Introduction to the New Virginia Stormwater Design Specifications

The following is an introduction to the new design specifications for 15 non-proprietary stormwater control measures (BMPs, or Best Management Practices) listed below for use in the Commonwealth:

1. Rooftop (and Impervious Area) Disconnection
2. Sheetflow to Open Space and Grass Filter Areas
3. Grass Channels
4. Soils Compost Amendments
5. Vegetated Roofs
6. Rainwater Harvesting
7. Permeable Pavement
8. Infiltration
9. Bioretention (including Urban Bioretention)
10. Dry Swales
11. Wet Swales
12. Filtering Practices
13. Constructed Wetlands
14. Wet Ponds
15. Dry Extended Detention Ponds

What's New?

This section outlines the new methods, concepts and performance standards inherent in the new design specifications. It also includes cross-cutting guidance, information and specifications that apply more than one of the individual specifications.

1. The Spreadsheet versus the Specifications

The new regulations herald a shift to the runoff reduction paradigm, where designers focus on reducing the post-development stormwater runoff volume from a site, as well as meeting more stringent nutrient load reduction requirements. The DCR compliance spreadsheet is used to verify whether runoff and nutrient reduction targets are actually being met at the site (**Figure 1**).

In most cases, designers will need to analyze a lot of design options with the spreadsheet, and will end up with a system or sequence of multiple practices across the site. While the compliance spreadsheet helps determine whether a site is in compliance, designers must still meet design criteria for individual practices at the site.

Land Cover Summary	
Forest/Open Space cover (acres)	6.00
Weighted Rv (forest)	0.04
% Forest	15%
Managed Turf Cover (acres)	20.00
Weighted Rv (turf)	0.21
% Managed Turf	50%
Impervious Cover (acres)	14.00
Rv (impervious)	0.95
% Impervious	35%
Total Site Area (acres)	40.00
Site Rv	0.45
Post-Development Treatment Volume (acre-ft)	1.48
Post-Development Treatment volume (cubic feet)	64,614
Post-Development Load (TP)	43.78
Post-Development Load (TP) check	43.72
%RR Without RR Practices	74%

Figure 1. Output from the DCR Compliance Spreadsheet

NOTE: The Runoff Reduction Method (RRM) spreadsheet computes the required treatment volume for a site, and analyzes the type and design levels of stormwater practices that are needed to comply with runoff and nutrient reduction targets. Designers then must use the design criteria contained in the new design specifications to ensure the practices will be hydrologically effective.

2. Maximizing Runoff Reduction (RR)and Nutrient Removal

The new stormwater regulations put a premium on maximizing the degree of runoff volume reduction and nutrient removal achieved at a development site. Each practice has a different capability to reduce annual runoff volumes, as well as a different treatment efficiency to reduce the event mean concentration (EMC) of nutrients as they pass through the practice. Consequently, designers should carefully review **Table 1** to determine which practices (and design levels) maximize annual runoff and nutrient reduction rates.

The computed annual load (lbs/ac/yr) is a product of the reduced volume multiplied by the reduced pollutant concentration. Some practices may achieve reductions solely through pollutant removal and provide no runoff reduction, while others may provide only runoff reduction and no measureable pollutant removal. Therefore, as the practices serve to reduce one or both values, a total annual mass load reduction is achieved. The technical support for these numbers can be found in CWP and CSN (2008) and extensive reviews of BMP performance monitoring studies incorporated into the National Pollution Removal Performance Database (CWP, 2007). Estimates for a few practices should be considered provisional (e.g., filter strips) due to limited data. The table will be updated over time to reflect new stormwater research.

At most sites, designers may need to employ several practices in a “roof to stream” sequence to meet the stringent runoff and pollutant reduction targets (e.g., rooftop disconnection to front yard bioretention to dry swale to constructed wetland).

Another relatively new feature is the inclusion of managed turf as a land cover that generates a pollutant load. In the spreadsheet, designers must account for the load contributed by managed turf in addition to impervious cover. Designers must also select the most appropriate practices to treat turf areas and turf-intensive land uses, such as sports fields, golf courses, and parkland. In many cases, some of the “lower-tech” approaches, such as Sheet Flow to Vegetated Filters and Conserved Open Space (Specification #2) and Grass Channels (Specification #3) may be appropriate. If the drainage area contains both managed turf and impervious cover, then the full range of practices should be considered.

