

VIRGINIA DCR-DEQ STORMWATER
DESIGN SPECIFICATION No. 2

**SHEET FLOW TO A VEGETATED
FILTER STRIP OR
CONSERVED OPEN SPACE**

VERSION 2.0

January 1, 2013



SECTION 1. DESCRIPTION

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 (1) *Conserved Open Space* and (2) designed *Vegetated Filter Strips*. The design, installation, and management of these design variants are quite different, as outlined in this specification.

In both instances, stormwater **must** enter the Vegetated Filter Strip or Conserved Open Space as sheet flow. A typical configuration consists of the stormwater runoff from the paved area uniformly entering the practice along a linear edge (such as the edge of a road or parking lot) and draining across the length of the Filter Strip or Open Space) ~~width~~length (parallel to the flow). This configuration would be accompanied by a gravel diaphragm or other “pre-treatment” practice to establish a non-erosive transition between the pavement and the filter strip or open space. If the inflow to the filter strip is from a pipe or channel, an engineered Level Spreader (ELS) **must** be designed in accordance with the criteria contained herein to convert the concentrated flow to sheet flow.

SECTION 2. PERFORMANCE

With proper design and maintenance, these practices can provide relatively high runoff reduction as shown in **Table 2.1**.

Table 2.1: Summary of Stormwater Functions Provided by Filter Strips ¹

Stormwater Function	Conservation Area		Vegetated Filter Strip	
	HSG Soils A and B	HSG Soils C and D	HSG Soils A	HSG Soils B ⁴ , C and D
	Assume no CA ² in Conservation Area		No CA ³	With CA ²
Annual Runoff Vol. Reduction (RR)	75%	50%	50%	50%
Total Phosphorus (TP) EMC Reduction ⁵ by BMP Treatment Process	0		0	
Total Phosphorus (TP) Mass Load Removal	75%	50%	50%	50%
Total Nitrogen (TN) EMC Reduction by BMP Treatment Process	0		0	
Total Nitrogen (TN) Mass Load Removal	75%	50%	50%	50%
Channel Protection and Flood Mitigation	Partial. Designers can use the VRRM Compliance spreadsheet to adjust curve number for each design storm for the contributing drainage area; <i>and</i> designers can account for a lengthened Time-of-Concentration flow path in computing peak discharge.			
¹ CWP and CSN (2008); CWP (2007) ² CA = Compost Amended Soils (see Design Specification No. 4) ³ Compost amendments are generally not applicable for undisturbed A soils, although it may be advisable to incorporate them on mass-graded A or B soils and/or filter strips on B soils, in order to maintain runoff reduction rates. ⁴ The plan approving authority may waive the requirement for compost amended soils for filter strips on B soils under certain conditions (see Section 6.2 below) ⁵ There is insufficient monitoring data to assign a nutrient removal rate for filter strips at this time.				

Leadership in Energy and Environmental Design (LEED®). The LEED® point credit system designed by the U.S. Green Building Council (USGBC) and implemented by the Green Building Certification Institute (GBCI) awards points related to site design and stormwater management. Several categories of points are potentially available for new development and redevelopment projects. **Chapter 6 of the Virginia Stormwater Management Handbook (2nd Edition, 2013) and the introduction to this chapter** provides a more thorough discussion of the site planning process and design considerations as related to the environmental site design and potential LEED credits. However, ~~VDCR~~ the Virginia Department of Environmental Quality is not affiliated with the USGBC or GBCI and any information on applicable points provided here is based only on basic compatibility. **Designers should research and verify scoring criteria and applicability of points as related to the specific project being considered through USGBC LEED resources.**

Table 2.2. Potential LEED® Credits for Sheet Flow to Conserved Open Space or Vegetated Filter Strip¹

Credit Category	Credit No.	Credit Description
Sustainable Sites	SS5.1	Site Development: Protect or Restore Habitat ²
Sustainable Sites	SS5.2	Site Development: Maximize Open Space
Sustainable Sites	SS6.1	Stormwater Design: Quantity Control
Sustainable Sites	SS6.2	Stormwater Design: Quality Control
Sustainable Sites	SS7.1	Heat Island Effect: Non-Roof ³
Water Efficiency	WE1.1	Water Efficient Landscaping: Reduce by 50% ⁴
Water Efficiency	WE1.2	Water Efficient Landscaping: No Potable Water Use or No Irrigation ⁴

¹ Actual site design and/or BMP configuration may not qualify for the credits listed. Alternatively, the project may actually qualify for credits not listed here. Designers should consult with a qualified individual (LEED AP) to verify credit applicability.

² Not applicable for *turf* Vegetated Filter Strips, since turf grass is not considered native, adaptive, or biodiverse.

³ Applied if reforestation canopy covers hardscape areas.

⁴ Filter Strips and Conserved Open Spaces are typically not irrigated beyond first year establishment.

SECTION 3. DESIGN TABLE

Conserved Open Space and Vegetated Filter Strips do not have two levels of design. Instead, each **must** meet the appropriate minimum criteria outlined in **Table 2.3** (next page) and **Section 6** (below) to qualify for the indicated level of runoff reduction. In addition, designers **must** conduct a site reconnaissance prior to design to confirm topography and soil conditions.

SECTION 4. TYPICAL DETAILS

Figure 2.1 shows a typical approach for sheet flow to a Conserved Open Space (adapted from Capiella *et al.*, 2006). **Figure 2.2a-c** illustrates the ~~sheet flow~~-gravel diaphragm providing pre-treatment, and **Figure 2.3a-c** details an ELS with a rigid and a vegetated overflow lip. **Figure 2.4** illustrates a outfall pipe “energy dissipater” (adapted from Henrico County’s *Environmental Program Manual*; Chapter 9, Minimum Design Standard 9.01, <http://www.co.henrico.va.us/works/eesd/>.) **Figure 2.5** Illustrates the combination of simple disconnection (Design Specification No. 1) to Conserved Open Space as the downstream practice.

