

VIRGINIA ~~DCR-DEQ~~ STORMWATER
DESIGN SPECIFICATION No. 3**GRASS CHANNELS**

VERSION 2.0

July 1, 2013

**SECTION 1: DESCRIPTION**

Grass 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 grass channels will vary depending on the underlying soil permeability (Table 1). Grass channels, however, are not capable of providing the same stormwater functions as dry swales as they lack the storage volume and filtering capabilities associated with the engineered soil media (see Specification No. 10). Their runoff reduction performance can be boosted when compost amendments are added to the bottom of the swale (See Stormwater Design Specification No. 4). Grass channels are a preferable alternative to both curb and gutter and storm drains as a stormwater conveyance system, where development density, topography and soils permit. Grass channels can also be used to treat runoff from the managed turf areas of turf-intensive land uses, such as sports fields and golf courses, and drainage areas with combined impervious and turf cover (e.g., roads and yards).

SECTION 2: PERFORMANCE

Table 3.1. Summary of Stormwater Functions Provided by Grass Channels ¹

Stormwater Function	HSG Soils A and B		HSG Soils C and D	
	No CA ²	With CA	No CA	With CA
Annual Runoff Volume Reduction (RR)	20%	NA ³	10%	20%
Total Phosphorus (TP) EMC Reduction ⁴ by BMP Treatment Process	15%		15%	
Total Phosphorus (TP) Mass Load Removal	32%		24% (no CA) to 32% (with CA)	
Total Nitrogen (TN) EMC Reduction ⁴ by BMP Treatment Process	20%		20%	
Total Nitrogen (TN) Mass Load Removal	36%		28% (no CA) to 36% (with CA)	
Channel & Flood Protection	Partial. <ul style="list-style-type: none"> • Use VRRM Compliance spreadsheet to calculate a Curve Number (CN) adjustment⁵; OR • Design extra storage in the stone underdrain layer and peak rate control structure (optional, as needed) to accommodate detention of larger storm volumes. 			

¹ CWP and CSN (2008) and CWP (2007).
² CA= Compost Amended Soils, see Stormwater Design Specification No. 4.
³ Compost amendments are generally not applicable for A and B soils, although it may be advisable to incorporate them on mass-graded and/or excavated soils to maintain runoff reduction rates. In these cases, the 30% runoff reduction rate may be claimed, regardless of the pre-construction HSG.
⁴ Change in event mean concentration (EMC) through the practice. Actual nutrient mass load removed is the product of the pollutant removal rate and the runoff volume reduction rate (see Table 1 in the *Introduction to the New Virginia Stormwater Design Specifications*).
⁵ NRCS TR-55 Runoff Equations 2-1 thru 2-5 and Figure 2-1 can be used to compute a curve number

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 2013 *Virginia Stormwater Management Handbook* (2nd Edition) provides a more thorough discussion of the site planning process and design considerations as related to Environmental Site Design and potential LEED credits. However, the Virginia Department of ~~Conservation and Recreation (DCR)~~ 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 3.2. Potential LEED® Credits for Grass Channels¹

Credit Category	Credit No.	Credit Description
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

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 LEED AP.

SECTION 3: DESIGN TABLE

Grass channels only have *one* level of design, and must meet the minimum criteria outlined in **Table 3.2** to qualify for the indicated level of runoff reduction.

Table 3.2. Grass Channel Design Guidance

Design Criteria
The bottom width of the channel should be set to maintain the peak flow rate for the 1-inch storm design treatment volume (T_v) ¹ at less than 4 inches in depth and ≤ 1 ft/s velocity.
The channel side-slopes should be 3H:1V or flatter.
The maximum total contributing drainage area to any individual grass channel is 5 acres.
The longitudinal slope of the channel should be no greater than 4%. (Check dams may be used to reduce the effective slope in order to meet the limiting velocity requirements.)
The dimensions of the channel should ensure that flow velocity is non-erosive during the 2-year and 10-year design storm events and the 10-year design flow is contained within the channel (minimum of 0.3 feet of freeboard).

¹ The design of grass channels should consider the entire T_v of the contributing drainage area (rather than the T_v BMP which would reflect a decrease in T_v based on upstream runoff reduction practices) in order to ensure non-erosive conveyance during all design storm conditions.

