# 8. Level Spreader - Vegetative Filter Strip System

**Description**

A level spreader - vegetative filter strip (LS-VFS) consists of a level spreader in series with a vegetative filter strip. A LS-VFS will typically be installed for one or more of the following purposes: to provide diffuse flow per a buffer rule, to meet stormwater rule provisions, or to provide pollutant removal. Design requirements for the system vary based on the regulatory requirements that apply and the type of ground cover in the VFS. A VFS will be placed into one of four categories: protected riparian buffer, wooded stormwater setback/buffer, herbaceous stormwater setback/buffer, or engineered filter strip. The VFS will usually be 30 feet in width except when the LS-VFS is being used to meet stormwater rule requirements in SA waters, in which case the VFS must be a minimum of 50 feet in width.

| **Regulatory Credits** * | | **Feasibility Considerations** | |
|---|---|---|---|
| *Pollutant Removal* | | | |
| 40% | Total Suspended Solids | Med | Land Requirement |
| 30% | Total Nitrogen | Low | Cost of Construction |
| 35% | Total Phosphorus | Low | Maintenance Burden |
| *Water Quantity* | | Low | Treatable Basin Size |
| some | Peak Attenuation | Med | Possible Site Constraints |
| no | Volume Capture | High | Community Acceptance |

* Pollutant removal credits are achieved when the VFS is an engineered filter strip.

**Advantages**

– Meets diffuse flow requirements under the buffer and stormwater programs.
– Can reduce particulate pollutants such as sediment, organic matter, and trace metals.
– Slows down the water and promotes infiltration.

**Disadvantages**

– Only receives credit for 40 percent TSS removal.
– Does not provide a significant amount of runoff storage to significantly reduce peak discharge.
– Typically functions as only a component in a stormwater management system.

### Major Design Elements

| **Required by the NC Administrative Rules of the Environmental Management Commission.** Other specifications may be necessary to meet the stated pollutant removal requirements. |
|---|
| 1. Sizing shall take into account all runoff at ultimate build-out, including off-site drainage. |
| 2. The BMP shall be located in a recorded drainage easement with a recorded access easement to a public ROW. |
| 3. A distribution device shall be used to provide even distribution of runoff across the BMP. |
| 4. When it is being used to meet Stormwater Rule requirements, the VFS shall have a longitudinal slope of five percent or less where practicable. |

**Major Design Elements (Continued)**

| **Required by DWQ policy.** These are based on available research, and represent what the DWQ considers necessary to achieve the stated pollutant removal efficiencies and other design objectives. |
|---|
| 5. The LS shall be constructed with a uniform slope of zero percent (or level). |
| 6. The LS must be constructed of concrete (or other permanently stable material), with a blind swale immediately upslope for stormwater distribution and aggregate stone not exceeding one inch in diameter immediately downslope for stormwater dissipation. |
| 7. The length of the LS-VFS shall be determined based on the flow rate that is directed to it. Please see Table 8-1 for details. |
| 8. The minimum length of a LS shall be 10 feet and the maximum length shall be 100 feet. |
| 9. The LS must be straight or convex. |
| 10. The minimum width of the VFS shall be 30 feet except when the LS-VFS is being used to meet stormwater rule requirements in SA waters, in which case the minimum width of the VFS shall be of 50 feet in width. Please see Table 8-1 for details. |
| 11. A flow bypass system shall be provided when the flow rates from a drainage area or a BMP exceed the capacity of the LS-VFS. Please see Table 8-1 for more details. |
| 12. When the LS-VFS is receiving flow directly from the drainage area, a forebay shall be provided. The forebay shall be designed so that its surface area is 0.2% of the contributing area's impervious surface. The recommended depth is three feet at the inlet of the forebay and sloping upward to one foot at the outlet (see Figure 8-3). The forebay can be omitted if the swale is lined with rip rap. |
| 13. When the LS-VFS is receiving flow from a BMP, an energy dissipation device shall be provided before the flow is directed to the LS. |
| 14. If the blind swale is lined with grass, then the stormwater shall be discharged parallel to the swale. If the blind swale is lined with rip rap, then there are no requirements for the entrance angle. |
| 15. If the slope in the VFS exceeds that given in Table 8-1, then a LS-VFS **may not be used** in that location. |
| 16. If a natural riparian buffer, herbaceous stormwater setback/buffer, or wooded stormwater setback/buffer contains draws or channels, then a LS-VFS **may not be used** in that location. |
| 17. For engineered filter strips, the filter strip and any adjacent cut slopes must be covered with at least 6 inches of loose topsoil with appropriate soil amendments and an appropriate turf grass species. The engineered filter strip must be constructed with a uniform transverse slope. |
| 18. In the VFS, the topsoil must be amended with lime and organic matter and an appropriate species of grass must be selected for the applicable climatic zone. |

