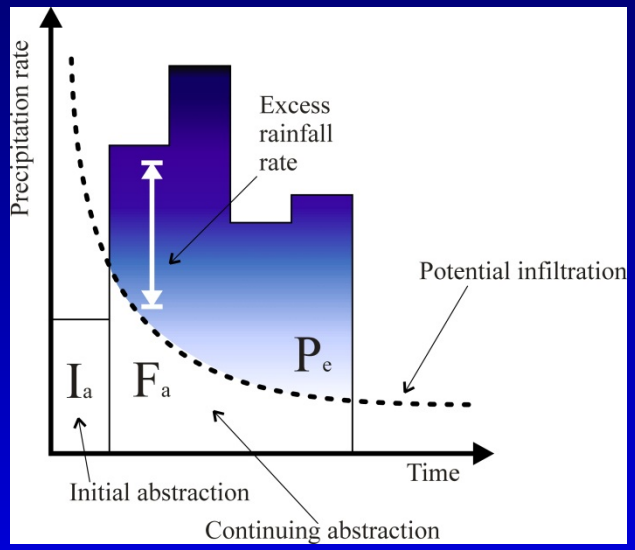
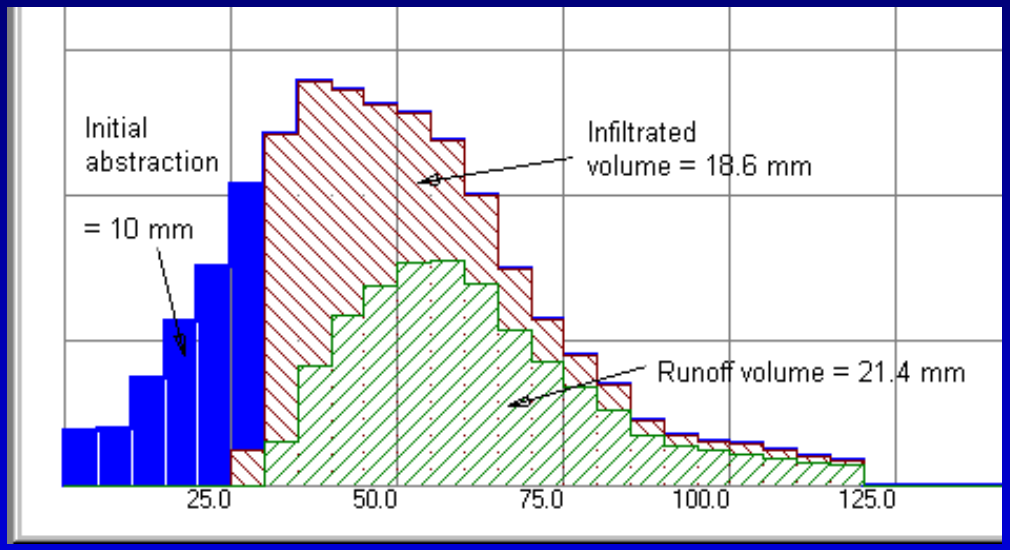
Revisions to the Delaware Sediment & Stormwater Regulations

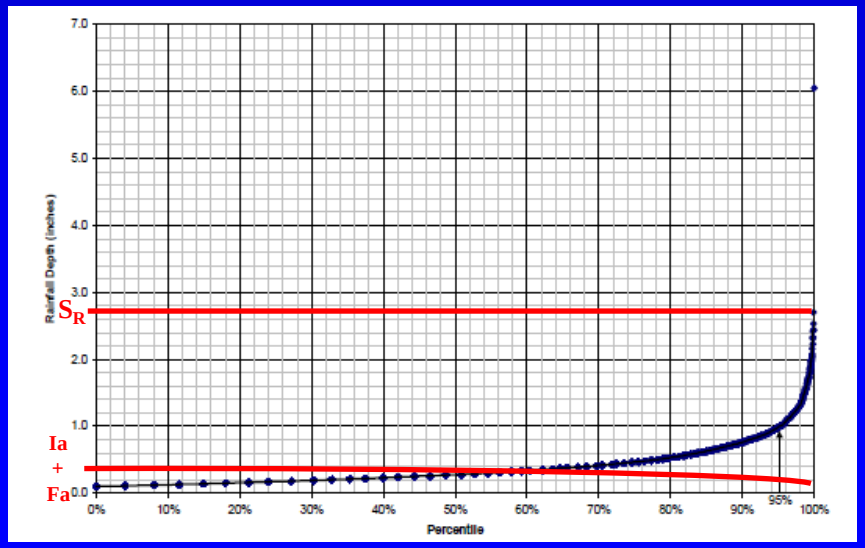
Technical Subcommittee Meeting
December 12, 2011

Review of Stormwater BMPs for the Resource Protection Event (RPv)

RPv BMP Hydrology







Runoff Reduction BMPs

GREEN TECHNOLOGY

Biofiltration Swales

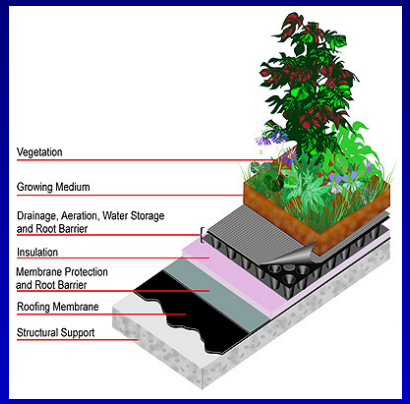
Biofiltration swales convey runoff at shallow flow depths through wide, flat-bottomed swales. They can be very effective in removing Total Suspended Solids (TSS) and adsorbed metals, although less effective in terms of decreasing the amount of nutrients contained in water.

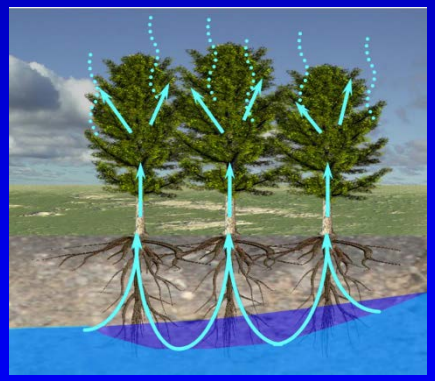
Infiltration Trenches

Most Green Technology BMPs incorporate infiltration as part of the treatment process. Specific infiltration facilities include infiltration trenches. Infiltration trenches located in swales provide additional wetted surface area and storage volume, and often they can be designed to penetrate shallow impermeable soil profiles to recharge deeper soil horizons.

FOR MORE INFORMATION

For more information, please contact the Delaware Department of Natural Resources and Environmental Control, Sediment and Stormwater Program at (302) 739-9921.





- Retention Practices (i.e., storage)
- Annual Reduction Practices (i.e., abstraction)

DURMM v.2

Runoff Reduction
&
Pollutant Reduction Modeling

DURMM v.2: BMP Categories

- Volume Management Practices
  - Reduce pollutant load
    - Retention Practices
      - Design criteria based on storage capacity for 1-YR event
      - *ex.*; bioretention w/o underdrain
    - Annual Runoff Reduction Practices
      - Design criteria based on reduction of annual runoff
      - *ex.*; filter strip
- Stormwater Treatment Practices
  - Reduce pollutant concentration
  - Design criteria based on empirical removal efficiency data
  - ex.; wet pond

DURMM v.2: BMP Performance Standards

	DURMM v.2				
BMP	TN	TP	TSS	RR, A/B Soil	RR, C/D Soil
Runoff Reduction Practices					
Urban Infiltration Practices with Sand/Vegetation (including Bioretention w/o Underdrain)	100% of Load Reduct.	100% of Load Reduct.	100% of Load Reduct.	100% of Storage	100% of Storage
Urban Infiltration Practices without Sand/Vegetation	100% of Load Reduct.	100% of Load Reduct.	100% of Load Reduct.	100% of Storage	100% of Storage
Bioretention with Underdrain (including planter boxes, etc.)	Max 60% inc. Load Reduct.	Max 50% inc. Load Reduct.	Max 80% inc. Load Reduct.	50% of Storage	50% of Storage
Permeable Pavement with Sand/Vegetation	100% of Load Reduct.	100% of Load Reduct.	100% of Load Reduct.	100% of Storage	100% of Storage
Permeable Pavement without Sand/Vegetation	100% of Load Reduct.	100% of Load Reduct.	100% of Load Reduct.	100% of Storage	100% of Storage
Vegetated Roofs	100% of Load Reduct.	100% of Load Reduct.	100% of Load Reduct.	100% of Storage	100% of Storage
Rainwater Harvesting	100% of Load Reduct.	100% of Load Reduct.	100% of Load Reduct.	75% of Storage	75% of Storage
Impervious Disconnection	100% of Load Reduct.	100% of Load Reduct.	100% of Load Reduct.	20%	10%
Bioswale	Max 45% inc. Load Reduct.	Max 45% inc. Load Reduct.	Max 80% inc. Load Reduct.	50%	25%
Vegetated Open Channels	Max 20% inc. Load Reduct.	Max 20% inc. Load Reduct.	Max 50% inc. Load Reduct.	20%	10%
Filter Strip	Max 20% inc. Load Reduct.	Max 20% inc. Load Reduct.	Max 80% inc. Load Reduct.	20%	15%
Urban Riparian Forest Buffers	Max 25% inc. Load Reduct.	Max 50% inc. Load Reduct.	Max 50% inc. Load Reduct.	25%	15%
Urban Tree Planting	N/A	N/A	N/A	0%	0%
Soil Amendments	N/A	N/A	N/A	0%	0%
Sheetflow to Turf Open Space	100% of Load Reduct.	100% of Load Reduct.	100% of Load Reduct.	40%	40%
Sheetflow to Forested Open Space	100% of Load Reduct.	100% of Load Reduct.	100% of Load Reduct.	65%	40%
Wet Swales and Ephemeral Wetlands	Max 40% inc. Load Reduct.	Max 25% inc. Load Reduct.	Max 80% inc. Load Reduct.	0%	10%
Stormwater Treatment Practices					
Dry Extended Detention Basins	20%	20%	60%	10%	10%
Dry Detention Ponds	5%	10%	10%	0%	0%
Hydrodynamic Structures	5%	10%	10%	0%	0%
Urban Filtering Practices	40%	60%	80%	0%	0%
Wetlands and Wet Ponds	20%	45%	60%	0%	0%
Source Control Practices					
Urban Nutrient Management	17%	22%	N/A	0%	0%
Street Sweeping	3%	3%	9%	0%	0%
Other Practices					
Urban Stream Restoration	0.02 lbs N/ft	0.003 lbs P/ft	2 lbs TSS/ft	0%	0%

BLUE: BMPs contained in CB P5 Model
RED: BMPs not currently modeled in CB P5 Model

Standards & Specifications for Post-Construction Stormwater BMPs

3.06.2 Standards & Specifications for Post-Construction Stormwater BMPs

1. Infiltration
2. Bioretention
3. Permeable Pavement
4. Vegetated Roofs
5. Rainwater Harvesting
6. Regenerative SW Conveyance
7. Rooftop Disconnection
8. Vegetated Channels
9. Sheet Flow to Open Space
10. Detention Practices
11. Filtering Practices
12. Wetlands
13. Wet Ponds
14. Soil Amendments
15. Proprietary Practices

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Article 3. Plan Review and Approval

- 3.01 Goals and Objectives
  - 3.01.1 Standard Plans
    - 3.01.1.1 Residential
    - 3.01.1.2 Agricultural Structure
    - 3.01.1.3 Utility Construction
- 3.02 Plan Review Process - Detailed Plans
  - 3.02.1 Step 1 Project Application Meeting
    - Appx. 3.02.1.1 Stormwater Assessment Study Checklist *NEW!*
    - Appx. 3.02.1.2 Project Application Meeting Discussion and Agreement Items *NEW!*
    - Appx. 3.02.1.3 Stormwater Assessment Report *NEW!*
    - Appx. 3.02.1.4 Workflow for Site Hydrologic Analysis
    - Appx. 3.02.1.5 Example Project Application Package
  - 3.02.2 Step 2 Preliminary Sediment and Stormwater Plan *NEW!*
    - Appx. 3.02.2.1 Preliminary Sediment and Stormwater Plan Checklist *NEW!*
    - Appx. 3.02.2.2 Hydraulics and Hydrology Analysis Procedure *NEW!*
    - Appx. 3.02.2.3 Workflow for Level 1 Analysis
    - Appx. 3.02.2.4 Workflow for Level 2 Analysis
    - Appx. 3.02.2.5 Example Construction Site Stormwater Management Schematic Plan
    - Appx. 3.02.2.6 Example Unit Discharge Computations
    - Appx. 3.02.2.7 Example Preliminary Sediment and Stormwater Plan Submittal Package
      - Appx. 3.02.2.7.1 Residential *NEW!*
      - Appx. 3.02.2.7.2 Commercial *NEW!*
      - Appx. 3.02.2.7.3 Institutional *NEW!*
      - Appx. 3.02.2.7.4 Redevelopment *NEW!*
  - 3.02.3 Step 3 Sediment and Stormwater Plan *NEW!*
    - Appx. 3.02.3.1 Sediment and Stormwater Management Plan Checklist *NEW!*
    - Appx. 3.02.3.2 Example Sediment and Stormwater Management Plan
- 3.03 Construction Site Stormwater Management *NEW!*
  - Appx. 3.03.1 Turbid Discharges Best Available Technology Policy
- 3.04 Post Construction Stormwater Management *NEW!*
  - Appx. 3.04.1 Stormwater Management Compliance Flow Chart
  - Appx. 3.04.2 Runoff Reduction Guidance
  - Appx. 3.04.3 Adjusted Curve Number Methodology
  - Appx. 3.04.4 DURMM v.2 Spreadsheet NOTE: **Please save a copy of this file to your computer before using it.**
  - Appx. 3.04.5 DURMM v.2 Quick Start Guide
  - Appx. 3.04.6 DURMM v.2 User Guide
  - Appx. 3.04.7 Approved Hydraulics and Hydrology Software
- 3.05 General Plan Requirements *NEW!*
  - Appx. 3.05.1 Typical Sequence of Construction *NEW!*
  - Appx. 3.05.2 Example Sediment and Stormwater Plan Coversheet *NEW!*
- 3.06 Sediment and Stormwater BMP Standards and Specifications
  - Appx. 3.06.1 Delaware Erosion and Sediment Control Handbook
  - Appx. 3.06.2 Standards and Specifications for Green Technology BMPs
    - Appx. 3.06.2.1 Infiltration *NEW!*
    - Appx. 3.06.2.2 Bioretention *NEW!*
    - Appx. 3.06.2.3 Permeable Pavement
    - Appx. 3.06.2.4 Vegetated Roofs *NEW!*
    - Appx. 3.06.2.5 Rainwater Harvesting *NEW!*
    - Appx. 3.06.2.6 Regenerative Stormwater Conveyance
    - Appx. 3.06.2.7 Rooftop Disconnection *NEW!*
    - Appx. 3.06.2.8 Vegetated Channel
    - Appx. 3.06.2.9 Sheet Flow to Open Space *NEW!*
    - Appx. 3.06.2.10 Detention Practices *NEW!*
    - Appx. 3.06.2.11 Filtering Practices *NEW!*
    - Appx. 3.06.2.12 Wetlands
    - Appx. 3.06.2.13 Wet Ponds *NEW!*
    - Appx. 3.06.2.14 Soil Amendments *NEW!*
    - Appx. 3.06.2.15 Proprietary Practices *NEW!*
  - Appx. 3.06.3 Pond Code 378
  - Appx. 3.06.4 Design of Stormwater Conveyance Systems
  - Appx. 3.06.5 Design of Flow Control Structures

Unknown Zone (Mixed) 100%

1.0 Infiltration

1.0 Stormwater Infiltration

Definition: Practices that capture and temporarily store the design storm volume before allowing it to infiltrate into the soil over a two day period.

