In this tutorial you will learn:

- The design criteria for vegetative filter strips.
- Differences and applications for: basic VFS, CAVFS, and narrow area VFS.
- How to use StormSHED to determine the design flow rate for a VFS area.
- Introduce Media Filter Drain and provide an overview of the design criteria.

Introduction to Vegetative Filter Strips

A Vegetative Filter Strip is a BMP's that uses areas of dense planted vegetation (typically grass) and a flat cross slope to maintain sheet flow and remove sediment and other pollutants from runoff coming directly off pavement. Vegetative filter strips are only intended to provide runoff treatment and are therefore situated between the pavement surface and a surface water collection system, pond, wetland, or river. The short duration storm should be used when determining runoff values.

This tutorial provides three methods for sizing filter strips: narrow area filter strips, basic area filter strips, and compost-amended vegetative filter strip CAVFS. The narrow area VFS is the simplest to design, however it is limited to 30' flow paths from impervious surfaces. If space allows or for flow paths that exceed 30', either the basic VFS or CAVFS should be used. The Figure below illustrates a typical VFS.

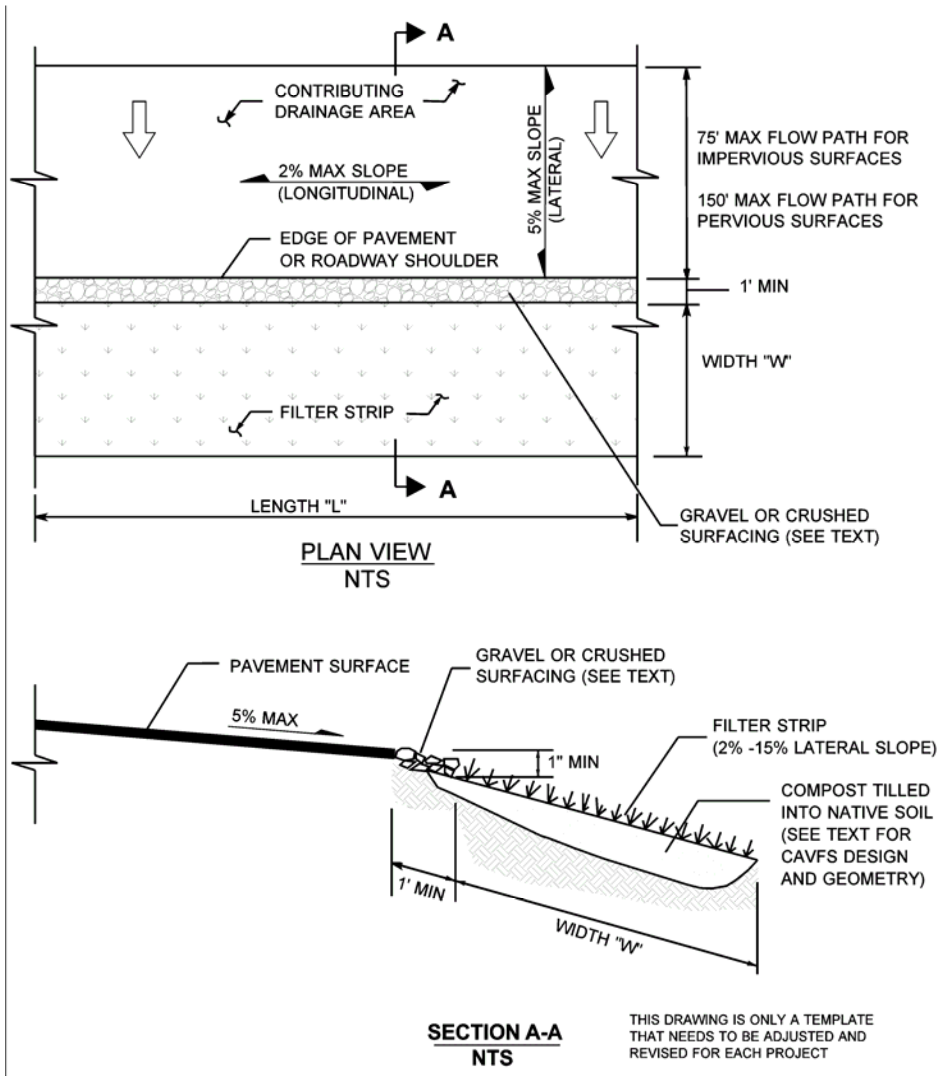


Figure RT.02.1. Typical vegetated filter strip.