Table 1. Comparative Runoff Reduction and Nutrient Removal for Practices

Practice	Design Level	Runoff Reduction	TN EMC Removal[3]	TN Load Removal	TP EMC Removal	TP Load Removal [6]
Rooftop Disconnect	*1 [2]*	*25 to 50 [1]*	*0*	*25 to 50 [1]*	*0*	*25 to 50 [1]*
	No Level 2 Design					
Sheet Flow to Veg. Filter or Conserv. Open Space	*1*	*25 to 50 [1]*	*0*	*25 to 50 [1]*	*0*	*25 to 50 [1]*
	2 [5]	*50 to 75 [1]*	*0*	*50 to 75 [1]*	*0*	*50 to 75 [1]*
Grass Channels	*1*	*10 to 20 [1]*	*20*		*15*	*23*
	No Level 2 Design					
Soil Compost Amendment	Can be used to Decrease Runoff Coefficient for Turf Cover at Site. See the design specs for Rooftop Disconnection, Sheet Flow to Vegetated Filter or Conserved Open Space, and Grass Channel					
Vegetated Roof	*1*	*45*	*0*	*45*	*0*	*45*
	2	*60*	*0*	*60*	*0*	*60*
Rainwater Harvesting	*1*	*Up to 90 [3, 5]*	*0*	*Up to 90 [3, 5]*	*0*	*Up to 90 [3, 5]*
	No Level 2 Design					
Permeable Pavement	*1*	*45*	*25*	*59*	*25*	*59*
	2	*75*	*25*	*81*	*25*	*81*
Infiltration Practices	*1*	*50*	*15*	*57*	*25*	*63*
	2	*90*	*15*	*92*	*25*	*93*
Bioretention Practices	*1*	*40*	*40*	*64*	*25*	*55*
	2	*80*	*60*	*90*	*50*	*90*
Urban Bioretention	*1*	*40*	*40*	*64*	*25*	*55*
	No Level 2 Design					
Dry Swales	*1*	*40*	*25*	*55*	*20*	*52*
	2	*60*	*35*	*74*	*40*	*76*
Wet Swales	*1*	*0*	*25*	*25*	*20*	*20*
	2	*0*	*35*	*35*	*40*	*40*
Filtering Practices	*1*	*0*	*30*	*30*	*60*	*60*
	2	*0*	*45*	*45*	*65*	*65*
Constructed Wetlands	*1*	*0*	*25*	*25*	*50*	*50*
	2	*0*	*55*	*55*	*75*	*75*
Wet Ponds	*1*	*0*	*30 (20) [4]*	*30 (20) [4]*	*50 (45) [4]*	*50 (45) [4]*
	2	*0*	*40 (30) [4]*	*40 (30) [4]*	*75 (65) [4]*	*75 (65) [4]*
Ext. Det. Ponds	*1*	*0*	*10*	*10*	*15*	*15*
	2	*15*	*10*	*24*	*15*	*31*

Notes [1] Lower rate is for HSG soils C and D, Higher rate is for HSG soils A and B.

[2] The removal can be increased to 50% for C and D soils by adding soil compost amendments, and may be higher yet if combined with secondary runoff reduction practices.

[3] Credit up to 90% is possible if all water from storms of 1-inch or less is used through demand, and the tank is sized such that no overflow occurs. The total credit may not exceed 90%.

[4] Lower nutrient removal in parentheses apply to wet ponds in coastal plain terrain.

[5] See BMP design specification for an explanation of how additional pollutant removal can be achieved.

[6] Total mass load removed is the product of annual runoff reduction rate and change in nutrient EMC.

3. Level 1 and Level 2 Design Standards.

Perhaps the most dramatic change in the new specifications is the design level approach. Almost every practice has two design levels that correspond to different runoff and/or nutrient reduction rates. Each design level contains specific performance standards to improve the internal geometry of practices and enhance their hydrologic and nutrient removal performance. For example, the Level 1 and 2 design standards for bioretention basins are shown in **Table 2**. The reader is encouraged to review the discussion in Section 12 of this Introduction for a description of the Level 1 and Level 2 design criteria that may influence the selection of practices intended to provide Channel Protection and Flooding control.

Table 2. Bioretention Basin Design Guidelines

Level 1 Design (RR 40 TP: 25)	Level 2 Design (RR: 80 TP: 50)
Sizing (Sec. 5.1): Surface Area (ft^2) = Tv = [(1.0")(Rv)(A)/12] – volume reduced by upstream BMP	Sizing (Sec. 5.1): Surface Area (ft^2) = Tv = [(1.25")(Rv)(A)/12] – volume reduced by upstream BMP
Maximum Drainage Area = 2 acres	
Maximum Ponding Depth = 6 to 12 inches	Maximum Ponding Depth = 6 to 12 inches[1]
Filter media depth minimum = 24 inches; recommended maximum = 6 feet	Filter media depth minimum = 36 inches; recommended maximum = 6 feet
Media & Surface Cover (Sec. 5.6) = supplied by vendor; tested for acceptable phosphorus index	
Sub-soil testing (Sec. 5.2): not needed if underdrain used; Min infiltration rate > 1.0 inch/hour to remove underdrain requirement;	Sub-soil testing (Sec. 5.2): one per 1,000 sf of filter surface; Min infiltration rate > 1.0 inch/hour to remove underdrain requirement
Underdrain (Sec. 5.7) = Schedule 40 PVC with clean-outs	Underdrain & Underground Storage Layer (Sec. 5.7) = Schedule 40 PVC with clean outs, and a minimum 12" stone sump below invert OR none if soil infiltration requirements are met (Sec. 5.2)
Inflow = sheetflow, curb cuts, trench drains, concentrated flow, or equivalent	
Geometry (Sec. 5.3): Length of shortest flow path/Overall length = 0.3 OR other design methods to prevent short-circuiting One cell design (not including pretreatment cell)	Geometry (Sec. 5.3): Length of shortest flow path/Overall length = 0.8 OR other design methods to prevent short-circuiting Two cell design (not including pretreatment cell)
Pretreatment (Sec. 5.4): = pretreatment cell, grass filter strip, gravel/stone diaphragm, gravel/stone flow spreader, or other approved (manufactured) pretreatment structure	Pretreatment (Sec. 5.4) = pretreatment cell + one of the following: grass filter strip, gravel/stone diaphragm, gravel/stone flow spreader, or other approved (manufactured) pretreatment structure
Planting Plan (Sec. 5.8) = planting template to include turf, herbaceous, shrubs, and/or trees to achieve surface area coverage of at least 75% within 2 years	Planting Plan (Sec. 5.8) = planting template to include turf, herbaceous, shrubs, and/or trees to achieve surface area coverage of at least 90% within 2 years. If using turf, must combine with other types of vegetation[1].
Building setbacks (Sec. 4): 0 to 0.5 Ac CDA = 10' down-gradient; 50' up-gradient 0.5 to 2.5 Ac CDA = 25' down-gradient; 100' up-gradient	
Deeded maintenance O&M plan (Sec. 7)	

