A Community Guide to

E. Himlan, Mass. Watershed Coalition

Berkshire Design Group

Growing Greener

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Introduction

The Community Guide to Growing Greener is a set of guidelines for developers, designers and community boards intended to advance greener growth and cleaner water in Wachusett communities. It will help local builders, businesses and community residents to use effective, low-cost measures that can cleanse runoff from their property and prevent it from harming water supplies and habitats. This guidance will also help to attract development that can protect the Town's character and its valuable natural resources.

Stormwater from roads, homes and businesses is the greatest source of pollution in our area. Yet, few people know how to use practices such as rain gardens and low impact designs to cleanse the most polluted 'first flush' of storm runoff. Stormwater is produced by the entire community, and everyone can prevent pollution. The solutions explained in the guide will enable municipal boards, builders, businesses and residents to make a difference in improving the quality of their environment.

The Guide describes design and construction practices for stormwater management, erosion and sedimentation control, landscape design, and site planning. This Guide will also be useful to communities required to meet the U.S. Environmental Protection Agency's Phase II stormwater regulations.

None of the practices in the Guide are new, and many have been used extensively in Massachusetts. The Guide also provides a consistent reference book for designers and reviewers working in the Wachusett region. Since many low impact practices are site-dependent, the Guide identifies a range of methods that may be useful to development and redevelopment projects on a variety of sites.

Applicants for a Stormwater or Low Impact Development Permit, or who seek approval under Subdivision, Site Plan or other regulations, will find this Guide to be a helpful reference on low impact practices. **However, the Guide to Growing Greener is not a substitute for meeting the specific procedures and requirements of individual towns. Please be sure to consult community officials about applicable bylaws and regulations. This Guide accords with the MA Department of Environmental Protection's (DEP's) Stormwater Management Standards and Handbook, from which much of the information has been drawn. If you are required to meet DEP standards in the design and construction of stormwater management devices, please refer to the Stormwater Management Standards and Handbook for details.**

The Guide is divided into five sections. Section I is a **checklist for designers** to help them determine which best development practices are likely to be applicable to their project. Project reviewers may also use this checklist to assess the project's conformity with the objectives set forth in the Guide to Growing Greener. Sections II through V discuss low impact practices related to **stormwater management**, **erosion and sedimentation control**, **landscape design**, and **site planning**. These four sections describe the best development practices that are applicable in different situations and some technical details of the practices. References are provided for those who seek more information and design specifications for the various practices.

Thank you for taking the time to read this Guide. With your help Wachusett communities will become models for attractive and environmentally responsible community development.

We are grateful to the Town of Franklin, MA for providing their Best Development Practices Guide, upon which this Guide is based.

I. Checklist for Designers

The Checklist for Designers is a summary of the best development practices that this Guide recommends, and when they should be used. Prior to submitting an application for review, the applicant is encouraged to fill out this checklist to verify that he or she has complied with the community's development objectives and planned the development or redevelopment site in a way that furthers the goals discussed below. The checklist may be submitted with an application. The Planning Board and their technical consultants may use the checklist to evaluate whether the application conforms with this Guide.

Stormwater Management

GOALS and NEEDS addressed:

1. Protect local and regional wetlands and water bodies
2. Maximize groundwater recharge to retain a viable local groundwater supply and reduce flooding

COMMUNITY OBJECTIVES:

(A) All new development projects in this community should meet the following three stormwater management performance objectives. All redevelopment projects should meet the objectives to the maximum feasible extent, and, if they fail to meet the objectives, should retrofit or expand existing stormwater management systems to improve existing conditions.

1. Post-development peak discharge rates from the site should not exceed pre-development peak discharge rates from the site.
2. Annual groundwater recharge from the post-development site should approximate annual recharge from the pre-development site.
3. The stormwater management system should remove at least 80% of the average annual load of total suspended solids (TSS) from the post-development stormwater created on the developed site.

(B) Low impact, non-structural stormwater management systems should be used wherever site conditions allow as outlined in the Guide. Drain pipe/catch basin systems may be used, in part or in whole, if the applicant can demonstrate that other systems are not feasible due to site conditions.

BEST DEVELOPMENT PRACTICES One or more of the following may be used to meet the above objectives.	Incorporated into Project?
Vegetated water quality swales (Dry & Wet) *(recommended to collect runoff from roadways & parking lots)*	☐
Vegetated filter strips *(recommended to filter and infiltrate runoff from roadways, parking lots, and driveways; use with vegetated swales along roadsides and parking lots)*	☐
Constructed wetlands *(preferred method for stormwater retention & pollutant removal)*	☐
Bioretention cells (Rain Gardens) *(recommended on residential lots and parking lot islands)*	☐
Porous pavement *(recommended in overflow parking and low-traffic areas)* Can narrower roadways be used in low-traffic areas?	☐
Tree box filter *(recommended in urbanized locations)*	☐
Green roofs *(encouraged on flat commercial and industrial rooftops)*	☐
Wet basins *(less preferred method for stormwater retention & pollutant removal)*	☐
Dry detention basins *(less preferred, but may be used in series with other practices, such as constructed wetlands, to provide pre-treatment)*	☐
Deep sump catch basin *(discouraged, unless other stormwater collection and conveyance systems have been demonstrated not to be feasible due to site conditions)*	☐
Have you evaluated the feasibility of leaching catch basins?	☐

Erosion and Sedimentation Control

GOALS and NEEDS addressed:

1. Minimize erosion
2. Prevent sedimentation of water bodies and its attendant environmental impacts

COMMUNITY OBJECTIVES:

(A) Any proposed project on a previously undeveloped site should accommodate the development program in a way that minimizes clearing and regrading, especially in areas of steep slopes, erosion-prone soils, or sensitive vegetation. The site plan for redevelopment projects should concentrate development in previously-disturbed areas to the extent possible.

(B) Proposed projects should submit and adhere to a construction management plan that addresses soil stabilization, sediment retention, perimeter protection, construction scheduling, traffic area stabilization and dust control.

BEST DEVELOPMENT PRACTICES The applicant should comply with the following:	Incorporated into Project?
Is a U.S. EPA Construction General Permit required?	☐
Clearing and regrading have been minimized	☐
Development is focused in previously disturbed areas *(for redevelopment projects)*	☐
A construction management plan has been prepared	☐
The construction management plan addresses:	
Soil stabilization *(cover or stabilize erodible surfaces not in immediate use)*	☐
Sediment retention *(runoff interceptors and sediment traps/ponds)*	☐
Perimeter protection *(vegetated buffers or silt fences at the limit of work)*	☐
Construction scheduling *(minimize disturbed area at any given time)*	☐
Traffic area stabilization *(crushed rock or similar at construction vehicle entrance and parking areas)*	☐
Dust control *(plan for stabilizing dusty surfaces when necessary)*	☐

Landscape Design

GOALS and NEEDS addressed:

1. Minimize demand for irrigation water
2. Maximize groundwater recharge from landscaped areas
3. Preserve native biodiversity by retaining habitat and defending against invasive species
4. Maximize the value to wildlife of human-managed landscapes

COMMUNITY OBJECTIVES:

(A) Site plans and landscape plans for all proposed projects should take appropriate steps, as outlined in the Guide, to minimize water use for irrigation and to allow for natural recharge of groundwater.

(B) Landscape plans should follow the guidelines in the Guide for selecting species that are most appropriate to the site conditions. Native species and habitat-creating species should be used in all landscape plans to the maximum extent possible while still meeting the site's landscaping needs. Prohibited and invasive species identified in this Guide should not be planted under any condition.

BEST DEVELOPMENT PRACTICES The applicant should comply with the following:	Incorporated into Project?
Clearing and regrading have been minimized *(natural vegetation should be retained to the maximum extent possible, given the development program)*	☐
Irrigation, if present, is water efficient *(if an in-ground irrigation systems is proposed, it is a water efficient system with automatic sensors to prevent overwatering)*	☐
Landscaped areas retain water *(gardens are mulched and designed for water infiltration)*	☐
No prohibited or invasive species are used *(species from the prohibited and invasive species lists may not be used)*	☐
Native and habitat-creating species are used *(species from these lists have been incorporated into the landscape design whenever possible)*	☐
Species are appropriate to the soil, site, and microclimate conditions *(select appropriate species from the lists of salt-tolerant, urban-tolerant, wetland, moist-tolerant and drought-tolerant species)*	☐

Site Planning

GOALS and NEEDS addressed:

1. Protect the community's natural environment, including habitat, water resources and ecosystem services
2. Create a visually appealing community
3. Preserve the Town's historic and cultural heritage
4. Stabilize and increase property values
5. Encourage sustainable development

COMMUNITY OBJECTIVES:
Subdivision plans and site plans for all forms of development should adhere to the principles of *environmental compatibility*, *aesthetic compatibility* and *energy-efficient design*.

BEST DEVELOPMENT PRACTICES The site plan should address the following principles:	Incorporated into Project?
Unique natural features have been preserved *(the development should protect and/or showcase significant natural features)*	☐
Historic and cultural resources have been preserved *(the development should protect and/or showcase significant historic and cultural features)*	☐
Clearing, grading, and building placement consider viewsheds	☐
Cut and fill have been minimized	☐
Impervious surfaces are minimized	☐
Narrower roadways are used where appropriate	☐
Buildings blend into the natural topography	☐
Buildings are oriented to the sun and wind for maximum energy efficiency	
Vegetated protection from northwest (winter) winds is provided	☐
Deciduous species planted or retained close to the E, S and W building edges	☐

II. Stormwater Management

a. Overview and Objectives

The need for strong and innovative stormwater management practices is an attempt to address several challenges:

- Communities have numerous streams, ponds and wetlands, all of which are affected by polluted runoff.
- Hilly topography contributes to stormwater runoff and flooding in developed areas. Better groundwater recharge will reduce flooding and help maintain base flows of rivers and streams.
- Some towns rely on local groundwater aquifers for public water supplies. Groundwater recharge is essential to help reduce water shortages.
- The U.S. Environmental Protection Agency (EPA) and MA Department of Environmental Protection (DEP) are creating more stringent requirements for communities to manage polluted runoff effectively.[1] (Notes and references are provided in the endnotes.)

In order to attain a minimum level of stormwater management for development and redevelopment projects, our community has adopted the following stormwater management performance objectives.[2] The performance objectives allow the design engineer to select one or more stormwater management systems that are most appropriate and cost-effective for the particular site.

COMMUNITY OBJECTIVES: All new development projects should meet the following three stormwater management performance objectives. All redevelopment projects should meet the objectives and if they fail to meet the objectives, should retrofit or expand existing stormwater management systems to improve existing conditions.

1. Post-development peak discharge rates from the site should not exceed pre-development peak discharge rates from the site.
2. Annual groundwater recharge from the post-development site should approximate annual recharge from the pre-development site.
3. The stormwater management system should remove at least 80% of the average annual load of total suspended solids (TSS) from the post-development stormwater created on the developed site.

There is a growing realization among water resource professionals that conventional systems of stormwater collection, conveyance, and end-of-the-pipe dry-basin detention are not sufficient to improve the water quality of surface water bodies. Therefore, the community's preference is that stormwater be conveyed and treated in natural and vegetated systems such as vegetated swales, filter strips, constructed wetlands, and bioretention cells (rain gardens). While some of these practices may be new to our

COMMUNITY OBJECTIVES: Low impact, non-structural stormwater management systems should be used wherever site conditions allow, as outlined in the Guide. Drain pipe/catch basin systems may be used, in part or in whole, if the applicant can demonstrate that other systems are not feasible due to site conditions.

community, they have been used successfully in other towns and states and have gained support from the EPA and MA DEP because of their generally superior performance in attenuating peak runoff rates, filtering pollutants, recharging groundwater, and retaining the natural landscape. Recognizing that non-structural systems are not appropriate in all situations, the Guide also discusses other practices that can be used in certain situations.

This section of the Guide discusses ten stormwater management practices that can be used, alone or in combination, to meet the performance objectives. Other systems not discussed in this Guide may also be appropriate if the applicant can demonstrate their fulfillment of the above objectives. Table 2-1 provides a summary of the practices discussed in this chapter and when each practice is encouraged. This list is not exhaustive, and many other practices are available. Please consult the MA DEP Stormwater Handbook, Volume 2, Chapter 2 for details about these and other stormwater management practices.

Table 2-1: Use of Stormwater Management Practices

Practice	Community Objective	Appropriate Uses
Vegetated Water Quality Swales (Dry & Wet)	Encouraged	Roadsides, parking lots
Vegetated Filter Strips	Strongly encouraged	Roadsides, residential frontage areas, parking lots, perimeter protection
Constructed Wetlands	Strongly encouraged	Commercial and industrial sites, office campuses, subdivisions
Bioretention Cells (Rain Gardens)	Strongly encouraged	Residential lots, parking lot islands, urban & suburban locations; retrofits
Porous Pavement	Encouraged	Parking overflow areas, driveways, walkways
Tree Box Filter	Encouraged	Along streets and sidewalks in urbanized locations
Green Roofs	Encouraged	Office/industrial buildings
Wet Basins	Neutral	Subdivisions, office developments
Dry Detention Basins	Can be used in combination with other practices or when other systems are not practical due to site constraints	All areas of development, if necessary
Deep Sump Catch Basin	Can be used when other systems are not practical due to site constraints	All areas of development, if necessary

There are several factors to consider when deciding on which practice(s) to implement in any given project. Among these factors are the space required, soils and slopes on site, depth to the water table, maintenance requirements, pollutant removal efficiencies, cost and ability to meet stormwater performance objectives.

b. Summary of Practices

Table 2-2 provides a summary of design and site considerations for selected stormwater management systems.

Table 2-2: Design and Site Considerations for Stormwater Practices[3]

	Vegetated Water Quality Swales (Dry & Wet)	Vegetated Filter Strips	Constructed Wetlands	Bioretention Cells (Rain Gardens)	Porous Pavement	Tree Box Filter	Wet Basins	Dry Detention Basins
Space Required	Bottom width: 2 ft. min. 8 ft. max.	Minimum length, 25 feet. Minimum width should be 20% of the length of flow path or 8 ft., whichever is greater	1% to 2% of watershed drainage area. Generally a watershed contributing area >10 to 25 acres is needed	Device size should be 5% to 7% of the area draining to it. Devices perform best with contributing area <5 acres	Not a factor	Not a factor	Min. pool surface area: 0.25 acres. Require drainage area from 20 acres to 1 sq. mi.	1 acre foot per 4 acres drainage area
Soils	Permeable soils perform better, but wet swales can be used in less permeable soils	Permeable soils perform best. Avoid using in soils with high clay content or soils that cannot sustain grass cover	Preferred soils are medium-fine textured soils such as loams and silt loams	Man-made soil mix is used consisting of sand, topsoil and compost. Under-drains allow for less permeable soils.	Soils with permeability of at least 0.17 inches per hour	Man-made soil mix is used. Under-drains allow for les permeable soils.	Soils should allow permanent pool of water. Where soils are highly permeable, a liner may be used	Highly impermeable soils may not allow water to drain
Slope of Catchment Area	Longitudinal slope of swale should be <5%. Slope should allow non-erosive flow rate	Slope of contributing area should be between 2% and 6%	Max. 15% for forested; 5% for shrubs/ Herbs	Devices perform best on slopes of ~5%. Do not site on slopes >20%	Use on slopes <5%	Not a factor	Maximum 15%	Maximum 15%
Water Table and Bedrock	The bottom of Dry Swales should be separated by 2 to 4 ft. from the seasonal high water table	Filter strips should be separated by 2 to 4 feet from the seasonal high water table	Water table should be at or near soil surface, or else a liner can be used to retain water	Separate bottom of device from groundwater to avoid groundwater contamination	Minimum of 3 ft. vertical separation of bottom of storage layer from seasonal high groundwater level	Not a factor	Not a factor	Bottom of basin should not intercept groundwater table
Proximity to Building Foundations	Min. 10 ft. down-gradient from buildings & foundations recom'd	Min. 10 ft. down-gradient from buildings & foundations recom'd	Min. distance 10 ft.	Min. 10 ft. downgradient from buildings & foundations recom'd	Not a factor	Not a factor	Min. distance of 10 ft	Min. distance of 10 ft.
Max. Depth	For Dry Swales maintain at least 1 foot of freeboard above volume expected for 10-year storm	N/A	4 to 6 ft.	2 to 4 ft.. of soil media	2.5 to 4 ft. for filtering and storage beds beneath surface	N/A	8 ft. 3 to 6 ft. pool depth preferred	3-12 ft.
Maintenance Requirement	Low: routine landscape maint.	Low: routine landscape maint.	Moderate; depends on sediment'n rate	Low: property owner can include in normal site landscape maint.	Low: routine sweeping to reduce clogging of pores	Low: rake soil media to maintain filtration; check tree	Moderate; depends on sediment'n rate	Moderate: routine sediment removal

Table 2-3 may be used for comparison with MA DEP's 80% TSS removal standard. Other systems not discussed in this Guide may also be used if the applicant can demonstrate that they meet stormwater management performance standards detailed in DEP's Stormwater Standards and Handbook.

