NEW JERSEY SITE IMPROVEMENT ADVISORY BOARD

RESOLUTION #02-1

SPECIAL AREA STANDARDS FOR STORMWATER MANAGEMENT IN THE TOWNSHIP OF HARDING, MORRIS COUNTY

WHEREAS, proposed special area standards have been submitted to the Site Improvement Advisory Board for review, pursuant to N.J.A.C. 5:21-3.5, by the Township of Harding, Morris County; and

WHEREAS, the Site Improvement Advisory Board held an informal public hearing, pursuant to N.J.A.C. 5:21-3.5(c), on July 31, 2001 to discuss the special area standard provisions, which consist of standards for stormwater quality and the recharge of stormwater within Harding Township; and

WHEREAS, in reviewing the application, the Stormwater Management Standards Committee of the Site Improvement Advisory Board and Harding made several revisions to the submitted application to ensure that the special area standards were predictable, not unduly burdensome, and based on the best available science; and

WHEREAS, the Stormwater Management Standards Committee reviewed a number of case studies that were performed using the special area standard provisions, and found the results to indicate that the special area standards were both clear and reasonable with respect to cost and application; and

WHEREAS, the majority of the members of the Site Improvement Advisory Board recognize the Great Swamp as a significant ecological resource worthy of higher standards for the reduction of water pollution from stormwater runoff and worthy *of special consideration with respect to enhancing baseflow, thereby modulating the flow of stormwater into the Great Swamp; and*

WHEREAS, the New Jersey Department of Environmental Protection (DEP) has recognized the Great Swamp Watershed as an environmentally sensitive area; and

WHEREAS, the Township has agreed to apply for and obtain a New Jersey Pollutant Discharge Elimination System (NJPDES) (N.J.A.C. 7:14A-7) permit from the DEP within the next 12 months; and

WHEREAS, the proposed special area standards are within the jurisdiction of the Site Improvement Advisory Board; and

WHEREAS, the Site Improvement Advisory Board finds that the modifications to N.J.A.C. 5:21-7, submitted by the municipality and enumerated below, meet the criteria for special area standards set forth at N.J.A.C. 5:21-3.5(k) as follows:

1. *They are consistent with the intent of the Site Improvement Act.*

2. *They are reasonable and not unduly burdensome.*

3. *They meet the needs of public health and safety.*

4. *They take into account existing infrastructure and surrounding development possibility.*

NOW, THEREFORE, BE IT RESOLVED that N.J.A.C. 5:21-7 shall be modified as follows for the Township of Harding.

N.J.A.C. 5:21-7.2(c) is amended as follows:

c) For the runoff peak rate of discharge calculation, design engineers shall have the option to choose the methodology to estimate peak rate of discharge. For small drainage areas of up to three acres or any drainage area having a time of concentration less than 0.1 hours, as estimated by use of TR-55, the hydrologic and hydraulic design analysis may be performed using the Rational Method or the Modified Rational Method. In that event, the peak rate of runoff shall be computed as set forth in N.J.A.C. 5:21-7(c)2 and the time of concentration shall be estimated as set forth in N.J.A.C. 5:21-7.2(c)3. Rainfall intensity as a function of duration and storm frequency shall be based upon N.J.A.C. 5:21, Figure 7.2, Rainfall Intensity Curves, and/or local rainfall frequency data, where available. A minimum time of concentration of ten minutes shall be used to determine peak flows.

1. For areas greater than three acres, design engineers shall calculate peak rate of runoff in conformance with methods developed by the Soil Conservation Service (SCS), and published in the National Engineering Handbook, Section 4 – Hydrology and the following publications, incorporated herein by reference:

i. Urban Hydrology for Small Watersheds, Technical Release No.55 (TR-55), U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, as supplemented or amended to date, except that the runoff curve numbers shall be as shown in Table III of the Handbook for Stormwater Detention Basins, Somerset County, N.J., December 1991, as supplemented or amended to date.

ii. Computer Program for Project Formulation - Hydrology, Technical Release No. 20 (TR-20), U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, as supplemented or amended to date.

iii. The New HEC-1 Flood Hydrograph Package, Technical Paper No. 82, Hydraulic Engineering Center, U.S. Army Corps of Engineers, used in appropriate conditions with appropriate values.

iv. Rainfall-frequency relationships shall be as shown in Technical Paper No. 40, Rainfall Frequency Atlas of the United States, published by the U.S. Weather Bureau, or as shown in Table 1 of the Handbook for Stormwater Detention Basins, Somerset County, N.J., December 1991.

v. Design Engineers shall estimate the time of concentration following procedures outlined in Chapter 3 of TR-55, *Urban Hydrology for Small Watersheds, U.S. Department of Agriculture, Soil Conservation Service, as supplemented or amended to date.*

Section 5:21-7.2(c)4 is amended as follows:

4. For storm sewer design, a 10-year to 25-year storm frequency consistent with localized circumstances shall be considered as a minimum unless special *circumstances are involved such as inadequate downstream stormwater facilities, lack of positive overland relief, or evidence of local flooding. In such special circumstances, design engineers shall design to accommodate, as a minimum, the following storm frequencies:*

- *i. Ten-year storm for storm drain systems where excess flow can continue down grade in the street and not exceed the gutter capacity. Also, ten-year storms shall be used at low points in storm drain systems with overland relief.*
- *ii. Twenty-five-year storm where flow in a storm drain is totally carried by a pipe when conditions under (i) above do not apply.*
- *iii. Twenty-five-year storm for culvert design where the culvert will be located in streams shown as a blue line in the New Jersey State Atlas or the United States Coast and Geodetic Survey maps. Culverts with an upstream drainage area of 50 acres or more shall be designed to accommodate a 100-year frequency storm, in accordance with Flood Hazard Area Control Regulations, N.J.A.C. 7:13-2.16.*
- *iv. Twenty-five-year storm for open channels where the upstream drainage area is less than 50 acres. When the upstream drainage area is 50 acres or more, design engineers shall design open channels to accommodate the 100-year storm in accordance with Flood Hazard Area Control Regulations, N.J.A.C. 7:13-2.16.*
- *v. Adequate provisions shall be made to safely transport the runoff from a 100-year, 24-hour design storm from all locations on a site to detention and/or retention facilities. Flow over the ground surface is permitted to the extent that it will not cause significant flood or erosion damage.*

Section 5:21-7.2(d) is amended as follows:

(d) Design engineers shall use a consistent method to calculate peak rate of runoff and volume. If either TR-55, TR-20, or HEC-1 is used to calculate peak rate of runoff, then the same method shall be used to determine volume. If the Rational Method is used for peak flow calculations, design engineers shall use the Modified Rational Method to calculate peak volume to be used for basin routing. A maximum drainage area of three acres shall be used for the Modified Rational Method.

Sections 5:21-7.5(b) and 7.5(c) are amended as follows:

(b) Design engineers shall coordinate structural detention requirements with non-structural practices such as cluster land-use development, open-space acquisition, riparian buffers, natural ponding, flood hazard controls, and grading to minimize concentrated flows and lengthen the time of concentration.

(c) Detention basins and all other stormwater facilities shall conform to the New Jersey DEP's Stormwater Management Rules, at N.J.A.C. 7:8-3.4. Design engineers shall also adhere to, when applicable, the stormwater design requirements in the following rules:

1. Dam Safety Standards, N.J.A.C. 7:20;

2. Soil Erosion and Sediment Control Standards, N.J.A.C. 2:90-1;

3. Flood Hazard Area Regulations, N.J.A.C. 7:13-1.1; and

4. Freshwater Wetlands Protection Act Rules, N.J.A.C. 7:7A.

Section 5:21-7.5(c) is further modified to include the following:

The runoff curve numbers used in the design of stormwater detention/retention basins shall conform to the standards set forth in Table III of the Handbook for Stormwater Detention Basins, Somerset County, N.J., supplemented or amended to date. The structural details shall conform to those shown in the handbook.

Section 5:21-7.5(d) is amended as follows:

(d) Where detention facilities are required, they shall accommodate site runoff generated from 2-year, 10-year, and 100-year storms as routed to the basin, considered individually, unless the detention basin is classified as a dam, in which case the facility also must comply with the Dam Safety Standards, N.J.A.C. 7:20.

1. These design storms shall be defined as either a 24-hour storm using Type III rainfall distribution when using U.S. Soil Conservation Service procedures (such as TR-20 or TR-55 tabular method), or the design storm resulting in the greatest storage volume to achieve the maximum permitted outflow using a design method such as the Modified Rational Method. Runoff greater than that occurring from the 100-year, 24-hour storm shall be passed through an emergency spillway.

2. Detention facilities shall be designed to accommodate runoff from the development of the site for the 2-, 10-, and 100-year storm events so that predevelopment peak flow rates that impact on downstream properties, watercourses, and/or drainage systems are reduced and released in accordance with the requirements presented in N.J.A.C. 5:21-7.5(d)3 and 5:21-7.6.

i. The peak rate of runoff from a site to be developed at its point of discharge into a stream, or onto adjacent private or public property, shall not exceed the rate computed based on runoff curve numbers as presented in Table III of the Handbook for Detention Basins, Somerset County, N.J., 1991.

ii. Where the drainage area is less than three acres or the time of concentration is less than 0.1 hours, the peak rate of runoff from a site to be developed at its point of discharge may be calculated using the Rational Method based on runoff coefficients, as shown in Table 7.2 of the Residential Site Improvement Standards (N.J.A.C. 5:21) and as modified by adjustment factors in Table 7.3 when appropriate.

iii. Where the increase in runoff from a small area of a site is shown to be negligible and has no significant impact on the receiving stream, or on adjacent or nearby private or public property, the planning board may approve the plan provided the runoff discharged from another area of the site is reduced by the amount of the increase.

3. Where there is not a regional stormwater plan, as specified below in 7.5(d)4, then the design engineer shall design detention facilities such that the post-project construction peak runoff for the 2-year storm event is 50 percent of the pre-project construction peak runoff rate. The post-project construction peak runoff rates for the 10-year and 100-year storm events shall be 75 and 80 percent, respectively, of the pre-project construction peak runoff rates. It should be noted that these percentages only apply to the portion of the post-project runoff from the site under development. Offsite runoff may be computed at 100 percent of the pre-project rate.

4. If a Phase II stormwater management plan for the region or watershed exists, consistent with stormwater rules administered by the New Jersey DEP (N.J.A.C. 7:8), then the design engineer may design stormwater management systems to conform to that plan. For some parts of the watershed, this may mean a detention basin is unnecessary.

5. If the development site is not part of a Phase II regional or watershed stormwater management plan, then the design engineer may model the watershed, consistent with regulations administered by the New Jersey DEP, and design stormwater management facilities to conform to that plan. This analysis shall include impacts of existing development and all potential future development in the drainage area. For some parts of the watershed, this may mean detention is unnecessary.

Section 5:21-7.5(f)1.iii is amended as follows:

iii) A concrete cradle shall be placed under all outlet pipes larger than eight inches in diameter to ensure good compaction of soil around the pipe and to provide stability of the outlet pipe.

Section 5:21-7.6 is amended as follows:

5:21-7.6 Stormwater Management: Water Quality

a) In addition to addressing water quantity generated by development, a stormwater management system shall also prevent, to the greatest extent feasible, an increase in non-point pollution.

1. It is the intent of these amended provisions that water discharged from developed properties will support an unimpaired aquatic community in the Great Swamp Wildlife Refuge and its tributary watercourses.

2. Development design standards shall emphasize advanced bio-filtration Best Management Practices (BMPs) that can be seamlessly incorporated into private landscaping or installed on limited public land areas. An approach utilizing distributed small facilities as opposed to large centralized facilities is recommended. The following BMPs recommended are appropriate for drainage areas of five acres or less. Specific BMPs shall include:

i. Infiltration trenches and below-grade infiltration beds.

ii. Pocket sand filters.

iii. Dry swale bioretention, with high-rate filtration.

iv. Raingardens (i.e., on-lot or community bioretention).

v. Bioretention meadows.

vi. Upward flow anaerobic filters (vegetated rock filters).

vii. Forested buffer filter strips.

3. Additional acceptable BMP practices are extended detention basins, wet ponds, and constructed wetlands. Properly constructed vegetated basins, treatment wetlands, and wet ponds can be effective methods for removing pollutants; however, they are suitable only in areas where there is a perennial source of inflow to the facility. These devices should be designed according to the guidelines provided in the <u>Stormwater and Non-Point Source Pollution Control Best Management Practices Manual</u> (New Jersey DEP, as supplemented or amended to date).

4. The implementation of all BMPs should consider good design techniques, such as:

i. Design with small impervious surface drainage units.

ii. Breaking up of existing large contiguous impervious areas with vegetated strips or islands.

iii. Installing BMPs as close as possible to the source of runoff generation.

b) *Stormwater management shall provide for the control of a water quality design storm. The water quality design storm shall be defined as a 5-hour, 1.6-inch rainfall event, distributed so that 1.25 inches of precipitation occurs within the central 2 hours. The distribution is as follows:*

End of Interval (Minutes)	***Incremental Rainfall (Inches)***	***Cumulative Rainfall (Inches)***
15	*0.01*	*0.02*
30	*0.02*	*0.04*
45	*0.02*	*0.05*
60	*0.03*	*0.08*
75	*0.03*	*0.11*
90	*0.03*	*0.14*
105	*0.03*	*0.17*
120	*0.05*	*0.22*
135	*0.10*	*0.32*
150	*0.25*	*0.57*
165	*0.60*	*1.17*
180	*0.13*	*1.30*
195	*0.06*	*1.36*
210	*0.05*	*1.41*
225	*0.05*	*1.46*
240	*0.03*	*1.49*
255	*0.03*	*1.52*
270	*0.03*	*1.55*
285	*0.03*	*1.58*
300	*0.02*	*1.60*

c) *All detention/retention basins shall include an extended detention function in accordance with existing regulations. However, water quality BMPs other than detention/retention basins are preferred for water quality management. Therefore, basins in drainage areas served by approved water quality and runoff retention BMPs need not include retention of the water quality storm. In any case, extended detention shall not be acceptable as a water quality BMP unless* *it is in combination with additional BMP treatment devices, such as the ones listed in amended Subsection 7.6(a)2.*

d) The criteria for the design of BMPs is related to the water quality volume, the water quality volumetric flow rate, and the water quality surface loading rate. The water quality volume is the total runoff derived from the design storm, as accumulated at the BMP. On lots with low rates of imperviousness and with runoff capture devices installed, the water quality volume will be small. Likewise, the water quality volumetric flow rate is the maximum runoff rate derived from the water quality design storm, as experienced at the BMP. The water quality volumetric flow rate divided by the surface area of a facility is equal to the water quality surface loading rate. The water quality volume and water quality volumetric flow rate should be calculated using the SCS cover-complex method. Runoff Curve Numbers (CN), as specified in Table III of the Handbook for Stormwater Detention Basins, Somerset County, N.J., should be used. Composite CNs can be computed by averaging the CNs of adjacent surfaces provided 1) the least-permeable surface is tributary to the most-permeable surface, and 2) runoff from the upgradient surface is not discharged to the downgradient surface as concentrated flow. For example, street areas may not be combined with adjacent lawns, since the tributary surface (i.e., the lawn) is more permeable. Roof areas may be combined with lawns provided the roof runoff is distributed across the lawn as sheet flow.

1. *Land uses shall be classified into "Harmfulness Classes" as shown in Table 7.7. Runoff generating surface in Harmfulness Class 1 will require water quality BMPs to treat Total Suspended Solids (TSS), metals, Total Phosphorus (TP), and Total Nitrogen (TN). Due to the contribution of nutrients associated with the accumulation of animal wastes, public open space maintained in turf grasses will also require treatment for TN.*

2. *It is the goal in controlling runoff to restore, as closely as possible, the water balance that was characteristic of pre-settlement conditions. The criteria for runoff capture is that the percent of annual rainfall retained on a parcel after development should not be significantly different from the pre-settlement period. Thus, the water retained will eventually be returned to the atmosphere through the process of evapotranspiration or percolate to ground water.*

TABLE 7.7 RUNOFF HARMFULNESS CLASSES		
Harmfulness Class	**Zone**	**Surface in Zone**
1 **(water quality treatment required)**	*All*	*Turf lawns (not deed restricted for no chemical fertilizer or pesticide)*
	Any	*Road, 300 or more vehicles per day*
	Residential (R-1, R-2, R-3, R-4)	*Driveways and parking pads, if runoff is not retained on lot*[1]
2	*All*	*Roofs*
	All	*Turf lawns (deed restricted for no chemical fertilizer or pesticide)*
	All	*Sidewalks*
	Any	*Roads, less than 300 vehicles per day*
	Residential (R-1, R-2, R-3, R-4)	*Driveways and parking pads, if runoff is retained on lot*[2]

[1] Runoff retention volume.

[2] Areas covered by permeable pavement are exempt provided that the permeable pavement complies with Subsection 5:21-7.6(g)1.iv of these standards and the permeability of the underlying soil is not less than the permeability that existed prior to the pavement construction.

i. The development must be designed to retain the runoff from the runoff retention design storm to preserve the overall water budget for the Watershed. The runoff retention design storm is the design rainfall event having the property that the volume of rainfall contributed annually equals the volume of water that was retained on the watershed during the pre-settlement period.

ii. The runoff retention design storm rainfall depth varies according to the recharge zone. The New Jersey Geologic Survey (NJGS) has established annual ground water recharge depths for seven recharge zones as characterized by their infiltration potential. A map showing the distribution of the recharge zones entitled "Estimated Ground-Water Recharge in Harding Township, Morris County" has been prepared by the NJGS and is available through the municipality. The runoff retention design storm depths and associated recharge zones are shown in Table 7.8.

TABLE 7.8 RUNOFF RETENTION DESIGN STORM DEPTHS AND ASSOCIATED RECHARGE ZONES	
Recharge Zone	***Runoff Retention Design Storm Depth (P) (inches)***
1	*1.25*
2	*1.25*
3	*1.25*
4	*1.15*
5	*0.85*
6	*0.60*
7	*0.40*

iii. If it can be shown that the soil series that exists on a site, or a portion of a site, is different from the soil series associated with the recharge zone shown for the site on the map, the recharge zone associated with the soil series found on the site shall be used to determine the runoff detention design storm depth.

iv. Compliance will be achieved when there is no runoff generated from a parcel during storms with the rainfall depths indicated above. For impervious surfaces, such as roofs,[1] driveways, and roads, the required runoff retention volume is computed by multiplying the runoff retention design storm depth by the area of the impervious surface. Water quality BMPs that incorporate retention[2] or infiltration can be used to satisfy the runoff retention requirement (e.g., raingardens). The displacement volume of granular fill must be taken into account. The porosity of granular fill shall be assumed to be 25 percent, unless laboratory tests are provided showing higher porosity.

3. The size of runoff retention devices or infiltration devices can be greatly reduced when the upgradient drainage area is managed to minimize the post-development runoff curve number or to hold runoff in shallow, landscaped depressions. For example, in a Recharge Zone 4 parcel with a composite CN of 80 and landscaping to provide an initial precipitation abstraction (IA) of 0.50 inches (SCS, 1981), the runoff retention volume can be estimated as follows:

$$R/A = \frac{(P-IA)^2}{(P+(S-IA))} \quad ;S=(1000/CN)-10$$

$$R/A = \frac{(1.15-.50)^2}{(1.15+(2.5-0.50))} \quad ;S=(1000/80)-10=2.5$$

R/A = 0.14 inches

Where: *R = runoff retention volume*
A = area of the parcel
P = runoff retention design storm depth
IA = initial precipitation abstraction

[1]*The infiltration of roof runoff is governed by a stricter requirement (see NJDEP standards for dry well installation).*

[2]*Stormwater detention basins with extended detention may not be used to satisfy this requirement, except in Recharge Zones 6 and 7.*

The runoff retention volume should be computed using 0.2S to represent IA in the previous equation. When the IA equals or exceeds the magnitude of the runoff retention design storm, then the retention requirement is satisfied and no supplemental retention volume must be provided.

Runoff associated with land uses in Harmfulness Class 2 may be infiltrated without treatment. All nonexempt sources of runoff, including public roads, should be treated prior to infiltration.

i. *By assigning runoff retention design storms of smaller magnitude to areas with lower potential ground-water recharge, runoff retention volume requirements will remain manageable.*

ii. *In Recharge Zones 6 and 7, extended detention volumes can be applied to satisfy the runoff retention volume requirement, since these areas can support little or no infiltration or rainfall to regional ground water.*

iii. *For convenience in sizing water quality BMPs, runoff retention volume may be computed using 0.2S to represent IA in the previous equation. When the IA equals or exceeds the magnitude of the runoff retention design storm depth, then the retention requirement is satisfied (i.e., no supplemental retention volume must be provided).*

e) *Landscape management practices should be utilized, when feasible, to improve stormwater runoff quality, and reduce the size and cost of water quality BMPs needed for treatment. The following landscape management practices are recommended for the Great Swamp Watershed.*

- *Disconnect impervious surfaces.*
- *Preserve or restore wooded buffers to watercourses.*

- *Restore meadow environments, in lieu of turf grass landscaping.*
- *Retain runoff by providing depression storage.*
- *Vegetate detention basins.*

Implementation of one or more of these practices as part of an approved site development plan will relieve the parcel owner from pretreatment requirements. In addition, forested buffers or meadows that comply with the guidelines can be used to satisfy treatment requirements, as indicated in Section 7.6(f).

1. *Disconnect impervious surfaces.*
   This practice involves breaking up impervious areas with vegetated strips, vegetated islands, and permeable pavement. This is the most effective way of reducing runoff and pollutant loads in development areas. The design principles include:

   - *Reducing the length of the flow path across impervious surfaces.*
   - *Separating runoff from different types of impervious surfaces. For instance, runoff from roofs, pedestrian plazas, and drives.*
   - *Directing runoff to numerous points around the periphery of paved areas, where water quality BMPs can be most effectively installed.*

   To be credited as a landscape management practice, the following criteria must be satisfied:

   - *No flow path across impervious surfaces shall exceed 75 feet before encountering a vegetated surface, permeable pavement, or BMP. The measurement of flow path length should include gutter flow.*
   - *No impervious surface shall discharge directly to a storm sewer inlet.*

   Acceptable permeable paving systems are permeable bituminous concrete and interlocking, open-work concrete pavers. When pavers are selected, the openings must be in-filled with either gravel or crushed stone. Strips of permeable pavement can be used to break up flow paths across otherwise impervious areas. Properly installed permeable pavement, with an equivalent runoff curve number of 40, can be used to reduce site imperviousness[1].

   Composite CNs can be computed for immediately adjacent surfaces provided 1) neither of the surfaces are impervious (e.g., roofs and non-pervious pavement), 2) the least-permeable surface is tributary to the most-permeable surface, and 3) runoff from the up-gradient surface is not discharged to the down-gradient surface as concentrated flow.

[1]*To use this CN in stormwater computations, the storage volume of the base must equal the water quality volume.*

Designers are also encouraged to direct runoff from impervious areas onto adjacent pervious surfaces. Examples would be patios, private drives, and walkways that can discharge to adjacent open areas. The runoff retention volume, the water quality volume, and the water quality volumetric flow rate should be computed separately for the pervious and impervious areas. However, when this practice is followed, the "effective" area of the impervious surface can be halved. The following example applies to a parcel in Recharge Zone 4 in which runoff from a ¼-acre driveway is directed across an adjacent ¾-acre lawn area with a CN of 70.

$$R/A\ (lawn) = \frac{(1.15-.86)^2}{(1.15+(4.3-.86))} \qquad ;S=(1000/70)-10 = 4.3$$

R/A (lawn) = 0.06 inches

R/A (driveway) = 1.15 inches

$$R\ (surfaces\ uncombined) = \frac{(.25x1.15 + .75 \times .06)}{12}=0.028\ ac\text{-}ft$$

$$R\ (surfaces\ combined) = \frac{(.25x1.15/2 + .75\ x.06)}{12}=0.015\ ac\text{-}ft$$

The runoff retention volume, in this case 0.015 acre-feet, can be provided in a variety of ways, including roadside infiltration trenches or swales. This approach is only permissible when 1) the impermeable surface is tributary to the permeable surface, 2) runoff from the impermeable area is not discharged to the downgradient permeable surface as concentrated flow, and 3) the impervious area does not represent more than 30 percent of the combined area from which runoff is derived.

2. *Preserve or restore wooded buffers to watercourses.*
   To be credited as a landscape management practice, buffers must comply with the design standards for forested buffer strips presented in this section. In addition, existing confining walls and structural revetments must be removed. As required, stream banks should be stabilized using bioengineering techniques such as willow fascines, reed rolls, or willow "gabions." Forested buffer filter strips are an acceptable means of achieving pollutant removals, including total nitrogen.

3. *Restore meadow environments, in lieu of turf grass landscaping.*
   Meadow environments enhance the infiltration potential of open space areas. They also provide much more effective filtration of runoff than turf grass. Meadow areas should be periodically over-seeded with annual and perennial flowering plants and grasses. Meadows should be mowed at most twice annually to discourage woody plants and shrubs. However, in

order to provide access for the enjoyment of the meadow plants and wildlife, it is a common practice to include closely cropped footpaths through the meadows. Recommendations for meadow vegetation are provided in Appendix A, Landscape Guidance for Stormwater BMPs. To be credited as a landscape management practice, at least 33 percent of open space in a parcel must be placed into forest or meadow. Designs that comply with the performance standards for "bioretention meadows" are an acceptable means of achieving pollutant removals, including total nitrogen.

4. *Retain runoff by providing depression storage.*
   Depression storage may be introduced by grading open areas to include terraces or closed swales. These areas should not pond water to a depth greater than six inches. Depressions may provide some of the benefits of raingardens, but differ in that they are not underlain by a deep bed of filter media. In general, turf grasses will not thrive in these areas. Depending upon soil properties, depth to the water table, and local topography, depressions may be naturally suited for the establishment of terrestrial, facultative, or wetland plant communities. The introduction of depression storage is generally accomplished as part of an overall landscaping concept for a parcel. The landscape plan may be credited as being a landscape management practice if the combined effects of depression storage can be shown to reduce the water quality volume by 25 percent or more.

   This practice generally is associated with landscape features that will also lengthen the runoff path and increase the resistance to flow. As a result, the time of concentration for a parcel may be significantly altered. Landscape designs with long times of concentration are typically more intricate and visually exciting. Lengthening the time of concentration will reduce the water quality volumetric rate, allowing water quality BMPs to operate more efficiently and permitting reductions in BMP size.