Design variants include:

- 1-A Infiltration Trench
- 1-B Infiltration Basin

Infiltration practices use temporary surface or underground storage to allow incoming stormwater runoff to exfiltrate into underlying soils. Runoff first passes through multiple pretreatment mechanisms to trap sediment and organic matter before it reaches the practice. As the stormwater penetrates the underlying soil, chemical and physical adsorption processes remove pollutants. Infiltration practices are suitable for use in residential and other urban areas where *measured* soil permeability rates exceed 1 inch per hour. To prevent possible groundwater contamination, infiltration should not be utilized at sites designated as stormwater hotspots. Extraordinary care shall be taken to assure that long-term infiltration rates are achieved through the use of performance bonds, post construction inspection and long-term maintenance.

1.1 Infiltration Stormwater Credit Calculations

Infiltration practices receive 100% retention volume credit (R_v) for the volume stored and infiltrated by the practice (**Table 1.1**). No additional pollutant removal credit is awarded.

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- Definition
- Variants

1.0 Infiltration

Table 1.1 Infiltration Performance Credits

Runoff Reduction	
Retention Allowance	100%
RPv	100% of Retention Storage
Cv	100% of Retention Storage
Fv	100% of Retentions Storage
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction

The practice must be sized using the guidance detailed in *Section 1.5. Infiltration Design Criteria*

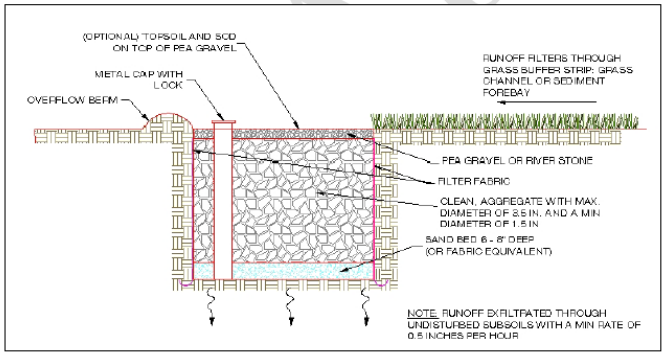

Figure 1.1. Example of an Infiltration Trench.

- Table *X*.1
  - Runoff Reduction
    - Retention Allowance
    - Annual Runoff Reduction
    - % Reduction for RPv, Cv, Fv
  - Pollutant Reduction
    - RR Practices
      - % Load Reduction
    - Treatment Practices
      - % Removal Efficiency
- Graphic for Variants

1.0 Infiltration

1.2 Infiltration Design Summary

Table 1.2 summarizes design criteria for infiltration practices, and Table 1.3 summarizes the materials specifications for these practices. For more detail, consult Sections 1.3 through 1.7. Sections 1.8 describes practice construction and maintenance criteria.

Table 1.2 Infiltration Design Summary

	Basins	Trenches
Feasibility (Section 1.3)	• Minimum soil infiltration of 1"/hr • Restrictions for treating hotspots, high loads, or dry weather flows • 2 foot separation from seasonal high groundwater for infiltration without underdrain • For infiltration with underdrain, invert of underdrain must be above seasonal high groundwater • Setbacks from wells, buildings and utilities	
Conveyance (Section 1.4)	• Must safely convey the Conveyance Event (Cv)	
Pretreatment (Section 1.5)	• 25% to 50% of retention volume in pretreatment, depending on soil infiltration rate • All runoff must be treated • Several pretreatment options may be used	
Sizing (Maximum Depth) (Section 1.6)	$d_{max} = \frac{1}{2} i \times t_d$	$d_{max} = \left(\frac{1}{2} i \times t_d\right) / \eta_r$
	Maximum depth limits as well, based on practice size and CDA (See Table 1.4)	
Sizing (Surface Area) (Section 1.6)	$SA = Sv / (d + \frac{1}{2} i \times t_f)$	$SA = Sv / (\eta_r \times d + \frac{1}{2} i \times t_f)$
Variables:	t_d = maximum drawn down time (days - 2) i = field-verified infiltration rate for the native soils (ft./day) η_r = available porosity of the stone reservoir (assume 0.4) Sv = Retention volume treated by the practice d = Infiltration depth (ft.) t_f = Time to fill the infiltration facility (days – typically 2 hours, or 0.083 days)	
Geometry (Section 1.6)	• Flat trench or basin bottom • 4:1 or flatter internal side slopes for basins • 2' or lower maximum ponding depth for basins	• Wider than they are deep to avoid injection well status
Landscaping (Section 1.7)	Maintain vegetation in the buffers and practice drainage area to minimize erosion and debris	

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- Table *X*.2
  - BMP Design Summary
  - References to appropriate section for more info

1.0 Infiltration

Table 1.3. Infiltration Material Specifications

Material	Specification	Notes
Surface Layer (optional)	Topsoil and grass layer	
Stone Layer	Clean, aggregate with a maximum diameter of 2.5 inches and a minimum diameter of 0.5 inches (Delaware #3).	
Observation Well	Install a vertical 6-inch Schedule 40 PVC perforated pipe, with a lockable cap and anchor plate	Install one per 50 feet of length of infiltration practice, minimum 1 well per practice
Overflow collection pipe (optional)	Use 4-inch or 6-inch rigid schedule 40 PVC pipe, with 3/8" perforations at 6 inches on center	
Filter Fabric (sides only)	Use polypropylene geotextile with a flow rate of > 110 gallons/min./sq. ft. (e.g.,GD-II)	

1.3 Infiltration Feasibility Criteria

Infiltration practices have very high storage and retention capabilities when sited and designed appropriately. Designers should evaluate the range of soil properties during initial site layout and seek to configure the site to conserve and protect the soils with the greatest recharge and infiltration rates. In particular, areas of Hydrologic Soil Group A or B soils shown on NRCS soil surveys should be considered as primary locations for infiltration practices. Additional information about soil and infiltration are described in more detail later in this section. During initial design phases, designers should carefully identify and evaluate constraints on infiltration, as follows:

EPA Requirements for Class V Injection Wells. Certain types of practices in this category may be classified as a Class V Injection Wells, which are subject to regulations under the Federal Underground Injection Control (UIC) program. In general, if the facility allows stormwater runoff to come in direct contact with groundwater it would meet this criterion. Facilities with a minimum 2' vadose zone separation from the groundwater table would not meet the criterion. Designers are advised to contact the DNREC Groundwater Discharges Section for additional information regarding UIC regulations and possible permitting requirements.

Contributing Drainage Area. To be most effective minimize the contributing drainage area (CDA). The CDA should be as close to 100% impervious as possible to minimize organic capping and maintenance concerns. The facility specific design, pretreatment and maintenance requirements will differ depending on the size of the infiltration practice.

Site Topography. Infiltration shall not be located on slopes greater than 5%. Further, unless slope stability calculations demonstrate otherwise, infiltration practices should be located a minimum

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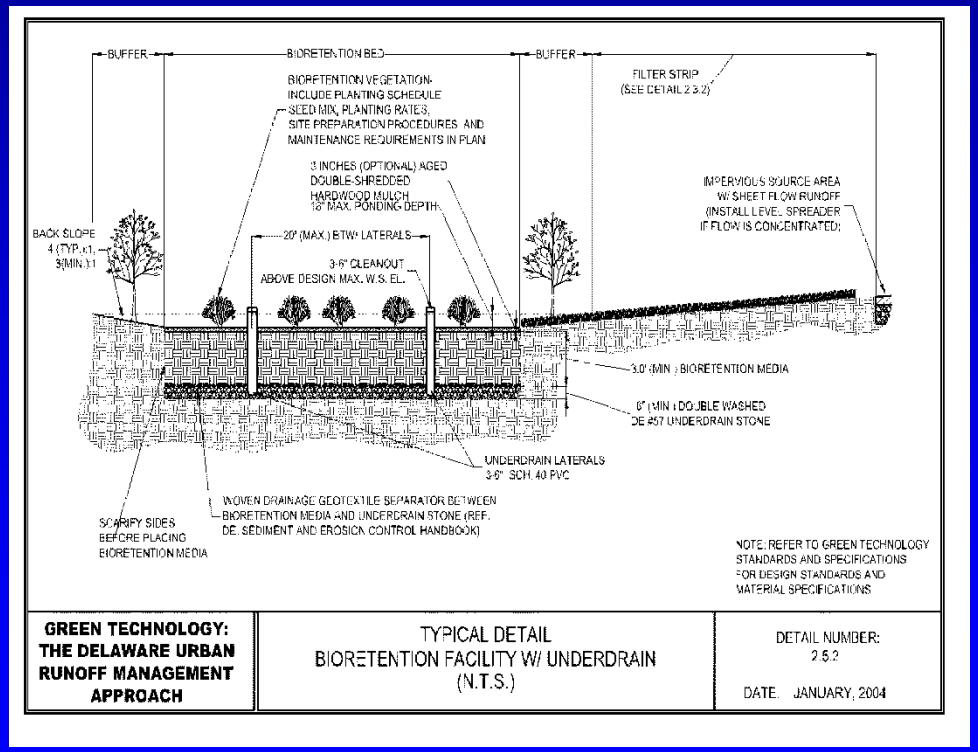
- Table *X*.3 (as needed)
  - Material Specifications
- Remaining Sections
  - Feasibility Criteria
  - Detailed Design Criteria
  - Detailed Material Specs (as needed)
  - Landscaping Criteria (as needed)
  - Construction Info
  - Maintenance Criteria
  - References

2.0 Bioretention

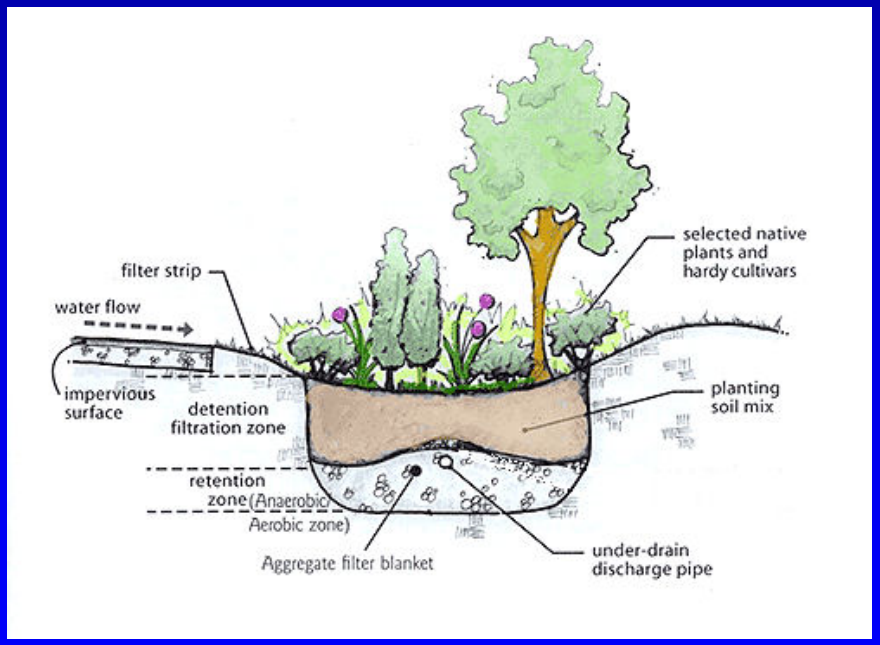
Typical Section (Current)



- 2”-3” mulch (optional)
- Min. 3’ planting soil
- Woven geotextile; $\geq$ 110 gpm
- Underdrain layer
  - 4”-6” pipe
  - 6”-8” DE #57 stone

2.0 Bioretention

Typical Section NEW!



- Underdrain layer
  - 4”-6” cpp
  - 2’ ~~DE #57~~ rice gravel (1/4”) sump

2.0 Bioretention

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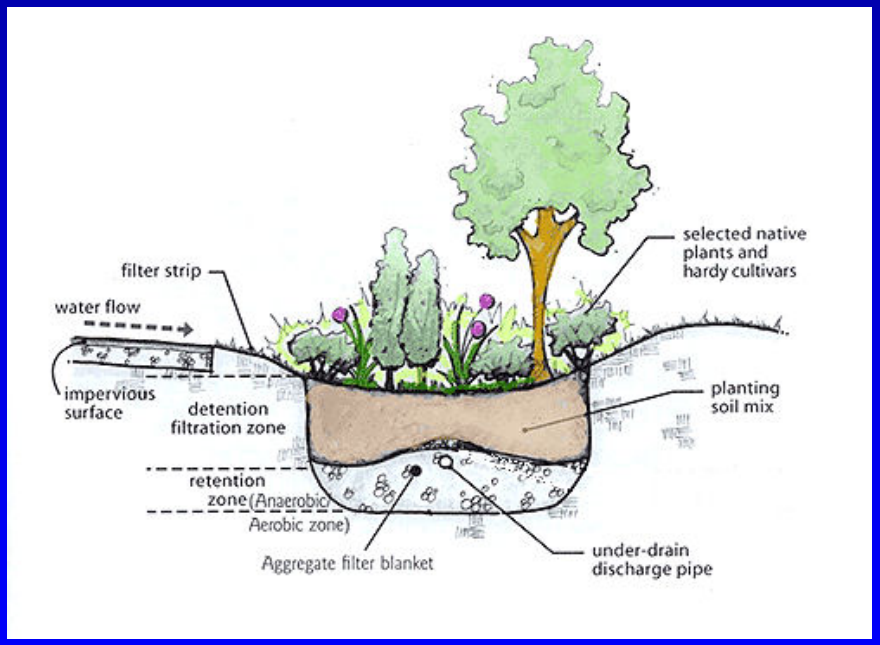
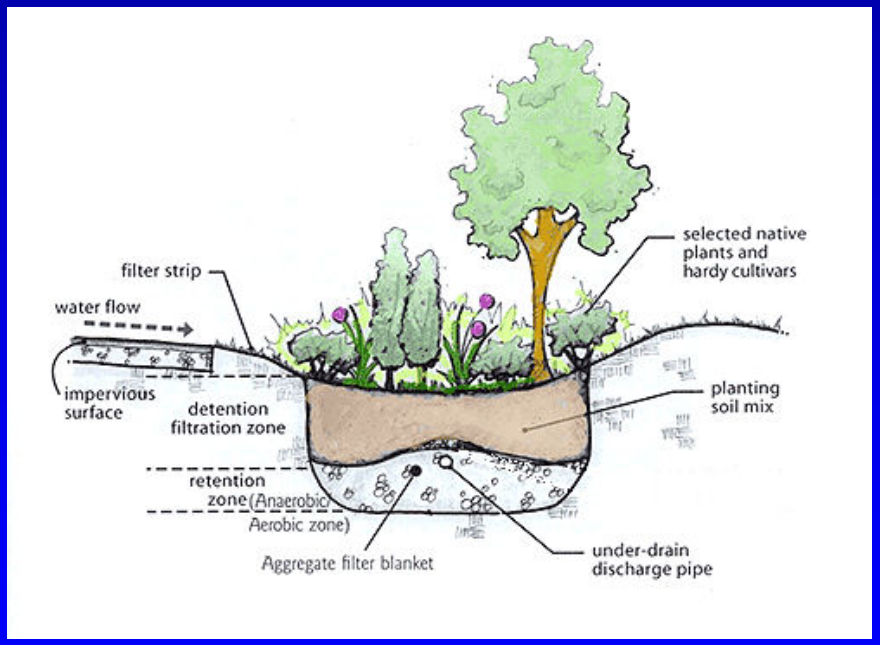


