VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 11

WET SWALE

VERSION 1.9
March 1, 2011

SECTION 1: DESCRIPTION

Wet swales can provide runoff filtering and treatment within the conveyance system and are a cross between a wetland and a swale. These linear wetland cells often intercept shallow groundwater to maintain a wetland plant community. The saturated soil and wetland vegetation provide an ideal environment for gravitational settling, biological uptake, and microbial activity. On-line or off-line cells are formed within the channel to create saturated soil or shallow standing water conditions (typically less than 6 inches deep).

SECTION 2: PERFORMANCE

While Wet Swales do not provide runoff volume reduction, they do provide moderate pollutant removal, depending on their design (see **Table 11.1**). Wet Swales are particularly well suited for the flat terrain and high water table of the coastal plain.

Table 11.1. Summary of Stormwater Functions Provided by Wet Swales

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	0%	0%
Total Phosphorus (TP) EMC Reduction[1] by BMP Treatment Process	20%	40%
Total Phosphorus (TP) Mass Load Removal	20%	40%
Total Nitrogen (TN) EMC Reduction[1] by BMP Treatment Process	25%	35%
Total Nitrogen (TN) Mass Load Removal	25%	35%
Channel Protection	Limited – reduced Time of Concentration (TOC); and partial Channel Protection Volume (CPv) can be provided above the Treatment Volume (T_v), within the allowable maximum ponding depth.	
Flood Mitigation	Limited – reduced TOC	
[1] Change in event mean concentration (EMC) through the practice.		

Sources: CWP and CSN (2008), CWP, 2007

SECTION 3: DESIGN TABLE

The major design goal for Wet Swales is to maximize nutrient removal. To this end, designers may choose the baseline design (Level 1) or an enhanced design (Level 2) that maximizes nutrient removal.

Table 11.2. Wet Swale Design Criteria

Level 1 Design (RR:0; TP:20; TN:25)	Level 2 Design (RR:0; TP:40; TN:35)
T_v = [(1 inch)(R_v)(A)] / 12 – the volume reduced by an upstream RR BMP	T_v = [(1.25 inch)(R_v)(A)] / 12 – the volume reduced by an upstream RR BMP
Swale slopes less than 2% [1]	Swale slopes less than 1% [1]
On-line design	Off-line swale cells
No planting	Wetland planting within swale cells
Turf cover in buffer	Trees within swale cells
[1] Wet Swales are generally recommended only for flat coastal plain conditions with a high water table. A linear wetland is always preferred to a wet swale. However, check dams or other design features that lower the effective longitudinal grade of the swale can by applied on steeper sites, to comply with these criteria.	

SECTION 4: TYPICAL DETAILS

Figure 11.1 provides a standard plan and profile detail for an on-line Wet Swale with an off-line wetland cell. **Figure 11.2** shows a typical plan, profile, and section for a Wet Swale.

