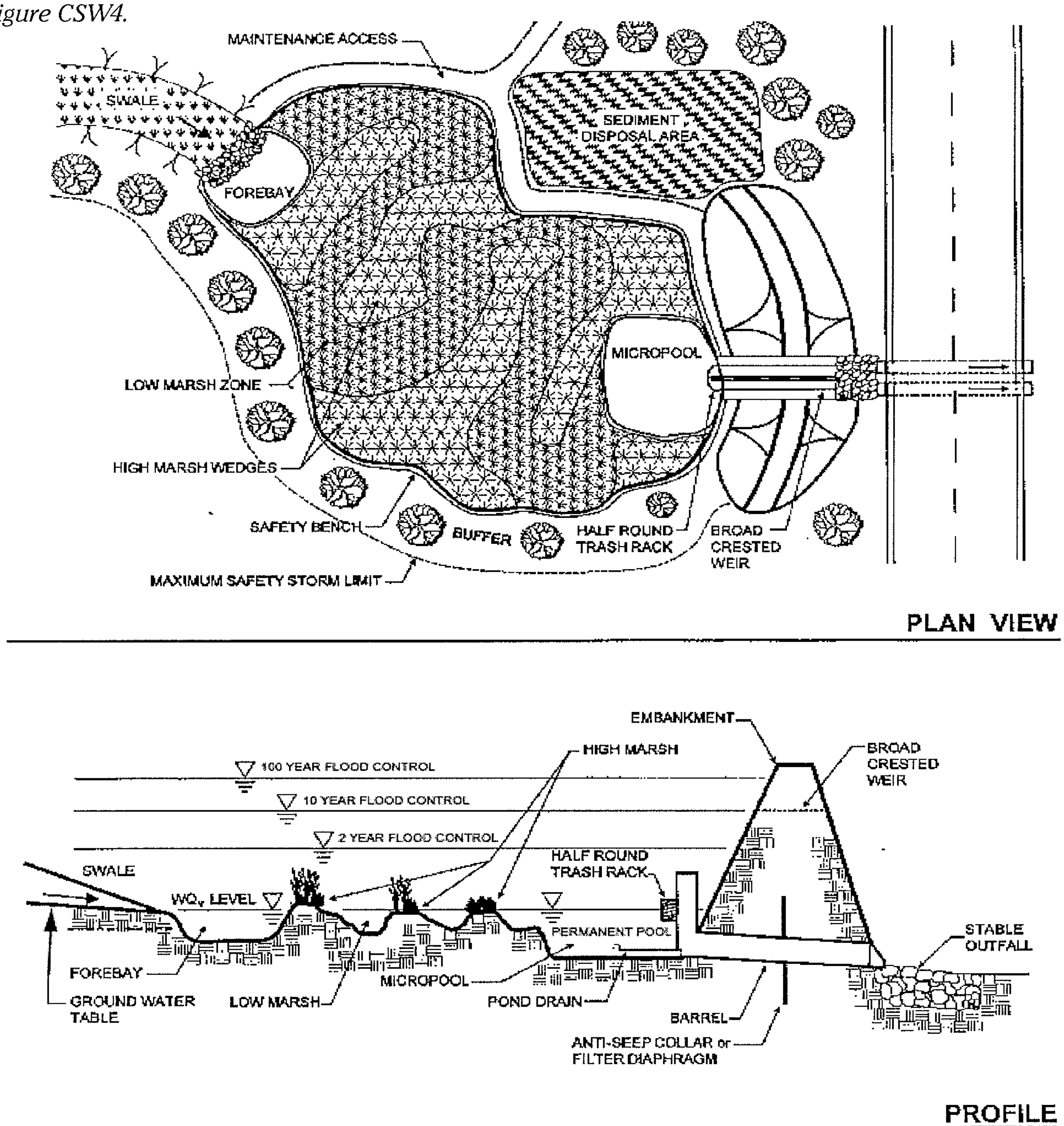


Extended Wetland Constructed Stormwater Wetland adapted from Schueler 1992

Extended detention wetlands

Extended detention wetlands provide a greater degree of downstream channel protection. These systems require less space than shallow marsh systems, because temporary vertical storage substitutes for shallow marsh storage. The additional vertical storage area also provides extra runoff detention above normal elevations. Water levels in the extended detention wetlands may increase by as much as three feet after a storm, and return gradually to normal within 24 hours of the rain event. The growing area in extended detention wetlands expands from the normal pool elevation to the maximum surface water elevation. Wetlands plants that tolerate intermittent flooding and dry periods should be selected for the extended detention area above the shallow marsh elevations.

Figure CSW4.



Pocket Wetland Constructed Stormwater Wetland adapted from Schueler 1992

Pocket wetlands

Use these systems for smaller drainage areas from one to ten acres. To maintain adequate water levels, excavate pocket wetlands to the groundwater table. Pocket wetlands that are supported exclusively by stormwater runoff generally will have difficulty maintaining marsh vegetation during normal dry periods each summer.

Applicability

Never use constructed stormwater wetlands to manage runoff during site grading and construction. Site constraints that can limit the suitability of constructed stormwater wetlands include inappropriate soil types, depth to groundwater, contributing drainage area, and available land area. Soils consisting entirely of sands are inappropriate unless the groundwater table intersects the bottom of the constructed wetland or the constructed stormwater wetland is installed over the sand to hold water. Where land area is not a limiting factor, several wetland design types may be possible. Consider pocket wetlands where land area is limited.

Do not locate constructed stormwater wetlands within natural wetland areas. These engineered stormwater wetlands differ from wetlands constructed for compensatory storage purposes and wetlands created for restoration or replication. Typically, constructed stormwater wetlands will not have the full range of ecological functions of natural wetlands. Constructed stormwater wetlands are designed specifically to improve water quality. Note that constructed stormwater wetlands do not create any additional wetland resource area or buffer zones as discussed in Volume 1, Chapter 2.

Before designing and siting constructed stormwater wetlands, investigate soil types, depth to bedrock, and depth to water table. Medium-fine texture soils (such as loams and silt loams) are best at establishing vegetation, retaining surface water, facilitating groundwater discharge, and capturing pollutants. At sites where infiltration is too rapid to sustain permanent soil saturation (such as sandy soils), consider using an impermeable liner. Liners are also required where the potential for groundwater contamination from runoff is high, such as from sites with high potential pollutant loads.

At sites where bedrock is close to the surface, high excavation costs may make constructed stormwater wetlands infeasible. Table CSW.1 lists the recommended minimum design criteria for constructed stormwater wetlands.

Effectiveness

A review of the existing performance data indicates that the removal efficiencies of constructed stormwater wetlands are significantly higher than the removal efficiencies of dry extended detention basins. Indeed constructed stormwater wetlands are among the most effective treatment practices.

To preserve their effectiveness, MassDEP requires placing a sediment forebay as pretreatment for all constructed stormwater wetlands.

Studies indicate that removal efficiencies of constructed stormwater wetlands decline when they are covered by ice or receive runoff derived from snow melt. Performance also declines during the non-growing season and the fall when vegetation dies off. Expect lower pollutant removal efficiencies until vegetation is re-established.

One preferred wetland installation is to combine an off-line stormwater wetland design, for runoff quality treatment, with an on-line runoff quantity control, because large surges of water can damage wetlands. Further, the shallow depths required to maintain the wetlands conflict with the need to store large volumes to control runoff quantity.

Planning Considerations

Carefully evaluate sites when planning constructed stormwater wetlands. Investigate soils, depth to bedrock, and depth to water table before designing, permitting, and siting constructed wetlands. Proponents must consider a "pond-scaping plan" for each constructed stormwater wetland. The plan must contain the location, quantity and propagation methods for the wetland plants as well as site preparation and maintenance. The plan should also include a wetland design and configuration, elevations and grades, a site/soil analysis, estimated depth zones, and hydrological calculations or water budgets. The water budget must demonstrate that a continuous supply of water is available to sustain the constructed stormwater wetland. Develop the water budget during site selection and then check it after the preliminary site design. The water budget analysis must be based on the Thornwaite method, arranging data in a "bookkeeping" or "spreadsheet" format. The water budget must take into account prcipitation, runoff, evaporatranspiration, soil moisture, and groundwater inputs. Drying periods of longer than two months adversely affect the richness of the plant community, so make sure that the water budget confirms that the drying time will not exceed two months.

Chapter 3

Checklist for Redevelopment Projects

Standard 7: A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural stormwater best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

Redevelopment is defined to include

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

Components of redevelopment projects that include development of previously undeveloped sites do not meet this definition. The portion of the project located in a previously developed area must meet Standard 7, but project components within undeveloped areas must meet all the Standards.

MassDEP recognizes that site constraints often make it difficult to comply with all the Standards at a redevelopment site. These constraints are as follows:

> **Lack of space**. Because of the presence of existing structures, on-site subsurface sewage disposal systems, stormwater best management practices, and water bodies and wetlands, and easements, the space available for the installation of additional stormwater BMPs may be quite limited. On many suites it may be difficult or impossible to use space-intensive BMPs such as wet detention basins.
>
> **Soils**: The presence of bedrock or clay can limit the effectiveness of infiltration or detention BMPs. Often soils at redevelopment sites have been compacted by buildings and heavy traffic, impairing their ability to infiltrate stormwater into the ground.
>
> **Underground utilities**. The presence of underground utilities including gas and water mains, sewer pipes and electric cable conduits can greatly reduce the amount of land available for BMPs.

This chapter provides specific guidance and checklists to ensure that the applicant has met his/her obligations under Standard 7. Because it may be difficult for a redevelopment project to comply with all the Stormwater Management Standards, Standard 7 provides that a redevelopment project is required to comply with the following Standards only "to the maximum extent practicable": Standard 2, Standard 3, and the pretreatment and structural stormwater best management practice requirements of Standards 4, 5, and 6. Existing outfalls shall be brought into compliance with Standard 1 only to the maximum extent practicable.

As set forth in Standard 7, the phrase "to the maximum extent practicable" means that:

(1) Proponents of redevelopment projects have made all reasonable efforts to meet the requirements of Standards 2 and 3 and the pretreatment and structural stormwater best management practices requirements of Standards 4, 5, and 6 and to bring existing outfalls into compliance with Standard 1.

(2) They have made a complete evaluation of possible stormwater management measures, including environmentally sensitive site design that minimizes land disturbance and impervious surfaces, low impact development techniques and structural stormwater BMPs; and

(3) If not in full compliance with Standard 1 for existing outfalls, Standards 2 and 3 and the pretreatment and structural stormwater best management practice requirements of Standards 4, 5, and 6, they are implementing the highest practicable level of stormwater management.

Generally, an alternative is practicable if it can be implemented within the site being redeveloped, taking into consideration cost, land area requirements, soils and other site constraints. However, offsite alternatives may also be practicable. Proponents must document the evaluation of practicable alternatives with sufficient information to support the conclusions of the analysis.

At the same time, stormwater runoff from redevelopment projects must be properly managed. To this end, Standard 7 provides that redevelopment projects shall comply with all other requirements of the Stormwater Management Standards, including, without limitation, the pollution prevention requirements of Standards 4, 5, and 6, the erosion and sedimentation control requirements of Standard 8, the operation and maintenance requirements of Standard 9, and the prohibition of illicit discharge set forth in Standard 10. Proponents must also improve existing conditions.

Proponents of redevelopment projects shall document their compliance with these requirements. To assist proponents and reviewers in determining whether a redevelopment project complies with Standard 7, MassDEP has prepared the following redevelopment checklist.

[*Proponents of MassHighway redevelopment projects and Conservation Commissions reviewing such projects may follow the guidelines for redevelopment provided in the MassHighway Stormwater Handbook for Highways and Bridges (May 2004 or latest version) in lieu of the guidance set forth in this chapter.*[1] *The MassHighway Stormwater Handbook was developed by the Massachusetts Highway Department and issued by joint correspondence of May 7, 2004 by MassHighway and MassDEP. It provides detailed guidance on the evaluation and implementation of stormwater management practices for MassHighway road and bridge redevelopment projects, including a methodology for screening and selecting Best Management Practices (BMPs). Proponents and reviewers of other public roadway redevelopment projects may find useful information in the MassHighway Stormwater Handbook.*]

[1] The MassHighway Handbook published in 2004 must be revised to make it consistent with this Handbook.

Redevelopment Checklist

Existing Conditions

- On-site: For all redevelopment projects, proponents should document existing conditions, including a description of extent of impervious surfaces, soil types, existing land uses with higher potential pollutant loads, and current onsite stormwater management practices.
- Watershed: Proponents should determine whether the project is located in a watershed or subwatershed, where flooding, low streamflow or poor water quality is an issue.

The Project

Is the project a redevelopment project?

- Maintenance and improvement of existing roadways
- Development of rehabilitation, expansion or phased project on redeveloped site, or
- Remedial stormwater project

For non-roadway projects, is any portion of the project outside the definition of redevelopment?

- Development of previously undeveloped area
- Increase in impervious surface

If a component of the project is not a redevelopment project, the proponent shall use the checklist set forth below to document that at a minimum the proposed stormwater management system fully meets each Standard for that component. The proponent shall also document that the proposed stormwater management system meets the requirements of Standard 7 for the remainder of the project.

The Stormwater Management Standards

The redevelopment checklist reviews compliance with each of the Stormwater Management Standards in order.

Standard 1: (Untreated discharges)
No new stormwater conveyances (e.g., outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.
Same rule applies for new developments and redevelopments.

Full compliance with Standard 1 is required for new outfalls.

- What BMPs are proposed to ensure that all new discharges associated with the discharge are adequately treated?
- What BMPs are proposed to ensure that no new discharges cause erosion in wetlands or waters of the Commonwealth?
- Will the proposed discharge comply with all applicable requirements of the Massachusetts Clean Waters Act and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00?

Existing outfalls shall be brought into compliance with Standard 1 to the maximum extent practicable.

- Are there any existing discharges associated with the redevelopment project for which new treatment could be provided?
- If so, the proponent shall specify the stormwater BMP retrofit measures that have been considered to ensure that the discharges are adequately treated and indicate the reasons for adopting or rejecting those measures. (See Section entitled "Retrofit of Existing BMPs".)
- What BMPs have been considered to prevent erosion from existing stormwater discharges?

Standard 2: (Peak rate control and flood prevention)

Stormwater management systems must be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for land subject to coastal storm flowage.

Full compliance for any component that is not a redevelopment

Compliance to the Maximum Extent Practicable:

- Does the redevelopment design meet Standard 2, comparing post-development to pre-development conditions?
- If not, the applicant shall document an analysis of alternative approaches for meeting the Standard. (See Menu of Strategies to Reduce Runoff and Peak Flows and/or Increase Recharge Menu included at the end of this chapter.)

Improvement of existing conditions:

- Does the project reduce the volume and/or rate of runoff to less than current estimated conditions? Has the applicant considered all the alternatives for reducing the volume and/or rate of runoff from the site? (See Menu.)
- Is the project located within a watershed subject to damage by flooding during the 2-year or 10-year 24-hour storm event? If so, does the project design provide for attenuation of the 2-year and 10-year 24-hour storm event to less than current estimated conditions? Have measures been implemented to reduce the volume of runoff from the site resulting from the 2 year or 10 year 24 hour storm event? (See Menu.)
- Is the project located adjacent to a water body or watercourse subject to adverse impacts from flooding during the 100-year 24-hour storm event? If so, are portions of the site available to increase flood storage adjacent to existing Bordering Land Subject to Flooding (BLSF)?
- Have measures been implemented to attenuate peak rates of discharge during the 100-year 24-hour storm event to less than the peak rates under current estimated conditions? Have measures been implemented to reduce the volume of runoff from the site resulting from the 100-year 24-hour storm event? (See Menu.)