- ~~Woven geotextile; ≥ 110 gpm~~
- Underdrain layer
  - 4”-6” cpp
  - 2’ ~~DE #57~~ rice gravel (1/4”) sump

2.0 Bioretention

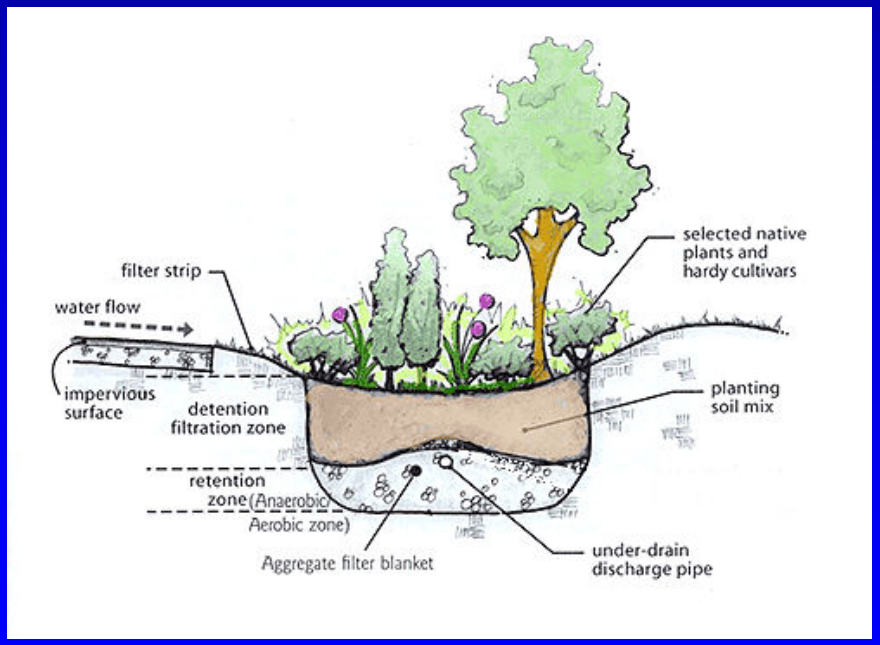
Typical Section NEW!



- Min. ~~3'~~ 2' planting soil
- ~~Woven geotextile; ≥ 110 gpm~~
- Underdrain layer
  - 4"-6" cpp
  - 2' ~~DE #57~~ rice gravel (1/4") sump

2.0 Bioretention

Typical Section NEW!



- 2”-3” mulch ~~(optional)~~
- Min. ~~3’~~ 2’ planting soil
- ~~Woven geotextile; ≥ 110 gpm~~
- Underdrain layer
  - 4”-6” cpp
  - 2’ ~~DE #57~~ rice gravel (1/4”) sump

Material Specifications: Sand

- ASTM C-33 concrete sand
- Clean, washed
- Fineness modulus of 2.75 or greater

Material Specifications: Mulch

- Free of dirt & debris
- Triple shredded hardwood
- Single shredded may be used as top dressing

Material Specifications: Peat Moss

- Virgin sphagnum peat moss
- Typically must be imported from Canada

Material Specifications: **Compost**

- Yard waste based
- Aged
- **Certified**

US Composting Council

Material Specifications

Bioretention Soil Mix NEW!

- Volumetric quantities
  - **60%** concrete sand
  - **20%** triple shredded hardwood mulch
  - **20% aged, <u>certified</u> compost**
- Drum mixed batch
- DNREC approved supplier

2.0 Bioretention

2.0 Bioretention

Definition: Practices that capture and store stormwater runoff and pass it through a filter bed of engineered soil media comprised of sand, lignin and organic matter. Filtered runoff may be collected and returned to the conveyance system, or allowed to infiltrate into the soil. Design variants include:

- 2-A Traditional Bioretention
- 2-B In-Situ Bioretention (including Residential Rain Gardens)
- 2-C Streetscape Bioretention
- 2-D Engineered Tree Pits
- 2-E Stormwater Planters
- 2-F Advanced Bioretention Systems

Bioretention systems are typically not designed to provide stormwater detention of larger storms (e.g., 10-yr) but they may be in some circumstances. Bioretention practices shall generally be combined with a separate facility to provide those controls.

For each of the design variants above, there are two basic configurations:

- *Underdrain Designs*: Practices with a standard underdrain design; pollutant reduction occurs through a combination of runoff reduction and treatment by the filtering media. Addition of an infiltration sump is required to maximize runoff reduction performance. Advanced systems may provide greater pollutant removal capabilities through the use of improved media components and/or internal modifications that encourage partial anaerobic conditions.
- *Infiltration Designs:* Practices with no underdrains that can infiltrate the design storm volume in 48 hours; pollutant reduction is based solely on load reduction provided by the retention storage volume.

The particular design configuration to be implemented on a site is typically dependent on specific site conditions and the characteristics of the underlying soils. These criteria are further discussed below.

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- Variants
  - 2-A Traditional Bioretention
  - 2-B In-Situ Bioretention (including Residential Rain Gardens)
  - 2-C Streetscape Bioretention
  - 2-D Engineered Tree Pits
  - 2-E Stormwater Planters
  - 2-F Advanced Bioretention Systems
- Sub-Categories
  - Underdrain Designs
  - Infiltration Designs

2.0 Bioretention

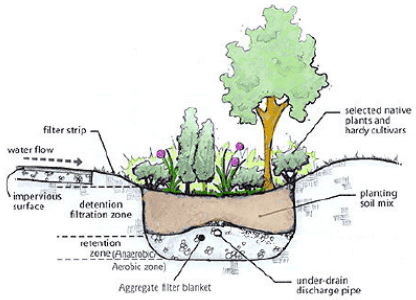

Figure 2.1. Bioretention Underdrain Design.

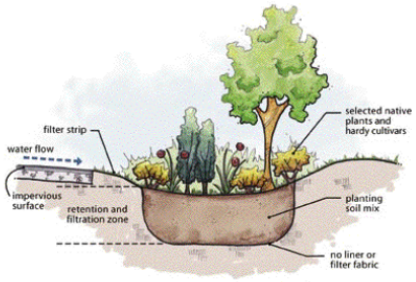

Figure 2.2. Bioretention Infiltration Design

2.1(a) Bioretention With Underdrain Performance Credits	
Runoff Reduction	
Retention Allowance	50%
RPv -A/B Soil	100% of Retention Storage
RPv - C/D Soil	100% of Retention Storage
Cv	100% of Retention Storage
Fv	100% of Retention Storage
Pollutant Reduction	
TN Reduction	100% of Load Reduction (max. 60% Removal Efficiency)
TP Reduction	100% of Load Reduction (max. 50% Removal Efficiency)
TSS Reduction	100% of Load Reduction (max. 80% Removal Efficiency)

2.1(b) Bioretention Without Underdrain Performance Credits	
Runoff Reduction	
Retention Allowance	100%
RPv -A/B Soil	100% of Retention Storage
RPv - C/D Soil	100% of Retention Storage
Cv	100% of Retention Storage
Fv	100% of Retention Storage
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction

3.0 Permeable Pavement

3.0 Permeable Pavement Systems

Definition: Alternative paving surfaces that capture and temporarily store the RPv by filtering runoff through voids in the pavement surface into an underlying stone reservoir. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially infiltrate into the soil.

Design variants include:

- 3-A Porous Asphalt (PA)
- 3-B Pervious Concrete (PC)
- 3-C Permeable interlocking concrete Pavers (PP) or Concrete grid Pavers (CP)
- 3-D Plastic Grid Pavers (GP)

Other variations of permeable pavement that are DDOE approved permeable pavement surface materials are also encompassed in this section.

Permeable pavement systems are not typically designed to provide stormwater detention of larger storms (e.g., 10-yr, 100-yr), but they may be in some circumstances. Permeable pavement practices shall generally be combined with a separate facility to provide those controls.

There are two different types of permeable pavement design configurations:

- *Standard Designs*: Practices with a standard underdrain design and no infiltration sump or water quality filter
- *Enhanced Designs*: Practices with no underdrains that can infiltrate the design storm volume in 48 hours OR practices with underdrains that contain a water quality filter layer AND an infiltration sump beneath the underdrain sized to drain the design storm in 48 hours.

The particular design configuration to be implemented on a site is typically dependent on specific site conditions and the characteristics of the underlying soils. These criteria are further discussed below.

DRAFT

- Variants
  - 3-A Porous Asphalt (PA)
  - 3-B Pervious Concrete (PC)
  - 3-C Permeable Interlocking Concrete Pavers (PP) or Concrete Grid Pavers (CP)
  - 3-D Plastic Grid Pavers (GP)

3.0 Permeable Pavement

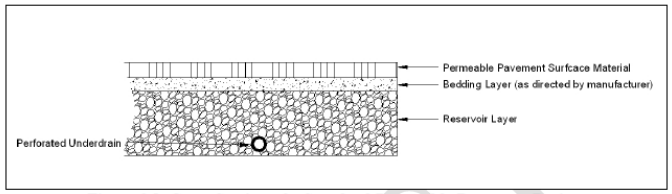

Figure 3.1. Cross Section of a Standard Permeable Pavement Design.

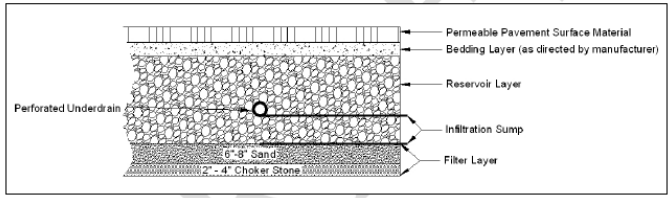

Figure 3.2. Cross Section of an Enhanced Permeable Pavement Design with an Underdrain.

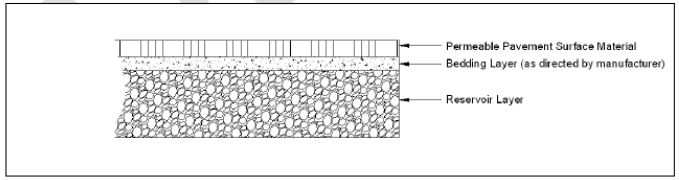

Figure 3.3. Cross Section of an Enhanced Permeable Pavement Design without an Underdrain.

3.1 Permeable Pavement Performance Credits	
Runoff Reduction	
Retention Allowance	100%
RPv -A/B Soil	100% of Storage
RPv - C/D Soil	100% of Storage
Cv	100% of Storage
Fv	100% of Storage
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction

4.0 Vegetated Roofs

4.0 Vegetated Roofs

© Element Design Group, Berkley River Restaurant, Lewes

Definition: Practices, on top a building, that capture and store rainfall in an engineered growing media, which is designed to support plant growth. A portion of the captured rainfall evaporates or is taken up by plants, which helps reduce runoff volumes, peak runoff rates, and pollutant loads on development sites. Vegetated Roofs, also known as green roofs, typically contain a layered system of roofing, which is designed to support plant growth and retain water for plant uptake while preventing ponding on the roof surface. The roofs are designed so that water drains vertically through the media and then horizontally along a waterproofing layer towards the outlet. Two types of vegetated roofs exist: extensive or intensive. They vary based on the depth of soil and type of plants.

Design variants include:

- 4-A Extensive Vegetated Roofs: Shallow growing media with drought resistant succulent plants, such as sedums
- 4-B Intensive Vegetated Roofs: Deep growing media with traditional plantings and irrigation

Vegetated Roofs are typically not designed to provide stormwater detention of larger storms (e.g., 10-yr, 100-yr) although some intensive vegetated roof systems may be designed to meet or partially meet these criteria, or the vegetated roof could be integrated with a rainwater harvesting system. However, most vegetated roof designs generally are combined with a separate facility located away from the building to provide large storm controls.

This specification is intended for situations where the primary design objective of the Vegetated Roof is stormwater management. Green roof benefits go beyond just stormwater management, but the ancillary benefits are not covered within this specification.

- Variants
  - 4-A Extensive Vegetated Roofs
  - 4-B Intensive Vegetated Roofs

4.0 Vegetated Roofs

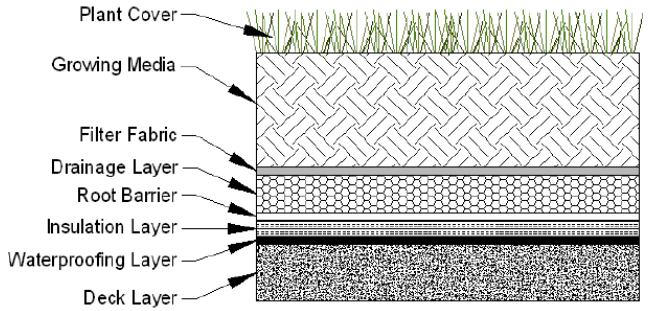

Figure 4.1. Typical Layers for a Vegetated Roof.

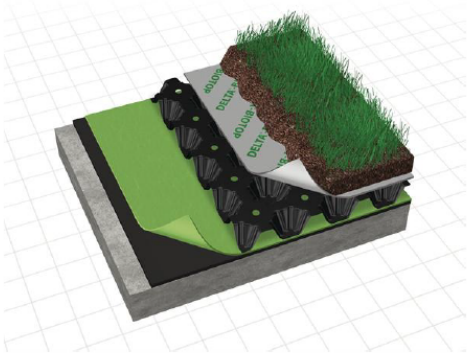

Figure 4.2. Drainage Layer (Delta Floraxx) Designed to Capture Water in Cups (Photo Source: http://www.ecohomemagazine.com/green-products/drainage-system-for-green-roofs-from-cosella-dorken.aspx)

4.1(a) Extensive Vegetated Roof Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil	50% Annual Runoff Reduction
RPv - C/D Soil	0%
Cv	5%
Fv	1%
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	N/A

4.1(b) Intensive Vegetated Roof Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil	75% Annual Runoff Reduction
RPv - C/D Soil	0%
Cv	8%
Fv	2%
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	N/A

5.0 Rainwater Harvesting

5. Rainwater Harvesting

Photo courtesy of Lake County (IL) Stormwater Management Commission

Definition: Rainwater Harvesting systems intercept, divert, store and release rainfall for future use. Rainwater that falls on a rooftop is collected and conveyed into an above- or below-ground storage tank (also referred to as a cistern or rain tank), where it can be used for non-potable water uses and on-site stormwater disposal/infiltration. Non-potable uses may include landscape irrigation, exterior washing (e.g. car washes, building facades, sidewalks, street sweepers, fire trucks, etc.), flushing of toilets and urinals inside buildings, fire suppression (sprinkler) systems, supply for chilled water cooling towers, replenishing and operation of water features and water fountains, distribution to a green wall or living wall system, and laundry. In many instances, Rainwater Harvesting can be combined with a secondary (down-gradient) stormwater practice to enhance stormwater retention and/or provide treatment of overflow from the Rainwater Harvesting system.