5. *Vegetate Detention Basins.*
   Detention basins, especially those that incorporate extended detention, should be vegetated with native plants. Areas vegetated with native plants should not be mowed more than twice each year. Creatively landscaped basins may require no mowing. Potential vegetation types include emergent wetland and facultative plants. Shrubs may also be incorporated in basin landscapes. Properly vegetated detention basins provide two functions:

   - *Enhance bio-filtration by providing foliage and root fibers as a substrate to support bacterial metabolism of nutrients and biochemical oxygen demand.*

- *Stabilize fine sediment that settles out in the basins and minimizes re-suspension of these pollutants.*

Recommendations for the vegetation of stormwater basins are provided in Appendix A, Landscape Guidance for Stormwater BMPs. Basin designs or retrofit plans approved and monitored by the engineer will be credited as landscape management practices. At a minimum, the following criteria should be satisfied:

- *Basin geometry conforming to the pretreatment standard presented in Section 7.6(g).*
- *Eighty percent native plant cover within the high marsh and riparian fringe zones of the basin.*

Additional guidance for the design of stormwater detention basins is provided in the <u>Stormwater and Non-Point Source Pollution Control Best Management Practices Manual</u> (New Jersey DEP, 1994, or most recent).

(f) The Ten Towns Committee of the Great Swamp Watershed has developed "no-net-increase" goals for water quality protection with the Great Swamp Watershed. To meet these goals, stormwater management BMPs must be capable of a 90 percent reduction in TSS, lead, and zinc; a 65 percent reduction in TP; and a 75 percent reduction in TN. While many of the BMPs listed in Section 7.6(g) may be capable of meeting some of these reduction targets, <u>very few are capable of meeting all of them</u>. Table 7.9 lists each of the recommended BMPs and provides information about whether the BMP can meet each of the established pollutant removal targets. In this table, a check indicates that the BMP is capable of meeting the stated targets, while an "X" indicates that it is not able to meet the target. If a single BMP design is not able to meet all of these targets, then multiple BMPs may be required to provide adequate treatment.

TABLE 7.9 BMP SELECTION						
BMP	***TSS (90%)***	***Lead (90%)***	***Zinc (90%)***	***TP (65%)***	***TN (75%)***	***Runoff Retention***
Infiltration Measured	1	√	√	√	X	√
Pocket Sand Filters	√	√	√	√	X	2
Dry Swale Bioretention	√	√	√	√	X	2
Raingardens	√	√	√	√	X	2,6
Bioretention Meadows	√	√	√	√	√	5
Vegetated Rock Filters	1	X	X	√	√	X
Forested Buffer Filter Strips	X	√	√	√	√	X
Extended Detention Basins (vegetated)	3	X	X	X	X	4
Wet Basins	√	√	√	√	X	X
Constructed Wetlands	√	√	√	√	√	X

Notes:
1. Pretreatment to remove TSS is required to preserve the function of the BMP.
2. May meet goals if specifically designed to retain and ex-filtrate runoff retention volume.
3. May be used for pretreatment in concert with other BMPs.
4. May be used to satisfy runoff retention requirement in Recharge Zones 6 and 7, only.
5. May meet goals if specifically designed to provide depression storage equal to the runoff retention volume.
6. Extended detention raingardens can be used to satisfy the runoff retention requirement in Recharge Zones 6 and 7.

1. *The following step-by-step design process in deploying BMPs is recommended for preparing efficient site plans that will comply with the requirements of Section 5:21-7.6, Stormwater Management Water Quality.*

   i. *Identify the existing hydrologic assets of the site.* *Examples of features that should be regarded as assets are gently sloping open space areas; areas with deep, well-drained soil; and existing stands of forest. These all contribute to reducing the rate and quantity of runoff, and offer natural mechanisms for filtering runoff. In many cases, the site will already be partially developed and the list of assets may also include existing detention basins or swales.*

   ii. *Determine where beneficial conditions can be accentuated.* *Examples of site improvements may include restoring meadow or forest to areas of the parcel that will remain in open space. Also, depression storage or terraces can be integrated into the landscape* *plan. A carefully conceived plan should integrate aesthetic concerns with the requirement for runoff management. The result should be the creation of a biologically diverse and visually interesting landscape.*

iii. *Break up impervious surfaces and isolate surfaces in Harmfulness Class 1.*
Look for opportunities to decrease the contiguous area of impervious parking areas, patios, driveways, etc. A combination of green strips, islands, and permeable paving can be used. The plan might include planters and flowerbeds that double as places to intercept and utilize runoff.

The goal is to minimize the quantity of runoff that must be treated. Therefore, precautions should be taken to prevent water from other sources from discharging onto surfaces in Harmfulness Class 1.

The site drainage should be organized to intercept runoff from Harmfulness Class 1 surfaces and convey it to appropriate treatment BMPs. Where possible, runoff derived from Harmfulness Class 2 surfaces should be bypassed.

iv. *Introduce dry wells according to requirements set forth in the New Jersey DEP's <u>Best Management Practices Manual</u> and amended to date.*

v. *Compute water quality volume and the water quality volumetric flow rate for all surfaces in Harmfulness Class 1.*

The water quality volume and volumetric flow rate is based on the 5-hour, 1.6-inch rainfall event distributed in accordance with Subsection 7.6(d)2, Table 7.8.

vi. *Select water quality BMPs to satisfy all treatment requirements with the help of Table 7.9.*

Select combinations of BMPs that will satisfy the treatment requirements, remembering to consider pretreatment and bypass requirements. Where practical, take advantage of landscape management practices to treat runoff, or to eliminate pretreatment requirements.

vii. *Conduct preliminary sizing of BMPs as described in Section 5:21-7.6(g).*

When combining BMPs in "treatment trains," it is important to consider the effect of each BMP in reducing the water quality volume and water quality volumetric flow rate experienced by downstream BMPs. This can greatly reduce the size of *downstream BMPs. Most BMPs will discharge water at a slower rate than the inflow rate. This contributes directly to a reduced water quality volumetric rate for downstream BMPs.*

viii. *Compute total site runoff associated with the runoff retention design storm and determine the runoff retention volume requirements.*

Depending upon the site planning decisions made in steps i, ii, iii, iv, and vi, the residual runoff retention requirement may be small. Measures should be selected to satisfy any remaining runoff retention requirements for the site. Examples may include adding depression storage by grading open areas to include terraces or closed swales. Alternatively, infiltration trenches or below-grade infiltration beds can be introduced.

ix. *Revise site plan to further reduce the size of BMPs.*

The designer has the option of making further reductions in the water quality volume or the water quality volumetric flow rate that will allow BMPs to be downsized. Opportunities to achieve additional efficiencies may be found in landscape management practices, such as the creation of on-lot depression storage, or in the introduction of stormwater detention devices (with or without extended detention). When taking into account the benefit of upstream BMPs, which may include detention functions as well as runoff retention, an effective IA may be applied for the area draining to a BMP accounting for the runoff retained in upstream BMPs and shall be computed as follows:

$$IA,\ effective\ (in.) = 0.2*S + \frac{(runoff\ retention,\ ft^3*12,in)}{(Area,\ ft^2\ *1\ ft)}$$

x. *Evaluate site plan for runoff detention requirements. In evaluating detention requirements, consider the effect of landscape management practices and all BMPs in reducing peak flow rates. Locate stormwater detention basins as required to satisfy State and local detention regulations. By adhering to steps i through viii, the size of stormwater detention basins will be minimized. If on-lot detention facilities are introduced, it will generally be advantageous to revisit the design process to determine if further reduction in the size of BMPs is possible. In particular, the installation of detention facilities with extended detention in front of BMPs may have a large impact in reducing the size and cost of these facilities.*

(g) *This section describes specific BMPs that are recommended for the Great Swamp Watershed and provides design specifications for these practices. These BMPs include infiltration trenches, below-grade infiltration beds, upward* *flow anearobic filters, dry-swale bioretention, raingardens, bioretention meadows, and forested buffer filter strips.*

The performance of most water quality BMPs may be adversely affected by the presence of fine silt and clay sediments suspended in runoff. As a result, many of the BMPs will require pretreatment measures to preserve their function and enhance longevity. Pretreatment may be eliminated where upgradient areas that contribute runoff are managed according to the recommendations in Section 7.6(e), Landscape Management Practices. Also, there are many stormwater basins with extended detention in the Watershed that may be enhanced to improve TSS removal and provide pretreatment for most BMPs.

The pretreatment standard for basins is as follows:

- *Extended detention volume equal to 25 percent of the water quality volume.*
- *Length-to-width ratio of 2:1, or greater.*
- *Water quality surface loading rate, based on the Camp-Hazen formula, must be less than:*

$$WQSLR = \frac{W}{\ln(1-E)}$$

Where: W = particle settling velocity (0.0004 ft/sec, typ)
E = sediment trapping efficiency (use 0.9)
WQSLR = water quality surface loading rate

1. Infiltration Trenches and Below Grade Infiltration Beds
Infiltration systems are practices that capture the runoff retention volume and allow it to ex-filtrate into the surrounding soil. Infiltration systems are appropriate throughout much of the Watershed. They are particularly suitable in areas underlain by the following soil series: Klineville, Parker, Pompton, Riverhead, Ellington, Edneyville, and Pattenburg. Dry wells and permeable pavement are special cases of infiltration measures. This section does not address the design and implementation of dry wells. Dry wells shall be designed in accordance with the New Jersey DEP's Best Management Practices Manual, as amended to date. Special considerations associated with permeable pavement are discussed at the end of this section.

i. Design Criteria
There shall be a three-foot vertical separation from the bottom of an infiltration facility and the seasonal high-water table. In addition, the minimum depth of bedrock below the bottom of the infiltration facility shall be four feet.

The surface shall be stabilized by turf; river stone; porous asphalt pavement; or modular, interlocking, concrete paving blocks. Other measures may be used with the approval of the municipal engineer.

Below-ground infiltration practices shall incorporate a six-inch basal layer of coarse sand placed in direct contact with the soil, followed by a layer of clean, coarse crushed stone or river stone (AASHTO No. 1 or 3). The crushed-stone layer shall not be less than ten inches thick and shall be separated from the coarse sand by filter fabric. The geo-textile shall conform to AASHTO M288 Class A for use in contact with coarse stone backfill. The geo-textile shall have a flow rate of 110 gallons per minute, as specified in ASTM D4491.

The runoff retention volume shall be intercepted and infiltrated within 72 hours. In well-drained soils, the volume of the infiltration device may be less than the runoff retention volume, since infiltration can be assumed to occur during the runoff retention design storm. In these cases, the design must be based on an acceptable flow routing procedure.

Dry wells that comply with the New Jersey DEP or municipal guidelines will satisfy the runoff retention requirement for the roofs served by them. However, dry-well storage cannot be used to help satisfy the runoff retention requirement for other areas of a parcel that are not tributary to the dry well.

The porosity of granular fill shall be assumed to be 25 percent, unless laboratory tests can be provided that show higher porosity. The hydraulic design of these facilities shall be based on infiltration rates determined using guidelines provided in Special Area Standards Appendix A to Subchapter 7.

ii. Pretreatment Criteria
A dense and vigorous vegetative cover shall be established over the contributing drainage areas before runoff can be directed toward the device. Pretreatment shall be provided to remove TSS and other particulates prior to infiltration practices. Pretreatment shall consist of a bioretention facility, sand filter, or one of the approved landscape management practices.

iii. Maintenance Criteria
Standpipes (observation wells) shall be provided in all below-grade infiltration structures for inspection of the water level. Provisions shall be made for inspecting water levels in underground infiltration structures to determine if the 72-hour dewatering requirement is being satisfied. Facilities that do not drain within 72 hours must be cleaned or repaired.

iv. Special Considerations for Permeable Pavement

Acceptable permeable paving systems are permeable bituminous concrete and interlocking, open-work concrete pavers. When pavers are selected, the openings must be in-filled with either gravel or crushed stone. Permeable pavement is appropriate in pedestrian or lightly traveled areas, including driveways and overflow parking areas at commercial or institutional facilities. Since the function of permeable pavement can be destroyed by the accumulation of loamy soil, or by the application of sealers, its use should be restricted to locations where the long-term survival of the surface can be assured. A useful source of information on designing with permeable pavement is the Pennsylvania Handbook of Best Management Practices for Developing Areas (PACD, 1998).

Like all below-grade infiltration beds, permeable pavement must be underlain by a porous base of at least ten inches. Open-graded crushed stone is preferable for use as a base material. AASHTO No.1 stone is commonly specified. The purpose of the base layer is to store the runoff that infiltrates through the permeable surface layer. The base layer shall be overlain by a finer "choker" course to provide a firm foundation for the pavement. An overflow drain is required to prevent the ponding of water to the level of the pavement.

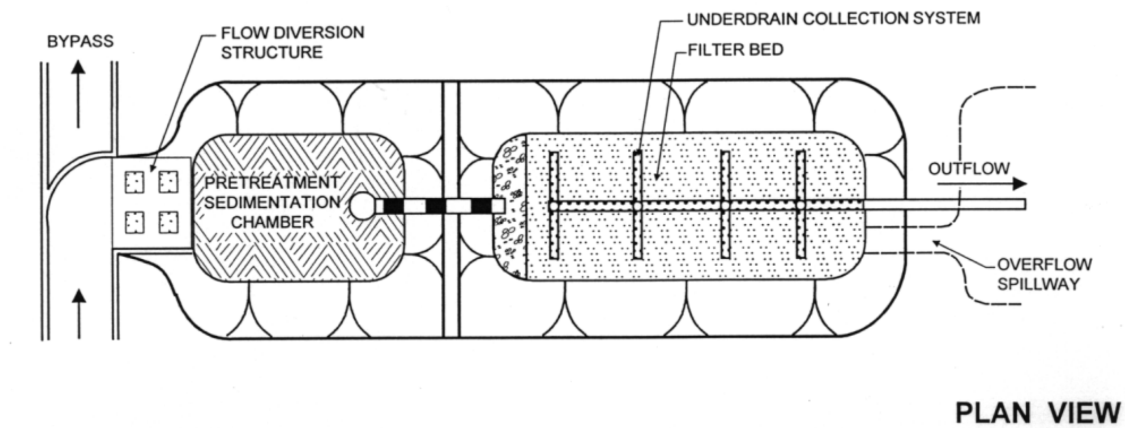
2. Pocket Sand Filters

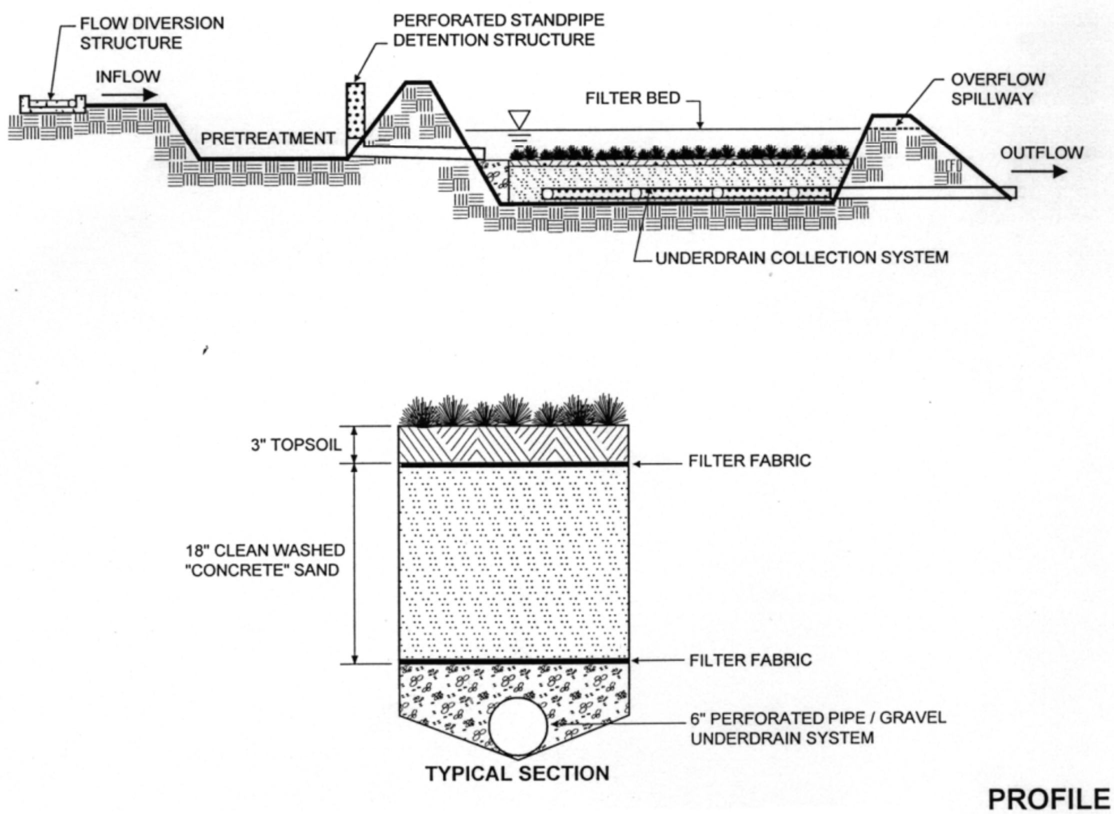
Pocket sand filters are practices that intercept the water quality volume and pass it through a granular filtering media. Filtered runoff may be collected and returned to a conveyance system, or if conditions are admissible, allowed to ex-filtrate into the soil. Typically, filtering systems cannot meet nitrogen removal requirements.

i. Feasibility Criteria

Filtering systems normally require two to six feet of head. The maximum contributing area to individual filtering systems is five acres. Pocket sand filters are used in areas where reduction of total suspended solids and associated pollutants are a primary concern. Examples are commercial parking areas, public recreation facilities, and similar areas.

Figure 7.1 Pocket Sand Filter





ii. Design Criteria

Pocket sand filters shall be designed to achieve the required pollutant removal efficiency for the water quality volumetric flow rate. If runoff is delivered by a storm drain system or runoff swale, a flow-splitting device shall be required. The flow-splitting device shall bypass flows that are in excess of the water quality volumetric flow rate. Bypassed flow shall be provided to a non-erosive outlet.

Pocket sand filters shall be equipped with a minimum four-inch perforated pipe underdrain (six inches is preferred) in a gravel layer. A permeable filter fabric shall be placed between the gravel layer and the filter media.

The design storage volume, V_s, of the filtering system should be equal to or greater than 75 percent of the water quality volume, minus the extended detention volume of any pretreatment devices.

$V_s = (0.75 \times WQV) - V_p$

Where: V_s = Volume of water ponded over the filter
WQV = water quality volume
V_p = extended detention volume of pretreatment devices

The filter layer should be a minimum depth of 18 inches and shall conform to the specifications listed in Table 7.10.

The filter shall be designed to drain completely in 1.67 days or less. The filter area shall be sized based on the principles of Darcy's Law. The hydraulic conductivity, Ks, of clean sand conforming to the specifications in Table 7.10 shall be assumed to be 3.5 feet per day. The required areas of the filter bed can be computed using the following:

The sizing of the sand filter is based on two criteria: 1) it must store at least 50 percent of the WQV and 2) it must fully dewater within 40 hours. When a filter permeability of 3.5 ft/day is assumed, the storage criteria (and not the dewatering criteria) is controlling for most situations encountered in small-scale project design. Therefore, the facility may be undersized. For this reason, it is necessary to add a second equation:

$A_f - V_s/D$*; where D can range from 2 to 6 feet*

The selected depth, D, must also be checked using the existing equation to insure that the dewatering criteria will be satisfied.

The required area of the filter bed can be computed using the following equation:

$A_f = Vs/D$ (1)

$h_f = 0.2 \times D$ (2)

$a = V_s \times D_f / [K_s \times t_f \times (d_f + h_f)]$ (3)

If $a > A_f$: Then $A_f = a_1$ and (4)

$D = V_s / a$

(iterate with equation 2, 3, and 4)

Where Af = minimum surface area of filter bed (ft^2)

Vs = design storage volume
Df = filter bed depth (ft)
Ks – hydraulic conductivity of the filter media (ft/day)
hf – 20% of the maximum height of water above filter bed (ft)
Tf – design filter bed drain time (days) – use 1.67 days
D – maximum height of the water above the filter bed (ft)

Note: D may vary between 2 and 6 feet.

Surface filters may be grassed cover to aid in pollutant absorption. The grass should be capable of withstanding frequent periods of inundation and drought.

TABLE 7.10 FILTERING MATERIAL SPECIFICATIONS			
Material	***Specification/Test Method***	***Size***	***Notes***
Sand	*Clean AASHTO M6 or ASTM C33 concrete sand*	*0.02" to 0.04"*	*Sand substitutions, such as Diabase and Graystone #10, are not acceptable. No calcium carbonate or dolomitic sand substitutions are acceptable. No "rock dust" can be used for sand.*
Peat	*Ash content < 15%* *PH range: 5.2 to 4.9* *Loose bulk density 7.5 to 9.5 pcf*	*N/A*	*The material must be reed sedge humic peat, shredded, uncompacted, uniform, and clean.*
Topsoil	*Silt loam or sand loam, containing less than 10 percent clay (particles less than 2 microns)*	*N/A*	*Soils must be free of cobbles and stones, wood, clay balls, frost, and other deleterious materials.*
Underdrain Gravel	*AASHTO M43*	*According to specification*	
Geo-textile Fabric	*ASTM D4833 (puncture strength – 125 lb.)* *ASTM D4632 (tensile strength – 300 lbs.)*	*0.08" thick equivalent opening size of #80 sieve*	*Must maintain 125 gpm per. sq. ft. flow rate. Note: a 4" pea gravel layer may be substituted for geo-textiles meant to "separate" sand filter layers.*
Impermeable Liner	*ASTM D4833 (thickness)* *ASTM D412 (tensile strength 1,100 lb., elongation 200%)* *ASTM D624 (tear resistance – 150 lb/in)* *ASTM D471 (water absorption = 8 to - -2% mass)*	*30 mil thickness*	*Liner to be ultraviolet resistant. A geo-textile fabric should be used to protect the liner from puncture.*
Underdrain Piping	*F 758, Type PS 28, or AASHTO M278*	*4" to 6" rigid schedule 40 PVC or SDR 35*	*3/8" perforations @ 6" on center, 4 holes per row; minimum of 3" of gravel over pipes; not necessary underneath pipes.*

iii. Pretreatment Criteria

A dense and vigorous vegetative cover shall be established over the contributing drainage areas before runoff can be accepted into the filtering system. If heavy sediment loads are likely, pretreatment is recommended to reduce the maintenance *requirements for the filter bed. Pretreatment typically consists of a sediment chamber.*

iv. Maintenance Criteria

The sediment chamber outlet devised shall be cleaned regularly to remove accumulated sediment, trash, and debris. Convenient access to clean the chamber should be provided.

When the filtering capacity of the system diminishes substantially (e.g., when water ponds on the surface of the filter bed for more than 72 hours), the top few inches of discolored material shall be removed and shall be replaced with fresh material. The removed sediments shall be disposed in an acceptable manner. Also, silt and sediments should be removed from the filter bed when the accumulation exceeds one inch, regardless of the filtration rate. As an aid for maintenance, filter fabric may be installed two inches below the surface of the sand filter media. The fabric, together with the overlaying sand, may be removed and replaced as needed to preserve filtration capacity.

Filtering systems that have a grass cover should be mowed a minimum of three times per growing season to maintain maximum grass heights less than 12 inches.

3. Dry Swale Bioretention

Dry swale bioretention systems involve vegetated channels designed to promote rapid percolation of water to underlying perforated storm sewers. Runoff is treated by two filtration processes: 1) flow through and across vegetation in the channels, and 2) flow through a prepared bed of filtering media. These systems may be used to provide ground water recharge if the prevailing soil properties are conducive to ex-filtration.

Dry swale bioretention systems are ideally suited for installation in existing public rights-of-way that are already designated for runoff control. This measure represents a modification to a typical stormwater utility. The modified system involves replacing the existing storm-sewer pipe with perforated pipe, or pipe laid with open joints. The overlying roadside drainage swale is also modified to enhance infiltration. Runoff may enter the swale either as overland flow from adjacent areas, or where storm sewers are "daylighted" into the swale.

i. The open channel shall have longitudinal slopes no greater than four percent. If the existing slope is greater than four percent, then a drop-in-grade structure may be used to reduce the slope to four percent.

The peak velocity for the ten-year storm shall be non-erosive for the soil and vegetative cover provided, pursuant to the <u>Standards for</u>

<u>Soil Erosion and Sediment Control in New Jersey</u>, 1999, as supplemented or amended to date. Additionally, the channel flow velocity associated with the water quality volumetric flow rate shall not exceed 0.5 fps. When calculating the volumetric flow rate, credit may be taken for percolation.

The water quality surface-loading rate for dry bioretention swales should be 0.0013 feet per second or less. The water quality surface-loading rate is based on the water surface area of the swale computed for the water quality design storm. Divide the water quality volumetric flow rate by the surface area to obtain the design water quality surface-loading rate.

Ideally, side slopes should not be greater than 2:1 to minimize the potential for erosion. However, side slopes may be constructed more steeply as spatial constraints require. Steeper side slopes must be stabilized with a permanent turf reinforcement system. Reinforcing mesh constructed from nylon and polypropylene are commercially available. Alternatively, soil cell isolation grids can be used.

On gently sloping channels, ponding of runoff may be introduced as a water quality enhancement. Ponding can be achieved by raising the inlet. Dry swale bioretention should allow a maximum ponding depth of 18 inches at the downstream endpoint of the swale. In these cases, the design shall ensure the ponded areas are dewatered within 48 hours or less.

The underlying storm sewer shall have the capacity to convey the ten-year rainfall runoff without pressure flow occurring. The sewer pipe shall be either perforated or installed with open joints to allow water percolating from the overlying swale to enter the pipe.

A hydraulic conductivity, Ks, of 2.0 ft/day shall be assumed when computing the flow through the filter media. Filtering media shall consist of a mixture as follows:

Clean sand	*50% (by volume)*
Peat	*20% (by volume)*
Topsoil	*30% (by volume)*

Materials shall conform to the specifications in Table 7.1. The minimum depth of the filtering media layer shall be two feet. The storm sewer shall be enclosed in coarse aggregate (AASHTO No. 57). A filter fabric shall be used to separate the aggregate from the overlying filter media.