Table 2.23. Filter Strip Design Criteria

Design Issue	Conserved Open Space	Vegetated Filter Strip
Soil and Vegetative Cover (Sections 6.1 and 6.2)	Undisturbed soils and native vegetation	Amended soils and dense turf cover or landscaped with herbaceous cover, shrubs, and trees
Overall Slope and Width-length (perpendicular parallel to the flow) (Section 5)	0.5% to 3% Slope – Minimum 35 ft widthlength 3% to 6% Slope – Minimum 50 ft lengthwidth The first 10 ft. of filter must be 2% or less in all cases ²	1% ¹ to 4% Slope – Minimum 35 ft. lengthwidth 4% to 6% Slope – Minimum 50 ft. lengthwidth 6% to 8% Slope – Minimum 65 ft. lengthwidth The first 10 ft. of filter must be 2% or less in all cases
Contributing Area of Sheet Flow (Section 5)	Maximum flow length of 150 ft. from adjacent pervious areas; Maximum flow length of 75 ft. from adjacent impervious areas	
Level Spreader for dispersing Concentrated Flow (Section 6.3)	Length of ELS ⁶ Lip = 13 lin. ft. per each 1 cfs of inflow if area has 90% Cover ³ Length = 40 lin. ft. per 1 cfs for forested or re-forested Areas ⁴ (ELS ⁶ length = 13 lin.ft. min; 130 lin.ft. max.)	Length of ELS ⁶ Lip = 13 lin.ft. per each 1 cfs of inflow (13 lin.ft. min; 130 lin.ft. max.)
Construction Stage (Section 8)	Located outside the limits of disturbance and protected by ESC controls	Prevent soil compaction by heavy equipment
Typical Applications (Section 5)	Adjacent to stream or wetland buffer or forest conservation area	Treat small areas of IC (e.g., 5,000 sf) and/or turf-intensive land uses (sports fields, golf courses) close to source
Compost Amendments (Section 6.1)	No	Yes (B, C, and D soils) ⁵
Boundary Spreader (Section 6.3)	GD ⁶ at top of filter	GD ⁶ at top of filter PB ⁶ at toe of filter
¹ A minimum of 1% is recommended to ensure positive drainage. ² For Conservation Areas with a varying slope, a pro-rated length may be computed only if the first 10 ft. is 2% or less. ³ Vegetative cover is described in Section 6.2 . ⁴ Where the Conserved Open Space is a mixture of native grasses, herbaceous cover and forest (or re-forested area), the length of the ELS ⁶ Lip can be established by computing a weighted average of the lengths required for each vegetation type. Refer to Section 6.3 for design criteria ⁵ The plan approving authority may waive the requirement for compost amended soils for filter strips on B soils under certain conditions (see Section 6.1). ⁶ ELS = Engineered Level Spreader; GD = Gravel Diaphragm; PB = Permeable Berm.		

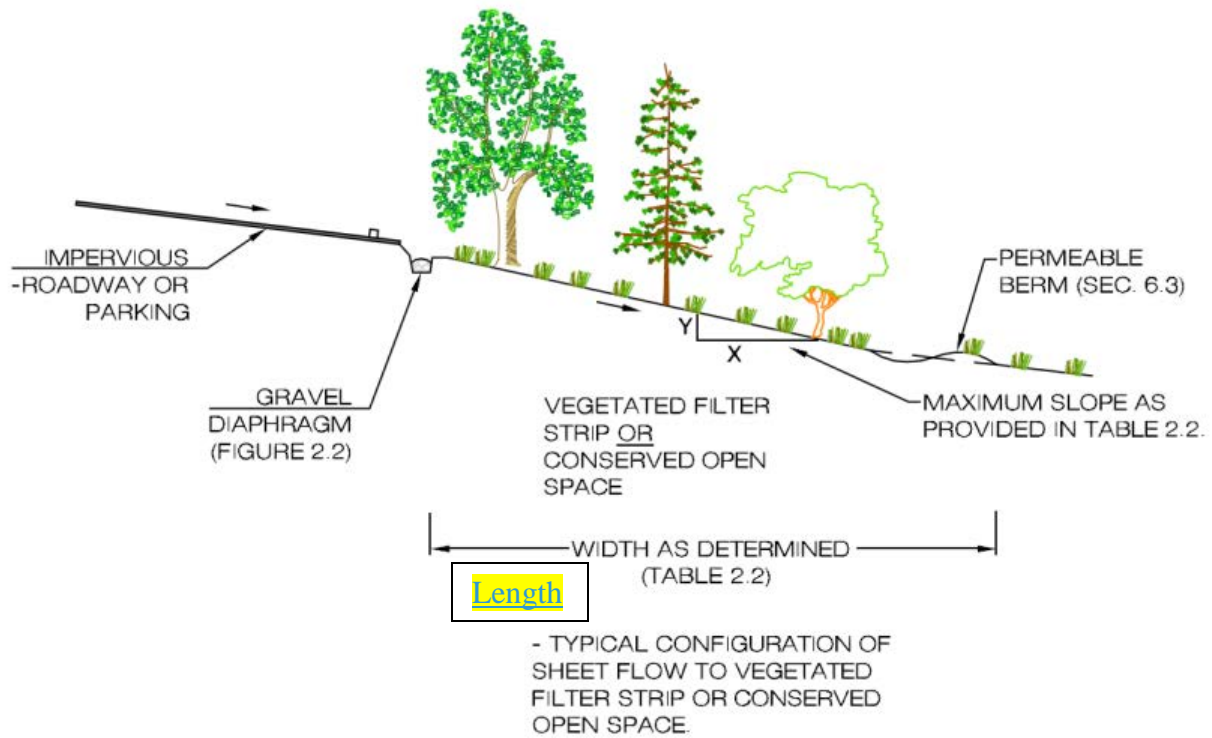


Figure 2.1. Typical Configuration of Sheet Flow to Filter Strip or Conserved Open Space

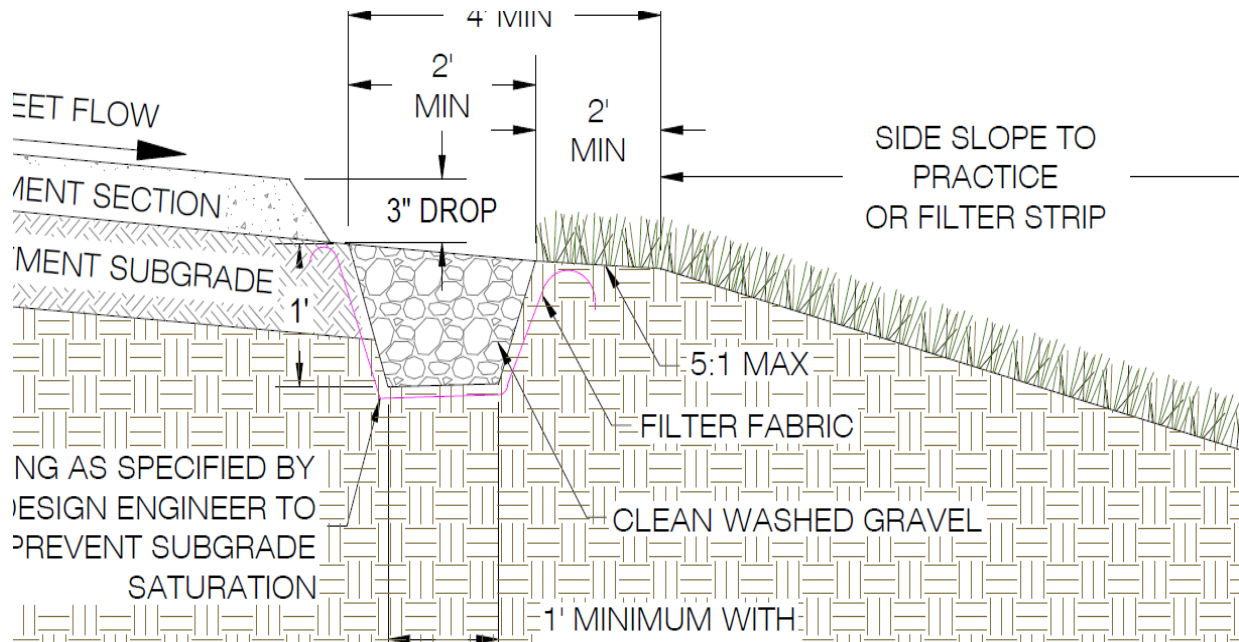


Figure 2.2a. Gravel Diaphragm - Sheet Flow Pre-treatment



Figure 2.2a2b. Lack of Gravel Diaphragm



Fig 2.2b2c. Gravel Diaphragm

(Photo: BAE Stormwater Engineering Group, NCSU)