Design Area Limitations

- VFS are designed to treat small areas. Flow must enter as sheet flow and not exceed a depth of 1”.
- For narrow VFS the contributing flow path must not exceed 30’. For CAVFS and basic VFS the maximum flow path must not exceed 75’.
- The longitudinal slope of the contributing drainage area parallel to the pavement should be 2% or less.
- The lateral slope of the contributing drainage area perpendicular to the pavement edge should be 5% or less.
- The limits of the lateral slope for embankment are 2%-15%. Slopes between 15% and 25% can only be constructed with CAVFS.
- VFS should have atleast 10’ (basic and CAVFS) and 4’ for narrow VFS, of available embankment.
- Filter Strips should be placed at least 1 foot, from the edge of pavement to accommodate a vegetative free zone or install a flow spreader. The first foot should be as flat as possible to encourage sheet flow. Consider using aggregate that meets the specification for base course, as a flow spread.
- Once a filter strip has treated stormwater, it will need to be collected and conveyed to a stormwater flow control BMP.

Construction and Maintenance Criteria

- Vegetated filter strips should be constructed after construction is completed, i.e. they should not be used for Temporary Erosion Control (TESC).
- Groomed filter strips planted in grasses should be mowed during the summer to promote growth.
- Inspect filter strips periodically, especially after periods of heavy runoff. Remove sediments and reseed as necessary. Catch basins or sediment sumps that precede filter strips should be cleaned to maintain proper function.

Narrow Area Filter Strips

Narrow Area Vegetative Filter Strip Sample Problem Description

A new highway near the city of Spokane is being constructed that will be 25' wide, have a 2% cross-section slope and a continuous 3% profile off the road. The average slope of the embankment is 10%. It has been determined that a vegetative filter strip is the BMP for this site.

Design Procedure

This procedure is based on the Narrow Area Filter Strips presented in the 1998 King County Surface Water Design Manual and also in the HRM. The filter strip is sized using the width of the flow-path and the longitudinal slope of the filter strip itself (parallel to the flow-path). Since filter strips only provide basic treatment, they should be used where the roadway ADT is less than 30,000.

1. **Determine width of roadway surface parallel to flow path draining to the vegetative filter strip.**

   Determine the width of the flow-path from the upstream to the downstream edge of the impervious area draining to the filter strip.

   For this example the width of the flow path is the width of the road or ***25'****.*

2. **Determine average lateral slope of the vegetated filter strip:**

   Calculate the lateral slope of the filter strip (parallel to the flow-path), averaged over the total width of the filter strip. If the slope is less than 2 percent, use 2 percent for sizing purposes. The maximum longitudinal slope allowed is 15 percent.

   For this tutorial the longitudinal slope of the filter strip is ***10%****. This value will likely be determined by the road geometry and natural terrain where the filter strip will be located.*

3. **Determine required length of the filter strip:**

   Use Figure RT.02.1 to size the filter strip based on flow-path length and filter strip (lateral) slope. To use the figure, find the width of the flow-path on one of the curves (interpolate between curves as necessary). Move along the curve to the point where the design lateral slope of the filter strip is directly below. Read the filter strip width to the left on the y-axis. The filter strip must be designed to provide this width "W" along the entire length of pavement providing runoff to the VFS.

Given a road width of 25' shedding runoff to the filter strip, designers should estimate between the 20' and 30' lines. Then locate a 10% slope for a filter strip, and from the y-axis the filter strip should be 12' long and run parallel to the road.