4. Defined Flow Path

Many of the design specifications contain standards to assure that a minimum flow path is attained through the stormwater practice. **Figure 2** illustrates how these critically important hydrologic parameters are measured and defined.

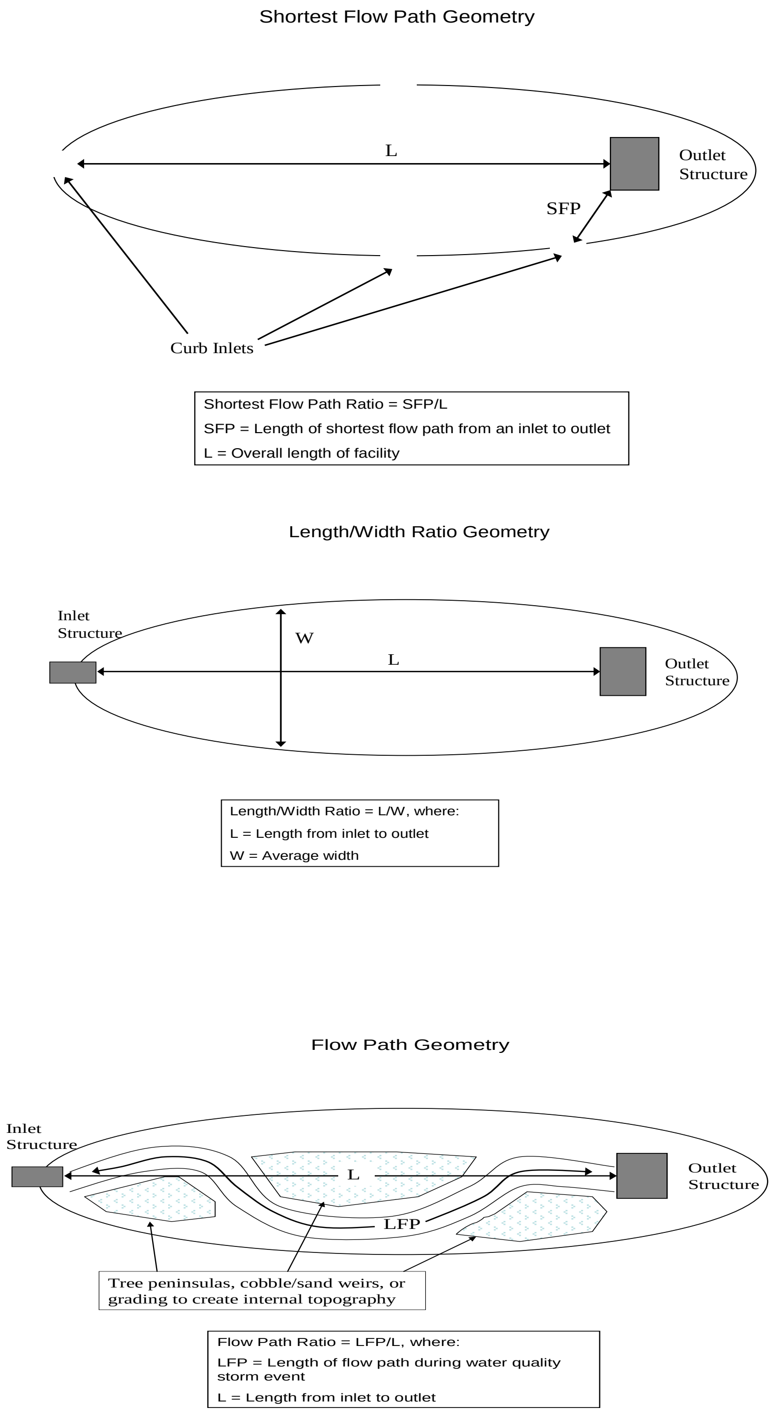

Figure 2. Typical BMP Flow Path Parameters

5. Integrating Water Quality Treatment with Control of Larger Storms

Designers must also design stormwater practices to provide channel protection and flood control. The new specs allow for a runoff reduction credit that can be applied to reduce the detention storage volume needed to control larger design storm events. This is generally accomplished using the Runoff Reduction Method design spreadsheet.