Standard 3: (Recharge to Ground water)

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

Full compliance for any component that is not a redevelopment

Compliance to the Maximum Extent Practicable:

- Does the redevelopment design meet Standard 3, comparing post-development to pre-development conditions?
- If not, the applicant shall document an analysis of alternative approaches for meeting the Standard?
- What soil types are present on the site? Is the site is comprised solely of C and D soils and bedrock at the land surface?
- Does the project include sites where recharge is proposed at or adjacent to an area classified as contaminated, sites where contamination has been capped in place, sites that have an Activity and Use Limitation (AUL) that precludes inducing runoff to the groundwater, pursuant to MGL Chapter 21E and the Massachusetts Contingency Plan 310 CMR 40.0000; sites that are the location of a solid waste landfill as defined in 310 CMR 19.000; or sites where groundwater from the recharge location flows directly toward a solid waste landfill or 21E site?[2]
- Is the stormwater runoff from a land use with a higher potential pollutant load?
- Is the discharge to the ground located within the Zone II or Interim Wellhead Protection Area of a public water supply?
- Does the site have an infiltration rate greater than 2.4 inches per hour?

Improvements to Existing Conditions:

- Does the project increase the required recharge volume over existing (developed) conditions? If so, can the project be redesigned to reduce the required recharge volume by decreasing impervious surfaces (make building higher, put parking under the building, narrower roads, sidewalks on only one side of street, etc.) or using low impact development techniques such as porous pavement?
- Is the project located within a basin or sub-basin that has been categorized as under high or medium stress by the Massachusetts Water Resources Commission, or where there is other evidence that there are rivers and streams experiencing low flow problems? If so, have measures been considered to replace the natural recharge lost as a result of the prior development? (See Menu.)
- Has the applicant evaluated measures for reducing site runoff? (See Menu.)

Standard 4: (80% TSS Removal)

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

> ***a. Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan and thereafter are implemented and maintained;***
> ***b. Stormwater BMPs are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and***
> ***c. Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.***

Full compliance for any component that is not a redevelopment
Full compliance with the long-term pollution plan requirement for new developments and redevelopments.

- Has the proponent developed a long-term pollution plan that fully meets the requirements of Standard 4?
- Does the pollution prevention plan include the following source control measures?
  - Street sweeping

[2] A mounding analysis is needed if a site falls within this category. See Volume 3.

  - Proper management of snow, salt, sand and other deicing chemicals
  - Proper management of fertilizers, herbicides and pesticides
  - Stabilization of existing eroding surfaces

Compliance to the Maximum Extent Practicable for the other requirements:

- Does the redevelopment design provide for treatment of all runoff from existing (as well as new) impervious areas to achieve 80% TSS removal? If 80% TSS removal is not achieved, has the stormwater management system been designed to remove TSS to the maximum extent practicable?
- Have the proposed stormwater BMPs been properly sized to capture the prescribed runoff volume?
  - One inch rule applies for discharge
    - within a Zone II or Interim Wellhead Protection Area,
    - near or to another critical area,
    - from a land use with a higher potential pollutant load
    - to the ground where the infiltration rate is greater than 2.4 inches per hour
- Has adequate pretreatment been proposed?
  - 44% TSS Removal Pretreatment Requirement applies if:
    - Stormwater runoff is from a land use with a higher potential pollutant load
    - Stormwater is discharged
      - To the ground within the Zone II or Interim Wellhead Protection Area of a Public Water Supply
      - To the ground with an infiltration rate greater than 2.4 inches per hour
      - Near or to an Outstanding Resource Water, Special Resource Water, Cold-Water Fishery, Shellfish Growing Area, or Bathing Beach.

- If the stormwater BMPs do not meet all the requirements set forth above, the applicant shall document an analysis of alternative approaches for meeting the these requirements. (See Section on Retrofitting Existing BMPs (the "Retrofit Section").

Improvements to Existing Conditions:

- Have measures been provided to achieve at least partial compliance with the TSS removal standard?
- Have any of the best management practices in the Retrofit Section been considered?
- Have any of the following pollution prevention measures been considered?
  - Reduction or elimination of winter sanding, where safe and prudent to do so
  - Tighter controls over the application of fertilizers, herbicides, and pesticides
  - Landscaping that reduces the need for fertilizer, herbicides and pesticides
  - High frequency sweeping of paved surfaces using vacuum sweepers
  - Improved catch basin cleaning
  - Waterfowl control programs
- Are there any discharges (new or existing) to impaired waters? If so, see TMDL section.

<u>Standard 5 (Higher Potential Pollutant Loads (HPPL)</u>

For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable. If through source control and/or pollution prevention, all land uses with higher potential pollutant loads cannot

be completely protected from exposure to rain, snow, snow melt and stormwater runoff, the proponent shall use the specific stormwater BMPs determined by the Department to be suitable for such use as provided in the Massachusetts Stormwater Handbook. Stormwater discharges from land uses with higher potential pollutant loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53, and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.
Full compliance for any component that is not a redevelopment.
Full compliance with pollution prevention requirements for new developments and redevelopments.

Pollution Prevention

- Has the proponent considered any of the following operational source control measures?
  - Formation of a pollution prevention team,
  - Good housekeeping practices,
  - Preventive maintenance procedures,
  - Spill prevention and clean up,
  - Employee training, and
  - Regular inspection of pollutant sources.

- Has the proponent considered implementation of any of the following operational changes to reduce the quantity of pollutants on site?
  - Process changes,
  - Raw material changes,
  - Product changes, or
  - Recycling.

- Has the proponent considered making capital improvements to protect the land uses with higher potential pollutant loads from exposure to rain, snow, snow melt, and stormwater runoff?

  - Enclosing and/or covering pollutant sources (e.g. placing pollutant sources within a building or other enclosure, placing a roof over storage and working areas, placing tarps under pollutant source)

  - Installing a containment system with an emergency shutoff to contain spills?

  - Physically segregating the pollutant source to prevent run-on of uncontaminated stormwater?

Treatment

- If applicable, compliance with the treatment and pretreatment requirements of Standard 5 only to the Maximum Extent Practicable by directing the stormwater runoff from land uses with higher potential pollutant loads to appropriate stormwater BMPs?

  - Are the BMPs selected capable of removing the pollutants associated with the higher potential pollutant load land ("LUHPPL") use?

  - Is the land use likely to generate stormwater with high concentrations of oil and grease? If so has an oil grit separator, sand filter, filtering bioretention area or equivalent been proposed for pretreatment?

Improvement of Existing Conditions.

- If the redevelopment converts a site from a non-LUHPPL use to a LUHPPL use, the applicant shall document how the stormwater BMPs shall be modified or replaced to come into compliance with Standard 5.

- What specific measures have been considered to offset the anticipated impacts of land uses with higher potential pollutant loads?

- If the redevelopment proposal is a brownfield project, the applicant shall demonstrate how the stormwater management measures have been designed to prevent mobilization or remobilization of soil and groundwater contamination. (See Brownfield section)

Other Requirements

- Does the discharge comply with all applicable requirements of the Massachusetts Clean Waters Act, 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00?

Standard 6 (Critical Areas)
Stormwater discharges to a Zone II or Interim Wellhead Protection Area of a public water supply and stormwater discharges near or any other critical area require the use of the specific source control and pollution prevention measures and the specific stormwater best management practices determined by the Department to be suitable for managing discharges to such area, as provided in the Massachusetts Stormwater Handbook. A discharge is near a critical area if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors. Stormwater discharges to Outstanding Resource Waters or Special Resource Waters shall be set back from the receiving water and receive the highest and best practical method of treatment. A "stormwater discharge," as defined in 314 CMR 3.04(2)(a)1. or (b), to an Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of the public water supply.
Full compliance for component of project that is not a redevelopment
Full compliance with pollution prevention requirements for new developments and redevelopments.

If applicable, compliance to the Maximum Extent Practicable with the pretreatment and treatment requirements of Standard 6:

- Does the redevelopment project utilize the pretreatment, treatment and infiltration BMPs approved for discharges near or to critical areas?
- If the redevelopment project does not comply with Standard 6, the applicant shall document an analysis of alternative measures for meeting Standard 6. (See Section on Specific Redevelopment Projects.)

Improvements to Existing Conditions:

- Have measures to protect critical areas been considered, including additional pollution prevention measures and structural and non-structural BMPs?

Other Requirements

- Does the discharge comply with the Massachusetts Clean Waters Act, 314 CMR 3.00, 314 CMR 4.00, and 314 CMR 5.00?

Standard 8: (Erosion, Sediment Control)

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

All redevelopment projects shall fully comply with Standard 8.

- Has the proponent submitted a construction period erosion, sedimentation and pollution prevention plan that meets the requirements of Standard 8?

Standard 9: (Operation and Maintenance)
A long-term operation and maintenance plan must be developed and implemented to ensure that stormwater management systems function as designed.
All redevelopment projects shall fully comply with Standard 9.

- Has the proponent submitted a long-term Operation and Maintenance plan that meets the requirements of Standard 9?

Standard 10 (Illicit Discharges)
All illicit discharges to the stormwater management system are prohibited.
All redevelopment projects shall fully comply with Standard 10.

- Are there any known or suspected illicit discharges to the stormwater management system at the redevelopment project site?
- Has an illicit connection detection program been implemented using visual screening, dye or smoke testing?
- Have an Illicit Discharge Compliance Statement and associated site map been submitted verifying that there are no illicit discharges to the stormwater management system at the site?

Improvements to Existing Conditions:

- Once all illicit discharges are removed, has the proponent implemented any measures to prevent additional illicit discharges?

Figure 5-1

Menu of Strategies to Reduce Runoff or Peak Flows and/or Increase Recharge

- Rehabilitate the soils
- Plant trees and other vegetation
- Install a green roof
- Maximize naturally vegetated areas
- Reduce impervious surfaces
- Disconnect roof runoff from direct discharge to the drainage system
- Disconnect other existing paved areas from direct discharge to the drainage system, allowing controlled flow over pervious areas or through BMPs providing at least partial recharge
- Install porous pavement and/or other recharge measures (where sustainable and maintainable for promoting infiltration)
- Apply LID techniques for runoff reduction
- Install additional structural BMPs that are appropriate for redevelopment sites including infiltration trenches, subsurface structures, oil-grit separators, proprietary BMPs
- Retrofit existing BMPs

Retrofitting Existing BMPs

Many BMPs can be effectively retrofitted depending on site conditions and the water quantity or quality objectives trying to be achieved.[3] The objective of stormwater retrofitting is to remedy problems associated with, and improve water quality mitigation functions of, older, poorly designed, or poorly maintained stormwater management systems. Prior to the development of the stormwater standards, site drainage design did not require stormwater detention for controlling post-development peak flows. As a result, drainage, flooding, and erosion problems can be common in many older developed areas of the state. Furthermore, a majority of the dry detention basins throughout the state have been designed to control peak flows, without regard to water quality mitigation. Therefore, many existing dry detention basins provide only minimal water quality benefit. Incorporating stormwater retrofits into existing developed sites or into redevelopment projects can reduce the adverse impacts of uncontrolled stormwater runoff.

Bioretention Area Retrofits - can be used as a stormwater retrofit, by modifying existing landscaped areas, or if a parking lot is being resurfaced. In highly urban watersheds, they are one of the few practical retrofit options.

Catch Basin Retrofits or Reconstruction - Older catch basins without sumps can be replaced with catch basins having four foot-deep sumps. Sumps provide storage volume for coarse sediments, assuming that accumulated sediment is removed on a regular basis. Hooded outlets, which are covers over the catch basin outlets that extend below the standing water line, can also be used to trap litter and other floatable materials. Leaching catch basins can be installed adjacent to deep sump catch basins to achieve 80% TSS removal. Be aware, however, that many products are being touted as catch basin inserts, but the effectiveness of these devices can vary significantly.

Dry Detention Basin Retrofits - Traditional dry detention basins can be modified to become extended dry detention basins, wet basins, or constructed stormwater wetlands for enhanced pollutant removal. This is one of the most commonly and easily implemented retrofits, since it typically requires little or no additional land area, capitalizes on an existing facility for which there is already some resident acceptance of stormwater management, and involves minimal impacts to environmental resources (Claytor, Center for Watershed Protection, 2000).

There are numerous retrofit options that will enhance the removal of pollutants in detention basins:

- Excavate the basin bottom to create more permanent pool storage.
- Raise the basin embankment to obtain additional storage for extended detention.
- Modify the outfall structure to create a two-stage release to better control small storms while not significantly compromising flood control detention for large storms.
- Increase the flow path from inflow to outflow and eliminate short-circuiting by using baffles, earthen berms or micro-pond topography to increase residence time.
- Incorporate stilling basins at inlets and outlets.
- Regrade the basin bottom to create a wetland area near the basin outlet or revegetate parts of the basin bottom with wetland vegetation to enhance pollutant removal, reduce mowing, and improve aesthetics.
- Create a wetland shelf along the perimeter of a wet basin to improve shoreline stabilization, enhance pollutant filtering, and enhance aesthetic and habitat functions.
- Create a low maintenance "no-mow" wildflower ecosystem in the drier portions of the basin.

[3] Additional information on retrofitting stormwater BMPs can be found in the Urban Stormwater Retrofit Practices Manual. See http://www.cwp.org/Downloads/ELC_USRM3app.pdf.

- Provide a high flow bypass to avoid resuspension of captured sediments/pollutants during high flows.
- Eliminate low-flow bypasses.

Drainage Channel Retrofits - Existing channelized streams and drainage conveyances such as drainage channels can be modified to reduce flow velocities and enhance pollutant removal. Weir walls or riprap check dams placed across a channel create opportunities for ponding, infiltration, and establishment of wetland vegetation upstream of the retrofit. In-stream retrofit practices include stream bank stabilization of eroded areas and placement of habitat improvement structures (i.e., flow deflectors, boulders, pools/riffles, and low-flow channels) in natural streams and along stream banks. In-stream retrofits may require an evaluation of potential flooding and floodplain impacts resulting from altered channel conveyance, as well as requirements for local, state, or federal approval for work in wetlands and watercourses.

Parking Lots and Roadways- Parking lots offer ideal opportunities for a wide range of stormwater retrofits:

1. Incorporate bioretention areas into parking lot islands and landscaped areas; tree planter boxes can be converted into functional bioretention areas, rain gardens, or treebox filters to reduce and treat stormwater runoff.
2. Remove curbing and add slotted curb stops. Curbs along the edges of parking lots can sometimes be removed or slotted to re-route runoff to vegetated filter strips, water quality swales, grass channels, or bioretention facilities. The capacity of existing swales may need to be evaluated and expanded as part of this retrofit option.
3. Incorporate new treatment practices such as bioretention areas, sand filters, and constructed stormwater wetlands at the edges of parking lots.
4. In overflow parking or other low-traffic areas, asphalt can be replaced with porous pavement.