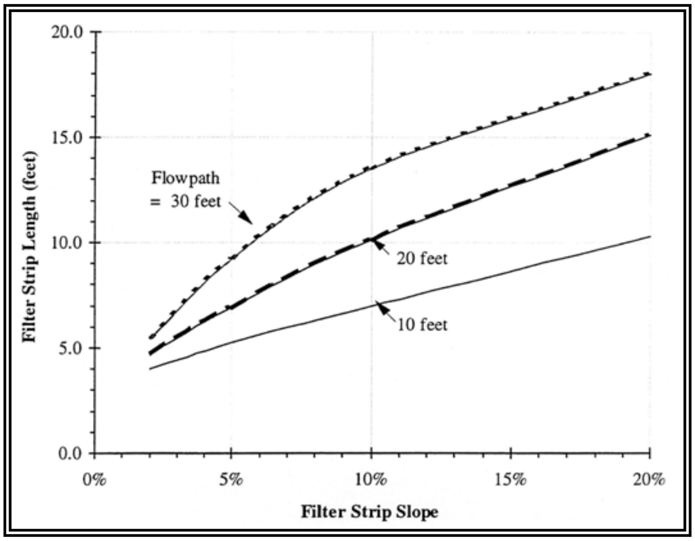


Figure RT.01.1 Narrow area vegetated filter strip design graph

Basic VFS and CAVFS

The design methods for basic and CAVFS are identical. In addition to the design area limitations listed above, there are a few additional requirements that only apply to basic VFS and CAVFS.

- VFS should provide a minimum residence time of 9 minutes for full runoff treatment.
- The Manning's n can be selected from Table RT.02.1.
- The maximum flow velocity for runoff treatment design flow velocity is 0.5ft/sec.

Design Procedure

This is a summary of the basic VFS and CAVFS design method from the HRM. For more information, designers should consult the HRM or contact the Region Hydraulics Engineer. The sizing of the VFS is more complicated than with the narrow filter strip method. Unlike the narrow filter strip that only requires the width of the contributing flow path and the lateral slope of the VFS embankment, the basic VFS and CAVFS also requires: the Manning's value of the VFS surface and the design flow Q_{WQ} from the road surface.

The design procedure for VFS and CAVFS is exactly the same; the primary difference between the two is noted below:

Basic VFS – Uses a compacted roadside embankment that is subsequently hydroseeded. Basic VFS can only provide basic runoff treatment on embankments with up to 15% side slopes.

Compost Amended Vegetative Filter Strips – Incorporates compost into the native soils to improve infiltration characteristics, increase the surface roughness, improve plant stability and improve removal of contaminants. CAVFS meets the criteria for both basic and enhanced runoff treatment and can also be used on embankments with side slopes up to 25%.

Construction and Maintenance Criteria

The Construction and Maintenance Criteria are the same as for Narrow Vegetated Filter Strips.

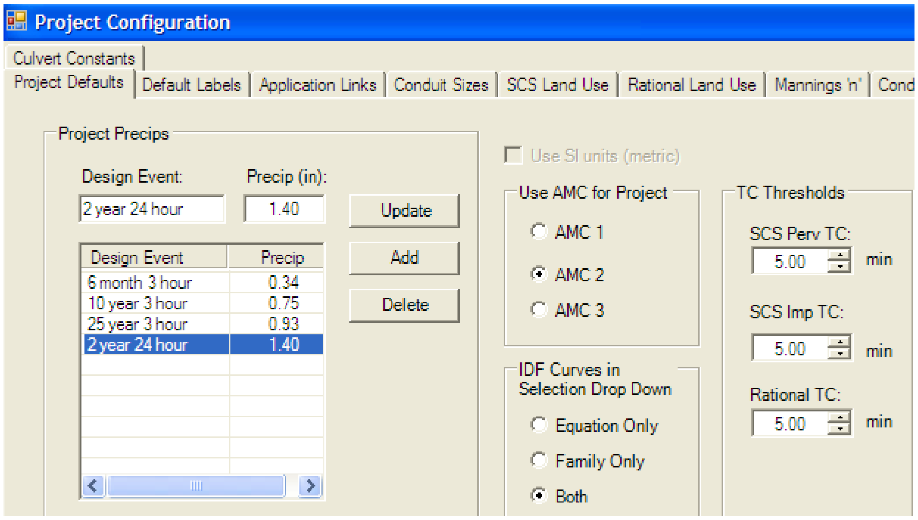
Basic and CAFVS Sample Problem Description