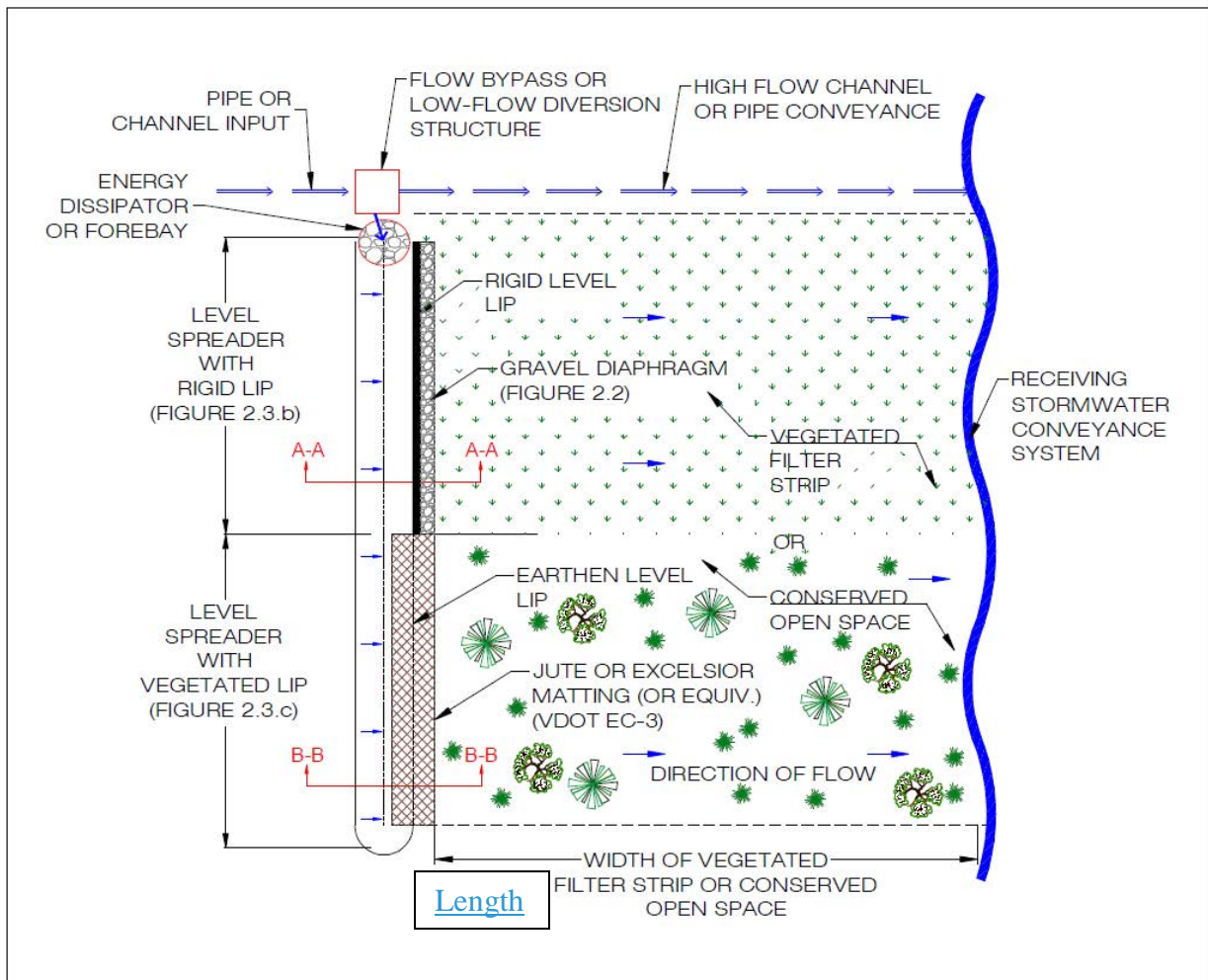


Figure 2.3a: Plan View – Level Spreaders (Rigid Lip – top; & Earthen Lip – bottom)