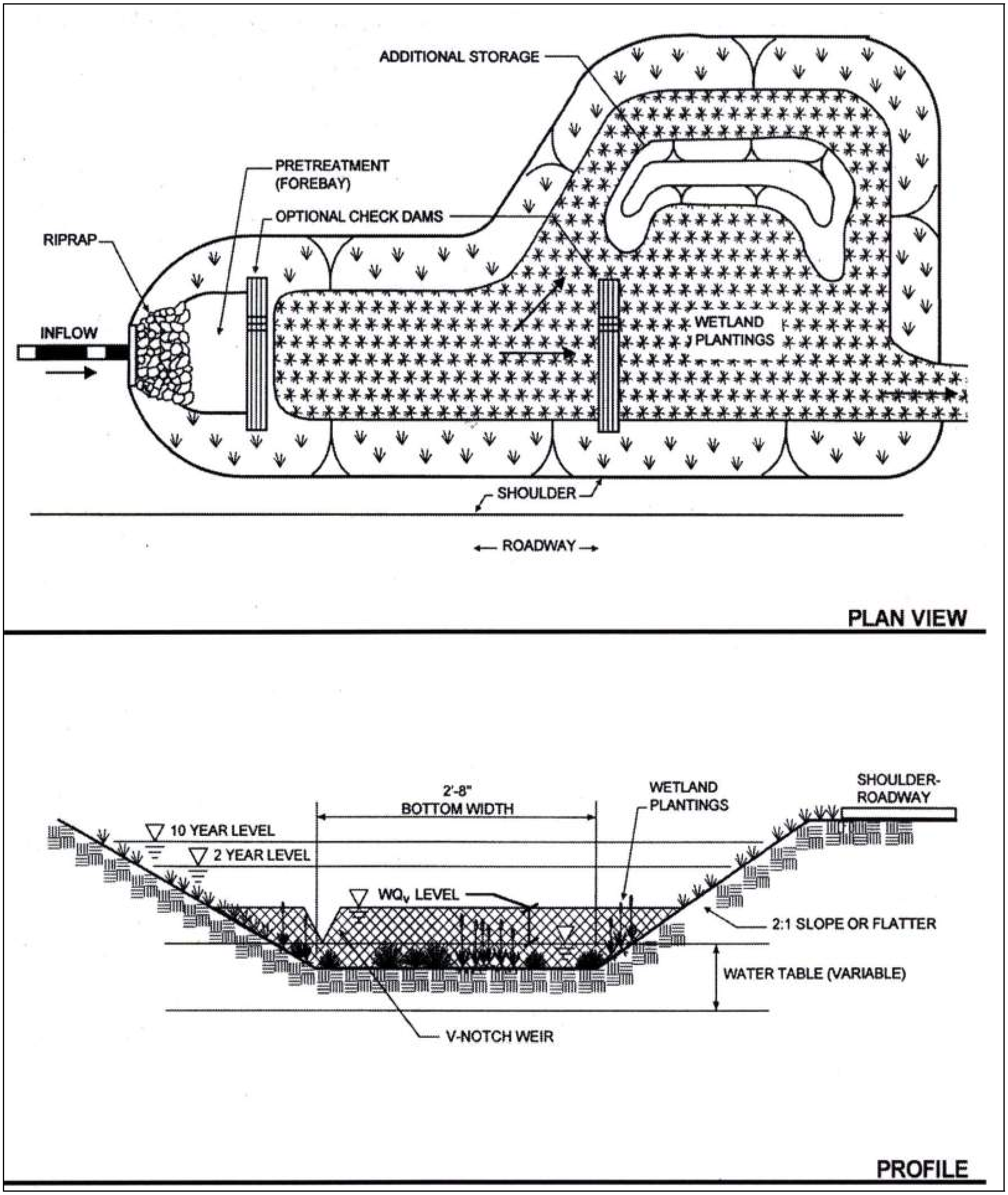

Figure 11.1. Wet Swale Details

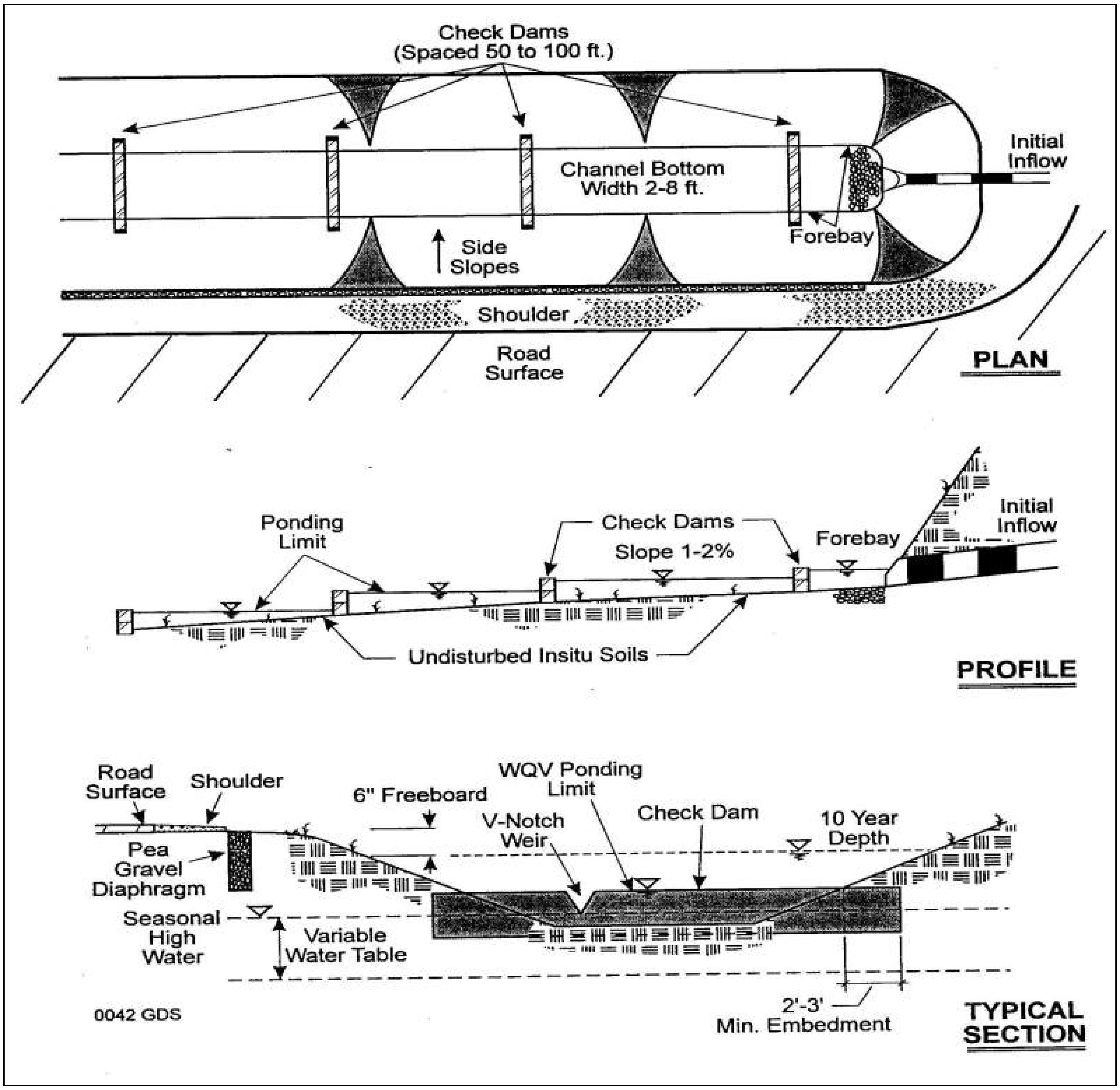

Figure 11.2. Typical Wet Swale Schematics

SECTION 5: PHYSICAL FEASIBILITY & DESIGN APPLICATIONS

Wet swales can be implemented on development sites where development density, topography, and soils are consistent with the following criteria.

Contributing Drainage Area. The maximum contributing drainage area (CDA) to a Wet Swale should not exceed 5 acres, but preferably will be less.

Space Required. Wet Swale footprints usually cover about 5% to 15% of their contributing drainage area.

Site Topography. Site topography constrains Wet Swales; some gradient is needed to provide water quality treatment, but not so much that treatment is impeded. Wet swales generally work best on sites with relatively flat slopes (i.e., less than 2% gradient).

A modification of the wet swale is the Regenerative Conveyance System (RCS). The RCS can be used to bring stormwater down steeper grades through a series of step pools. Refer to Section 7: Regional and Special Case Design Adaptations.

Depth to Water Table. It *is* permissible for wet swales to intersect the water table.

Soils. Wet Swales work best on the more impermeable Hydrologic Soil Group (HSG) C or D soils.