Sand Filter Retrofits - are suitable where space is limited, because they consume little surface space and have few site restrictions. Since sand filters cannot treat large drainage areas, retrofitting many small individual sites may be the only option. This option may be expensive.

Storm Drain Outfalls - New stormwater treatment practices can be constructed at the outfalls of existing drainage systems. The new stormwater treatment practices are commonly designed as *off-line devices* to treat the first flush volume and bypass larger storms. Water quality swales, bioretention areas, sand filters, constructed stormwater wetlands, and wet basins are commonly used for this type of retrofit. Other stormwater treatment practices may also be used if there is enough space for construction and maintenance.

Specific Redevelopment Projects

Redevelopment projects present unique challenges for controlling stormwater. It is possible that site constraints may prevent a redevelopment project from complying with one or more of the Stormwater Management Standards. Even if a redevelopment project cannot meet all of the Standards, there may be ample opportunity to improve existing site conditions depending on the other water quality or quantity issues in the watershed. The following special considerations provide unique opportunities for identifying how existing conditions may be improved:

A. Groundwater Recharge Areas - Redevelopment projects located within these areas (Zone II, Interim Wellhead Protection Areas (IWPA), aquifer protection districts, etc.) should place a high priority on ground water recharge BMPs.
   1) Disconnecting Rooftop Runoff – In some instances, building roof drains connected to the stormwater drainage system can be disconnected and re-directed to vegetated filter strips, bioretention facilities, or infiltration structures (dry wells or infiltration trenches).
   2) Use of Porous Paving Materials - Existing impermeable pavement in overflow parking or other low-traffic areas can sometimes be replaced with alternative permeable materials such as modular concrete paving blocks, modular concrete or plastic lattice, or cast-in-place concrete grids. Site-specific factors including traffic volumes, soil permeability, maintenance, sediment loads, and land use must be carefully considered prior to selection.

B. Cold-Water Fisheries - Redevelopment projects adjacent to these areas should place a high priority on mitigating potential thermal impacts. Techniques to consider include:

   1) Maintain Time of Concentration - Time of concentration (Tc) is based on the flow path and length, ground cover, slope and channel shape. When development occurs, Tc is often shortened due to the impervious area, causing greater flows to occur over a shorter period of time. Increasing the Tc will help to reduce the thermal impact of stormwater runoff from warm surface areas. Options to consider include:
      - Increasing the length of the runoff flow path
      - Increasing the surface roughness of the flow path
      - Detaining flows on site
      - Minimizing land disturbance
      - Creating flatter slopes.
   2) Disconnecting impervious areas – Breaking up large impervious expanses with vegetated zones will reduce the potential temperature increases of stormwater flowing across hot pavement.

C. Brownfield Redevelopment – Redeveloping urban and non-urban brownfield sites (which in Massachusetts includes most "disposal sites" under the Massachusetts Contingency Plan [MCP]) are a Commonwealth priority, with ramifications for urban sprawl as well as the remediation of historically contaminated properties. Proponents of brownfield redevelopment projects should evaluate BMPs that will prevent the significant uncontrolled mobilization or remobilization of soil or ground water contamination. BMP considerations at these sites should consider such factors as:
   - The location of stormwater infiltration units with respect to contaminated areas
   - Ground water mounding effects on the rate and direction of migration of ground water contaminants
   - The location of outfalls
   - Water quality BMPs.

D. Runoff to Impaired Water Bodies – If MassDEP has issued a Total Maximum Daily Load (TMDL) that establishes a waste load allocation for stormwater discharge and/or a TMDL Implementation Plan that identifies remedies aimed at reducing the amount of pollutants from stormwater discharges, proponents may be required to install stormwater BMPs that are consistent with the TMDL.

E. Runoff to Areas of Localized Flooding – Project proponents must also understand the potential impacts of stormwater runoff in areas prone to localized flooding. When completing the checklist, proponents should consider the capacity of the receiving water and/or storm drainage system. When evaluating discharges to areas subject to localized flooding, the proponent should evaluate the ability to maintain and/or improve existing site cover and reduce runoff volume.

Chapter 4

Proprietary Stormwater BMPs

Proprietary Stormwater best management practices are manufactured systems that use proprietary settling, filtration, absorption/adsorption, vortex principles, vegetation, and other processes to meet the Stormwater Management Standards. There are two general types of Proprietary BMPs: hydrodynamic separators and filtering systems. Both types may be used for retrofits.

Hydrodynamic separators typically use either chambered systems or swirl concentrators to trap and retain sediment from a designed stormwater flow, and use different methods to help prevent the resuspension of sediment during high flow storm events. The retained sediment is removed through periodic maintenance.

Filtering systems typically use a settling chamber and filtering system that removes specific pollutants. The choice of filtering media or cartridges is typically based on the target pollutants.

Subsurface structures, even those that have manufactured storage chambers, are not proprietary BMPs, since the treatment occurs in the soil below the structure not the structure itself.

The effectiveness of Proprietary BMPs varies with the size of the unit, flow requirements, and specific site conditions. The UMass Stormwater Technologies Clearinghouse database evaluates the quality of proprietary BMP effectiveness studies. MassDEP urges Conservation Commissions to use this database when verifying the effectiveness of Proprietary BMPs: www.mastep.net

Advantages/Benefits:

- Useful for pretreatment/removal of TSS
- Can be an excellent choice in ultra-urban or other constrained sites
- Useful for redevelopments and to improve local conditions
- Longevity can be high with proper maintenance

Disadvantages/Limitations:

- Must be sized carefully to achieve design removal efficiencies
- Efficiency may be affected by size of sediment and rate of sediment loading
- Must ensure regular maintenance to achieve design removal efficiencies
- Not appropriate for terminal treatment for runoff from LUHPPLs or discharges near or to critical areas, unless determined suitable for such use by TARP or STEP.

Two Ways to Approve or Deny the Use of Proprietary Stormwater BMPs

1. MassDEP has reviewed the performance of a technology as determined by TARP or STEP and assigned a TSS removal efficiency.
    - If the conditions under which it is proposed to be used are similar to those in the performance testing, presume that the proprietary BMP achieves the assigned TSS removal rate
    - Look at sizing, flow and site conditions.
2. Issuing Authority makes a case-by-case assessment of a specific proposed use of a proprietary technology at a particular site and assigns a TSS removal efficiency.
    - Proponent must submit reports or studies showing effectiveness of BMP.
    - MassDEP strongly recommends using UMass Stormwater Technologies Clearinghouse database to ensure that reports and studies are of high quality (www.mastep.net).
    - Look at sizing, flow and site conditions.
    - For ultra-urban and constrained sites, proprietary BMPs may be the best choice.

Evaluation of Proprietary Stormwater Systems

Local agencies see a range of proposed stormwater management systems ranging from LID systems that mimic natural hydrology to traditional dry detention basins and manufactured systems.

The Stormwater Management Standards require proponents to consider the use of environmentally sensitive site design and LID techniques *before* selecting the appropriate BMPs for their development or redevelopment projects. After that consideration, the proponents may choose among a variety of stormwater BMPs to provide pretreatment, treatment, peak rate attenuation, and infiltration. These include LID BMPS, the traditional BMPs listed in the BMP charts presented in Volume 1, Chapter One, as well as a number of Proprietary BMPs.

MassDEP encourages proponents to consider proprietary BMPs, particularly where site constraints limit the use of LID techniques or traditional BMPs. If sized properly, manufactured (or "proprietary") BMPs can play a pivotal role in meeting the Stormwater Management Standards, particularly on smaller sites where adequate space for other BMPs is not available.

This Chapter provides the following information:

- Process To Approve or Deny the Use of Proprietary Stormwater Technology
- How to Evaluate the Effectiveness of Proprietary BMPs that Do Not Have a MassDEP TSS Removal Efficiency Rating
- Additional Information about Proprietary BMPs, including sources of information and detailed evaluation guidance for each of the 10 Stormwater Standards

If a developer proposes to include a proprietary BMP as a component of the stormwater management system, the local permitting authority must determine

- whether the proprietary BMP can meet the applicable Stormwater Standards;
- if proposed to meet the TSS removal requirements of Standard 4, whether there is sufficient information available to assess the TSS removal efficiency of the proposed proprietary BMP and, if so;
- assign a TSS removal credit.

This task is not easy. Only a few proprietary technologies have had their TSS removal effectiveness evaluated and approved by the Commonwealth. The overwhelming majority of proprietary technologies have not been evaluated by the state. Those technologies may still be used in Massachusetts, if the Conservation Commission or other local permitting authority determines that they can be used to meet the Stormwater Management Standards at a particular site.

Although MassDEP encourages proponents to consider the use of proprietary technologies to manage stormwater, local permitting agencies have the authority and responsibility to decide how these innovative or manufactured systems may be used, whether they are sized correctly for the intended purpose, and, in most cases, assess the proprietary BMP's ability to remove TSS.

Accordingly, **MassDEP encourages Conservation Commissions** and other local agencies to:

- Evaluate proposed proprietary BMPs by consulting the UMASS Stormwater Technologies Clearinghouse (www.mastep.net) and reviewing the information on the proposed technology.

- Ensure that BMPs described as already having been assessed by Massachusetts (through EEA's legacy STEP program) meet the conditions of those approvals, including model numbers, sizing requirements and site conditions. If such a BMP does not meet all applicable conditions, the TSS removal efficiency number established by the State can be questioned by the local permitting authority.
- Use proprietary systems for specialized situations – like heavily constrained redevelopment sites or other locations - where LID techniques or traditional structural BMPs may not provide needed improvements.

MassDEP encourages manufacturers of proprietary technologies to:

- Have their BMP's operating parameters evaluated though the multi-state Technology Acceptance Reciprocity Partnership (TARP) Program. When a technology completes TARP process, MassDEP will assign a specific TSS removal number or range for the tested use of that technology.
- Submit the results of other studies to the UMASS stormwater technology database clearinghouse (www.mastep.net).
- Promote specialized and niche uses of proprietary technologies to provide Conservation Commissions with more tools to improve the environment.

Ideally the developer of a property proposing these kinds of systems and the local agency evaluating the use of a manufactured or innovative stormwater technology will work cooperatively and agree that the proposed technology is appropriate for its intended use and likely to achieve the results intended.

To do that, developers must provide sufficient analytical information to the local agency (preferably third party analysis) so that it can evaluate the proprietary BMP. The local agency may reasonably deny the use of a proposed technology, if it finds that: (a) there is not sufficient information to assess the effectiveness of the technology; or (b) based on the available information, the proposed use of the technology does not meet all the requirements of the Stormwater Management Standards. In order to perform that analysis, local agencies must evaluate the studies provided to them describing the use and effectiveness of these technologies. Local agencies may not unreasonably deny the use of a proposed technology.

Process To Approve or Deny the Use of Proprietary Stormwater Technology

There are only two ways to evaluate a proposed use of a proprietary BMP in Massachusetts:

1. The Commonwealth has evaluated the performance of the technology and assigned a TSS removal efficiency.

In this case, Conservation Commissions and MassDEP shall presume that the proprietary BMP achieves the assigned TSS removal, provided the conditions under which it is proposed to be used are similar to those in the performance testing. MassDEP reserves the right to change the TSS removal number assigned to a proprietary technology based upon its review of subsequent studies.

The performance of a small number of proprietary BMPs was evaluated through EEA's legacy STEP program. In almost all cases, these STEP approvals were for specific sizing and flow requirements and specific site conditions. Those conditions are listed in the STEP reports. When reviewing this information, Conservation Commissions must analyze the STEP report to verify that the unit being proposed is within the scope of the STEP approval.

Although the STEP program no longer conducts these evaluations, MassDEP will review the performance of and assign a TSS removal efficiency to any proprietary BMPs that successfully complete the multi-state "Technology Acceptance and Reciprocity Partnership" (TARP) assessment process. Currently, MassDEP has not made a similar commitment to assign TSS removal efficiencies based on evaluations conducted under similar programs in other states or third party studies. MassDEP reserves the right to do so in the future.

2. The issuing authority has evaluated the proposed use of a particular proprietary BMP at a specific site and assigned a TSS removal efficiency based upon its own case-by-case review of the effectiveness and intended use of the proprietary BMP.

MassDEP strongly recommends that the issuing authority evaluate proposed BMPs using studies reviewed by the University of Massachusetts and posted on its stormwater database website (www.mastep.net). That database includes information on the relative quality of the studies, and should be used as the basis for a local agency's evaluation of the effectiveness of a proprietary system. Based on this information, the issuing authority may decide to approve or deny the use of any proprietary technology. The issuing authority may not unreasonably deny the use of a proposed technology.

If the operating parameters and performance claims of a proprietary technology have not been fully verified by STEP or TARP and a MassDEP removal efficiency rating has not been assigned, the technology vendor must submit evaluative information to the local agency regarding the technology's effectiveness.

> *Please note that Proprietary BMPs are NOT required to be evaluated by MassDEP to be used in Massachusetts. Only a small number of proprietary BMPs have been evaluated by the Commonwealth, and those evaluations are limited to the specific conditions that were reviewed. In most case in Massachusetts, a proposed use of a particular proprietary BMP at a specific site will be reviewed by the local agency on a case–by-case basis.*

How to Evaluate the Effectiveness of Proprietary BMPs that Do Not Have a MassDEP TSS Removal Efficiency Rating

MassDEP recognizes that the process of reviewing a proposed use of a particular proprietary BMP at a specific site may be daunting. MassDEP has prepared guidance for conducting this review.

Step One: Information that should be submitted as part of the Wetlands NOI.

As more fully set out below, issuing authorities require sufficient information to evaluate proposed uses of proprietary BMPs. If sufficient information is not submitted with the NOI, the Conservation Commission should request additional information as part of the review process.

Specific information that a Conservation Commission may want to request prior to a hearing include:

A A complete description of the proprietary technology or product including a discussion of the advantages of the technology when compared to conventional stormwater treatment systems and LID practices, including:

- Size: What volume is it designed to hold and/or treat? How is the system sized to meet the performance standards in order to handle the required water quality volume, rate of runoff, and types of storms? Standard 4 requires treatment for a required water quality volume, not for a specified design flow rate.
- Technical description, schematic and process flow diagram: How does it work? What are the technical configurations of the unit? Are there any pretreatment requirements? How does it fit in combination with other treatment systems?
- Capital costs and installation process and costs: What does this size system cost? Are there any consumable materials that need to be replaced and if so, how often and how much do they cost? How will the system be installed and who will supervise the installation to ensure that it is done properly? What mistakes can happen during installation? Is any special handling, installation techniques or equipment required?
- Potential disadvantages at this site: Any physical constraints? Weight or buoyancy issues? Durability issues? Energy requirements?
- Operation and maintenance (O&M) requirements and costs: New technologies will not have long-term data on O&M requirements, so it is particularly important that an applicant provide all available information for evaluation.