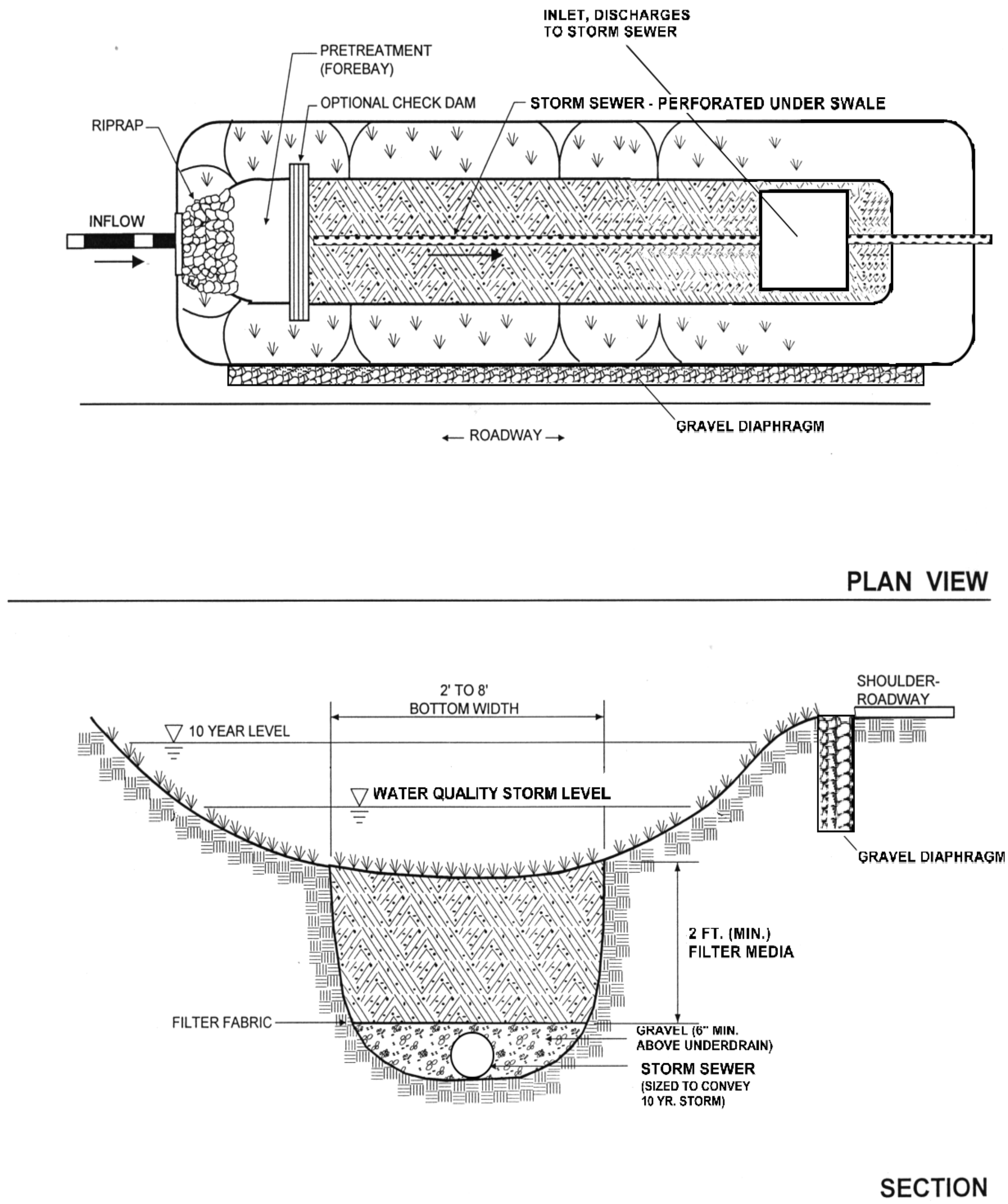
ii. Pretreatment Criteria
In existing publicly owned right-of-ways, pretreatment for sediment is recommended, but not required, if there is insufficient space

within the right-of-way for such pre-treatment facility. Pretreatment is required for privately owned facilities. The pretreatment requirement can be fulfilled in one of the following ways:

- *Institute one of the approved landscape management practices in immediately upstream areas.*
- *Introduce extended detention equal to 25 percent of the water quality volume. This storage may be obtained by providing check dams at pipe inlets and/or driveway crossings.*
- *For lateral overland flow into the swale that is directly derived from roads and other impervious surfaces, a gravel diaphragm should be provided along the edge of the channels to intercept sediment.*

Lateral overland flow from vegetated surfaces will not require pretreatment.

Figure 7.2 Dry Swale Bioretention



iii. Maintenance Criteria

Channels should be mowed as necessary to prevent the establishment of woody plants and shrubs. Typically, mowing two or three times each year should be sufficient. Best performance is achieved when grass and plants are allowed to grow to heights of 12 inches or more.

Sediment build-up within the bottom of the channel or filter strip shall be removed when 25 percent of the original design depth has been exceeded. Care must be taken to prevent sediment release during removal. A mulch erosion mat providing an allowable tractive stress of 2.0 psf or greater should be used to protect the new seedbed after sediment removal.

4. Raingardens

Raingardens are on-lot or small, community bioretention systems that combine open space and vegetation with a filtering media to treat stormwater runoff for water quality.

Raingardens may be installed on both poorly drained and well-drained soils. On well-drained soils, these measures may also provide infiltration benefits. The key criterion is availability of open space with gentle slopes situated down gradient of the watershed area to be treated.

Raingardens that incorporate extended detention can be used to help satisfy the site runoff peak flow rate control requirements.

i. Design Criteria

Raingardens shall be designed to achieve the required pollutant removal efficiency for the water quality volumetric flow rate. A flow-splitting device shall be provided that will bypass flows that are in excess of the water quality volumetric flow rate. Bypassed flow shall be provided to a non-erosive outlet.

Rain-garden systems shall consist of the following treatment components: a gravel or sand underdrain layer, a 2.5- to 4-foot deep planting/filtration media bed, and a surface mulch layer. The maximum ponding depth over the filter bed shall be 6 inches.

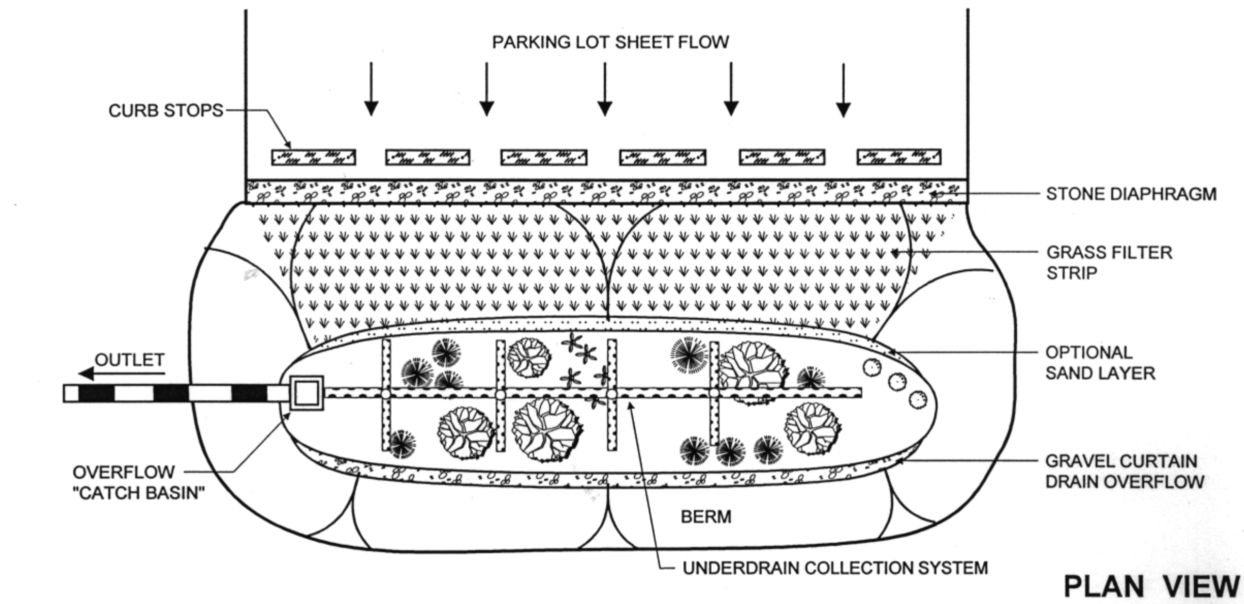
For high-rate filtration, the planting/filter media shall be the same as that specified for dry swale bioretention. However, where extended detention of runoff is desired, the relative proportion of topsoil can be increased. Hydraulic conductivity, Ks, may range from 2 ft/day for high-rate bio-filtration to a minimum of 0.5 ft/day for raingardens with extended detention. Bench-scale testing of media mixtures is *required to establish the appropriate hydraulic conductivity. Use a factor of safety of at least 2.0 when using bench-scale data.*

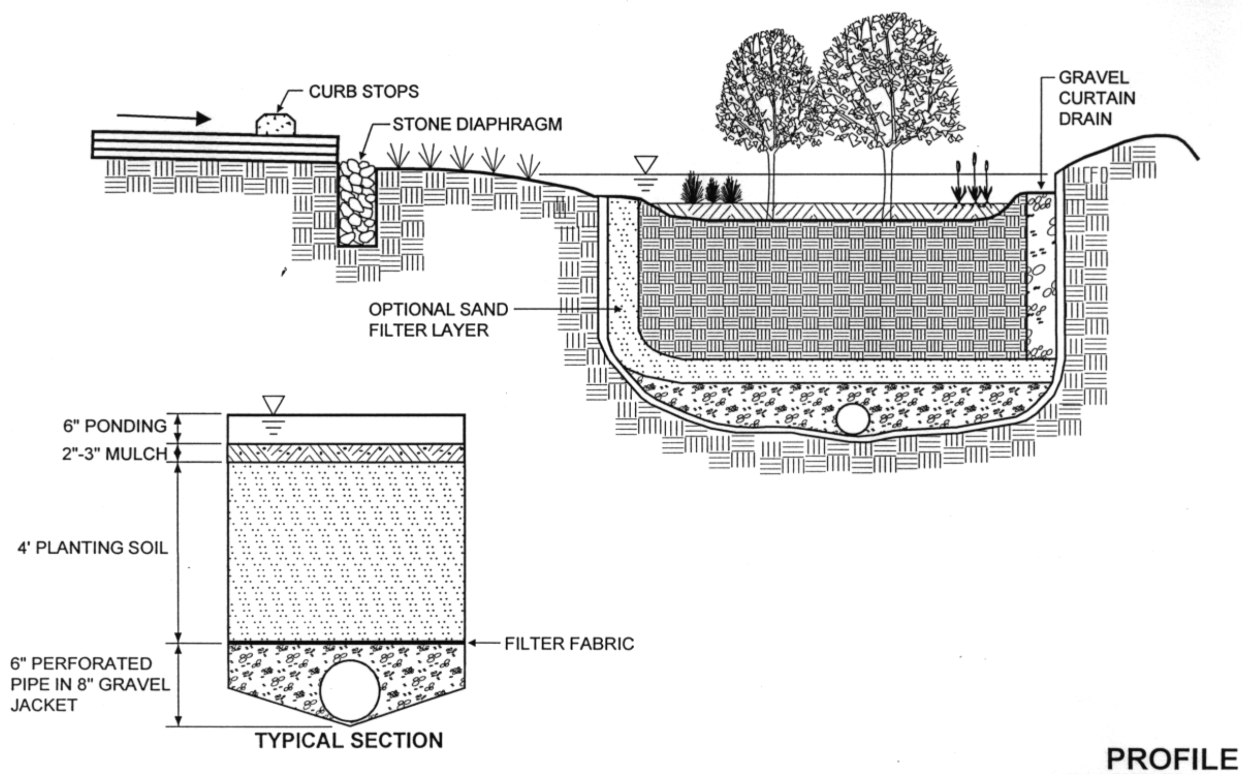
Different criteria should be used to size high-rate and extended detention raingarden systems:

1) *High-rate raingardens: The water quality surface-loading rate shall be 0.0013 feet per second or less.*

2) *Extended detention raingardens: The area of the raingarden, in square feet, shall be numerically equal to the water quality volume in cubic feet (i.e., the design storage volume of the raingarden shall equal 50 percent of the water quality volume).*

Figure 7.3 Raingarden



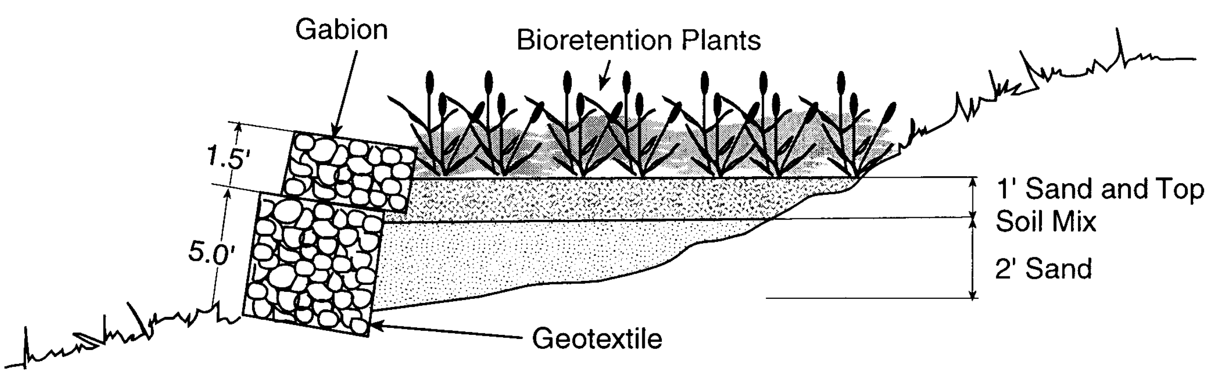


Landscaping is critical to the performance and function of bioretention areas. Therefore, a complete grading plan must accompany designs for bioretention areas. Planting recommendations for bioretention areas are as follows:

- *Native plant species should be specified over nonnative species.*
- *Vegetation should be selected on a specified zone of hydric tolerance.*
- *A selection of trees with an under-story of shrubs and herbaceous materials should be provided.*
- *Woody vegetation should not be specified at inflow locations.*

On sloping parcels, raingardens can be implemented in a series of terraces. However, the cumulative design storage volume of the terraces must equal 50 percent of the water quality volume.

Figure 7.4 Terraced Bioretention



ii. *Pretreatment Criteria*

Raingardens are effective in removing TSS. However, excessive accumulation of fine clay and silt-sized sediments can compromise their long-term performance. Measures should be introduced to manage sediment. Options for this include:

- *Use of one or more of the recommended landscape management practices.*
- *Install a sacrificial sand-filter layer (usually located only at the margin of the facility).*

- *Install gravel diaphragms.*

Where sacrificial sand layers are used, vegetation must be limited to grasses so that the layer can be periodically serviced.

iii. Maintenance Criteria
All bioretention systems must drain completely in less than 48 hours. If the water stands for longer than 48 hours, the system should be investigated to determine the reason of the overly long drain times. Possible problems may include obstruction of the underdrain pipe or clogging of the surface layers of the system.

Unlike dry swale bioretention systems, the growth of deep-rooted, woody vegetation should be encouraged. Where native perennials are installed, mowing of the facility is not required. These plants help maintain vertical percolation and contribute to nutrient removal. The facility should be planted to anticipate sediment accumulation during the design life span. Routine removal of sediment should not be required, except in pretreatment areas.

The surface mulch layer should be refreshed as necessary to maintain a thickness of approximately three inches.

5. Bioretention Meadow
Bioretention meadows are intended for use in projects that also involve meadow restoration. The advantages of this BMP include:

- *They can be installed on sloping land areas.*
- *They are visually unobtrusive.*
- *They provide high-quality upland habitats.*
- *They do not require pretreatment measures.*

Bioretention meadows are appropriate only on well-drained soils. These include the following soil series: Klinesville, Parker, Pompton, Riverhead, Ellington, Edneyville, and Pattenburg. Installation involves creating a vigorous native meadow environment, augmented as necessary by hedgerow terraces. The hedgerows consist of shallow sand-filled trenches planted with tall meadow grasses and shrubs. The meadow may be allowed to develop through the process of natural succession. However, in most instances, the meadow area will be over-seeded with attractive flowering native species to accelerate the transition and to enhance the beauty of the area.

i. Design Criteria
Unlike other bioretention measures, terraced bioretention is comparatively forgiving of sedimentation. Therefore, pretreatment is not required.

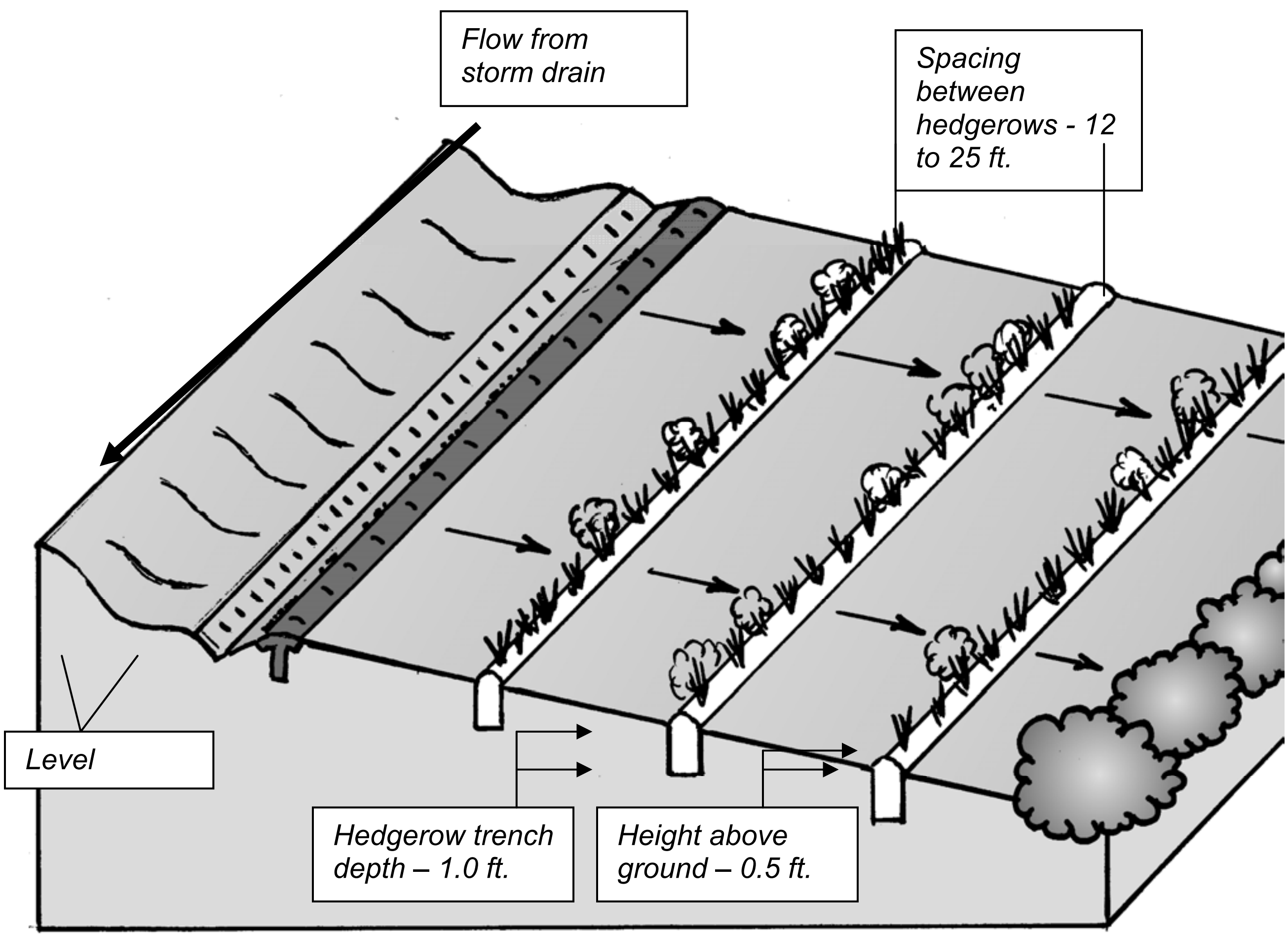
Like other bioretention measures, bioretention meadows shall be designed to achieve the required pollutant removal efficiency for the water quality volumetric flow rate. The width of the system shall result in a flow rate no greater than 0.03 cubic feet per second per linear foot of width. A flow-splitting device shall be provided that will bypass flows that are in excess of the water quality volumetric flow rate. Typically, the bypassed flow is conveyed via a grass swale to the point of discharge. Although most bioretention meadows will be situated adjacent to natural watercourses and water bodies, these measures may also be used where the outflow will be discharged to roadside swales and storm-sewer catchments.

Terraced bioretention systems shall have longitudinal slopes no greater than eight percent. Vertical drops between hedgerows shall be no more than one foot. Runoff shall enter each terrace as sheet flow. Overall, the system shall provide sufficient depression storage to equal 50 percent of the water quality volume.

The maximum flow path across up-gradient areas shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces. The average contributing slope shall be five percent or less. Runoff shall enter the buffer as sheet flow. A velocity reducer/equalizer may be utilized where sheet flow can no longer be maintained at the edge of the meadow. Bioretention meadows may also be used to transition flow from storm-sewer outfalls into natural watercourses and/or water bodies. In these instances velocity reducer/equalizer will be required to establish sheet flow. To be acceptable as a pollutant removal measure, the following criteria must be satisfied:

Average Slope ft/ft	***Minimum Flow Path Length ft***	***Maximum Hedgerow Spacing ft***
less than .02	*75*	*No hedgerow required*
.02 to .04	*100*	*No hedgerow required*
.02 to .04	*50*	*25*
.04 to .06	*150*	*No hedgerow required*
.04 to .06	*60*	*15*
.06 to .08	*60*	*12*

Figure 7.5 Bioretention Meadow



The hedgerows shall be planted with tall meadow grasses and shrubs. The vegetation should form a dense barrier that will slow runoff, encourage sedimentation, and detain water so that it can infiltrate. The accumulation of sediment behind the hedgerows is a normal part of the maturing of the terraced system. The area between the hedgerows should be managed as fallow meadow. Deep-rooted grasses and plants are necessary to preserve the infiltration capacity of the soils.

ii. Maintenance Criteria
Once or twice annually, the meadow areas should be mowed. However, to insure a thick vegetative cover through the winter, mowing should not occur after September 15. Breaches in the hedgerows, or other areas of potential concentrated flow, should be filled with granular material, reinforced with turf mesh, and re-vegetated.

6. Upward Flow Anaerobic Filters (Vegetated Rock Filters)
These are bio-filters in which the inflow is introduced through a manifold at the base of a bed of crushed stone. Quiescent, anoxic conditions in the bed promote denitrification reactions. These devices present great opportunities for removal of nitrogen, especially when used in conjunction with discharge to wooded buffers.

i. Design Criteria
The facility shall be designed to achieve the design nitrogen removal efficiency for the water quality volumetric flow rate. A flow-splitting device shall be provided that will bypass flows in excess of the water quality volumetric flow rate. Bypassed flow shall be provided to a non-erosive outlet.

The depth of the bed of crushed stone should be at least four feet deep. The minimum surface area of the vegetated rock filter shall be the lesser of:

1) the area required to achieve a water quality surface-loading rate of 0.0013 feet per second or less.

2) the area required to contain the water quality volume, taking into account the porosity of the rock fill.

The bottom of each cell shall be sealed with low-permeable liner (e.g., thermoplastic membrane or bentonite clay). The liner shall be protected from puncture with a 16-oz., nonwoven geo-textile. Each cell shall be filled with crushed rock, AASHTO No. 1 or 3, according to the specifications in Table 7.10.

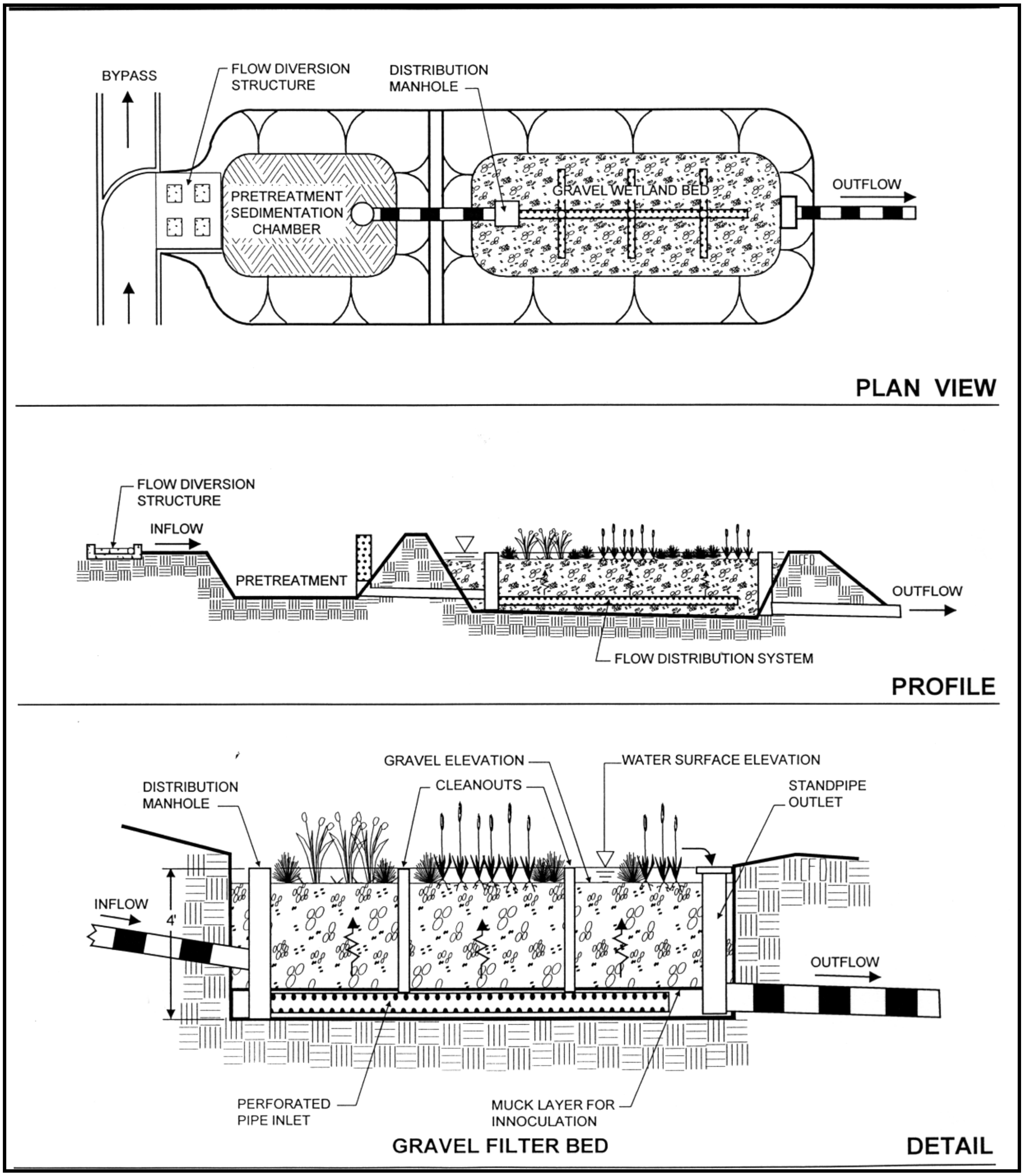
Each cell shall be planted with one or more emergent wetland plant species.

ii. *Pretreatment Criteria*

This BMP is very vulnerable to reductions on performance caused by sediment accumulations. Pretreatment storage of 25 percent of the water quality volume is required. The pretreatment volume may be provided in a fore-bay, as shown in the illustration. Alternatives include:

- *Landscape management practices.*
- *Bioretention facility, or stormwater basin with extended detention.*
- *Sedimentation chamber (densely developed areas only)*

Figure 7.6 Upward Flow Anaerobic Filter



iii. Maintenance Criteria
The sediment chamber and outlet devices shall be inspected and cleaned regularly.