If more than one practice is used to achieve the required 80% TSS removal, the removal efficiency rates must be multiplied together, not added. For example, if the first practice has a 60% TSS removal rate and the second practice has a 20% removal rate, a total of 68% of TSS would be removed. (60% of the total, plus 20% of the remaining 40% of TSS.)

Table 2-3: TSS Removal Rates for Stormwater Management Practices[4]

Practice	**Design Rate for TSS Removal** (use this number to calculate compliance with the 80% TSS removal requirement)	**Range of Average TSS Removal Rates**
Vegetated water quality swales (Dry & Wet)	70%, when provided with pre-treatment device such as sediment forebay with check dam	60-70%
Vegetated filter strip	10% if filter strip is 25 ft. wide; 45% if filter strip is 50 ft. wide	10-65%, depending on width
Constructed wetland[a]	80% with sediment forebay for pre-treatment	30-80%
Bioretention cells (Rain Gardens)	90%[b] with appropriate pre-treatment such as a vegetated filter strip	65-90%
Porous pavement	80%	65-90%
Tree box filter	80%, presumed	Insufficient data
Wet basin[a]	80%, when provided with pre-treatment sediment forebay	60-80%
Dry detention basins[c]	MA DEP does not give credit for TSS removal	Insufficient data
Deep sump catch basin	25%, only if used for pretreatment and designed as off-line systems	25% w/cleanout

[a] Must have sediment a forebay or pre-treatment.

[b] If an underdrain is used, the water must be conveyed to a secondary treatment device such as a constructed wetland or a wet basin.

[c] Post-treatment is required (e.g., by a constructed wetland or wet basin).

c. Discussion of Practices

Each of the ten stormwater management practices is discussed in more detail below. Most of the information has been taken from the MA DEP Stormwater Management Handbook. References in the endnotes provide additional information on the use, design, and construction of these practices.

This guidance is not a substitute for meeting the specific procedures and requirements of individual towns. Please be sure to consult community officials about applicable bylaws and regulations. If you are required to meet DEP standards in the design and construction of stormwater management devices, please refer to the Stormwater Management Standards and Handbook for details.

1. Vegetated Water Quality Swales (Dry & Wet)

Figure 2-1 Dry water quality swale

Swales are earthen channels most commonly covered with a dense growth of grass or other vegetation, and are designed primarily to control water quantity and quality from a 10-year storm without causing erosion.[5] The design of vegetated swales has improved over the years, enabling engineers and hydrologists to implement them for a variety of different purposes. Depending on hydrological conditions and design, swales can be dry or wet:

- **Dry swales** Dry swales are designed to temporarily hold the water quality volume of a storm in a pool or series of pools created by permanent check dams at culverts or driveway crossings. The soil bed consists of native soils or highly permeable fill material, underlain by an underdrain system.
- **Wet swales** Wet swales also temporarily store and treat the required water quality volume. However, unlike dry swales, wet swales are constructed directly within existing soils and are not underlain by a soil filter bed or underdrain system. Wet swales store the water quality volume within a series of cells within the channel, which may be formed by berms or check dams and may contain wetland vegetation. The pollutant removal mechanisms in wet swales are similar to those of stormwater wetlands, which rely on sedimentation, adsorption, and microbial breakdown.

Design Considerations

Swales are easily implemented on large lot residential sites (½ to 1 acre or larger), office and industrial campuses, roadways where right-of-way widths are adequate, and parking lot medians and edges (Figure 2-1). Ideally, stormwater should flow from the impervious surface through a vegetated filter strip before entering the swales (see Figure 2-3). Typically, dry swales are used for low density residential projects or very small impervious areas and require soils that have infiltration rates of 0.27-0.50 inches per hour. Wet

swales, on the other hand, are convenient for treating highway runoff in low lying or flat terrain areas and need to be planted with water tolerant vegetation.

Swales should be built at a gentle slope so that water flows at a relatively low velocity. The minimum slope should be ½%, while the maximum slope is based on velocity. Water velocity in the swale should generally not exceed 3 feet per second, which typically corresponds to a maximum slope of about 5%. If necessary, the swale may be steeper in places, provided that riprap or other stabilization is used to prevent scouring and erosion within the swale. The side slopes should be at a maximum of 3:1, and the length of the swale should be calculated to accommodate the entire calculated runoff volume from a 10-year storm. Regular maintenance such as mowing, sodding, and repair of eroded areas is necessary for swales. In addition, the accumulated sediment may need to be periodically removed, particularly during the construction and early site stabilization periods.

In some circumstances an infiltration trench might be used as an alternative to a vegetated swale. See the MA DEP Stormwater Handbook, Volume 2, Chapter 2 for details.

2. Vegetated Filter Strips

Filter strips are typically bands of close-growing vegetation, placed between pollutant source areas and the receiving water body (either a natural water body or a constructed swale). To protect natural water bodies (e.g., streams or wetlands), filter strips should consist of natural buffer strips already existing on the site. Not only do filter strips protect sensitive areas such as wetlands, woodlands and erodible soils; they also reduce runoff impacts by trapping sediment and sediment-bound pollutants, provide some infiltration, and slow and disperse stormwater flow over a wide area.[6] Figure 2-3 illustrates some of the biochemical processes by which filter strips remove pollutants.[7]

Figure 2-2 Vegetated filter strip

Design Considerations

Treatment of stormwater in filter strips is accomplished physically by a combination of filtration through the standing vegetation and infiltration into the underlying soils. In order to treat stormwater effectively, filter strips must be designed to function as overland flow systems where stormwater is evenly distributed. Because there is a high potential for short-circuiting of the filter strips and reduced pollutant removal, grading must be designed carefully to provide uniform flow into the filter strips, via devices such as a level spreader.

If filter strips are wide enough and planted with appropriate plant species, they will provide wildlife habitat as well as visual amenities in the landscape. It is important to note that filter strips are usually implemented in combination with other stormwater management devices that specifically control stormwater volume. Finally, for a filter strip to be efficient, a minimum width of 15 to 30 feet is recommended. Upkeep of filter strips should be incorporated into routine landscape maintenance, which would include raking the filter strip, removing large trash or debris, and regularly cleaning up sediment.

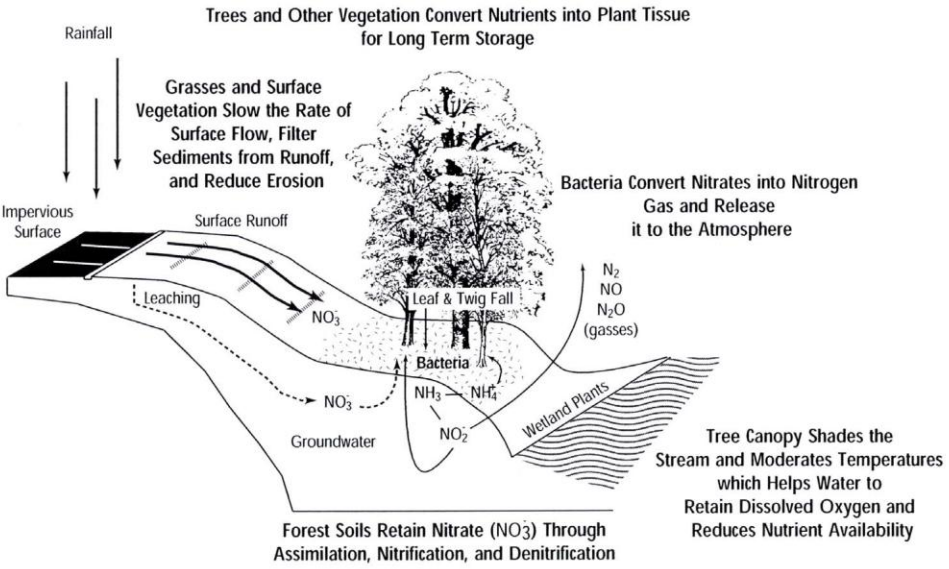

Figure 2-3 Processes by which vegetated filters remove pollutants

3. Constructed Wetlands

Figure 2-4 Constructed stormwater wetland

Constructed wetlands (or stormwater wetlands) are shallow pools that create growing conditions suitable for marsh plants. These systems are designed to maximize pollutant removal through retention, settling, and uptake by wetland plants.[8] Stormwater wetlands serve several benefits simultaneously. The primary purpose of constructed wetlands is to improve water quality by removing sediment and pollutants.

However, these wetlands can also provide excellent habitat for wildlife and waterfowl. In general, a constructed wetland would be a suitable stormwater management practice for residential subdivisions and commercial developments. Constructed stormwater wetlands do not create additional, regulated water resource or buffer areas.

Design Considerations

Constructed wetlands must be designed with consideration to the size of the contributing watershed area, amount of baseflow, soil type, and available space. A contributing drainage area should be at least 10 acres. While the contributing watershed may be as small as 1 acre, the smaller the watershed area, the more difficult it is to create sufficient drainage and runoff to keep the wetland perpetually wet. Since wetlands need to maintain soil moisture throughout the year, it is important to have a dry-weather baseflow or a groundwater supply. The preferred soil types for constructed wetlands are less-permeable soils that have relatively small pores and are less prone to evaporation.

The surface area of constructed wetlands should be at least 1% of the contributing drainage area, and the wetlands should have a length to width ratio of at least 2:1.[9] In order to increase the efficiency of the retention pond, a sediment forebay must be incorporated as a pretreatment device.

As with all stormwater management practices, stormwater wetlands require ongoing maintenance to retain maximum effectiveness. However, several design features can decrease the amount of maintenance that a wetland needs. For example, a reverse-slope pipe or a weir outlet with a trash rack should be used to prevent clogging of the outlet; orifices should have diameters no less than 3"; and direct maintenance access should be provided to the forebay to allow for sediment removal. Selection of plant species is one of the most important parts of creating a stormwater wetland, as the plants are largely responsible for the pollutant and sediment retention and uptake. Please refer to Figure 2-5[10] for a sample wetland layout and **Section IV** for a list of plant species suitable for planting in constructed wetlands.

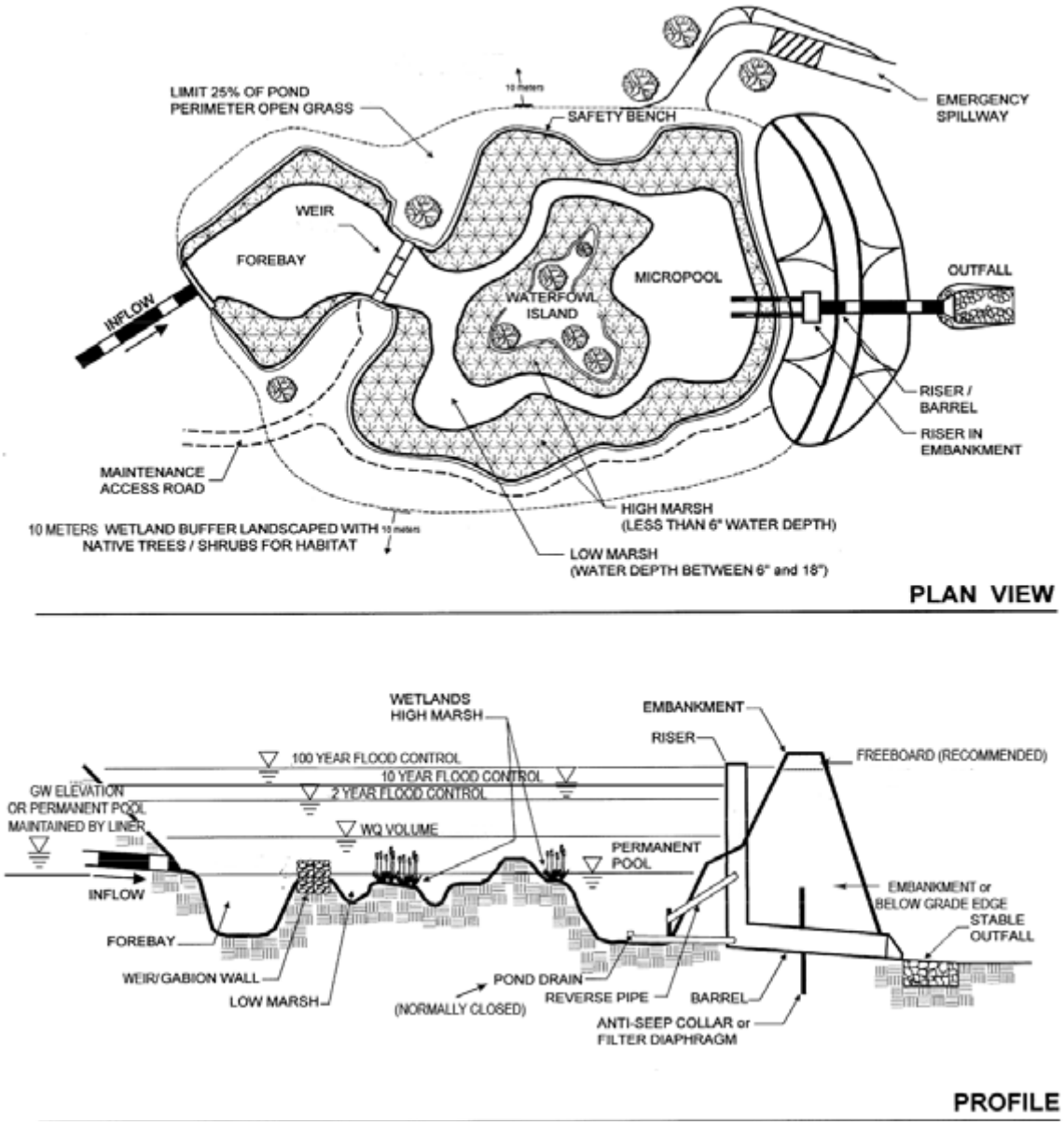

Figure 2-5 Example of constructed stormwater wetland, shallow marsh type

4. Bioretention Cells (Rain Gardens)

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.

Figure 2-6 Rain garden on a residential lot

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 treatment 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.

Runoff is conveyed to the treatment area, which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants (see Figure 2-8[11]). Runoff passes first over or through a sand bed, which slows the runoff and distributes it evenly along the ponding area. The ponding area is made up of a surface organic layer, ground cover and the underlying planting soil. The ponding area is graded so that there is a depression in the middle where water remains until it infiltrates or evaporates. The depression should be designed to hold 6 to 8 inches of water.[12] An overflow structure should be provided for situations where the ponding area is not sufficient.

Bioretention cells can be used in both residential and commercial projects. In residential areas, rain gardens are used to retain and infiltrate stormwater locally so that it does not need to be conveyed and treated by means of a more extensive stormwater management system. Each residential lot would typically have one or more rain gardens that receive stormwater from the roof and driveway and infiltrate it to the ground. Homeowners are responsible for maintaining the rain gardens on their property, just as they would maintain their gardens.

In commercial projects, bioretention cells are installed as depressed islands in the parking lot. Stormwater is directed to these islands, where it is treated and infiltrates into the ground.