B. Data on how well the alternative technology works:

- Flow proportional sampling from laboratory testing and full-scale operations that is representative of the potential range of rainfall events (for example, a sufficient number of storms is generally at least 15) and located at sites similar to the conditions of the installation under review.
- Calculation of TSS removal rate should be presented. If there is a removal rating for a similar technology and use posted at http://www.mass.gov/dep/, and the proponent makes a claim for a higher TSS removal rate than for the similar system posted, the applicant must provide sufficient data to support the claim. Removal rates should show removal of various particle sizes across the full range of operating conditions including maximum, minimum and optimal conditions for reliable performance.
- A copy of the site's operation and maintenance plan including operational details on any full-scale installations: e.g., locations, length of time in operation, maintenance logs (logs should record the dates of inspections and cleaning, actions performed, quantities of solids removed, and time required for work).
- Information on any system failures, what those failures were, and how were they corrected.
- Copies of any articles from peer-reviewed, scientific or engineering journals.
- Any approvals or permits from other authorities.
- References along with contact information from other installations.

C. Operation and Maintenance (O&M) Plan:

- To ensure that the system will function as designed, all stormwater management systems must have a written operation and maintenance plan in accordance with Stormwater Management Standard 9. MassDEP stresses the importance of routine maintenance for all stormwater control technologies. A number of alternative technologies perform very well, but only if they are installed and maintained as specified by the manufacturer. For example, some alternative wet vaults may be able to achieve a high TSS removal rate, but only if they are cleaned often enough to prevent re-entrainment of previously trapped sediment.

- The O & M Plan shall
  - Identify access points to all components of the stormwater system;
  - Specify equipment, personnel, and training needed to inspect and maintain system;
  - Include a list of any safety equipment and safety training required for personnel;
  - Set forth a suggested frequency of inspection and cleaning; and
  - Provide a sample inspection checklist and maintenance log.

Please refer to Standard 9 in the Stormwater Technical Handbook (Volume 1, Chapter 1 and Volume 2, Chapter 1) for further guidance about O&M.

Step Two: Evaluate the submitted information.

An issuing authority (Conservation Commission or MassDEP upon appeal) may want to ask the questions set forth below to determine whether a proposed use of an alternative technology, either as a stand-alone product or in combination with other stormwater control practices and technologies, meets all of the Stormwater Management Standards:

A. **Why is this technology being proposed for this site?** Possible reasons are the alternative technology provides a higher level of environmental protection, uses less land area, and is less expensive on a capital or operation and maintenance cost basis. The performance data and other information provided with the application must support these claims. For example, if the applicant proposes an alternative technology, because it is less expensive to maintain than a conventional stormwater control technology system, the applicant must submit information supporting that claim.

B. **How convincing is the performance data?** Applicants must be able to demonstrate that their calculations show satisfactory performance in a laboratory, and preferably, adequate field-testing results. Were performance data (laboratory or field) collected by the technology developer or by independent organizations? Independent data are preferable, but may not always be available. If applicable, do the data and calculations support the claim of a higher TSS removal rate? Is the site similar to other locations where the alternative technology is already properly operating? The greater the similarity in key factors (e.g., soil conditions, climate, sediment loading rates, surficial geography, slopes), the greater the likelihood that the technology will properly work at the proposed site.

C. **Are the data sets complete?** If there are any gaps, why? Are you satisfied with the reasons given as to why there are gaps? For example, if maintenance data are provided for a two-year period, and there is a six-month gap in the record, a reasonable explanation for the gap should be provided. Is there enough information to persuade the issuing authority that the technology will work as proposed?

D. **Technologies may not work all the time or at all locations, and therefore, failures may be expected.** If there have been failures, either in the laboratory or in real settings, is the applicant able to adequately explain the reasons for the failure? Examples could be poor design, improper sizing, and higher sediment loading than anticipated, extreme hydrologic events, poor installation, or poor maintenance. If it was a design problem, has the design of the technology been modified to address the problem? For failures that were not design related, what corrections were made to prevent future failure? Were systems rechecked to see if they were functioning properly after corrections were made?

E. **If only limited data is available, is it possible to assess how the technology will work over its expected life?** If seasonality is an issue, the Commission should see data collected over a full change of seasons that reflect a normal weather year, or at least an estimate of normal annual operations based on available data. Can the technology function well for the full range of storm events that must be controlled? If not, is there a way to address this problem?

F. **Is it possible that a technology may effectively meet one Standard, but hamper compliance with other Standards?** For example, a technology might increase the rate of TSS removal, but limit the annual recharge. The applicant should provide documentation to help the Commission make this evaluation. Do the advantages of the technology potentially outweigh its disadvantages?

G. **Check any references provided by the applicant to find out whether previous installations are properly functioning.** If the information indicates that other Conservation Commissions have previously approved this technology for use in their municipalities, check with those Commissions to verify that the system has performed properly. Were there unexpected operation and maintenance costs? If there were problems, did the vendor assist in resolving them?

See the Detailed Proprietary BMP Evaluation Guidance below for more information.

Step Three: Make a decision on the filings.

If there appears to be sufficient information, the Conservation Commission must issue a decision approving (with or without special conditions) or denying the use of the proposed technology to meet the Stormwater Management Standards. There may be instances where the Conservation Commission may want to add conditions to the Order of Conditions to ensure the proper functioning of the alternative stormwater control technology and, if covered in a local wetlands bylaw, require a bond to be posted to pay for any repairs that may be necessary if the alternative system does not perform as designed. Particular attention to inspection and maintenance is advised and should be included in the conditions.

If a Conservation Commission denies the use of a proprietary technology, it must specify the reasons in writing. Because these decisions are subject to appeal, written documentation is critical.

If insufficient information exists, and the Commission cannot adequately evaluate the proposed technology, the Conservation Commission may either deny the project based on the lack of information (and specify what information is lacking in the denial) or ask the applicant to supply additional information The Conservation Commission may also direct the technology vendor to the TARP contacts listed in the References Section of this Chapter.

Other Proprietary BMP Information

Information about the STEP and TARP programs

The two Massachusetts-accepted evaluation programs - the Massachusetts Strategic Envirotechnology Partnership (STEP) and the multi-state "Technology Acceptance and Reciprocity Partnership" (TARP), were established to ensure rigorous testing and independent analysis of the effectiveness of manufactured or innovative (i.e., "proprietary") stormwater systems. Since each of these programs require significant testing, only a small number of systems have completed the programs and have had their effectiveness officially evaluated.

TARP

TARP was formed by the states of California, Illinois, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Virginia to provide reliable performance information about emerging technologies and to reduce the regulatory and permit hurdles that slow down or prevent their use. More information on TARP is available at this web site:
http://www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/

STEP

Before ending in 2003, the STEP program evaluated a number of different emerging technologies. STEP produced 2 reports and fact sheets on 3 stormwater technologies. Each was assigned a TSS removal efficiency. The reports are located here
http://www.mass.gov/envir/lean_green/documents/techassessments.htm
and the Facts Sheets are located here:
http://www.mass.gov/envir/lean_green/documents/factsheets.htm

Local agencies must note that the STEP verifications are limited to the specific models being used under specific conditions. If the conditions being proposed are significantly different than the conditions under which the units were tested, or the proposed models are different than the model tested, or the flow rates proposed are different than the flow rates tested, the local permitting authority may question whether the evaluations are applicable and may determine that the proposed proprietary technology is not appropriate for the proposed use or may not be able to remove TSS at the proposed rate.

Since the STEP process was less rigorous than the TARP process, and since the conditions under which STEP evaluations occurred were more limited than the TARP's protocol, developers proposing STEP technologies MUST provide the entire STEP Fact Sheet describing the proposed technology. A Conservation Commission may ask to see the entire report, and, upon request, the developer must provide it.

Conservation Commissions and other local agencies shall NEVER rely solely on information contained in STEP-related letters or excerpts from the STEP Fact Sheets or Reports found in vendor-provided literature or advertising when evaluating these systems.

When developers propose a specific use of a particular proprietary stormwater technology that has not been evaluated by the TARP or STEP program, the local agency is responsible for developing a TSS removal number based upon the site conditions, the proposed use of the technology, and information assessing the effectiveness of the technology.

If a proprietary BMP is proposed that has not been evaluated by STEP or TARP, MassDEP strongly encourages local agencies to use third party studies listed on the UMASS Stormwater Technologies Clearinghouse database (www.mastep.net) as the basis for their evaluation of the effectiveness of the proprietary system. While manufactured stormwater technologies are not required to have third party studies to be used in Massachusetts, local agencies in turn are not required to approve the use of these technologies.

The UMASS website (www.mastep.net) grades the quality of the studies evaluating proprietary BMPs. Local agencies must consider this information when deciding whether to approve the use of the proposed technology or what TSS number it will assign to a proposed use of a particular proprietary technology.

If a local agency denies the specific use of a particular alternative technology, the reasons should be specified in writing. This written documentation is important, because denials are subject to appeal and may be overturned, if permission is unreasonably withheld.

Other Sources of Information about Manufactured Stormwater Systems

There are other sources of information about the effectiveness of proprietary BMPs that may be used by local agencies to estimate TSS removal rates.

- ETV: This federal EPA verification program's information can be found at http://www.epa.gov/etv/verifications/vcenter9-9.html. EPA Region I hosts a "virtual trade show" of stormwater technologies with vendor provided information at http://www.epa.gov/ne/assistance/ceitts/stormwater/techs.html.
- New Jersey has a searchable database found at http://www.njcat.org/verification/Verifications.cfm
- Washington Department of Ecology evaluates emerging stormwater treatment technologies, more information and state approvals are found at http://www.ecy.wa.gov/programs/wq/stormwater/newtech
- CSTEV: The University of New Hampshire (UNH) Stormwater Center is evaluating the performance of several stormwater control technology technologies real time and on the ground. Information can be found at http://www.unh.edu/erg/cstev/.
- The American Society of Civil Engineers, EPA and others sponsor an international stormwater best management practices database at http://www.stormwater control technologydatabase.org/.
- MassDEP at http://www.mass.gov/dep/water/wastewater/stormwat.htm has information about stormwater.
- The University of Connecticut: UConn's website at http://nemo.uconn.edu/tools/stormwater/ has information about the interrelationship between increased stormwater runoff and associate pollutants.
- Center for Watershed Protection: This national non-profit at http://www.cwp.org/ provides resource information for local officials.

How To Evaluate the Use of Proprietary BMPs in Critical Areas and for Land Uses with Higher Potential Pollution Load: Standards 5 and 6

The Stormwater Management Standards limits the type of stormwater systems that may be used for treatment in **Critical Areas and Land Uses with Higher Potential Pollutant Loads.**

For new development, proprietary stormwater systems[1] may be used in such areas ONLY as a pretreatment device to one of the devices listed in the Stormwater Management Handbook as suitable for such areas or land uses. See Volume 1, Chapter One. For redevelopment sites, these systems may be used for discharges to Critical Areas or from Land Uses with Higher Potential Pollutant Loads ONLY if site constraints prevent use of the devices determined by MassDEP to be suitable for such areas and land uses.

Since the devices listed by MassDEP for discharges to Critical Areas or from Land Uses with Higher Potential Pollutant Loads were selected based on their ability to capture or treat constituents in addition to TSS (such as toxics, pathogens, nutrients, or temperature), proprietary systems proposed for redevelopment projects in these areas must provide similar capabilities.

How Proprietary Stormwater Systems Can Improve Local Conditions

In some cases local agencies will look further than TSS removal in analyzing the effectiveness of proprietary stormwater systems. Removal efficiencies can vary substantially with the size of particles and there are other valid ways than TSS to measure sediment reductions, so local agencies may need to examine closely the system's effectiveness for the specific site at which it is proposed.

Local agencies may be concerned about other contaminants such as toxics (metals such as lead, copper, zinc, or nickel), nutrients, pathogens or physical changes (such as temperature). If a Conservation Commission or other local agency is concerned about any of these parameters, because the receiving water is impaired or the designated use of the receiving water dictates removal of other pollutants, the local agency may want to request and analyze that kind of data.

Detailed Proprietary BMP Evaluation Guidance for each of the 10 Stormwater Standards

The purpose of this detailed guidance is to provide proponents and local agencies with the kinds of questions used by states when verifying the effectiveness of Proprietary BMPs. These questions should be used to address specific questions local agencies may have about the effectiveness of Proprietary BMPs to meet a specific Stormwater Management Standard. This guidance is not intended as a mandatory checklist that every proponent must submit for every Proprietary BMP.

Both proponents and reviewers of proprietary BMPs can use the following questions to determine if the information submitted about a proprietary BMP is sufficient to allow the proposed use.

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[1] Subsurface structures, even if they have manufactured storage chambers, are not proprietary BMPs, since the treatment occurs in the soil below the structure, not in the structure itself.

Using these questions will help proponents and reviewers determine whether a sufficient evaluation of the proprietary BMP has been performed, identify where deficiencies may be present, and reasonably predict the performance of a proprietary BMP at the project site.

General Information

Has the applicant provided a detailed description of the characteristics of the site, described how the proposed proprietary product addresses the unique storm water management requirements of the site, and shown that the proprietary product is in compliance with the Stormwater Management Standards? Has the applicant shown that the BMP is advantageous to the site? Have LID and site design techniques been considered when developing the site design? Items to consider include but are not limited to:

- What is the BMP's proposed use: pretreatment or treatment? Separator, filtration, infiltration or other use?
- Is the project for new development or re-development?
- Are there site constraints that limit what other BMPs can be used?
- Is it in an area of higher potential pollutant loads? (See Standard 5)
- Is there discharge to or near a critical area? (See Standard 6)
- Is there a high flow contribution from off-site?
- Is there a high TSS contribution anticipated from site soils, winter sand application, or other source?
- Are there TMDL requirements or recommendations applicable to the site?
- Are there other reasons that specific pollutants in addition to TSS should be reduced (e.g., Phosphorus, Nitrogen, Bacteria, hydrocarbons)?

Has the applicant provided documentation that the sizing of the device is correct? Is there any reason to allow a smaller size than proposed? Has the applicant demonstrated that the device meets both of the following:

- The Stormwater Management Standards; and
- The sizing procedures and calculations established by the manufacturer and verified through laboratory/field testing.

Has the applicant provided documentation that the product manufacturer's performance claims have been verified through laboratory and/or field-testing? Does the evaluation indicate that the device will work well on this specific site?

- Has the product been approved for use by other agencies in other states; if so, for what pollutants, pollutant levels and/or land use?
- Has the product been listed in the UMASS Stormwater Technologies database, and if so, how have the studies of the product been rated?

Is the product intended for construction period erosion and sedimentation control? If so, has the applicant provided documentation that the product is effective for such use? (See Standard 8 below.)

Did the STEP program evaluate the proposed BMP model and size and assess its TSS removal efficiency? If so, has the applicant:

- provided the complete STEP report (not excerpts or manufacturers' letters)?
- shown that the BMP proposed is one of the models that was evaluated?
- shown that the proposed sizing is the same as the sizing used for the STEP evaluation?

Is the product listed in the UMASS Stormwater Technologies database? If not, has the applicant provided documentation comparable to the studies cited in the database?

If not, are there compelling site-specific reasons why the proprietary BMP should be used (e.g., severe location or space constraints, need to reduce a specific pollutant, flooding, filter devices proposed)?

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Information Required to Address Specific Stormwater Management Standards

<u>Standard 1: (Untreated discharges)</u>: No new stormwater conveyances (e.g., outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

No new untreated discharges

- Does the use of the product enable the applicant to provide adequate treatment for its new discharges?
- Does the use of the product enable the applicant to retrofit an existing discharge, achieving an improvement over existing conditions (see Standard 7)?
- Is the system designed to prevent erosion and scour?