**Note:** The 2H .1000 rules designate the length of the VFS as parallel to flow and the width as perpendicular to flow. However, the buffer rules designate the length of the VFS as perpendicular to flow and the width as parallel to flow. This manual observes the more prevalent buffer rule convention to avoid confusion.

## 8.1 General Characteristics and Purpose

As its name implies, a level spreader - vegetative filter strip (LS-VFS) consists of two primary components that are used together: a LS and a vegetative filter strip. Depending on the application of the LS-VFS, the design may also include a high flow bypass system, a forebay and an underdrain. See Figures 8-1, 8-2 and 8-3 for photos and diagrams of LS-VFS systems. The purpose of the LS-VFS is to disperse concentrated stormwater flows to achieve and maintain diffuse flow. "Diffuse flow" means the overland flow of water occurring in a disperse and non-erosive manner.

**Figure 8-1:**
Photos of a LS and a LS-VFS System

A LS (LS) is a poured concrete linear constructed with a uniform slope of zero percent. The length of the LS is based on the discharge rate of the stormwater that is directed to it, the purpose of the LS and the vegetation in the VFS (see Table 8-1). The LS does not remove a significant amount of pollutants by itself; however, it is an indispensible engineering device needed to bring about pollutant removal in the VFS. The minimum lengths per flow for the LS are based on achieving non-erosive velocities throughout the VFS and an overland flow depth of approximately 1.2 inches across the VFS.

A vegetative filter strip (VFS) is a vegetated area immediately down slope of the LS. The length of the LS-VFS is determined based on the flow rate directed to the system. The width of the VFS is either 30 or 50 feet based on the purpose of the system and the water quality classification of the receiving stream (see Table 8-1). The vegetation and soils in the VFS remove pollutants primarily via filtration and infiltration.

Other elements that may be part of the LS-VFS include a flow bypass system, a forebay and an underdrain. This chapter describes when these elements are needed and how they should be designed.

**Figure 8-2:**
Plan View of a LS with Engineered Filter Strip Adjacent to a Riparian Buffer
(from Winston and Hunt 2010)