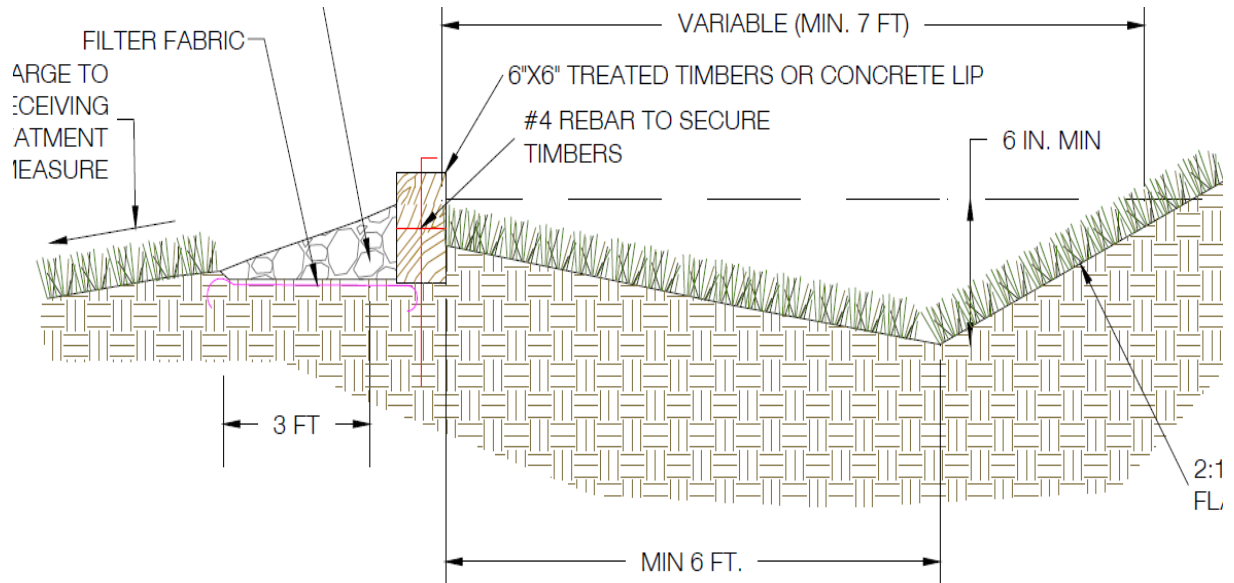


Figure 2.3b: Section – Level Spreader with Rigid Lip

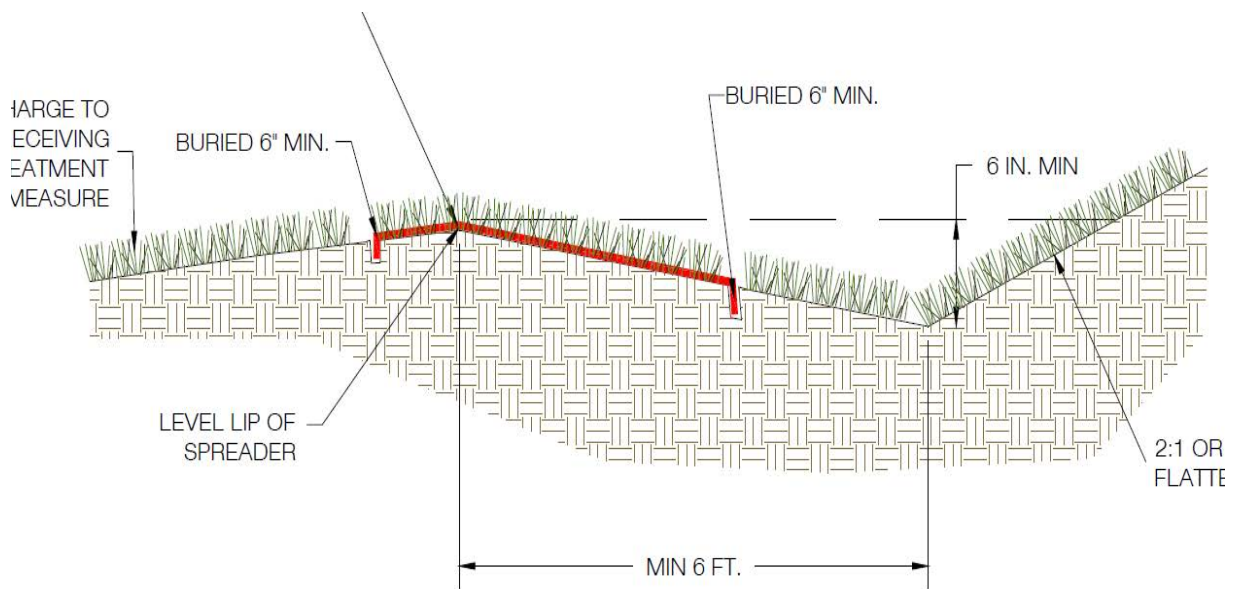


Figure 2.3c: Section – Level Spreader with Vegetated Lip

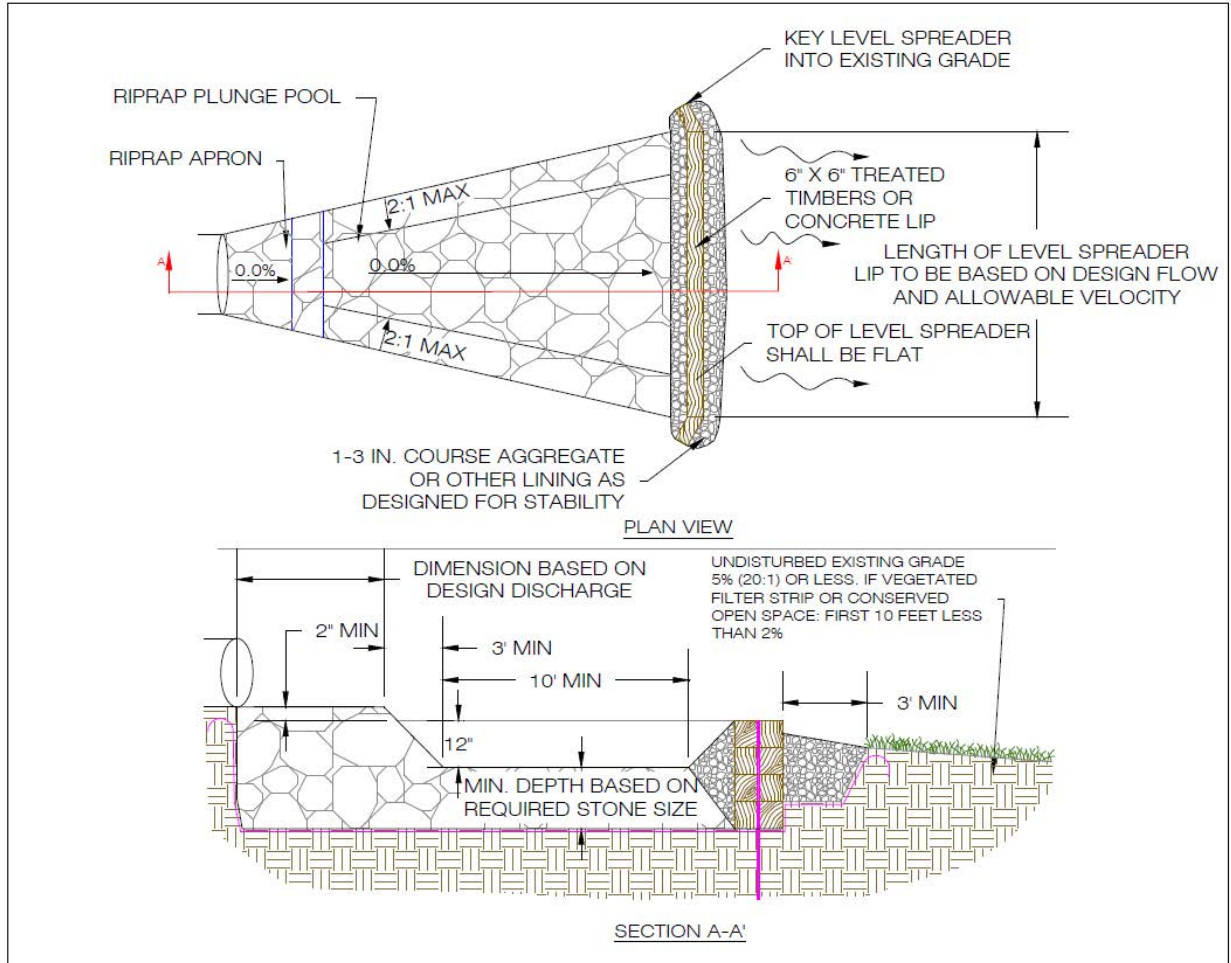


Figure 2.4: Level Spreader: Pipe or Channel Flow to Filter Strip or ~~Preserved~~ Conserved Open Space