Rainwater Harvesting systems are separated into two categories. Design variants include:

- 5-A Seasonal Rainwater Harvesting Systems
- 5-B Continuous Rainwater Harvesting Systems

By providing a reliable and renewable source of water to end users, Rainwater Harvesting systems can also have environmental and economic benefits beyond stormwater management (e.g., increased water conservation, water supply during drought and mandatory municipal water supply restrictions, decreased demand on municipal or groundwater supply, decreased water costs for the end-user, potential for increased groundwater recharge, etc.).

- Variants
  - 5-A Seasonal Rainwater Harvesting Systems
  - 5-B Continuous Rainwater Harvesting Systems

5.0 Rainwater Harvesting

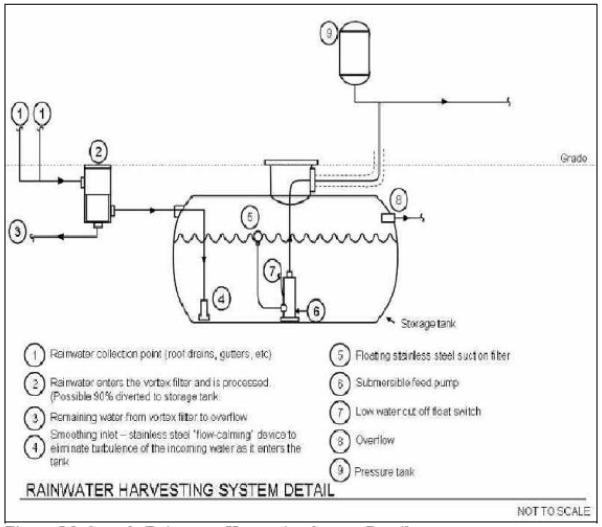

Figure 5.1. Sample Rainwater Harvesting System Detail

5.1(a) Seasonal Rainwater Harvesting Performance Credits	
Runoff Reduction	
Retention Allowance	50%
RPv -A/B Soil	50% of Storage
RPv - C/D Soil	50% of Storage
Cv	0% of Storage
Fv	0% of Storage
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction

5.1(b) Continous Rainwater Harvesting Performance Credits	
Runoff Reduction	
Retention Allowance	75%
RPv -A/B Soil	75% of Storage
RPv - C/D Soil	75% of Storage
Cv	0% of Storage
Fv	0% of Storage
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction

6.0 Regenerative Stormwater Conveyance Systems (RSCS)

6.0 Regenerative Stormwater Conveyance Systems (RSCS)

Definition: Regnerative Stormwater Conveyance Systems, also known as Coastal Plain Outfalls, are open-channel conveyance structures that convert, through attenuation ponds and a sand seepage filter, surface storm flow to shallow groundwater flow. In doing so, these systems safely convey, attenuate, and treat the quality of stormwater runoff.

Photo: Hala Flores, Anne Arundel Co., MD

These structures utilize a series of constructed shallow aquatic pools, riffle grade control, native vegetation, and an underlying sand/woodchip mix filter bed media. The physical characteristics of the RSC channel are best characterized by the Rosgen A or B stream classification types, where "bedform occurs as a step/pool, cascading channel which often stores large amounts of sediment in the pools associated with debris dams" (Rosgen, 1996). The pretreatment, recharge, and water quality sizing criteria presented in these guidelines are similar to criteria for a typical stormwater filtering device. These structures feature surface/subsurface runoff storage seams and an energy dissipation design that is aimed at attenuating the flow to a desired level through energy and hydraulic power equivalency principles. Design variants include:

- 6-A. Step Pool RSCS
- 6-B. Seepage Wetland RSCS

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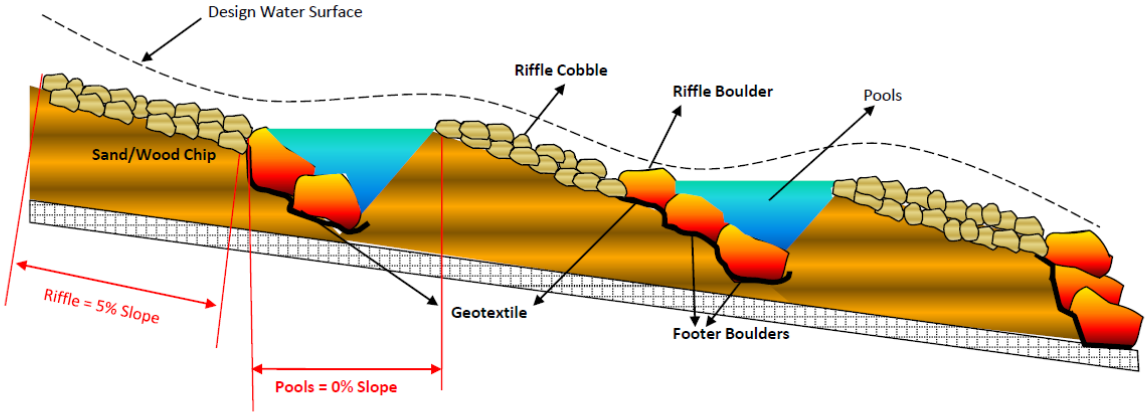
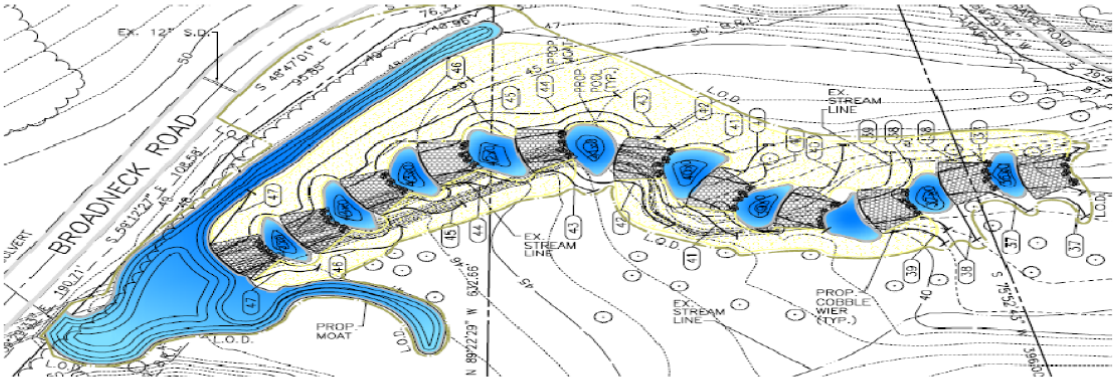
- a.k.a Coastal Plain Outfalls
- Variants
  - 6-A Step Pool RSCS
  - 6-B Seepage Wetland RSCS

6.0 Regenerative Stormwater Conveyance Systems (RSCS)

Functional Components of Step Pool Storm Conveyance (SPSC)

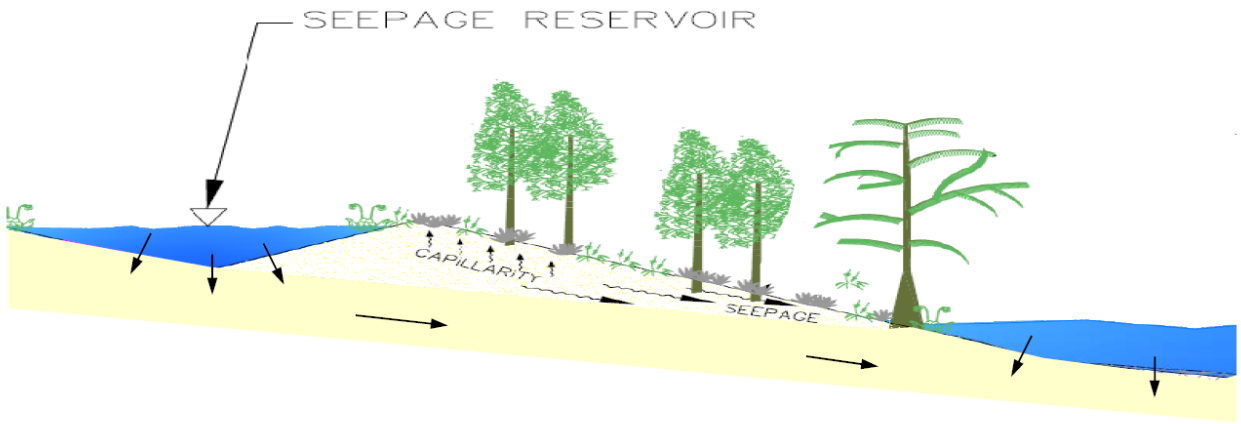


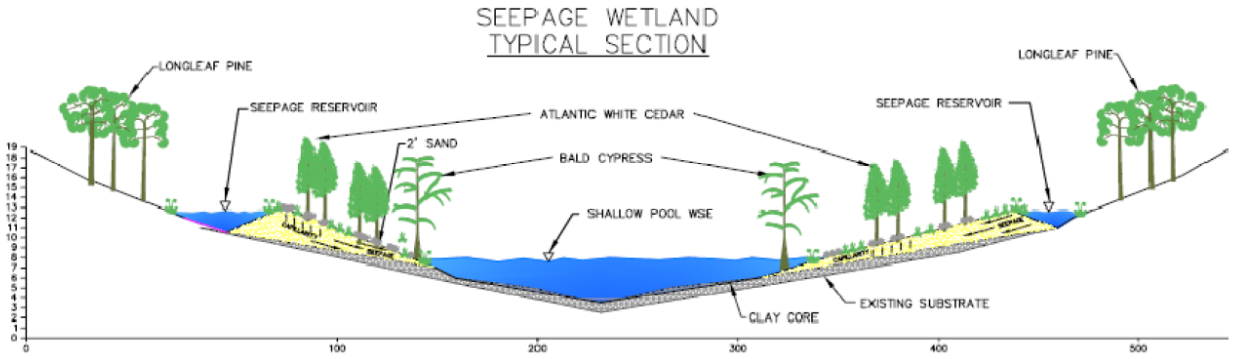


6.0 Regenerative Stormwater Conveyance Systems (RSCS)

6.0 Regenerative Stormwater Conveyance Systems (RSCS)

Other Geometric Configurations (Wetland Seepage)





6.0 Regenerative Stormwater Conveyance Systems (RSCS)

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6.0 Regenerative Stormwater Conveyance Systems (RSCS)

6.0 Regenerative Stormwater Conveyance Systems (RSCS)

Stormwater conveyance

Stormwater attenuation

Retrofit failed systems

Restoration of reconnected floodplain wetlands

6.0 Regenerative Stormwater Conveyance Systems (RSCS)

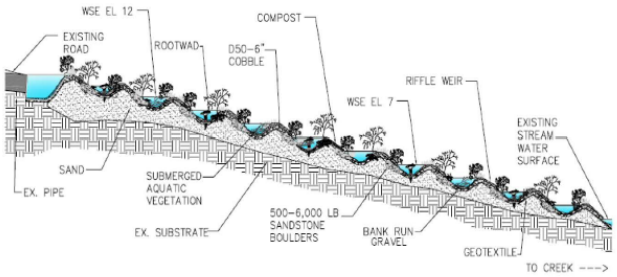

Figure 6.1 Example of a Step Pool RSCS

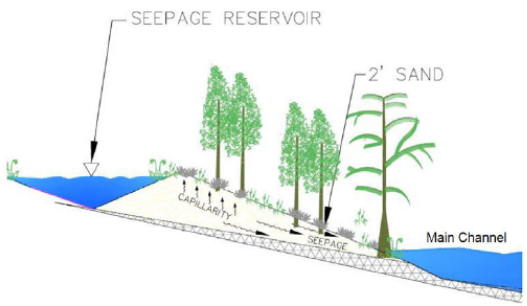

Figure 6.2 Example of a Seepage Wetland RSCS

6.1 RSCS Performance Credits	
Runoff Reduction	
Retention Allowance	TBD on Case-by-Case Basis
RPv -A/B Soil	TBD on Case-by-Case Basis
RPv - C/D Soil	TBD on Case-by-Case Basis
Cv	TBD on Case-by-Case Basis
Fv	TBD on Case-by-Case Basis
Pollutant Reduction	
TN Reduction	TBD on Case-by-Case Basis
TP Reduction	TBD on Case-by-Case Basis
TSS Reduction	TBD on Case-by-Case Basis

6.0 Regenerative Stormwater Conveyance Systems (RSCS)

- Appendix 6-1

7.0 Rooftop Disconnection

7.0 Rooftop Disconnection

Photo courtesy of Montgomery County, Maryland

Definition: Rooftop Disconnection involves managing runoff close to its source by intercepting, infiltrating, filtering, treating or reusing it as it moves from the rooftop to the drainage system. Rooftop Disconnection practices can be used to reduce the volume of runoff that enters the combined or separate storm sewer systems.

Rooftop Disconnection reduces a portion of the Resource Protection Volume (RPv). In order to meet requirements for larger storm events, Rooftop Disconnection must be combined with additional practices.

Rooftop impervious areas may be disconnected from the drainage system and flow to other BMPs for management, including:

- Sheet flow to a filter strip or open space (see *Specification 9.*)
- Infiltration by small infiltration practices such as dry wells or french drains (see *Specification 1.*)
- Filtration by rain gardens or stormwater planters (see *Specification 2.*)
- Storage and reuse with a rain barrel, cistern or other storage system (see *Specification 5.*)

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- Variants
  - N/A

7.0 Rooftop Disconnection

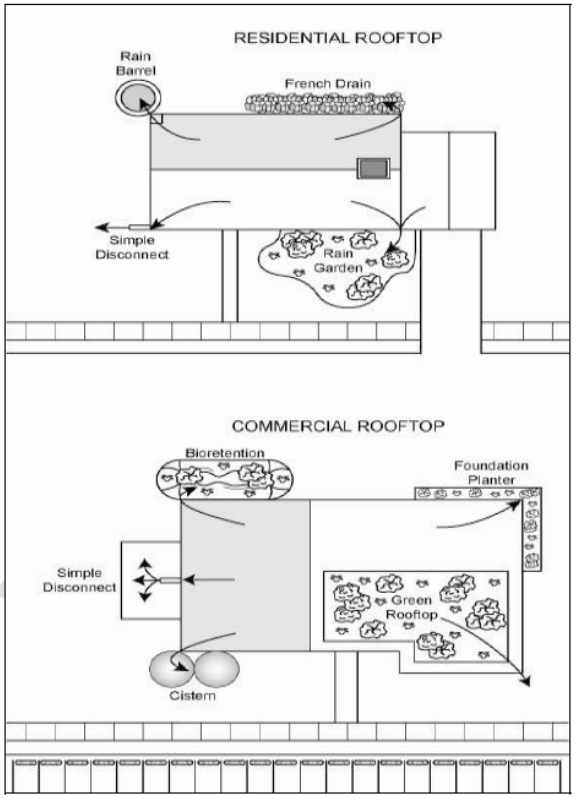

Figure 7.1. Rooftop Disconnection with Alternative Runoff Reduction Practices.