Hydraulic Capacity. When a Wet Swale is used as an on-line practice (Level 1 design), it must be designed with enough capacity to convey runoff from the 10-year design storm and be non-erosive during both the 2-year and 10-year design storms. This means that the surface dimensions are largely determined by the need to pass these larger storm events.

When a Wet Swales is used as an off-line practice (Level 2 design), a bypass or diversion structure must be designed to divert the large storm (e.g., when the flow rate and/or volume xceeds the water quality Treatment Volume) to an adequate channel or conveyance system. The Wet Swale is then designed to provide the required volume and meet the velocity and residence time criteria for the T_v.

Hotspot Land Uses. Wet Swales are not recommended to treat stormwater hotspots, due to the potential interaction with the water table and the risk that hydrocarbons, trace metals, and other toxic pollutants could migrate into the groundwater. For a list of designated stormwater hotspots, consult Stormwater Design Specification No. 8 (Infiltration).

Highway Runoff. The linear nature of Wet Swales makes them well suited to treat highway or low- and medium-density residential road runoff, if there is adequate right-of-way width and distance between driveways.

SECTION 6: DESIGN CRITERIA

6.1. Sizing of Wet Swales

Wet Swales should be designed to capture and treat the Treatment Volume (T_v) remaining from the upstream runoff reduction practices. Runoff treatment credit can be taken for any temporary or permanent storage created within each Wet Swale cell. This includes the permanent wet storage below the normal pool level and up to 12 inches of temporary storage created by check dams or other design features. Designers must also demonstrate that *on-line* Wet Swales have sufficient capacity to safely convey the 10-year design storm event. Refer to the hydraulic design methods outlined in Stormwater Design Specification No. 3 (Grass Channels). (NOTE: After the new Virginia Stormwater Management Regulation revisions take effect, the above requirement will be driven by the SWM Regulations (4 VAC 50-60-66 A 1 and B 1), which will supersede the MS-19 criteria of the Virginia E&S Control Regulations.)

6.2. Swale Pretreatment and Geometry

The Wet Swale should follow the general design guidance contained in Sections 6.2 and 6.3 of Stormwater Design Specification No. 3 (Grass Channels).

6.3. Other Design Issues for Wet Swales

- The average normal pool depth (dry weather) throughout the swale should be 6 inches or less.
- The maximum temporary ponding depth in any single Wet Swale cell should not exceed 18 inches at the most downstream point (e.g., at a check dam or driveway culvert).
- Check dams should be spaced as needed to maintain the effective longitudinal slope identified for the Level 1 or Level 2 design, as appropriate. A typical plan and profile for the check dams is provided in **Figure 11.2** above.
- Individual Wet Swale segments formed by check dams or driveways should generally be at least 25 to 40 feet in length.
- Wet Swale side slopes should be no steeper than 4H:1V to enable wetland plant growth. Flatter slopes are encouraged where adequate space is available, to enhance pre-treatment of sheet flows entering the channel. Under no circumstances are side slopes to steeper than 3H:1V.

6.4. Planting Wet Swales

Designers should choose grass and wetland plant species that can withstand both wet and dry periods as well as relatively high velocity flows within the channel. For a list of wetland plant species suitable for use in Wet Swales, refer to the wetland panting guidance and plant lists provided in Stormwater Design Specification No. 13 (Constructed Wetlands). If roadway salt will be applied to the contributing drainage area, swales should be planted with salt-tolerant non-woody plant species.

6.5. Material Specifications

Consult **Section 6.7** of Stormwater Design Specification No. 3 (Grass Channels) for criteria pertaining to suitable materials for check dams and other swale features.

SECTION 7: REGIONAL & SPECIAL CASE DESIGN ADAPTATIONS

7.1. Karst Terrain

Wet swales are generally *not* feasible in karst terrain, since the water table rarely reaches the land surface**.**

7.2. Coastal Plain

Wet Swales work well in areas of high water table, and consist of a series of on-line or off-line storage cells. Designers should design cells such that the underlying soils are typically saturated, but do not cause standing water between storm events. It may also be advisable to incorporate sand or compost into surface soils to promote a better growing environment. Wet Swales should be planted with wet-footed species, such as sedges or wet meadows. Wet Swales are not recommended in residential areas, due to concerns about mosquito breeding.