SECTION 4: TYPICAL DETAILS

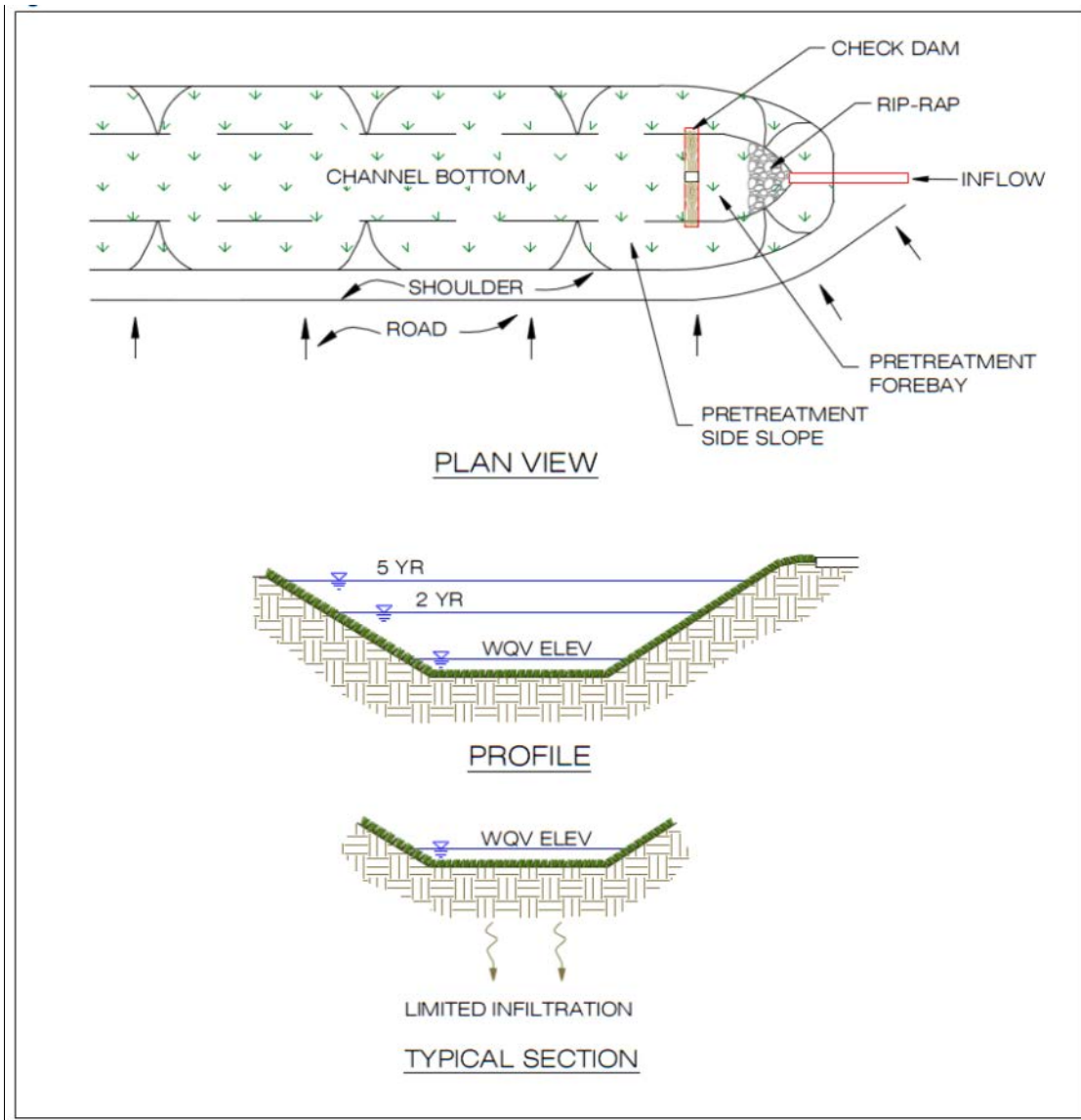


Figure 3.1. Grass Channel – Typical Plan, Profile and Section

NOTE: NEED ORIGINAL CAD OR OTHER IMAGE – THIS ONE TRUNCATED TOP AND BOTTOM

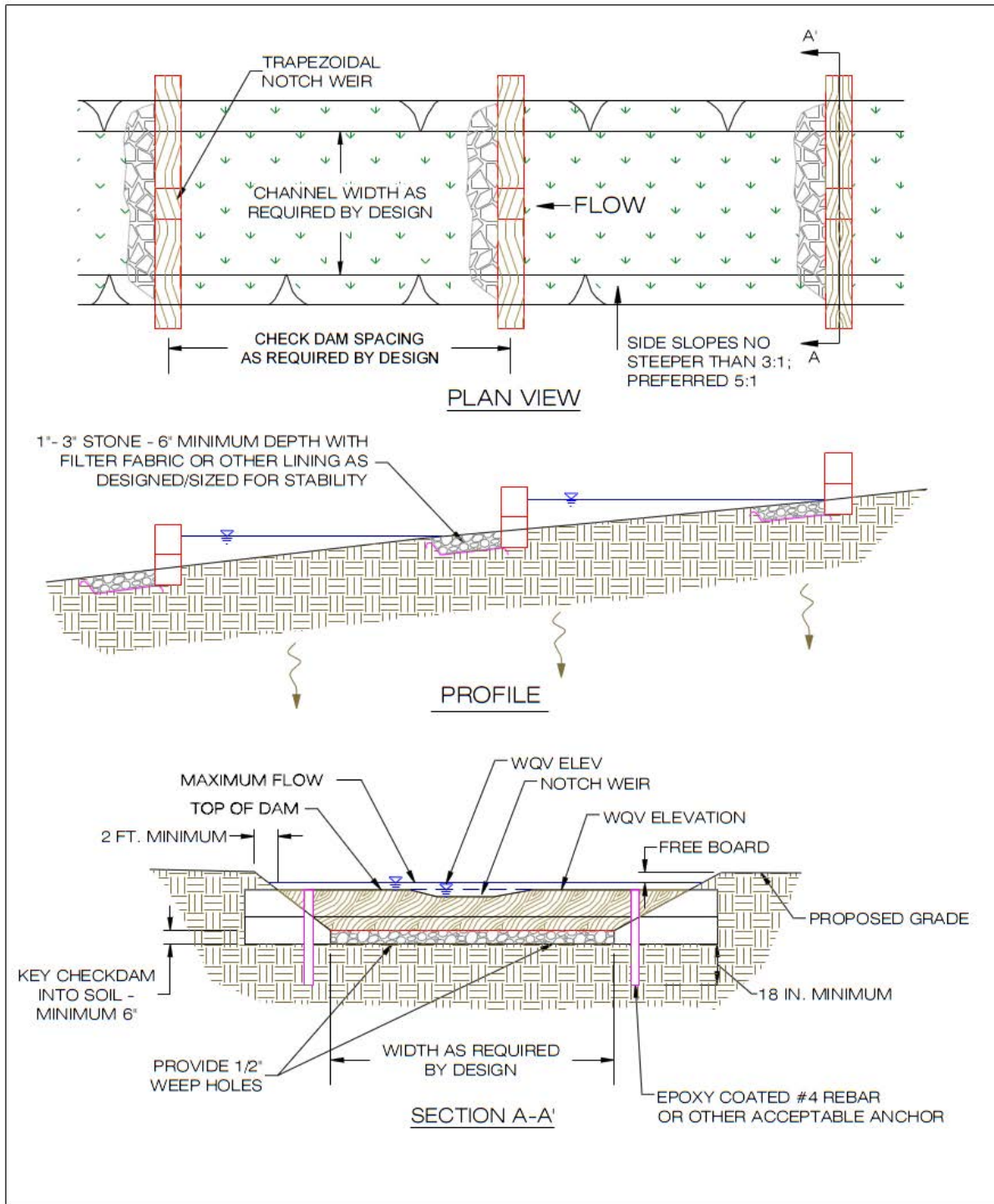


Figure 3.2 Grass Channel with Check Dams – Typical Plan, Profile, and Section
NOTE: NEED ORIGINAL CAD OR OTHER IMAGE – THIS ONE TRUNCATED TOP AND BOTTOM