7.1 Rooftop Disconnection Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv - A/B Soil or Compost Amended C Soil	25% Annual Runoff Reduction
RPv - C/D Soil	10% Annual Runoff Reduction
Cv	10% of RPv Allowance
Fv	1% of RPv Allowance
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction

8.0 Vegetated Channels

8.0 Vegetated Channels

Definition: Vegetated open channels that are designed to convey the design storm volume (RPv and Cv, may also convey the Fv as designed).

Design variants include:

- 8-A Bioswale
- 8-B Vegetated Channel

Grass channels systems shall not be designed to provide stormwater detention. Vegetated channels can provide a modest amount of runoff filtering and volume attenuation within the stormwater conveyance system resulting in the delivery of less runoff and pollutants than a traditional system of curb and gutter, storm drain inlets and pipes. The performance of Vegetated channels will vary depending on the underlying soil permeability. Their runoff reduction performance can be boosted when compost amendments are added to the bottom of the channel. Vegetated channels are a preferable alternative to both curb and gutter and storm drains as a stormwater conveyance system, where development density, topography, soils, and water table permit.

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- Variants
  - 8-A Bioswale
  - 8-B Vegetated Channel

8.0 Vegetated Channels

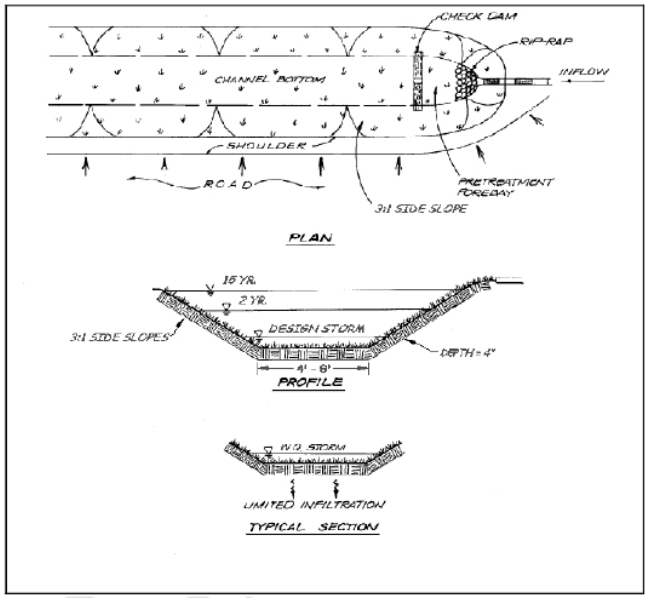

Figure 8.1. Vegetated Channel Typical Plan, Profile, and Section (O-1).

8.1 Vegetated Channel Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil or Compost Amended C Soil	Bioswale : 50% Annual Runoff Reduction Veg. Channel: 20% Annual Runoff Reduction
RPv - C/D Soil	Bioswale: 25% Annual Runoff Reduction Veg. Channel: 10% Annual Runoff Reduction
Cv	10% of RPv Allowance
Fv	1% of RPv Allowance
Pollutant Reduction	
TN Reduction	100% of Load Reduction (max. 45% Removal Efficiency)
TP Reduction	100% of Load Reduction (max. 45% Removal Efficiency)
TSS Reduction	100% of Load Reduction (max. 80% Removal Efficiency)

9.0 Sheet Flow

9.0 Sheet Flow to Filter Strip or Open Space

Definition:

Filter strips are vegetated areas that treat sheet flow delivered from adjacent impervious and managed turf areas by slowing runoff velocities and allowing sediment and attached pollutants to settle and/or be filtered by the vegetation. The two design variants of filter strips are *Vegetated Filter Strips* and *Conserved Open Space*. The design, installation, and management of these design variants are quite different, as outlined in this specification.

In both instances, stormwater must enter the filter strip or conserved open space as sheet flow. If the inflow is from a pipe or channel, an engineered level spreader must be designed in accordance with the criteria contained herein to convert the concentrated flow to sheet flow.

Applicable practices include:

- 9-A. Sheet Flow to Vegetated Filter Strip
- 9-B. Sheet Flow to Vegetated Conserved Open Space

Sheet flow practices reduce a portion of the Resource Protection Volume (RPv). In order to meet requirements for larger storm events, sheet flow practices must be combined with additional practices.

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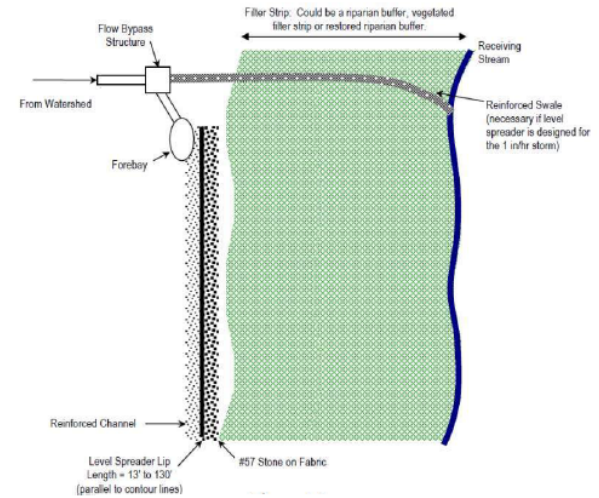
- Variants
  - 9-A Sheet Flow to Vegetated Filter Strip
  - 9-B Sheet Flow to Conserved Open Space
- Sub-Categories
  - Turf
  - Forest

9.0 Sheet Flow



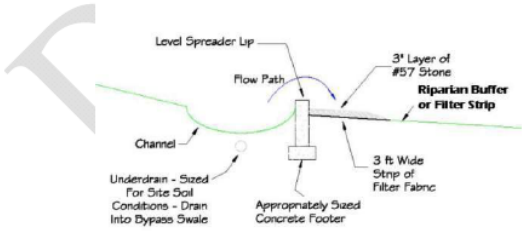


Figure 9.1: Plan and Cross Section of Engineered Level Spreader (ELS) and Filter Strip (Hathaway 2006)

9.1(a) Sheet Flow to Vegetated Filter Strip Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil or Compost Amended C Soil	Turf: 25% Annual Runoff Reduction Forest: 40% Annual Runoff Reduction
RPv - C/D Soil	Turf: 10% Annual Runoff Reduction Forest: 20% Annual Runoff Reduction
Cv	10% of RPv Allowance
Fv	1% of RPv Allowance
Pollutant Reduction	
TN Reduction	100% of Load Reduction (max. 20% Removal Efficiency)
TP Reduction	100% of Load Reduction (max. 20% Removal Efficiency)
TSS Reduction	100% of Load Reduction (max. 80% Removal Efficiency)

9.1(b) Sheet Flow to Vegetated Open Space Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil or Compost Amended C Soil	Turf: 50% Annual Runoff Reduction Forest: 65% Annual Runoff Reduction
RPv - C/D Soil	Turf: 20% Annual Runoff Reduction Forest: 40% Annual Runoff Reduction
Cv	10% of RPv Allowance
Fv	1% of RPv Allowance
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction

10.0 Detention Practices

10.0 Detention Practices

Definition: Detention Practices are storage practices that are explicitly designed to provide stormwater detention for the Conveyance Event, Cv (10-year) and Flooding Event, Fv (100-year). Design variants include:

- 10-A Dry Detention Pond
- 10-B Dry Extended Detention Basin
- 10-C Underground Detention Facilities

Dry Detention Ponds and Dry Extended Detention Basins are widely applicable for most land uses and are best suited for larger drainage areas. An outlet structure restricts stormwater flow so it backs up and is stored within the basin. The temporary ponding reduces the maximum peak discharge to the downstream channel, thereby reducing the effective shear stress on the bed and banks of the receiving stream. Dry Detention Ponds receive some credit for pollutant removal, while Dry Extended Detention Basins receive both runoff reduction and pollutant removal credits.

The key difference between Dry Detention Ponds and Dry Extended Detention Basins is that, in addition to management of the Cv and Fv, a Dry Extended Detention Basin provides up to a 24-hour detention of all or a portion of the Resource Protection Volume (RPv). An under-sized outlet structure restricts stormwater flow so it backs up and is stored within the basin. The temporary ponding enables particulate pollutants to settle out and reduces the maximum peak discharge to the downstream channel, thereby reducing the effective shear stress on banks of the receiving stream. Extended detention differs from a Dry Detention Pond's stormwater detention, since it is designed to achieve a minimum drawdown time, rather than a maximum peak rate of flow. Dry Detention Ponds, which are designed only to manage the larger Conveyance Event and Flooding Event will often detain smaller storm events for only a few minutes or hours.

Underground Detention Facilities include vaults and tanks. Underground Detention Vaults are box-shaped underground stormwater storage facilities typically constructed with reinforced concrete. Underground Detention Tanks are underground storage facilities typically constructed with large diameter metal or plastic pipe. Both serve as an alternative to surface dry detention for stormwater quantity control, particularly for space-limited areas where there is not adequate land for a dry detention basin or multi-purpose detention area. Prefabricated concrete vaults are available from commercial vendors. In addition, several pipe manufacturers have developed packaged detention systems. Underground detention vaults do not receive any runoff reduction or pollutant removal credit, and should be considered only for management of larger storm events.

- Variants
  - 10-A Dry Detention Pond
  - 10-B Dry Extended Detention Pond
  - 10-C Underground Detention Facilities

10.0 Detention Practices

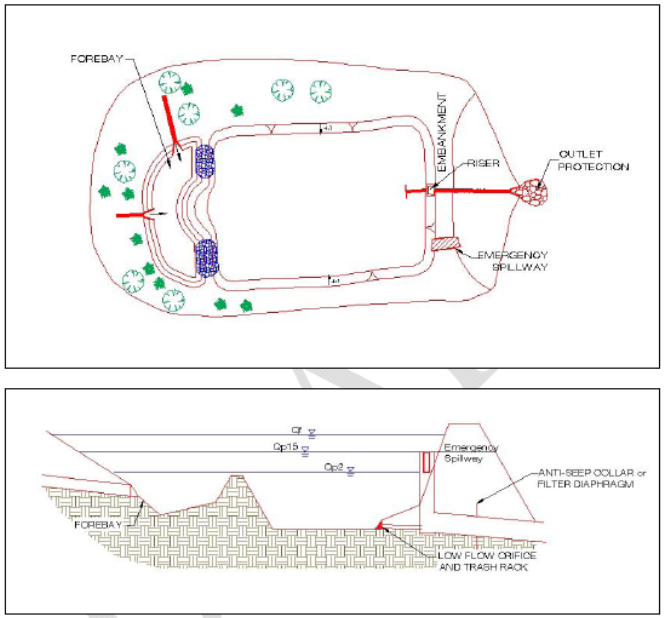


Figure 10.2. Example of a Dry Detention Pond (10-A).

Table 10.1(a) Dry Detention Pond Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil	0%
RPv - C/D Soil	0%
Cv	0%
Fv	0%
Pollutant Reduction	
TN Reduction	5%
TP Reduction	10%
TSS Reduction	10%

Table 10.1(b) Dry ED Basin Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil	10%
RPv - C/D Soil	10%
Cv	1%
Fv	0%
Pollutant Reduction	
TN Reduction	20%
TP Reduction	20%
TSS Reduction	60%

11.0 Stormwater Filtering Systems

11. Stormwater Filtering Systems

Definition:

Practices that capture and temporarily store the design storm volume and pass it through a filter bed of sand media. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially infiltrate into the soil. Design variants include:

- 11-A Non-Structural Sand Filter
- 11-B Surface Sand Filter
- 11-C Three-chamber Underground Sand Filter
- 11-D Perimeter Sand Filter (including "Delaware" Modular Sand Filter)

Bioretention also functions as a stormwater filtering system; however, due to the prevalence and variety of these particular practices, bioretention is included as in a separate specification (*Specification 2, Bioretention*).

Stormwater filters are a useful practice to treat stormwater runoff from small, highly impervious sites. Stormwater filters capture, temporarily store, and treat stormwater runoff by passing it through an engineered filter media, collecting the filtered water in an underdrain, and then returning it back to the storm drainage system. The filter consists of two chambers: the first is devoted to settling, and the second serves as a filter bed consisting of a sand filter media.

Stormwater filters are a versatile option because they consume very little surface land and have few site restrictions. They provide moderate pollutant removal performance at small sites where space is limited. However, filters have limited or no runoff volume reduction capability, so designers should consider using up-gradient runoff reduction practices, which have the effect of decreasing the design storm volume (and size) of the filtering practices. Filtering practices are also suitable to provide special treatment at designated stormwater hotspots.

Filtering systems are typically not to be designed to provide stormwater detention (Cv and Fv), but they may be in some circumstances. Filtering practices shall generally be combined with a separate facility to provide those controls. However, the three-chamber underground sand filter can be

- Variants
  - 11-A Non-Structural Sand Filter
  - 11-B Surface Sand Filter
  - 11-C Three-Chamber Underground Sand Filter
  - 11-D Perimeter Sand Filter (inc. "Delaware" Modular Sand Filter)

11.0 Stormwater Filtering Systems

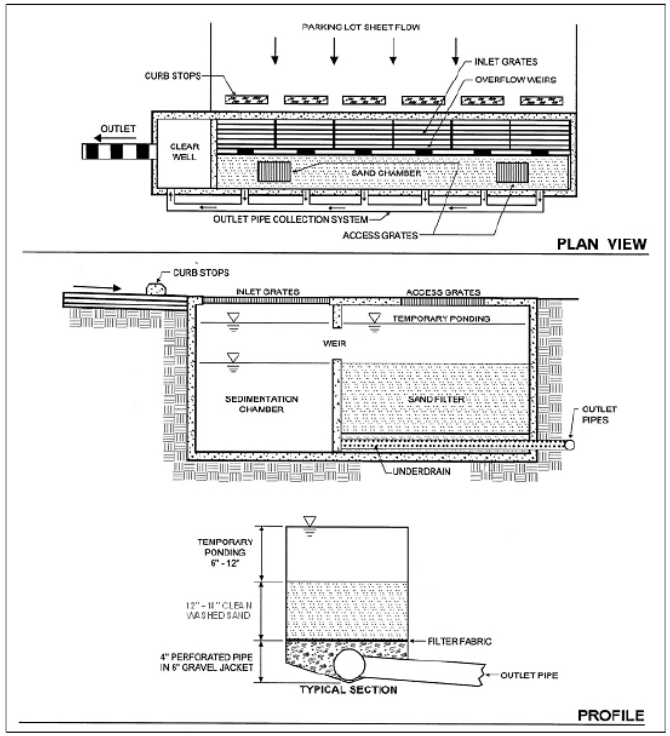


Figure 11.4. Example of Perimeter Sand Filter (11-D).