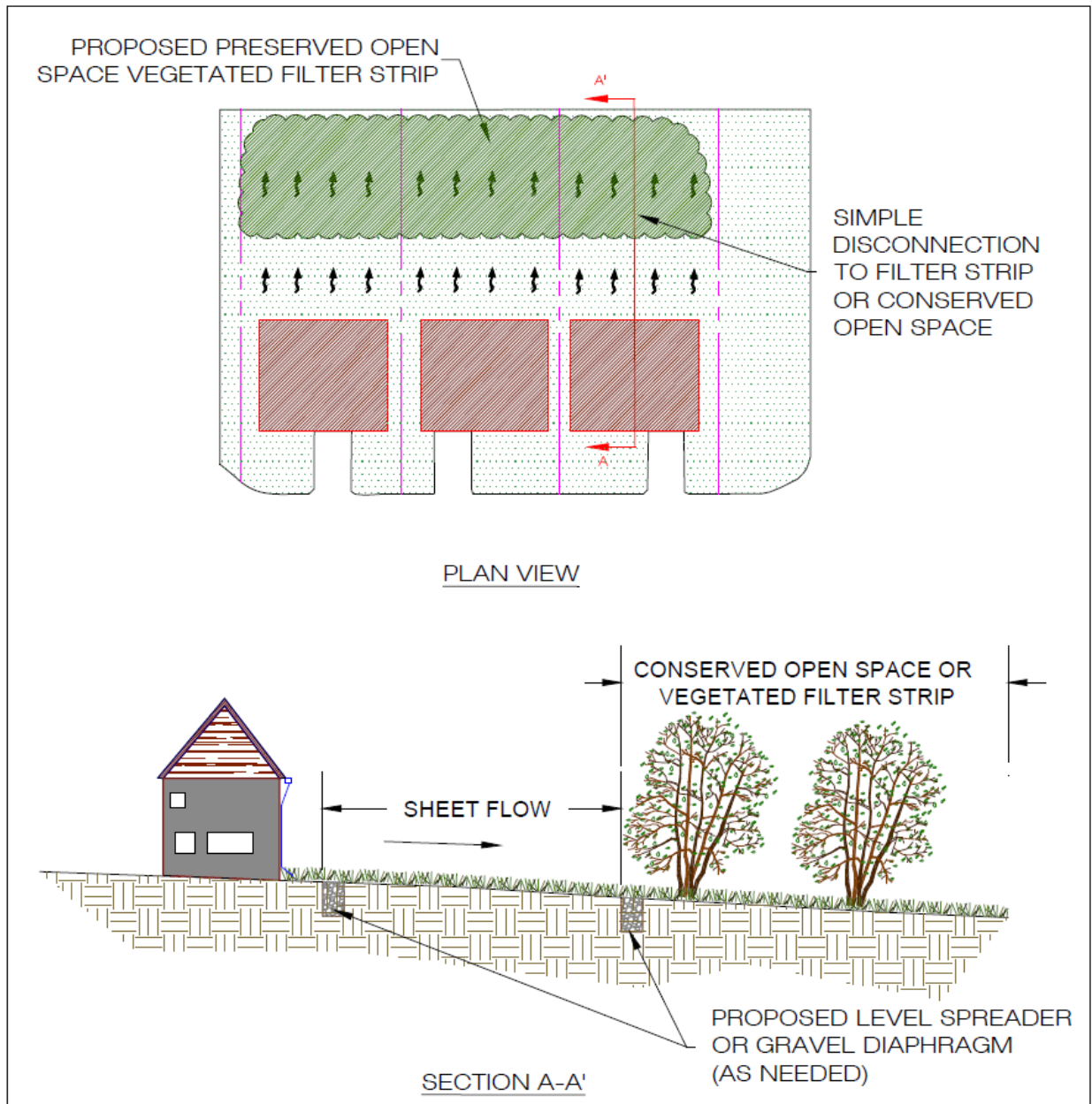


Figure 2.65: Simple Disconnection to downstream ~~Preserved~~ Conserved Open Space or Vegetated Filter Strip

SECTION 5. PHYSICAL FEASIBILITY & DESIGN APPLICATIONS

5.1 Conserved Open Space

The most common design applications of Conserved Open Space are on sites that are hydrologically connected to a protected stream buffer, wetland buffer, floodplain, forest conservation area, or other protected lands. Conserved Open Space is an ideal component of the "outer zone" of a stream buffer, such as a Resource Protection Area (as is required in some parts of the state), which normally receives runoff as sheet flow. Care should be taken to locate all energy dissipaters or flow spreading devices outside of the protected area.

Designers may apply a runoff reduction credit to any impervious or managed turf cover that is hydrologically connected and effectively treated by a protected Conserved Open Space that meets the following eligibility criteria:

- The goal of establishing Conserved Open Space is to protect a vegetated area contiguous to a receiving system, such as a stream or natural channel, for treating stormwater runoff. Establishing isolated Conserved Open Space pockets on a development site may not achieve this goal unless they effectively serve to connect the surface runoff to the receiving system. **Therefore, a locality may choose to establish goals for minimum acreage to be conserved (in terms of total acreage or percentage of the total project site), and the physical location (adjacent to a stream, or other criteria) in order for the cumulative Conserved Open Space to qualify for the runoff reduction credit.**
- No major disturbance **shall** occur within the Conserved Open Space during or after construction (i.e., no clearing or grading is allowed except temporary disturbances associated with incidental utility construction, restoration operations, or management of nuisance vegetation). The Conserved Open Space area **shall** not be stripped of topsoil. Some light grading may be needed at the boundary to establish a level entry into the Conserved Open Space. This **shall** be accomplished using tracked vehicles to prevent compaction.
- The limits of disturbance **shall** be clearly shown on all construction drawings and protected by acceptable signage and erosion control measures.
- A long term vegetation management plan **must** be prepared to maintain the Conserved Open Space in a natural vegetative condition. Generally, Conserved Open Space management plans do not encourage or even allow any active management. However, a specific plan should be developed to manage the unintended consequences of passive recreation, control invasive species, provide for tree and understory maintenance, etc. Managed turf is not considered an acceptable form of vegetative management, and only the passive recreation areas of dedicated parkland are eligible for the practice (e.g., the actively used portions of ball fields and golf courses are not eligible), although conservation areas can be ideal treatment practices at the edges of turf-intensive land uses.
- The Conserved Open Space **must** be protected by a perpetual easement or deed restriction that assigns the responsible party to ensure that no future development, disturbance, or clearing may occur within the area.
- The practice does *not* apply to jurisdictional wetlands that are sensitive to increased inputs of stormwater runoff (e.g., bogs and fens).

5.2 Vegetated Filter Strips

Vegetated Filter Strips are best suited to treat runoff from small segments of impervious cover (usually less than 5,000 sq. ft.) adjacent to road shoulders, small parking lots and rooftops. Vegetated Filter Strips may also be used as pretreatment for another stormwater practice such as a dry swale, bioretention, or infiltration areas. If sufficient pervious area is available at the site, larger areas of impervious cover can be treated by vegetated filter strips, using an ELS to recreate sheet flow. Vegetated Filter Strips are also well suited to treat runoff from turf-intensive land uses, such as the managed turf areas of sports fields, golf courses, and parkland.

Conserved Open Space and Vegetated Filter Strips can be used in a variety of situations; however there are several constraints to their use:

- Soil compaction or disturbance in the area of a proposed Vegetated Filter Strip should be minimized to the extent practical. If this is unavoidable, the area should be restored by tilling or otherwise re-establishing the soil permeability. The plan approving authority may require the applicant to verify the restoration of the soils, either through compost amendments or other means sufficient to achieve the goal of treating runoff from up-gradient areas.
- The proposed vegetated filter strip **shall** be shown on the erosion and sediment control plan.
- A vegetation management plan should be developed to maintain the vegetation density of the filter strip. Turf grass should be managed to the extent necessary to maintain a healthy grass cover. However, any fertilizing or other maintenance, such as mowing, should be identified in a management plan as part of the long term BMP operation and maintenance plan (**Section 9**).
- The Vegetated Filter Strip should be identified and protected in a perpetual easement, deed restriction, or other accepted mechanism that assigns the responsible party to ensure that no future development, disturbance or clearing may occur within the area, except as stipulated in the vegetation maintenance plan.