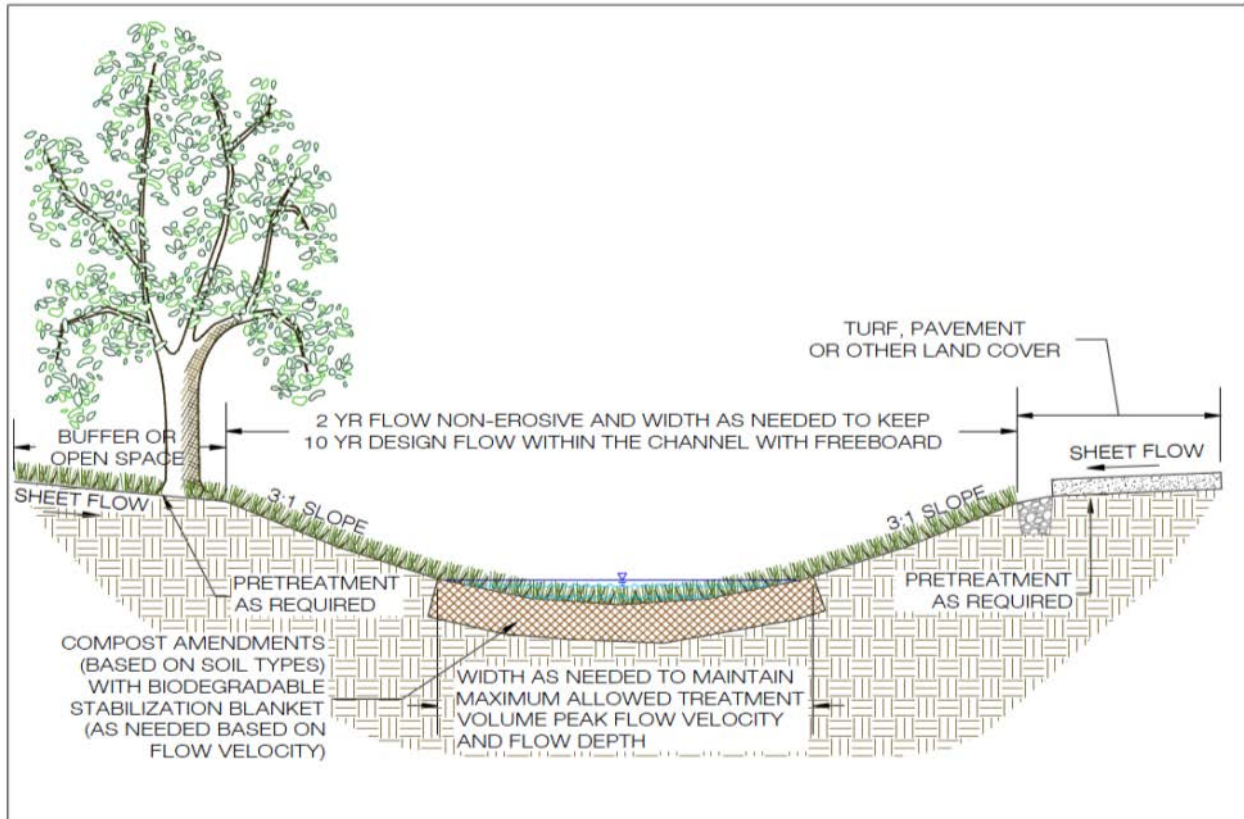


Figure 3.3: Grass Channel with Compost Amendments - Section

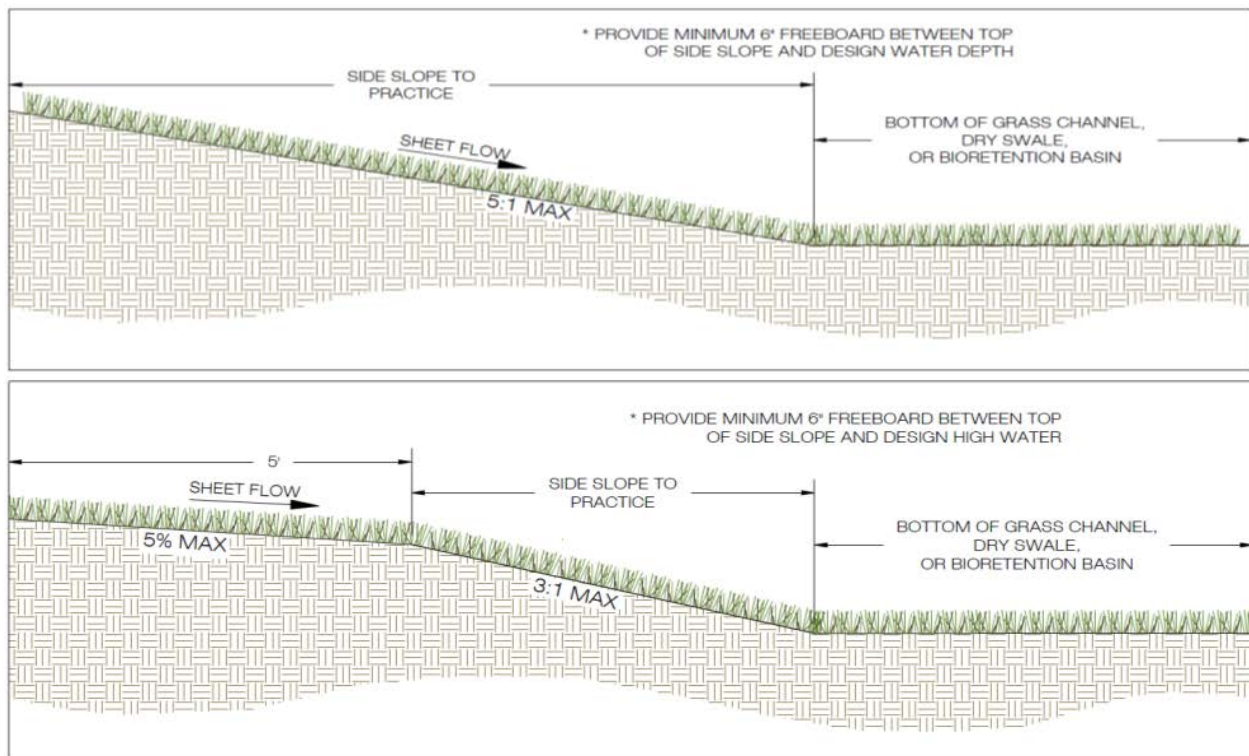


Figure 3.4: Pretreatment I and II - Grass Filter for Sheet Flow

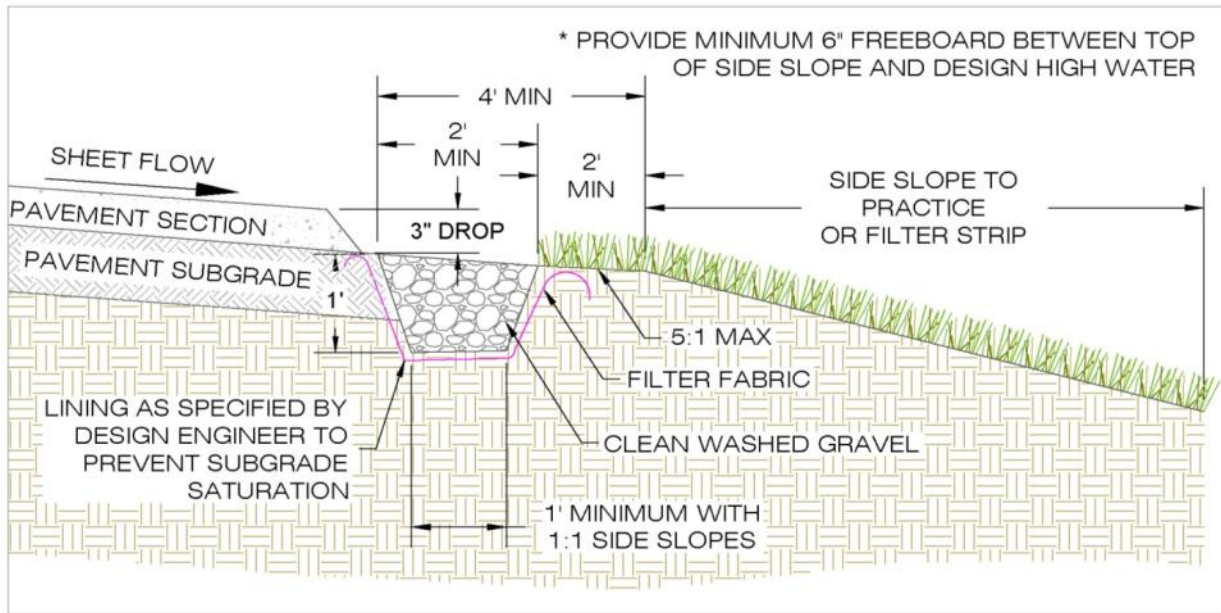


Figure 3.5: Pretreatment – Gravel Diaphragm for Sheet Flow from Impervious or Pervious