11.1 Filtering Practices Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil	0%
RPv - C/D Soil	0%
Cv	0%
Fv	0%
Pollutant Reduction	
TN Reduction	40%
TP Reduction	60%
TSS Reduction	80%

12.0 Constructed Wetlands

12.0 Constructed Wetlands

Definition: Practices that create shallow marsh areas to treat urban stormwater which often incorporate small permanent pools and/or extended detention storage. Constructed Wetlands are explicitly designed to provide stormwater detention for larger storms (Cv and Fv) above the RPv storage. Design variants include:

- 12-A Traditional Constructed Wetland
- 12-B Submerged Gravel Wetland (to be added at a later date)

Constructed Wetlands are shallow depressions that receive stormwater inputs for water quality treatment. The majority of the wetland surface area is covered by shallow (<1' deep) wetland area, with greater depths in the forebay and pools within the wetland. Wetlands possess variable microtopography to promote dense and diverse wetland cover. Runoff from each new storm displaces runoff from previous storms, and the long residence time allows multiple pollutant removal processes to operate. The wetland environment provides an ideal environment for gravitational settling, biological uptake, and microbial activity.

Constructed Wetlands should be considered for use after all other upland runoff reduction opportunities have been exhausted and there is still a remaining treatment volume or runoff from larger storms (i.e. 10-year, 100-year or flood control events) to manage.

Constructed Wetlands do not receive any stormwater retention credit and should be considered only for management of the water quality volume or larger storm events. Constructed Wetlands have both community and siting criteria (see ***Section12.3 Wetland Feasibility Criteria***) that should be considered before incorporating the stormwater practice onsite.

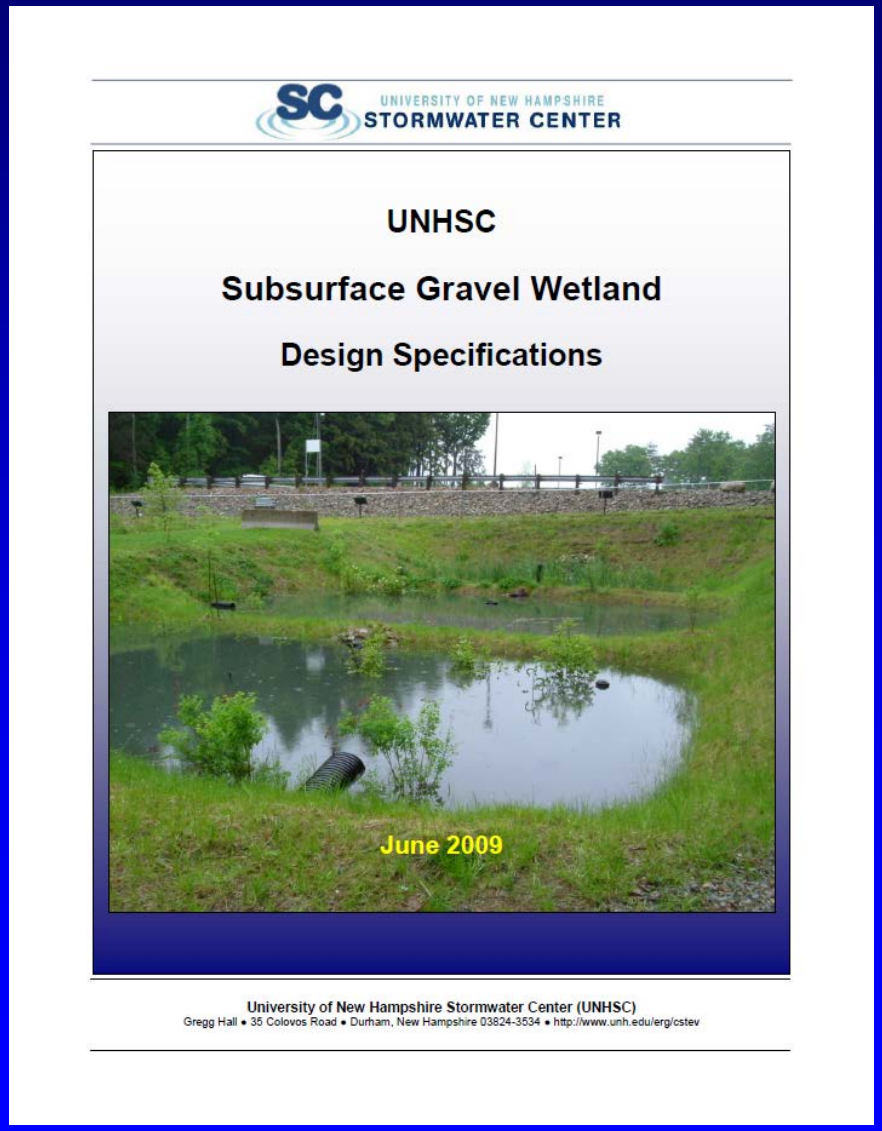
Important Note:

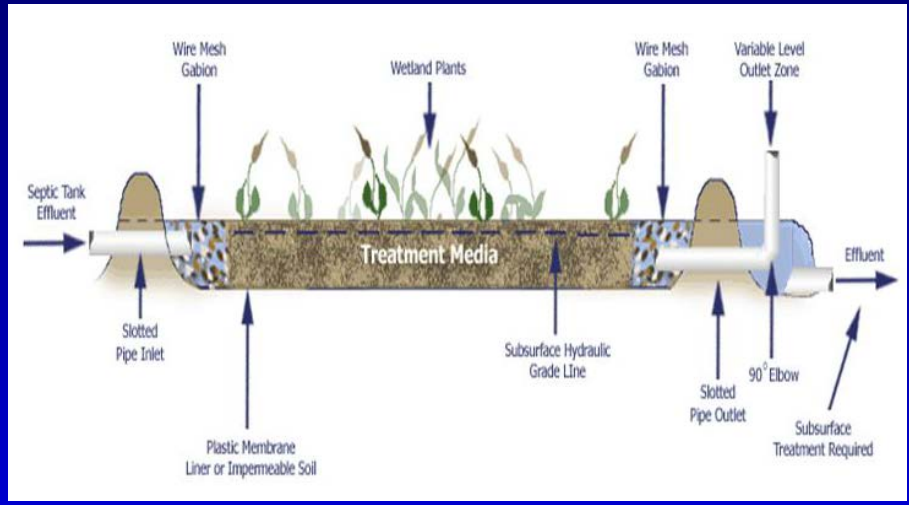
- *The Wet Pond performance criteria presented in Specification 13 also apply to the design of stormwater wetlands. Additional criteria that govern the geometry and establishment of created wetlands are presented in this section.*

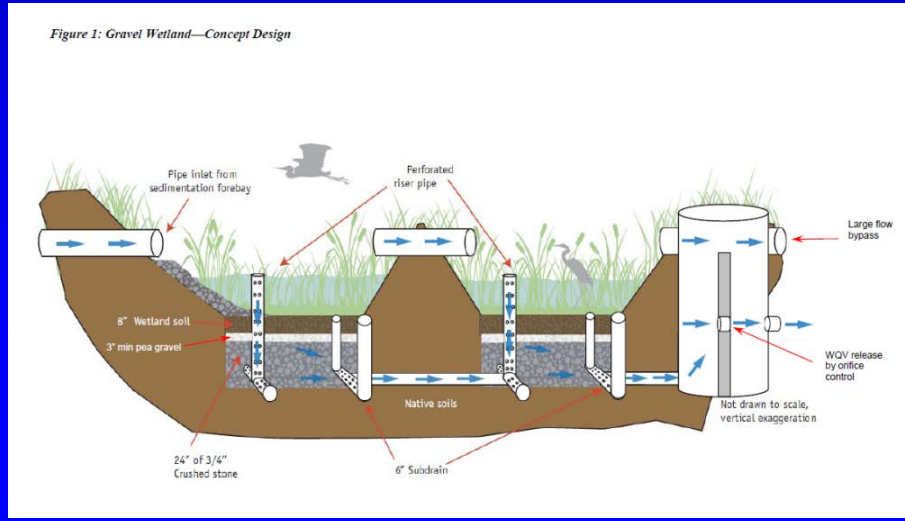
DRAFT

- Variants
  - 12-A Traditional Constructed Wetland
  - 12-B Submerged Gravel Wetland (future)
- Possible Additions
  - Ephemeral Wetlands
  - Wet Swales

12.0 Constructed Wetlands

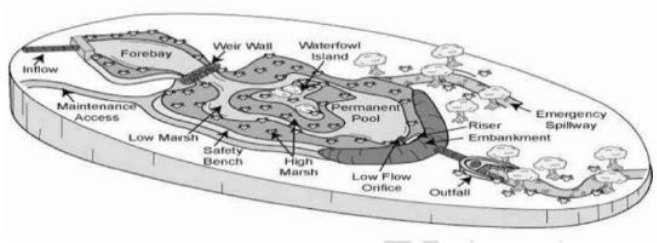


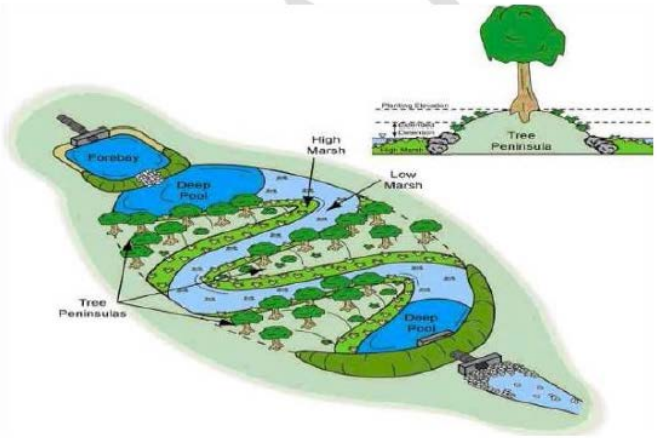




12.0 Constructed Wetlands

Figures 12.1 and 12.2. Typical Shallow Wetland Plan Views





12.1 Constructed Wetlands Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil	0% of Storage
RPv - C/D Soil	0% of Storage
Cv	0% of Storage
Fv	0% of Storage
Pollutant Reduction	
TN Reduction	20% of Storage Volume
TP Reduction	45% of Storage Volume
TSS Reduction	60% of Storage Volume

13.0 Ponds

13.0 Wet Ponds

Definition: Wet Ponds are stormwater storage practices that consist of a combination of a permanent pool, micropool, or shallow marsh that promote a good environment for gravitational settling, biological uptake and microbial activity. Wet Ponds are widely applicable for most land uses and are best suited for larger drainage areas. Runoff from each new storm enters the wet pond and partially displaces pool water from previous storms. The pool also acts as a barrier to re-suspension of sediments and other pollutants deposited during prior storms. When sized properly, wet ponds have a residence time that ranges from many days to several weeks, which allows numerous pollutant removal mechanisms to operate. Wet Ponds can also provide storage above the permanent pool to help meet stormwater management requirements for larger storms. Design variants include:

- 13-A Wet Pond
- 13-B Wet Extended Detention (ED) Pond

A Wet ED Pond differs from a typical Wet Pond in that a Wet ED Pond provides 24-hour detention of all or a portion of the Resource Protection Volume (RPv). Optional internal baffles in the Wet ED Pond extend the flow path through the pond from the inflow point to the outlet. In addition, an undersized outlet structure restricts stormwater flow so it backs up and is stored within the Wet ED Pond. The temporary ponding enhances the ability of particulate pollutants to settle out and reduces the maximum peak discharge to the downstream channel, thereby reducing the effective shear stress on banks of the receiving stream.

Wet Ponds should be considered for use after all other upland runoff reduction opportunities have been exhausted and there is still a remaining treatment volume or runoff from larger storms (i.e. Cv an Fv) to manage.

Wet Ponds do not receive any stormwater retention credit and should be considered only for pollutant removal efficiency and to manage flood events. Wet Ponds have both community and environmental concerns (see *Section 13.3 Wet Pond Feasibility Criteria*) that need to be considered before applying them.

DRAFT

- Variants
  - 13-A Wet Pond
  - 13-B Wet Extended (ED) Pond

13.0 Ponds

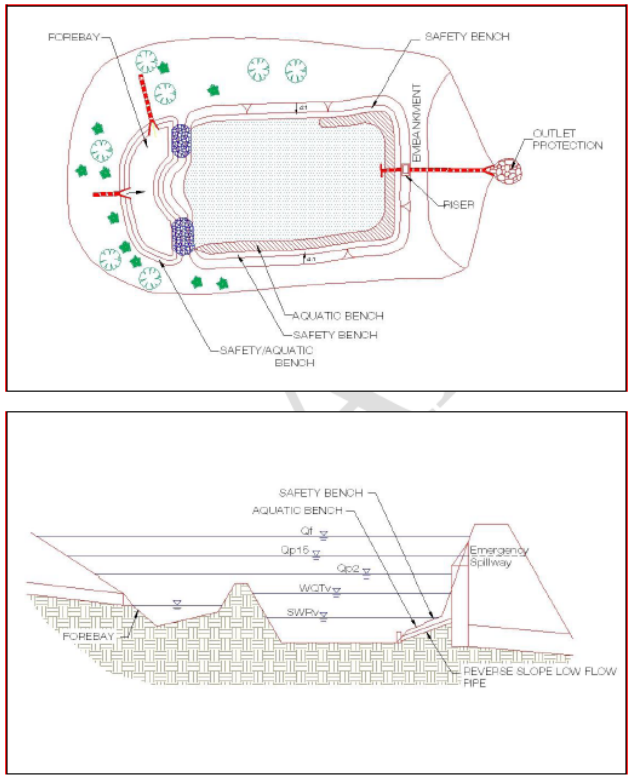


Figure 13.1. Wet Pond (13-A) Design Schematics.

13.1 Wet Pond/Wet ED Pond Performance Credits	
Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil	0%
RPv - C/D Soil	0%
Cv	0%
Fv	0%
Pollutant Reduction	
TN Reduction	20%
TP Reduction	45%
TSS Reduction	60%

14.0 Soil Amendments

14.0 Soil Amendments

Definition:

Soil amendment (also called soil restoration) is a technique applied after construction to till compacted soils and restore their porosity by amending them with compost. These soil amendments can reduce the generation of runoff from compacted urban lawns and may also be used to enhance the performance of impervious cover disconnections and grass channels.

14.1 Soil Amendment Stormwater Credit Calculations

Soil amendment does not receive a retention allowance. However, the use of soil amendments in accordance with this specification allows disturbed areas to receive a reduction credit for the annual runoff. The adjustment varies depending on the soil's Hydrologic Soil Group. Pollutant loads are assumed to be reduced by the equivalent reduction in runoff. **Table 14.1** summarizes the runoff and pollutant reduction credits for this practice. Soil amendments can also enhance the performance of other runoff reduction practices that rely on surface infiltration. Runoff and pollutant reduction credits for these types of applications are discussed in the respective specifications for those practices.

14.1 Soil Amendment Performance Credits

Runoff Reduction	
Retention Allowance	0%
RPv	HSG A – 38% Annual Runoff Reduction HSG B – 50% Annual Runoff Reduction HSG C - 29% Annual Runoff Reduction HSG D – 13% Annual Runoff Reduction
Cv	10% of RPv Allowance
Fv	1% of RPv Allowance
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction
NOTE: Runoff reduction allowances are for amendment area only.	