Figure 2-7 Bioretention cell at a commercial site
Photo courtesy Berkshire Design Group

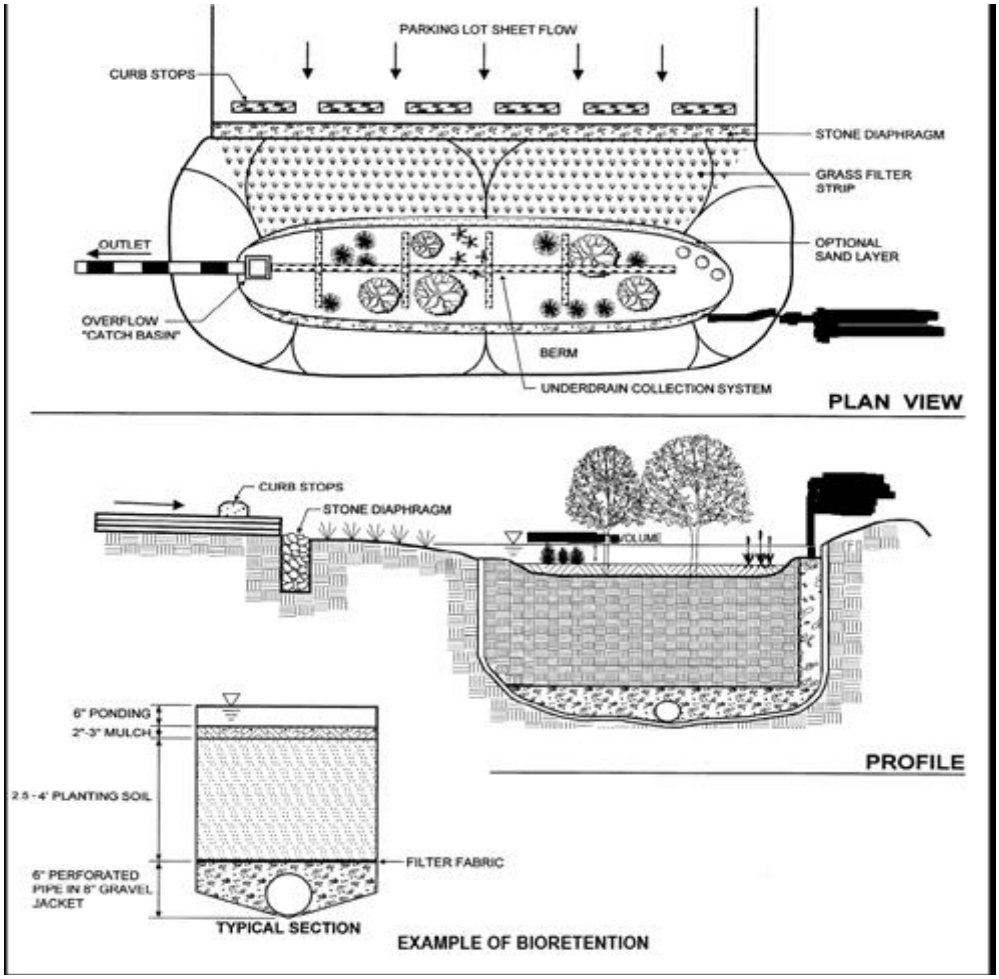

Figure 2-8 Example of bioretention

Design Considerations

The design of bioretention cells must consider the site area, slope, soils, groundwater, and maintenance needs. Bioretention cells should be designed to occupy 5 to 7 percent of the drainage area. Bioretention cells receiving parking lot runoff are recommended to have minimum dimensions of approximately 15 feet by 40 feet. Rain gardens on individual house lots can be much smaller, on the order of 10 feet by 15 feet.

The site should have shallow slopes (approximately 5% or less) so that water flow is guaranteed but velocity is not too high. An underdrain should be used in situations where soils are less permeable and there is a concern about the cell backing up or flooding. (Bioretention cells may be constructed by importing more permeable soils for the cell itself, in combination with an underdrain which prevents water from ponding above a less permeable natural soil layer.) An underdrain should also be used where the water table is close to the surface and there is a concern about groundwater pollution. In other situations, an underdrain generally is not needed.

Bioretention cells need to be maintained regularly to ensure the presence of mulch and good soil, attend to any diseased or dead plants, and remove collected sediment, litter and debris.

5. Porous Pavement

Porous pavement typically consists of a permeable surface with an underlying crushed/broken stone reservoir to temporarily store runoff before it infiltrates into the ground. The main purposes of this application are to reduce the amount of stormwater runoff from paved areas and to infiltrate stormwater into the underlying soils. By reducing the amount of stormwater runoff, pervious paving surfaces reduce the cost of stormwater management. Porous pavement may be used for walkways, patios, plazas, driveways, parking stalls, and overflow parking areas.

Figure 2-9 Porous asphalt

Porous pavement that is now available includes porous asphalt, pervious concrete and grass pavers. Porous asphalt and pervious concrete appear to be the same as traditional pavement from the surface, but incorporate void spaces to allow infiltration.

These systems have been applied successfully in New England locations where soils consist of well-drained sands and gravels that allow the pores to drain rapidly. Porous pavement can be successfully installed in cold climates as long as the design includes features to reduce frost heaving (Figure 2-11).

Figure 2-10 Grass pavers

Grass pavers (Figure 2-10) consist of concrete interlocking blocks or a synthetic fibrous gridded system with open areas designed to allow grass to grow. The design should allow for infiltration into the underlying soils so that stormwater does not pond near the surface.

Design Considerations

Grass pavers are most suitable for low-traffic areas such as the overflow areas of commercial or office parking lots, residential driveways, and service areas that will be subject to light traffic. Our community recommends their use in these situations. If these systems are used, stormwater calculations should account for the reduced amount of runoff generated by areas with grass pavers. In general, grass paver systems should not be salted in the winter because this will threaten the viability of the plants.

However, salting will not typically be required in the low-traffic areas where grass pavers are recommended.

Narrower Roadways

Consider using narrower roadways where appropriate to reduce stormwater runoff. Street width should be correlated with traffic volume, land use, and parking demand. Residential streets with fewer than 500 trips per day (generally serving fewer than 50 houses) can be designed at a minimum width so as to accommodate a fire truck and other emergency vehicles. The National Fire Protection Administration

Uniform Fire Code (2003) recommends a minimum unobstructed width of just 20 feet, and the State Fire Marshall recommends a minimum of 18 feet.

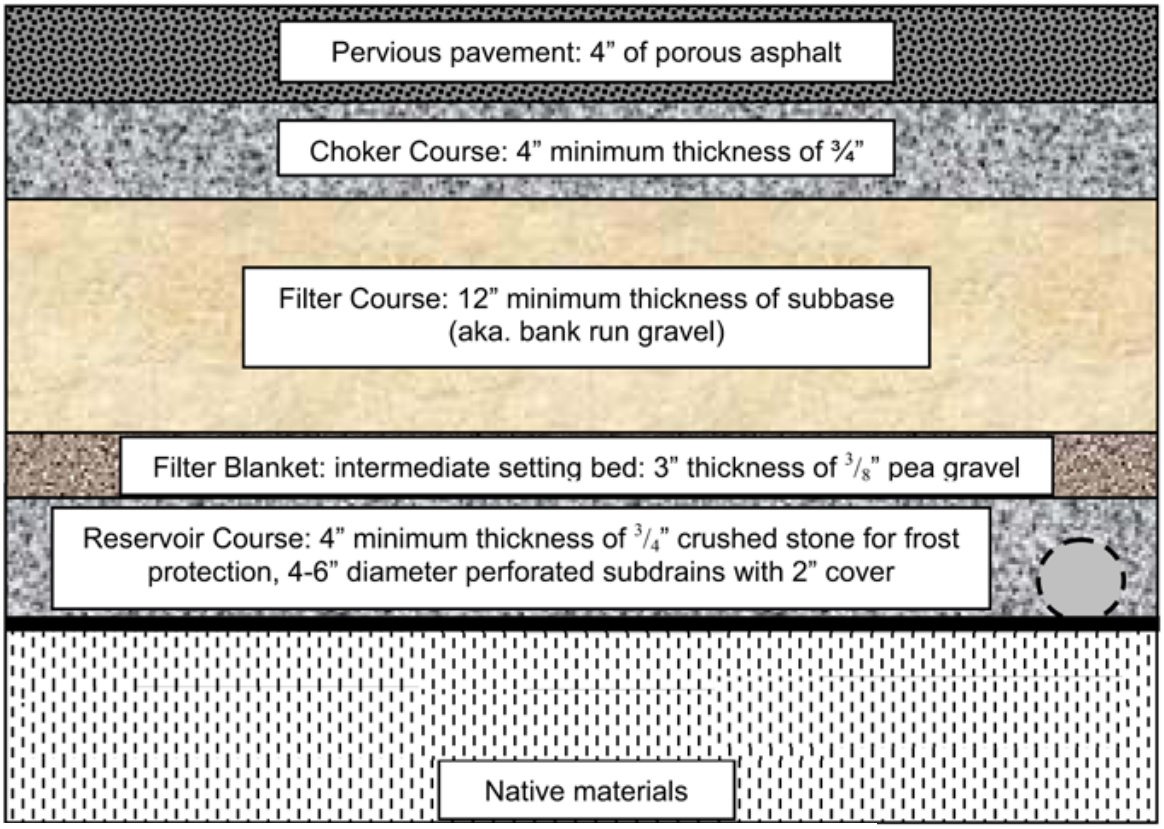

Figure 2-11 Example of road cross section for pervious pavement

6. Tree Box Filter

Figure 2-12 Tree box filter

A tree box filter is a small bioretention system that provides effective water quality treatment for stormwater in urban settings where space is limited. It often consists of a concrete barrel, usually with an open bottom, that contains a porous soil mix, a crushed gravel underdrain and a tree or shrub. Stormwater is directed from the sidewalk and street into the tree box where sediment and other pollutants are filtered through the soil mix. Treated stormwater overflow from the tree box filter is directed to the underdrain and may then enter a storm drain or other stormwater treatment device.

Tree box filters are effective pretreatment devices which also reduce stormwater volume and rate of runoff.

They can be useful as retrofits in urban settings and at redevelopment sites. Tree boxes, however, treat relatively small volumes of water. The contributing area for a tree box should not exceed 0.1 acre.

7. Green Roofs

Green roofs are a permanent rooftop planting system containing live plants in a lightweight engineered soil medium designed to retain precipitation where the water is taken up by plants and transpired into the air. As a result, much less water runs off the roof compared to conventional rooftops. Green roofs provide several benefits such as reducing stormwater runoff volume and pollutant load, increasing the energy efficiency of buildings, improving air quality by removing particles in the air and by photosynthesis, and increasing the aesthetic value of the area. Green roofs can be built on almost any rooftop, from a residential building to a commercial or industrial building. Figure 2-13 shows a typical application.[13] Green roofs are well-suited for use in large commercial, office, and institutional buildings that have flat or gently sloping roofs.

Figure 2-13 Green roof

Green roofs with a restricted variety of plants (resistant to frost, wind and drought: sedum, herbs and grasses) require minimal long-term maintenance.

During the initial stage some watering might be required; however, within six months the plants are usually able to sustain themselves. Since the soil layer is not deep, it will not support tall vertical growth or large plants; therefore, cutting or mowing is not required. Load reserves of at least 15 pounds per square feet beyond snow load requirements are needed to install a roof garden.[14] If properly built over a suitable roofing membrane, green roofs do not present a leaking problem.

8. Wet Basins

Figure 2-14 Wet basin

Wet basins are constructed to have a permanent pool of water to treat stormwater. The pool allows settling of sediments, removal of soluble pollutants by algal uptake, and some groundwater recharge as shown in Figure 2-14[15]. The basins are designed to include additional storage capacity to control peak discharge rates. The primary component of a wet basin is a deep, permanent pool, and the basin must also include a shallow marsh or a sediment forebay to increase sediment and nutrient removal.[16]

In general, our community does not recommend that wet basins be used as the primary means of attenuating peak runoff rates or removing pollutants. Constructed wetlands are generally a preferred system since they have greater pollutant uptake functions. However, wet basins may be used in subdivisions as well as commercial and industrial areas when other stormwater management systems are not feasible or sufficient because of site conditions or the nature of the development program. Wet basins may also be used in series with constructed wetlands as a sediment trap, particularly during construction.

Design Considerations

Wet basins must drain a sufficiently large area to maintain a permanent pool of water. The minimum recommended area is 20 acres, assuming impervious surface percentages typical of suburban developments.[17] Within the watershed area that drains to the wet basin, the slopes and the stormwater conveyance system must result in a metered flow of stormwater that does not flood the basin all at once. The use of filter strips and swales can help slow and infiltrate water on its way to the basin.

Wet basins can be constructed in a wide range of soil types. However, when native soils have a rapid percolation rate, soils should be compacted or supplemented sufficiently so that the pond does not dry up during the dry season. The soils should retain sufficient infiltration potential so that the pond also continues to play a role in groundwater recharge. In order to increase the efficiency of the wet basin, a sediment forebay must be incorporated as a pretreatment device. As with constructed wetlands, wet basins should use non-clogging outlets and large orifices (not less than 3 inches in diameter), and should provide easy dredging access to reduce long-term maintenance requirements and difficulties.

9. Dry Detention Basins

Dry detention basins are depressed areas whose outlets have been designed to detain stormwater runoff for some minimum time to allow particles and associated pollutants to settle. Since the aim of dry detention basins is mainly to control flooding and remove sediments, they do not need to have a permanent pool and therefore can be dry during non-flood conditions. Typically, they are used as a primary treatment in conjunction with other stormwater management systems such as wet basins or constructed wetlands.

Figure 2-15 Dry detention basin

Our community discourages the use of detention basins as the primary means of flood control.

Instead, dry water quality swales, vegetated filter strips and bioretention should be used whenever possible to attenuate peak runoff rates. When site characteristics do not allow use of such practices, however, detention basins may be considered as part of the stormwater management system. In addition, detention basins may be used as a pre-treatment device to settle out particulates prior to discharge to a constructed wetland or wet basin, where additional treatment and infiltration will occur.

Design Considerations

Dry detention basins are most practical for use on sites of at least 10 acres, which allows for the use of larger outlet orifices that are less likely to clog. Detention basins can be used on sites with slopes up to 15 percent. To provide drainage, make the minimum slope of the bottom 2 percent. If soils on site are relatively impermeable (such as Soil Group D), a dry detention basin may experience problems with standing water. On the other hand, if the soils are highly permeable, such as well-drained sandy and gravely soils (Soil Group A), it will be difficult to establish a shallow marsh component in the basin. Dry detention basins should be designed with sediment forebays which allow sediment to be trapped prior to entering the detention basin. This feature also reduces maintenance requirements for the detention basin. As with constructed wetlands, detention basins should use non-clogging outlets and large orifices (not less than 3 inches in diameter), and should provide easy dredging access to reduce long-term maintenance requirements and difficulties.

Any dry detention basin in our community must provide landscaping and planting to minimize its visual impacts. The plants selected for the ponding area should be able to withstand both wet and dry periods. Along the perimeter of the basin, however, the plants should be adapted to dry conditions and should create a visual vegetated buffer.