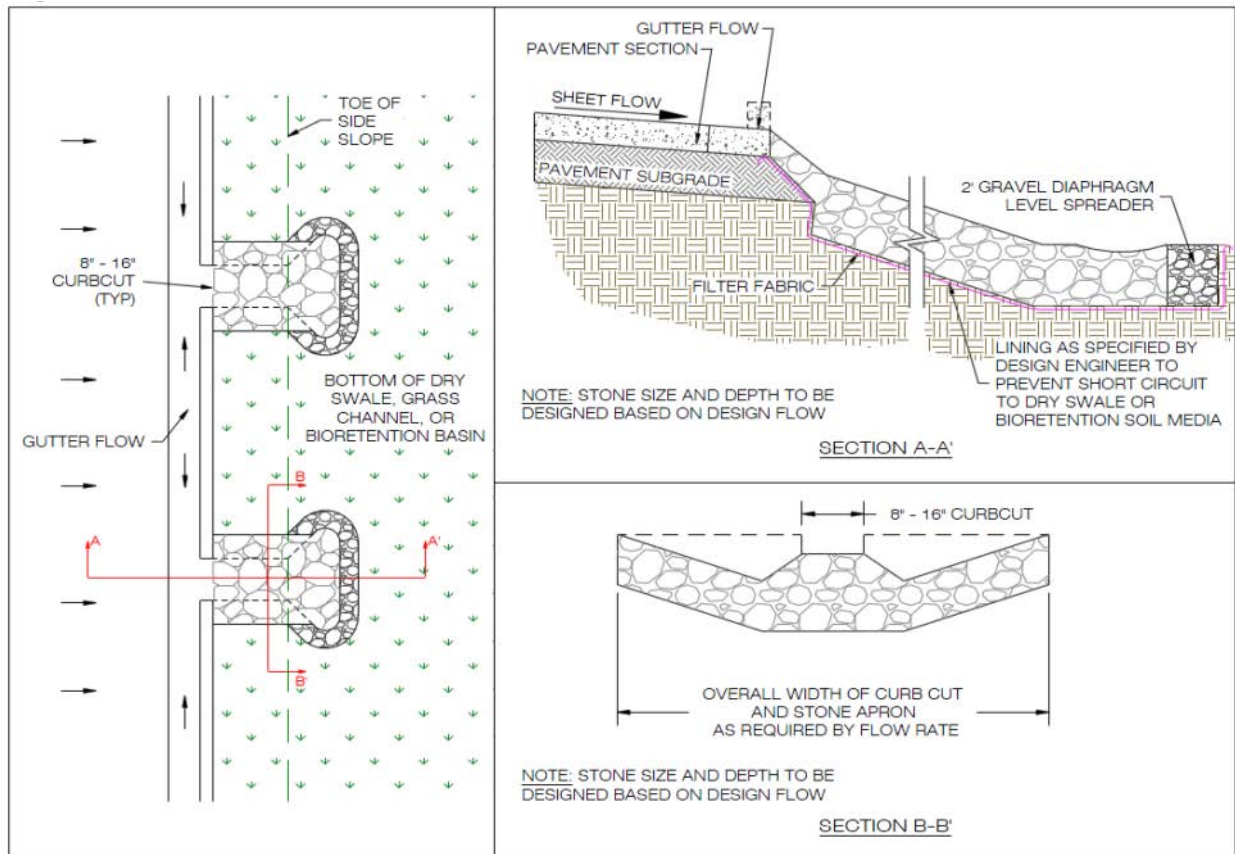
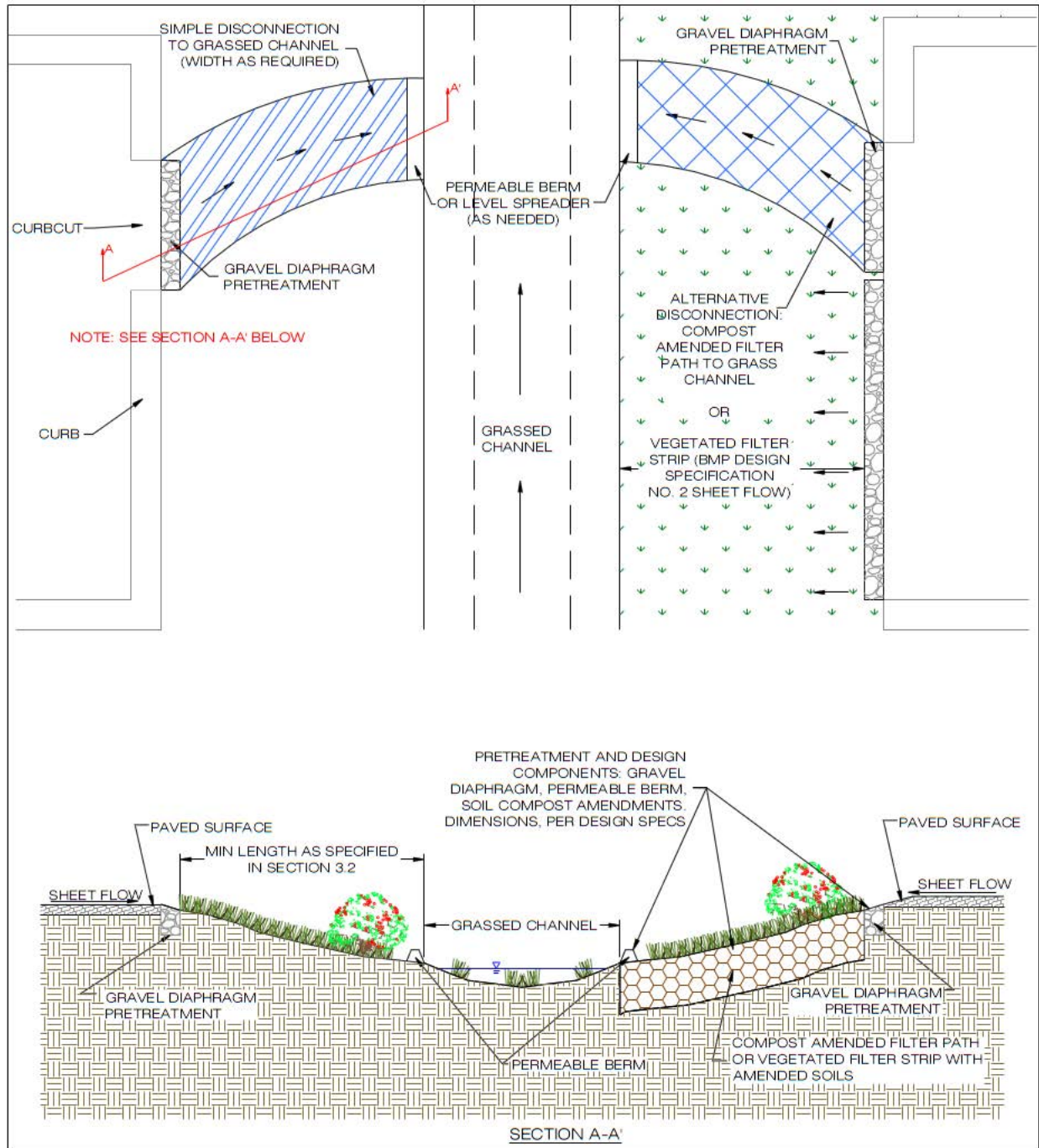