The practices listed in **Table 3** that provide an RR value do so either through a storage component and/or an elongation of the time of concentration, both of which attenuate the runoff and encourage infiltration and abstraction, resulting in a decrease in the computed release volume and peak discharge. The effectiveness of a practice to provide a reduction in volume or discharge during larger storms is a function of the relative volume of storage provided versus the volume of runoff. As the runoff depth increases, say from a 1-year frequency rainfall to a 10-year frequency event, the effectiveness of the storage at reducing the volume or peak discharge decreases.

The RRM spreadsheet provides the designer with this relative value for controlling larger storms by utilizing the annual RR value as retention storage and computing an adjusted (reduced) curve number using the TR-55 Runoff Equations (Equations 2-1 through 2-4; and/or in conjunction with TR-55 Figure 2-1). This new curve number is then used for computing the peak discharge for the larger storm as required by the channel protection of flooding requirements.

If the practice has a storage component that can be expanded in order to provide a great volume of storage for larger storm events, the designer may increase those components in accordance with guidance provided in the specifications or in the updated SWM Handbook. The designer may than choose to utilize the *actual storage volume provided* (rather than the RR value) and compute an adjusted curve number directly from TR-55 for the desired storm events.

It should be noted that a curve number must be computed for each storm event due to the diminishing effect of the storage as the rainfall depth increases. It should also be noted that the RR credit assigned in the spreadsheet, and not the actual storage, must be used for the water quality calculations. Additional guidance and computational procedures will be provided in the updated SWM Handbook.

The flow chart shown in **Figure 3** outlines the general design process for accounting for channel protection and flood control storm events when runoff reduction practices are employed. In most cases, use of upland runoff reduction practices will greatly diminish or even eliminate the storage volumes needed to manage the larger storm events associated with channel protection and/or flood control.

The reader is encouraged to review the discussion in Section 12 of this Introduction for a description of the Level 1 and Level 2 design criteria that may influence the selection of practices intended to provide Channel Protection and Flooding control where runoff reduction practices do not provide adequate reductions.