5.3 Feasibility Criteria for Conserved Open Space and Vegetated Filter Strips

- **Filter Slopes and ~~Widths~~Lengths.** Maximum slopes for Conserved Open Space and Vegetated Filter Strips are 6% and 8% respectively, in order to maintain sheet flow through the practice. In addition, the overall contributing drainage area **must** likewise be relatively flat to ensure sheet flow draining into the filter. Where this is not possible, alternative measures, such as an ELS, can be used. Minimum ~~widths-lengths~~ (flow path) for Conserved Open Space and Vegetated Filter Strips are dependent on slope, as specified in **Table 2.3** above.
- **Soils.** Vegetated Filter Strips are appropriate for all soil types, except fill soils. The runoff reduction rate, however, is dependent on the underlying Hydrologic Soil Groups and whether soils receive compost amendments (see **Table 2.1** above).
- **Contributing Flow Path to Filter.** Vegetated Filter Strips are used to treat very small drainage areas of a few acres or less. The limiting design factor is the length of flow directed to the filter. As a rule, flow tends to concentrate after 75 feet of flow length from impervious surfaces, and 150 feet from pervious surfaces (Claytor, 1996). When flow concentrates, it moves too rapidly to be effectively treated by a Vegetated Filter Strip, unless an ELS is used. When the existing flow at a site is concentrated, a vegetated swale should be used instead of

a Vegetated Filter Strip (Lantin and Barrett, 2005).

- **Hotspot Land Uses.** Vegetated Filter Strips should not receive hotspot runoff, since the infiltrated runoff could cause groundwater contamination.
- **Turf-Intensive Land Uses.** Both Conserved Open Space and Vegetated Filter Strips are appropriate to treat managed turf and the actively-used areas of sports fields, golf courses, parkland, and other turf-intensive land uses.
- **Proximity of Underground Utilities.** Underground pipes and conduits that cross the Vegetated Filter Strip are acceptable.

SECTION 6. DESIGN CRITERIA

6.1. Compost Soil Amendments

Compost soil amendments will enhance the runoff reduction capability of a Vegetated Filter Strip when located on hydrologic soil groups B, C, and D, subject to the following design requirements:

- The compost amendments should extend over the full length and width of the filter strip.
- The amount of approved compost material and the depth to which it **must** be incorporated is outlined in **Stormwater Design Specification No. 4**.
- The amended area will be raked to achieve the most level slope possible without using heavy construction equipment, and it will be stabilized rapidly with perennial grass and/or herbaceous species.
- If slopes exceed 3%, a protective biodegradable fabric or matting (e.g., EC-2) should be installed to stabilize the site prior to runoff discharge.
- Compost amendments should not be incorporated until the gravel diaphragm and/or ELS are installed (see **Section 6.3**).
- The local plan approval authority may waive the requirement for compost amendments on HSG-B soils in order to receive credit as a filter strip if (1) the designer can provide verification of the adequacy of the on-site soil type, texture, and profile to function as a filter strip, and (2) the area designated for the filter strip will not be disturbed during construction.

6.2. Planting and Vegetation Management

Conserved Open Space. No grading or clearing of native vegetation is allowed within the Conserved Open Space. An invasive species management plan should be developed and approved by the local plan approval authority.

Reforested Conserved Open Space. At some sites, the proposed Conserved Open Space may be in turf or meadow cover, or overrun with invasive plants and vines. In these situations, a landscape architect or horticulturalist should prepare a reforestation or restoration plan for the Conserved Open Space. The entire area can be planted with native trees and shrubs or planted to achieve a gradual transition from turf to meadow to shrub and forest. Trees and shrubs with deep rooting capabilities are recommended for planting to maximize soil infiltration capacity (PWD, 2007). Over-plant with seedlings for fast establishment and to account for mortality. Plant larger stock at desired spacing intervals (25 to 40 feet for large trees) using random spacing (Cappiella

et al., 2006). Plant ground cover or a herbaceous layer to ensure rapid vegetative cover of the surface area.

Vegetated Filter Strips. Vegetated Filter Strips should be planted at such a density to achieve a 90% grass/herbaceous cover after the second growing season. Vegetated Filter Strips should be seeded, not sodded. Seeding establishes deeper roots, and sod may have muck soil that is not conducive to infiltration (Wisconsin DNR, 2007). The filter strip vegetation may consist of turf grasses, meadow grasses, other herbaceous plants, shrubs, and trees, as long as the primary goal of at least 90% coverage with grasses and/or other herbaceous plants is achieved. Designers should choose vegetation that stabilizes the soil and is salt tolerant. Vegetation at the toe of the filter, where temporary ponding may occur behind the permeable berm, should be able to withstand both wet and dry periods. The planting areas can be divided into zones to account for differences in inundation and slope.

6.3. Diaphragms, Berms and Level Spreaders

Gravel Diaphragms: A pea gravel diaphragm at the top of the slope is required for both Conserved Open Space and Vegetated Filter Strips that receive sheet flow. The pea gravel diaphragm is created by excavating a 2-foot wide and 1-foot deep trench that runs on the same contour at the top of the filter strip. The diaphragm serves two purposes. First, it acts as a pre-treatment device, settling out sediment particles before they reach the practice. Second, it acts as a Level Spreader, maintaining sheet flow as runoff flows over the Filter Strip. Refer to **Figure 2.2a-c**.

- The flow should travel over the impervious area and to the practice as sheet flow and then drop at least 2 inches onto the gravel diaphragm. The drop helps to prevent runoff from running laterally along the pavement edge, where grit and debris tend to build up (thus allowing by-pass of the Filter Strip).
- A layer of filter fabric should be placed between the gravel and the underlying soil trench.
- If the contributing drainage area is steep (6% slope or greater), then larger stone (clean bank-run gravel that meets VDOT #57 grade) should be used in the diaphragm.
- If the contributing drainage area is solely turf (e.g., sports field), then the gravel diaphragm may be eliminated.

Permeable Berm: Vegetated Filter Strips should be designed with a permeable berm at the toe of the Filter Strip to create a shallow ponding area. Runoff ponds behind the berm and gradually flows through outlet pipes in the berm or through a gravel lens in the berm with a perforated pipe. During larger storms, runoff may overtop the berm (Cappiella *et al.*, 2006). The permeable berm should have the following properties:

- A wide and shallow trench, 6 to 12 inches deep, should be excavated at the upstream toe of the berm, parallel with the contours.
- Media for the berm should consist of 40% excavated soil, 40% sand, and 20% pea gravel.
- The berm 6 to 12 inches high should be located down gradient of the excavated depression and should have gentle side slopes to promote easy mowing (Cappiella *et al.*, 2006).
- Stone may be needed to armor the top of berm to handle extreme storm events.
- A permeable berm is not needed when Vegetated Filter Strips are used as pretreatment to another stormwater practice.

Engineered Level Spreaders. The design of an ELS should conform to the following design criteria, or a locally approved standard that meets the intent of these criteria, in order to ensure non-erosive sheet flow into the vegetated buffer area. **Figure 2.3** above represents a configuration that includes a bypass structure that diverts the design storm to the Level Spreader, and bypasses the larger storm events around the Conserved Open Space or Vegetated Filter Strip through an improved channel.

An alternative approach is that used by Henrico County, where pipe or channels discharge at the landward edge of a floodplain or stream (Resource Protection Area or RPA) buffer. The entire flow is directed through a stilling basin energy dissipater and then a Level Spreader such that the entire design storm for the conveyance system (typically a 10-year frequency storm) is discharged as sheet flow through the buffer. (Refer to Henrico County's *Environmental Program Manual*; Chapter 9, Minimum Design Standard 9.01 "Energy Dissipator": <http://www.co.henrico.va.us/works/eesd/>.)