<u>Standard 2: (Peak rate control and flood prevention)</u>: Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.

Peak rate control

- Does the product have a significant function in managing peak rates of runoff?
- If so, has the applicant documented this function with hydrologic/hydraulic data in lab or field studies?
- How is product performance affected by peak discharges?
- Has the applicant documented its performance with hydrologic/hydraulic in lab or field studies?
- Is the product susceptible to re-suspension and flushing of captured contaminants during a 2 -year or 10-year storm?
- Is the product designed to prevent such re-suspension and flushing? Is this documented in the laboratory/field studies? Was the particle size in those studies comparable to that used to calculate the performance and size of the proprietary BMP?
- If the product is not designed to address re-suspension and flushing, does the project design provide for "off-line" placement of the device?
- Is the product subject to damage or filling by sediment during a flood event or a coastal storm event?

<u>Standard 3: (Recharge)</u>: Loss of annual recharge to ground water shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.

Recharge

- Is the product proposed as part of a recharge system? If so,
- Is it a pre-treatment device intended to remove particulates and/or other pollutants prior to discharge to a recharge BMP?
- Is it a recharge BMP that requires protection by another pre-treatment BMP?
- Does it provide both pre-treatment and recharge?

Standard 4: (80% TSS Removal): Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This standard is met when:

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

b. Stormwater best management practices are sized to capture the prescribed runoff volume; and

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

Water Quality Treatment

- Does the product remove TSS?
- Has the applicant provided documentation that the TSS removal capability of the device is based on a particle size distribution meeting accepted evaluation protocols? (See www.mastep.net)
- Does the product provide for control or prevention of re-suspension, scour, and/or flushing of captured solids or other contaminants treated by the product?
- Has the product been sized per manufacturer's standards, as verified by laboratory/filed testing?
- Does the product treat other pollutants, and if so, has applicant provided performance documentation (with verification documented by or consistent with the MassSTEP Database)?
- Is the proposed use of the product in the correct sequence in the "treatment train"?

    - Pretreatment (e.g., coarse particle separation, e.g., sand sized particles such as OK-110 floatables removal)
    - Terminal treatment (e.g. fine particle settling, e.g., silt and fine sand particles such as NJDEP PSD)
    - Polishing treatment (e.g., filtration, bacteria absorption or adsorption)
    - Infiltration

- How will the future use of the site influence the kinds of pollutants to be treated and loading rates of those pollutants (e.g., residential may mean more nutrients, a roadway may mean more coarse TSS)?

Standard 5 (Land Use with Higher Potential Pollutant Loads (LUHPPL)): For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable. If through source control and/or pollution prevention all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, and stormwater runoff, the proponent shall use the specific structural stormwater BMPs determined by the Department to be suitable for such uses as provided in the Massachusetts Stormwater Handbook. Stormwater

discharges from land uses with higher potential pollutant loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53 and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.

Land Uses with Higher Potential Pollutant Loads (LUHPPL)

Does this standard apply to the site? If so,

- Is the product used consistent with the source control requirements of the Stormwater Management Standards?
- Does the technology provide pretreatment prior to discharge to a technology that has been determined to be suitable for runoff LUHPPL? ?
- What pollutants are associated with the LUHPPL? What demonstration can be provided that shows that the proposed BMP is capable of removing and/or treating those pollutants?
- Does the LUHPPL have the potential to generate stormwater runoff that has high concentrations of oil and grease? If so, has the technology been proposed in addition to an oil grit separator or sand filter or as an alternative method of achieving oil and grease removal in place of an oil grit separator or sand filter? If the technology is proposed in place of an oil grit separator or sand filter, what evidence is there that the technology is effective in removing oil and grease?

Standard 6 (Critical Areas): Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply and stormwater discharges near or to any other critical area require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas as provided in the Massachusetts Stormwater Handbook. A discharge is near a critical area, if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors. Stormwater discharges to Outstanding Resource Waters and Special Resource Waters shall be removed and set back from the receiving water or wetland and receive the highest and best practical method of treatment. A "storm water discharge" as defined in 314 CMR 3.04(2)(a)1 or (b) to an Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply.

Critical Areas

Does this standard apply to the site? If so,

- Is the product used for pretreatment prior to discharge to a technology that the Department has determined is suitable for the particular critical area?
- Does the product have any operating characteristics that could adversely affect the critical area, such as
  - Thermal impacts to coldwater fisheries
  - Release of bacteria to shellfish growing areas, bathing beaches
  - Release of previously captured pollutants (scour)

Standard 7 (Redevelopment): A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural best management practice

requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

Redevelopment

- Do site constraints make a proprietary BMP a better choice than a traditional BMP?
- Does the product performance documentation enable the Conservation Commission to determine a quantitative rating of the product for achieving one or more of Standards 2-6?
- If the answers to both b and c are "no", does the product documentation enable the Commission to qualitatively determine that the product improves existing conditions relative to one or more of Standards 2-6?

Standard 8: (Erosion, Sediment Control): A plan to control construction related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.

Erosion and Sediment Control

- Is the product intended to control erosion and sedimentation during the construction process?
- If so, has the applicant documented this function? How does it fit into the construction period erosion, sedimentation and pollution prevention plan?
- Is the product susceptible to adverse impact by erosion and sedimentation during construction, and if so, has the applicant documented how the product will be protected from such impact?

Standard 9: (Operation and Maintenance): A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.

Operation and Maintenance

- Has the applicant completely described the installation, operation, and maintenance of the device? Has the applicant documented how the required maintenance will be done and who will do it?
- Has the applicant included a copy of the manufacturer's installation, inspection, operation, and maintenance procedures in the project O&M plan?
- Is the proposed BMP included in the project's O&M plan?
- Does the product require special materials or equipment for cleaning? If so, what materials or equipment are necessary?
- Has the O&M plan funding accounted for such equipment and materials?
- Does the inspection or maintenance of the device require confined space entry protocols?
- Is the frequency of maintenance and cleaning documented by pollutant loading/removal estimates, experience at other installations, or other information demonstrating that the proposed frequency is adequate?
- How will the future use of site influence O&M needs? More frequent? Less frequent?

Standard 10 (Illicit Discharges): All illicit discharges to the stormwater management system are prohibited.

Have steps been taken to prevent illicit discharges from entering the proprietary BMP?

Chapter 5
Miscellaneous Stormwater Topics

Mosquito Control in Stormwater Management Practices

Both aboveground and underground stormwater BMPs have the potential to serve as mosquito breeding areas. Good design, proper operation and maintenance and treatment with larvicides can minimize this potential.

EPA recommends that stormwater treatment practices dewater within 3 days (72 hours) to reduce the number of mosquitoes that mature to adults, since the aquatic stage of many mosquito species is 7 to 10 days. Massachusetts has had a 72-hour dewatering rule in its Stormwater Management Standards since 1996. The 2008 technical specifications for BMPs set forth in Volume 2, Chapter 2 of the Massachusetts Stormwater Handbook also concur with this practice by requiring that all stormwater practices designed to drain do so within 72 hours.

Some stormwater practices are designed to include permanent wet pools. These practices – if maintained properly – can limit mosquito breeding by providing habitat for mosquito predators. Additional measures that can be taken to reduce mosquito populations include increasing water circulation, attracting mosquito predators by adding suitable habitat, and applying larvicides.

The Massachusetts State Reclamation and Mosquito Control Board (SRMCB), through the Massachusetts Mosquito Control Districts, can undertake further mosquito control actions specifically for the purpose of mosquito control pursuant to Massachusetts General Law Chapter 252. The Mosquito Control Board, http://www.mass.gov/agr/mosquito/, describes mosquito control methods and is in the process of developing guidance documents that describe Best Management Practices for mosquito control projects.

The SRMCB and Mosquito Control Districts are not responsible for operating and maintaining stormwater BMPs to reduce mosquito populations. The owners of property that construct the stormwater BMPs or municipalities that "accept" them through local subdivision approval are responsible for their maintenance.[1] The SRMCB is composed of officials from MassDEP, Department of Agricultural Resources, and Department of Conservation and Recreation. The nine (9) Mosquito Control Districts overseen by the SRMCB are located throughout Massachusetts, covering 176 municipalities.

Construction Period Best Management Practices for Mosquito Control

To minimize mosquito breeding during construction, it is essential that the following actions be taken to minimize the creation of standing pools by taking the following actions:

- ***Minimize Land Disturbance:*** Minimizing land disturbance reduces the likelihood of mosquito breeding by reducing silt in runoff that will cause construction period controls to clog and retain standing pools of water for more than 72 hours.
- ***Catch Basin inlets:*** Inspect and refresh filter fabric, hay bales, filter socks or stone dams on a regular basis to ensure that any stormwater ponded at the inlet drains within 8 hours after precipitation stops. Shorter periods may be necessary to avoid hydroplaning in roads

[1] MassDEP and MassHighway understand that the numerous stormwater BMPs along state highways pose a unique challenge. To address this challenge, the 2004 MassHighway Stormwater Handbook will provide additional information on appropriate operation and maintenance practices for mosquito control when the Handbook is revised to reflect the 2008 changes to the Stormwater Management Standards..

caused by water ponded at the catch basin inlet. Treat catch basin sumps with larvicides such as *Bacillus sphaericus* (*Bs*) using a licensed pesticide applicator.

- ***Check Dams:*** If temporary check dams are used during the construction period to lag peak rate of runoff or pond runoff for exfiltration, inspect and repair the check dams on a regular basis to ensure that any stormwater ponded behind the check dam drains within 72 hours.
- ***Design construction period sediment traps*** to dewater within 72 hours after precipitation. Because these traps are subject to high silt loads and tend to clog, treat them with the larvicide *Bs* after it rains from June through October, until the first frost occurs.
- ***Construction period open conveyances:*** When temporary manmade ditches are used for channelizing construction period runoff, inspect them on a regular basis to remove any accumulated sediment to restore flow capacity to the temporary ditch.
- ***Revegetating Disturbed Surfaces:*** Revegetating disturbed surfaces reduces sediment in runoff that will cause construction period controls to clog and retain standing pools of water for greater than 72 hours.
- ***Sediment fences/hay bale barriers:*** When inspections find standing pools of water beyond the 24-hour period after a storm, take action to restore barrier to its normal function.

<u>Post-Construction Stormwater Treatment Practices</u>

- Mosquito control begins with the environmentally sensitive site design. Environmentally sensitive site design that minimizes impervious surfaces reduces the amount of stormwater runoff. Disconnecting runoff using the LID Site Design credits outlined in the Massachusetts Stormwater Handbook reduces the amount of stormwater that must be conveyed to a treatment practice. Utilizing green roofs minimizes runoff from smaller storms. Storage media must be designed to dewater within 72 hours after precipitation.
- Mosquito control continues with the selection of structural stormwater BMPs that are unlikely to become breeding grounds for mosquitoes, such as:
    - ***Bioretention Areas/Rain Gardens/Sand Filter:*** These practices tend not to result in mosquito breeding. If any level spreaders, weirs or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
    - ***Infiltration Trenches:*** This practice tends not to result in mosquito breeding. If any level spreaders, weirs, or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
- Another mosquito control strategy is to select BMPs that can become habitats for mosquito predators, such as:
    - ***Constructed Stormwater Wetlands:*** Habitat features can be incorporated in constructed stormwater wetlands to attract dragonflies, amphibians, turtles, birds, bats, and other natural predators of mosquitoes.
    - ***Wet Basins:*** Wet basins can be designed to incorporate fish habitat features, such as deep pools. Introduce fish in consultation with Massachusetts Division of Fisheries and Wildlife. Vegetation within wet basins designed as fish habitat must be properly managed to ensure that vegetation does not overtake the habitat. Proper design to ensure that no low circulation or "dead" zones are created may reduce the potential for mosquito breeding. Introducing bubblers may increase water circulation in the wet basin.

Effective mosquito controls require proponents to design structural BMPs to prevent ponding and facilitate maintenance and, if necessary, the application of larvicides. Examples of such design practices include the following:

- ***Basins:*** Provide perimeter access around wet basins, extended dry detention basins and dry detention basins for both larviciding and routine maintenance. Control vegetation to ensure that access pathways stay open.
- ***BMPs without a permanent pool of water:*** All structural BMPs that do not rely on a permanent pool of water must drain and completely dewater within 72 hours after precipitation. This includes dry detention basins, extended dry detention basins, infiltration basins, and dry water quality swales. Use underdrains at extended dry detention basins to drain the small pools that form due to accumulation of silts. Wallace indicates that extended dry extended detention basins may breed more mosquitoes than wet basins. It is, therefore, imperative to design outlets from extended dry detention basins to completely dewater within the 72-hour period.
- ***Energy Dissipators and Flow Spreaders:*** Currier and Moeller, 2000 indicate that shallow recesses in energy dissipators and flow spreaders trap water where mosquitoes breed. Set the riprap in grout to reduce the shallow recesses and minimize mosquito breeding.
- ***Outlet control structures:*** Debris trapped in small orifices or on trash racks of outlet control structures such as multiple stage outlet risers may clog the orifices or the trash rack, causing a standing pool of water. Optimize the orifice size or trash rack mesh size to provide required peak rate attenuation/water quality detention/retention time while minimizing clogging.
- ***Rain Barrels and Cisterns:*** Seal lids to reduce the likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over inlets. The cistern system should be designed to ensure that all collected water is drained into it within 72 hours.
- ***Subsurface Structures, Deep Sump Catch Basins, Oil Grit Separators, and Leaching Catch Basins:*** Seal all manhole covers to reduce likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over the outlet (CALTRANS 2004).

The Operation and Maintenance Plan should provide for mosquito prevention and control.

- ***Check dams:*** Inspect permanent check dams on the schedule set forth in the O&M Plan. Inspect check dams 72 hours after storms for standing water ponding behind the dam. Take corrective action if standing water is found.
- ***Cisterns:*** Apply *Bs* larvicide in the cistern if any evidence of mosquitoes is found. The Operation and Maintenance Plan shall specify how often larvicides should be applied to waters in the cistern.
- ***Water quality swales:*** Remove and properly dispose of any accumulated sediment as scheduled in the Operation and Maintenance Plan.
- ***Larvicide Treatment:*** The Operation and Maintenance Plan must include measures to minimize mosquito breeding, including larviciding.
- The party identified in the Operation and Maintenance Plan as responsible for maintenance shall see that larvicides are applied as necessary to the following stormwater treatment practices: catch basins, oil/grit separators, wet basins, wet water quality swales, dry extended detention basins, infiltration basins, and constructed stormwater wetlands. The Operation and Maintenance Plan must ensure that all larvicides are applied by a licensed pesticide applicator and in compliance with all pesticide label requirements.
- The Operation and Maintenance Plan should identify the appropriate larvicide and the time and method of application. For example, *Bacillus sphaericus (Bs)*, the preferred

larvicide for stormwater BMPs, should be hand-broadcast.[2] Alternatively, Altosid, a Methopren product, may be used. Because some practices are designed to dewater between storms, such as dry extended detention and infiltration basins, the Operation and Maintenance Plan should provide that larviciding must be conducted during or immediately after wet weather, when the detention or infiltration basin has a standing pool of water, unless a product is used that can withstand extended dry periods.