7. Forested Buffer Filter Strips
Stormwater runoff may be effectively treated to remove nitrogen using forested buffers that are managed for this function. In particular, wooded buffers are appropriate measures for treating overland runoff from landscaped areas that are managed using chemical fertilizers and that are adjacent to watercourses.

Although most forested buffer filter strips will be situated adjacent to natural watercourses and water bodies, these measures may also be used where the outflow will be discharged to roadside swales and storm-sewer catchments.

i. Design Criteria
The minimum buffer length shall be 50 feet, measured in the flow direction. The maximum flow path across up-gradient areas shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces. The average contributing slope shall be five percent or less. Runoff shall enter the buffer as sheet flow. A velocity reducer/equalizer may be utilized where sheet flow can no longer be maintained at the edge of the buffer.

The use of forested buffers to receive the water discharged from stormwater detention basins and BMPs is encouraged. In these instances, a velocity reducer/equalizer will be required to transition the flow into the buffer. The width of the system shall result in a flow rate no greater than 0.015 cubic feet per second per linear foot of width, measured perpendicular to the flow direction. Soil stability for point discharges shall be demonstrated pursuant to the Standards for Soil Erosion and Sediment Control in New Jersey.

Buffer areas shall be managed to encourage the growth of native under-story trees and shrubs, as well as forest floor plants. As necessary, planting should be introduced to accelerate the development of under-story vegetation.

If the forest floor has been partially denuded by past activities, scarify the surface of the soil and introduce a layer of hardwood compost. Precautions should be taken to prevent the buffer from being used for foot trails. Where access through the buffer is desired, a raised boardwalk (or other method approved by the engineer) shall be employed to minimize the potential for creating *pathways for concentrated flow. Areas that develop scour traces or erode shall be filled with granular material and covered with mulch.*

Figure 7.7 Forested Buffer Filter Strip

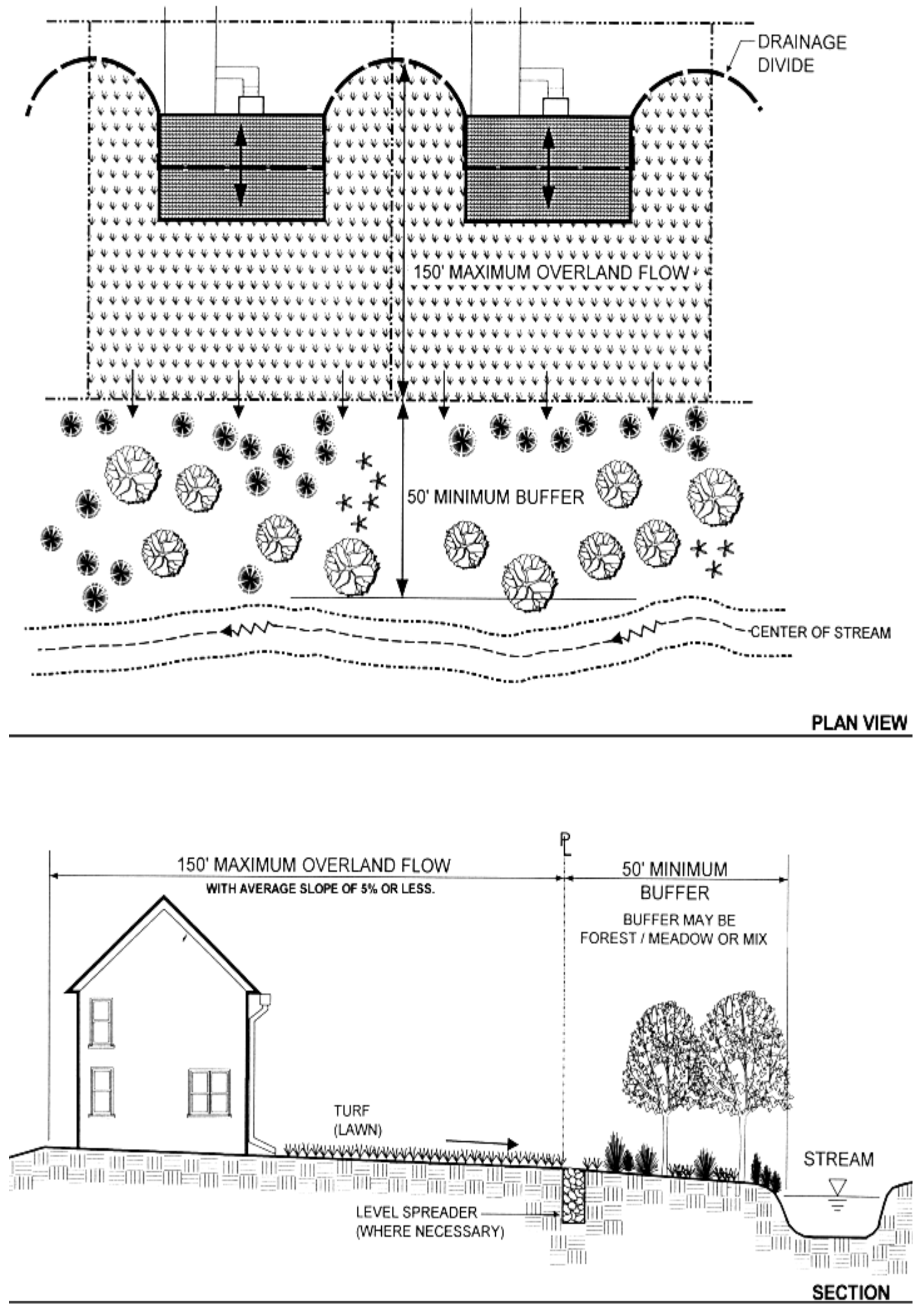
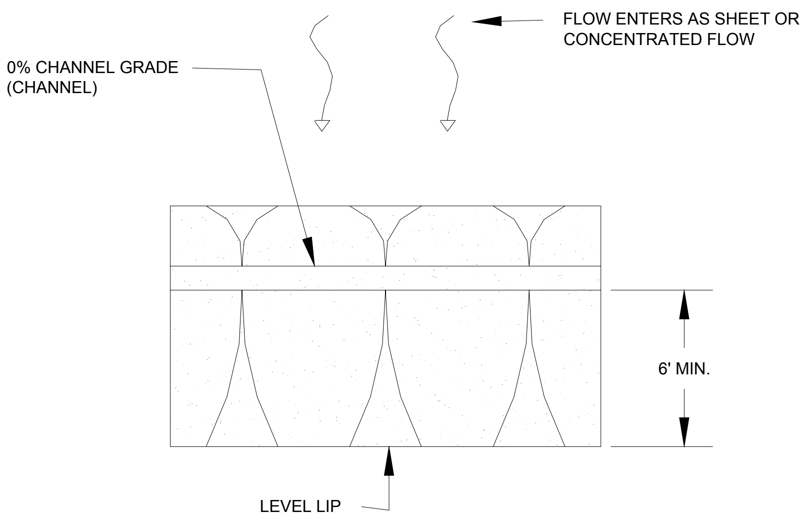
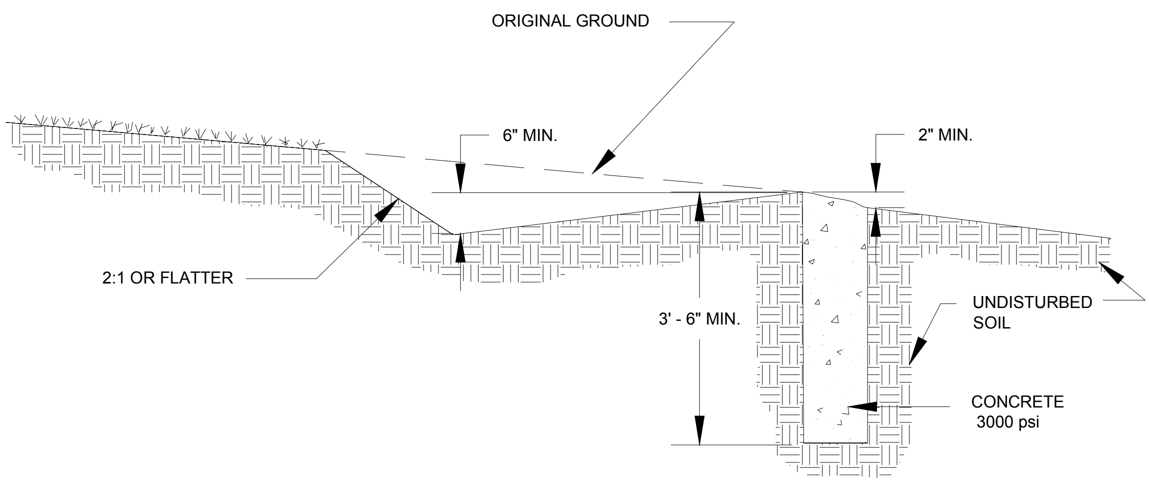


FIGURE 7.8 VELOCITY REDUCER/EQUALIZER





NOTE: CONCRETE WALL SHALL BE CONSTRUCTED PARALLEL TO A GROUND SURFACE ELEVATION CONTOUR LINE. THE TOP OF THE WALL SHALL BE LEVEL WITH A TOLERANCE OF ± 1/8" AT ANY POINT ALONG THE WALL.

Buffers shall be located within an acceptable conservation easement, or other enforceable instrument, that ensures perpetual protection of the proposed buffer. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked.

The restoration of a mature forested buffer will require decades. However, during this transitional phase, the buffer will be regarded by the local municipality as though it were completely functional. No temporary or supplemental measures will be required during this period.

N.J.A.C. 5:21-7 is modified to add a new section setting forth requirements for maintainability and maintenance of stormwater management facilities:

N.J.A.C. 5:21-7.7 Maintainability and Maintenance

(a) Planning and Design for Maintainability

1. *A goal for the planning and design of a stormwater management facility is for its efficient operation with the least practical amount of maintenance. To accomplish this, the facility shall be developed to eliminate avoidable maintenance tasks; minimize the long-term amount of regular maintenance; facilitate the performance of required maintenance tasks; and reduce the potential for excessive, difficult, and costly remedial or emergency efforts.*

2. *Strong, durable, and noncorrodible materials, components, and fasteners shall be used to reduce required maintenance efforts. These include, but are not limited to, noncorrodible metals such as stainless steel or aluminum for trash racks, orifice plates, and access hatches; hardy, disease-resistant grasses for bottoms and side slopes of detention basins as prescribed by the Standards for Soil Erosion and Sediment Control in New Jersey; reinforced concrete for structures and head walls; and rock rip-rap for channel and outlet linings.*

3. *Detention facilities shall be designed to minimize propagation of insects, particularly mosquitoes.*

4. *Detention facility outlets shall be designed to function without manual, electric, or mechanical controls.*

5. *Responsibility for operation, maintenance, repair, and safety of stormwater management facilities, including periodic removal and disposal of accumulated particulate material and debris, shall remain with a*

designated party or parties and successors, unless assumed by a governmental agency.

6. *Prior to granting approval, or as a condition of final subdivision or site plan approval, to any project subject to review under these regulations, an applicant shall enter into an agreement with the approving authority to ensure the long-term, perpetual operation, maintenance, repair, and safety of the stormwater facility. Where property is subdivided and sold as separate lots, a homeowners' association or similar permanent entity shall be established as the responsible party, absent an agreement by a governmental agency to assume responsibility. It shall be demonstrated to the municipality that any proposed responsible entity has the capability to perform the required maintenance.*

7. *Where a stormwater management facility is used for sediment control during construction, a debris- and sediment-disposal site shall be confirmed before the facility is constructed. The disposal site may or may not be at the site of the proposed development. Disposal site(s) shall be included in the approved Soil Erosion and Sediment Control Plan.*

(b) *Maintenance and Operation Plans; Maintenance and Repair Records:*

1. *A required maintenance plan shall include specific maintenance techniques and schedules for each type of stormwater management facility on the site. If maintenance of the system will be the responsibility of a person or party other than a State, County, or local agency, the approved maintenance plan shall be recorded upon the deed of record for the property.*

2. *The maintenance plan shall include the name and address of the party or parties responsible for long-term maintenance. Documentation of their assumption of this responsibility shall be submitted as part of any final site plan or subdivision application. The transfer of maintenance responsibility to individual property owners in residential subdivisions is prohibited, except through a homeowners' association agreement.*

3. *Written maintenance and repair records for all stormwater management systems shall be maintained for at least five years by the responsible party identified in (2) above, and shall be provided to the municipality upon request.*

4. *The party or parties responsible for operation, maintenance, repair, and safety shall file a report with the municipal engineer annually during the month of April stating or showing the condition of stormwater management facilities, maintenance work that has been performed, maintenance work that is necessary, and any safety hazards. The report shall include a*

schedule for performing needed maintenance, repairs, or safety improvements. The municipal engineer shall be notified when all such work has been completed.

5. *Maintenance of constructed wetlands shall include, but not be limited to:*

   i. *documented visual inspection of all components of the system at least once every six months.*

   ii. *documented removal of silt and other debris from catch basins, inlets, and drainage pipes at least once every six months, and upon noticeable buildup.*

   iii. *documented vegetation replacement as necessary.*

6. *Maintenance of detention basins shall include, but not be limited to:*

   i. *documented visual inspection of all components of the detention basin at least once every six months.*

   ii. *documented removal of silt, litter, and other debris from all catch basins, inlets, and drainage pipes at least once every six months and upon noticeable buildup.*

   iii. *documented maintenance and necessary replacement of vegetation at least once each year.*

7. *Maintenance of ponds and retention basins shall include, but not be limited to, annual documented monitoring of water quality, dissolved oxygen, vegetative growth, temperature, and fish population for a period of three years to ensure that the pond or retention basin is performing as intended.*

8. *In the event that the stormwater management facility becomes a danger to public safety or public health, or if it is in need of maintenance, the municipality shall so notify the responsible party in writing. Upon receipt of that notice, the responsible party shall have 30 days to effect maintenance and repair of the facility in a manner that is approved by the municipal engineer. If for reasons of safety there is need for immediate action, the responsible party shall act forthwith to remove the danger. If the responsible party fails or refuses to perform such maintenance and repair, the township may immediately proceed to do so, and shall be reimbursed for the cost thereof by the responsible person or entity.*

5:21-7.8 Safety Measures

(a) Safety measures are to be incorporated in the design of all stormwater management systems. These may include, but not be limited to, fencing,

warning signs, staff gauges indicating depth at lowest point, and outlet structures designed to limit access.

SPECIAL AREA STANDARDS
APPENDICES A AND B
TO SUBCHAPTER 7

APPENDIX A:
LANDSCAPE GUIDANCE FOR STORMWATER BMPS

APPENDIX B:
TECHNICAL SUPPORT DOCUMENT

APPENDIX A

LANDSCAPE GUIDANCE FOR STORMWATER BMPs

I. Hydrologic Plant Zones

For planting within a stormwater management facility, it is necessary to determine what hydrologic zones will be created. Hydrologic zones describe the degree to which an area is inundated by water. Plants have differing tolerances to inundation and the six zones described in this section will dictate which plants will survive where.

Table A.1 HYDROLOGIC ZONES

Zone #	*Zone Description*	*Hydrologic Conditions*
Zone 1	*Deep Water Pool*	*1- to 6-foot deep permanent pool*
Zone 2	*Low Marsh*	*6 inches to 1 foot deep*
Zone 3	*High Marsh*	*Regularly inundated*
Zone 4	*Riparian Fringe*	*Periodically inundated*
Zone 5	*Floodplain Terrace*	*Infrequently inundated*
Zone 6	*Upland Slopes*	*Seldom or never inundated*

Various BMPs may incorporate one or more of these zones. The appropriate selection of plant varieties will require an estimation of the frequency of inundation, or the characteristic soil moisture conditions. The following table suggests the range of environments that may be encountered in a particular type of BMP. However, since BMP design is very flexible and dependent upon site conditions, other hydrologic zones may be relevant for a specific facility.

Table A.2 CORRELATION OF HYDROLOGIC ZONES WITH STORMWATER BMPS

BMP	Applicable Hydrologic Zone	Comment
Dry Swale Bioretention	3	
Pocket Sand Filter	3	
Raingarden Bioretention	3 and 5	Refer to Figure A.4
Vegetated Rock Filter	2 and 3	Planting restricted to edges
Wooded Treatment Buffer	4 and 5	Zone designation depends on frequency of inundation or degree of saturation
Terraced Bioretention and Bioretention Meadows	3, 4, 5, and 6	Zone designation depends on frequency of inundation or degree of saturation
Dry Pond with Extended Detention	3, 4, 5, and 6	Refer to Figures A.1 and A.3
Wet Pond	1, 2, 3, 4, 5, and 6	Refer to Figures A.1 and A.3

Table A.3 provides planting guidance for each of the hydrologic zones based on water depth tolerances of wetland plant species suitable for the Harding/Morris County Highlands and Piedmont physiographic environment. Recommended species are native to this area, tolerant of some water fluctuation, and have moderate to very high wildlife value (for either food, nesting, or cover). For diversity, both herbaceous and woody species are specified.

Any planting below the permanent pool elevations does not require mulching or fertilization. A nurse crop of annual rye grass (or substitute recommended by the local conservation district) is recommended as a stabilizing groundcover through which the other plants are installed. Unless there is a problem with natural soil structure or fertility, there will be significant volunteering or natural recolonization of the disturbed areas that will enhance overall habitat diversity.

The wetland indicator status (from Region 1, Reed, 1988) has been included to show "the estimated probability of a species occurring in wetlands versus non-wetlands" (Reed, 1988). Reed defines the indicator categories as follows:

> *Obligate Wetland (OBL): Plants which nearly always (more than 99 percent of the time) occur in wetlands under natural conditions.*
>
> *Facultative Wetland (FACW): Plants which usually occur in wetlands (from 67 to 99 percent of the time), but occasionally are found in non-wetlands.*
>
> *Facultative (FAC): Plants which are equally likely to occur in wetlands and non-wetlands, and are found in wetlands from 34 to 66 percent of the time.*

Facultative Upland (FACU): Plants which usually occur in non-wetlands (from 67 to 99 percent of the time), but occasionally are found in wetlands (from 1 to 33 percent of the time).

Upland (UPL): Plants which almost always (more than 99 percent of the time), under natural conditions, occur in non-wetlands.

A given indicator status shown with a "+" or a "-" means that the species is more (+) or less (-) often found in wetlands than other plants with the same indicator status without the "+" or "-" designation.

Table A.3 RECOMMENDED PLANT LIST

Zone 2: Shallow Marsh (6 inches to 1 foot deep)		
Species	***Wetland Indicator Status***	***Notes***
Decodon verticillatus	*OBL*	*Native swamp loosestrife with long, arching branches that root at tips; attractive pink flowers; spreads rapidly; tolerates some shade*
Nuphar luteum	*OBL*	*Tolerates more than 2' of fluctuation; slow growing, floating/semi-emergent aquatic with yellow waterlily flower*
Peltandra virginica	*OBL*	*Tolerates inundation of more than 1'; slow growing, but large; wood duck prefers seed*
Pontederia cordata	*OBL*	*Tolerates inundation of more than 1'; medium rate of spread; showy blue flowers*
Sagittaria latifolia	*OBL*	*Tolerates inundation of more than 1'; rapid spread; high value food for numerous duck species*
Scirpus validus	*OBL*	*Tolerates inundation of about 1'; tall up to 8'; moderate wildlife value*
Scirpus pungens	*OBL*	*Tolerates inundation of about 0.5'; rapidly spreads; high value wildlife food; erect grasslike appearance that contrasts with broad-leaved emergents above*
Elodea canadensis	*OBL*	*A perennial, rooted, submerged aquatic species that prefers quiet, clear waters and permanent inundation; can absorb excess nutrients from water column; spreads rapidly; waterfowl food*

Typha latifolia	*OBL*	*Tolerates inundation of about 1'; forms dense, persistent stands; high wildlife value*
Zone 3: High Marsh/Pond Shoreline (regularly inundated and fluctuating)		
Species	***Wetland Indicator Status***	***Notes***
Alnus serrulata	*OBL*	*Native shrub/tree; fast growing; good nitrogen fixer; high wildlife value; forms thickets*
Cephalanthus occidentalis	*OBL*	*Native shrub; tolerates some dryness; common to pond and stream edges*
Hibiscus moscheutos	*OBL*	*Tolerates partial sun; slow growth; large showy flowers*
Rhododendron periclymenoides	*FAC*	*Deciduous shrub found in edges of swamps and bogs in New Jersey; tolerates shade, but not full sun*
Leersia oryzoides	*OBL*	*Perennial native grass; tolerates dry periods; very good erosion control; high wildlife food value*
Panicum virginica	*FAC*	*Perennial native grass; clump forming; very high wildlife value*
Salix nigra	*FACW+*	*Native tree; tolerates inundation; spreads rapidly by suckers; used in streambank stabilization; high wildlife value*
Sambucus canadensis	*FACW+*	*Native shrub; fast growing; tolerates inundation; spreads by suckers; high wildlife value*
Veronia noveboracensis	*FACW+*	*Perennial native forb; tall, with intense purple flowers; slow starter, but spreads well later*
Zone 4: Riparian Fringe (periodically inundated)		
Species	***Wetland Indicator Status***	***Notes***
Vaccinium corymbosum	*FACW-*	*Native shrub; high wildlife value*

Acer rubrum	*FACW+*	*Native deciduous tree; moderately fast growing; tolerates inundation or saturation up to 25% of the growing season; tolerates partial shade; high wildlife food, cover, and nesting value*
Leucothoe racemosa	*FACW*	*Native deciduous shrub common to moist and acid riparian areas, and rich woods; tolerates full shade*
Viburnum trilobum	*FACW*	*Native deciduous shrub; common in shrub swamps and seasonally inundated forests; tolerates full shade; high wildlife food and cover value (fruits preferred by cedar waxwings, berries persist into winter to provide emergency food); tolerates drought*
Cornus amomum	*FACW*	*Native shrub; very high wildlife value*
Ilex verticillata	*FACW+*	*Native shrub; high wildlife value*
Zone 5: Floodplain Terrace (infrequently inundated)		
Species	***Wetland Indicator Status***	***Notes***
Lindera benzoin	*FACW*	*Native deciduous shrub; common in seasonally wet forests, floodplains, and moist upland woods; tolerates full shade; slow growing, but hardy; high food value to wildlife*
Betula allegheniensis (lenta)	*FAC*	*An associate of swamp forests in northern New Jersey; requires full sun; high wildlife value*
Nyssa sylvatica	*FAC*	*Native tree; high wildlife value*
Panicum virginica	*FAC*	*Native perennial grass; clump forming; very high wildlife value; good transitional species; tolerates drought*
Acer rubrum	*FACW+*	*Native deciduous tree; moderately fast growing; tolerates inundation or saturation up to 25% of the growing season; tolerates partial shade; high wildlife food, cover, and nesting value*
Hamamelis virginiana	*FAC-*	*Native small tree with unusual yellow flowers in late autumn; tolerates full shade; high food value*

Zone 1: Deep Water Area (1 to 6 feet)

Ponds and wetlands both have deep pool areas that comprise Zone 1. These pools range from one to six feet in depth and are best colonized by submergent plants, if at all. This pondscaping zone has not been routinely planted for several reasons. First, the availability of plant materials that can survive and grow in this zone is limited, and it is also feared that plants could clog the stormwater facility outlet structure. In many cases, these plants will gradually become established through natural recolonization (e.g., transport of plant fragments from other ponds by waterfowl). If submerged plant material becomes more commercially available and clogging concerns are addressed, this area can be planted. The function of the planting is to reduce sedimentation and improve oxidation, while creating a greater aquatic habitat.

- *Plant material must be able to withstand constant inundation of water of one foot or greater in depth.*
- *Plants may be submerged partially, or entirely.*
- *Plants should be able to enhance pollutant uptake.*
- *Plants may provide food and cover for waterfowl, desirable insects, and other aquatic life.*

Some suggested emergent or submergent species include but are not limited to lotus, wild celery, and redhead grass.