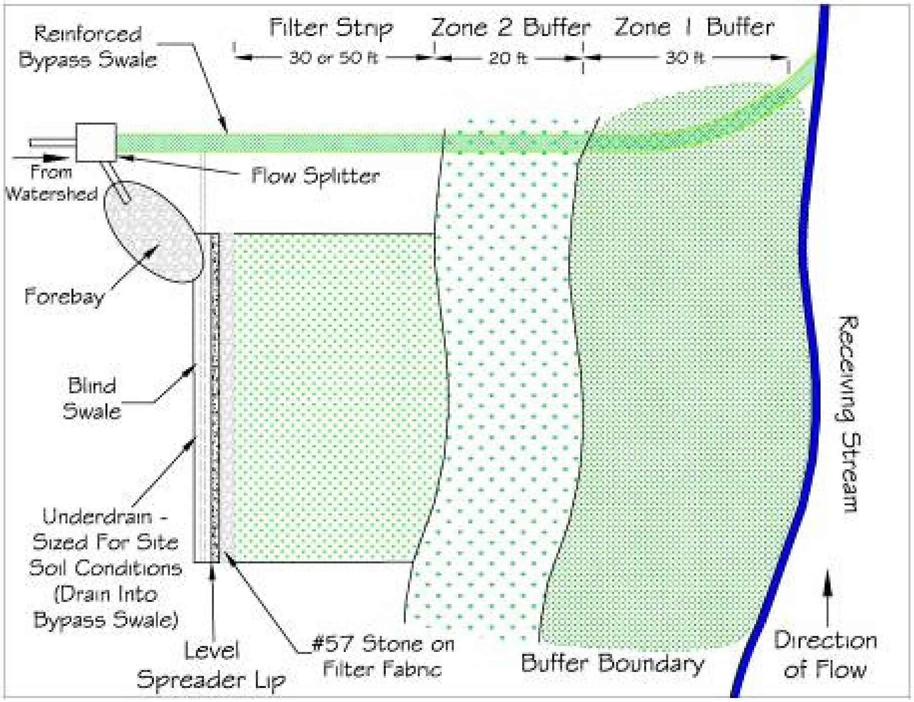



**Figure 8-3:**
Profile View of a LS-VFS with Engineered Filter Strip (from Winston and Hunt 2010)

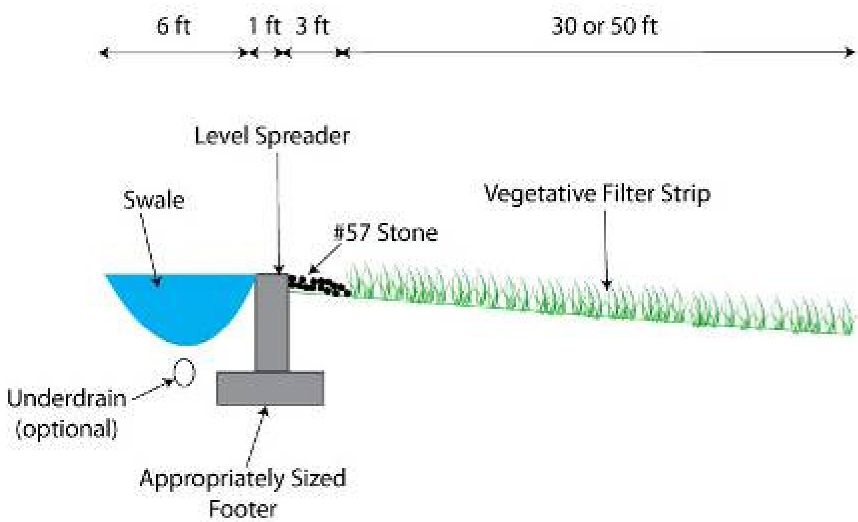


**Table 8-1:**
Summary of LS Purposes and Design Requirements

| Purpose | Receiving flow from | Type of VFS | Design flow (Bypass larger flows) | Criteria for sizing LS | Minimum width of VFS | Maximum slope of VFS |
|---|---|---|---|---|---|---|
| **Diffuse Flow per Buffer Rule**[1] | Drainage area | Protected riparian buffer | 1 in/hr storm (bypass larger flows) | 50 ft/cfs | 50 ft (entire riparian buffer) | 5% |
| | BMP | Protected riparian buffer | 10-yr storm discharge up to 2 cfs (bypass flows exceeding 2 cfs) | 50 ft/cfs | 50 ft (entire riparian buffer) | 5% |
| **SW Rule Provisions in. SL 2008-211 (Coastal Cos.) & 2H .1008**[2] | 85% TSS removal wet pond or a standard infiltration system | Wooded setback/ buffer/ filter strip | 10-yr storm discharge up to 2 cfs (bypass flows exceeding 2 cfs) | 50 ft/cfs | 30 ft in most watersheds 50 ft in SA waters | 5% |
| | | Herbaceous setback/ buffer/ filter strip | 10-yr storm discharge up to 5 cfs (bypass flows exceeding 5 cfs) | 20 ft/cfs | 30 ft in most watersheds 50 ft in SA waters | 8%[3] |
| | | Engineered filter strip | 10-yr storm discharge up to 10 cfs (bypass flows exceeding 10 cfs) | 10 ft/cfs | 30 ft in most watersheds 50 ft in SA waters | 8% |
| **Pollutant Removal** | Drainage area | Engineered filter strip | 1 in/hr storm (bypass larger flows) | 10 ft/cfs | 30 ft | 8% |
| | BMP | Engineered filter strip | 10-yr storm discharge up to 10 cfs (bypass flows exceeding 10 cfs) | 10 ft/cfs | 30 ft | 8% |

## Important Notes:

[1] If the slope in the riparian buffer exceeds 5% or the 1 in/hr storm from the drainage area exceeds 2 cfs, then an LS may not be used adjacent to the buffer. Instead of diffuse flow, a BMP that removes at least 30% TN and 30% TP must be provided. A BMP that removes 30% TN and 30% TP may discharge through the buffer with a buffer authorization from the DWQ 401 program.

[2] Wet detention ponds designed to remove 90% of TSS do not require the use of an LS-VFS per Chapter 10 of the BMP Manual. Infiltration basins designed per Section 16.3.9 do not require the use of an LS-VFS.