Figure 3.6: Pre-Treatment – Gravel Flow Spreader for Concentrated Flow



NOTE: NEED ORIGINAL CAD OR OTHER IMAGE – THIS ONE TRUNCATED TOP AND BOTTOM. ALSO, SECTION LINE ABOVE DOESN'T REFLECT FULL SECTION BELOW. ALSO, RED "SECTION A-A" LINE ON UPPER DRAWING DOES NOT CORRECTLY DEPICT THE SECTION SHOWN IN THE LOWER DRAWING. IN ORDER TO CORRECT THIS, THE "SECTION A-A" LINE IN THE UPPER DRAWING SHOULD CROSS THE ENTIRE DRAWING. NEED TO FIX THIS.

SECTION 5: PHYSICAL FEASIBILITY AND DESIGN APPLICATIONS

Grass channels can be implemented on suitable development sites where development density, topography and soils are suitable. The linear nature of grass channels makes them well-suited to treat highway runoff, low and medium density residential road and yard runoff (if there is an adequate right-of-way width and distance between driveways), and small commercial parking areas or driveways. Grass channels can also provide pre-treatment for other stormwater treatment practices.

Grass channels are not recommended when residential density exceeds more than 4 dwelling units per acre due to a lack of space in the front yards of lots for shallow slopes. Also, frequent driveway crossings along the channel create potential maintenance problems.

A Dry Swale (Design Specification 10) is an alternative to the Grass Channel and will provide greater performance credit for both runoff volume and pollutant EMC reduction.

Key constraints for grass channels include:

- **Land Uses.** Grass channels can be used in residential, commercial, or institutional development settings. Residential uses are typically limited to densities of 4 dwelling units per acre in order to avoid safety and nuisance conditions.
- Large commercial site applications may require multiple channels in order to effectively break up the drainage areas and meet the design criteria.
- The linear nature of grass channels 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.
- Grass channels can be used to treat the managed turf areas of sports fields, golf courses, and other turf-intensive land uses, or to treat drainage areas with both impervious and managed turf cover (such as residential streets and yards), as long as drainage area limitations and design criteria can be met.

Contributing Drainage Area. The maximum contributing drainage area to a grass channel should be 5 acres, and preferably less. When grass channels treat and convey runoff from drainage areas greater than 5 acres, the velocity and flow depth through the channel becomes too great to treat runoff or prevent erosion in the channel. The design criteria for maximum channel velocity and depth are applied along the entire length, and must meet regulatory requirements (4 VAC 50-60-66) at the downstream limit.

Available Space. Grass channels can be incorporated into linear development applications (e.g., roadways) by utilizing the footprint typically required for an open section drainage feature. The footprint required will likely be greater than that of a typical conveyance channel (VDOT or equivalent). However, the benefit of the runoff reduction may reduce the footprint requirements for stormwater management elsewhere on the development site.

Channel Configuration. Grass channels are especially suited for both conveyance and water quality treatment when applied in linear configurations parallel to the contributing impervious cover, with runoff entering as sheet flow, such as roads and small parking areas.

Longitudinal Slope. Grass channels are limited to longitudinal slopes of less than 4%. However, the limiting velocity requirements will typically require check dams to reduce the effective slope. Slopes steeper than 4% create rapid runoff velocities that can cause erosion and do not allow enough contact time for infiltration or filtering, unless check dams are used.

Longitudinal slopes of less than 2% are ideal and may eliminate the need for check dams. However, channels designed with longitudinal slopes of less than 1% should be monitored carefully during construction to ensure a continuous grade along the entire length of the channel, in order to avoid flat areas with pockets of standing water.

Soils. Grass channels can be used on sites with any type of soils. However, grass channels situated on Hydrologic Soil Group C and D soils will require soil amendments in order to improve performance, as noted in **Table 3.1** (Stormwater Design Specification No. 4, *Soil Compost Amendment*).

Hydraulic Capacity. Grass channels can be designed as an off-line practice, however they are typically an on-line practice and as such must be designed with enough capacity to convey runoff from the 10-year design storm event within the channel banks and be non-erosive during both the 2-year and 10-year design storm events. This means that the much of the surface dimensions are driven by the need to pass these larger storm events.

Depth to Water Table. Designers should ensure that the bottom of the grass channel does not intercept the seasonally high water table to ensure that the channel remains dry between storm events..

Utilities. Designers should consult local utility design guidance for the horizontal and vertical clearance between utilities and the channels. Typically, utilities can cross grass channels if they are specially protected (e.g., double-casing) or are located below the channel invert.

Hotspot Land Uses. Grass channels are not recommended to treat stormwater hotspots, due to the potential for infiltration of hydrocarbons, trace metals and other toxic pollutants into groundwater. For a list of typical stormwater hotspots, see Stormwater Design Specification No. 8 (Infiltration).

Minimum Setbacks. Local ordinances and design criteria should be consulted to determine minimum setbacks from property lines, structures, utilities, and wells. As a general rule, grass channels should be set back at least 10 feet from building foundations, 35 feet from septic system fields and 50 feet from private wells.

SECTION 6: DESIGN CRITERIA

6.1. Sizing of Grass Channels

Unlike other stormwater practices, grass channels are designed based on a peak rate of flow. Designers must demonstrate channel conveyance and treatment capacity in accordance with the following guidelines:

- The longitudinal slope of the channel should ideally be between 1% and 2% in order to avoid scour and short-circuiting within the channel. Longitudinal slopes up to 4% are acceptable; however, check dams will likely be required in order to meet the allowable maximum flow velocities.
- Hydraulic capacity should be verified using Manning’s Equation or an accepted equivalent method, such as erodibility factors and vegetal retardance (NOVA 2007).
 - The flow depth for the T_v peak flow (1-inch rainfall) should be maintained at 4 inches or less.
 - Manning’s “n” value for grass channels should be 0.2 for flow depths up to 4 inches, decreasing to 0.03 at a depth of 12 inches (which would apply to the 2-year and 10-year storms if an on-line application – NOVA, 2007; Haan et. al, 1994).
 - Peak Flow Rates for the 2-year and 10-year frequency storms must be non-erosive, in accordance with **Table 3.3**, or subject to a site-specific analysis of the channel lining material and vegetation; and the 10-year peak flow rate must be contained within the channel banks (with a minimum of 4 inches of freeboard).
- Calculations for peak flow depth and velocity should reflect any increase in flow along the length of the channel, as appropriate. If a single flow is used, the flow at the outlet should be used.
- The hydraulic residence time (the time for runoff to travel the full length of the channel) should be a minimum of 9 minutes for the T_v (1-inch rainfall) design storm (Spyridakis, Mar, and Horner, 1982; Keblin, Walsh, Malina, and Charbeneau, 1998; Washington State Department of Ecology, 2005). If flow enters the swale at several locations, a 9 minute minimum hydraulic residence time should be demonstrated for each entry point, using Equations 3.1 and 3.2 below (Equations 5-1 and 5-2, NOVA 2007).
- The minimum length or residence time may be achieved with multiple swale segments connected by culverts with energy dissipaters.