Zone 2: Low Marsh (6 inches to 1 foot)

Zone 2 includes all areas that are inundated below the normal pool to a depth of one foot and is the primary area where emergent plants will grow in stormwater wetlands. Zone 2 coincides with the aquatic bench found in wet stormwater ponds and with portions of vegetated rock filters. This zone offers ideal conditions for the growth of many emergent wetland species. These areas may be located at the edge of a pond, or on low mounds of earth located below the surface of the water within a pond. When planted, Zone 2 can be an important habitat for many aquatic and nonaquatic animals, creating a diverse food chain. This food chain includes predators, allowing a natural regulation of mosquito populations, thereby reducing the need for insecticide applications.

- *Plant material must be able to withstand constant inundation of water to depths between six inches and one foot deep.*
- *Plants will be partially submerged.*
- *Plants should be able to enhance pollutant uptake.*
- *Plants may provide food and cover for waterfowl, desirable insects, and other aquatic life.*

Plants will stabilize the bottom of a pond, as well as the edge of a pond, absorbing wave impacts and reducing erosion when water level fluctuates. In addition to slowing water velocities and increasing sediment deposition rates, plants can also reduce re-

suspension of sediments caused by the wind. Plants can also soften the engineered contours of the pond and can conceal drawdowns during dry weather.

Some suggested species for Zone 2 include lobelia, bayberry, many asters, turtlehead, pond cypress, iris, and blue flag. It is important to recognize that a plant typically found in wetlands may be cultivated in non-wetland conditions. It is important to obtain plant stock that is cultivated in hydrologic and soil conditions similar to those present in the stormwater management facility. A plant typically found in wetlands, but cultivated in non-wetland conditions, may not survive if installed in wetland conditions. A non-wetland plant cultivated in wetland conditions should thrive when introduced to wetland conditions.

Zone 3: High Marsh (regularly inundated)

Zone 3 encompasses the shoreline of a pond and extends vertically about one foot in elevation above the normal pool. This zone includes the safety bench of a pond and may also be periodically inundated if storm events are subject to extended detention. This zone occurs in a wet pond, the extended detention zone of some dry ponds, all bioretention BMPs, and vegetated rock filters. It can be the most difficult to establish since plants must be able to withstand inundation of water during storms, as well as occasional drought during the summer. In order to stabilize the soil in this zone, Zone 3 must have a vigorous cover.

- *Shoreline plants should be deep rooted to stabilize soil and minimize erosion caused by wave and wind action, or water fluctuation.*
- *Plant material must be able to withstand occasional inundation of water. Plants will be partially submerged at this time.*
- *Plants should enhance pollutant uptake.*
- *Plants may provide food and cover for waterfowl, songbirds, and wildlife. Large plants could also be selected and located to control overpopulation of waterfowl.*
- *Plants should be located to reduce human access where there are potential hazards, but should not block the maintenance access.*
- *Plants should have very low maintenance requirements because they may be difficult or impossible to reach.*
- *Plants should be resistant to disease and other problems that require chemical applications (since chemical application is not advised in stormwater ponds).*
- *Native plants are preferred because they are low maintenance and disease resistant.*

Many of the emergent wetlands plants also thrive in Zone 3. Some other species that do well include bentgrass, foxtail, panic grass, and hawthorn. If shading is needed along the shoreline, the following tree species are suggested: river birch, ash, willow, red maple, and willow oak.

Zone 4: Riparian Fringe (periodically inundated)

Zone 4 extends from one to four feet in elevation above the normal pool. Plants in this zone are subject to periodic inundation after storms and may experience saturated, or partly saturated, soil. Most of the extended detention region of dry detention basins is included within this zone.

- *Plants must be able to withstand periodic inundation of water after storms, as well as occasional drought during the warm summer months.*
- *Plants should stabilize the ground from erosion caused by runoff.*
- *Plants should shade the low-flow channel to reduce pool warming whenever possible.*
- *Plants should enhance pollutant uptake.*
- *Plant material should have very low maintenance, since they may be difficult or impossible to access.*
- *Plants may provide food and cover for waterfowl, songbirds, and wildlife. Plants may also be selected and located to control overpopulation of waterfowl.*
- *Plants should be located to reduce pedestrian access to the deeper pools.*
- *Native plants are preferred because they are low maintenance and disease resistant.*

Some frequently used plant species in Zone 4 include coneflower, violets, primrose, milkwort, nannyberry, lespedeza, lilies, flatsedge, hollies, forsythia, lovegrass, hawthorn, spiraea, birch, and sugar maple.

Zone 5: Floodplain Terrace (infrequently inundated)

Zone 5 is periodically inundated by floodwaters that quickly recede in a day or less. Operationally, Zone 5 extends from the maximum two-year or Cp_v *water surface elevation up to the 10- or 100-year maximum water surface elevation. Key landscaping objectives for Zone 5 are to stabilize the steep slopes characteristic of this zone and establish low-maintenance natural vegetation.*

- *Plant material should be able to withstand occasional, but brief, inundation during storms. In between storms, typical moisture conditions may be moist, slightly wet, or even swing entirely to drought conditions during the dry weather periods.*
- *Plants should stabilize the basin slopes from erosion.*
- *Ground cover should be very low maintenance, since it may be difficult to access on steep slopes, or if frequency of mowing is limited. A dense tree cover may help reduce maintenance and discourage resident geese.*
- *Plants may provide food and cover for waterfowl, songbirds, and wildlife.*
- *Placement of plant material in Zone 5 is often critical, as it often creates a visual focal point, and provides structure and shade for a greater variety of plants.*

Some commonly planted species in Zone 5 include solomon's seal, nannyberry, many fescues, many viburnums, cherries, chestnut oak, post oak, and phlox.

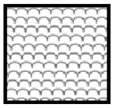
Zone 6: Upland Slopes/Pond Buffer (seldom or never inundated)

The last zone extends above the maximum 100-year water surface elevation and often includes the outer buffer of a pond. Unlike other zones, this upland area may have sidewalks, bike paths, retaining walls, and maintenance access roads. Care should be taken to locate plants so they will not overgrow these routes, or create hiding places that might make the area unsafe.

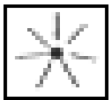
- *Plant selections should be made based on soil condition, light, and function within the landscape because little or no water inundation will occur.*
- *Ground covers should require infrequent mowing to reduce the cost of maintaining this landscape.*
- *Placement of plants in Zone 6 is important since they are often used to create a visual focal point, frame a desirable view, screen undesirable views, serve as a buffer, or provide shade to allow a greater variety of plant materials. Particular attention should be paid to seasonal color and texture of these plantings.*

Some frequently used plant species in Zone 6 include eastern cottonwood, american yew, linden, bald cypress, magnolia, and mountain ash.

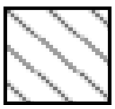
Figure A.1 HYDROLOGIC ZONES AROUND STORMWATER FACILITIES – LEGEND



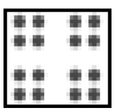
Deep Water Area: *1.0- to 6.0-foot depth below normal pool elevation. (Water Lily, Deep Water Duck Potato, Sago Pond Plant, Wild Celery, Redhead Grass.)*



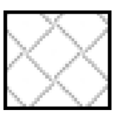
Low Marsh Area: *6-inch to 1.0-foot depth below normal pool elevation. (Blue Flag Iris, Duck Potato, Flowering Bulrush, Softrush, Sedges, Lobelia, Pond Cypress, various Asters.)*



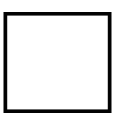
High Marsh Area*: 6 inches below to 1.0 foot above normal pool elevation. [New England Aster, Marsh Aster, Marsh Marigold (Appalachian Plateau), Tussock Sedge, Spotted Joe Pye Weed, Forget Me Nots, Inkberry, Purple Osier Dogwood, Pin Oak, River Birch, Sycamore, Swamp White Oak (Coastal Plain), Weeping Willow, Dawn Redwood.]*



Riparian Fringe: *1.0 to 4.0 feet above normal pool elevation. [Purple Cone Flower, Birds Foot Trefoil, Slender Rush, Deer Tongue Grass, Lespedeza, Switch Grass, Serviceberry, Gray Birch, Hackberry, Sweet Pepper Bush (Coastal Plain), Gray Stem Dogwood, Red Osier Dogwood, Green Ash.]*

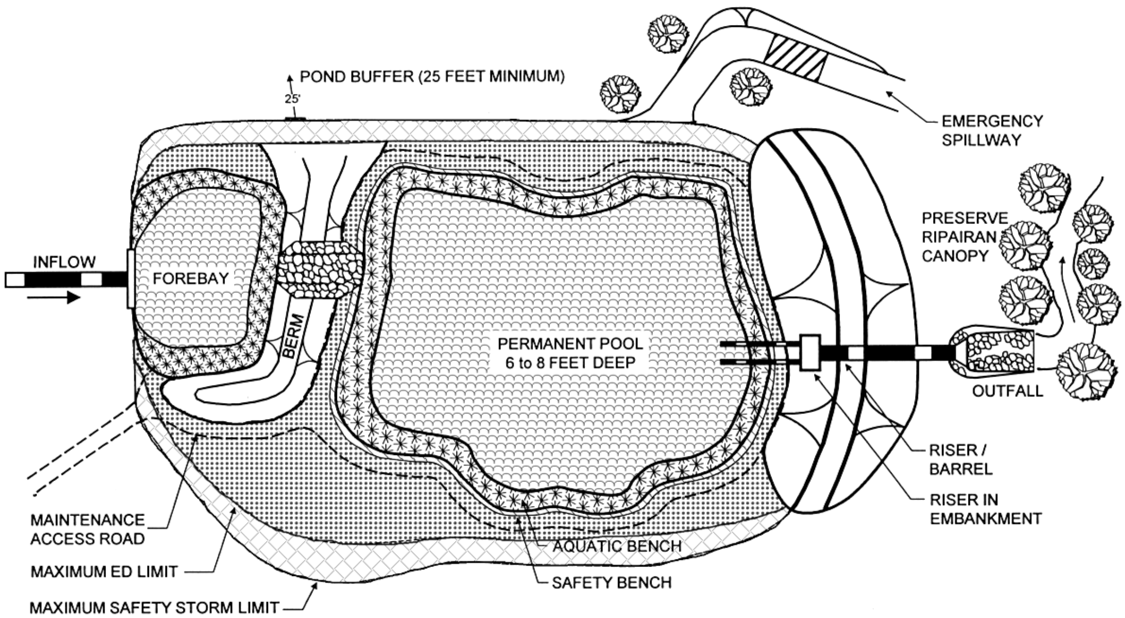


Floodplain Terrace: *periodically inundated. Many wildflowers and native grasses. (American Holly, Witch Hazel, Ninebark, Red Oak, American Elderberry, American Hemlock, Lowbush Blueberry, Maple Leaf Viburnum, Nannyberry, Blackhaw Viburnum.)*

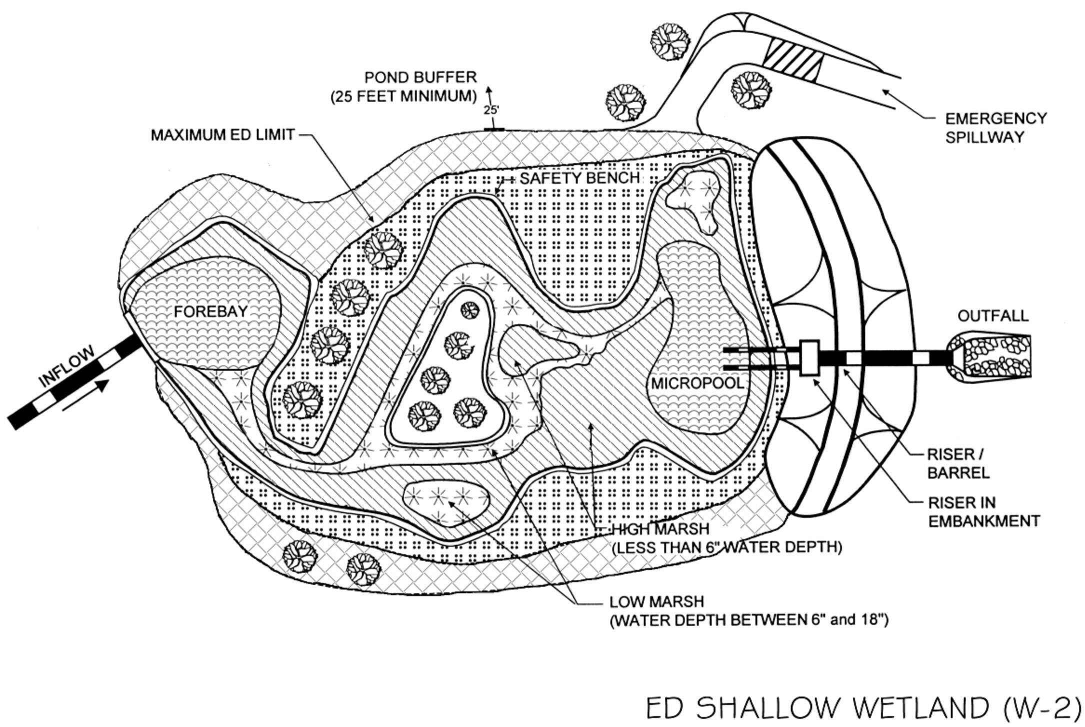


Upland Slopes/Pond Buffer: *seldom or never inundated. All species must be able to tolerate flood-plain conditions. (Hackberry, Pitch Pine, Sheep Fescue, wildflowers, many native grasses.)*

Figure A.1 HYDROLOGIC ZONES AROUND STORMWATER FACILITIES



WET ED POND (P-3)



ED SHALLOW WETLAND (W-2)

Figure A.2 SECTION OF TYPICAL STORMWATER MANAGEMENT DETENTION POND

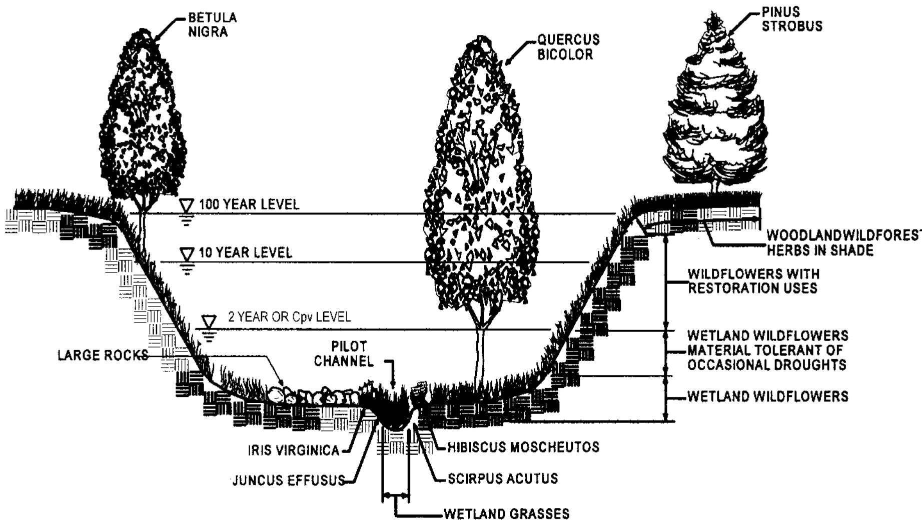
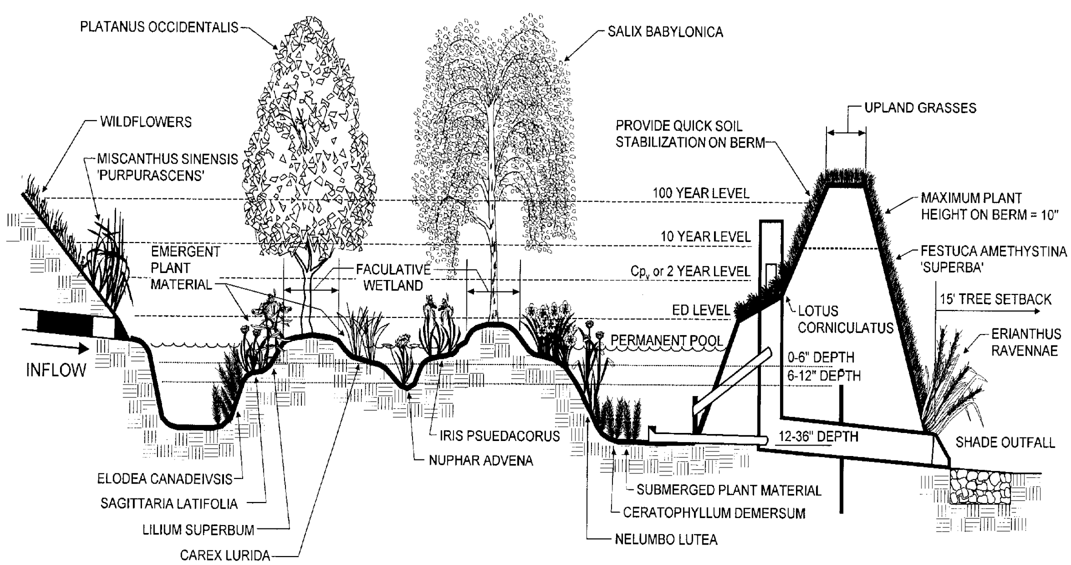


Figure A.3 SECTION OF TYPICAL SHALLOW EXTENDED DETENTION WETLAND SYSTEM



II. <u>Bioretention</u>

Soil Bed Characteristics

The characteristics of the soil for the bioretention facility are perhaps as important as the facility location, size, and treatment volume. The soil must be permeable enough to allow runoff to filter through the media, while having characteristics suitable to promote and sustain a robust vegetative cover crop. In addition, much of the nutrient pollutant uptake (nitrogen and phosphorus) is accomplished through absorption and microbial activity within the soil profile. Therefore, soils must balance their chemical and physical properties to support biotic communities above and below ground.

The planting soil should be a sandy loam, loamy sand, or a loam/sand mix (should contain a minimum of 35 to 60 percent sand, by volume). The clay content for these media should be less than 25 percent by volume [Environmental Quality Resources (EQR), 1996; Engineering Technology, Inc. and Biohabitats, Inc. (ETAB), 1993]. Media should fall within the SM, ML, SC classifications, or the Unified Soil Classification System (USCS). A permeability of at least 1.0 feet per day (0.5"/hr) is required (a conservative value of 0.5 feet per day is used for design). The soil should be free of stones, stumps, roots, or other woody material over 1 inch in diameter. Brush or seeds from noxious weeds (e.g., Johnson Grass, Mugwort, Nutsedge, and Canada Thistle, or other noxious weeds as specified under COMAR 15.08.01.05.) should not be present in the soils. Placement of the planting soil should be in 12-inch to 18-inch lifts that are loosely compacted (tamped lightly with a backhoe bucket, or traversed by dozer tracks). The specific characteristics are presented in Table A.3.

Table A.4 PLANTING SOIL CHARACTERISTICS
(Adapted from EQR, 1996; ETAB, 1993)

Parameter	***Value***
pH range	*5.2 to 7.00*
Organic matter	*1.5 to 4.0% (by weight)*
Magnesium	*35 lbs. per acre, minimum*
Phosphorus (phosphate - P_2O_5)	*75 lbs. per acre, minimum*
Potassium (potash - K_2O)	*85 lbs. per acre, minimum*
Soluble salts	*□ 500 ppm*
Clay	*10 to 25%*
Silt	*30 to 55%*
Sand	*35 to 60%*

Mulch Layer

The mulch layer plays an important role in the performance of the bioretention system. The mulch layer helps maintain soil moisture and avoids surface sealing that reduces permeability. Mulch helps prevent erosion and provides a microenvironment suitable for soil biota at the mulch/soil interface. It also serves as a pretreatment layer, trapping the finer sediments that remain suspended after the primary pretreatment.

The mulch layer should be standard landscape style, single- or double-shredded hardwood mulch or chips. The mulch layer should be well aged (stockpiled or stored for at least 12 months), uniform in color, and free of other materials, such as weed seeds, soil, roots, etc. The mulch should be applied to a maximum depth of three inches. Grass clippings should not be used as a mulch material.

Planting Guidance

Plant material selection should be based on the goal of simulating a terrestrial, forested community of native species. Bioretention simulates an upland-species ecosystem. The community should be dominated by trees, but should have a distinct community of under-story trees, shrubs, and herbaceous materials. By creating a diverse, dense plant cover, a bioretention facility will be able to treat stormwater runoff and withstand urban stresses from insects, disease, drought, temperature, wind, and exposure.

The proper selection and installation of plant materials is key to a successful system. There are essentially three zones within a bioretention facility (Figure A.4). The lowest elevation supports plant species adapted to standing and fluctuating water levels. The middle elevation supports plants that like drier soil conditions, but can still tolerate occasional inundation by water. The outer edge is the highest elevation and generally supports plants adapted to dryer conditions. A sample of appropriate plant materials for bioretention facilities is included in Table A.5. The objective is to have a system that resembles a random and natural plant layout, while maintaining optimal conditions for plant establishment and growth. For a more extensive bioretention plan, consult ETAB, 1993 or Claytor and Schueler, 1997.

Figure A.4 PLANTING ZONES FOR A BIORETENTION FACILITY

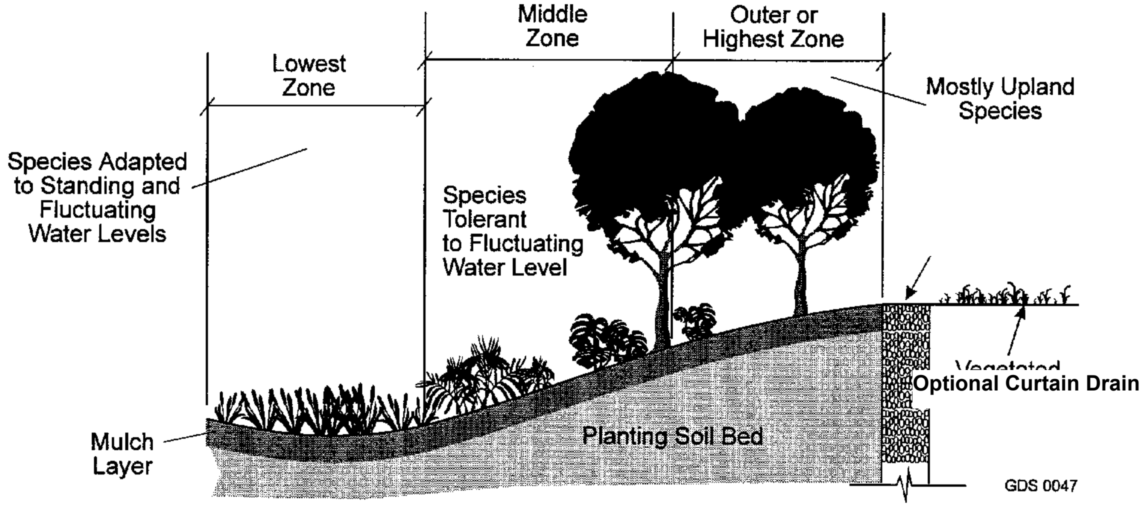


Table A.5 COMMONLY USED SPECIES FOR BIORETENTION AREAS

Trees	*Shrubs*	*Herbaceous Species*
Acer rubrum *Red Maple*	*Aesculus pariviflora* *Bottlebrush Buckeye*	*Andropogon virginicus* *Broomsedge*
Betula nigra *River Birch*	*Cephalanthus occidentalis* *Buttonbush*	*Eupatorium perpurea* *Joe Pye Weed*
Juniperus virginiana *Eastern Red Cedar*	*Hamemelis virginiana* *Witch Hazel*	*Scirpus pungens* *Three Square Bulrush*
Chionanthus virginicus *Fringe-Tree*	*Vaccinium corymbosum* *Highbush Blueberry*	*Iris versicolor* *Blue Flag*
Nyssa sylvatica *Black Gum*	*Ilex glabra* *Inkberry*	*Lobelia cardinalis* *Cardinal Flower*
Diospyros virginiana *Persimmon*	*Ilex verticillata* *Winterberry*	*Panicum virgatum* *Switchgrass*
Platanus occidentalis *Sycamore*	*Viburnum dentatum* *Arrowwood*	*Dichanthelium scoparium* *Broom Panic Grass*
Quercus palustris *Pin Oak*	*Lindera benzoin* *Spicebush*	*Rudbeckia laciniata* *Tall Coneflower*
Quercus phellos *Willow Oak*	*Myrica pennsylvanica* *Bayberry*	*Scirpus cyperinus* *Woolgrass*
Salix nigra *Black Willow*		*Vernonia noveboracensis* *New York Ironweed*
Note 1: For more options on plant selection for bioretention, consult Bioretention Manual (ETAB, 1993) or the Design of Stormwater Filtering Systems (Claytor and Schueler, 1997).		

III. Meadows

Meadows are beneficial as water-quality buffers and wildlife habitats. Both upland and riparian areas are good sites for meadow restoration.

Meadows are generally considered temporary ecosystems in the eastern deciduous forest occurring in forest openings and in areas disturbed by farming or frequent flooding. Potential sites for meadow establishment include extensive residential lawns bordering creeks and aquatic systems. The easiest way to create natural meadows is to stop mowing and allow old-field succession to occur, maintaining the desired meadow stage by only periodic mowing, and by planting wildflower plugs or over-seeding with meadow mixtures of grasses and wildflowers. Many grassland species such as eastern meadowlark, grasshopper sparrow, savannah sparrow, upland sandpiper, and bobwhite quail have declined drastically over the years due to loss of meadow habitat from development and changes in farming practices.

General recommendations for establishment of natural meadows include:

- *To enhance wildlife value, the timing and frequency of mowing is critical, and will have a dramatic effect on the composition of the meadow and what wildlife it will support; avoid mowing between April 1 and July 1 when animals are nesting.*
- *Mowing in early to mid-July promotes the natural dominance of native, warm-season grasses; a late winter mowing in March will control invasives such as multiflora rose and thistle, while maximizing bird and animal habitat use.*
- *Mow meadows when the ground is dry, and cut to a height of six to eight inches for the summer mowing and four to six inches for the winter cut.*
- *Gradually increase the diversity of meadows by planting wildflower plugs, or over-seeding with native species meadow mixes that include both flowers and native warm-season grasses.*
- *Install nesting boxes for birds like Eastern bluebird and American kestrel.*
- *Monitor for invasive plants and eliminate them.*
- *To transition to another land use or natural area, consider planting edges with small trees and shrubs using the floodplain plant list, or the woody species list.*

IV. Stormwater Plant List

The pages at the end of this appendix present an extensive list of herbaceous, tree, and shrub plants native to this region and suitable for planting in stormwater management facilities. The list is intended as a resource for general planting purposes and planning considerations. Knowledgeable landscape designers and nursery suppliers may provide additional information for considering specific conditions for successful plant establishment, and accounting for the variable nature of stormwater hydrology.