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[2] *Bacillus thuringienis israelensis* or *Bti* is usually applied by helicopter to wetlands and floodplains

Roads and Stormwater BMPs

In general, the stormwater BMPs used for land development projects can also be used for new roadways and roadway improvement projects. However, for improvement of existing roads, there are often constraints that limit the choice of BMP. These constraints derive from the linear configuration of the road, the limited area within the existing right-of-way, the structural and safety requirements attendant to good roadway design, and the long-term maintainability of the roadway drainage systems. The MassHighway Handbook provides strategies for dealing with the constraints associated with providing stormwater BMPs for roadway redevelopment projects.

Roadway design can minimize impacts caused by stormwater. Reducing roadway width reduces the total and peak volume of runoff. Designing a road with country drainage (no road shoulders or curbs) disconnects roadway runoff. Disconnection of roadway runoff is eligible for the Low Impact Site Design Credit provided the drainage is disconnected in accordance with specifications outlined in Volume 3.

Like other parties, municipalities that work within wetlands jurisdictional areas and adjacent buffer zones must design and implement structural stormwater best management practices in accordance with the Stormwater Management Standards and the Stormwater Management Handbook. In addition, in municipalities and areas where state agencies operate stormwater systems, the DPWs (or other town or state agencies) must meet the "good housekeeping" requirement of the municipality's or agency's MS4 permit.

MassHighway has taken stormwater management one step further by working with MassDEP to develop the MassHighway Storm Water Handbook for Highways and Bridges. The purpose of the MassHighway Handbook is to provide guidance for persons involved in the design, permitting, review and implementation of state highway projects, especially those involving existing roadways where physical constraints often limit the stormwater management options available. These constraints, like those common to redevelopment sites, may make it difficult to comply precisely with the requirements of the Stormwater Management Standards and the Massachusetts Stormwater Handbook.[3] In response to these constraints, MassDEP and MHD developed specific design, permitting, review and implementation practices that meet the unique challenges of providing environmental protection for existing state roads. The information in the MassHighway Handbook may also aid in the planning and design of projects to build new highways and to add lanes to existing highways, since they may face similar difficulties in meeting the requirements of the Stormwater Management Standards.

Although it is very useful, the MassHighway Handbook does not allow MassHighway projects to proceed without individual review and approval by the issuing authority when subject to the Wetlands Protection Act Regulations, 310 CMR 10.00, or the 401 Water Quality Certification Regulations, 314 CMR 9.00. For example, MassHighway must provide a Conservation Commission with a project-specific Operation and Maintenance Plan in accordance with Standard 9 that documents how the project's post-construction BMPs will be operated and maintained.[4]

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[3] The 2004 MassHighway Handbook outlines standardized methods for dealing with these constraints as they apply to highway redevelopment projects. MassDEP and MassHighway intend to work together to provide guidance for add a lane projects when the 2004 Handbook is revised to reflect the 2008 changes to the Stormwater Management Standards.

[4] The general permit for municipal separate storm sewer systems (the MS4 Permit) requires MassHighway to develop and implement procedures for the proper operation and maintenance of stormwater BMPs. To

Some municipalities have asked if the MassHighway Handbook governs municipal road projects. The answer is no.[5] The MassHighway Handbook was developed in response to the unique problems and challenges arising out of the management of the state highway system. Like other project proponents, cities and towns planning road or other projects in areas subject to jurisdiction under the Wetlands Protection Act must design and implement LID, non-structural and structural best management practices in accordance with the Stormwater Management Standards and the Massachusetts Stormwater Handbook.

avoid duplication of effort, MassHighway may be able rely on the same procedures to fulfill the operation and maintenance requirements of Standard 9 and the MS 4 Permit.

[5] Although the MassHighway Handbook does not govern municipal road projects, cities and towns may find some of the information presented in the Handbook useful.

Appendix Operating and Source Control BMPs

This appendix identifies specific pollution prevention measures for use at certain industrial and commercial facilities. Implementation of these measures can help the operators of these facilities prevent the pollutants generated by their operations from entering surface waters or groundwater.[1]

Pollution prevention measures are identified for the following facilities:

- Auto Salvage Yards (Auto recycling facilities)
- Auto Fueling Facilities (Gas stations)
- Building, Repair, and Maintenance of Boats and Ships
- Commercial Animal Handling Areas
- Commercial Composting
- Commercial Printing Operations
- Loading and Unloading Areas for Liquid or Solid Material
- Painting/Finishing/ Coating of Vehicles/Boats/ Buildings/ Equipment
- Railroad Yards

[1] For additional information on pollution prevention at commercial and industrial sites. See Volume IV of the Stormwater Manual for Western Washington at http://www.ecy.wa.gov/pubs/0510032.pdf. See also the EPA web site at http://cfpub.eap.gov/npdes/stormwater/swppp-msgp.cfm

BMPs for Auto Salvage Yards

The auto salvage business offers great opportunities for recycle / reuse. The dismantling of vehicles for reusable parts and fluids and the sale of remaining materials as scrap has gone a long way toward lessening the burden on our landfills. Unfortunately, the methods used in dismantling and storage can, and often have, resulted in serious negative impacts on the environment.

Fluids Handling

Properly remove and handle automobile fluids. Fluids associated with auto salvage include:

Drained motor oil	Window cleaner
Antifreeze	Oil recovered from steam cleaning
Hydraulic oil/fluid	Water recovered from steam cleaning
Transmission fluid	Storm water run off from storage area
Brake fluid	

Drained Motor Oil: An accepted practice is to allow oil to remain in the engine. It and the associated filters are sold with the engine. However, this is not true of all salvage yards. Used motor oil can be stored and sold to a processor or re-refiner or used as a fuel or energy source. Store used oil inside under cover or in covered containers on an impervious pad with adequate containment.

Antifreeze: Most salvaged vehicles have antifreeze in their systems. Due to heavy metal accumulation in the antifreeze and chemical makeup of antifreeze (ethylene-glycol), it is not recommended to use the sewer for disposal. Reclaim and reuse antifreeze. Store used antifreeze inside under cover or in covered containers on an impervious pad with adequate containment.

Other Vehicle Fluids: Brake fluid, transmission fluid, and hydraulic oils are not considered financially feasible for recovery. Store these fluids under cover or in covered containers on an impervious pad with adequate containment. Dispose of these fluids as a hazardous waste.

Wastewater and Stormwater Runoff: Steam-cleaning of engines and parts results in oil-contaminated wastewater. Segregate this water from domestic-type wastewater. Steam clean engines and parts inside and under cover to prevent exposure to rain, snow, snowmelt and runoff.

This wastewater should be given time to allow for solids settlement. If possible, separate the used oil for recycling and collection by a permitted used-oil transporter.
Dispose of the remaining sludge as a hazardous waste.

Other Recyclable Materials: Other salvage yard materials that can be recycled include:
Lead Acid Batteries (State law prohibits disposal in a landfill)

Radiators, Engines, Air Conditioning Coils, Catalytic Converters
Scrap Metals and Plastic
Rubber-Related Materials

All of these materials are recyclable and whenever possible, they should be recycled instead of being disposed of in landfills.

BMPs for Auto Fueling Facilities (Gas stations)

Description of Pollutant Sources: A fueling station is a facility dedicated to the transfer of fuels from a stationary pumping station to mobile vehicles or equipment. It includes above- or under-ground fuel storage facilities. In addition to general service gas stations, fueling may also occur at 24-hour convenience stores, construction sites, warehouses, car washes, manufacturing establishments, port facilities, and businesses with fleet vehicles. Typically, stormwater contamination at fueling stations is caused by leaks/spills of fuels, lube oils, radiator coolants, and vehicle washwater.

Pollutant Control Approach: Construct new or substantially remodeled fueling stations on an impervious concrete pad under a roof to keep out rainfall and stormwater run-on. Use a treatment BMP such as an oil grit separator, sand filter or equivalent for contaminated stormwater and wastewaters in the fueling containment area.

Applicable Operational BMPs:

- Prepare an emergency spill response and cleanup plan and have designated trained person(s) available either on-site or on call at all times to promptly and properly implement that plan and immediately cleanup all spills. Keep suitable cleanup materials, such as dry adsorbent materials, on-site to allow prompt cleanup of a spill.
- Train employees on the proper use of fuel dispensers. Post "No Topping Off" signs (topping off gas tanks causes spillage and vents gas fumes to the air). Make sure that the automatic shutoff on the fuel nozzle is functioning properly.
- The person conducting the fuel transfer must be present at the fueling pump during fuel transfer, particularly at unattended or self-serve stations.
- Keep drained oil filters in a suitable container or drum. Drums should be closed on an impervious pad with adequate containment.
- For more information about when you need to report a spill to MassDEP and how quickly you need to report it (in many instances a spill must be reported within 2 hours), go to this MassDEP web page: http://mass.gov/dep/cleanup/dealin01.htm

Applicable Structural Source Control BMPs:

• Design the fueling island to control spills (e.g., use dead-end sumps or spill-control separators) and to treat collected stormwater and/or wastewater to required levels. Slope the concrete containment pad around the fueling island toward drains; either trench drains, catch basins and/or a dead-end sump. Drains to treatment should have a shutoff valve, which must be closed in the event of a spill.
• Alternatively, design the fueling island as a spill-containment pad with a sill or berm raised to a minimum of four inches to prevent the runoff of spilled liquids and to prevent run-on of stormwater from the surrounding area.
• The fueling pad should be paved with Portland cement concrete, or equivalent.
• The fueling island should have a roof or canopy to prevent the direct entry of precipitation onto the spill containment pad. The roof or canopy should, at a minimum,

cover the spill containment pad (within the grade break or fuel dispensing area) and preferably extend several additional feet to reduce the introduction of windblown rain. Convey all roof drains to storm drains outside the fueling containment area.
• Convey the stormwater collected on the fuel island containment pad to a sanitary sewer system, if approved by the sanitary authority; or to an approved treatment system such as an oil/grit separator, sand filter or equivalent. Alternatively, a lined vegetated filter strip can also convey the stormwater from the fuel island to a bioretention area with an under-drain. Discharges from treatment systems to storm drains or surface waters or to the ground must not display ongoing or recurring visible sheen and must meet the requirements of the permit under which they are discharged.
• Alternatively, stormwater collected on the fuel island containment pad may be collected and held for proper off-site disposal.
• Transfer the fuel from the delivery tank trucks to the fuel storage tank in impervious contained areas and ensure that appropriate overflow protection is used. Alternatively, cover nearby storm drains during the filling process and use drip pans under all hose connections.

Additional BMPs for Vehicles 10 feet high or greater:

A roof or canopy may not be practicable at fueling stations that regularly fuel vehicles that are 10 feet high or taller. At those types of fueling facilities, consider using the following additional BMPs:

• If a roof or canopy is impractical, equip the concrete fueling pad with emergency spill controls, including a shutoff valve for the drainage from the fueling area. The valve must be closed in the event of a spill. An electronically actuated valve is preferred to minimize the time lapse between spill and containment. Spills must be cleaned up and contaminated materials disposed off-site in accordance with MassDEP policies and regulations: http://mass.gov/dep/cleanup/dealin01.htm
• The valve may be opened to convey contaminated stormwater to a sanitary sewer, if approved by the sewer authority, or to oil removal treatment such as an API oil/grit separator, sand filter or equivalent treatment, and then to a basic treatment BMP. Discharges from treatment systems to storm drains or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain a significant amount of oil and grease.

An explosive or flammable mixture is defined under state and federal regulations, based on a flash point determination of the mixture. See Appendix B IV for sources of information for flammability and other chemical risks: http://www.osha.gov/dsg/hazcom/ghd053107.html If contaminated stormwater is determined not to be explosive or flammable, then it could be conveyed to a sanitary sewer system.

BMPs for the Building, Repair, and Maintenance of Boats and Ships

Description of Pollutant Sources: Sources of pollutants at boat and shipbuilding, repair, and maintenance at boatyards, shipyards, ports, and marinas include pressure washing, surface preparation, paint removal, sanding, painting, engine maintenance and repairs, and material handling and storage, if conducted outdoors. If feasible, these activities should be done inside under cover. If done outside, use an impervious surface with adequate containment. Potential pollutants include spent abrasive grits, solvents, oils, ethylene glycol, wash water, paint over-spray, cleaners/ detergents, anti-corrosive compounds, paint chips, scrap metal, welding rods, resins, glass fibers, dust, and miscellaneous trash. Pollutant constituents include TSS, oil and grease, organics, copper, lead, tin, and zinc.

Pollutant Control Approach: Apply good housekeeping, preventive maintenance and cover and containment BMPs in and around work areas. See http://mass.gov/dep/recycle/boatyard.htm

Applicable Operational BMPs: Applicable operational BMPs are:

- Regularly clean all accessible work, service and storage areas to remove debris, spent sandblasting material, and any other potential stormwater pollutants.
- Sweep rather than hose debris on the dock. If hosing is unavoidable, collect and convey the hose water to a wastewater treatment system or facility.
- Collect spent abrasives regularly and store under cover to await proper disposal.
- Dispose of greasy rags, oil filters, air filters, batteries, spent coolant, and degreasers properly.
- Drain oil filters before disposal or recycling.
- Immediately repair or replace leaking connections, valves, pipes, hoses and equipment that causes the contamination of stormwater.
- Use drip pans, drop cloths, tarpaulins or other protective devices in all paint mixing and solvent operations unless carried out in impervious contained and covered areas.
- Convey sanitary sewage to pump-out stations, portable on-site pump-outs, or commercial mobile pump-out facilities or other appropriate onshore facilities.
- Maintain automatic bilge pumps in a manner that will prevent waste material from being pumped automatically into surface water.
- Prohibit uncontained spray painting, blasting or sanding activities over open water or in any area where these activities may be exposed to rain, snow, snow melt or runoff.
- Do not dump or pour waste materials down floor drains, sinks, or outdoor storm drain inlets that discharge to surface water or groundwater. Plug floor drains that are connected to storm drains or to surface water. If necessary, install a sump that is pumped regularly.
- Prohibit outside spray painting, blasting or sanding activities during windy conditions that render containment ineffective.
- Do not paint and/or use spray guns on topsides or above decks.
- Immediately clean up any spillage on dock, boat or ship deck areas and dispose of the wastes properly.

Applicable Structural Source Control BMPs:

• Use fixed platforms with appropriate plastic or tarpaulin barriers as work surfaces and for containment when performing work on a vessel in the water to prevent blast material or paint overspray from contacting stormwater or the receiving water. Use of such platforms will be kept to a minimum and at no time be used for extensive repair or construction (anything in excess of 25 percent of the surface area of the vessel above the waterline).
• Use plastic or tarpaulin barriers beneath the hull and between the hull and dry dock walls to contain and collect waste and spent materials. Clean and sweep regularly to remove debris.
• Enclose, cover, or contain blasting and sanding activities to the maximum extent practicable to prevent abrasives, dust, and paint chips from reaching storm sewers or receiving waters. Use plywood and/or plastic sheeting to cover open areas between decks when sandblasting (scuppers, railings, freeing ports, ladders, and doorways).
• Direct deck drainage to a collection system sump for settling and/or additional treatment.
• Store cracked batteries in a covered secondary container.
• Apply source control BMPs provided in this chapter for other activities conducted at the marina, boat yard, shipyard, or port facility (BMPs for Fueling at Dedicated Stations, BMPs for Washing and Steam Cleaning Vehicle/Equipment/Building Structures, and BMPs for Spills of Oil and Hazardous Substances).