The bottom width of the grass channel is therefore sized to maintain the appropriate flow geometry as follows:

Equation 3.1: Manning’s Equation

$$V = \left[\left(\frac{1.49}{n} \right) D^{2/3} s^{1/2} \right]$$

Where:

V = flow velocity (ft./sec.)

n = roughness coefficient (0.2, or as appropriate)

D = flow depth (ft.) (NOTE: D approximates hydraulic radius for shallow flows)

s = channel slope (ft./ft.)

Equation 3.2: Continuity Equation

$$q_{pTv} = VA = V(W \times D)$$

Where:

q_{pTv} = design T_v peak flow rate (cfs) (**Section 11.5.3** of **Chapter 11** of the *Virginia Stormwater Management Handbook* (2nd Edition, 2013))

A = flow cross sectional area (ft²)

V = design flow velocity (ft./sec.)

W = channel width (ft.)

D = flow depth (ft.)

(NOTE: channel width (W) x depth (D) approximates the cross sectional flow area for shallow flows.)

Combining Equations 3.1 and 3.2, and re-writing them provides a solution for the minimum width:

Equation 3.3: Minimum Width

$$W = (n)(q_{pTv}) / (1.49D^{5/3}S^{1/2})$$

Solving Equation 3.2 for the corresponding velocity provides:

Equation 3.4: Corresponding Velocity

$$V = q_{pTv} / (W \times D)$$

The resulting velocity should be less than 1 ft./sec. The width, slope, or Manning's "n" value can be adjusted to provide an appropriate channel design for the site conditions. However, if a higher density of grass is used to increase the Manning's "n" value and decrease the resulting channel width, it is important to provide material specifications and construction oversight to ensure that the denser vegetation is actually established. Equation 3.5 can then be used to ensure adequate hydraulic residence time.

Equation 3.5: Grass Channel Length for Hydraulic Residence Time of 9 minutes (540 seconds)

$$L = 540V$$

Where:

L = minimum swale length (ft.)

V = flow velocity (ft./sec.)

Table 3.3: Maximum Permissible Velocities for Grass Channels

Cover Type	Slope (%)	Erosion Resistant Soils (ft./sec.)	Easily Eroded Soils (ft./sec.)
Bermudagrass	0 – 5	6	4.5
Kentucky bluegrass Reed Canarygrass Tall fescue	0 – 5	5	3.8
Bermudagrass	5 – 10	5	3.8
Kentucky bluegrass Reed Canarygrass Tall fescue	5 – 10	4	3
Grass-legume mixture	0 – 5	4	3
	5 - 10	3	2.3
Kentucky bluegrass Reed Canarygrass Tall fescue	> 10	3	2.3
Red fescue	0 - 5	2.5	1.9

Sources: Virginia E&S Control Handbook, 1992; Ree, 1949; Temple et al, 1987; NOVA, 2007

6.2. Geometry and Site Layout

- Grass channels should generally be aligned adjacent to and the same length (minimum) as the contributing drainage area identified for treatment.
- Grass channels should be designed with a trapezoidal or parabolic cross section. A parabolic shape is preferred for aesthetic, maintenance and hydraulic reasons.
- The bottom width of the channel should be between 4 to 8 feet wide. If a channel will be wider than 8 feet, the designer should incorporate benches, check dams, level spreaders or multi-level cross sections to prevent braiding and erosion along the channel bottom.
- Grass channel side slopes should be no steeper than 4H:1V for ease of mowing and routine maintenance. Flatter slopes are encouraged, where adequate space is available, to aid in pre-treatment of sheet flows entering the channel. Under no circumstances are side slopes to exceed 3H:1V.

6.3. Pretreatment

Pretreatment is recommended for grass channels to dissipate energy, trap sediments and slow down the runoff velocity. The selection of a pre-treatment method depends on whether the channel will experience sheet flow or concentrated flow. Several reliable options are as follows:

- **Check dam forebays** (channel flow): The most common form of pre-treatment at concentrated inflow points is a forebay formed by a check dam.
- **Tree Check dams** (channel flow): These are street tree mounds that are placed within the bottom of grass channels up to an elevation of 9 to 12 inches above the channel invert. One side has a gravel or river stone bypass to allow runoff to percolate through (Cappiella et al, 2006).
- **Grass Filter Strip** (sheet flow): Grass filter strips extend from the edge of the pavement to the bottom of the grass channel at a slope of 5:1 or less. Alternatively, provide a combined 5 feet

of grass filter strip at a maximum 5% (20:1) cross slope and 3:1 or flatter side slopes on the grass channel.

- **Gravel or Stone Diaphragm** (sheet flow): The gravel diaphragm is located at the edge of the pavement or the edge of the roadway shoulder and extends the length of the channel to pre-treat lateral runoff. This requires a 2 to 4 inch elevation drop from a hard-edged surface into a gravel or stone diaphragm.
- **Gravel or Stone Flow Spreaders** (concentrated flow). The gravel flow spreader is located at curb cuts, downspouts, or other concentrated inflow points, and should have a 2 to 4 inch elevation drop from a hard-edged surface into a gravel or stone diaphragm. The gravel should extend the entire width of the opening and create a level stone weir at the bottom or treatment elevation of the channel.

6.4. Check dams

Check dams may be used for pre-treatment, to reduce the effective longitudinal slope, and to increase the hydraulic residence time in the channel. Design requirements for check dams are as follows:

- Check dams should be spaced based on the channel slope, as needed to increase residence time, provide T_v storage volume, or any additional volume attenuation requirements. The ponded water at a downhill check dam should not touch the toe of the upstream check dam.
- The maximum desired check dam height is 12 inches (for maintenance purposes). The average ponding depth throughout the channel should be 12 inches.
- Armoring may be needed at the downstream toe of the check dam to prevent erosion.
- Check dams must be firmly anchored into the side-slopes to prevent outflanking; check dams must also be anchored into the channel bottom a minimum of 6 inches so as to prevent hydrostatic head from pushing out the underlying soils.
- Check dams must be designed with a center weir sized to pass the channel design storm peak flow (10-year storm event if an on-line practice).
- The check dam should be designed so that it facilitates easy mowing (gravel check dams are discouraged for this reason).
- Each check dam should have a weep hole or similar drainage feature so it can dewater after storms.
- Check dams should be composed of wood, concrete, stone, or other non-erodible material, or be should be configured with elevated driveway culverts.
- Individual channel segments formed by check dams or driveways should generally be at least 25 to 40 feet in length.