The planting list is in alphabetical order according to the common name, with the scientific name also provided. Life forms indicate whether a plant species is an "annual," "perennial," "grass," "fern," "shrub," or "tree".

Each plant species has a corresponding hydrologic zone provided to indicate the most suitable planting location for successful establishment. While the most common zones for planting are listed in parentheses, the listing of additional zones indicates that a plant may survive over a broad range of hydrologic conditions.

The Reed wetland indicator is provided. However, since the wetland indicator status alone does not provide an indication of the depth or duration of flooding that a plant will tolerate, the "Inundation Tolerance" section is designed to provide further guidance. Where a plant species is capable of surviving in standing water, a "yes" is designated in this column. Additional information is provided for depth of inundation for aquatic vegetation and tolerance for seasonal inundation, or saturated soil conditions. Because individual plants often have unique life requirements difficult to convey in a general listing, it will be necessary to research specific information on the plant species proposed in order to ensure successful plant establishment.

Hardiness zones are provided for the United States Department of Agriculture hardiness zones. The herbaceous plant list identifies the range of zones the plant may survive in, while the tree and shrub list shows the coldest zone where the plant may naturally occur.

V. References

The following is a list of resources used in compiling these guidelines and the list of plant materials:

- *Art, Henry W. 1986. A Garden of Wildflowers, 101 Native Species and How to Grow Them. Storey Communications, Inc., Pownal, VT.*
- *Brown, Melvin L. and Brown, Russell G. 1984. Herbaceous Plants of Maryland. Port City Press, Baltimore, MD.*
- *Brown, Melvin L. and Brown, Russell G. 1992. Woody Plants of Maryland. Port City Press, Baltimore, MD.*
- *Clausen, Ruth Rogers and Ekstrom, Nicolas, H. 1989. Perennials for American Gardens. Random House, New York, NY.*
- *Dirr, Michael A. 1990. Manual of Woody Landscape Plants, Their Identification, Ornamental Characteristics, Culture, Propagation, and Uses. 4th Edition. Stipes Publishing Company, Champaign, IL.*
- *Engineering Technology Associates, Inc. and Biohabitats, Inc. (ETA&B). 1993. Design Manual for Use of Bioretention in Stormwater Management. Prince Georges County Department of Environmental Resources, Upper Marlboro, MD.*
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- *Hill, Steven R. and Duke, Peggy K. 1985-86. 100 Poisonous Plants of Maryland, Bulletin No. 314. University of Maryland Cooperative Extension Services, Ellicott City, MD.*
- *Longenecker, G. 1983. Woody Plant List for West Virginia. Landscape Architecture Department, Division of Resource Management, West Virginia University, Morgantown, WV.*
- *Maryland Department of the Environment. 1994. 1994 Maryland Standards and Specifications for Soil Erosion and Sediment Control. Water Management Administration and Maryland Soil Conservation Service, Baltimore, MD.*
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- *Maryland Natural Heritage Program. 1994. Rare Species of Submerged Aquatic Vegetation in Maryland. Department of Natural Resources, Annapolis, MD.*
- *Miles, B. 1996. Wildflower Perennials for Your Garden, A Detailed Guide to Years of Bloom from America's Native Heritage. Stackpole Books, Mechanicsburg, PA.*
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- *Schueler, Thomas R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Department of Environmental Programs, Metropolitan Washington Council of Governments, Metropolitan Information Center, Washington, D.C.*
- *Schueler, Thomas R. 1996. Design of Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetland Systems in the Mid-Atlantic Region. Department of Environmental Programs, Metropolitan Washington Council of Governments, Metropolitan Information Center, Washington, D.C.*
- *Schueler, Thomas R. and Claytor, Richard A. 1997. Design of Stormwater Filtering Systems: Appendix B and C. Chesapeake Bay Consortium, Silver Spring, MD.*
- *Cooperative Extension Service. Weed Identification. File No. IVC9 10M386, U. Ed. 85-439 and File No. IVC9 10M587 U. Ed. 86-356. College of Agriculture, Pennsylvania State University, University Park, PA.*

- *Thunhorst, Gwendolyn A. 1993. Wetland Planting Guide for the Northeastern United States: Plants for Wetland Creation, Restoration, and Enhancement. Environmental Concern, Inc., St. Michael, MD.*
- *Tiner, Ralph W., Jr. 1988. Field Guide to Non-Tidal Wetland Identification. U.S. Fish and Wildlife Service, Maryland Department of Natural Resources, and Maryland Geological Survey, Annapolis, MD.*

Section A-4.1 Stormwater Plant List -- Woody Vegetation

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
ALDER, BROOK-SIDE	*Alnus serrulata*	Tree	[1, 2], 3	OBL	0-3"	
ALDER, SEASIDE	*Alnus maritima*	Tree	[1, 2], 3	OBL	YES	
ALDER, SPECKLED	*Alnus rugosa*	Tree	1 [2, 3]	FACW+	YES	2
ARROW-WOOD	*Viburnum dentatum*	Shrub	[3, 4], 5	FAC	SEASONAL	2
ASH, BLACK	*Fraxinus nigra*	Tree	[2, 3], 4	FACW	SATURATED	2
ASH, GREEN	*Fraxinus pennsylvanica*	Tree	[2, 3], 4	FACW	SEASONAL	2
ASH, WHITE	*Fraxinus americana*	Tree	[4, 5], 6	FACU	NO	3
ASPEN, BIG-TOOTH	*Populus grandidentata*	Tree	[4, 5, 6]	FACU	NO	3
ASPEN, QUAKING	*Populus tremuloides*	Tree	[4, 5], 6	FACU	YES	1
AZALEA, DWARF	*Rhododendron atlanticum*	Shrub	[2, 3, 4], 5	FAC, FAC+	YES	
AZALEA, EARLY	*Rhododendron prinophyllum*	Shrub	[2, 3, 4], 5	FAC, FAC+	YES	3
AZALEA, HOARY	*Rhododendron canescens*	Shrub	[2, 3], 4	FACW	YES	
AZALEA, PINK	*Rhododendron*	Shrub	2, [3, 4], 5	FAC	SEASONAL	3
AZALEA, SMOOTH	*Rhododendron arborescens*	Shrub	[3, 4], 5	FAC	YES	4
AZALEA, SWAMP	*Rhododendron viscosum*	Shrub	[1, 2, 3], 4	FACW+, OBL	SEASONAL	3
BASSWOOD, AMERICAN	*Tilia americana*	Tree	3, [4, 5], 6	FACU	NO	2
BAYBERRY, NORTHERN	*Myrica pennsylvanica*	Shrub	[3, 4], 5	FAC	SEASONAL	2
BAYBERRY, SOUTHERN	*Myrica cerifera*	Shrub	[2, 3, 4], 5	FAC, FAC+	REGULARLY	
BEECH, AMERICAN	*Fagus grandifolia*	Tree	[4, 5], 6	FACU	NO	3
BIRCH, GRAY	*Betula populifolia*	Tree	[3, 4], 5	FAC	SEASONAL	5
BIRCH, RIVER	*Betula nigra*	Tree	[2, 3], 4	FACW	SEASONAL	4
BIRCH, YELLOW	*Betula alleghaniensis*	Tree	[3, 4], 5	FAC	YES	3
BLACK GUM, SWAMP TUPELO	*Nyssa sylvatica*	Tree	1, [2, 3]	FACW+	SEASONAL	4
BLACK-HAW	*Viburnum prunifolium*	Shrub	[3, 4, 5], 6	FACU, FACU+	YES	3
BLACK-HAW, RUSTY	*Viburnum rufidulum*	Shrub	3, [4, 5, 6]	UPL, FACU	NO	5

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
BLADDERNUT, AMERICAN	*Staphylea trifolia*	Shrub-Tree	[3, 4], 5	FAC	YES	3
BLUEBERRY, BOG	*Vaccinium uliginosum*	Shrub	2, 3, 4, 5, 6	FACU+, FACW+	YES	
BLUEBERRY, CREEPING	*Vaccinium crassifolium*	Shrub	[2, 3, 4], 5	FAC, FAC+	YES	
BLUEBERRY, HIGHBUSH	*Vaccinium atrococcum*	Shrub	[2, 3]	FACW	SEASONAL	3
BLUEBERRY, LOWBUSH	*Vaccinium angustifolium*	Shrub	3, [4, 5, 6]	FACU-, FACU	NO	2
BLUEBERRY, VELVET-LEAF	*Vaccinium myrtilloides*	Shrub	1, 2, [3, 4, 5]	FACU, FACW-	YES	2
BOX-ELDER	*Acer negundo*	Tree	2, [3, 4]	FAC+	SEASONAL	2
BUCKTHORN, CAROLINA	*Rhamnus caroliniana*	Shrub	2, [3, 4, 5, 6]	FACU-, FAC	YES	5-6
BUCKTHORN, LANCE-LEAF	*Rhamnus lanceolata*	Shrub	6	NI	NO	5
BUFFALO-BERRY, CANADA	*Shepherdia canadensis*	Shrub	6	NI	NO	
BURNING-BUSH, EASTERN	*Euonymus atropurpureus*	Shrub	[2, 3, 4, 5], 6	FACU, FAC+	YES	4
BUTTERNUT	*Juglans cinerea*	Tree	[3, 4, 5, 6]	FACU-, FACU+	YES	3
BUTTONBUSH, COMMON	*Cephalanthus occidentalis*	Shrub	[1, 2], 3	OBL	0-3'	
CEDAR, ATLANTIC WHITE	*Chamaecyparis thyoides*	Tree	[1, 2], 3	OBL	SATURATED	3
CEDAR, EASTERN RED	*Juniperus virginiana*	Shrub	4, 5, 6	FACU	NO	2
CEDAR, NORTHERN WHITE	*Thuja occidentalis*	Tree	[2, 3], 4	FACW	SEASONAL	2
CHERRY, BLACK	*Prunus serotina*	Tree	[4, 5], 6	FACU	NO	3
CHERRY, CHOKE	*Prunus virginiana*	Tree	4, 5, 6	FACU	YES	5, 6
CHERRY, FIRE	*Prunus pensylvanica*	Tree	4, 5, 6	FACU	NO	2
COTTON-WOOD, EASTERN	*Populus deltoides*	Tree	[3, 4], 5	FAC	SEASONAL	2
COTTON-WOOD, SWAMP	*Populus heterophylla*	Tree	[2, 3]	FACW+	YES	
CRANBERRY, MOUNTAIN	*Vaccinium vitis-idaea*	Shrub	2, [3, 4], 5	FAC	YES	2
CRANBERRY, SMALL	*Vaccinium oxycoccos*	Shrub	[1, 2], 3	OBL	YES	2
CRANBERRY, SOUTHERN MOUNTAIN	*Vaccinium erythrocarpum*	Shrub	2, [3, 4], 5	FAC	YES	5
CYPRESS, BALD	*Taxodium distichum*	Tree	[1, 2], 3	OBL	SATURATED	4
DANGLE-BERRY	*Gaylussacia frondosa*	Shrub	2, [3, 4], 5	FAC	YES	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
DEERBERRY	*Vaccinium stamineum*	Shrub	[3, 4, 5, 6]	FACU-, FACU+	YES	5
DOG-HOBBLE, COASTAL	*Leucothoe axillaris*	Shrub	[1, 2, 3, 4], 5	FACW, FACW+	YES	6
DOG-HOBBLE, RED-TWIG	*Leucothoe recurva*	Shrub	3, [4, 5], 6	FACU	NO	5
DOGWOOD, GRAY	*Cornus racemosa*	Shrub	2, [3, 4]	FAC+	SEASONAL	
DOGWOOD, FLOWERING	*Cornus florida*	Shrub-Tree	4, 5, 6	FACU-	NO	4
DOGWOOD, ROUGH-LEAF	*Cornus asperifolia*	Shrub	1, 2, [3, 4, 5]	FAC-, FACW-	YES	
DOGWOOD, ROUGH-LEAF	*Cornus drummondii*	Shrub	2, [3, 4], 5	FAC	YES	4
DOGWOOD, SILKY	*Cornus amomum*	Shrub	[2, 3], 4	FACW	SEASONAL	5
ELDER, EUROPEAN RED	*Sambucus racemosa*	Shrub	[3, 4, 5], 6	FACU, FACU+	YES	4
ELM, SLIPPERY	*Ulmus rubra*	Tree	[3, 4], 5	FAC	YES	3
FALSE-WILLOW, EASTERN	*Baccharis halimifolia*	Shrub	1, [2, 3, 4], 5	FAC, FACW	0-6"	
FARKLEBERRY	*Vaccinium arboreum*	Shrub	3, [4, 5], 6	FACU	NO	7
FETTER-BUSH	*Lyonia lucida*	Shrub	1, [2, 3, 4], 5	FACW	YES	
FETTER-BUSH	*Leucothoe racemosa*	Shrub	1, [2, 3, 4], 5	FACW	SEASONAL	5
GERMANDER, AMERICAN	*Teucrium canadense*	Shrub	1, [2, 3, 4], 5	FAC+, FACW	YES	
GROUNDSEL TREE	*Baccheris halimifolia*	Shrub	[2, 3], 4	FACW		
GUM, SWEET	*Liquidambar styraciflua*	Tree	[3, 4], 5	FAC	YES	4
HACKBERRY, COMMON	*Celtis occidentalis*	Shrub-Tree	4, 5, 6	FACU	SEASONAL	5
HAWTHORN, BEAUTIFUL	*Crataegus pulcherrima*	Tree	2, [3, 4], 5	FAC	YES	4
HAWTHORN, COCKSPUR	*Crataegus crus-galli*	Tree	2, [3, 4, 5], 6	FACU, FAC	YES	4
HAWTHORN, DOWNY	*Crataegus mollis*	Tree	1, 2, [3, 4, 5]	FACU, FACW-	YES	4
HAWTHORN, GREEN	*Crataegus viridis*	Tree	1, [2, 3, 4], 5	FAC, FACW	YES	4
HAWTHORN, LITTLE-HIP	*Crataegus spathulata*	Tree	1, [2, 3, 4], 5	FAC, FACW	YES	4
HAWTHORN, PARSLEY	*Crataegus marshallii*	Tree	[1, 2, 3, 4], 5	FACU+, FACW	YES	4
HAWTHORN, WASHINGTON	*Crataegus phaenopyrum*	Tree	2, [3, 4, 5]	FAC-, FAC	YES	4
HAZEL-NUT, AMERICAN	*Corylus americana*	Shrub	3, [4, 5, 6]	UPL, FACU	NO	4

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
HAZEL-NUT, BEAKED	*Corylus cornuta*	Shrub	3, [4, 5, 6]	UPL, FACU	NO	4
HEATHER	*Calluna vulgaris*	Shrub	2, [3, 4], 5	FAC	YES	4
HEMLOCK, EASTERN	*Tsuga canadensis*	Tree	4, 5, 6	FACU	NO	3
HICKORY, BIG SHELLBARK	*Carya laciniosa*	Tree	1, [2, 3, 4], 5	FAC, FACW	YES	5
HICKORY, BITTER-NUT	*Carya cordiformis*	Tree	4, 5, 6	FACU+	NO	4
HICKORY, PECAN	*Carya illinoensis*	Tree	1, [2, 3, 4, 5]	FACU, FACW	YES	5
HICKORY, RED	*Carya ovalis*	Tree	3, [4, 5, 6]	UPL, FACU	NO	4
HICKORY, SHAG-BARK	*Carya ovata*	Tree	[3, 4, 5, 6]	FACU-, FACU+	YES	4
HICKORY, SWEET PIGNUT	*Carya glabra*	Tree	3, [4, 5, 6]	FACU-, FACU	NO	4
HOLLY, WINTERBERRY	*Ilex laevigata*	Shrub	[1, 2], 3	OBL	YES	4
HOLLY, AMERICAN	*Ilex opaca*	Shrub	4, 5, 6	FACU	LIMITED	5
HOLLY, BAY-GALL	*Ilex coriacea*	Shrub	1, [2, 3, 4], 5	FACW	YES	
HOLLY, DECIDUOUS	*Ilex decidua*	Shrub	1, [2, 3, 4, 5]	FACW-, FACW	SEASONAL	
HOLLY, GEORGIA	*Ilex longipes*	Shrub	1, [2, 3, 4], 5	FAC, FACW	YES	
HOLLY, SARVIS	*Ilex amelanchier*	Shrub	[1, 2], 3	OBL	YES	
HOP-HORNBEAM, EASTERN	*Ostrya virginiana*	Shrub-Tree	[3, 4, 5, 6]	FACU-, FACU+	YES	4
HORNBEAM, AMERICAN	*Carpinus caroliniana*	Tree	[3, 4], 5	FAC	SOME	2
HUCKLEBERRY, BLACK	*Gaylussacia baccata*	Shrub	3, [4, 5], 6	FACU	NO	2
HUCKLEBERRY, DWARF	*Gaylussacia dumosa*	Shrub	2, [3, 4], 5	FAC	YES	2
HYDRANGEA, PANICLE	*Hydrangea paniculata*	Shrub	2, [3, 4], 5	FAC	YES	4
HYDRANGEA, WILD	*Hydrangea arborescens*	Shrub	3, [4, 5, 6]	UPL, FACU	NO	4
INK-BERRY	*Ilex glabra*	Shrub	[2, 3], 4	FACW-	SEASONAL	3
LAUREL, MOUNTAIN	*Kalmia latifolia*	Shrub	4, 5, 6	FACU	NO	4
LOCUST, BLACK	*Robinia pseudoacacia*	Tree	4, 5, 6	FACU	YES	5
MAGNOLIA, UMBRELLA	*Magnolia tripetala*	Tree	2, [3, 4, 5], 6	FACU, FAC	YES	4
MALEBERRY	*Lyonia ligustrina*	Shrub	1, [2, 3, 4], 5	FACW	YES	3

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
MAPLE, MOUNTAIN	*Acer spicatum*	Tree	4, 5, 6	FACU	NO	2
MAPLE, RED	*Acer rubrum*	Tree	[3, 4], 5	FAC	SEASONAL	3
MAPLE, SILVER	*Acer saccharinum*	Tree	[2, 3], 4	FACW	SEASONAL	3
MAPLE, STRIPED	*Acer pensylvanicum*	Shrub-Tree	3, [4, 5, 6]	FACU-, FACU	NO	3
MARSH ELDER	*Iva frutescens*	Shrub	1, [2, 3]	FACW+		
MEADOW-SWEET, BROAD-LEAF	*Spiraea latifolia*	Shrub	[2, 3, 4]	FAC+, FACW	YES	2
MEADOW-SWEET, NARROW-LEAF	*Spiraea alba*	Shrub	[1, 2, 3, 4], 5	FACW, FACW+	YES	4
MEADOW-SWEET, VIRGINIA	*Spiraea virginiana*	Shrub	1, [2, 3, 4, 5]	FACU, FACW	YES	5
MEADOW-SWEET, WILLOW-LEAF	*Spiraea salicifolia*	Shrub	1, [2, 3]	FACW+	YES	4
NANNYBERRY	*Viburnum lentago*	Shrub	[3, 4], 5	FAC	SEASONAL	2
NINEBARK, EASTERN	*Physocarpus opulifolius*	Shrub	[2, 3], 4	FACW-	YES	2
OAK, PIN	*Quercus palustris*	Tree	[2, 3], 4	FACW	SEASONAL	4
OAK, SCARLET	*Quercus coccinea*	Tree	6		NO	
OAK, BUR	*Quercus macrocarpa*	Tree	3, [4, 5], 6	FAC-	YES	2
OAK, CHERRY-BARK	*Quercus falcata var. pagodafolia*	Tree	1, [2, 3, 4], 5	FAC+, FACW	YES	5-6
OAK, CHESTNUT	*Quercus prinus*	Tree	4, 5, 6	FACU	NO	5, 6
OAK, CHINKAPIN	*Quercus muhlenbergii*	Tree	[3, 4], 5	FAC	YES	5
OAK, LAUREL	*Quercus laurifolia*	Tree	1, [2, 3, 4, 5]	FACW-, FACW	YES	
OAK, LIVE	*Quercus virginiana*	Tree	4, 5, 6	FACU	YES	7
OAK, OVERCUP	*Quercus lyrata*	Tree	[1, 2], 3	OBL	YES	5
OAK, POST	*Quercus stellata*	Tree	3, [4, 5, 6]	UPL, FACU	NO	5
OAK, RED	*Quercus rubra*	Tree	6		NO	
OAK, SHINGLE	*Quercus imbricaria*	Tree	[3, 4], 5	FAC	YES	5
OAK, SHUMARD	*Quercus shumardii*	Tree	2, [3, 4]	FAC+	YES	5
OAK, SWAMP CHESTNUT	*Quercus michauxii*	Tree	1, [2, 3, 4, 5]	FACW-, FACW	YES	
OAK, SWAMP WHITE	*Quercus bicolor*	Tree	1, [2, 3]	FACW+	SEASONAL	3

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
OAK, WATER	*Quercus nigra*	Tree	[3, 4], 5	FAC	SEASONAL	6
OAK, WHITE	*Quercus alba*	Tree	[4, 5, 6]	FACU	YES	4
OAK, WILLOW	*Quercus phellos*	Tree	2, [3, 4]	FAC+	SEASONAL	5
PEPPER-BUSH, SWEET	*Clethra alnifolia*	Shrub	2, [3, 4]	FAC+	SEASONAL	3
PINE, EASTERN WHITE	*Pinus strobus*	Tree	4, 5, 6	FACU	NO	3
PINE, JERSEY	*Pinus viginiana*	Tree	6		NO	
PINE, LOBLOLLY	*Pinus taeda*	Tree	3, [4, 5], 6	FAC-	SEASONAL	
PINE, PITCH	*Pinus rigida*	Tree	4, 5, 6	FACU	SEASONAL	4
PINE, POND	*Pinus serotina*	Tree	[1, 2], 3	OBL	YES	
REDBUD, EASTERN	*Cercis canadensis*	Shrub-Tree	3, [4, 5, 6]	UPL, FACU	NO	4
RHODODENDRON	*Rhododendron canadense*	Shrub	1, [2, 3, 4], 5	FACW	YES	2
RHODODENDRON, ROSEBAY	*Rhododendron maximum*	Shrub	[3, 4], 5	FAC	YES	3
ROSEMARY, BOG	*Andromeda polifolia*	Shrub	[1, 2], 3	OBL	YES	
SAND-MYRTLE	*Leiophyllum buxifolium*	Shrub	3, 4, [5, 6]	FACU-	NO	
SASSAFRAS	*Sassafras albidum*	Tree	3, [4, 5, 6]	FACU-, FACU	NO	4
SERVICE-BERRY, DOWNY	*Amelanchier arborea*	Shrub-Tree	2, [3, 4, 5], 6	FAC-	YES	
SHEEP-LAUREL	*Kalmia angustifolia*	Shrub	3, [4, 5], 6	FAC	YES	2
SILVER-BERRY, AMERICAN	*Elaeagnus commutata*	Shrub	[6]	UPL	NO	
SNOWBELL, BIG-LEAF	*Styrax grandifolia*	Shrub	3, [4, 5, 6]	FACU-, FACU	NO	5
SPICEBUSH, NORTHERN	*Lindera benzoin*	Shrub	[2, 3], 4	FACW-	SEASONAL	3-5
STAGGER-BUSH, PIEDMONT	*Lyonia mariana*	Shrub	2, [3, 4, 5, 6]	FACU-, FAC	YES	5
STEEPLE-BUSH	*Spiraea tomentosa*	Shrub	1, [2, 3, 4], 5	FACW	YES	4
STRAWBERRY-BUSH, AMERICAN	*Euonymus americanus*	Shrub	1, [2, 3, 4, 5]	FACU, FACW	YES	5
SUGAR-BERRY	*Celtis laevigata*	Shrub	1, [2, 3, 4, 5, 6]	UPL, FACW	YES	
SWEETSHRUB	*Calycanthus fertilis*	Shrub	[3, 4, 5], 6	FACU, FACU+	YES	5
SYCAMORE, AMERICAN	*Platanus occidentalis*	Tree	[2, 3], 4	FACW-	SATURATED	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
TEABERRY	*Gaultheria procumbens*	Shrub	3, [4, 5], 6	FACU	NO	3
TREE, TULIP	*Liriodendron tulipifera*	Tree	2, [3, 4, 5], 6	FACU, FAC	YES	4
VIBURNUM, MAPLE-LEAF	*Viburnum acerifolium*	Shrub	3, [4, 5, 6]	UPL, FACU	NO	3
VIBURNUM, POSSUM-HAW	*Viburnum nudum*	Shrub	[1, 2], 3	OBL	YES	6
WILLOW, BLACK	*Salix nigra*	Tree	[2, 3]	FACW+	SEASONAL	3
WILLOW, HEART-LEAF	*Salix cordata*	Shrub	1, [2, 3, 4], 5	FAC, FACW	YES	3
WILLOW, SILKY	*Salix sericea*	Shrub	[1, 2], 3	OBL	YES	3
WILLOW, TALL PRAIRIE	*Salix humilis*	Shrub	3, [4, 5], 6	FACU	NO	3
WILLOW, VIRGINIA	*Itea virginica*	Shrub	[1, 2], 3	OBL	0-6"	5
WINTERBERRY, COMMON	*Ilex verticillata*	Shrub	1, [2, 3]	FACW+	SEASONAL	3
WITCH-ALDER, DWARF	*Fothergilla gardenii*	Shrub	1, [2, 3, 4], 5	FACW	YES	
WITCH-HAZEL, AMERICAN	*Hamamelis virginiana*	Shrub-Tree	3, [4, 5], 6	FAC-	NO	4
WITCH-HAZEL, AMERICAN	*Hamamelis virginiana*	Shrub-Tree	2, 3, [4, 5], 6	FACU, FAC-	NO	4
WITHE-ROD	*Viburnum cassinoides*	Shrub	1, [2, 3, 4], 5	FACW	YES	3
YAUPON	*Ilex vomitoria*	Shrub	3, [4, 5], 6	FAC-	YES	
YEW, AMERICAN	*Taxus canadensis*	Shrub	2, [3, 4, 5], 6	FACU, FAC	YES	2