<u>Recommended Additional Operational BMPs</u>:

• Consider recycling paint, paint thinner, solvents, used oils, oil filters, pressure wash wastewater and any other recyclable materials.
• Perform activities like paint mixing, solvent mixing, fuel mixing on shore inside or under cover or on an impervious area with adequate containment.

BMPs for Commercial Animal Handling Areas

<u>Description of Pollutant Sources</u>: Animals at racetracks, kennels, fenced pens, veterinarians, and businesses that provide boarding services for horses, dogs, cats, and other animals, can generate pollutants from the following activities: manure deposits, animal washing, grazing and any other animal handling activity that could contaminate stormwater. Pollutants can include coliform bacteria, nutrients, and total suspended solids.

<u>Pollutant Control Approach</u>: To prevent, to the maximum extent practicable, the discharge of contaminated stormwater from animal handling and keeping areas.

<u>Applicable Operational BMPs:</u>

- Regularly sweep and clean animal keeping areas to collect and properly dispose of droppings, uneaten food, and other potential stormwater contaminants
- Do not hose down to storm drains or to receiving water those areas that contain potential stormwater contaminants
- Do not allow any wash waters to be discharged to storm drains. Wash water is wastewater that must not be discharged to the stormwater management system.
- If animals are kept in unpaved and uncovered areas, the ground should either have vegetative cover or some other type of ground cover such as mulch
- If animals are not leashed or in cages, surround the area where animals are kept with a fence or other means that prevents animals from moving away from the controlled area where BMPs are used.

BMPs for Commercial Composting

Description of Pollutant Sources: Commercial compost facilities, operating outside without cover, require large areas to decompose wastes and other feedstocks. Design these facilities so as to separate stormwater from leachate (i.e., industrial wastewater) to the greatest extent practicable. When stormwater is allowed to contact any active composting areas, including waste receiving and processing areas, it becomes leachate.

Pollutants in leachate include nutrients, biochemical oxygen demand (BOD), organics, coliform bacteria, acidic pH, color, and suspended solids. Stormwater at a compost facility consists of runoff from areas at the facility that are not associated with active processing and curing, such as product storage areas, vehicle maintenance areas, and access roads.

Applicable Operational BMPs:

- Ensure that the compost feedstocks do not contain dangerous or hazardous wastes, or solid wastes that are not beneficial to the composting process. Train employees to screen these materials in incoming wastes.
- Store finished compost properly, such as in a covered area, to prevent contamination of stormwater.

Applicable Structural Source Control BMPs:

- Provide curbing for all compost pads to prevent stormwater run-on and leachate run-off.
- Slope all compost pads sufficiently to direct leachate to collection devices.
- Provide one or more sumps or catch basins capable of collecting leachate and conveying it to the leachate holding structure for all compost pads.

Applicable Treatment BMPs:

- Convey all leachate from composting operations to a sanitary sewer, holding tank, or on-site treatment systems designed to treat the leachate and TSS.
- Line the ponds used to collect, store, or treat leachate and other contaminated waters associated with the composting process to prevent groundwater contamination.

Recommended Additional BMPs:
- Regularly clean up debris from yard areas.
- Locate stored residues in areas designed to collect leachate.
- Limit storage times of residues to prevent degradation and generation of leachate.
- Consider using leachate as make-up water in early stages of the composting process. Because leachate can contain pathogenic bacteria, take care to avoid contaminating finished product or nearly finished product with leachate.
- In areas of the state with dry climates, consider using evaporation as a means of reducing the quantity of leachate.

BMPs for Commercial Printing Operations

Description of Pollutant Sources: Materials used in the printing process include inorganic and organic acids, resins, solvents, polyester film, developers, alcohol, vinyl lacquer, dyes, acetates, and polymers. Waste products may include waste inks and ink sludge, resins, photographic chemicals, solvents, acid and alkaline solutions, chlorides, chromium, zinc, lead, spent formaldehyde, silver, plasticizers, and used lubricating oils. As the printing operations are conducted indoors, the only likely points of potential contact with stormwater are the outside temporary storage of waste materials and offloading of chemicals at external unloading bays. Pollutants can include TSS, pH, heavy metals, oil and grease, and COD.

Pollutant Control Approach: Ensure appropriate disposal of process wastes. Cover and contain stored raw and waste materials.

Applicable Operational BMPs:

- Discharge process wastewaters to a sanitary sewer, if approved by the local sewer authority, or to an approved process wastewater treatment system.
- Do not discharge process wastes or wastewaters into storm drains, groundwater or surface water.
- Determine whether any of these wastes qualify for regulation as dangerous wastes and dispose of them accordingly.

Applicable Structural Source Control BMP: Store raw materials or waste materials that could contaminate stormwater in covered and contained areas.

Recommended Additional BMPs:

- Train all employees in pollution prevention, spill response, and environmentally acceptable materials-handling procedures.
- Store materials in proper, appropriately labeled containers. Identify and label all chemical substances.
- Regularly inspect all stormwater management devices and maintain them as necessary.
- Try to use press washes without listed solvents, and with the lowest VOC content possible. Don't evaporate ink cleanup trays to the outside atmosphere.
- Place cleanup sludges into a container with a tight lid and dispose of as hazardous waste. Do not dispose of cleanup sludges in the garbage or in containers of soiled towels.

BMPs for Loading and Unloading Areas for Liquid or Solid Material

Description of Pollutant Sources: Loading/unloading of liquid and solid materials at industrial and commercial facilities are typically conducted at shipping and receiving, outside storage, and fueling areas. Materials transferred can include products, raw materials, intermediate products, waste materials, fuels, scrap metals, etc. Leaks and spills of fuels, oils, powders, organics, heavy metals, salts, acids, and alkalis during transfer are potential causes of stormwater contamination. Spills from hydraulic line breaks are a common problem at loading docks.

Pollutant Control Approach: Cover and contain the loading/ unloading area where necessary to prevent run-on of stormwater and runoff of contaminated stormwater.

Applicable Operational BMPs:

At All Loading/ Unloading Areas:

• A significant amount of debris can accumulate outside uncovered loading/unloading areas. Sweep these surfaces frequently to remove material that could otherwise be washed off by stormwater. Sweep outside areas that are covered for a period of time by containers, logs, or other material after the areas are cleared.
• Place drip pans, or other appropriate temporary containment device, at locations where leaks or spills may occur, such as hose connections, hose reels and filler nozzles. Always use drip pans when making and breaking connections. Check loading and unloading equipment such as valves, pumps, flanges, and connections regularly for leaks and repair as needed.

At Tanker Truck and Rail Transfer Areas to Above/Below-ground Storage Tanks:

• To minimize the risk of accidental spillage, prepare an "Operations Plan" that describes procedures for loading/unloading. Train employees, especially forklift operators, in its execution and post it or otherwise have it readily available to employees.
• Prepare and implement an Emergency Spill Cleanup Plan for the facility that includes the following BMPs:
- Ensure the cleanup of liquid/solid spills in the loading/ unloading area immediately, if a significant spill occurs, and, upon completion of the loading/unloading activity, or at the end of the working day.
- Retain and maintain an appropriate oil spill cleanup kit on-site for rapid cleanup of material spills

- Ensure that an employee trained in spill containment and cleanup is present during loading/unloading.
- Notify MassDEP as required: http://mass.gov/dep/cleanup/dealin01.htm

At Rail Transfer Areas to Above/below-ground Storage Tanks: Install a drip pan system within the rails to collect spills/leaks from tank cars and hose connections, hose reels, and filler nozzles.

Applicable Structural Source Control BMPs:

At All Loading/ Unloading Areas:

• To the extent practicable, conduct unloading or loading of solids and liquids in a manufacturing building, under a roof, or lean-to, or other appropriate cover.
• Berm, dike, and/or slope the loading/unloading area to prevent run-on of stormwater and to prevent the runoff or loss of any spilled material from the area.
• Large loading areas frequently are not curbed along the shoreline. As a result, stormwater passes directly off the paved surface into surface water. Place curbs along the edge, or slope the edge such that the stormwater can flow to an internal storm drain system that leads to a treatment BMP.
• Pave and slope loading/unloading areas to prevent the pooling of water. The use of catch basins and drain lines within the interior of the paved area must be minimized as they will frequently be covered by material, or they should be placed in designated "alleyways" that are not covered by material, containers or equipment.

Recommended Structural Source Control BMP: For the transfer of pollutant liquids in areas that cannot contain a catastrophic spill, install an automatic shutoff system in case of unanticipated off-loading interruption (e.g. coupling break, hose rupture, overfill, etc.).

At Loading and Unloading Docks:

• Install/maintain overhangs, or door skirts that enclose the trailer end, to prevent contact with rainwater.
• Design the loading/unloading area with berms and grading to prevent the run-on of stormwater.
• Retain on-site the necessary materials for rapid cleanup of spills.

At Tanker Truck Transfer Areas to Above/Below-Ground Storage Tanks:

• Pave the area on which the transfer takes place. If any transferred liquid, such as gasoline, is reactive with asphalt, pave the area with Portland cement concrete.
• Slope, berm, or dike the transfer area to a dead-end sump, spill containment sump, an oil/grit separator, or other spill control device.

BMPs for Painting/Finishing/ Coating of Vehicles/Boats/ Buildings/ Equipment

Description of Pollutant Sources: Surface preparation and the application of paints, finishes and/or coatings to vehicles, boats, buildings, and/or equipment outdoors can be sources of pollutants. Potential pollutants include organic compounds, oils and greases, heavy metals, and suspended solids.

Pollutant Control Approach: Cover and contain painting and sanding operations and apply good housekeeping and preventive maintenance practices to prevent the contamination of stormwater with painting oversprays and grit from sanding.
http://www.dtsc.ca.gov/PollutionPrevention/ABP/upload/IntroAuto_Body_and_Paint.pdf

Applicable Operational BMPs:

- Train employees in the careful application of paints, finishes, and coatings to reduce misuse and over spray. Use ground- or drop-cloths underneath outdoor painting, scraping, sandblasting work, and properly clean and temporarily store collected debris daily.
- Do not conduct spraying, blasting, or sanding activities over open water or where wind may blow paint into water.
- Wipe up spills with rags and other absorbent materials immediately. Do not hose down the area to a storm drain or receiving water or conveyance ditch to receiving water.
- On marine dock areas, sweep rather than hose down debris. Collect any hose water generated and convey to appropriate treatment and disposal.
- Use a storm drain cover, filter fabric, or similarly effective runoff control device if dust, grit, washwater, or other pollutants may escape the work area and enter a catch basin. The containment device(s) must be in place at the beginning of the workday. Collect contaminated runoff and solids and properly dispose of such wastes before removing the containment device(s) at the end of the workday.
- Use a ground cloth, pail, drum, drip pan, tarpaulin, or other protective device for activities such as paint mixing and tool cleaning outside or where spills can contaminate stormwater.
- Properly dispose of all wastes and prevent all uncontrolled releases to the air, ground or water.
- Clean brushes and tools covered with non-water-based paints, finishes, or other materials in a manner that allows collection of used solvents (e.g., paint thinner or turpentine) for recycling or proper disposal.
- Store toxic materials under cover during precipitation events and when not in use to prevent contact with stormwater.

Applicable Structural Source Control BMPs: Enclose and/or contain all work while using a spray gun or conducting sand blasting. Do not conduct outside spraying, grit blasting, or sanding activities during windy conditions that render containment ineffective.

Recommended Additional Operational BMPs:

• Clean paintbrushes and tools covered with water-based paints in sinks connected to sanitary sewers or in portable containers that can be dumped into a sanitary sewer drain.
• Recycle paint, paint thinner, solvents, pressure washwater, and any other recyclable materials.
• Use efficient spray equipment such as electrostatic, air-atomized, high-volume/low-pressure, or gravity feed spray equipment.
• Purchase recycled paints, paint thinner, solvents, and other products if feasible.

BMPs for Railroad Yards.

Note: MassDEP requires an oil grit separator, sand filter or equivalent to manage stormwater runoff from this land use.

Description of Pollutant Sources: Pollutant sources can include drips/leaks of vehicle fluids onto the railroad bed, human waste disposal, litter, locomotive/railcar/equipment cleaning areas, fueling areas, outside material storage areas, the erosion and loss of soil particles from the railroad bed, maintenance and repair activities at railroad terminals, switching yards, and maintenance yards, and herbicides used for vegetation management. Waste materials can include waste oil, solvents, degreasers, antifreeze solutions, radiator flush, acids, brake fluids, soiled rags, oil filters, sulfuric acid and battery sludges, and machine chips with residual machining oil and toxic fluids/solids lost during transit. Potential pollutants include oil and grease, TSS, BOD, organics, pesticides, and metals.

Pollutant Control Approach: Apply good housekeeping and preventive maintenance practices to control leaks and spills of liquids in railroad yard areas.

Applicable Operational and Structural Source Control BMPs:

- Do not allow discharge to outside areas from toilets while a train is in transit. Pump out facilities should be used to service these units.
- Use drip pans at hose/pipe connections during liquid transfer and other leak-prone areas.
- During maintenance, do not discard debris or waste liquids along the tracks or in railroad yards.

Applicable Treatment BMPs: In areas subjected to leaks/spills of oils or other chemicals, convey the contaminated stormwater to appropriate treatment such as a sanitary sewer, if approved by the appropriate sewer authority, or to an oil/grit separator for floating oils, or other treatment, as approved by the local jurisdiction.

Retail and Wholesale.

- **Restaurants/Fast Food (SIC: 5800)**

Description: Businesses that provide food service to the general public, including drive-through facilities.

Potential Pollutant Generating Sources: Potential pollutant sources include high-use customer parking lots and garbage dumpsters. The cleaning of roofs and other outside areas of restaurant and cooking vent filters in the parking lot can cause cooking grease to be discharged to the storm drains. MassDEP prohibits discharging wash water or grease to storm drains or surface water.

- **Retail/General Merchandise (SIC: 5300, 5600, 5700, 5900, and 5990)**

Description: This group includes general merchandising stores such as department stores, shopping malls, variety stores, 24-hour convenience stores, and general retail stores that focus on a few product types such as clothing and shoes. It also includes furniture and appliance stores.

Potential Pollutant Generating Sources: Of particular concern are the high-use parking lots of shopping malls and 24-hour convenience stores. Furniture and appliance stores may provide repair services in which dangerous wastes may be produced.

- **Retail/Wholesale Vehicle and Equipment Dealers (SIC: 5010, 5080, and 5500, 7510 excluding fueling stations)**

Description: This group includes all retail and wholesale businesses that sell, rent, or lease cars, trucks, boats, trailers, mobile homes, motorcycles and recreational vehicles. It includes both new and used vehicle dealers. It also includes sellers of heavy equipment for construction, farming, and industry. With the exception of motorcycle dealers, these businesses have large parking lots. Most retail dealers that sell new vehicles and large equipment also provide repair and maintenance services.