7.3 Regenerative Conveyance System (Coastal Plain Outfalls)

Regenerative stormwater conveyance (RSC) systems are open-channel, sand seepage filtering systems that utilize a series of shallow aquatic pools, riffle weir grade controls, native vegetation and underlying sand channel to treat and safely detain and convey storm flow, and convert stormwater to groundwater via infiltration at coastal plain outfalls and other areas where grades make traditional practices difficult to implement. RSC systems combine features and treatment benefits of swales, infiltration, filtering and wetland practices. In addition, they are designed to convey flows associated with extreme floods (i.e., 100 year return frequency event) in a non-erosive manner, which results in a reduction of channel erosion impacts commonly encountered at conventional stormwater outfalls and headwater stream channels.

RCS systems are referred to as Step Pool Storm Conveyance (SPSC) channels in Ann Arundel County, MD where systems have been installed and observed. The physical characteristics of the SPSC 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). Due to their ability to safely convey large flood events, RSC systems do not require flow splitters to divert smaller events for water quality treatment, and reduce the need for storm drain infrastructure in the conveyance system.

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. RSC systems have the added benefit of creating dynamic and diverse ecosystems for a range of plants, animals, amphibians and insects. These ecosystems enhance pollutant uptake and assimilation and provide a natural and native aesthetic at sites. RSC systems are unique in that they can be located on the front or tail end of a treatment system and still provide water quality and groundwater recharge benefits. Where located on the front end of a treatment train, they provide water quality, groundwater recharge, and channel protection, while also providing non-erosive flow conveyance that delivers flow to the stormwater quantity practice - a constructed wetland, wet pond, ED Pond, or combination.

The Ann Arundel County design specification can be found at:
http://www.aacounty.org/DPW/Watershed/StepPoolStormConveyance.cfm

SECTION 8: CONSTRUCTION

Consult the construction criteria outlined in Section 8 of both Stormwater Design Specification No. 3 (Grass Channels) and Stormwater Design Specification No. 13 (Constructed Wetlands). An example construction phase inspection checklist for Wet Swales can be accessed at the CWP website at:

http://www.cwp.org/Resource_Library/Controlling_Runoff_and_Discharges/sm.htm
(scroll to Tool6: Plan Review, BMP Construction, and Maintenance Checklists)

SECTION 9: MAINTENANCE

Wet Swales have maintenance needs similar to Dry Swales, although woody wetland vegetation may need to be removed periodically. Please consult the maintenance criteria outlined in Section 9 of Stormwater Design Specification No. 3 (Grass Channels), Stormwater Design Specification No. 10 (Dry Swales), and Stormwater Design Specification No. 13 (Constructed Wetlands). Example maintenance inspection checklists for Wet Swales can be accessed in Appendix C of Chapter 9 of the *Virginia Stormwater Management Handbook* (2010) or at the CWP website at:

http://www.cwp.org/Resource_Library/Controlling_Runoff_and_Discharges/sm.htm
(scroll to Tool6: Plan Review, BMP Construction, and Maintenance Checklists)

SECTION 10: COMMUNITY & ENVIRONMENTAL CONCERNS

The main concerns of adjacent residents are perceptions that Wet Swales will create nuisance conditions or will be hard to maintain. Common concerns include the continued ability to mow grass, landscaping preferences, and the risks of unsightly weeds, standing water, and mosquitoes breeding. For these reasons, Wet Swales are not recommended in residential settings, because the shallow, standing water in the swale is often viewed as a potential nuisance by homeowners.

SECTION 11: REFERENCES

Anne Arundel County Watershed Ecosystems and Restoration Services, *Step Pool Conveyance Systems*, Annapolis, MD. Available online at:
http://www.aacounty.org/DPW/Watershed/StepPoolStormConveyance.cfm

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