DRAFT

- Variants
  - N/A

14.1 Soil Amendment Performance Credits

Runoff Reduction	
Retention Allowance	0%
RPv	HSG A – 38% Annual Runoff Reduction
	HSG B – 50% Annual Runoff Reduction
	HSG C - 29% Annual Runoff Reduction
	HSG D – 13% Annual Runoff Reduction
Cv	10% of RPv Allowance
Fv	1% of RPv Allowance
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction
NOTE: Runoff reduction allowances are for amendment area only.	

15.0 Proprietary Practices

15.0 Proprietary Practices

Definition: Proprietary practices are manufactured stormwater treatment practices that utilize settling, filtration, absorptive/adsorptive materials, vortex separation, vegetative components, and/or other appropriate technology to manage the impacts caused by stormwater runoff.

Certain proprietary practices may be eligible for some amount of treatment credit, provided they have been approved by the Department and meet the performance criteria outlined in this specification. Proprietary practices will generally not be eligible for retention volume credit unless the practice can demonstrate the occurrence of runoff reduction processes.

15.1 Proprietary Practice Stormwater Credit Calculations

Proprietary practices will receive no retention credit (R_v) unless explicitly approved by the Department. However, they may be credited as treatment practices, provided they meet the performance criteria outlined in *Section 15.5. Proprietary Practice Design Criteria*.

15.1 Proprietary Practices Performance Credits

Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil	0%
RPv - C/D Soil	0%
Cv	0%
Fv	0%
Pollutant Reduction	
TN Reduction	See *Appendix ---*
TP Reduction	See *Appendix ---*
TSS Reduction	See *Appendix ---*

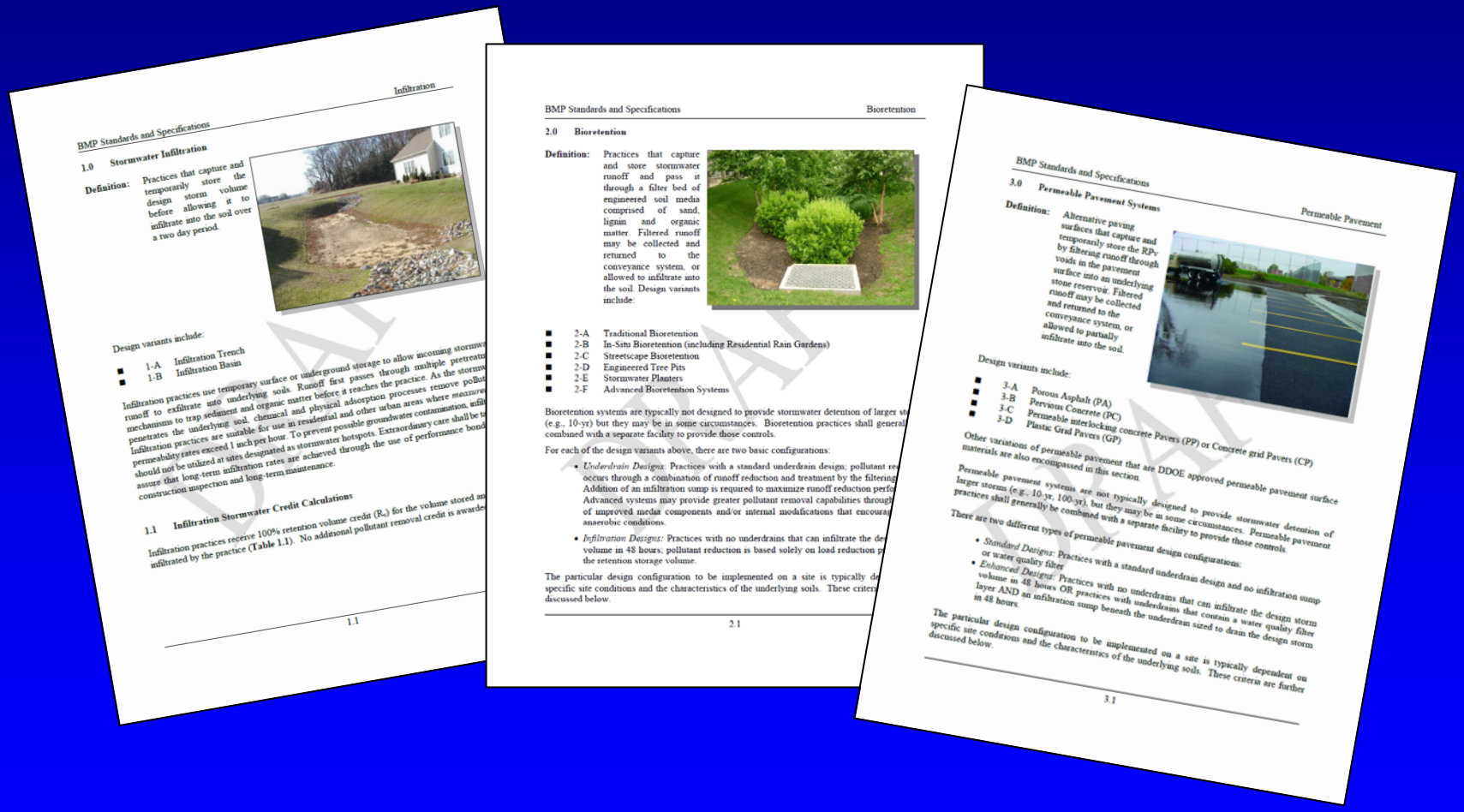
DRAFT

- Variants
  - Vary By Manufacturer

15.1 Proprietary Practices Performance Credits

Runoff Reduction	
Retention Allowance	0%
RPv -A/B Soil	0%
RPv - C/D Soil	0%
Cv	0%
Fv	0%
Pollutant Reduction	
TN Reduction	See *Appendix ---*
TP Reduction	See *Appendix ---*
TSS Reduction	See *Appendix ---*

Questions/Discussion



BMP Standards and Specifications — Infiltration

1.0 Stormwater Infiltration

Definition: Practices that capture and temporarily store the design storm volume before allowing it to infiltrate into the soil over a two day period.

Design variants include:

- 1-A Infiltration Trench
- 1-B Infiltration Basin

Infiltration practices use temporary surface or underground storage to allow incoming stormw runoff to exfiltrate into underlying soils. Runoff first passes through multiple pretreatm mechanisms to trap sediment and organic matter before it reaches the practice. As the stormw penetrates the underlying soil, chemical and physical adsorption processes remove pollut Infiltration practices are suitable for use in residential and other urban areas where measured permeability rates exceed 1 inch per hour. To prevent possible groundwater contamination, infil should not be utilized at sites designated as stormwater hotspots. Extraordinary care shall be t assure that long-term infiltration rates are achieved through the use of performance bond construction inspection and long-term maintenance.

1.1 Infiltration Stormwater Credit Calculations

Infiltration practices receive 100% retention volume credit (R_v) for the volume stored an infiltrated by the practice (Table 1.1). No additional pollutant removal credit is awarde

1.1

BMP Standards and Specifications — Bioretention

2.0 Bioretention

Definition: Practices that capture and store stormwater runoff and pass it through a filter bed of engineered soil media comprised of sand, lignin and organic matter. Filtered runoff may be collected and returned to the conveyance system, or allowed to infiltrate into the soil. Design variants include:

- 2-A Traditional Bioretention
- 2-B In-Situ Bioretention (including Residential Rain Gardens)
- 2-C Streetscape Bioretention
- 2-D Engineered Tree Pits
- 2-E Stormwater Planters
- 2-F Advanced Bioretention Systems

Bioretention systems are typically not designed to provide stormwater detention of larger st (e.g., 10-yr) but they may be in some circumstances. Bioretention practices shall general combined with a separate facility to provide those controls.

For each of the design variants above, there are two basic configurations:

- *Underdrain Designs:* Practices with a standard underdrain design; pollutant re occurs through a combination of runoff reduction and treatment by the filtering Addition of an infiltration sump is required to maximize runoff reduction perfo Advanced systems may provide greater pollutant removal capabilities through of improved media components and/or internal modifications that encoura anaerobic conditions.
- *Infiltration Designs:* Practices with no underdrains that can infiltrate the de volume in 48 hours; pollutant reduction is based solely on load reduction p the retention storage volume.

The particular design configuration to be implemented on a site is typically de specific site conditions and the characteristics of the underlying soils. These criteri discussed below.

2.1

BMP Standards and Specifications — Permeable Pavement

3.0 Permeable Pavement Systems

Definition: Alternative paving surfaces that capture and temporarily store the RPv by filtering runoff through voids in the pavement surface into an underlying stone reservoir. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially infiltrate into the soil.

Design variants include:

- 3-A Porous Asphalt (PA)
- 3-B Pervious Concrete (PC)
- 3-C Permeable interlocking concrete Pavers (PP) or Concrete grid Pavers (CP)
- 3-D Plastic Grid Pavers (GP)

Other variations of permeable pavement that are DDOE approved permeable pavement surface materials are also encompassed in this section.

Permeable pavement systems are not typically designed to provide stormwater detention of larger storms (e.g., 10-yr, 100-yr), but they may be in some circumstances. Permeable pavement practices shall generally be combined with a separate facility to provide those controls.

There are two different types of permeable pavement design configurations:

- *Standard Designs:* Practices with a standard underdrain design and no infiltration sump or water quality filter
- *Enhanced Designs:* Practices with no underdrains that can infiltrate the design storm volume in 48 hours OR practices with underdrains that contain a water quality filter layer AND an infiltration sump beneath the underdrain sized to drain the design storm in 48 hours.

The particular design configuration to be implemented on a site is typically dependent on specific site conditions and the characteristics of the underlying soils. These criteria are further discussed below.

3.1

DURMM v.2

Update

DURMM v.2: RPv Sheet

Retention Practices →

Annual RR Practices →

	A	B	C
1	PROJECT:	0	
2	DRAINAGE SUBAREA ID:	0	
3	LOCATION (County):	0	
4			
5	RESET	BMP 1	
6		Type:	
7	*Step 1 - Calculate Initial RPv*	Data	
8	1.1 Total contributing area to BMP (ac)	0.00	
9	1.2 C.A. RCN	#DIV/0!	
10	1.3 Total Contributing Area DURMM Runoff (in)	#DIV/0!	
11	1.4 RPv for Contributing Area (in)	#DIV/0!	
12	1.5 Req'd RPv Reduction for Contributing Area (in)	#DIV/0!	
13	1.6 Req'd RPv Reduction for Contributing Area (%)	#DIV/0!	
14	1.7 C.A. allowable discharge rate (cfs)	#DIV/0!	
15			
16	*Step 2 - Adjust for Retention Reduction*		
17	2.1 Storage volume (cu. ft.)		
18	2.2 Retention reduction allowance (%)	#N/A	
19	2.3 Retention reduction volume (ac-ft)	#N/A	
20	2.4 Retention reduction volume (in)	#N/A	
21	2.5 Runoff volume after retention reduction (in)	#DIV/0!	
22	2.6 CN*	#DIV/0!	
23			
24	*Step 3 - Adjust for Annual Runoff Reduction*		
25	3.1 Annual CN (ACN)	#DIV/0!	
26	3.2 Annual runoff (in.)	#DIV/0!	
27	3.3 Proportion A/B soils in BMP footprint (%)		
28	3.4 Annual runoff reduction allowance (%)	0%	
29	3.7 Annual runoff after reduction (in.)	#DIV/0!	
30	3.8 Adjusted ACN	#DIV/0!	
31			
32	*Step 4 - Calculate RPv with BMP Reductions*		
33	4.1 RPv runoff volume after all reductions (in.)	#DIV/0!	
34	4.2 Total RPv runoff reduction (in)	#DIV/0!	
35	4.3 Total RPv runoff reduction (%)	#DIV/0!	
36	4.4 Equivalent TR-55 RCN for H&H modeling	#DIV/0!	
37	4.5 Req'd reduction met?	#DIV/0!	
38			

DURMM v.2: TMDL Sheet

Load Reduction

Concentration Reduction

	A	B	C	D	E
1	PROJECT:	0			
2	DRAINAGE SUBAREA ID:	0			
3	TMDL WATERSHED:				
4					
5		BMP 1			
6		Type:	0		
7	***Step 1 - Calculate Annual Runoff Volume***	Data	TN	TP	TSS
8	1.1 Total contributing area to BMP (ac)	0.00			
9	1.2 Contributing area RCN	#DIV/0!			
10	1.3 Annual runoff volume (in)	#DIV/0!			
11	1.4 Annual runoff volume (liters)	#DIV/0!			
12					
13	***Step 2 - Calculate Annual Pollutant Load***				
14	2.1 EMC (mg/l)		2.00	0.27	80
15	2.2 Load (mg/yr)		#DIV/0!	#DIV/0!	#DIV/0!
16	2.3 Load (lb/ac/yr)		#DIV/0!	#DIV/0!	#DIV/0!
17					
18	***Step 3 - Adjust for Runoff Reduction***				
19	3.1 BMP Runoff Reduction (%)	#DIV/0!			
20	3.2 Adjusted load (lb/ac/yr)		#DIV/0!	#DIV/0!	#DIV/0!
21					
22	***Step 4 - Adjust for BMP Treatment***				
23	4.1 BMP Removal Efficiency		#N/A	#N/A	#N/A
24	4.2 Adjusted load (lb/ac/yr)		#DIV/0!	#DIV/0!	#DIV/0!
25					
26	***Step 5 - Calculate Pollutant Reduction***				
27	5.1 TMDL (lb/ac/yr)		#N/A	#N/A	#N/A
28	5.2 Reduction met?		#DIV/0!	#DIV/0!	#DIV/0!
29					

Questions?