Section A-4.2 Stormwater Plant List -- Herbaceous Vegetation

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
ARROW-GRASS, MARSH	*Triglochin palustre*	Grass	[1, 2], 3	OBL	YES	
ARROW-HEAD, BROAD-LEAF	*Sagittaria latifolia*	Perennial	[1, 2], 3	OBL	0-2'	
ARROW-HEAD, COASTAL	*Sagittaria falcata*	Perennial	[1, 2], 3	OBL	YES	
ARROW-HEAD, GRASS-LEAF	*Sagittaria graminea*	Perennial	[1, 2], 3	OBL	0-1'	
ARROW-HEAD, NORTHERN	*Sagittaria cuneata*	Perennial	[1, 2], 3	OBL	YES	
ARROW-HEAD, SHORT-BEAK	*Sagittaria brevirostra*	Perennial	[1, 2], 3	OBL	YES	
ARROW-HEAD, WAPATO DUCK POTATO	*Sagittaria latifolia*	Perennial	[1, 2], 3	OBL	0-2'	3-8
ASTER, ANNUAL SALTMARSH	*Aster subulatus*	Annual	[1, 2], 4	OBL	YES	
ASTER, BOG	*Aster nemoralis*	Perennial	[2, 3], 4	FACW+	YES	
ASTER, BUSH	*Aster dumosus*	Perennial	[3, 4], 5	FAC	NO	
ASTER, CALICO	*Aster lateriflorus*	Perennial	[2, 3, 4]	FACW-	SEASONAL	
ASTER, CROOKED-STEM	*Aster prenanthoides*	Perennial	[3, 4], 5	FAC	NO	
ASTER, FLAT-TOP WHITE	*Aster umbellatus*	Perennial	[2, 3], 4	FACW	YES	
ASTER, NEW ENGLAND	*Aster novae-angliae*	Perennial	[2, 3], 4	FACW	YES	
ASTER, NEW YORK	*Aster novi-belgii*	Perennial	[2, 3], 4	FACW+	YES	
ASTER, ONTARIO	*Aster ontarionis*	Perennial	[3, 4], 5	FAC	NO	
ASTER, PANICLED	*Aster simplex*	Perennial	[2, 3], 4	FACW	YES	
ASTER, PERENNIAL SALTMARSH	*Aster tenuifolius*	Perennial	1, [2, 3]	OBL	YES	
ASTER, SMALL WHITE	*Aster vimineus*	Perennial	[3, 4, 5]	FAC	NO	
ASTER, SWAMP	*Aster puniceus*	Perennial	1, [2, 3]	OBL	YES	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
ASTER, TRADESCANT	*Aster tradescanti*	Perennial	[2, 3], 4	FACW	YES	
ASTER, WHITE HEATH	*Aster ericoides*	Perennial	3, [4, 5, 6]	FACU	NO	
ASTER, WILLOW-LEAF	*Aster praealtus*	Perennial	[2, 3], 4	FACW	YES	
BABY-BLUE-EYES, SMALL-FLOWER	*Nemophila aphylla*	Annual	[2, 3], 4	FACW	YES	
BEACHGRASS, AMERICAN	*Ammophila breviligulata*	Grass	4, [5, 6]	FACU-	NO	
BEAKRUSH, FASCICULATE	*Rhynchospora fascicularis*	Grass	[1, 2], 3	OBL	YES	
BEAKRUSH, GRAY'S	*Rhynchospora grayi*	Grass	2, 3, 4, 5, 6	FAC	NO	
BEAKRUSH, PINELAND	*Rhynchospora perplexa*	Grass	[2, 3], 4	FACW+	YES	
BEAKRUSH, TALL	*Rhynchospora macrostachya*	Grass	[1, 2], 3	OBL	YES	
BEARDTONGUE	*Penstemon digitalis*	Perennial	3, 4, 5	FAC	NO	3-8
BEARDTONGUE, LONG-SEPAL	*Penstemon calycosus*	Perennial	[4, 5, 6]	UPL, FACU	NO	
BEARDTONGUE, LOWLAND	*Penstemon alluviorum*	Perennial	[2, 3, 4]	FACW	YES	
BEEBALM	*Monarda didyma*	Perennial	3, 4, 5	FAC+	SATURATED	4-8
BENTGRASS, BROWN	*Agrostis canina*	Grass	[4, 5, 6]	FACU	NO	
BENTGRASS, PERENNIAL	*Agrostis perennans*	Grass	[4, 5], 6	FACU	YES	
BENTGRASS, SPREADING	*Agrostis stolonifera*	Grass	[2, 3], 4	FACW	YES	
BENTGRASS, WINTER	*Agrostis hyemalis*	Grass	[3, 4], 5	FAC	NO	
BERGAMOT, WILD	*Monarda fistulosa*	Perennial	[4, 5, 6]	UPL	NO	
BLACK-EYED SUSAN	*Rudbeckia hirta (yellow)*	Perennial	4, 5, 6	FACU-	NO	3-7
BLADDERWORT, COMMON	*Utricularia macrorhiza*	Perennial	[1, 2], 3	OBL	YES	
BLOODROOT	*Sanguinaria canadensis*	Perennial	4, [5, 6]	UPL, FACU-	NO	
BLUE-EYE GRASS	*Sisyrinchium capillare*	Grass	[2, 3] 4	FACW+	YES	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
BLUEBELLS, VIRGINIA	*Mertensia virginica*	Perennial	[2, 3], 4	FACW	YES	
BLUEFLAG, SOUTHERN	*Iris shrevei*	Perennial	1, [2], 3	OBL	YES	
BLUEFLAG, VIRGINIA	*Iris virginica*	Perennial	1, [2], 3	OBL	YES	
BLUEGRASS, BOG	*Poa paludigena*	Grass	[2, 3], 4	FACW+	YES	
BLUEGRASS, GROVE	*Poa alsodes*	Grass	2, [3, 4], 5	FACW-	SEASONAL	
BLUEGRASS, LOW	*Poa alpigena*	Grass	2, [3, 4], 5	FACW-	SEASONAL	
BLUESTEM, BIG	*Andropogon gerardii*	Grass	[4, 5], 6	FAC	NO	
BLUESTEM, BUSHY	*Andropogon glomeratus*	Grass	[2, 3], 4	FACW+	YES	
BROOM-SEDGE	*Andropogon virginicus*	Grass	[4, 5], 6	FACU	NO	
BULRUSH, HARDSTEMMED	*Scirpus acutus*	Perennial	[1, 2], 3	OBL	0-3'	8
BULRUSH, SOFTSTEM	*Scirpus validus*	Perennial	[1, 2,], 3	OBL	0-1'	8
BULRUSH, ALKALI	*Scirpus robustus*	Grass	1, [2], 3	OBL	SALT, EDGE	
BULRUSH, CLINTON'S	*Scirpus clintonii*	Grass	[4, 5, 6]	FACU	NO	
BULRUSH, OLNEY'S	*Scirpus americanus*	Grass	[1, 2], 3	OBL	0-6"	
BULRUSH, RIVER	*Scirpus fluviatilis*	Grass	[1, 2], 3	OBL	0-1'	
BULRUSH, SPREADING	*Scirpus divaricatus*	Grass	[1, 2], 3	OBL	YES	
BULRUSH, THREE-SQUARE	*Scirpus pungens*	Grass	[2, 3], 4	FACW+	0-6"	
BURREED, AMERICAN	*Sparganium americanum*	Grass	[1, 2], 3	OBL	0-1'	
BURREED, GIANT	*Sparganium eurycarpum*	Grass	[1, 2], 3	OBL	YES	
BUSHCLOVER, NARROW-LEAF	*Lespedeza angustifolia*	Groundcover	4, 5, 6	FACU	NO	
BUTTER-CUP, ALLEGHENY MOUNTAIN	*Ranunculus allegheniensis*	Perennial	[3, 4], 5	FAC	NO	
BUTTER-CUP, POND	*Ranunculus subrigidus*	Perennial	[1, 2], 3	OBL	YES	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
BUTTER-CUP, SEASIDE	*Ranunculus cymbalaria*	Perennial	[1, 2], 3	OBL	YES	
CAMPION, SNOWY	*Silene nivea*	Perennial	[3, 4], 5	FAC	NO	4-8
CARDINAL FLOWER	*Lobelia cardinalis*	Perennial	1, [2, 3], 4	FACW+	YES	2-8
CHICORY	*Cichorium intybus*	Perennial	5, 6	UPL	NO	3-8
CLUB, GOLDEN	*Orontium aquaticum*	Perennial	[1, 2], 3	OBL	YES	
COLTSFOOT, SWEET	*Petasites palmatus*	Perennial	1, [2, 3], 4	FACW+	YES	
COLUMBINE, WILD	*Aquilegia canadensis*	Perennial	[3, 4], 5	FAC	NO	
CONEFLOWER, CUT-LEAF	*Rudbeckia laciniata*	Perennial	[2, 3], 4	FACW	YES	
CONEFLOWER, ORANGE	*Rudbeckia fulgida*	Perennial	[3, 4], 5	FAC	NO	
CONEFLOWER, SWEET	*Rudbeckia subtomentosa*	Perennial	[3, 4], 5	FAC	NO	
CORDGRASS, BIG	*Spartina cynosuroides*	Grass	[1, 2], 3	OBL	SALT, EDGE	
CORDGRASS, PRAIRIE	*Spartina pectinata*	Grass	[1, 2], 3	OBL	SALT, EDGE	
CORDGRASS, SALTMARSH	*Spartina alterniflora*	Grass	[1, 2], 3	OBL	SALT, EDGE	
CORDGRASS, SALTMEADOW	*Spartina patens*	Grass	1, [2, 3], 4	FACW+	SALT, EDGE	
CORNFLOWER	*Centaurea cyanus*	Perennial	5, 6	UPL	NO	
CUTGRASS, RICE	*Leersia oryzoides*	Grass	[1, 2], 3	OBL	0-6"	
DAISY, OXEYE	*Chrysanthemum levcanthemum*	Perennial	5, 6	UPL	NO	
DRAGON-HEAD, FALSE	*Physostegia virginiana*	Perennial	2, [3, 4], 5	FAC+	SATURATED	
DRAGON-HEAD, PURPLE	*Physostegia purpurea*	Perennial	[2, 3], 4	FACW	YES	
DRAGON-HEAD, SLENDER	*Physostegia intermedia*	Perennial	2, [3, 4]	FACW-	SEASONAL	
DRAGON-HEAD, SLENDER-LEAF	*Physostegia leptophylla*	Perennial	[1, 2], 3	OBL	YES	
DROPSEED, SEASHORE	*Sporobolus virginicus*	Grass	1, [2, 3], 4	FACW+	YES	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
DUCKWEED	*Lemna trinervis*	Perennial	[1, 2], 3	OBL	Free Float	
DUCKWEED, LEAST	*Lemna minima*	Perennial	[1, 2], 3	OBL	Free Float	
DUCKWEED, LESSER	*Lemna minor*	Perennial	[1, 2], 3	OBL	Free Float	
DUCKWEED, MINUTE	*Lemna perpusilla*	Perennial	[1, 2], 3	OBL	Free Float	
DUCKWEED, PALE	*Lemna valdiviana*	Perennial	[1, 2], 3	OBL	Free Float	
DWARF PLAINS COREOPSIS	*Coreopsis tinctoria (dwarf)*	Annual	3, [4, 5], 6	FAC-	NO	
EELGRASS	*Zostera marina*	Perennial	[1, 2], 3	OBL	2-6'	3-8
FALSE-HELLEBORE, AMERICAN	*Veratrum viride*	Perennial	[2, 3, 4]	FACW+	YES	
FALSE-SOLOMON'S-SEAL, FEATHER	*Smilacina racemosa*	Perennial	[4, 5], 6	FACU-	NO	
FERN, CINNAMON	*Osmunda cinnamomea*	Fern	[2, 3], 4	FACW	SATURATE	
FERN, NEW YORK	*Thelypteris noveboracensis*	Fern	[3, 4], 5	FAC	SATURATE	
FERN, ROYAL	*Osmunda regalis*	Fern	[1, 2], 3	OBL	SATURATE	
FERN, SENSITIVE	*Onoclea sensibilis*	Fern	[2, 3], 4	FACW	SATURATE	
FESCUE, MEADOW	*Festuca pratensis*	Grass	[3, 4, 5, 6]	FACU-	NO	
FESCUE, NODDING	*Festuca obtusa*	Grass	[4, 5], 6	FACU	NO	
FESCUE, RED	*Festuca rubra*	Groundcover	[4, 5]	FACU	NO	
FLATSEDGE, MARSH	*Cyperus pseudovegetus*	Grass	[2, 3], 4	FACW	YES	
FLATSEDGE, POORLAND	*Cyperus compressus*	Grass	[3, 4], 5	FAC+	SATURATE	
FLATSEDGE, RUSTY	*Cyperus odoratus*	Grass	[2, 3], 4	FACW	YES	
FLATSEDGE, SHORT-LEAF	*Cyperus brevifolius*	Grass	[1, 2], 3	OBL	YES	
FLATSEDGE, SLENDER	*Cyperus filicinus*	Grass	2, [3, 4, 5, 6]	UPL, FAC	YES	
FLAX, VIRGINIA	*Linum virginianum*	Perennial	5, 6	FACU	NO	1-8

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
FLOATING-HEART, YELLOW	*Nymphoides peltata*	Perennial	[1, 2], 3	OBL	YES	
FORGET-ME-NOT, FIELD	*Myosotis arvensis*	Perennial	[3, 4, 5, 6]	UPL	NO	
FOUR-O'CLOCK, HEART-LEAF	*Mirabilis nyctaginea*	Perennial	[4, 5, 6]	FACU	NO	
FOXTAIL, MEADOW	*Alopecurus geniculatus*	Grass	[1, 2], 3	OBL	YES	
FOXTAIL, MEADOW	*Alopecurus pratensis*	Grass	[2, 3], 4	FACW	YES	
FOXTAIL, MOUSE	*Alopecurus myosuroides*	Grass	[2, 3], 4	FACW	YES	
FOXTAIL, SHORT-AWN	*Alopecurus aequalis*	Grass	[1, 2], 3	OBL	YES	
FOXTAIL, TUFTED	*Alopecurus carolinianus*	Grass	[2, 3], 4	FACW	YES	
GLASSWORT, VIRGINIA	*Salicornia virginica*	Perennial	[1, 2], 3	OBL	SALT, EDGE	
GOLDEN-ROD	*Solidago austrina*	Perennial	[1, 2], 3	OBL	YES	
GOLDEN-ROD, COAST	*Solidago spathulata*	Perennial	4, [5, 6]	FACU-	NO	
GOLDEN-ROD, SEASIDE	*Solidago sempervirens*	Perennial	[2, 3], 4	FACW	YES	
GOLDEN-ROD, STIFF	*Solidago rigida*	Perennial	1, 2, 3	OBL	NO	
GRASS, BROOM PANIC	*Dichanthelium scoparium*	Grass	[2, 3], 4	FACW	YES	
GRASS, CANADA MANNA	*Glyceria canadensis*	Grass	[1, 2], 3	OBL	0-1'	
GRASS, EASTERN MANNA	*Glyceria septentrionalis*	Grass	[1, 2], 3	OBL	0-1'	
GRASS, FOWL MANNA	*Glyceria striata*	Grass	[1, 2], 3	OBL	SEASONAL	
GRASS, PANIC	*Dichanthelium acuminatum*	Grass	[2, 3], 4	FAC	NO	
GRASS, PANIC	*Panicum longifolium*	Grass	[1, 2], 3	OBL	YES	
GRASS, ROUGH BARNYARD	*Echinochloa muricata*	Grass	[2, 3], 4	FACW+	YES	
GRASS, SALTMARSH ALKALI	*Puccinellia fasciculata*	Grass	[1, 2], 3	OBL	YES	
GRASS, SALTMEADOW	*Spartina caespitosa*	Grass	[1, 2], 3	OBL	YES	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
HORNWORT, COMMON	*Ceratophyllum demersum*	Perennial	[1, 2], 3	OBL	1-5'	
HORSETAIL, ROUGH	*Equisetum hyemale*	Grass	[2, 3], 4	FACW	YES	
INDIAN-TOBACCO	*Lobelia inflata*	Perennial	[4, 5, 6]	FACU	NO	
IRIS, BLUE WATER	*Iris versicolor*	Perennial	[1, 2], 3	OBL	0-6"	2-7
IRIS, BEACH-HEAD	*Iris hookeri*	Perennial	4, [5, 6]	FACU-	NO	
IRIS, BEACH-HEAD	*Iris setosa*	Perennial	[3, 4], 5	FAC	NO	
IRIS, COPPER	*Iris fulva*	Perennial	[1, 2], 3	OBL	YES	
IRIS, LAMANCE	*Iris brevicaulis*	Perennial	[1, 2], 3	OBL	YES	
JACK-IN-THE-PULPIT, SWAMP	*Arisaema triphyllum*	Perennial	[2, 3], 4	FACW	SEASONAL	
JACOB'S LADDER	*Polemonium reptans*	Perennial	[4, 5], 6	FACU	NO	3-8
JACOB'S LADDER, BOG	*Polemonium van-bruntiae*	Perennial	[3, 4], 5	FAC+	SATURATED	
LILY, CANADA	*Lilium canadense*	Perennial	2, [3, 4]	FAC+	YES	
LILY, CAROLINA	*Lilium michauxii*	Perennial	[3, 4, 5]	FAC	NO	
LILY, GRAY'S	*Lilium grayi*	Perennial	3, [4, 5], 6	FACU	NO	
LILY, SOUTHERN RED	*Lilium catesbaei*	Perennial	[2, 3, 4]	FACW	YES	
LILY, TURK'S-CAP	*Lilium superbum*	Perennial	[2, 3, 4]	FACW+	YES	
LIZARDS TAIL	*Saururus cemuus*	Perennial	2, 3, 4	OBL	0-1'	2-8
LOBELIA, BOYKIN'S	*Lobelia boykinii*	Perennial	[1, 2], 3	OBL	YES	
LOBELIA, BROOK	*Lobelia kalmii*	Perennial	[1, 2], 3	OBL	YES	
LOBELIA, DOWNY	*Lobelia puberula*	Perennial	[2, 3, 4]	FACW-	SEASONAL	
LOBELIA, ELONGATED	*Lobelia elongata*	Perennial	[1, 2], 3	OBL	YES	
LOBELIA, GEORGIA	*Lobelia georgiana*	Perennial	[2, 3, 4]	FACW	YES	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
LOBELIA, GREAT BLUE	*Lobelia siphilitica*	Perennial	[2, 3], 4	FACW+	YES	
LOBELIA, NUTTALL'S	*Lobelia nuttallii*	Perennial	[2, 3, 4]	FACW	YES	
LOBELIA, PALE-SPIKE	*Lobelia spicata*	Perennial	[3, 4, 5]	FAC-	NO	
LOBELIA, SOUTHERN	*Lobelia amoena*	Perennial	[1, 2], 3	OBL	YES	
LOBELIA, WATER	*Lobelia dortmanna*	Perennial	[1, 2], 3	OBL	YES	
LOTUS, AMERICAN	*Nelumbo lutea*	Perennial	[1, 2], 3	OBL	1-5'	
LOTUS, SACRED	*Nelumbo nucifera*	Perennial	[1, 2], 3	OBL	1-5'	
LOVEGRASS, MEADOW	*Eragrostis refracta*	Grass	[2, 3,] 4	FACW	YES	
LOVEGRASS, PURPLE	*Eragrostis pectinacea*	Grass	[4, 5], 6	FAC	NO	
MALLOW, VIRGINIA SEASHORE	*Kosteletzkya virginica*	Perennial	[1, 2], 3	OBL	SALT, EDGE	
MARSH MARIGOLD	*Caltha palustris*	Perennial	3, 4	OBL	6" SATURATE	3-8
MARSH SMARTWEED	*Polygonum hydropiperoides*	Perennial	2, 3	OBL	0-1'	2-8
MARSH SMARTWEED	*Polygonum puntatum*	Perennial	2, 3	OBL	SATURATE	2-8
MARSH-MALLOW, COMMON	*Althaea officinalis*	Perennial	[1, 2, 3]	FACW+	YES	
MEADOW-RUE, PIEDMONT	*Thalictrum macrostylum*	Perennial	[2, 3, 4]	FACW	YES	
MILKWORT, MARYLAND	*Polygala mariana*	Annual	[2, 3, 4]	FACW	YES	
MONKEY-FLOWER	*Mimulus ringens*	Perennial	[1, 2], 3	OBL	YES	3-8
MONKEY-FLOWER, COMMON LARGE	*Mimulus guttatus*	Annual	[1, 2], 3	OBL	YES	
MOUNTAIN-MINT, NARROW-LEAF	*Pycnanthemum flexuosum*	Perennial	[2, 3, 4]	FACW	YES	
MUHLY, MARSH	*Muhlenbergia glomerata*	Grass	[2, 3], 4	FACW	YES	
NIMBLE-WILL	*Muhlenbergia schreberi*	Grass	[3, 4, 5]	FAC	NO	
NUTRUSH	*Scleria flaccida*	Grass	[2, 3], 4	FACW	YES	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
PANSY, FIELD	*Viola bicolor*	Annual	[4, 5, 6]	FACU	NO	
PARTRIDGE-BERRY	*Mitchella repens*	Groundcover	[4, 5], 6	FACU	NO	
PENNSYLVANIA SMARTWEED	*Polygonum pensylvanicum*	Annual	[2, 3]	FACW	0-6"	2-8
PENNY-WORT, MANY-FLOWER	*Hydrocotyle umbellata*	Perennial	[1, 2], 3	OBL	0-1'	
PHLOX, FALL	*Phlox paniculata*	Perennial	[4, 5], 6	FACU	NO	
PHLOX, MEADOW	*Phlox maculata*	Perennial	[2, 3, 4]	FACW	YES	
PHLOX, WOODLAND	*Phlox divaricata*	Perennial	[4, 5, 6]	FACU	NO	
PICKERELWEED	*Pontederia cordata*	Perennial	2, 3	OBL	0-1'	2-8
PLANTAIN, SEASIDE	*Plantago maritima*	Perennial	1, 2, 3, 4	FACW	YES	
PLUMEGRASS, SUGARCANE	*Erianthus giganteus*	Grass	[2, 3]	FACW+	YES	
PONDWEED, CLASPING-LEAF	*Potamogeton perfoliatus*	Perennial	[1, 2], 3	OBL	1' MIN-6'	
PONDWEED, LONG-LEAF	*Potamogeton nodosus*	Perennial	[1, 2]	OBL	1' MIN-6'	
PONDWEED, SAGO	*Potamogeton pectinatus*	Perennial	[1, 2]	OBL	1' MIN-24'	
PRIMROSE, BIRDSEYE	*Primula laurentiana*	Perennial	[4], 5	FAC	NO	
REED, MEADOWGRASS	*Glyceria maxima*	Grass	[1, 2], 3	OBL	YES	
REEDGRASS, BLUE-JOINT	*Calamagrostis canadensis*	Grass	[1, 2], 3	FACW+	6" SATURATE	
ROCKCRESS, ALPINE	*Arabis alpina*	Perennial	[3, 4, 5]	FAC+	SATURATE	
ROSE-GENTIAN, NARROW-LEAF	*Sabatia brachiata*	Annual	[4, 5, 6]	FACU	NO	
RUSH, ARCTIC	*Juncus arcticus*	Grass	[1, 2], 3	OBL	YES	
RUSH, GRASS-LEAF	*Juncus marginatus*	Grass	[2, 3], 4	FACW	YES	
RUSH, NARROW-PANICLE	*Juncus brevicaudatus*	Grass	[1, 2], 3	OBL	YES	
RUSH, NEEDLEGRASS	*Juncus roemeranus*	Grass	[1, 2], 3	OBL	SALT, EDGE	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
RUSH, SALTMEADOW	*Juncus gerardii*	Grass	[2, 3], 4	FACW+	YES	
RUSH, SLIM-POD	*Juncus diffusissimus*	Grass	[2, 3], 4	FACW	YES	
RUSH, SOFT	*Juncus effusus*	Grass	[2, 3], 4	FACW+	0-1'	4-8
RUSH, TURNFLOWER	*Juncus biflorus*	Grass	[2, 3], 4	FACW	YES	
RYEGRASS, PERENNIAL	*Lolium perenne*	Groundcover	[4, 5, 6]	FACU-	NO	
SALTGRASS, SEASHORE	*Distichlis spicata*	Grass	[2, 3,] 4	FACW+	SALT, EDGE	
SAWGRASS, SMOOTH	*Cladium mariscoides*	Grass	[1, 2], 3	OBL	YES	
SAXIFRAGE, SWAMP	*Saxifraga pensylvanica*	Perennial	[1, 2], 3	OBL	YES	
SAXIFRAGE, VIRGINIA	*Saxifraga virginiensis*	Perennial	[4, 5]	FAC-	NO	
SEA-LAVENDER, CAROLINA	*Limonium carolinianum*	Perennial	[1, 2], 3	OBL	YES	
SEA-LAVENDER, NORTHERN	*Limonium nashii*	Perennial	[1, 2], 3	OBL	YES	
SEA-OATS	*Uniola paniculata*	Grass	[4, 5, 6]	FACU-	NO	
SEDGE, BEARDED	*Carex comosa*	Grass	[1, 2], 3	OBL	6" SATURATE	
SEDGE, BENT	*Carex styloflexa*	Grass	2, [3, 4]	FACW-	YES	7-8
SEDGE, CAT-TAIL	*Carex typhina*	Grass	[2, 3], 4	FACW+	YES	5-8
SEDGE, CRESTED	*Carex cristatella*	Grass	[1, 2], 3, 4	FACW	YES	
SEDGE, FESCUE	*Carex festucacea*	Grass	[3, 4, 5]	FAC	NO	4-6
SEDGE, FOX	*Carex vulpinoidea*	Grass	[1, 2], 3	OBL	SAT. 0-6"	
SEDGE, FRINGED	*Carex crinita*	Grass	[1, 2], 3	OBL	YES	
SEDGE, GRACEFUL	*Carex gracillima*	Grass	[4, 5], 6	FACU	NO	7
SEDGE, HOARY	*Carex canescens*	Grass	[1, 2], 3	OBL	YES	
SEDGE, INLAND	*Carex interior*	Grass	1, [2, 3]	OBL	YES	5-8