A new four-lane roadway section is being constructed near Spokane. A vegetative filter strip is to be constructed on each side of a 2000 ft section of the highway with a 4-foot inside shoulder (does not drain to VFS), two 12-foot lanes, and a 12-foot outside shoulder shedding runoff toward each filter strip. The road has a 2% cross section and 2% continuous profile. The filter strip will have a lateral slope of 3% and will be constructed of Type B soil, fully compacted, and hydro seeded soil.

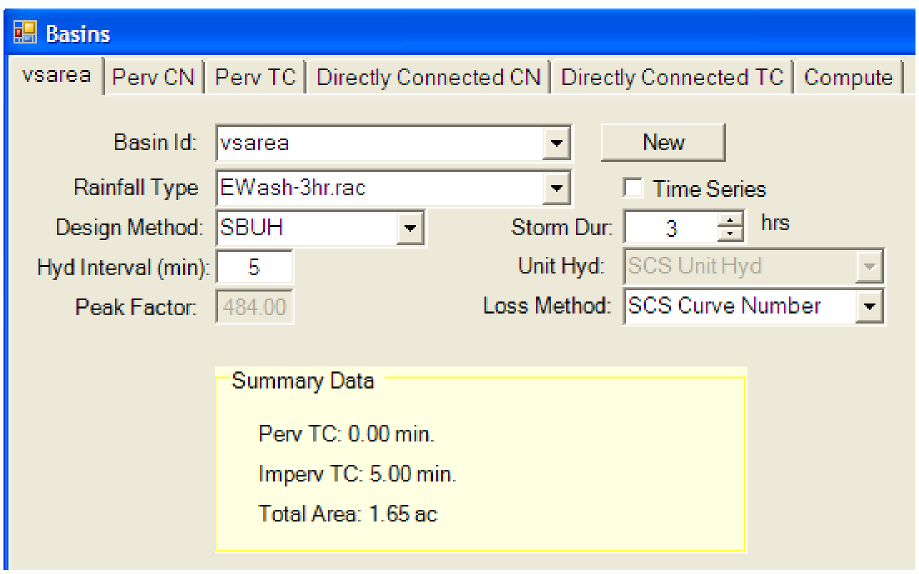
1. **Determine the runoff treatment design flow Q.**

   For eastern Washington, the design flow rate is determined using a 5-minute interval for the 6-month, 3-hour event. Storm Shed will be used to obtain this value.

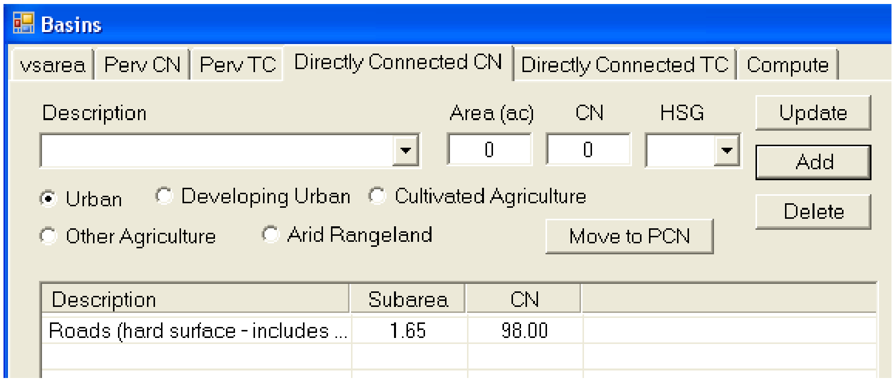
- Create a **new project** called **VFS**.
- Select **Data>Config** from the main tool bar to open the ***Project Configuration*** dialog box. Set the Project Precipitation rates the same as for the Biofiltration Swale as shown below. For further discussion on how the values were obtained, see the Short Duration Storm tutorial.