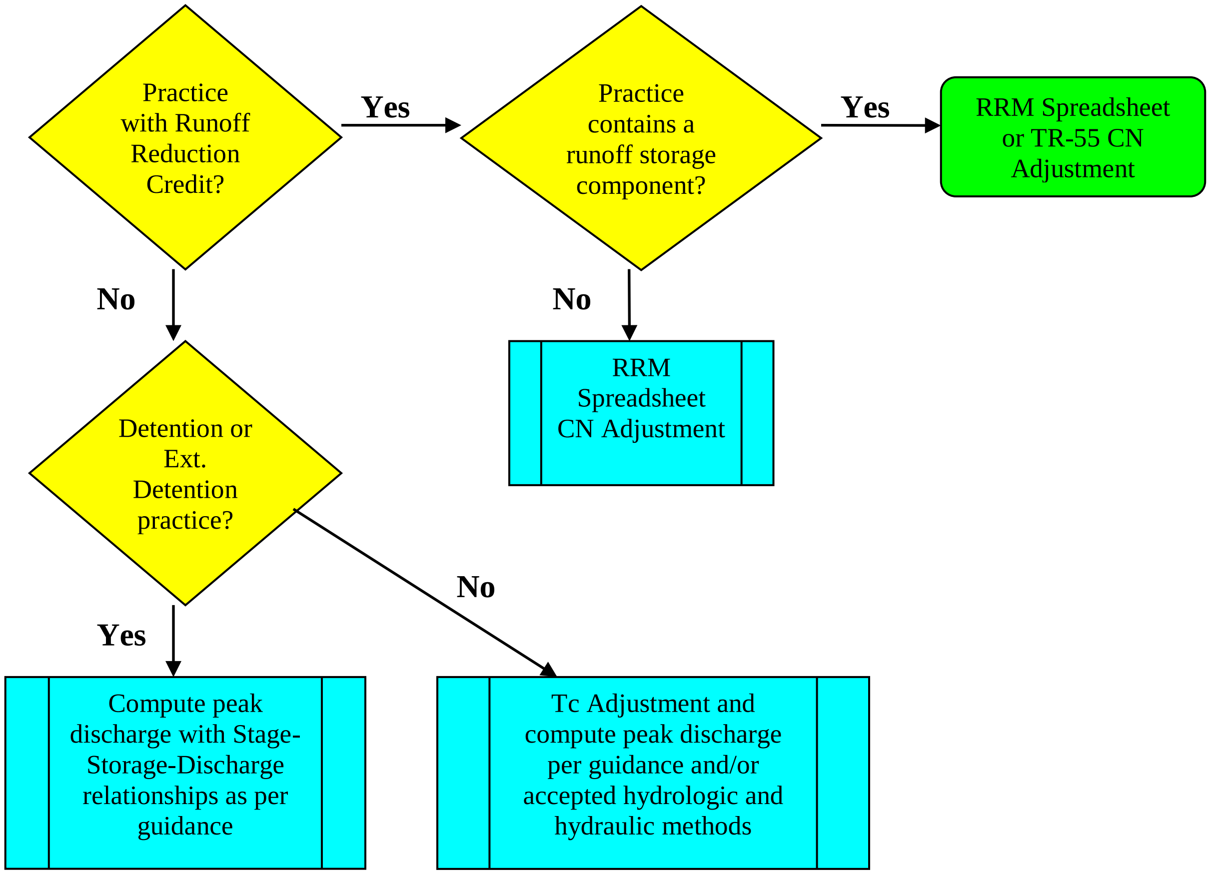

Figure 3.Design Process for Modeling RR Adjustments for Larger Storm Events

6. Stormwater Hotspots

Stormwater hotspots are operations or activities that are known to produce higher concentrations of stormwater pollutants and/or have a greater risk for spills, leaks or illicit discharges. The actual hotspot generating area may only occupy a portion of the entire proposed site. If a site is designated as a potential stormwater hotspot, designers must prepare a Stormwater Pollution Prevention Plan (SWPPP) that outlines pollution prevention and treatment practices that will be implemented to minimize polluted discharges from the site. Depending on the potential severity of the hotspot, there may also be restrictions on practices that infiltrate stormwater into groundwater (see **Table 4**).

- **Restricted Infiltration**. A minimum of 50% of the total treatment volume must be treated by a filtering or bioretention practice prior to any infiltration. Portions of the site that are not associated with the hotspot generating area should be diverted away and treated by another acceptable stormwater practice.

- **Infiltration Prohibition.** The risk of groundwater contamination from spills, leaks or discharges is so great at these sites that infiltration of stormwater or snowmelt is ***prohibited.***

Table 3. Differences in Practice Sizing for Water Quality and Larger Storm Events

Practice	No	Treatment Volume ON/ OFF [1]	Treatment Volume Level 1	Treatment Volume Level 2	Control of Larger Storm Events: Channel Protection and Peak Discharge Control Capability?
Rooftop Disconnection	1	OFF	1 in *	NA	**Partial**, Adjust CDA CN using RRM Spreadsheet
Sheetflow to Veg. Filter of Conserved Open Space	2	OFF	1 in	NA	**Partial**, Adjust CDA CN using RRM Spreadsheet
Grass Channels	3	ON	1 in *	NA	**Partial**, Adjust CDA CN using RRM Spreadsheet and Increase Tc
Soil Compost Amendments	4	ON OFF	1 in *	NA	**None**
Vegetated Roofs	5	ON	1 in *	1	**Partial**, Adjust CDA CN using RRM Spreadsheet
Rainwater Harvesting	6	ON	1 in *	1.1	**Partial**, Adjust CDA CN using RRM Spreadsheet
Permeable Pavement	7	ON	1 in #	1.1	**Partial to Full**, Adjust CDA CN using RRM Spreadsheet and Add Storage in Reservoir
Infiltration	8	OFF	1 in #	1.1	**Partial to Full**, Adjust CDA CN using RRM Spreadsheet and Add Storage below underdrain
Bioretention	9	ON OFF	1 in #	1.25	**Partial to Full**, Adjust CDA CN using RRM Spreadsheet and add extra storage on surface, in soil, and below underdrain
Urban Bioretention	9A	OFF	1 in *	NA	**None.**
Dry Swales	10	ON	1 in *	1.1	**Partial**, Adjust CDA CN using RRM Spreadsheet and Increase Tc
Wet Swales	11	ON	1 in *	1.25	**Limited.** Adjust Tc
Filtering Practices	12	OFF	1 in	1.25	**Partial**, Adjust CDA CN using RRM Spreadsheet
Constructed Wetlands	13	ON	1 in	1.5	**Full.** Detention storage can be provided above pool or max ED level in the basin for channel protection and flood control
Wet Ponds	14	ON	1 in	1.5	
Ext. Detention Ponds	15	ON	1 in	1.25	

Notes: [1] Whether the practice is normally designed as an on-line (ON) or off-line (OFF) relative to the primary flow path (*) indicates the practice may be designed to provide only a fraction of the treatment volume (Tv) when multiple practices are combined together. (#) indicates that small or micro-scale design applications may be designed with only partial treatment volume. **Other terms**: CDA= contributing drainage area Cpv = channel protection volume, ED = extended detention Tc= time of concentration CN= curve number NA= not applicable RRM = runoff reduction method