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
SEDGE, LAKEBANK	*Carex lacustris*	Grass	[1, 2], 3	OBL	SAT. 0-2'	
SEDGE, LOOSE-FLOWERED	*Carex laxiflora*	Grass	[4, 5, 6]	FACU	NO	5-8
SEDGE, RETRORSE	*Carex retrorsa*	Grass	[2, 3], 4	FACW+	SAT. 0-6"	
SEDGE, SHALLOW	*Carex lurida*	Grass	[1, 2], 3	OBL	YES	5-8
SEDGE, SWAN'S	*Carex swanii*	Grass	[4, 5, 6]	FACU	NO	5-8
SEDGE, UPTIGHT	*Carex stricta*	Grass	[1, 2], 3	OBL	SAT. 0-6"	
SEDGE, WOOLY	*Carex lanuginosa*	Grass	[1, 2], 3	OBL	SAT. 0-6"	
SEDGE, YELLOW-FRUIT	*Carex annectens*	Grass	[2, 3,] 4	FACW+	YES	
SEEDBOX	*Ludwigia x lacustris*	Annual	[1, 2], 3	OBL	YES	
SENNA, MARYLAND	*Cassia marilandica*	Groundcover	3, [4, 5]	FAC+	SATURATED	
SKULLCAP	*Scutellaria churchilliana*	Perennial	[2, 3], 4	FACW	YES	
SOLOMON'S-SEAL, GREAT	*Polygonatum commutatum*	Perennial	[4, 5, 6]	FACU	NO	
SOLOMON'S-SEAL, SMALL	*Polygonatum biflorum*	Perennial	[4, 5, 6]	FACU	NO	
SPIKERUSH, BLUNT	*Eleocharis obtusa*	Grass	[1, 2], 3	OBL	0-6"	
SPIKERUSH, CREEPING	*Eleocharis palustris*	Grass	[1, 2], 3	OBL	SEASONAL	
SPIKERUSH, ENGELMANN'S	*Eleocharis engelmannii*	Grass	[2, 3], 4	FACW+	YES	
SPIKERUSH, SQUARE-STEM	*Eleocharis quadrangulata*	Grass	[1, 2], 3	OBL	0-1'	
SPRING BLUE EYE, MARY	*Collinsia verna*	Perennial	4, 5, 6	FAC-	NO	1-8
ST. JOHN'S-WORT, MARSH	*Triadenum fraseri*	Perennial	[1, 2], 3	OBL	YES	
STARWORT, MARSH	*Stellaria palustris*	Perennial	[5], 6	FACU	NO	
STONECROP, ROCK	*Sedum pulchellum*	Perennial	[4, 5, 6]	FACU	NO	
STONECROP, ROSEROOT	*Sedum rosea*	Perennial	3, 4, 5, 6	FACU	NO	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
SWAMP MILKWEED	*Asclepias incarnata*	Perennial	2, 3	OBL	SATURATED	3-8
SWAMP ROSE MALLOW	*Hibiscus moscheutos*	Perennial	2, 3	OBL	0-3"	4-8
SWAMP SMARTWEED	*Polygonum coccineum*	Perennial	2, 3, 4	OBL	0-3'	2-8
SWAMP-LOOSESTRIFE, HAIRY	*Decodon verticillatus*	Perennial	[1, 2], 3	OBL	YES	
SWITCHGRASS	*Panicum virgatum*	Grass	2, [3, 4], 5	FAC	SEASONAL	
TREFOIL, BIRD'S-FOOT	*Lotus corniculatus*	Perennial	4, 5, 6	FACU-	NO	2-8
TURTLEHEAD, RED	*Chelone obliqua*	Perennial	[1, 2], 3	OBL	YES	
TURTLEHEAD, WHITE	*Chelone glabra*	Perennial	[1, 2], 3	OBL	YES	
VALERIAN, EDIBLE	*Valeriana edulis*	Perennial	[1, 2], 3	OBL	YES	
VERVAIN, BLUE	*Verbena hastata*	Perennial	2, 3, 4	FACW+	YES	
VIOLET, APPALACHIAN BLUE	*Viola appalachiensis*	Perennial	[4, 5], 6	FACU	NO	
VIOLET, COASTAL	*Viola brittoniana*	Perennial	[3, 4], 5	FAC	NO	
VIOLET, COMMON BLUE	*Viola papilionacea*	Perennial	[3, 4, 5]	FAC	NO	
VIRGINIA WILD RYE	*Elymus virginicus*	Grass	2, [3, 4]	FACW-	YES	
WATER SMARTWEED	*Polygonum amphibium*	Perennial	2, 3	OBL	SAT. 6"	2-8
WATER-CRESS, TRUE	*Nasturtium officinale*	Annual	[1, 2], 3	OBL	2"-1'	
WATER-LILY, PYGMY	*Nymphaea tetragona*	Perennial	[1, 2], 3	OBL	1-3'	
WATER-LILY, WHITE	*Nymphaea odorata*	Perennial	[1, 2], 3	OBL	1-3'	
WATER-LILY, WHITE	*Nymphaea tuberosa*	Perennial	[1, 2], 3	OBL	1-3'	
WATER-LILY, YELLOW/ SPATTERDOCK	*Nuphar advena/luteum*	Perennial	[1, 2], 3	OBL	1-3'	
WHORLED COREOPSIS	*Coreopsis verticillata*	Perennial	[2, 3], 4	FACW	YES	3-8
WIDGEON-GRASS	*Ruppia maritima*	Grass	[1, 2], 3	OBL	1' MIN	

COMMON	SCIENTIFIC	FORM	ZONE	INDICATOR	INUNDATION TOLERANCE	HARDINESS
WILD LILY-OF-THE-VALLEY	*Maianthemum canadense*	Perennial	[4, 5], 6	FAC-	NO	
WITCHGRASS, HELLER'S	*Dichanthelium oligosanthes*	Grass	[4, 5, 6]	FACU	NO	
WITCHGRASS, NEEDLE-LEAF	*Dichanthelium aciculare*	Grass	[4, 5, 6]	FACU	NO	
WOOD-REEDGRASS, SLENDER	*Cinna latifolia*	Grass	[2, 3, 4]	FACW	YES	
WOODRUSH, COMMON	*Luzula multiflora*	Grass	[4, 5, 6]	FACU	NO	
WOOL-GRASS	*Scirpus cyperinus*	Grass	[2, 3], 4	FACW+	SEASONAL	

APPENDIX B

TECHNICAL SUPPORT DOCUMENT

Procedure for designing infiltration in conjunction with infiltration trenches, bioretention and pervious pavement BMPs

Infiltration rates are used in two types of computations:

1. *Estimation of time for an infiltration facility to dewater (a dewatering time of 72-hours or less is required for all BMPs).*
2. *Estimation of the permissible reduction in storage volume, based on the assumption that water will be infiltrating during the runoff capture design storm.*

When computing infiltration rates for the purposes of estimating dewatering time, it will be sufficient to determine an average steady infiltration rate for the device. In making this calculation, assume the water level within the device is no greater than 1/5 of its potential maximum depth.

When computing infiltration rates for the purposes of routing runoff through an infiltration device, it will be necessary to develop an inflow hydrograph. The hydrograph shall be the runoff predicted for the up-gradient drainage area during the water quality design storm. The computation of runoff can be truncated after the required runoff retention design storm volume has been evaluated. For example, in Recharge Zone 4, where the required runoff capture design storm is 1.15 inches, the runoff analysis can be terminated after 165 minutes. The inflow hydrograph will be influenced by runoff control measures that are installed up-gradient of the infiltration device (e.g., sand filters, detention basins).

In all dynamic analyses, a method of routing flow through the BMP will be required. The storage/indication or Modified Puls algorithm (PACD, 1998) shall be used, unless an alternative approach is approved by the engineer. Be sure to take the displacement volume of granular fill into account. The porosity of granular fill shall be assumed to be 25 percent, unless laboratory tests can be provided that show higher porosity.

Two approaches, based on unsaturated flow or saturated flow assumptions, are available. Initial infiltration rate is dependent upon both capillary and gravitational potentials. As the "wetted front" moves downward and radially outward from the infiltration device, the envelope of saturated soil enlarges and the rate of flow decreases in response to the reduction in the potential gradient. However, this effect is partially offset by increases in the effective hydraulic conductivity associated with higher moisture content. After the soil is fully saturated, seepage flow is governed by

Darcy assumptions for saturated gravitational flow. Generally, initial infiltration rates associated with unsaturated flow will be more rapid than infiltration under saturated conditions. Therefore, estimates of infiltration based on saturated flow assumptions will lead to conservative results.

Option I: Saturated Flow with Factor of Safety

The rate of infiltration can be approximated conservatively using the following assumptions:

1. *Saturated hydraulic conductivity*
2. *Unit hydraulic gradient*
3. *Area equal to the bottom area of the trench or infiltration bed*

Such that:

$$IN = K_s \times A$$

; where: IN = infiltration rate

K_s = saturated hydraulic conductivity

A = bottom area

Alternatively, the Dupuit-Forscheimer equation for radial flow can be used, in which the infiltration device is treated as if it were an injection well. In this approach, an injection "well diameter," d, is selected that will provide an area equal to the bottom area of the infiltration bed or trench.

$$IN = \frac{\pi \times K_s \times (h^2 - H^2)}{\ln(D/2) - \ln(d/2)}$$

; where: d = effective diameter

h = depth of water level in the device above bedrock

H = depth of water table above bedrock

D = diameter of the area of influence

For a linear trench, the equation becomes:

$$IN/b = \frac{K_s \times (h^2 - H^2)}{L/2 - l/2}$$

; where: b = length of the trench

l = width of the trench

L = width of area of influence

The saturated hydraulic conductivity, K_s, can be derived from field testing, or generic values can be used (see below). A factor of safety of 2.0 should be applied to account for energy losses at the soil-water boundary and uncertainties related to vertical-flow gradients. The primary advantage of this approach is its sensitivity to the thickness of the permeable soil strata.

Option II: Variably Saturated Flow

This approach can be used where the soil profile is deep and saturated flow assumptions are likely to significantly underestimate actual infiltration rates. Today, the most expedient way to predict unsaturated infiltration flow is with a two-dimensional computer model. Many easy-to-use models are available. One of these is HYDRUS2D, distributed by the International Ground Water Modeling Center (IGWMC) (Simunek, 1999). This program solves the Richard's equation for variably saturated flow in two dimensions (Maidment, 1993, p. 5.19). The IGWMC also offers INFIL, a program that solves the one-dimensional form of the Richard's equation. These models will accept the inflow hydrograph developed for the device and predict time-varying rate of infiltration during the design event. As with all variably saturate flow algorithms, the solution is strongly influenced by the assumed initial moisture conditions.

Other algorithms for predicting variably saturated flow include the familiar Green-Ampt model. The Green-Ampt model predicts one-dimensional time-varying seepage flow. The model predicts higher infiltration rates at early times. However, as time progresses, the infiltration rate approaches the steady flow rate for saturated conditions.

$$IN = K_s \times A + \frac{(\phi - \theta_i) \times S_f}{F};$$

where: ϕ = *soil porosity*

θ_i = *moisture content in advance of the wetted front*

S_f = *suction at the wetted front (about 10 cm for soils typical of this area; Maidment, 1993)*

F = *cumulative rainfall*

The Green-Ampt method can be readily implemented using a spreadsheet. Computer programs using this algorithm are also available and are acceptable for estimating infiltration rates.

Hydraulic Conductivity

An estimate of saturated hydraulic conductivity will be required to design infiltration devices. The following generic values may be used. Alternatively, field testing may be used to measure insitu hydraulic conductivity. Hydraulic conductivity should be measured at the soil horizon that will be encountered by the bottom of the infiltration device. Double-ring infiltrometers or basin flooding tests should be used in accordance with Environmental Protection Agency guidance (EPA, 1981). A factor of safety of at least 3.0 should be used in association with all field measurements to account for inhomogeneity and for reduction in permeability over time.

Bare Earth, Minimal Compaction

Appropriate for BMPs where grading or compaction can be minimized. Examples are infiltration trenches, raingardens, and packet sand filters.

Hydraulic conductivity greater than or equal to 2.0 in/hr

Soils Series: Klinesville, Parker, Pompton, Riverhead

Hydraulic conductivity greater than or equal to 0.6 in/hr

Soil Series: Califon, Cokesbury, Ellington, Reaville, Whippany, Minoa, Neshaminy, Edneyville, Pattenburg

Hydraulic conductivity greater than or equal to 0.2 in/hr

Soil Series: Parsippany, Penn, Biddeford

Bare Earth, With Compaction

Appropriate for BMPs where site requirements will require moderate compaction, or where grading activities are likely to compact soil. Examples are below-grade infiltration beds (e.g., permeable pavement) and bioretention terraces.

Hydraulic conductivity greater than or equal to 0.6 in/hr

Soil Series: Klinesville, Parker, Pompton, Riverhead

Hydraulic conductivity greater than or equal to 0.2 in/hr

Soil Series: Ellington, Edneyville, Pattenburg

Not acceptable for infiltration after compaction, unless field measurements demonstrate hydraulic conductivity greater than 0.6 (prior to applying 3.0 factor of safety):

Soil Series: Biddeford, Parsippany, Penn, Califon, Cokesbury, Reaville, Whippany, Minoa, Neshaminy

A. Analysis of Rainfall Distribution

A detailed statistical analysis of rainfall distribution in northern New Jersey has been prepared using daily rainfall summaries from the Boonton NOAA recording weather station. This information has been used to develop specific recommendations about design criteria for water quality BMPs. In particular, a close examination of rainfall patterns shows that relatively more rainfall is associated with smaller storms than previously reported.

24-Hour Rainfall Depth (inches)	*Fraction of Total Annual Rainfall[1] (percent)*
0.06	*10*
0.13	*20*
0.20	*30*
0.30	*40*
0.43	*50*
0.59	*60*
0.85	*70*
1.25	*78*
1.42	*80*
1.58	*90 (water quality design storm)*
1.93	*99*
2.75	*99.7 (one-year frequency)*

A report by Tourbier and Walmsley (1996), citing a study by CH2M HILL (1992), recommended that 69 percent of annual rainfall be retained on the Watershed to eventually evapotranspirate or percolate to ground water. On a watershed-wide basis, 17 percent of rainfall was presumed to percolate to regional ground water. According to the present analysis, 70 percent of annual precipitation occurs in storms that deliver 0.85 inches of rainfall or less. The model ordinance, based on the earlier analysis, recommended that the threshold for runoff from developed sites be 1.25 inches.

A recent study by the New Jersey Geologic Survey (NJGS) concluded that the water balance varies across the Watershed. The NJGS report identifies seven recharge zones with associated pre-development percolation rates ranging from 40 percent to 0. Based on this information, pre-development rainfall retention ranged between 50 and 80 percent. This is associated with 1.4 to 0.4 inches of rainfall.

It is important to note that this approach will assign a runoff retention requirement even for D soils. The rationale is that, while retention of water in these areas will not necessarily contribute to regional ground water resources, it will still offer benefits of augmenting base flow in adjacent streams, sustaining wetland vegetation, filtering runoff, lengthening times of concentration, and reducing the frequency and depth of inundation within the Refuge.

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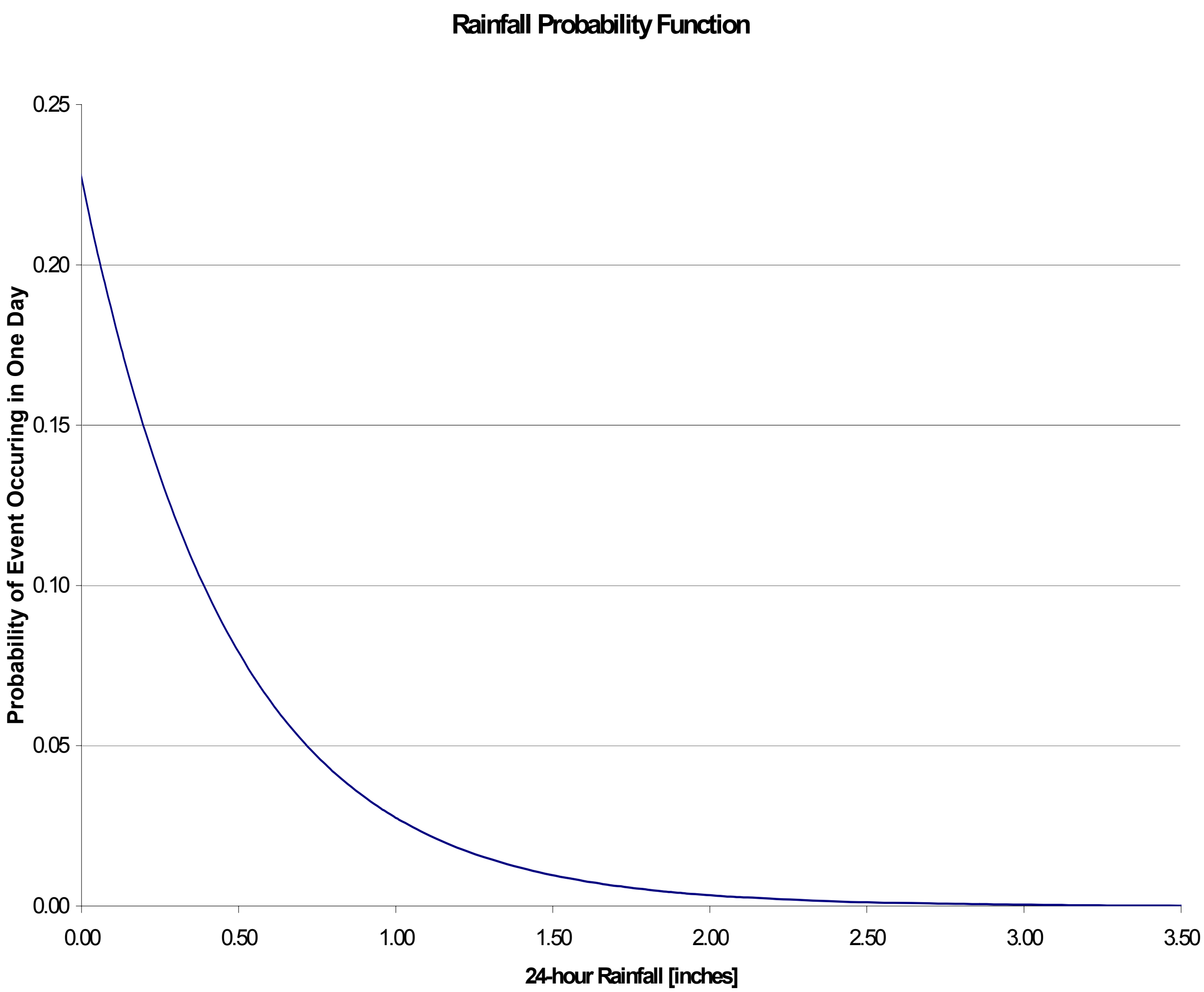
[1] *Fraction of total annual rainfall contributed by all 24-hour rainfall events with magnitudes equal to or less than the stated rainfall depth.*


Rainfall Probability Function
Probability of Event Occuring in One Day
0.25
0.20
0.15
0.10
0.05
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
24-hour Rainfall [inches]

B. Landscape Standards for BMPs

Landscaping is a critical element to improve both the function and appearance of stormwater BMPs. This section provides landscaping criteria and plant selection guidance for effective stormwater BMPs. Specific guidance for plant selection is provided in Appendix A.

<u>Native Species</u>

This manual encourages the use of native plants in stormwater management facilities. Native plants are defined as those species that evolved naturally to live in this region. Practically speaking, this refers to those species that lived in the region before Europeans explored and settled in America. Many introduced species were weeds brought in by accident; others were intentionally introduced and cultivated for use as medicinal herbs, spices, dyes, fiber plants, and ornamentals.

Introduced species can often escape cultivation and begin reproducing in the wild. This is significant ecologically because many introduced species out-compete indigenous species and begin to replace them in the wild. Some introduced species like kudzu, phragmites, and dandelions are invasive, have few predators, and can take over naturally occurring species at an alarming rate. By planting native species in stormwater management facilities, we can protect the Great Swamp's natural heritage and provide a legacy for future generations.

Native species also have distinct genetic advantages over nonnative species for planting. Because they have evolved to live here naturally, indigenous plants are best suited for our local climate. This translates into greater survivorship when planted, and less replacement and maintenance during the life of a stormwater management facility. Both of these attributes provide cost savings for the facility owner.

Finally, people often plant exotic species for their ornamental value. While it is important to have aesthetic stormwater management facilities for public acceptance and the maintenance of property value, it is not necessary to introduce foreign species for this purpose. Many native species are aesthetically pleasing and can be used as ornamentals. For example, the following species are part of our natural heritage and provide high aesthetic value throughout the year: rhododendron, pink azalea, red maple, pin oak, sycamore, flowering dogwood, mountain laurel, willow, hemlock, white pine, bald cypress, Atlantic cedar, American holly, black-eyed susan, sunflower, lobelia, pickerel weed, marsh hibiscus, and yellow pond lily. When selecting ornamentals for stormwater management facilities, planting preference should be given to native ornamentals. Please refer to the plant list in Appendix A for a comprehensive list of native species available for stormwater management facility planting.

Because wildlife habitat is likely to be an important concern for the residents of Harding Township, the following additional design features that can promote wildlife value are also suggested for inclusion when designing landscapes:

- *Irregular shorelines or pond edges;*
- *Installation of nest boxes in the wooded buffers where they are near permanent water, such as a stream or pond;*
- *Grassy meadows that are only mowed once or twice a year to create "savannah" habitats for open meadow species, such as meadow larks, which are on the decline due to lack of habitat.*

General Landscaping Guidance for All BMPs

- *Trees, shrubs, and/or any type of woody vegetation, while encouraged within most BMPs, are not allowed on the embankment.*
- *Plant trees and shrubs at least 15 feet away from the toe of an embankment.*
- *Trees or shrubs known to have long taproots should not be permitted to establish within the vicinity of subsurface drainage facilities.*
- *Plant trees and shrubs at least 25 feet away from perforated pipes.*
- *Plant trees and shrubs at least 25 feet away from principal spillway structures.*
- *Provide 15-foot clearance from low-flow orifice.*
- *Use erosion control mats and fabrics in channels to reduce the potential for erosion.*
- *Stabilize all bypass channels and emergency spillways with plant material that can withstand strong flows. Root material should be fibrous and substantial, but lacking a taproot.*
- *Divert flows temporarily from seeded areas until stabilized.*
- *Do not block maintenance access to structures with trees or shrubs.*
- *To reduce thermal warming, shade inflow and outflow channels as well as southern exposures of detention ponds.*
- *Avoid plantings that will require routine or intensive chemical applications (i.e., turf area).*
- *Have soil tested to determine if there is a need for amendments.*
- *Native plant species should be specified over exotic or foreign species because they are well adapted to local on-site soil conditions and require little or no additional amendments.*
- *Decrease the areas where turf is used, in favor of low-maintenance*

meadow and ground cover plants.

- *Plant stream and water buffers with trees, shrubs, ornamental grasses, and herbaceous materials where possible to stabilize banks and provide shade.*
- *Maintain and frame desirable views. Be careful not to block views at entrances, exits, or difficult road curves. Screen unattractive views into the site. Aesthetics and visual characteristics should be a prime consideration.*
- *Use plants to discourage pedestrian access to pools or steeper slopes.*
- *The designer should carefully consider the long-term vegetation management strategy for the BMP, keeping in mind the "maintenance" legacy for the future owners. Make sure the facility maintenance agreement includes requirements to ensure vegetation cover in perpetuity.*
- *Provide signage for:*
    1. *Stormwater management areas to help educate the public.*
    2. *Wildflower areas, when possible, to designate limits of mowing.*
- *Utilize diverse plants to create a stable and robust plant community that can withstand periodic upsets from climatic or cultural disturbances.*
- *Preserve existing natural vegetation when possible.*

It is necessary to test the soil in which you are about to plant in order to determine the following:

- *pH: whether acid, neutral, or alkaline.*
- *major soil nutrients: nitrogen, phosphorus, potassium.*
- *minerals: such as chelated iron, lime.*

Have soil samples analyzed by experienced and qualified individuals who will explain in writing the results and what they mean, as well as the soil amendments that would be required. Certain soil conditions, such as marine clays, can present serious constraints to the growth of plant materials and may require the guidance of qualified professionals. When poor soils cannot be amended, seed mixes and plant material must be selected to establish ground cover as quickly as possible.

Areas that recently have been involved in construction can become compacted, so that plant roots cannot penetrate the soil. Also, seeds may lie on the surface of compacted soils and are often washed away, or eaten by birds. For planting success, soils should be loosened to a depth of three to five inches. Hard soils may require disking to a deeper depth. The soil should be loosened regardless of the ground cover. This will improve seed contact with the soil, increase germination rates, and allow the roots to penetrate the *soil. For areas to be sodded, disking is necessary so that the roots can penetrate the soil. Providing good growing conditions can prevent poor vegetative cover. This saves money because vegetation will not need to be replanted.*

If topsoil has been stockpiled in deep mounds for a long period of time, it is necessary to test the soil for pH, as well as microbial activity. If the microbial activity has been destroyed, it is necessary to inoculate the soil after application.

Remember that newly installed plant material requires water in order to recover from the shock of being transplanted. Be sure that some source of water is provided, especially during dry periods. This will reduce plant loss and provide the new plant materials with a chance to establish root growth.

BE IT FURTHER RESOLVED that this resolution shall take effect 30 days following approval, and shall continue in effect unless and until modified, except that it shall expire and have no further effect on the 366th day after approval if the New Jersey DEP has not issued a NJPDES permit or equivalent to the Township of Harding covering the operation and maintenance of the infiltration BMPs contained herein.

BE IT FURTHER RESOLVED that the Township of Harding shall file with the Site Improvement Advisory Board a copy of the ordinance adopting the special area standards with respect to stormwater management within 30 days of its final adoption.

APPROVED BY: The Site Improvement Advisory Board

DATE: October 24, 2002

Robert C. Kirkpatrick, Jr.
Chair

I HEREBY CERTIFY the foregoing to be a true copy of the resolution adopted by the New Jersey Site Improvement Advisory Board at its meeting of October 24, 2002.

Mary Ellen Handelman
Secretary to the Board