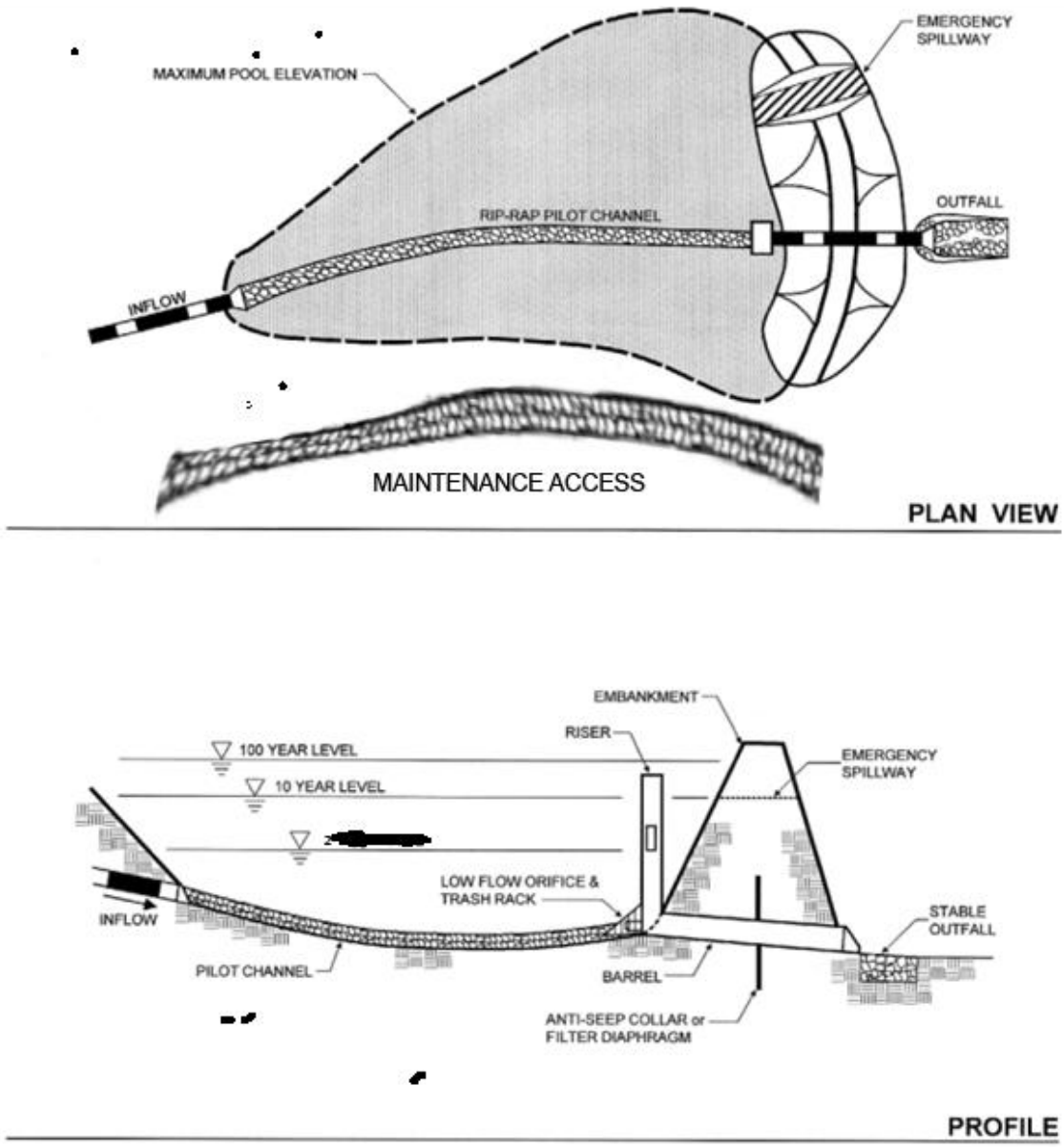

Figure 2-16 Dry detention basin schematic

10. Deep Sump Catch Basin

Figure 2-17 Deep sump catch basin inlet

Catch basins are storm drains that capture and roughly filter stormwater through a grate or curb inlet and capture sediment, debris and associated pollutants in a deep sump (Figure 2-17[18]). In most cases a hood is also included to separate oil and grease from the stormwater. The essential function of a catch basin is to act as a pretreatment device for other structures incorporated into a storm sewer system. The performance of a catch basin in removing sediment and pollutants will depend greatly on the size of the drainage area, the size of the sump, and the amount of maintenance it receives.

Although catch basins are currently used in virtually all circumstances, they typically cannot remove pollutants as well as most of the other practices described in this section, and they require frequent maintenance. Catch basins should be used only when other practices discussed in this section prove unfeasible.

When catch basins are used, the Town will consider it preferable if they discharge individually or in pairs to nearby swales, constructed wetlands, or bioretention cells, rather than carrying runoff further to a larger retention/infiltration system. Lengthy catch basin-piped drain-manhole networks are discouraged. In general, the goal is to use vegetated, low-velocity channels to hold and infiltrate stormwater locally, not to efficiently capture and deliver stormwater to watercourses.

Design Considerations

The contributing drainage area to any deep sump catch basin should not exceed 1/4 acre of impervious cover. Catch basins should have sumps that are at least four feet deep. The inlet openings must not allow flows greater than 3 cfs to enter the deep sump catch basin. Flow from the catch basin/drain pipe system should be directed to another stormwater management device, such as a constructed wetland, for further treatment. Catch basin inlets should be cleaned regularly (at least twice a year) and after large storms. Removed sediment should be disposed of in accordance with applicable local, state and federal guidelines and regulations.

Leaching Catch Basins

Leaching catch basins may provide an alternative to deep sump catch basins or may be used as a retrofit for sites with existing catch basins. A leaching catch basin is a pre-cast concrete barrel and riser with an open bottom that permits runoff to infiltrate into the ground. It can recharge groundwater and remove coarse sediment. When combined with a deep sump catch basin for pretreatment, it may remove 80 % of TSS. Leaching catch basins should be used as off-line devices in areas with highly permeable soils. Provide for the safe overflow from these devices in severe storm events, or in the event of clogging of the soils surrounding the device. Because leaching catch basins discharge runoff to groundwater, do not use them in areas of higher potential pollutant loadings (such as gas stations) without adequate pretreatment.

III. Erosion and Sedimentation Control

Erosion and sedimentation control practices should be incorporated into the planning, construction, and operation of any project in our community. Specific measures should be presented for review prior to construction. For more detailed information please consult the MA DEP Erosion and Sediment Control Guidelines.

a. Site Planning

The most important erosion control practice is to minimize clearing and regrading, as discussed in **Section V**, Site Planning.

COMMUNITY OBJECTIVES: Any proposed project on a previously undeveloped site should accommodate the development process in a way that minimizes clearing and regrading, especially in areas of steep slopes, erosion-prone soils, or sensitive vegetation. For redevelopment projects, the site plan should concentrate development in previously-disturbed areas to the extent possible.

The initial step to control erosion and sedimentation lies in developing a plan that is appropriate to the site features including topography, soils, drainage ways, and natural vegetation. The site planning process should begin with a thorough evaluation of sensitive areas requiring protection as well as less sensitive areas suitable for development. The site plan should delineate a limit of work that limits clearing and regrading and protects the most sensitive areas, based on the criteria in Table 3-1. For example, in residential subdivisions, native vegetation should be retained on individual house lots to the extent possible, rather than creating larger lawns.

Table 3-1: Guidelines for identifying sensitive site features[19]

Topography	Drainage	Soils	Natural vegetation
Slopes that are steeper and/or longer typically create more erosion. Slopes that exceed the following thresholds are likely to be sensitive and erosion-prone: • Slopes of 5-7% longer than 300 feet • Slopes of 7-15% longer than 150 feet • Slopes of more than 15% longer than 75 feet	Where possible, retain natural drainage ways and depressions and utilize for stormwater conveyance	Consider factors such as erodibility, permeability, depth to water table and bedrock, and soils with shrink/swell potential or slippage tendencies. The most erodible soils contain high proportions of silt and very fine sand. The presence of clay or organic matter tends to decrease erodibility.	This is the most important factor in preventing erosion. Vegetated buffers filter runoff, decrease runoff velocity, and increase infiltration capacity.

b. Construction Period Impacts

Prior to the commencement of construction, the limit of clearing and limit of work identified on the site plan should be suitably marked with survey tape or plastic fences. These markers are in addition to any fences that the Conservation Commission may require for sensitive areas such as wetlands, streams and their buffers. Construction activities and construction traffic should be limited to the area identified on the site plan, and no stockpiling of materials, soils, or debris or other activity should occur outside of the limit of work.

COMMUNITY OBJECTIVES: Every proposed project should adhere to a construction management plan that addresses soil stabilization, sediment retention, perimeter protection, construction scheduling, traffic area stabilization and dust control.

1. Soil Stabilization

The builder/developer should create a plan for cover and/or stabilization of erodible surfaces that are not the immediate focus of construction activity. The Town's objective is to minimize soil erosion and sedimentation in the Town's water bodies and storm sewer system. Cover measures should be implemented on areas that have already been disturbed but will not be worked on during the next 7 days during dry conditions or the next 2 days during wet conditions. Cover methods may include, but are not limited to, the use of mulch, erosion control nets and blankets, plastic covering, seeding and sodding. These are described in the following paragraphs.

Mulching is generally considered to be a suitable short-term protective measure. The main purpose of mulching is to protect the site from erosion by stabilizing soils and reducing stormwater runoff velocity. Mulch can also enhance plant establishment by conserving moisture, holding fertilizer, seed and topsoil in place, and moderating soil temperature. The most commonly used mulches include straw, wood fiber or cellulose, compost and wood chips. The effectiveness of mulching depends on site characteristics and maintenance: if the site is prone to high winds or has steep slopes, additional steps should be taken to anchor the mulch, such as planting vegetation or providing netting or blanketing. The thickness of the cover should be maintained at all times and any area that has eroded should be re-mulched and anchored until it has been stabilized.

Similar to mulching, plastic covering is also acceptable as a short-term protective measure. This technique simply involves covering the area of concern with a plastic sheet and using tires or sandbags to weight the plastic down. Plastic covering is generally used on cut and fill slopes and stockpiles. Plastic covering should not be used if there is a sensitive area located downslope, because of the rapid runoff created by the plastic covering. Although this is a fairly easy technique to apply, it requires careful maintenance. The plastic cover can easily be torn or damaged by the sun and can clog drainage systems if not removed properly. Therefore, regular maintenance should be provided to ensure that the plastic is undamaged at all times and fully removed after it is no longer needed.

Figure 3-1 Geotextiles used for stabilizing a hill

Seeding, sodding and erosion nets and blankets are usually more appropriate as long-term solutions for areas that will remain un-worked for months. **Section IV** lists recommended species to plant for erosion control purposes.

A well-designed landscaping plan can easily incorporate areas of planting for permanent erosion control. If the area must be stabilized immediately, then the use of sodding is more appropriate since it can provide immediate erosion protection. Sodding is appropriate for use on residential or commercial lawns, steeply-sloped areas, waterways and channels carrying intermittent flow, and areas around drop inlets that require stabilization.[20] Sod maintenance is essential during the establishment period. Sod should be provided with adequate moisture and fertilizer. If the sod does not root and stay healthy, it should be replaced by new sodding or a different technique.

Erosion control nets or blankets, also referred to as geotextiles, are another suitable long-term stabilization technique (see Figure 3-1[21]). Geotextiles are used for preventing erosion and holding seed and mulch in place on steep slopes, as well as in channels to aid vegetation establishment. Geotextiles can be made of synthetic materials such as polypropylene, polyester, polyethylene, nylon, and polyvinyl chloride as well as biodegradable materials such as mulch matting, jute, coconut fiber and other wood fibers. For effective stabilization, good contact with the ground must be maintained and no erosion should occur beneath the net or blanket. Synthetic geotextiles can be sensitive to light and wind; therefore, they should be inspected regularly and any problematic areas should be repaired immediately.

2. Sediment Retention

Sediment retention from construction sites is a three-step process. First, all surface runoff from disturbed areas should be intercepted since this runoff contains high sediment loads. Second, the runoff should be conveyed to a sediment trap or pond where sediment removal will occur. Finally, the cleaned runoff should be discharged downslope of any disturbed areas. Typically, interceptor dikes and swales are used to intercept runoff; check dams are used to reduce flow velocity and remove sediment; ditches and pipes are used to convey the runoff; and riprap or level spreaders are used to dissipate runoff velocity in a non-erosive manner. As shown in Figure 3-2[22], interceptor dikes can collect the runoff and direct it to pipes and/or ditches which can convey the runoff to a sediment pond. The outflow from the pond can be connected to a stream (as shown in this case) or to a vegetated area. Riprap may be used to stabilize outlets. Check dams can be incorporated into the design to reduce the velocity of the runoff. Typically, check dams are installed in swales or ditches and consist of small gravel, rock, sandbag, log or straw dams.

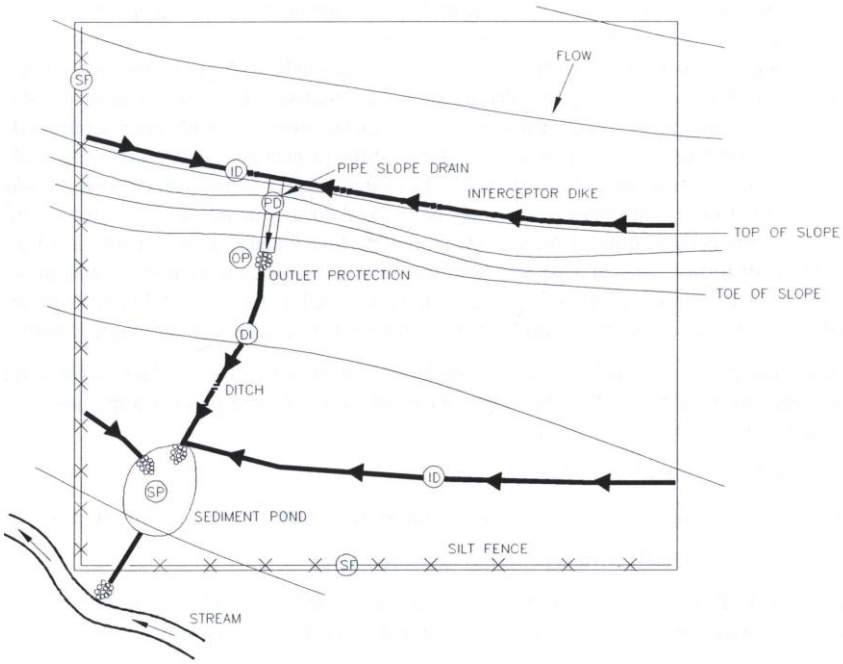

Figure 3-2 Sample sediment retention plan

As mentioned above, sediment should be conveyed to sediment traps or ponds prior to being discharged. Sediment traps should be used for areas less than about three acres, and sediment ponds should be used for larger areas. Stormwater runoff is conveyed through these structures, where sediment is settled (mostly small particles of 0.02 mm or so) and turbidity is slightly reduced.[23] When sediment reaches one foot in depth, the trap or the pond should be cleaned. Any embankments or slopes should also be routinely checked and any damage properly repaired.

The construction management plan should explain how surface runoff will be intercepted and settled before it is released into the ground or off-site.

3. Perimeter Protection

While interceptors and sediment traps/ponds discussed above will provide the primary sediment retention on construction sites, perimeter protection is also necessary to prevent residual sedimentation of adjacent lands and waters. The construction management plan should identify measures to prevent sediment from being transported off of the site. Again, the purpose is to minimize sedimentation in the Town's water bodies, storm sewer system, and adjacent properties. Measures such as vegetated filter strips, silt fences, or brush barriers should be provided at the limit of work to filter runoff and capture sediment. In places where the limit of work is not near the edge of the site, a natural vegetation buffer of 40 feet is generally considered to be an acceptable retention system, except where the natural vegetation is a wetland, a wetland buffer or otherwise sensitive landscape feature, in which case a silt fence or similar device should generally be used. Figure 3-3[24] illustrates proper installation of hay bales for sediment retention.