7. Adapting Practices for Unique Terrain

Table 4. Comparison of Practices in Different Water Resource Settings

Practice	Spec No.	Karst Terrain [1]	Coastal Plain [2]	Trout Waters [3]	Ultra-Urban [4]	Hotspots [5]
Rooftop Disconnection	1	Preferred	Preferred	Preferred	Restricted	Accepted
Sheetflow to Veg. Filter or Conserved Open Space	2	Preferred	Preferred	Preferred	Restricted	Restricted
Grass Channels	3	Accepted	Restricted	Accepted	Restricted	Restricted
Soil Compost Amendments	4	Accepted	Accepted	Preferred	Preferred	Restricted
Vegetated Roofs	5	Preferred	Accepted	Accepted	Preferred	Accepted
Rainwater Harvesting	6	Preferred	Preferred	Preferred	Preferred	Accepted
Permeable Pavement	7	Preferred	Preferred	Preferred	Preferred	Prohibited
Infiltration	8	SS: Acc. LS: Pro.	SS: Acc. LS: Rest.	Preferred	Restricted	Prohibited
Bioretention	9	SS: Acc LS: Rest.	Preferred	Preferred	Preferred	Accepted
Urban Bioretention	9A	Preferred	Accepted	Restricted	Preferred	Accepted
Dry Swales	10	Preferred	Preferred	Preferred	Restricted	Restricted
Wet Swales	11	Prohibited	Preferred	Accepted	Restricted	Restricted
Filtering Practices	12	Preferred	Accepted	Accepted	Preferred	Preferred
Constructed Wetlands	13	Accepted	Preferred	Accepted	Restricted	Restricted
Wet Ponds	14	Restricted	Accepted	Prohibited	Restricted	Accepted
Ext. Detention Ponds	15	Restricted	Restricted	Restricted	Restricted	Restricted
KEY	(green)	**Preferred Practice:** widely feasible and recommended				
	(white)	**Accepted Practice:** can work depending on site conditions				
	(yellow)	**Restricted Practice:** extremely limited feasibility				
	(pink)	**Prohibited Practice:** do not use due to environmental risk				

NOTES: SS = small scale applications LS = large scale applications
[1] CSN Tech Bulletin No. 1 [2] CSN Tech Bulletin No. 2 [3] CSN Tech Bulletin No. 6
[4] CSN Tech Bulletin No. 5 [5] CWP (2004)

The selection of the most effective stormwater practice depends on the nature of terrain, the intensity of development, and the sensitivity of the receiving water. To assist designers, **Table 4** presents a comparative matrix on which practices are recommended, acceptable, restricted or prohibited in the Commonwealth. These areas include karst and coastal plain terrain, trout watersheds, ultra-urban watersheds and stormwater hotspots.

8. Spatial Scale at Which Practices are Applied

The matrix provided in **Table 5** compares the different spatial scales by which the various stormwater practices can be applied to reduce runoff and remove nutrients.

Table 5. Comparison of Practices Based on Contributing Drainage Area Served

<table>
<tr><th>Practice</th><th>Spec No.</th><th>Micro Scale</th><th>Small Scale</th><th>Normal Scale</th><th>Moderate Scale</th><th>Large Scale</th></tr>
<tr><td>Rooftop Disconnection</td><td>1</td><td>250 to 1000 sf</td><td colspan="4"></td></tr>
<tr><td>Sheet Flow to Veg. Filter or Conserved Open Space</td><td>2</td><td></td><td>1000 to 5000 sf</td><td>5000 to 25,000 sf</td><td colspan="2"></td></tr>
<tr><td>Grass Channels</td><td>3</td><td colspan="2"></td><td colspan="2">20,000 sf to 250,000 sf</td><td></td></tr>
<tr><td>Soil Compost Amendments</td><td>4</td><td colspan="3">250 sf to 2 acres</td><td colspan="2"></td></tr>
<tr><td>Vegetated Roofs</td><td>5</td><td rowspan="2">Residential 250 to 2000 sf</td><td colspan="2" rowspan="2">Commercial 2,000 to 200,000 sf</td><td colspan="2"></td></tr>
<tr><td>Rainwater Harvesting</td><td>6</td><td colspan="2"></td></tr>
<tr><td>Permeable Pavement</td><td>7</td><td>250 to 1000 sf</td><td>1000 to 10,000 sf</td><td>10,000 to 200,000</td><td colspan="2"></td></tr>
<tr><td>Infiltration</td><td>8</td><td>250 to 2500 sf</td><td>2500 to 20,000 sf</td><td>20,000 to 100,000 sf</td><td colspan="2"></td></tr>
<tr><td>Bioretention</td><td>9</td><td>250 to 2500 sf</td><td>2500 to 20,000 sf</td><td>20,000 to 100,000 sf</td><td colspan="2"></td></tr>
<tr><td>Urban Bioretention</td><td>9A</td><td>250 to 2500 sf</td><td>2500 to 20,000 sf</td><td colspan="3"></td></tr>
<tr><td>Dry Swales</td><td>10</td><td colspan="2"></td><td colspan="2">20,000 to 250,000 sf</td><td></td></tr>
<tr><td>Wet Swales</td><td>11</td><td colspan="2"></td><td colspan="2">20,000 to 250,000 sf</td><td></td></tr>
<tr><td>Filtering Practices</td><td>12</td><td colspan="2"></td><td colspan="2">20,000 to 250,000 sf</td><td></td></tr>
<tr><td>Constructed Wetlands</td><td>13</td><td colspan="4"></td><td rowspan="3">10 + more acres, unless favorable water balance</td></tr>
<tr><td>Wet Ponds</td><td>14</td><td colspan="4"></td></tr>
<tr><td>Ext. Detention Ponds</td><td>15</td><td colspan="4"></td></tr>
</table>

The major change in the new specifications is that most practices are applied at a smaller spatial scale than had been done in the past, which means that more practices will need to be installed at each site. Note that the area ranges for the contributing drainage area (CDA) are approximate, and may be greater or smaller depending on design and site conditions. Multiple practices of the same or different kind may be used in combination to treat a larger CDA.