Key design elements of the ELS, as provided in **Figures 2.3 and 2.4**, include the following:

- High Flow Bypass provides safe passage for larger design storms through the filter strip. The bypass channel should accommodate all peak flows greater than the water quality design flow.
- A forebay should have a minimum depth of 12 inches (**Figure 2.4**). The forebay is sized such that the surface area is a minimum of 0.2% of the contributing impervious area. (A forebay is not necessary if the concentrated flow is from the outlet of an extended detention basin or similar practice).
- The length of the Level Spreader should be determined by the type of filter area and the design flow:
 - 13 feet of Level Spreader length per every 1 cubic foot per second (cfs) of inflow for discharges to a Vegetated Filter Strip or Conserved Open Space consisting of native grasses or thick ground cover;
 - 40 feet of Level Spreader length per every 1 cfs of inflow when the spreader discharges to a Conserved Open Space consisting of forested or reforested buffer (Hathaway and Hunt, 2006).
 - Where the Conserved Open Space is a mix of grass and forest (or re-forested), establish the Level Spreader length by computing a weighted average of the lengths required for each vegetation type.
 - The minimum Level Spreader length is 13 feet and the maximum is 130 feet.
 - For the purposes of determining the Level Spreader length, the peak discharge **shall** be determined using the computational procedure outlined in **Section 11.5.3 (Water Quality Design Tv Peak Flow Rate)** of **Chapter 5** of the *Virginia Stormwater Management Handbook* (2nd Edition, 2013).
- The Level Spreader lip should be concrete, wood, pre-fabricated metal, or other durable non-erodible material with a well-anchored footer..
- The ends of the Level Spreader section should be tied back into the slope to avoid scouring around the ends of the Level Spreader; otherwise, short-circuiting of the facility could create erosion.

- The width of the Level Spreader channel on the up-stream side of the level lip should be three times the diameter of the inflow pipe, and the depth should be 9 inches or one-half the culvert diameter, whichever is greater.
- The Level Spreader lip should be placed 3 to 6 inches above the downstream natural grade elevation to avoid blockage due to turf buildup. In order to prevent grade drops that re-concentrate the flows, a 3-foot wide section of VDOT # 3 stone, underlain by filter fabric, should be installed just below the spreader to transition from the level spreader to natural grade.
- Vegetated receiving areas down-gradient from the Level Spreader **must** be able to withstand the force of the flow coming over the lip of the device. It may be necessary to stabilize this area with a soil stabilization mat (VDOT EC-3) in accordance with the calculated velocity (on-line system peak, or diverted off-line peak) and material specifications, along with seeding and stabilization in conformance with the Virginia Erosion and Sediment Control Handbook.

6.4. Filter Design Material Specifications

Table 2.4 describes materials specifications for the primary treatment within filter strips.

Table 2.4. Vegetated Filter Strip Materials Specifications

Material	Specification	Quantity
Gravel Diaphragm	Pea Gravel (#8 or ASTM equivalent) or where steep (6% +) use clean bank-run VDOT #57 or ASTM equivalent (1-inch maximum).	Diaphragm should be 2 feet wide, 1 foot deep, and at least 2 inches below the edge of pavement.
Permeable Berm	40% excavated soil, 40% sand, and 20% pea gravel to serve as the media for the berm.	
Filter Fabric	Geotextile material appropriately selected for placement under rip rap or gravel to effectively separate the stone from the ground below.	
Engineered Level Spreader	Level Spreader lip should be concrete, metal, timber, or other rigid material; Reinforced channel on upstream of lip: VDOT EC-3. See Hathaway and Hunt (2006) or Henrico County Program Manual for alternate designs.	
Erosion Control Fabric or Matting	Where flow velocities dictate, use woven biodegradable erosion control fabric or mats that are durable enough to last at least 2 growing seasons. (e.g., VDOT Erosion Control matting EC-3).	
Topsoil	If existing topsoil is inadequate to support dense turf growth, imported top soil (loamy sand or sandy loam texture), with less than 5% clay content, corrected pH at 6 to 7, a soluble salt content not exceeding 500 ppm, and an organic matter content of at least 2% shall be used. Topsoil shall be uniformly distributed and lightly compacted to a minimum depth of 6 to 8 inches	
Compost	Compost shall be derived from plant material and provided by a member of the U.S. Composting Seal of Testing Assurance (STA) program, as outlined in Stormwater Design Specification No. 4.	

SECTION 7: REGIONAL & SPECIAL CASE DESIGN ADAPTATIONS

7.1. Karst Terrain

Conserved Open Space areas are highly recommended in karst terrain, particularly when storm flow discharges to the outer boundary of a karst protection area (see CSN, 2009).

Vegetated Filter Strips can also be used to treat runoff from small areas of impervious cover (e.g., less than 5,000 square feet). Some communities use wide grass filter strips to treat runoff from the roadway shoulder.

In no case should the use of a Conserved Open Space or Vegetated Filter Strip be considered as a replacement for an adequate receiving system for developed-condition stormwater discharges, unless the adequacy of the design has been demonstrated consistent with the Virginia Stormwater Management Handbook.

7.2. Coastal Plain

The use of Conserved Open Space areas and Vegetated Filter Strips are highly recommended in the coastal plain, particularly when sheet flow (or concentrated flow with an appropriately-sized Level Spreader) discharges to the outer boundary of a shoreline, stream or wetland buffer. Vegetated Filter Strips can also be used to treat runoff from small areas of impervious cover (e.g., less than 5,000 square feet). In both cases, however, the designer **must** consider the depth to the water table. In general, shallow water tables may inhibit the function of vegetated filter strips.

7.3. Linear Highway Sites

Vegetated Filter Strips are highly recommended to treat highway runoff if the median and/or road shoulder is wide enough to provide an adequate flow path.

SECTION 8: CONSTRUCTION

8.1. Construction Sequence for Conserved Open Space Areas

The Conserved Open Space **must** be fully protected during the construction stage of development and kept outside the limits of disturbance on the Erosion and Sediment (E&S) Control Plan.

- No clearing, grading or heavy equipment access is allowed except temporary disturbances associated with incidental utility construction, restoration operations or management of nuisance vegetation.
- The perimeter of the Conserved Open Space **shall** be protected from construction sediment by super silt fence, since the area is down gradient from areas of construction.
- The limits of disturbance should be clearly shown on all construction drawings and identified and protected in the field by acceptable signage, and chain link fence, orange safety fence,

snow fence or other protective barrier to keep unnecessary construction activity out of the area.

- Construction of the gravel diaphragm or ELS shall not commence until the contributing drainage area has been stabilized and perimeter E&S controls have been removed and cleaned out.
- Some light grading may be needed at the Conserved Open Space boundary; this should be done with tracked vehicles to prevent compaction.
- Stormwater should not be diverted into the Conserved Open Space until the gravel diaphragm and/or Level Spreader are installed and stabilized.