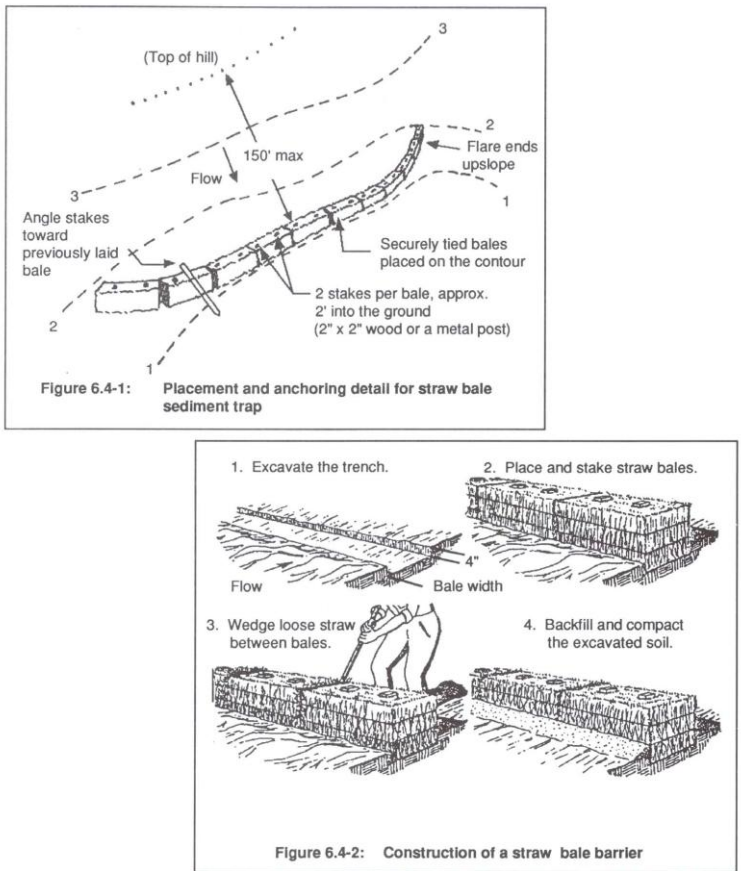

Figure 3-3 Installation of hay bales for sediment retention

4. Other Practices

Scheduling of Operations

The construction management plan should state when clearing, grubbing, grading, construction, and replanting will occur on each section of the site. Construction should be phased by area so that the smallest practical area of land is exposed for the shortest possible time.

Traffic Area Stabilization

To reduce the amount of sediment transported off site by construction vehicles and to reduce the erosion of areas disturbed by vehicle traffic, roads and parking areas should be stabilized immediately after initial grading. Not only will this stabilization reduce amount of sediment transported out of the site; it will also reduce the amount of easily erodible mud that forms on site. Stabilization can be achieved by use of a 6 inch deep layer of crushed rock, gravel base, or crushed surfacing base on the area of construction entrances or roads and parking areas. For any area that will be subject to long-term or high-volume construction vehicle traffic, a truck wash should be implemented, with dirty water channeled through sediment traps or ponds prior to discharge.

Dust Control

The construction management plan should commit to minimizing wind transport of dust from exposed soil surfaces onto roadways, drainage ways, and surfaces waters by spraying exposed soils with water until they are sufficiently damp so as to not produce dust, but not so wet as to produce runoff, whenever weather conditions are dry and windy.

IV. Landscape Design

This section of the Guide addresses three critical goals for the Town: stabilizing water use at a sustainable level; creating landscapes that minimize natural habitat destruction and maximize habitat value; and encouraging the development of landscapes that provide environmental quality and visual relief.

a. Water-Sensitive Landscaping

Development in our community and the attendant rise in impervious surfaces alters the natural hydrological cycle, reduces recharge to the groundwater and increases local flooding. Careful attention to water use and hydrologic systems will provide more stable water resources for the community.

On previously undeveloped ("greenfield") sites, the most important water-sensitive practice is to minimize the disturbance and clearing of natural vegetation. Guidelines to meet this objective are provided in **Section III** and **Section V** of this Guide. Typically, this will mean preserving some portion of the site as open space, plus reducing the area of lawn and garden in favor of native vegetation in both residential and commercial/industrial projects. In places where native vegetation is cleared, at least some of the area should function as a groundwater recharge system. For example, a landscaped garden could function as a bioretention cell through appropriate subsurface design and selection of species, or portions of a lawn could serve as vegetated filter strips for driveway runoff if properly graded. In general, the landscape design should aim to:

> **COMMUNITY OBJECTIVES:** Site plans and landscape plans for proposed projects should take appropriate steps, as outlined in this section, to allow for natural recharge of groundwater and minimize water use for irrigation.

- Retain and recharge water onsite;
- Preserve existing vegetation to the maximum extent possible;
- Preserve soil permeability during development; and
- Minimize the use of turf grass in landscaping, opting instead for a variety of native species.

To keep the water onsite, impervious areas need to be reduced to the maximum extent practical. Planting beds should be designed to conserve the water they receive. This can be achieved by grading the beds so that slope is gradual and stormwater runoff will have more time to percolate into the soil, and by using plant species that do not require large amounts of water.

To meet water conservation objectives, our community discourages in-ground irrigation systems. However, if irrigation systems are used, they should be water-efficient drip systems or soil soakers equipped with automatic sensors that prevent watering when soils are already wet, or when it is raining. Drip irrigation is defined as the frequent slow application of water to a very small area in the root zone of the plant. Water slowly drips through either porous plastic pipes or emitters located below the soil surface. Drip systems have been found to reduce water use by 20-50%.[25] Soil soakers consist of long plastic or canvas tubes perforated with tiny holes through which the water seeps as a fine mist. Soil soakers are connected to a garden hose and can be left in place on the surface of the planting bed or buried under the mulch.

For garden areas, landscape plans should specify the use of a suitable mulch. Use of mulch is beneficial for several reasons. Mulch layers:

- Help capture moisture for vegetation that would normally be lost through evaporation;

- Prevent erosion by protecting the soil surface from raindrop impacts and by reducing the velocity of overland flow;
- Help prevent crusting, sealing and compaction of the surface, thereby preserving the infiltration rate;
- Protect seeds by forming an insulating layer against extreme heat and cold and by creating a suitable microclimate for seed germination; and
- Reduce weed growth and the need for herbicide application.[26]

Good mulching materials include compost, pine bark, pine straw (pine needle bales), leaf mold, rotted manure, lawn clippings, aged and shredded hardwood bark, aged wood chips, and straw or chopped hay.

b. Plant Species

In the interest of striking an appropriate balance between community development and conservation, the Town is committed to retaining natural habitats and habitat functions on developed sites to the maximum extent possible. In addition, drought-tolerant species should be used in appropriate situations.

Landscape designers working on Town projects should use the following lists to select the most appropriate species for each portion of their site. Recognizing that many species are well-suited to several circumstances, there is much overlap among the nine lists of species provided below. Each list is also divided into different forms of plants, such as shade trees, ornamental trees, evergreen trees, deciduous shrubs, groundcovers, and flowers. The lists are not all-inclusive, and landscape designers may suggest

COMMUNITY OBJECTIVE: Landscape plans should follow the guidelines in this section for selecting species that are most appropriate to the site conditions. Native species and habitat-creating species should be used in landscape plans to the maximum extent possible. Invasive species identified in this section should not be planted in our community.

the use of other species not included here, provided they are not prohibited or invasive species. However, these lists are intended to provide a sufficiently wide range of species that the Town considers generally acceptable under different circumstances. Information in this list is based on several sources including 974 CMR 3.05,[27] the MA Department of Agricultural Resources, a wetlands creation manual,[28] landscaping catalogs,[29,30]and professional landscape architects and biologists.

1. Native Species

The following species are native to the Wachusett region or well-suited to the area's climate and conditions. Many of the species also provide good wildlife habitat.

Shade Trees

Botanical Name	*Common Name*
Acer rubrum	Red Maple
Acer saccharum	Sugar Maple
Betula lentaF	Sweet Birch[F]
Betula alleghaniensis[F]	Yellow Birch[F]
Betula papyrifera	Paper Birch
Carya ovata[+]	Shagbark Hickory[+]
Castanea dentate	American Chestnut
Fagus grandifolia	American Beech
Fraxinus americana	White Ash
Fraxinus pennsylvanica	Green Ash
Juglans cinerea[+]	Butternut[+]
Liquidambar styraciflua[F]	Sweetgum[F]
Liriodendron tulipifera[F]	Tulip Tree[F]
Nyssa sylvatica	Black Tupelo
Platanus occidentalis	American Sycamore
Quercus alba[+F]	White Oak[+F]
Quercus bicolor[+F]	Swamp White Oak[+F]
Quercus coccinea[+F]	Scarlet Oak[+F]
Quercus palustris[+F]	Pin Oak[+F]
Quercus rubra	Northern Red Oak
Salix nigra	Black Willow
Sassafras albidum	Common Sassafras
Tilia americana 'Redmond'	Redmond Linden
Ulmus americana, disease-resist. var.	American Elm

Notes:

[+] Recommended for planting on the portions of the site away from walks or roads.
[F] These trees need extra care if they are planted during the fall season.
^ Canadian Hemlock is currently under attack by an insect that has no predator.

Evergreen Trees

Botanical Name	*Common Name*
Ilex opaca	American Holly
Juniperus virginiana	Eastern Red Cedar
Pinus rigida	Pitch Pine
Pinus strobus	Eastern White Pine
Thuja occidentalis	American Arborvitae
Tsuga canadensis	Canadian Hemlock^

Ornamental Trees

Botanical Name	*Common Name*
Alnus rugosa	Speckled Alder
Amelanchier canadensis	Shadblow Serviceberry
Amelanchier laevis	Allegany Serviceberry
Betula nigra[F]	River Birch[F]
Betula papyrifera[F]	Paper Birch[F]
Carpinus caroliniana[F]	American Hornbeam [F]
Cercis canadensis	Eastern Redbud
Cornus alternifolia[F]	Pagoda Dogwood[F]
Cornus florida ^[F]	Flowering Dogwood ^ [F]
Crataegus punctata	Dotted Hawthorn
Hamamelis virginiana	Common Witchhazel
Larix laracina	American Larch
Larix decidua	European Larch
Ostrya virginiana	Hop Hornbeam
Prunus pennsylvanica[F]	Pin Cherry[F]
Prunus virginiana[F]	Common Chokecherry[F]
Salix discolor	Pussy Willow
Viburnum lentago	Nannyberry Viburnum

Notes:
^ Cornus florida has been adversely affected by an anthracnose epidemic in the Northeast U.S. in the past two decades. Anthracnose spreads rapidly to other flowering dogwoods. Before using this species, check with local agricultural extensions for the status of anthracnose.
[F] These trees need extra care if they are planted during the fall season.

Deciduous Shrubs

Botanical Name	*Common Name*
Arctostaphylos uva-ursi	Bearberry
Aronia melanocarpa	Black Chokeberry
Clethra alnifolia	Summersweet Clethra
Comptonia peregrina	Sweetfern
Cornus alterniflora	Pagoda Dogwood
Cornus amomum	Silky Dogwood
Cornus racemosa	Gray Dogwood
Cornus rugosa	Redleaf Dogwood
Ilex verticillata	Common Winterberry
Lindera benzoin	Common Spicebush
Myrica pennsylvanica	Northern Bayberry
Azalea nudiflorum	Early Deciduous Pink Azalea
Rhododendron roseum	Roseshell Azalea
Rhododendron viscosum	Swamp Azalea
Rhus glabra	Smooth Sumac
Rhus typhina	Staghorn Sumac
Rosa carolina	Carolina Rose
Rubus odoratus	Flowering Raspberry
Sambucus canadensis	American Elder
Vaccinium corymbosum	Highbush Blueberry
Viburnum acerifolium	Mapleleaf Viburnum
Viburnum cassinoides	Witherod Viburnum
Viburnum dentatum	Arrowwood Viburnum
Viburnum trilobum	American Cranberrybush Viburnum

Evergreen Shrubs

Botanical Name	*Common Name*
Juniperus communis 'Compressa'	Common Juniper
Kalmia angustifolia	Sheeplaurel
Kalmia latifolia	Mountainlaurel
Taxus canadensis	Canadian Yew

Groundcovers

Botanical Name	*Common Name*
Cornus canadensis	Bunchberry Dogwood
Gaultheria procumbens	Checkerberry Wintergreen
Mitchella repens	Partridgeberry
Vaccinium angustifolium	Lowbush Blueberry
Vaccinium macrocarpum	Cranberry

Meadow Grasses/Wildflowers

Botanical Name	*Common Name*
Festuca elatior	Tall Fescue
Lolium perenne	Palmer II Perr. Ryegrass
Sorghastrum nutans	Indian Grass
Panicum	Blackwell Switchgrass
Andropogon gerardii Vitman	Big Bluestem
Schizachyrium scoparium	Little Bluestem
Calamagrostis canadensis	Blue Joint Reedgrass
Antennaria alpina	Alpine Pussy-Toes
Aristida dichotoma	Poverty Grass
Aster linariifolius	Bristly Aster
Eragrostis spectabilis	Purple Lovegrass
Houstonia caerulea	Bluets
Juncus bufonius	Toad Rush
Senecio aureus	Golden Ragwort

2. Salt Tolerant Species

These species are well-suited to roadsides and other locations that are likely to collect salty winter runoff.

Shade Trees

Botanical Name	*Common Name*
Acer campestre	Hedge Maple
Aesculus hippocastanum	Horse-chestnut
*Betula lenta**[F]	Sweet Birch*[F]
*Betula alleghaniensis**[F]	Yellow Birch*[F]
*Fraxinus americana**	White Ash*
Gleditsia triacanthos inermis	Thornless Honeylocust
*Nyssa sylvatica**	Black Tupelo*
*Quercus alba**+	White Oak*+
Quercus macrocarpa+	Bur Oak+
Quercus robur+	English Oak+
Quercus rubra	Red Oak
Ulmus glabra	Scotch Elm
Ulmus pumila	Siberian Elm

Notes:
* Native Plants
+ Recommended for planting on portions of the site away from walks or roads.
[F] These trees need extra care if they are planted during the fall season.

Ornamental Trees

Botanical Name	*Common Name*
*Amelanchier canadensis**	Shadblow Serviceberry*
*Betula papyrifera**[F]	Paper Birch*[F]
*Betula populifolia**[F]	Gray Birch*[F]
*Prunus pennsylvanica**[F]	Pin Cherry*[F]
*Prunus virginiana**[F]	Common Chokecherry*[F]
Pyrus calleryana[F]	Callery Pear[F]
Pyrus calleryana 'Bradford'	Bradford Pear
*Salix discolor**	Pussy Willow*

Evergreen Trees

Botanical Name	*Common Name*
*Juniperus virginiana**	Eastern Red Cedar*
Picea pungens 'glauca'	Blue Colorado Spruce
Pinus nigra	Austrian Pine
Pinus ponderosa	Ponderosa Pine
*Pinus rigida**	Pitch pine*

Deciduous Shrubs

Botanical Name	*Common Name*
*Arctostaphylos uva-ursi**	Bearberry*
*Aronia melanocarpa**	Black Chokeberry*
*Aronia prunifolia**	Purplefruit Chokeberry*
Hippophae rhamnoides	Common Seabuckthorn
*Lindera benzoin**	Common Spicebush*
*Myrica pennsylvanica**	Northern Bayberry*
*Rhus glabra**	Smooth Sumac*
*Rhus typhina**	Staghorn Sumac*
*Salix humilis**	Prairie Willow*
*Salix lucida**	Shining Willow*
Shepherdia argentea	Buffaloberry
Tamarix ramosissima	Five Stamen Tamarisk
*Vaccinium corymbosum**	Highbush Blueberry*

*Viburnum cassinoides**	Witherod Viburnum*
*Viburnum dentatum**	Arrowwood Viburnum*

Evergreen Shrubs

Botanical Name	*Common Name*
Pinus mugo	Mugo Pine
*Taxus canadensis**	Canadian Yew*

Groundcovers

Botanical Name	*Common Name*
*Vaccinium angustifolium**	Late Lowbush Blueberry*
Vaccnium palladum	Early Lowbush Blueberry

Notes:
* Native Plants
+ Recommended for planting on portions of the site away from walks or roads.
[F] These trees need extra care if they are planted during the fall season.

3. Urban Tolerant Species

These species are suitable for planting in "high-stress" environments where there will be pavement within the tree's drip line, high levels of pedestrian or vehicular traffic, vehicle exhaust and air pollution, or other urban stressors. For example, most of these species are generally well-suited to being planted in parking lot islands or other narrow landscaped areas.