6.5. Compost Soil Amendments

Soil compost amendments serve to increase the runoff reduction capability of a grass channel. The following design criteria apply when compost amendments are used:

- The compost-amended strip should extend over the length and width of the channel bottom, and the compost should be incorporated to a depth as outlined in Stormwater Design Specification No. 4, *Soil Compost Amendment*.

- The amended area will need to be rapidly stabilized with perennial, salt tolerant grass species.
- For grass channels on steep slopes, it may be necessary to install a protective biodegradable geotextile fabric to protect the compost-amended soils. Care must be taken to consider the erosive characteristics of the amended soils when selecting an appropriate geotextile.
- For redevelopment or retrofit applications, the final elevation of the grass channel (following compost amendment) must be verified as meeting the original design hydraulic capacity.

6.6. Planting Grass Channels

Designers should choose grass species that can withstand both wet and dry periods as well as relatively high-velocity flows within the channel. For applications along roads and parking lots, salt tolerant species should be chosen. Taller and denser grasses are preferable, though the species of grass is less important than good stabilization. For a list of grass species suitable for use in grass channels, consult the Virginia Erosion Control Handbook.

Grass channels should be seeded at such a density to achieve a 90 % turf cover after the second growing season. Grass channels should be seeded and not sodded. Seeding establishes deeper roots and sod may have muck soil that is not conducive to infiltration (Wisconsin DNR, 2007). Grass channels should be protected by a biodegradable erosion control fabric to provide immediate stabilization of the channel bed and banks.

6.7. Grass Channel Material Specifications

The basic material specifications for grass channels are outlined in **Table 3.4** below.

Table 3.4. Grass Channel Materials Specifications

Component	Specification
Grass	A dense cover of water-tolerant, erosion-resistant grass. The selection of an appropriate species or mixture of species is based on several factors including climate, soil type, topography, and sun or shade tolerance. Grass species should have the following characteristics: a deep root system to resist scouring; a high stem density with well-branched top growth; water-tolerance; resistance to being flattened by runoff; an ability to recover growth following inundation; and, if receiving runoff from roadways, salt-tolerance.
Check Dams	<ul style="list-style-type: none"> • Check dams should be constructed of a non-erosive material such as wood, gabions, riprap, or concrete. All check dams should be underlain with filter fabric conforming to local design standards. • Wood used for check dams should consist of pressure treated logs or timbers, or water-resistant tree species such as cedar, hemlock, swamp oak or locust.
Diaphragm	Pea gravel used to construct pre-treatment diaphragms should consist of washed, open-graded, coarse aggregate between 3 and 10 mm in diameter and must conform to local design standards.
Erosion Control Fabric	Where flow velocities dictate, biodegradable erosion control netting or mats that are durable enough to last at least two growing seasons must be used, conforming to VDOT EC3.
Filter Fabric (check dams)	Filter fabric is applicable in several different capacities when construction a grass channel with check dams and/or rip rap, etc. Designers should select an appropriate filter fabric for the particular application based on AASHTO M288-06

SECTION 7: REGIONAL & SPECIAL CASE DESIGN ADAPTATIONS

7.1. Karst Terrain

Grass channels are an acceptable practice in karst terrain, as long as they do not treat hotspot runoff. The following design adaptations apply to grass channels in karst terrain:

- Soil compost amendments may be incorporated into the bottom of grass channels to improve their runoff reduction capability, as noted in **Table 3.1** above.
- Check dams are generally discouraged for grass swales in karst terrain, since they pond too much water (although flow spreaders that are flush with the ground surface and spaced along the channel length may be useful in spreading flows more evenly across the channel width).
- The minimum depth to the bedrock layer is 18 inches.
- A minimum slope of 0.5% must be maintained to ensure positive drainage.
- The grass channel may have off-line cells and should be tied into an adequate discharge point.

7.2. Coastal Plain

Although grass channels work reasonably well in the flat terrain and low head conditions of many coastal plain sites, they have very poor nutrient and bacteria removal rates, and should not be used as a stand-alone treatment system. Dry swales or wet swales are much superior options to the grass channel, unless the soils are in the highly permeable HSG “A” group. Where HSG-A soils occur:

- The minimum depth from the swale invert to the seasonally high water table should be 12 inches.
- A minimum slope of 0.5% must be maintained to ensure positive drainage.
- The grass channel may have off-line cells and should be tied into the ditch system

7.3. Steep Terrain

Grass swales are not practical in areas of steep terrain, although terracing a series of grass swale cells may work on slopes from 5% to 10%. The drop in elevation between check dams should be limited to 18 inches in these cases, and the check dams should be armored on the down-slope side with suitably sized stone to prevent erosion.

7.4. Cold Climate and Winter Performance

Grass swales can store snow and treat snowmelt runoff when they serve road or parking lot drainage. If roadway salt is applied in their CDA, grass swales should be planted with salt-tolerant species. Consult the Minnesota Stormwater Manual for a list of salt-tolerant grass species (MSSC, 2005).

7.5. Linear Highway Sites

Grass swales are a preferred stormwater practice for linear highway sites.

SECTION 8: CONSTRUCTION

8.1. Construction Sequence

The following is a typical construction sequence to properly install a grass channel, although steps may be modified to reflect different site conditions. Grass channels should be installed at a time of year that is best to establish turf cover without irrigation. Some local agencies restrict planting to the following periods of time: February 15 through April 15 and September 15 through November 15.

Step 1: Protection during Site Construction. Ideally, grass channels should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment. However, this is seldom practical, given that the channels are a key part of the drainage system at most sites. In these cases, temporary E&S controls such as dikes, silt fences and other erosion control measures should be integrated into the swale design throughout the construction sequence. Specifically, barriers should be installed at key check dam locations, and erosion control fabric should be used to protect the channel.

Step 2. Grass channel installation may only begin after the entire contributing drainage area has been stabilized with vegetation. Any accumulation of sediments that does occur within the channel must be removed during the final stages of grading to achieve the design cross-section. Erosion and sediment controls for construction of the grass channel should be installed as specified in the erosion and sediment control plan. Stormwater flows must not be permitted into the grass channel until the bottom and side slopes are fully stabilized.

Step 3. Grade the grass channel to the final dimensions shown on the plan.

Step 4. Install check dams, driveway culverts and internal pre-treatment features as shown on the plan. The top of each check dam should be constructed level with the overflow notch at the design elevation.

Step 5 (Optional). Till the bottom of the channel to a depth of 1 foot and incorporate compost amendments according to Stormwater Design Specification No. 4.