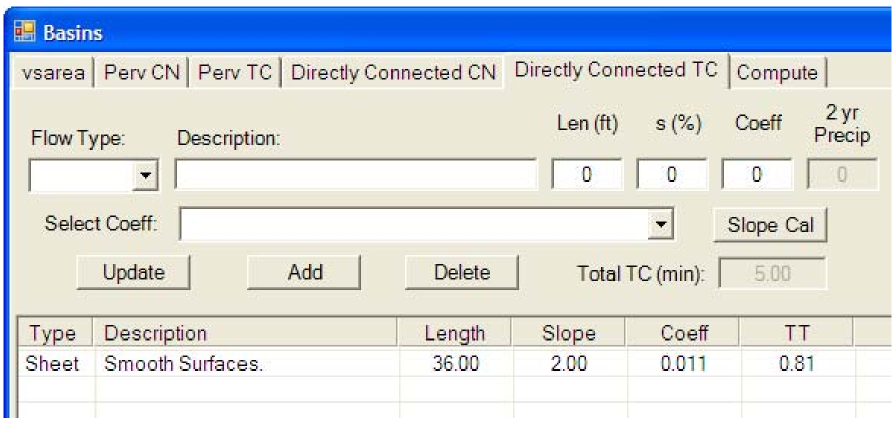
- Next create a new basin called **vsarea**. Modify the remaining basin data as shown below.



- There is no pervious area contributing to the vegetative filter strip, so the default values in the ***Perv. CN*** and ***Perv. TC*** tabs should be **deleted**.
- Select the ***Directly Connected CN*** tab and input the impervious area, calculated to be **1.65 AC,** with a **CN** value of **98**.

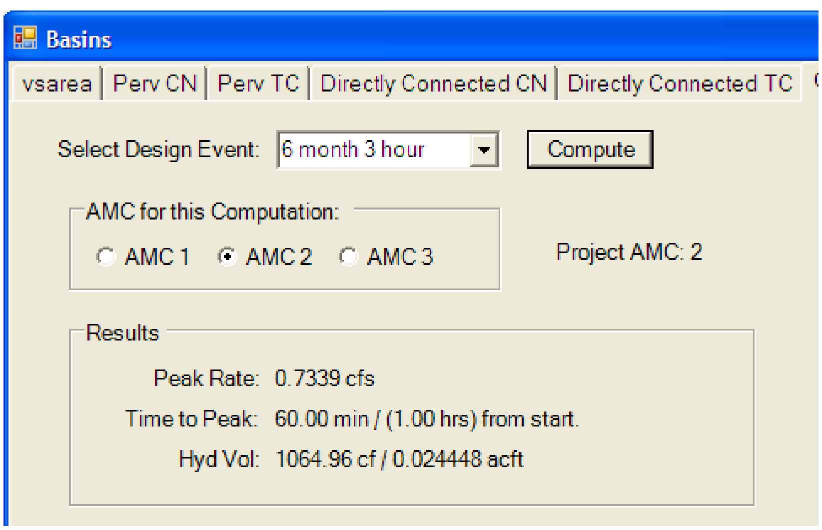


- Next, select the ***Directly Connected TC*** tab and input the values shown below. Note the only type of flow contributing to the filter strip is sheet flow.



- Finally select the ***Compute*** tab and pick the **<u>6 month 3 hour</u>** design event from the pull down menu and then select **<u>Compute</u>**.

  For this example the Q is found to be 0. 947 cfs as shown below.