Shade Trees

Botanical Name	*Common Name*
Acer campestre	Hedge Maple
*Acer rubrum**	Red Maple*
*Acer saccharum**	Sugar Maple*
Carpinus betulus fastigiata[F]	Pyramidal European Hornbeam [F]
Celtis occidentalis	Hackberry
Cladastris lutea	Yellowwood
Corylus colurna	Turkish Hazelnut
Eucommia ulmoides	Hardy Rubber Tree
*Fraxinus pennsylvanica**	Green Ash*
Gingko biloba	Maidenhair Tree (female +)
Gleditsia triacanthos inermis	Thornless Honeylocust
*Liquidambar styraciflua**[F]	Sweet Gum* [F]
Maclura pomifera inermis 'Park'	Park Osage Orange
*Nyssa sylvatica**	Black Tupelo*
Platanus acerifolia[F]	London Plane Tree [F]
Sophora japonica	Scholartree
Tilia cordata	Littleleaf Linden
Zelkova serrata[F]	Japanese Zelkova [F]

Notes:
* Native Plants
+ Recommended for planting on portions of the site away from walks or roads.
[F] These trees need extra care if they are planted during the fall season.

Ornamental Trees

Botanical Name	*Common Name*
*Betula nigra**[F]	River Birch* [F]
Cercidiphyllum japonicum	Katsuratree
Chionanthus virginicus	White Fringetree
Cornus kousa[F]	Kousa Dogwood [F]
Crataegus phaenopyrum	Washington Hawthorn
Magnolia stellata[F]	Star Magnolia [F]
*Ostrya virginiana**	American Hophornbeam*
Oxydendron arboreum[F]	Sourwood [F]
Prunus sargentii[F]	Sargent Cherry [F]
Pyrus calleryana [F]	Callery Pear [F]

Syringa reticulata	Japanese Tree Lilac

Deciduous Shrubs

Botanical Name	*Common Name*
Cornus sericea	Red Osier Dogwood
*Ilex verticillata**	Common Winterberry*
*Ilex verticillata 'Nana'**	Dwarf Winterberry*
Rhus aromatica 'Gro-low'	Dwarf Fragrant Sumac
Spiraea bumalda varieties	Spirea
*Vaccinium angustifolium**	Lowbush Blueberry*

Groundcovers

Botanical Name	*Common Name*
Cotoneaster horizontalis	Rockspray Cotoneaster
Hedera helix	English Ivy
Juniperus chinensis sargentii	Sargent Juniper
Juniperus horizontalis varieties	Creeping Juniper
Vinca minor	Periwinkle
Pachysandra terminalis	Japanese Pachysandra

4. Species for Erosion Control

These species can be used for stabilizing the ground and preventing erosion, and should be considered for planting in areas with steep slopes or unstable, erodible soils.

Botanical Name	*Common Name*
Aegopodioum podagraria 'Variegatum'	Variegated Snow-on-the-Mountain
Celastrus scandens	American Bittersweet
Clematis paniculata	Clematis
Cornus, shrubby types	Dogwood (Silky, Gray-stemmed, Gray, Redleaf)
Cotoneaster, low types	Cotoneaster
Cytisus spp.	Scotch Broom
Erica spp.	Heath
Euonymus fortunei 'Colorata' and cvs.	Wintercreeper
Forsythia suspensa and cvs.	Weeping Forsythia
Genista x 'Lydia'	Genista lydia
Hedera helix and cvs.	English Ivy
Hemerocallis, all	Daylilly
Houtuynia cordata 'Chameleon'	Chaeleon Houtuynia
Itea spp.	Sweetspire
Juniperus, low types	Juniper
Ligustrum, all	Privet
Myrica pennsylvanica	Northern Bayberry
Parthenocissus spp.	Ivy
Polygonum aubertii	Silver-vine Fleeceflower
Rhus aromatica and cvs.	Fragrant Sumac
Rosa, most	Most roses
Salix purpurea	Purpleosier Willow
Stephanandra incisa	Cutleaf Stephanandra
Symphoricarpos x chenaultii 'Hancock'	Chenault Coralberry
Vinca minor and cvs.	Periwinkle
Yucca filamentosa	Yucca

5. Wetland Species

This list of species is generally well-suited for planting in constructed wetlands, wet swales, and other stormwater management areas that will typically be wet. Plantings in each section of the wet area must be selected according to the hydrological conditions in that area.

Herbaceous Plants

Botanical Name	*Common Name*	*Water Depth (see below)*
Osmunda cinnamomea	Cinnamon fern	Transitional
Osmunda regalis	Royal fern	Transitional
Symplocarpus foetidus	Skunk cabbage	Transitional
Scirpus cyperinus	Woolgrass	Shallow
Thelypteris palustri	Marsh fern	Shallow
Caltha leptosepala	Marsh Marigold	Shallow
Polygonum coccineum	Pennsylvania smartweed	Shallow
Lobelia cardinalis	Cardinal Flower	Shallow
Lobelia siphilitica	Great Lobelia	Shallow
Iris versicolor	Blue Flag Iris	Medium
Acorus calamus	Sweet flag	Medium
Calla palustris	Water arum	Medium
Sparganium eurycarpum	Burreed	Medium
Scirpus americanus	Three-square	Medium
Scirpus fluviatilis	River bulrush	Medium
Sagittaria latifolia	Arrowhead	Medium
Ponetederia cordata	Pickerelweed	Medium
Peltandra cordata	Arrow arum	Medium
Potamogeton pectinatus	Sago pondweed	Deep
Vallisneria americana	Tapegrass	Deep
Ranunculus flabellaris	Yellow water buttercup	Deep
Ranunculus aquatilis	White water buttercup	Deep
Scirpus validus	Bulrush	Deep
Nymphea odorata	Fragrant white lily	Deep
Nuphar luteum	Spatterdock	Deep
Brasenia schrebrri	Watershield	Deep

Transitional: seasonally flooded; Shallow: seasonally flooded to permanently flooded to 15 cm; Medium: 15 to 50-cm water depths; Deep: 50 to 200-cm water depths.

Shrubs

Botanical Name	*Common Name*
Clethra alnifolia	Summersweet Clethra
Cornus amomum	Silky Dogwood
Ilex verticillata	Winterberry
Kalmia angustifolia	Sheep Laurel
Lindera benzoin	Spicebush
Rhodendron viscosum	Swamp Azalea
Viburnum recognitum	Northern Arrowwood
Vaccinium corymbosum	Highbush Blueberry

Trees

Botanical Name	*Common Name*
Nyssa sylvatica	Black gum
Quercus bicolor	Swamp oak
Fraxinus americana+	White ash+
*Fraxinus pennsylvanica**	Green Ash*
Acer rubrum+	Red Maple+
Quercus bicolor^	Swamp oak^
Betula nigra^	River birch^

Notes:
*Species that will tolerate flooding for more than 1 year
+Species that will tolerate flooding for one growing season
^Species that will tolerate flooding for less than 30 days during the growing season

Woody Wetland Plants

Botanical Name	*Common Name*
*Salix nigra**	Black Willow*
*Cephalanthus occidentalis**	Buttonbush*
*Cornus stolonifera**	Red-osier Dogwood*
Sambucus canadensis+	Elder+
Vaccinium corymbosum+	Blueberry+
Chamaecyparis thyoides+	Atlantic white cedar+
Alnus rugosa+	Spackled Alder+
Nyssa sylvatica^	Black gum^
Ilex opaca^	American Holly^

6. Moist Tolerant Species

These species require significant moisture, and many are adapted to survive periods of standing water. In general, these species should be planted only where local soil and topography produce moist conditions. Landscape designers should not rely upon irrigation to sustain these species.

Woody Plants

Botanical Name	*Common Name*
Acer negundo	Box Elder
Acer rubrum	Red Maple
Alnus rugosa	Speckled Alder
Amelanchier	Serviceberry
Andromeda polifolia	Bog Rosemary
Aralia spinosa	Devil's Walkingstick
Aronia arbutifolia	Chokeberry
Azalea arborescens	Sweet Azalea
Azalea vaseyi	Pinkshell Azalea
Azalea viscosum	Swamp Azalea
Betula nigra	River Birch
Calluna vulgaris	Heather
Calycanthus floridus	Common Sweetshrub
Campsis radicans	Trumpet Creeper
Cephalanthus occidentalis	Buttonbush
Chamaecyparis thyoides	Atlantic White Cedar
Clethra acuminata	Mountain Pepperbush
Clethra alnifolia	Summersweet
Cornus spp.	Dogwood (Silky, Shrub, Gray)
Erica carnea	Heath
Gymnocladus dioicus	Kentucky Coffee Tree
Halesia diptera	Two-winged Silverbell

Hamamelis virginiana	Witchhazel
Ilex spp.	Holly
Ilex verticillata	Winterberry
Kalmia latifolia	Mountain Laurel
Larix spp.	Larch
Leucothoe fontanesiana	Drooping Leucothoe
Lindera benzoin	Spicebush
Magnolia virginiana	Sweetbay Magnolia
Malus	Crabapple
Myrica pennsylvanica	Bayberry
Nyssa sylvatica	Black Gum
Rhododendron canadense	Rhodora (for bogs only)
Rhododendron maximum	Rosebay Rhododendron
Rhus aromatica	Fragrant Sumac
Salix	Willow
Sambucus canadensis	American Elder
Sassafras albidum	Common Sassafras
Vaccinium	Blueberry, Cranberry
Zenobia pulverulenta	Dusty Zenobia

Perennials

Botanic Name	*Common Name*
Aconitum carmichaelii	Monkshood
Amsonia hubrechtii	Star Flower
Aruncus dioicus	Goatsbeard
Clatha palustris	Marsh Marigold
Chelone lyonii	Turtlehead
Cimicifuga	Snakeroot
Epimedium	Bishops' Cap
Ferns	Ferns
Filipendula ulmaria	Meadowsweet
Gillenia trifoliate	Bowman's Root
Helleborus niger	Christmas Rose
Hemerocallis	Daylilly
Hibiscus moscheutos	Rosemallow
Iberis sempervirens	Candy Tuft
Iris ensata	Japanese Iris
Iris siberica	Siberian Iris
Kirengeshoma palmate	Yellow Waxbells
Liatris spicata	Gayfeather
Limonium latifolium	Sea Lavender (for salt marsh only)
Lobelia cardinalis	Cardinal Flower
Lobelia siphilitica	Big Blue Lobelia
Monarda didyma	Beebalm
Petasites	Butterbur
Phlox divaricata	Woodland Phlox
Platycodonj grandiflorus	Balloon flower
Polygonatum	Solomon's Seal
Tradescantia x andersonianan	Spiderwort
Trillium	Wakerobin
Trollius	Globeflower

Grasses

Botanical Name	*Common Name*
Carex muskingumensis	Palm Sedge
Miscanthus sacchariflorus Giganteus	Giant Silver Banner Grass
Pennisetum alopecuroides	Fountain Grass
Sisyrinchium	Blue-eyed Grass
Typha angustifolia	Cattail

7. Drought Tolerant Species

These species require relatively little water, can survive longer periods without water, and/or are adapted to grow in well-drained soils. In the interest of minimizing the demand for irrigation water, these species should be considered in sunny areas with well-drained soil that are likely to experience dry conditions.

Woody Plants

Botanical Name	*Common Name*
Abies concolor	White Fir
Acer truncatum	Shantung Maple
Aesculus x carnea	Ruby Horsechestnut
Aesculus pavia	Red Buckeye
Aralia spinosa	Devil's Walkingstick
Arctostaphylos uva-ursi	Bearberry
Buddleia alternifolia	Fountain buddleia
Calluna vulgaris	Heather
Campsis radicans	Trumpet Creeper
Caragana microphylla	Littleleaf Caragana
Carpinus betulus	European Hornbeam
Carpinus caroliniana	American Hornbeam
Chaenomeles speciosa	Flowering Quince
Chamaecyparis thyoides	Atlantic White Cedar
Comptonia peregrina	Sweet Fern
Cornus racemosa	Gray Dogwood
Corylus colurna	Turkish Filbert
Cotinus coggygria	Smoke Tree
Crataegus crusgalli	Cockspur Hawthorn
Fraxinus pennsylvanica	Green Ash
Gleditsia tricanthos inermis	Honeylocust
Gymnocladus dioicus	Kentucky Coffee tree
Hamamelis	Witchhazel
Hybiscus syriacus	Rose-of-Sharon
Hydrangea	Hydrangea
Indigofera gerardiana	Himalayan Indigo
Jasminum nudiflorum	Winter Jasmine
Juniperus	Juniper
Kerria japonica	Japanese Kerria
Koelreuteria paniculata	Golden Rain Tree
Kolkwitzia amabilis	Beautybush
Microbiata decussata	Siberian Carpet Cypress
Myrica pensylvanica	Northern Barberry
Pinus banksiana	Jack Pine
Pinus mugo	Mugo Pine
Pinus nigra austriaca	Austrian Pine
Pinus strobus	Eastern White Pine
Platanus x acerfolia	London Planetree

Potentilla fruticosa	Potentilla
Prunus maritima	Beach plum (especially back and scarlet)
Quercus	Oak
Rhus	Sumac
Rosa rugosa	Rugosa Rose
Salix	Willow
Sambucus canadensis	American Elder
Sassafras albidum	Common Sassafras
Shepherdia argentea	Buffalo Berry
Sophora japonica	Scholartree
Stephanandra incisa	Cutleaf Stephanandra
Vitex agnus-castus	Chastetree

Perennials

Botanical Name	*Common Name*
Anthemis tinctoria	Golden Marguerite
Artemisia	Wormwood
Armeria maritime	Thrift
Asclepias tuberosa	Butterfly Milkweed
Aubrieta deltoidea	False Rock Cress
Aurinia saxatilis	Basket-of-Gold
Callirhoe involucrata	Poppy Mallow
Campanula carpatica	Carpathian Bellflower
Centaurea Montana	Mountain Bluet
Cerastium tomentosum	Snow-in-Summer
Echinacea purpurea	Coneflower
Echinops ritro	Globe Thistle
Eryngium planum	Sea Holly
Eupatorium	Hardy Ageratum
Gaillardia x grandiflora	Blanket Flower
Geranium dalmaticum	Cranesbill
Geranium macrorhizum	Bigroot
Gypsophila	Baby's Breath
Helianthus grosse-serratus	Sawtooth Sunflower
Hemerocallis fulva	Daylilly
Lamium maculatum	Spotted Dead Nettle
Lewisia cotyledon	Bitter Root
Nepera x faassenii	Persian Catmint
Oenothera	Evening Primrose
Opuntia humifusa	Prickly Pear
Papaver orientale	Poppy
Perovskia atriplicifolia	Russian Sage
Phlox subulata	Moss Pink
Polemonium caereum	Jacob's Ladder
Rudbeckia	Coneflower
Salvia verticillata	Purple Rain
Santolina chamaecyparissus	Lavender Cotton
Sedum	Stonecrop
Sempervivum	Houseleek
Stachys byzantina	Lamb's Ears
Stokesia laevis	Stoke's Aster
Thymus serpyllum	Mother-of-Thyme
Yucca	Desert Candle

Grasses

Botanical Name	*Common Name*
Bouteloua gracilis	Blue Gramma
Elymus arenarius	Blue Lyme Grass
Festuca cinerea	Blue Fescue
Schizachyrium scoparium	Little Bluestem

8. Habitat Creating Species

Habitat creating species provide food or home sites for birds and other animals.

The following plants provide good habitat for birds and animals.