Potential Pollutant Generating Sources: Oil and other materials that have dripped from parked vehicles can contaminate stormwater at high-use parking areas. Vehicles are washed regularly, generating vehicle grime and detergent pollutants. The storm- or washwater runoff will contain oils and various organics, metals, and phosphorus. Repair and maintenance services generate a variety of waste liquids and solids including used oils and engine fluids, solvents, waste paint, soiled rags, and dirty used engine parts. Many of these materials are hazardous wastes.

- **Retail/Wholesale Nurseries and Building Materials (SIC: 5030, 5198, 5210, 5230, and 5260)**

Description: These businesses are placed in a separate group because they are likely to store much of their merchandise outside of the main building. They include nurseries, and businesses that sell building and construction materials and equipment, paint, and hardware.

Potential Pollutant Generating Sources: Some businesses may have small fueling capabilities for forklifts and may also maintain and repair their vehicles and equipment. Some businesses may have unpaved areas, with the potential to contaminate stormwater by leaching of nutrients, pesticides, and herbicides. Storm runoff from exposed storage areas can contain suspended solids, and oil and grease from vehicles and forklifts and high-use customer parking lots, and other pollutants. Runoff from nurseries may contain nutrients, pesticides and/or herbicides.

- **Retail/Wholesale Chemicals and Petroleum (SIC: 5160, 5170*)***

Description: These businesses sell plastic materials, chemicals and related products. This group also includes the bulk storage and selling of petroleum products such as diesel oil and automotive fuels.

Potential Pollutant Generating Sources: The general areas of concern are the spillage of chemicals or petroleum during loading and unloading, and the washing and maintenance of tanker trucks and other vehicles. Also, the fire code requires that vegetation be controlled within a tank farm to avoid a fire hazard. Herbicides are typically used. The concentration of oil in untreated stormwater is known to exceed the water quality effluent guideline for oil and grease. Runoff is also likely to contain significant concentrations of benzene, phenol, chloroform, lead, and zinc.

- **Retail/Wholesale Foods and Beverages (SIC 5140, 5180, 542, 54)**

Description: Included are businesses that provide retail food stores, including general groceries, fish and seafood, meats and meat products, dairy products, poultry, soft drinks, and alcoholic beverages.

Potential Pollutant Generating Sources: Vehicles may be fueled, washed and maintained at the business. Spillage of food and beverages may occur. Waste food and broken contaminated glass may be temporarily stored in containers located outside. High-use customer parking lots may be sources of oil and other contaminants.

- **Other Retail/Wholesale Businesses (SIC: 5010 (not 5012), 5040, 5060,5070, 5090)**

Description: Businesses in this group include sellers of vehicle parts, tires, furniture and home furnishings, photographic and office equipment, electrical goods, sporting goods and toys, paper products, drugs, and apparel.

Potential Pollutant Generating Sources: Pollutant sources include high-use parking lots, and delivery vehicles that may be fueled, washed, and maintained on premises.

BMPs for Road Salt Storage and Snow Disposal

Description:

The application and storage of deicing materials, most commonly salts such as sodium chloride, can lead to water quality problems for surrounding areas. Salts, gravel, sand, and other materials are applied to highways and roads to reduce the amount of ice during winter storm events. Salts lower the melting point of ice, allowing roadways to stay free of ice buildup during cold winters. Sand and gravel increase traction on the road, making travel safer.

MassDEP has developed a guidance document for communities regarding snow disposal, available on the web at: http://www.mass.gov/dep/water/laws/snowdisp.htm. This guidance document recommends the following to establish a snow disposal site. The key to selecting effective snow disposal sites is to locate them adjacent to or on pervious surfaces in upland areas away from water resources and wells. At these locations, the snow meltwater can filter in to the soil, leaving behind sand and debris which can be removed in the springtime. Snow dumping prohibitions include:

- Avoid dumping snow into any waterbody, including rivers, the ocean, reservoirs, ponds, or wetlands. In addition to water quality impacts and flooding, snow disposed of in open water can cause navigational hazards when it freezes into ice blocks.
- Do not dump snow within a Zone II or Interim Wellhead Protection Area (IWPA) of a public water supply well or within 75 feet of a private well, where road salt may contaminate water supplies.
- Avoid dumping snow on MassDEP-designated high- and medium-yield aquifers where it may contaminate groundwater (see the next page for information on ordering maps from MassGIS showing the locations of aquifers, Zone II's, and IWPAs in your community).
- Avoid dumping snow in sanitary landfills and gravel pits. Snow meltwater will create more contaminated leachate in landfills, posing a greater risk to groundwater, and in gravel pits there is little opportunity for pollutants to be filtered out of the meltwater because groundwater is close to the land surface.
- Do not place snow on top of storm drain catch-basins or in stormwater drainage swales or ditches. Snow combined with sand and debris may block a storm drainage system, causing localized flooding. A high volume of sand, sediment, and litter released from melting snow also may be quickly transported through the system into surface water.

In addition to carefully selecting disposal sites before the winter begins, it is important to prepare and maintain these sites to maximize their effectiveness. The following maintenance measures should be undertaken for all snow disposal sites:

- Securely place a silt fence or equivalent barrier on the downgradient side of the snow disposal site.
- To filter pollutants out of the meltwater, maintain a 50-foot vegetative buffer strip during the growth season between the disposal site and adjacent waterbodies.

- Clear debris from the site prior to using the site for snow disposal.
- Clear debris from the site and properly dispose of it at the end of the snow season.

Applicability:

This practice is applicable to areas that receive snowfall in winter months and require deicing materials. Municipalities in these areas must ensure proper storage and application for equipment and materials and identify appropriate areas for snow disposal.

Siting and Design Considerations:

Many of the problems associated with contamination of local waterways stem from the improper storage of deicing materials. Salts are very soluble when they come into contact with storm water. They can migrate into groundwater used for public water supplies and also contaminate surface waters.

More information about road deicing materials can be found at the American Association of State Highway and Transportation Officials web page at:
http://www.transportation.org/

Limitations:

Road salt is the least expensive material for deicing operations; however, once the full social costs are taken into account, alternative products and better management and application of salts become increasingly attractive options.

Maintenance Considerations:

Covering stored road salts may be costly; however, the benefits are greater than the perceived costs. Storing road salts correctly prevents the salt from lumping together, which makes it easier to load and apply. In addition, covering salt storage piles reduces salt loss from storm water runoff and potential contamination to streams, aquifers, and estuarine areas. Salt storage piles should be located outside the 100-year floodplain for further protection against surface water contamination.

During road salt application, certain best management practices can produce significant environmental benefits. Regulate the amount of road salt applied to avoid over-salting motorways and increasing runoff concentrations. Many drinking water supply watersheds in Massachusetts use lower amounts of road salt to protect the resource.

The amount of salt applied should be varied to reflect site-specific characteristics, such as road width and design, traffic concentration, and proximity to surface waters. Calibration devices for spreaders in trucks aid maintenance workers in the proper application of road salts. Use alternative materials, such as sand or gravel, in especially sensitive areas.

MassHighway and the Executive Office of Energy & Environmental Affairs have developed a Generic Environmental Impact Report on Snow and Ice Control that contains many suggestions to reduce road salt impacts on water resources. The Massachusetts DEP has issued the Massachusetts Guidelines on Deicing Chemical (Road Salt) Storage (1997), available on the web at: http://www.mass.gov/dep/water/laws/policies.htm#snowsalt

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BMPs for Service Industries

- **Animal Care Services (SIC: 0740, 0750)**

Description: This group includes racetracks, kennels, fenced pens, veterinarians and businesses that provide boarding services for animals including horses, dogs, and cats.

Potential Pollutant Generating Sources: The primary sources of pollution include animal manure, wash waters, waste products from animal treatment, runoff from pastures where larger livestock are allowed to roam, and vehicle maintenance and repair shops. Pastures may border streams and direct access to the stream may occur. Both surface water and groundwater may be contaminated. Potential stormwater contaminants include fecal coliform, oil and grease, suspended solids, BOD, and nutrients.

- **Commercial Car and Truck Washes (SIC: 7542)**

Description: Facilities include automatic systems found at individual businesses or at gas stations and 24-hour convenience stores, as well as self-service car washes. There are three main types: tunnels, rollovers and hand-held wands. The tunnel wash, the largest, is housed in a long building through which the vehicle is pulled. At a rollover wash, the vehicle remains stationary while the equipment passes over. Wands are used at self-serve car washes. Some car washing businesses also sell gasoline.

Potential Pollutant Generating Sources: Wash wastewater may contain detergents and waxes. Wastewater should be discharged to sanitary sewers. In self-service operations a drain is located inside each car bay. Although these businesses discharge the wastewater to the sanitary sewer, some washwater can find its way to the storm drain, particularly with the rollover and wand systems. Rollover systems often do not have air-drying. Consequently, as it leaves the enclosure the car sheds water to the pavement. With the self-service system, washwater with detergents can spray outside the building and drain to storm sewer. Users of self-serve operations may also clean engines and change oil, dumping the used oil into the storm drain. Potential pollutants include oil and grease, detergents, soaps, BOD, and TSS.

- **Equipment Repair (SIC: 7353, 7600)**

Description: This group includes several businesses that specialize in repairing different equipment including communications equipment, radio, TV, household appliances, and refrigeration systems. Also included are businesses that rent or lease heavy construction equipment, as miscellaneous repair and maintenance may occur on-site.

Potential Pollutant Generating Sources: Potential pollutant sources include storage and handling of fuels, waste oils and solvents, and loading/unloading areas. Potential pollutants include oil and grease, low/high pH, and suspended solids.

- **Laundries and Other Cleaning Services (SIC: 7211 through 7217)**

Description: This category includes all types of cleaning services such as laundries, linen suppliers, diaper services, coin-operated laundries and dry cleaners, and carpet and upholstery services. Wet washing may involve the use of acids, bleaches and/or multiple organic solvents. Dry cleaners use an organic-based solvent, and sometimes small amounts of water and detergent. Solvents may be recovered and filtered for further use. Carpets and upholstery may be cleaned with dry materials, hot water extraction processes, or in-plant processes using solvents followed by a detergent wash.

Potential Pollutant Generating Sources: Wash liquids are discharged to sanitary sewers. Stormwater pollutant sources include: loading and unloading of liquid materials, particularly at large commercial operations, disposal of spent solvents and solvent cans, high-use customer parking lots, and outside storage and handling of solvents and waste materials. Potential stormwater contaminants include oil and grease, chlorinated and other solvents, soaps and detergents, low/high pH, and suspended solids.

- **Marinas and Boat Clubs (SIC: 7999)**

Description: Marinas and yacht clubs provide moorage for recreational boats. Marinas may also provide fueling and maintenance services. Other activities include cleaning and painting of boat surfaces, minor boat repair, and pumping of bilges and sanitary holding tanks. Not all marinas have a system to receive pumped bilge water.

Potential Pollutant Generating Sources: Both solid and liquid wastes are produced as well as stormwater runoff from high-use customer parking lots. Waste materials include sewage and bilge water. Maintenance by the tenants will produce used oils, oil filters, solvents, waste paints and varnishes, used batteries, and empty contaminated containers and soiled rags. Potential stormwater contaminants include oil and grease, suspended solids, heavy metals, and low/high pH.

- **Golf and Country Clubs (SIC: 7992, 7997)**

Description: Public and private golf courses and parks are included.

Potential Pollutant Generating Sources: Maintenance of grassed areas and landscaped vegetation has historically required the use of fertilizers and pesticides. Golf courses contain small lakes that are sometimes treated with algaecides and/or mosquito larvicides. The fertilizer and pesticide application process can lead to inadvertent contamination of nearby surface waters by overuse, misapplication, or the occurrence of storms shortly after application. Heavy watering of surface greens in golf courses may cause pesticides or fertilizers to migrate to surface and shallow groundwater resources. The use of pesticides and fertilizers generates waste containers. Equipment must be cleaned and maintained.

- **Miscellaneous Services (SIC: 4959, 7260, 7312, 7332, 7333, 7340, 7395, 7641, 7990, 8411)**

Description: This group includes photographic studios, commercial photography, funeral services, amusement parks, furniture and upholstery repair and pest control services, and other professional offices. Pollutants from these activities can include pesticides, waste solvents, heavy metals, pH, and suspended solids, soaps and detergents, and oil and grease.

Potential Pollutant Generating Sources: Leaks and spills of materials from the following businesses can be sources of stormwater pollutants:
1. Building maintenance produces wash and rinse solutions, oils, and solvents.
2. Pest control produces rinse water with residual pesticides from washing application equipment and empty containers.
3. Outdoor advertising produces photographic chemicals, inks, waste paints, and organic paint sludges containing metals.
4. Funeral services produce formalin, formaldehyde, and ammonia.
5. Upholstery and furniture repair businesses produce oil, stripping compounds, wood preservatives and solvents.

- **Professional Services (SIC: 6000, 7000 and 8000, 806, 807)**

Description: The remaining service businesses include theaters, hotels/motels, finance, banking, hospitals, medical/dental laboratories, medical services, nursing homes, schools/universities, and legal, financial and engineering services. Stormwater from parking lots will contain undesirable concentrations of oil and grease, suspended particulates, and metals such as lead, cadmium and zinc. Dangerous wastes might be generated at hospitals, nursing homes and other medical services.

Potential Pollutant Generating Sources: The primary concern is runoff from high-use parking areas, maintenance shops, and storage and handling of dangerous wastes.

- **Vehicle Maintenance and Repair (SIC: 4000, 7530, 7600)**

Description: This category includes businesses that paint, repair and maintain automobiles, motorcycles, trucks, and buses and battery, radiator, muffler, lube, tune-up and tire shops, excluding those businesses listed elsewhere in this manual.

Potential Pollutant Generating Sources: Pollutant sources include storage and handling of vehicles, solvents, cleaning chemicals, waste materials, vehicle liquids, batteries, and washing and steam-cleaning of vehicles, parts, and equipment. Potential pollutants include waste oil, solvents, degreasers, antifreeze, radiator flush, acid solutions with chromium, zinc, copper, lead and cadmium, brake fluid, soiled rags, oil filters, sulfuric acid and battery sludge, and machine chips in residual machining oil.

- **Construction Businesses (SIC: 1500, 1600, and 1700)**

Description: This category includes builders of homes, commercial and industrial buildings, and heavy equipment as well as plumbing, painting and paper hanging, carpentry, electrical, roofing and sheet metal, wrecking and demolition, stonework, drywall, and masonry contractors. It does not include construction sites.

Potential Pollutant Generating Sources: Potential pollutant sources include leaks/spills of used oils, solvents, paints, batteries, acids, strong acid/alkaline wastes, paint/varnish removers, tars, soaps, coatings, asbestos, lubricants, anti-freeze compounds, litter, and fuels at the headquarters, operation, staging, and maintenance/repair locations of the businesses. Demolition contractors may store reclaimed material before resale. Roofing contractors generate residual tars and sealing compounds, spent solvents, kerosene, and soap cleaners, as well as non-hazardous-waste roofing materials. Sheet metal contractors produce small quantities of acids and solvent cleaners such as kerosene, metal shavings, adhesive residues and enamel coatings, and asbestos residues that have been removed from buildings. Asphalt paving contractors are likely to store application equipment such as dump trucks, pavers, tack coat tankers and pavement rollers at their businesses. Stormwater passing through this equipment may be contaminated by the petroleum residuals. Potential pollutants include oil and grease, suspended solids, BOD, heavy metals, pH, COD, and organic compounds.