9. Recommended Construction Sequence

Recent studies indicate the importance of proper construction methods to ensure that stormwater practices actually meet their intended design function (Hirschman et al, 2009). Consequently, each design specification contains extensive information on the proper construction method for the practice, along with checklists and other construction inspection criteria.

10. Maintenance Inspections

Maintenance is essential to ensure that practices achieve their hydrologic and pollutant removal functions over time. The new specifications include more detailed information on how to conduct maintenance inspections that, in turn, trigger specific tasks that must be done to maintain performance. An example of these maintenance inspection points (for Permeable Pavement) can be found in **Table 6**. The specifications also provide more detail on the minimum elements in required maintenance agreements, which are essential when more and smaller stortmwater practices are employed at a site.

Table 6. Suggested Annual Maintenance Inspection Points for Permeable Pavements

Activity
• The drawdown rate should be measured at the observation well for three days following a storm event in excess of 0.5 inch in depth. If standing water is still observed in the well after three days, this is a clear sign that that clogging is a problem.
• Inspect the surface of the permeable pavement for evidence of sediment deposition, organic debris, staining or ponding that may indicate surface clogging. If any signs of clogging are noted, schedule a vacuum sweeper (no brooms or water spray) to remove deposited material. Then, test sections by pouring water from a five gallon bucket to ensure they work.
• Inspect the structural integrity of the pavement surface, looking for signs of surface deterioration, such as slumping, cracking, spalling or broken pavers. Replace or repair affected areas, as necessary.
• Check inlets, pretreatment cells and any flow diversion structures for sediment buildup and structural damage. Note if any sediment needs to be removed
• Inspect the condition of the observation well and make sure it is still capped
• Generally inspect any contributing drainage area for any controllable sources of sediment or erosion

11. More Defined Feasibility Criteria

Table 7 compares some common feasibility constraints for the range of stormwater practices, including soil restrictions, maximum slopes, available head, space foot print and minimum depth to water table and bedrock. Designers should consult each individual practice specification for additional restrictions, setbacks and environmental constraints.

Table 7. Comparison of Site Feasibility of Practices

Practice	No.	Soils [1]		Other Site Constraints [2]			
		HSG A/B	HSG C/D	DEPTH WT/BR[3]	MIN HEAD[4]	MAX SLOPE[5]	SPACE (%) [6]
Rooftop Disconnection	1	B only	Yes, w/ 2nd RR [7]	2 ft	1 foot	1 - 2%	Nominal
Sheet Flow to Veg. Filter or Conserved Open Space	2	Yes	Yes, w/ CA [8]	2 ft	1-2 ft	6 - 8% [9]	15 - 25%
Grass Channels	3	Yes	Yes, w/ Ad. RT [10]	2 ft	2-3 ft	2 - 4%	5 - 15%
Soil Compost Amendments	4	Not on A soils	Yes	1.5 ft	1 ft	10%	Nominal
Vegetated Roofs	5	NA [11]	NA	NA	1-2 ft	Varies	Nominal
Rainwater Harvesting	6	NA	NA	NA	Varies	NA	Nominal
Permeable Pavement	7	Yes, w/ Ad IR[12]	Yes, w/ UD [13]	2 ft	2-4 ft	1 - 3% [14]	Nominal
Infiltration	8	Yes w/ Ad IR [12]	NO	2 ft	2-4 ft	0 to 5%	1 - 4%
Bioretention	9	Yes	Yes, w/ UD [13]	2 ft	4-5 ft	1 to 5%	3 - 5%
Urban Bioretention	9A	NA	NA	NA	3-5 ft	NA	Nominal
Dry Swales	10	Yes	Yes, w/ UD [13]	2 ft	3-5 ft	4%	5 - 15%
Wet Swales	11	No	Yes	0 ft [16]	2 ft	2%	5 - 15%
Filtering Practices	12	NA	NA	2 ft	2-10 ft	NA	0 - 3%
Constructed Wetlands	13	Yes, w/ Liner [15]	Yes	Below [16]	2-4 ft	NA	3%
Wet Ponds	14	Yes, w/ Liner [15]	Yes	Below[16]	6-8 ft	NA	1 - 3%
Ext. Detention Ponds	15	Yes, w/ Liner [15]	Yes	2 ft	6-10 ft	NA	1 - 3%

Notes [1] NRCS Hydrologic Soil Groups (HSG) [2] These are general ranges only. [3] vertical distance from bottom invert of practice and water table and bedrock, may be different in karst and/or coastal plain terrain [4] vertical distance from inflow to practice and its bottom invert [5] maximum internal slope of the practice [6] typical footprint of practice as percent of site area [7] with an acceptable secondary runoff reduction practice such as rain garden, dry well or CA-amended filter path [8] filter strip w/ compost amendment (CA) [9] 6% for conservation filter and 8% for grass filter strip [10] grass swale must achieve minimum residence time (RT) of ten minutes [11] Not Applicable (NA) [12] with minimum measured infiltration rate (IR) of 0.5 inches/hr [13] with underdrain [14] slopes can be broken up by terracing. [15] depending on borings, a liner may be needed to hold water [16] for water table only, 2 foot distance to bedrock still required