Trees

Botanical Name	*Common Name*
Acer rubrum	Red Maple
Acer saccharinum	Sugar Maple
Amelanchier canadensis	Serviceberry
Betula nigra	River Birch
Betula papyrifera	White Birch
Celtic occidentalis	Hackberry
Cornus, most	Dogwoods
Crataegus, most	Hawthorn
Malus, most	Crabapple
Nyssa sylvatica	Black gum
Picea glauca	White spruce
Picea pungens	Blue Spruce
Pinus strobus	White Pine
Populus, most	Poplars
Quercus alba	White Oak
Quercus palustris	Pin Oak
Quercus rubra	Red Oak
Sorbus aucuparia	Mountain Ash
Tsuga canadensis and cvs.	Eastern Hemlock

Shrubs

Botanical Name	*Common Name*
Amelanchier canadensis and cvs.	Serviceberry
Aralia spinosa	Devil's Walking Stick
Aronia spp. And cvs.	Chokeberry
Cornus, most	Dogwoods
Cotoneaster spp. and cvs.	Cotoneaster
Ilex glabra	Inkberry
Juniperus virginiana and cvs.	Eastern Red Cedar
Myrica pensylvanica	Bayberrry
Rosa rugosa	Rugosa Rose
Salix discolor	Pussy Willow
Viburnum dentatum	Arrowwood

The following plant species provide persistent fruit that lasts into the late fall and winter, thus providing food for wildlife during the critical months when food is most difficult to find.

Trees

Botanical Name	*Common Name*
Cornus mas	Cornelian Cherry Dogwood (Golden Glory)
Crataegus phaenopyrum	Washington Hawthorn
Malus spp., most	Crabapple

Shrubs

Botanical Name	*Common Name*
Aronia arbutifolia	Red Chokeberry
Ilex glabra	Inkberry
Juniperus spp. and cvs.	Juniper
Myrica pennsylvanica	Bayberry
Pyracantha coccinea and cvs.	Firethorn
Rhodotypos scandens	Black Jetbead
Rhus spp.	Sumac
Rosa rugosa and cvs.	Rugosa Rose
Rosa wichuriana and cvs.	Memorial Rose
Viburnum dilatatum	Linden Viburnum
Viburnum setigerum	Tea Viburnum

9. Invasive Species

Invasive plants are introduced species that tend to spread into natural habitats and outcompete native species because of their superior reproductive ability, aggressive growth pattern, or (most commonly) lack of native competitors, herbivores, parasites, or diseases. Invasive species are a serious threat to native biodiversity because they compete with native species for limited land, water and sunlight. **Plants on the following list should not be planted in our community**.

Shade Trees

Botanical Name	*Common Name*
Acer ginnala	Amur Maple
Acer platanoides	Norway Maple
Acer pseudoplatanus	Sycamore Maple
Populus alba	White Cottonwood
Robinia pseudoacacia	Black Locust

Deciduous Shrubs/Vines

Botanical Name	*Common Name*
Ampelopsis brevipedunculata	Porcelain Berry
Berberis thunbergii	Japanese Barberry
Berberis vulgaris	Common Barberry
Celastrus orbiculata	Oriental Bittersweet
Cynanchum louiseae	Black Swallow-wort
Elaeagnus umbellata	Autumn Olive
Elaeagnus angustifolia	Russian Olive
Euonymus alatus	Winged Euonymus
Euphorbia cyparissias	Cypress Spurge
Hesperis natonalis	Dame's Rocket
Ligustrum obtusifolium	Blunt-leaver Privet
Ligustrum vulgare	Privet

Lonicera japonica	Japanese Honeysuckle
Lonicera maackii	Amur Honeysuckle
Lonicera morrowii	Morrow's Honeysuckle
Lonicera tatarica	Tatarian Honeysuckle
Lonicera xbella	Morrow's x Tatarian Honeysuckle
Polygonum cuspidatum	Japanese Knotweed
Pueraria lobata	Kudzu
Rhamnus cathartica	Common Buckthorn
Rhamnus frangula	Shining Buckthorn
Rosa multiflora	Multiflora Rose

Meadow Grasses/Wildflowers

Botanical Name	*Common Name*
Achillea millefolium var. millefolium	Common Yarrow
Aegopodium podagraria	Goutweed
Alliaria petiolata	Garlic Mustard
Cabomba caroliniana	Fanwort
Centaurea maculosa	Spotted Knapweed
Cirsium canadense	Field or Canada Thistle
Coreopsis lanceolata	Lance-leaved Coreopsis (Tickseed)
Cytisus scoparius	Scotch Broom
Daucus carota	Queen Anne's Lace
Egeria densa	Giant Waterweek
Epilobium hirsutum	Hairy Willow-herb
Euphorbia cyparissias	Cypress Spurge
Galium mollugo	Field Madder
Glaucium flavum	Sea Poppy
Glechoma hederacea	Gill-over-the-ground (Ground Ivy)
Holcus lanatus	Velvet Grass
Hypericum perforatum	Common St. John's Wort
Iris pseudacorus	Yellow Iris
Linaria vulgaris	Butter and Eggs
Lysimachia nummularia	Moneywort
Lythrum salicaria	Purple Loosestrife
Myosotis scorpioides	True Forget-me-not
Myriophyllum heterophyllum	Variable Water-milfoil
Myriophyllum spicatum	Spiked Water-milfoil
Najas minor	Lesser Naiad
Nasturtium officinale	Watercress
Phalaris arundinace	Reed Canary Grass
Phragmites australis	Phragmites
Plantago lanceolata	Ribgrass (Lance-leaved Plantain)
Poa compressa	Canada Bluegrass
Potamogeton crispus	Curly or Crisped Pondweed
Ranunculus acris	Tall Buttercup
Ranunculus bulbosus	Bulbous Buttercup
Ranunculus repens	Creeping Buttercup
Ribes rubrum	Garden Red Currant
Rumex acetosella	Sheep Sorrel
Rumex crispus	Curled Dock
Rumex obtusifolius	Bitter or Broad-leaved Dock
Solanum dulcamara	Bittersweet Nightshade
Trapa natans	Water Chestnut
Tussilago farfara	Coltsfoot
Verbascum thapsus	Flannel-leaved Mullein

Lawn Grasses

Botanical Name	*Common Name*
Agrostis gigantea	Redtop, Upland Bentgrass
Festuca longifolia	Hard Fescue
Festuca ovina	Sheep Fescue

10. Prohibited Species

Massachusetts Prohibited Plant List (from MA Department of Agricultural Resources - MDAR)

Following is a list of plants for which importation and propagation is currently prohibited within the state of Massachusetts. The original list of prohibited plants went into effect January 1, 2006. Certain species were subject to a phase-out period that expired on January 1, 2009. As of this date, **the sale, trade, purchase, distribution and related activities for the species below are not allowed:**

Botanical Name	*Common Name*
Aeginetia spp.	Aeginetia
Lycium ferrocissimum	African boxthorn
Digitaria abyssinica; D. scalarum	African couch grass
Pennisetum macrourum	African feathergrass
Alectra spp.	Alectra
Drymaria arenarioides	Alfombrilla
Limnophila sessiliflora	Ambulia
Phellodendron amurense	Amur cork-tree
Lonicera maackii	Amur honeysuckle
Eichhornia azurea	Anchored water hyacinth
Avena sterilis	Animated oat
Prosopis strombulifera	Argentine screwbean
Sagittaria sagittifolia	Arrowhead
Leptochloa chinensis	Asian sprangletop
Elaeagnus umbellata	Autumn olive
Lonicera x bella [L. morrowii x L. tatarica]	Bell’s honeysuckle
Commelina benghalensis	Benghal dayflower
Aegopodium podagraria	Bishop's weed; goutweed
Robinia pseudoacacia	Black locust
Cynanchum louiseae	Black swallow-wort; Louise's swallow-wart
Ligustrum obtusifolium	Border privet
Spermacoce alata	Borreria
Imperata brasiliensis	Brazilian satintail
Egeria densa	Brazilian waterweed; Brazilian elodea
Najas minor	Brittle water-nymph; Lesser naiad
Lepidium latifolium	Broad-leafed pepperweed; Tall pepperweed
Orobanche spp.	Broomrape
Oryza rufipogon	Brownbeard rice; Red rice

Euonymus alatus	Burning bush; Winged euonymus
Cardamine impatiens	Bushy rock-cress; Narrowleaf bittercress
Homeria spp.	Cape tulip
Cabomba caroliniana	Carolina Fanwort; fanwort
Mimosa pigra	Catclaw mimosa
Setaria pallidifusca S. pallidefusca;S. pumila	Cattail grass; Yellow foxtail
Caulerpa taxifolia	Caulerpa
Ipomoea aquatica	Chinese waterspinach [PERMIT REQUIRED – contact MDAR]
Tridax procumbens	Coat buttons
Tussilago farfara	Coltsfoot
Berberis vulgaris	Common barberry; European barberry
Rhamnus cathartica	Common buckthorn
Crupina vulgaris	Common crupina
Phragmites australis	Common reed
Ranunculus repens	Creeping buttercup
Lysimachia nummularia	Creeping Jenny; Moneywort
Potamogeton crispus	Crisped pondweed; Curly pondweed
Ageratina adenophora	Crofton weed
Euphorbia cyparissias	Cypress spurge
Hesperis matronalis	Dames Rocket
Emex spinosa	Devil's thorn
Cuscuta spp.	Dodder
Ottelia alismoides	Duck-lettuce
Myriophyllum spicatum	Eurasian or European water-milfoil; Spike water-milfoil
Frangula alnus; Rhamnus frangula	European buckthorn; Glossy buckthorn
Sparganium erectum	Exotic bur-reed
Myosotis scorpioides	Forget-me-not
Alliaria petiolata	Garlic mustard
Mimosa diplotricha; M. invisa	Giant false sensitive plant; False sensitive plant
Heracleum mantegazzianum	Giant hogweed
Salvinia auriculata	Giant salvinia; Eared watermoss
Salvinia molesta	Giant salvinia; Kariba-weed
Salvinia biloba	Giant salvinia
Salvinia herzogii	Giant salvinia
Galega officinalis	Goatsrue
Festuca filiformis	Hair fescue; Fineleaf sheep fescue
Arthraxon hispidus	Hairy joint grass; Jointhead; Small carpetgrass
Epilobium hirsutum	Hairy willow-herb; Codlins and Cream
Glaucium flavum	Horned poppy; Sea poppy; Yellow hornpoppy
Hydrilla verticillata	Hydrilla; Water-thyme; Florida elodea
Rottboellia cochinchinensis	Itchgrass
Berberis thunbergii	Japanese Barberry
Lonicera japonica	Japanese honeysuckle
Humulus japonicus	Japanese hops

Polygonum cuspidatum; Fallopia japonica	Japanese knotweed
Carex kobomugi	Japanese sedge; Asiatic sand sedge
Microstegium vimineum	Japanese stilt grass; Nepalese browntop
Opuntia aurantiaca	Jointed prickly pear
Prosopis pallida	Kiawe
Pennisetum clandestinum	Kikuyugrass
Paspalum scrobiculatum	Kodo-millet
Pueraria montana	Kudzu; Japanese arrowroot
Pennisetum pedicellatum	Kyasuma grass
Euphorbia esula	Leafy Spurge; Wolf's Milk
Ranunculus ficaria	Lesser celandine; fig buttercup
Urochloa panicoides	Liverseed grass
Oryza longistaminata	Longstamen rice; Red rice
Melastoma malabathricum	Malabar melastome
Melaleuca quinquenervia	Melaleuca
Polygonum perfoliatum	Mile-a-minute vine or weed; Asiatic Tearthumb
Mikania micrantha	Mile-a-minute; Bittervine
Mikania cordata	Mile-a-minute; Heartleaf hempvine
Hygrophila polysperma	Miramar weed
Pennisetum polystachyon; P. polystachion	Missiongrass
Monochoria hastata	Monochoria
Lonicera morrowii	Morrow’s honeysuckle
Azolla pinnata	Mosquito fern
Rosa multiflora	Multiflora rose
Ischaemum rugosum	Murain-grass
Acer platanoides	Norway maple
Asphodelus fistulosus	Onion weed
Celastrus orbiculatus	Oriental or Asiatic bittersweet
Lagarosiphon major	Oxygen weed
Cynanchum rossicum	Pale swallow-wort
Myriophyllum aquaticum	Parrot-feather; Water-feather; Brazilian water-milfoil
Monochoria vaginalis	Pickerel weed
Chrysopogon aciculatus	Pilipiliula
Miscanthus sacchariflorus	Plume grass; Amur silvergrass
Ampelopsis brevipedunculata	Porcelain-berry; Amur peppervine
Lythrum salicaria	Purple loosestrife
Oryza punctata	Red rice
Phalaris arundinacea	Reed canary-grass; Ribbon grass
Nassella trichotoma	Serrated tussock
Alternanthera sessilis	Sessile joyweed
Centaurea biebersteinii;	Spotted knapweed
C. stoebe ssp. micranthos	Spotted knapweed
Acer pseudoplatanus	Sycamore maple
Glyceria maxima	Tall mannagrass; Reed mannagrass

Senecio jacobaea	Tansy ragwort; Stinking Willie
Lonicera tatarica	Tatarian honeysuckle
Emex australis	Three-cornered jack
Prosopis reptans	Tornillo
Ailanthus altissima	Tree of heaven
Solanum viarum	Tropical soda apple
Solanum torvum	Turkeyberry
Myriophyllum heterophyllum	Variable water-milfoil; Two-leaved water-milfoil
Digitaria velutina	Velvet fingergrass
Prosopis velutina	Velvet mesquite
Rorippa amphibia	Water yellowcress; Great yellowcress
Trapa natans	Water-chestnut
Solanum tampicense	Wetland nightshade
Rubus fruticosus	Wild blackberry complex
Rubus moluccanus	Wild blackberry
Anthriscus sylvestris	Wild chervil
Carthamus oxyacanthus; C. oxycantha	Wild safflower; Jeweled distaff thistle
Saccharum spontaneum	Wild sugarcane
Rubus phoenicolasius	Wineberry; Japanese wineberry; Wine raspberry
Striga spp.	Witchweed
Salsola vermiculata	Wormleaf salsola
Nymphoides peltata	Yellow floating heart
Iris pseudacorus	Yellow Iris

On the web at: http://www.mass.gov/agr/farmproducts/proposed_prohibited_plant_list_v12-12-05.htm

Contact: Jennifer Forman Orth, State Plant Pest Survey Specialist, Jennifer.Forman-Orth@state.ma.us - 617.626.1735.

V. Site Planning

The community's site planning objectives are intended to further our goals of:

- **Protecting the environment**, including wildlife habitat, water resources, and "ecosystem services" such as groundwater recharge, flood attenuation and pollutant removal;
- **Creating a visually appealing community**;
- **Preserving the Town's cultural heritage**, including historic sites, view corridors, trees and other noteworthy features;
- **Stabilizing and increasing property values**; and
- **Encouraging sustainable development** that minimizes energy use and pollution.

COMMUNITY OBJECTIVE: Subdivision plans and site plans for all forms of development should adhere to the principles of *environmental compatibility*, *aesthetic compatibility*, and *energy-efficient design*.

In order to minimize costs related to design and engineering (as well as construction), it is recommended that applicants follow the **four-step planning process** described in Appendix A. Creative designers will usually be able to find many cost savings in these site planning guidelines related to a reduction in clearing, cut and fill, replanting, and stormwater management.

Guidelines for site planning include the following:

- **Refrain from disturbing unique natural features of the site to the maximum extent possible.** Depending on the site, such features could include wooded areas, specimen trees, knolls, and rock outcroppings as well as the more typically conserved streams, wetlands and ponds. These features should be identified early in the site planning process (for example, in the survey or an early site visit) and incorporated into the site plan either as "focal points" for the development or as protected areas. In general, clearing of vegetation and alteration of topography should be limited to the maximum percent lot coverage stated in the zoning bylaw (structures plus paving) plus 10%. Native vegetation should be planted in disturbed areas as needed to enhance or restore wildlife habitat. Disturbance should be limited to construction areas only. Preservation of groups of trees (e.g., beech, oak, hickory, etc.) is encouraged.
- **Refrain from disturbing sites of historic and/or cultural significance.** Significant sites could include old buildings, cellar holes or graveyards, as well as historic trees that have a diameter at breast height of 20" or greater.
- **Preserve views and vistas both into and out of the site.** A visual analysis should be conducted to identify any scenic "windows" into the site and preserve the aesthetic value of these views whenever possible.
- **Minimize cut and fill.** Roads should follow the natural contours whenever possible, taking a steeper path only if necessary. Steep areas on individual house lots should generally be left as natural vegetation, not re-graded to allow for a sloping lawn. This approach can reduce grading costs and stormwater control costs because it often results in less land being disturbed, thereby creating fewer erosion or runoff problems. In addition, future homeowners will have fewer expenses and hassles related to maintaining steep lawns and landscaped areas, which are often costly to maintain and have low utility as yards.