8.2. Construction Sequence for Vegetated Filter Strips

Vegetated Filter Strips can be within the limits of disturbance during construction. The following procedures should be followed during construction:

- Before site work begins, Vegetated Filter Strip boundaries should be clearly marked.
- Only vehicular traffic used for filter strip construction should be allowed within 10 feet of the Vegetated Filter Strip boundary (City of Portland, 2004).
- If existing topsoil is stripped during grading, it shall be stockpiled for later use.
- Construction runoff should be directed away from the proposed filter strip site using appropriate erosion control measures and a diversion dike or other measure.
- Construction of the gravel diaphragm or ELS shall not commence until the contributing drainage area has been stabilized and perimeter E&S controls have been removed and cleaned out.
- Vegetated Filter Strips require light grading to achieve desired elevations and slopes. This should be done with tracked vehicles to prevent compaction. Topsoil and or compost amendments should be incorporated evenly across the filter strip area, stabilized with seed, and protected by biodegradable erosion control matting or blankets.
- Stormwater should not be diverted into the Filter Strip until the turf cover is dense and well established.

8.3. Construction Inspection

Construction inspection is critical to obtain adequate spot elevations, to ensure the gravel diaphragm or ELS is completely level, on the same contour, and constructed to the correct design elevation. As-built surveys should be required to ensure compliance with design standards. Inspectors should evaluate the performance of the filter strip after the first big storm to look for evidence of gullies, outflanking, undercutting or sparse vegetative cover. Spot repairs should be made, as needed.

The GPS coordinates should be logged for all filter strips and Conserved Open Spaces, upon acceptance, and submitted for entry into the local BMP maintenance tracking database.

An example construction phase inspection checklist for sheet flow to a filter strip or Conserved Open Space can be found at the end of this specification.

SECTION 9. MAINTENANCE

9.1. Maintenance Agreements

The Virginia Stormwater Management regulations (**4 VAC 50-60-112**) specify the circumstances under which a maintenance agreement **must** be executed between the owner and the VSMP authority, and sets forth inspection requirements, compliance procedures if maintenance is neglected, notification of the local program upon transfer of ownership, and right-of-entry for local program personnel.

- All Vegetated Filter Strips **must** be covered by a long term maintenance agreement and drainage easement consistent with the provisions of the VSMP regulations to allow inspection and maintenance.
- ~~If the vegetated filter strip is located on a residential private lot, the existence and purpose of the filter strip shall be noted on the deed of record.~~
- ~~Homeowners shall be provided a simple document that explains the purpose of the filter strip and routine maintenance needs. [Note: Aren't these three covered sufficiently by the last two bullets?]~~
- ~~A deed restriction or other mechanism enforceable by the VSMP Authority must be in place to help ensure that filter strips are maintained.~~
- Conserved Open Space **shall** be protected by a perpetual easement, deed restriction, or other mechanism enforceable by the VSMP Authority that assigns the responsible party to ensure that no future development, disturbance or clearing may occur within the area, except as stipulated in the vegetation maintenance plan.
- The existence and purpose of the open space **shall** be noted on the deed of record, and the owners **shall** be provided a simple document that explains the purpose of the open space and routine maintenance needs.

In cases of both Vegetated Filter Strips and Conserved Open Space, the protective mechanism for ensuring maintenance should, if possible, grant authority for local agencies to access the property for inspection or corrective action.

9.2. Maintenance Inspections

Annual inspections are used to trigger maintenance operations such as sediment removal, spot re-vegetation and Level Spreader repair. Ideally, inspections should be conducted in the non-growing season when it is easier to see the flow path.

Inspections should check to ensure that:

- Flows through the Vegetated Filter Strip do not short-circuit the overflow control section;
- Debris and sediment does not build up at the top of the Vegetated Filter Strip;
- Foot or vehicular traffic does not compromise the gravel diaphragm;
- Scour and erosion do not occur within the filter strip;
- Sediments are cleaned out of Level Spreader forebays and flow splitters; and
- Vegetative density exceeds a 90% cover in the boundary zone or grass filter.

Example maintenance inspection checklists for Sheet Flow to a Vegetated Filter Strip or Conserved Open Space areas can be accessed in Appendix C of Chapter 9 of the *Virginia Stormwater Management Handbook* (2nd Edition, 2013).

9.3. Ongoing Maintenance

Once established, Vegetated Filter Strips have minimal maintenance needs outside of the spring cleanup, periodic mowing, repair of check dams and other measures to maintain the hydraulic efficiency of the strip and a dense, healthy grass cover. Vegetated Filter Strips that consist of grass/turf cover should be mowed at least twice a year to prevent woody growth.

Sample Construction Inspection Checklist for Sheet Flow to Vegetated Filter Strip or Conserved Open Space: The following checklist provides a basic outline of the anticipated items for the construction inspection of sheet flow practices. Users of this information may wish to incorporate these items into a VSMP Authority Construction Checklist format consistent with the format used for erosion and sediment control and BMP construction inspections.

Sheet Flow to Conserved Open Space Areas

- Pre-construction meeting with the contractor designated to install the sheet flow practice has been conducted.
- Impervious cover has been constructed/installed and area is free of construction equipment, vehicles, material storage, etc.
- All pervious areas of the contributing drainage areas have been adequately stabilized and erosion control measures have been removed.
- Area of the Conserved Open Space has been clearly marked and protected from construction traffic with adequate signage and fencing, and is in good condition (undisturbed – other than for pruning or other vegetation management needs).
- Area of the Conserved Open Space has been clearly marked and protected from construction runoff and sediment with appropriate sediment control measures (super silt fence, berms, etc.).
- Stormwater has been diverted for the construction of the inflow (Level Spreader or gravel diaphragm).
- Any light grading required to establish the upper boundary of the Conserved Open Space has been performed with light equipment and minimal impact to the existing vegetation.
- Construction of engineered Level Spreader for concentrated inflow or a gravel diaphragm or other pretreatment measure for sheet flow has been completed and the area stabilized as needed.
- Stormwater runoff directed into Conserved Open Space after the area at the upper boundary has been stabilized.
- All erosion and sediment control practices have been removed.
- Follow-up inspection and as-built survey/certification has been scheduled.
- GPS coordinates have been documented for all Conserved Open Spaces on the parcel.

Sheet Flow to Vegetated Filter Strips

- Pre-construction meeting with the contractor designated to install the sheet flow practice has been conducted.
- Impervious cover has been constructed/installed and area is free of construction equipment, vehicles, material storage, etc.
- All pervious areas of the contributing drainage areas have been adequately stabilized and erosion control measures have been removed.
- Area of the Vegetated Filter Strip has been clearly marked and protected from construction traffic with adequate signage and fencing, and is in good condition; or
- Area of the Vegetated Filter Strip has been previously (temporarily) stripped of topsoil during construction is scheduled for restoration and soil amendments (if required).
- Topsoil and/or soil amendments are nearby and certified as meeting the design specifications
- Proper grades have been achieved with light equipment to avoid compaction to provide the required geometry of the disconnection practice: length and width, and slope, and prepare the upper boundary has been performed.
- Stormwater has been diverted for the construction of the inflow measures (Level Spreader or gravel diaphragm).
- Soil amendments, if specified, have been incorporated as specified (thickness of compost material and incorporated to the required depth).
- Construction of engineered Level Spreader for concentrated inflow or a gravel diaphragm or other pretreatment measure for sheet flow has been completed.
- The entire area of the Vegetated Filter Strip has been stabilized and achieved a dense turf cover prior to diverting runoff into the practice.
- All erosion and sediment control practices have been removed.
- Follow-up inspection and as-built survey/certification has been scheduled.
- GPS coordinates have been documented for all Vegetated Filter Strips on the parcel.

SECTION 10. REFERENCES

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