12. Level 1 and Level 2 Pond Selection

Large surface area basins, such as the Extended Detention (ED) Pond (BMP Spec No. 15), the Wet Pond (BMP Spec No. 14), and the Constructed Wetland (BMP Spec No. 13), are frequently used where large volumes of runoff must be managed for purposes of channel protection, flood protection, or both, in addition to the water quality Treatment Volume (Tv) design component. Where development projects include large areas of impervious cover and therefore require a similarly large volume of detention storage, designers can readily calculate the required storage volumes. The Tv requirements are typically met with the use of an extended detention, permanent pool, or wetland pool volume, and therefore the additional channel protection and flooding storage volumes will generally reflect only a modest increase in the design maximum water surface elevations (and facility footprint) due to the large overall base footprint of the facility.

Therefore, the use of these volume based facilities may be preferred in that they can provide a relatively inexpensive solution to multiple stormwater management objectives. However, it is important to note that these practices provide minimal runoff reduction and are therefore the third (or final) step in the Runoff Reduction Method roof-to-stream runoff reduction sequence. As such, sole use of any one of these practices may not provide adequate water quality pollutant removal performance and should be be considered for use after all other upland runoff reduction opportunities have been exhausted and there is still a remaining water quality or Channel Protection Volume to manage.

Designers will find that the use of simple disconnection, disconnection with alternative practices, and other runoff reduction practices can serve to dramatically decrease not only the required Tv (which serves as the basic BMP sizing parameter), but can also provide a significant benefit towards meeting the channel protection (1-year design storm)requirements as well.

The design specifications for the Level 1 and Level 2 ED, wet pond, and constructed wetland facilities include criteria for components that serve to enhance either the runoff reduction or the pollutant removal capabilities. On first glance, it may appear to be a simple decision to select the Level 2 design in order to achieve the higher pollutant removal credit. However, designers should review the different criteria carefully to identify the limiting design criteria with regard to available space (facility footprint): allowable ponding depths, facility geometry for minimum flow path and length to width requirements, multiple cells, etc., as required by the Level 1 and Level 2 design criteria.

A brief review of these three practices provides a tiered performance credit that starts with the ED pond. The ED pond provides only modest pollutant removal, and only the Level 2 provides a similarly modest runoff reduction. The critical design criteria is the relationship between the required Tv (1.0 times the site Tv, vs 1.25 for a Level 2) and the ability to allocate that Tv volume into the permanent pools (even a dry ED incorporates a wet pool volume in the forebay, outlet micro-pool, and any additional “wet” cells). While the decision to use a Level 2 would initially appear to be the best option in terms of facility size and depth, it is important to evaluate the impact of the additional geometry (flow path, length to width ratio, etc.) and pounding depth requirements.

A review of the wet pond and wetland designs reveal a similar hierarchy that easily encourages the selection of the Level 2 design on first glance, but ultimately may reflect a significant implementation challenge. The research of the performance of stormwater wet pond and wetland practices reveals a significant benefit to increased surface area, long flow paths, multiple cells, etc. over simple volume, thus the additional requirements for Level 2 designs. Designers that attempt to establish a preliminary footprint for the stormwater strategy based on a quick review of the criteria may select what appears to be the smaller overall Tv footprint based on the allocation between permanent pool and ED storage above the pool. However, the various geometry requirements may likely require a larger footprint for the Level 2 design.

13. Unified Terminology

Table 8 contains a list of the key terminology and abbreviations that are found throughout the specifications.

Table 8. List of Key Units and Abbreviations Used in Specs

A	Site Area (acres)	IP	Interlocking Concrete Pavers
ASTM	A. Society of Testing Materials	P	Annual Precipitation
CA	Compost Amendments	PA	Porous Asphalt
CDA	Contributing Drainage Area	PC	Porous Concrete
CEC	Cation Exchange Capacity	Rv	Runoff Coefficient
Cpv	Channel Protection Volume	RCS	Regenerative Conveyance System
CN	NRCS Curve Number	RRv	Runoff Reduction Volume
CSN	Chesapeake Stormwater Network	SA	Surface Area of Practice
CWP	Center for Watershed Protection	SRP	Secondary RRv Practice
ED	Extended Detention	Tc	Time of Concentration
EMC	Event Mean Concentration	Tv	Water Quality Treatment Volume
ESC	Erosion and Sediment Control	TP	Total Phosphorus
H:V	Horizontal to Vertical (slopes)	TN	Total Nitrogen
HSG	Hydrologic Soil Group	WQv	Really means Tv
IC	Impervious Cover		

14. Appendices to this Introduction Document

There are five Appendices attached to this introduction document. The Introduction involves information common to most or all of the BMPs. Similarly, these five Appendices were actually individual BMP specifications in the 1999 Virginia Stormwater Handbook for omponents of various pond practices. They include:

- Earthen Embankments

- Principal Spillways
- Vegetated Emergency Spillways
- Sediment Forebays
- Landscaping

Since these five specifications still apply to more than one other individual BMP design, they are presented here as Appendices A through E.

15. Acknowledgements

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