DURMM_v2_2010-06-15.xls [Compatibility Mode] - Microsoft Excel

PROJECT:
DRAINAGE SUBAREA ID:
LOCATION (County):
UNIT HYDROGRAPH:

Cover Type	Treatment	Hydrologic Condition	A Acres	A RCN	B Acres	B RCN	C Acres	C RCN	D Acres	D RCN
			Curve Numbers for Hydrologic Soil Type							
FULLY DEVELOPED URBAN AREAS (Veg Established)										
Open space (Lawns,parks etc.)										
	Poor condition; grass cover < 50%			68		79		86		89
	Fair condition; grass cover 50% to 75 %			49		69		79		84
	Good condition; grass cover > 75%			39		61		74		80
Impervious Areas										
	Paved parking lots, roofs, driveways			98		98		98		98
	Streets and roads									
	Paved; curbs and storm sewers			98		98		98		98
	Paved; open ditches (w/right-of-way)			83		89		92		93
	Gravel (w/ right-of-way)			76		85		89		91
	Dirt (w/ right-of-way)			72		82		87		89
Urban Districts		Avg % impervious								
	Commercial & business	85		89		92		94		95
	Industrial	72		81		88		91		93
Residential districts by average lot size		Avg % impervious								
	1/8 acre (town houses)	65		77		85		90		92
	1/4 acre	38		61		75		83		87
	1/3 acre	30		57		72		81		86
	1/2 acre	25		54		70		80		85
	1 acre	20		51		68		79		84
	2 acre	12		46		65		77		82
	User defined urban			**		**		**		**
DEVELOPING URBAN AREA (No Vegetation)										
	Newly graded area (pervious only)			77		86		91		94
			0		0		0		0	

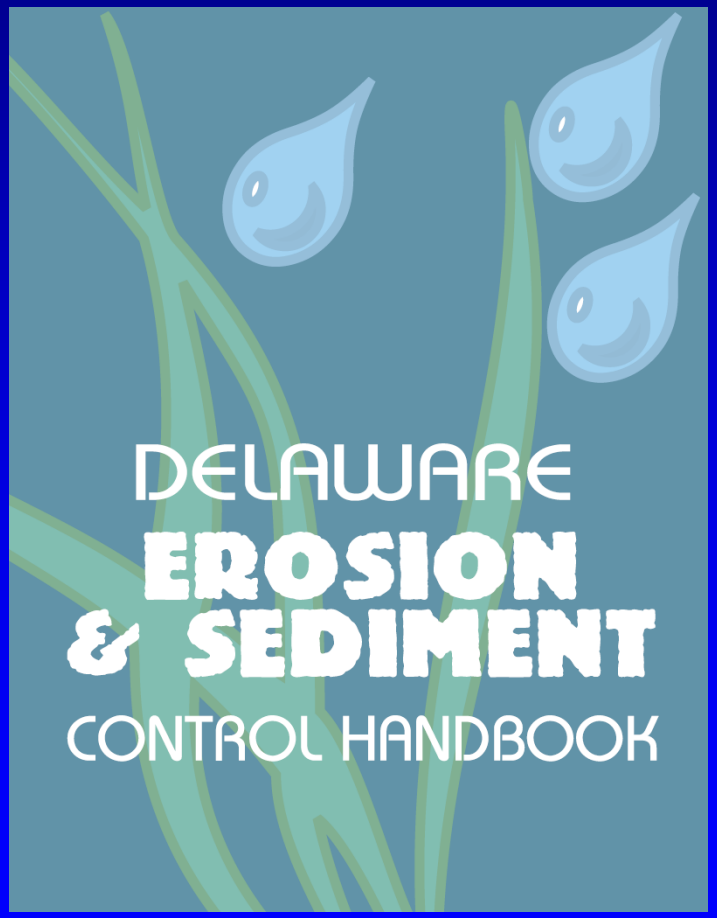
CLEAR TABLE

Total Acres 0

Weighted Runoff Curve Number (RCN) 0

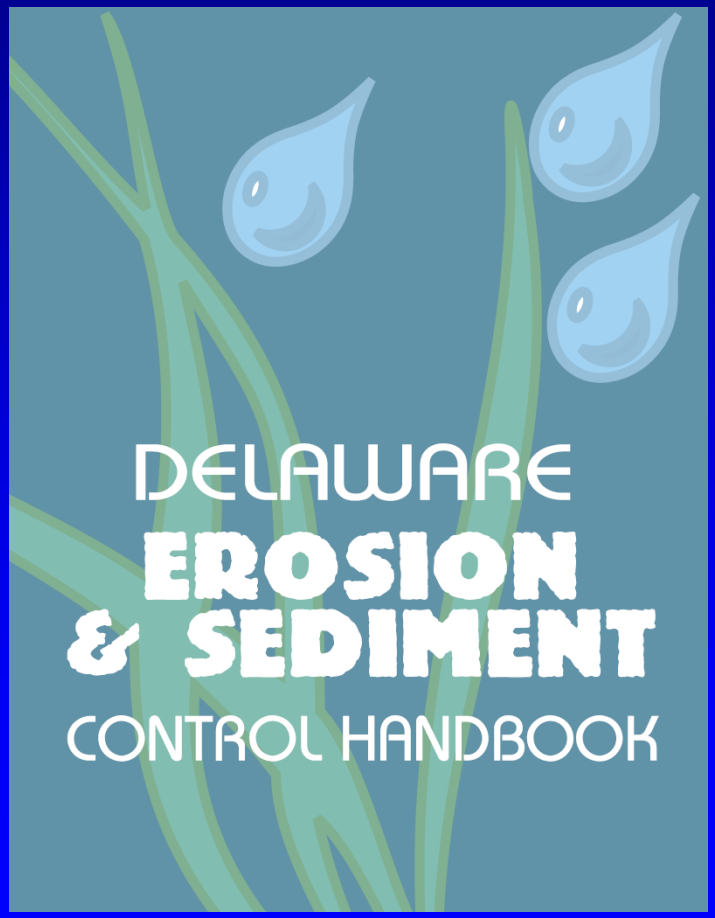
C.A. RCN | LOD | OLOD | RPv | TMDL | Cv | Fv | DURMM Report

Delaware ESC Handbook Updates



- Revisions
  - Culvert Inlet Protection (delete Silt Fence option)
  - Inlet Protection (add Type-3 for curb opening)
  - Tree Protection (expand to Sensitive Area Protection)

Delaware ESC Handbook Updates



- *NEW!*
  - Compost
    - Log
    - Blanket
    - Trap
  - Concrete Washout
  - Flocculants
  - Small Batch Plants
  - Stockpiles

Approved H&H Software Updates

H&H Software Endorsed by DNREC, Sediment & Stormwater Program
Effective Date: 8/05

Program (Distributor)	Stormwater Management											Storm Drainage					Misc.		
	NRCS Runoff Volume	NRCS Graphical Peak Discharge	NRCS Tabular Hydrograph	NRCS Dimensionless Unit Hydrograph	NRCS Delmarva Unit Hydrograph	Multiple-to-Composite Hydrograph	Short-Cut Reserv. Routing	Storage-Indication Reserv. Routing	Kinematic Hydrograph Translation	Reach Routing (Att-Kin or Equiv.)	Continuous Flow Modeling	Water Quality Modeling	Rational Method Peak Discharge	Culvert Design (HDS-5 Method)	Storm Drain System Design	Open Channel Design (Manning)	Open Channel Design (NRCS)	Water Surface Profile (Steady Flow)	Unsteady Flow Analysis (St. Venant)	Dam Breach Analysis	Hydraulic Structure Design/Modeling
Non-Proprietary																					
TR-55 (USDA-NRCS)	X	X	X		X	X	X		X												
WinTR-55 (USDA-NRCS)	X	X	X		X	X			X												X
TR-20 (USDA-NRCS)	X			X	X	X		X		X											
WinTR-20 (USDA-NRCS)	X			X	X	X		X		X											
OHIO (USDA-NRCS)	X	X												X		X	X	X			X
WSP2 (NRCS/FHWA)																		X			
HYDRAIN (FHWA)													X	X	X	X	X	X			
HY-8 (FHWA)														X							
HYCHL (FHWA)																X	X				
SWMM (EPA)											X	X							X		
HSPF (EPA)											X	X									
HEC-1 (COE)	X			X				X												X	
HEC-HMS (COE)	X			X		X		X	X	X											
HEC-2 (COE)																		X			
HEC-RAS (COE)																		X	X	X	
WMS (COE/BYU)	X			X	X	X		X		X											
DAMBRK (NWS)																			X	X	
SMPDBK (NWS)																				X	
THYSYS (Texas DOT)															X						
Proprietary																					
Quick TR-55 (Haestad)	X	X	X				X		X				X								
TR-20 (Haestad)	X			X	X	X		X		X											
Pond-2 (Haestad)						X		X													X
Flowmaster (Haestad)																X					
StormCAD (Haestad)															X						
CulvertMaster (Haestad)														X							
CivilSTORM (Bentley/Haestad)	X			X	X	X		X	X	X				X	X	X		X	X		X
HydroCAD (AMS)	X			X	X	X		X	X				X								X
Hydro/Plus (Plus III)	X			X	X	X		X					X								X
StormSHED (BOSS)	X			X	X	X		X		X											X
BOSS RMS (BOSS)																		X			
Hydraflow (Intelisolve)	X			X	X			X					X	X	X	X		X			
Storm Water Mgr. (Hydrosoft)	X		X					X													
PCSWMM (CHI)											X	X							X		
XP-SWMM (XP Software)											X	X							X		
TERRAMODEL (Spectra Precision)	X			X				X													
ICPR (Streamline Technologies)	X			X	X	X		X								X			X	X	X
HYDROCALC Hydraul. (Dodson & Assoc., Inc.)				(Not evaluated)																	
NETWORX (Streamline Technologies)				(Not evaluated)																	

- Delete obsolete software
- Review/update categories
- Add “Runoff Reduction” category
  - DURMM v.2
  - WinSLAMM

Approved SWM Structures Updates

Stormwater Treatment Structures Endorsed by DNREC, Sediment & Stormwater Program *Effective Date: 12/05*						
Manufacturer	**Product**	**Stand-Alone for TSS**	**Pre-Treatment for TSS**	**Petroleum Hydrocarbons**	**Trash/Gross Pollutant Removal**	**Component in Treatment Train**
Filtration Structures						
AquaShield, Inc.	Aqua-Filter		X	X		X
Gillespie & Son, Inc.	Pre-cast Modular Sand Filter	X		X		
National Concrete, Inc.	Pre-cast Modular Sand Filter	X		X		
Pipe & Precast Products, Inc.	Pre-cast Modular Sand Filter	X		X		
StormTreat Systems, Inc.	StormTreat		X	X		X
Stormwater 360	StormFilter	X		X		
Stormwater 360	StormGate		X	X		X
Hydrodynamic Separators						
Advanced Drainage Systems	ADS Water Quality Units		X	X		X
AquaShield, Inc.	Aqua-Swirl		X	X		X
BaySaver, Inc.	BaySaver		X	X		X
CDS Technologies	CDS Unit		X	X	X	X
H.I.L. Technology, Inc.	Downstream Defender		X	X	X	X
Rinker Materials Corp.	Stormceptor		X	X		X
Stormwater 360	Vortechs, VortSentry		X	X		X
Terre Hill Concrete Products	Terre-Kleen		X	X	X	X
Catch Basin Inserts						
AbTech	Ultra-Urban Filter				X	X
Best Management Practices, Inc.	Snout				X	X
Foss Environmental Services	StreamGuard Insert		X			X
Foss Environmental Services	StreamGuard Exert		X			X
Foss Environmental Services	SG Passive Skimmer			X		X
Hydro Compliance Management,	Hydro-Kleen		X	X	X	X
Suntree Technologies, Inc.	Grate Inlet Skimmer Box Curb Inlet Basket		X	X	X	X
Other Systems						
StormTech	Isolator Row Chambers	X		X	X	
Suntree Technologies, Inc.	Nutrient Seperating Baffle Box		X	X	X	X
Suntree Technologies, Inc.	Golf Green Filter				X	X

- Review/update categories
  - TSS removal no longer the perf. standard
  - TN & TP removal now important for TMDLs
- Review/update structures
- Appendix ***???***

Questions?

http://www.dnrec.delaware.gov/swc/Draina

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Services

- Conservation Districts
- Contractor Services
- Debris Pit Program
- Environmental Navigator
- Environmental Navigator (Revised - Beta version)
- Loans, Grants, Cost-Share
- Macroalgae Harvesting
- Permits, Licenses, Approvals
- Restoration

Information

- Alphabetical Listing of Information
- Delaware Estuarine Research Reserve
- Regs/Laws
- Request for

Sediment & Stormwater Technical Document

This series of articles has been assembled as a technical document to support the revisions to the Delaware Sediment and Stormwater Regulations. The articles and appendicies contain information, policies, procedures, checklists and examples to assist the regulated community in complying with the sediment and stormwater regulations.

DRAFT - Documents for **review only**

Article 1. Sediment and Stormwater Program Background

- 1.01 Executive Summary
- 1.02 Federal Clean Water Act Requirements
  - Appx. 1.02.1 Construction General Permit Program Delegation
  - Appx. 1.02.2 NPDES Construction General Permit Guidance
- 1.03 State Responsibilities ***NEW!***

Article 2. Policies and Procedures

- 2.01 Delegated Agencies
- 2.02 Plan Policies and Procedures ***NEW!***
- 2.03 Fees and Financial Guarantees
- 2.04 Offsets Provisions ***NEW!***
  - Appx. 2.04.1 In-Lieu Fee Proposal for On-Site Stormwater Management ***NEW!***
  - Appx. 2.04.2 Fee-In-Lieu Example ***NEW!***
  - 2.05 Regulatory Interpretation and Variances

Article 3. Plan Review and Approval

- 3.01 Goals and Objectives
  - 3.01.1 Standard Plans
    - 3.01.1.1 Residential
    - 3.01.1.2 Agricultural Structure
    - 3.01.1.3 Utility Construction
- 3.02 Plan Review Process - Detailed Plans
  - 3.02.1 Step 1 Project Application Meeting

Timeline Update

- December 31, 2011
  - Post Technical Documents
- January 10, 2012
  - RAC Meeting
- January 11, 2012
  - Submit Proposed Regulations to Registrar

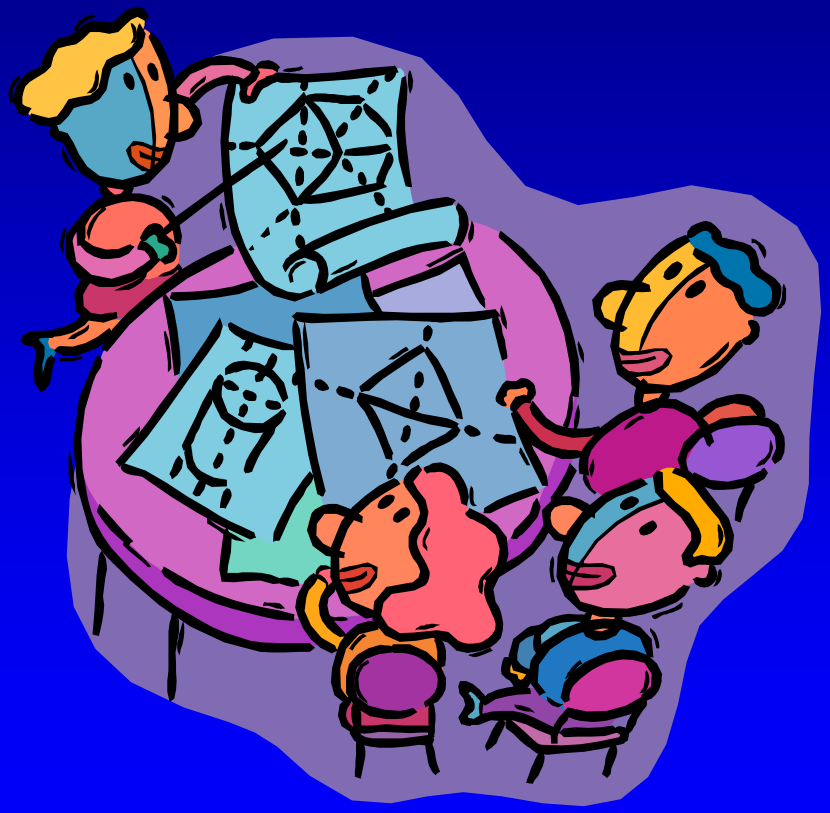
Timeline Update

- January 31, 2012
  - All Draft Technical Documents posted
- February 1, 2012
  - Proposed Regulations published in State Register
- February 2012 – date TBD
  - Public Hearing

Timeline Update

- May 1, 2012
  - Final Regs Published in State Register
- May 11, 2012
  - Promulgation Date
- Aug 11, 2012
  - Effective Date: revisions in Regulation Section 1.3 to allow for delayed effective date

Summer 2012

- Promulgation in May 2012
- Training throughout summer
  - DURMM v.2
  - Standards & Specifications
- Effective in August 2012

Discussion