- **Locate houses and buildings in a way that blends into the natural topography.** Buildings should not be set high up on a hill where they will be an eyesore or a focus of attention. Generally buildings should be situated near the grade of the road, unless this would require extensive regrading, in which case they may be higher or lower. For buildings located much above the road, an extra effort should be made to recess these buildings into the treeline to reduce their visual impact.
- **Conserve energy by orienting buildings to the sun and wind for maximum efficiency.** Buildings should be aligned to be protected from cold winter winds, shaded from summer sun, and open to winter sun. Protection from cold winter winds can be achieved by retaining natural vegetation at a building's northwest edge or by planting evergreen species such as white pine (*Pinus strobus*) in this location. For summer shading and winter heating, deciduous species can be planted close to the building, along the east, south and west exposures. Winter sunlight will penetrate the empty branches and provide heat. Home interiors should be laid out with time-of-day occupancy in mind.[31] Living and high-activity rooms should be placed on the south side where they are heated by the low winter sun and shaded from the high summer sun. Garages, utility rooms and closets can be positioned to provide insulating barriers on the northeast and northwest sides.

Appendix A - Four-step Site Design

This Guide encourages site plans and subdivision applications to consider the presence of natural, cultural, and aesthetic features on any proposed development or redevelopment site. The Town recommends that designers utilize a four-step planning process to identify and plan for these site features.[32] The Town also recommends this process as a way of expediting the project review and approval process and minimizing the need for re-designs.

Under the four-step process, the applicant first prepares an "environmental constraints and opportunities plan" for an initial Planning Board meeting. At this meeting, the applicant and the Planning Board identify those portions of the site that should be conserved (e.g., wetlands, viewsheds, specimen trees, historic sites), and those that are most suitable for development. This analysis should consider natural and visual features, as well as the site's orientation with respect to the sun and wind. With this input, the designer then identifies building sites and lays out the internal circulation network in a way that minimizes clearing, vegetation disturbance and regrading, and situates the buildings within the natural topography. The last step is to draw in the lot lines, if applicable. The goal of this process is not to reduce the overall development program, but rather to lay it out in a less expensive and more environmentally and aesthetically compatible fashion.

The four site planning steps are described below.

1. Constraints and Opportunities Plan

Figure A-1 Sample Constraints and Opportunities Plan showing significant viewsheds, natural and cultural features

Site planning should begin with the preparation of a **constraints and opportunities plan** to understand the site's features and its context. The plan should identify water resources (wetlands, streams, ponds, vernal pools, floodplains, and springs or seeps), site conditions (steep slopes, significant rock outcroppings, landforms such as knolls and hollows, hydric soils, and prime aquifer recharge areas), ecological features (woodlands, wildlife habitat, and rare species), scenic/visual features (specimen trees, farmland and meadows, and views both into and out from the site), and historic and archaeological resources. The constraints and opportunities plan may be prepared in conjunction with the site survey, but will require more investigation and analysis than a survey usually provides. Ideally a multidisciplinary team with an engineer, scientist, and landscape architect will visit the site and prepare the constraints and opportunities plan. During this step, the designer should also consider the location's context, including surrounding land uses, water resources,

historic sites, and other features. The constraints and opportunities plan could either be a single plan or a series of layers of clear plastic or tracing paper, each representing one set of site features.

2. Identify the Conservation and Development Areas

Once all of the information about existing conditions has been combined on the constraints and opportunities plan, the most suitable areas for development and conservation will become apparent. Conserved lands should include *primary conservation areas* (areas such as wetlands, floodplains, and steep slopes that are generally unbuildable due to environmental regulations or site conditions) as well as *secondary conservation areas* (unique or attractive site features, or areas that are important for environmental protection but not otherwise regulated). Working within the zoning guidelines, the designer should identify areas that will be conserved and areas that will be developed. The designer should be creative in trying to site the desired development program outside of the identified conservation areas.

3. Locate the Building Sites and Lay Out the Roads and Trails

Figure A-2 Sample plan identifying conservation and development areas

Building sites should be sited within the identified development areas to the maximum extent possible. Use of the community's flexible development options may be necessary to meet this goal. In addition, the site should be designed carefully, with the site's constraints and opportunities in mind. Sensitive features in the conservation areas (e.g., vernal pools) should be buffered from the development areas, while scenic or historic features (e.g., knolls, meadows, or rock outcroppings) could be "showcased" by providing an open view to toward them. In residential projects, natural vegetation will often need to be retained on individual house lots so that the total development program can fit into a development area that is only a fraction of the site's total land area. Finally, buildings should be sited with consideration to the view from the public way as well as the view out from the buildings. In suburban and rural sections of the Town, developments should generally be as naturally camouflaged as possible.

As discussed in **Section V**, buildings should also be oriented to the sun and wind for maximum efficiency. Protection from cold winter winds can be achieved by retaining natural vegetation along a building's northwest edge or by planting evergreen species such as white pine (*Pinus strobus*) in this location. For summer shading and winter heating, deciduous species can be planted close to the building, along the east, south and west exposures. Winter sunlight will penetrate the empty branches and provide heat. Home interiors should be laid out with time-of-day occupancy in mind. Living and high-activity rooms should be placed on the south side where they are heated by the low winter sun and shaded from

the high summer sun. Garages, utility rooms and closets can be positioned to provide insulating barriers on the east and west sides.

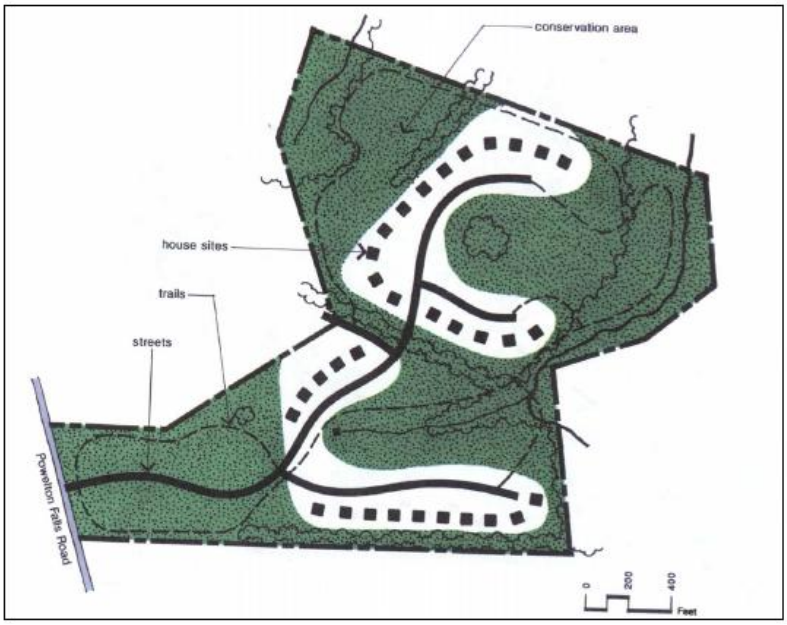

Figure A-3 Buildings and roads are sited within the development envelopes identified in Step 2

During this step, the system of roads and pedestrian network (if any) should be laid out based on the most efficient way to access the building sites with a minimum of environmental and aesthetic impacts. From an engineering standpoint, it is important to consider the topography; from an environmental approach, to consider mature tree stands, wildlife habitat areas, wetlands, etc.; and from an aesthetic and speed control perspective to build "slow" roads. "Slow" roads are naturally curving, or have short straight segments connected with relatively tight bends that force drivers to go slowly. As with the siting of buildings, preserving vistas should be a prime consideration.

4. Draw in the Lot Lines

Once steps 1 through 3 have been completed, the lot lines (if any) can be drawn in based on the building locations.

Appendix B - Glossary

Best Management Practice (BMP)--A structural device or practice designed to mitigate the effects of storm water runoff to attenuate flooding, reduce erosion, and reduce pollution. BMPs include a variety of **Low impact development** practices such as bioretention, sand filters, and infiltration trenches.

Bioretention--A structural storm water practice that uses soils and vegetation to treat pollutants in urban runoff and to encourage infiltration of storm water into the ground.

Buffer--Area in its natural state left between development and a shoreline, wetlands, or stream to protect water quality. Development is restricted in a buffer zone.

Erosion--The process of soil detachment and movement by the forces of water.

Filter Strips-- Bands of closely-growing vegetation, usually grass, planted between pollution sources and downstream receiving water bodies.

Habitat--An area or type of area that supports plant or animal life.

Hydrology--The science dealing with the waters of the earth, their distribution on the surface and underground, and the cycle involving evaporation, precipitation, flow to the seas, etc.

Groundwater--Water that is underground in cracks and spaces in soil, sand, and rocks. The layers of soil, sand, and rocks are also known as aquifers. Groundwater is used for drinking water by more than 50 percent of the U.S. population, including almost all residents of rural areas.

Impervious Area--Any area in the landscape that cannot effectively allow the absorption and infiltration of rainwater into the ground.

Impervious Cover--Any surface in the built environment that prohibits the percolation and infiltration.

Infiltration--The downward movement of water from the land surface into the soil.

Level Spreader--An outlet designed to convert concentrated runoff to sheet flow and disperse it uniformly across a slope to prevent erosion.

Low Impact Development (LID)--An approach to land development that uses various land planning and design practices and technologies for simultaneously conserving and protecting natural resource systems and reducing infrastructure costs.

Nonpoint Source Pollution--Water pollution caused by rainfall washing over and through land surfaces and carrying with it pollutants from the human environment. The Clean Water Act regulates nonpoint source pollution, which differs from point-source pollution.

Open Space--Land set aside to remain undeveloped for a community's public use and enjoyment.

Permeable--Soil or other material that allows the infiltration or passage of water or other liquids.

Phase II Community--Municipalities classified as urbanized areas and which have municipal separate storm sewer systems (MS4s) are required to obtain a permit from the US EPA for their stormwater discharges.

Recharge Area--A land area in which surface water infiltrates the soil and reaches the zone of saturation or groundwater table.

Right-of-Way--The width of the total land area required for street paving, curb and gutter, utilities, sidewalks, and street trees. Right-of-way widths should be the smallest measurement possible that accommodates these uses.

Riparian--Of or pertaining to stream systems or stream corridors. Riparian areas usually include a stream channel, its banks, the floodplain, and associated vegetated buffers.

Runoff--Water from rain, melted snow, or irrigation that flows over the land surface.

Sedimentation--The transport, deposit, and accumulation of soil material by wind and water. Sedimentation is usually associated with the accumulation of soil material in water bodies.

Sheetflow--The movement of rainwater across the surface of the landscape in response to topographic conditions.

Stormwater Management--An integrated system of practices and techniques for managing the safe and efficient handling of post-development rainwater.

Subdivision--The process of dividing parcels of land into smaller building units, roads, open spaces, and utilities.

Swale--A small, linear topographic depression used to move water from one location to another.

Watershed--The topographic boundary within which water drains into a particular river, stream, wetland, or body of water.

Zoning--Regulations governing the use, placement, spacing, and size of land and structures within a specific area.

Endnotes

[1] Overall, these practices will aid our community in meeting future stormwater requirements. The EPA's goals are to minimize polluted stormwater entering rivers and streams by reducing the discharge of pollutants to the maximum extent practicable; to protect water quality; and to satisfy the appropriate water quality requirements of the Clean Water Act. Phase I of EPA's plans was initiated in 1990 and regulated municipal separate storm sewer systems (MS4s) that were defined as "large" and "medium." Phase II, which was recently finalized, focuses on "small" MS4s. To comply with the Phase II requirements, the EPA requires that towns set in place regulations and programs that include public education and outreach, public involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control and pollution prevention/good housekeeping.

The Massachusetts Department of Environmental Protection (MA DEP) has recently adopted regulations requiring stormwater treatment for large areas of impervious cover. These and future state or federal regulations could affect the community.

[2] These stormwater management practices are adapted from the MA DEP *Stormwater Management Standards and Handbook*. The DEP standards already apply to any project that falls under the jurisdiction of the Wetlands Protection Act. Many communities have incorporated by reference the DEP's Stormwater Management Standards and Handbook in their Town's Stormwater or Low Impact Development Bylaw and Regulations. The Stormwater Management Standards and Handbook may be downloaded from the DEP's website at http://www.mass.gov/dep/water/laws/policies.htm#storm.

[3] Adapted from the *MA DEP Stormwater Management Handbook (2008), http://www.mass.gov/dep/water/laws/policies.htm#storm.* Additional information from the *Low Impact Development (LID) Design Strategies: An Integrated Design Approach*, Department of Environmental Resources, Prince George's County, Maryland, June 1999, http://www.epa.gov/OWOW/nps/lidnatl.pdf. and *EPA NPDES National Menu of Stormwater Best Management Practices*, http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

[4] Based on the *DEP Stormwater Management Handbook*, with additional information from *EPA Stormwater NPDES National Menu of Stormwater Best Management Practices*.

[5] Based on the *DEP Stormwater Management Handbook*, with additional information from the *Low Impact Development (LID) Design Strategies: An Integrated Design Approach*, Department of Environmental Resources, Prince George's County, Maryland and the *EPA Stormwater NPDES National Menu of Stormwater Best Management Practices.*

[6] *MA DEP Stormwater Management Handbook*.

[7] *Northern Virginia Planning District Commission (NVPDC) Nonstructural Urban BMP Handbook*, Department of Conservation and Recreation/Division of Soil and Water Conservation, December 1996, www.novaregion.org.

[8] *MA DEP Stormwater Management Handbook*.

[9] *MA DEP Stormwater Management Handbook*.

[10] *MA DEP Stormwater Management Handbook*.

[11] *MA DEP Stormwater Management Handbook*.

[12] *MA DEP Stormwater Management Handbook*.

[13] *MA DEP Stormwater Management Handbook*

[14] *Green Roofs: Stormwater Management From the Top Down*, Katrin Scholz-Brath, www.edcmag.com, January/February 2001.

[15] *MA DEP Stormwater Management Handbook*.

[16] *MA DEP Stormwater Management Handbook*.

[17] *MA DEP Stormwater Management Handbook*.

[18] *MA DEP Stormwater Management Handbook*.

[19] *Low Impact Development (LID) Design Strategies: An Integrated Design Approach*, Department of Environmental Resources, Prince George's County, Maryland.

[20] *EPA NPDES National Menu of Stormwater Best Management Practices*.

[21] Geotextiles and other erosion control and stormwater management products may be purchased from numerous commercial vendors. Vendors include Synthetic Industries, www.fixsoil.com; Pinelands Nursery, www.pinelandsnursery.com; North American Green, www.nagreen.com; and the American Excelsior Company, www.amerexcel.com/erosionindex.htm.

[22] *Surface Water Design Manual*, King County, Washington, Department of Natural Resources, September 1998.

[23] King County, WA, *Surface Water Design Manual*.

[24] *Best Management Practices for Minnesota: Protecting Water Quality in Urban Areas*, Minnesota Pollution Control Agency, 1991.

[25] *NVPDC Nonstructural Urban BMP Handbook*.

[26] *NVPDC Nonstructural Urban BMP Handbook*.

[27] Devens Enterprise Commission list of native species, invasive species, and other species for use in project landscaping. See www.devensec.com.

[28] *Creating Freshwater Wetlands*, Donald A. Hamoner, Lewis Publishers, Michigan, 1992.

[29] Lake County Nursery, Inc. Catalog, Perry, OH, 1995

[30] Weston Nurseries Catalog, Hopkinton, MA, 1999, www.westonnurseries.com.

[31] *Best Development* Practices, Reid H. Ewing *et al*., Planners Press, 1996.

[32]. This process is based on the work of Randall Arendt as presented in his book *Conservation Subdivision Design*, 1996. The images used in this section of the Handbook are taken from Arendt's book.