2. Calculate the design flow depth.

As noted in the design criteria, the design flow depth cannot exceed 1-inch. Use the following equation to determine the flow depth.

$$y = \left[\frac{nQ}{1.49Ls^{0.5}} \right]^{0.6}$$

Where:

Q = Runoff treatment design flow

n = Manning's roughness coefficient from Table RT.02.1 below

y = design flow depth (not to exceed 1-inch)

L = width of the filter strip parallel to the pavement edge

s = slope of the filter strip parallel to the direction of flow

Table RT.02.1. Surface roughness/Manning's *n* for VFS design calculations.

Option	Soil and Vegetation Conditions	Manning's *n*
1	Fully compacted and hydroseeded	0.20
2	Compaction minimized and soils amended, hydroseeded	0.35
3	Compaction minimized, soils amended to a minimum 10% organic content (App. 5A-2), hydroseeded, grass maintained at 95% density and 4-inch length via mowing, periodic reseeding, possible landscaping with herbaceous shrubs	0.40*
4	Compost-amended filter strip: Compaction minimized, soils amended to a minimum 10% organic content (App. 5A-2), filter strip top-dressed with ≥3 inches vegetated compost or compost/mulch (seeded and/or landscaped)	0.55*

* These values were estimated using the SCS TR-55 Peak Discharge and Runoff Calculator at http://www.lmnoeng.com/Hydrology/hydrology.htm. This tool lists the Manning's *n* values for woods–light underbrush at 0.4 and woods–dense underbrush at 0.8. The intent of Option 3 is to amend the soils so that they have surface roughness characteristics equivalent to forested conditions with light underbrush. Option 4 adds a 3-inch top dressing of compost or compost/mulch to simulate a thick forest duff layer, which warrants a higher Manning's *n*, estimated at 0.55.

$$y = \left[\frac{(0.2)(0.7339)}{1.49(2000)(0.03)^{0.5}} \right]^{0.6} = 0.0075 \text{ feet}$$

The maximum allowable depth is ***1-inch or 0.083 feet****, so the depth is acceptable and will maintain sheet flow. If the depth exceeds 1-inch, either adjust the filter strip geometry or use another runoff treatment BMP.*

3. Calculate the design flow velocity passing through the filter strip at the runoff treatment design flow rate.

The design flow velocity is based on the runoff treatment design flow rate, the length of the filter strip and the design flow depth as shown below:

$$V = \frac{Q}{Ly}$$

Where:

V = design flow velocity (feet per second)

$$V = \frac{0.7339}{2000x0.0075} = 0.05\,\text{ft/s}$$

As noted in the Design Criteria, the maximum design velocity cannot exceed 0.50ft/s, therefore the design velocity for this filter strip is acceptable.

4. Calculate the filter strip width

The width of the filter strip is determined by the residence time of the flow through the filter strip. A 9-minute (540-second) residence time is used to calculate the filter strip width as shown below:

$$W = 540 \text{ x } V$$

Where:

W = filter strip length (feet)

T = time (seconds)

$$W = 540\text{x } 0.05 = 27 \text{ feet}$$

5. Flow Spreaders

Gravel flow spreaders should be installed between the pavement surface and the filter strip. Flow spreaders serve three important functions: pretreatment, maintain sheet flow, and promote infiltration of runoff. The flow spreaders described in this tutorial are gravel, for other flow spreaders (such as concrete sill, curb stop, or curb and gutter with saw teeth cut into it) designers should consult section 5-4.4.4 of the HRM. The following is a summary of RT 02 in the HRM.

- Gravel flow spreader should be a minimum of 1-foot wide by 1-foot deep and placed 1-inch below the surface of the contributing impervious area.
- Gravel flow spreaders should use gravel that meets the specifications for shoulder ballast listed in Section 9-03.9(2) of the WSDOT Standard Specifications (see Table RT.02.2).
- If there are concerns that water percolating into the gravel flow spreader and runoff may exfiltrate into the highway prism, an impervious geotextiles can be used to line the bottom of the flow spreader.

Table RT.02.2. Shoulder ballast specification for gravel flow spreaders.

Sieve Size	Percent Passing
2.5 inches	100
¾ inch	40–80
¼ inch	5 maximum
#100	0–2