Step 6. Add soil amendments as needed, hydro-seed the bottom and banks of the grass channel, and peg in erosion control fabric or blanket where needed. After initial planting, a biodegradable erosion control fabric should be used, conforming to Standard and Specification 3.36 of the Virginia Erosion and Sediment Control Handbook.

Step 7. Prepare planting holes for any trees and shrubs, then plant materials as shown in the landscaping plan and water them weekly in the first two months. The construction contract should include a Care and Replacement Warranty to ensure vegetation is properly established and survives during the first growing season following construction.

Step 8. Conduct the final construction inspection and develop a punch list for facility acceptance.

8.2 Construction Inspection

Inspections during construction are needed to ensure that the grass channel is built in accordance with these specifications. An example construction phase inspection checklist for Grass Channels is at the end of this specification

Some common pitfalls can be avoided by careful post-storm inspection of the grass channel:

- Make sure the desired coverage of turf or erosion control fabric has been achieved following construction, both on the channel beds and their contributing side-slopes.
- Inspect check dams and pre-treatment structures to make sure they are at correct elevations, are properly installed, and are working effectively.
- Make sure outfall protection/energy dissipation at concentrated inflows is stable.
- Log the filtering practice's GPS coordinates and submit them for entry into the local BMP maintenance tracking database.

The real test of a grass swale occurs after its first big storm. Minor adjustments are normally needed as part of this post-storm inspection (e.g., spot reseeding, gully repair, added armoring at inlets, or realignment of outfalls and check dams).

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, a requirement to notify the local VSMP authority upon transfer of ownership, and right-of-entry for local program personnel.

- All water quality grass channels must include a long term maintenance agreement consistent with the provisions of the VSMP regulations, and must include the recommended maintenance tasks and a copy of an annual inspection checklist.
- When grass channels are located on individual private residential lots, homeowners will need to be educated regarding their routine maintenance needs.
- A deed restriction, drainage easement or other mechanism enforceable by the VSMP authority must be in place to help ensure that grass channels are maintained, as well as to pass the knowledge along to any subsequent owners.
- The mechanism should, if possible, grant authority for local agencies to access the property for inspection or corrective action. Where grass channels are designed to convey runoff from multiple lots or properties, a drainage easement that ensures the access for purposes of inspections and corrective actions must be provided.

9.2. Maintenance Inspections

Annual inspections are used to trigger maintenance operations such as sediment removal, spot re-vegetation and inlet stabilization. Several key maintenance inspection points are detailed in **Table 3.5**. Ideally, inspections should be conducted in the spring of each year. Example maintenance inspection checklists for Grass Channels can be accessed in Appendix C of Chapter 9 of the *Virginia Stormwater Management Handbook* (2010).

9.3. Ongoing Maintenance

Once established, grass channels have minimal maintenance needs outside of the spring clean up, regular mowing, repair of check dams and other measures to maintain the hydraulic efficiency of the channel and a dense, healthy grass cover.

Table 3.5. Suggested Spring Maintenance Inspections/Cleanups for Grass Channels

Activity
Add reinforcement planting to maintain 90% turf cover. Reseed any salt-killed vegetation.
Remove any accumulated sand or sediment deposits behind check dams.
Inspect upstream and downstream of check dams for evidence of undercutting or erosion, and remove trash or blockages at weep holes.
Examine channel bottom for evidence of erosion, braiding, excessive ponding or dead grass.
Check inflow points for clogging and remove any sediment.
Inspect side slopes and grass filter strips for evidence of any rill or gully erosion and repair.
Look for any bare soil or sediment sources in the contributing drainage area and stabilize immediately.

SECTION 10: COMMUNITY AND ENVIRONMENTAL CONCERNS

The main concerns of adjacent residents are perceptions that grass channels will create nuisance conditions or will be hard to maintain. Common concerns include the continued ability to mow grass, landscape preferences, weeds, standing water, and mosquitoes.

Sample Construction Inspection Checklist: Grass Channels

The following checklist provides a basic outline of the anticipated items for the construction inspection of grass channels for use as stormwater BMPs. 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.

- Pre-construction meeting with the contractor designated to install the grass channel 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.
- Grass channel has not been used during construction; or
- Grass channel has been used for construction and is scheduled to be restored by removing construction sediment and incorporating soil amendments.
- Stormwater has been diverted for the construction of the inflow measures (level spreader or gravel diaphragm).
- Proper grades have been achieved with light equipment to avoid compaction to provide the required geometry of the grass channel: length and longitudinal slope, bottom width, and side slopes.
- Soil amendments, if required, have been incorporated as specified (thickness of compost material and incorporated to the required depth).
- Check dams, (including driveway culverts, if required, have been installed in accordance with the approved plans (spacing, height, elevation of overflow notch, energy dissipaters, keyed into side slopes, etc.).
- Energy dissipater and sediment forebay (if required) have been installed at the areas of concentrated inflow in accordance with the approved plans.
- Pretreatment practices have been installed for sheet flow entry.
- Channel bed and banks and adjacent disturbed areas have all been adequately stabilized (with matting if required, or needed to ensure a dense vegetative cover) prior to diverting runoff into the channel.
- 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 grass channels on the parcel.

SECTION 11: DESIGN REFERENCES

Claytor, R. and T. Schueler. 1996. *Design of Stormwater Filtering Systems*. Center for Watershed Protection. Ellicott City, MD.

CWP. 2007. *National Pollutant Removal Performance Database Version 3.0*. Center for Watershed Protection, Ellicott City, MD.

Haan, C.T., Barfield, B.J., and Hayes, J.C. *Design Hydrology and Sedimentology for Small Catchments*. Academic Press, New York, 1994.

Lantin, A., and M. Barrett. 2005. *Design and Pollutant Reduction of Vegetated Strips and Swales*. ASCE. Downloaded September, 2005.

Maryland Department of Environment (MDE). 2000. *Maryland Stormwater Design Manual*. Baltimore, MD. Available online at:
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Northern Virginia Regional Commission. 2007. *Low Impact Development Supplement to the Northern Virginia BMP Handbook*. Fairfax, Virginia

Schueler, T., D. Hirschman, M. Novotney and J. Zielinski. 2007. *Urban Stormwater Retrofit Practices*. Manual 3 in the Urban Subwatershed Restoration Manual Series. Center for Watershed Protection, Ellicott City, MD.

Schueler, T. 2008. Technical Support for the Baywide Runoff Reduction Method. Chesapeake Stormwater Network. Baltimore, MD. www.chesapeakestormwater.net

Virginia Department of Conservation and Recreation (DCR). 1999. *Virginia Stormwater Management Handbook. Volumes 1 and 2*. Division of Soil and Water Conservation. Richmond, VA.

Wisconsin Department of Natural Resources. "Vegetated Infiltration Swale (1005)." *Interim Technical Standard, Conservation Practice Standards*. Standards Oversight Council, Madison, Wisconsin, 2004. Available online at:
http://dnr.wi.gov/org/water/wm/nps/pdf/stormwater/techstds/post/Interim_Infiltration_Swale_1005.pdf.