[3] If the herbaceous setback/buffer is located east of I-95 and the slope is less than 2%, then the LS lip may be sized based on the design standards for the engineered filter strip (10 ft/cfs).

**The three purposes of a LS-VFS listed in Table 8-1 are:**

1. Diffuse Flow per Buffer Rule: The "Diffuse Flow Requirement" in Item (5) of the buffer rules (Neuse, Tar-Pamlico, Randleman, Catawba and Jordan Lake) states that "concentrated runoff from new ditches or manmade conveyances shall be converted to diffuse flow before the runoff enters Zone 2 [the outer 20 feet] of the riparian buffer" and that "periodic corrective action to restore diffuse flow shall be taken if necessary to impede the formation of erosion gullies" (15A NCAC 2B .0200 rules).

   The LS-VFS is the approved technology for achieving diffuse flow. If the slopes in the buffer exceed five percent, then an LS-VFS may NOT be used. If the flow from the 1 inch/hour storm exceeds 2 cfs, then an LS-VFS may NOT be used. Instead, a BMP that removes at least 30% TN and 30% TP must be installed outside the buffer.

2. SW Rule Provisions: Stormwater rule 15A NCAC 2H .1008(c)(4) and Session Law 2008-211 (for Coastal Counties) require the use of a vegetative filter to handle the overflow of infiltration systems and the discharge from wet detention ponds. A "vegetative filter" is defined as "an area of natural or planted vegetation through which stormwater flows in a diffuse manner so that runoff does not become channelized and which provides for control of stormwater runoff through infiltration of runoff and filtering of pollutants" (15A NCAC 2H .1002(23).

   The slopes in a VFS that is used to meet stormwater rule provisions may NOT exceed five percent for wooded vegetation or eight percent for herbaceous vegetation. If the vegetated filter strip cannot be graded to an appropriate slope, then a BMP that does not require the use of an LS-VFS should be used.

3. Pollutant Removal: A LS-VFS does not remove a sufficient amount of TSS (40%) to be used as a stand-alone BMP. However, an LS-VFS that is designed for pollutant removal can be a useful component of s stormwater treatment train. In order to achieve pollutant removal, an engineered filter strip must be used.

**The four types of vegetated filter strips listed in Table 8-1 are:**

1. Protected Riparian Buffer: The LS-VFS must be designed based on wooded vegetation because the undisturbed buffer will eventually succeed to woods. This type of ground cover requires the longest LS lengths because it is most susceptible to erosion.

2. Wooded Stormwater Setback/Buffer/Filter Strip: The filter strip shall be considered to be wooded if 50 percent or more of the ground is covered by the drip zone of trees (when they are in leaf). A long LS is required upslope of wooded areas to avoid erosion through the filter strip.

3. Herbaceous Stormwater Setback/Buffer/Filter Strip: The filter strip shall be considered to be herbaceous if it consists primarily of herbaceous species, with less than 50 percent of the ground covered by the drip zone of trees. An ungraded,

grassed area is also considered to be herbaceous. If the herbaceous setback/buffer is located east of I-95 and the slope is less than 2%, then the designer may use the less conservative design standards for the engineered filter strip.

4. Engineered Filter Strip: An engineered filter strip must be carefully designed to promote infiltration and prevent erosion, which can be a significant source of sediment pollution to the receiving stream. This is achieved by grading the filter strip at a shallow, uniform transverse slope. Then, the filter strip must be covered with six inches of topsoil and sodded with an appropriate grass species. This type of filter strip is the least susceptible to erosion and therefore requires the shortest LS lengths. This chapter includes design standards for engineered filter strips.

## 8.2 Meeting Regulatory Requirements

Every LS-VFS must meet the major common design requirements presented on the first two pages of this chapter. Table 8-1 describes additional design requirements for LS-VFS that vary based on whether the system stands alone or is used with a BMP and the purpose of the system (diffuse flow, pollutant removal or at the bypass from an infiltration system/outlet of a wet detention pond).

*Pollutant Removal Calculations*

The pollutant removal credits for a LS-VFS that is designed in accordance with the standards for pollutant removal (LS length of 10 ft/cfs, 50-foot wide VFS, maximum slope of 8 percent) are:
- 40 percent for total suspended solids (TSS)
- 30 percent for total nitrogen (TN)
- 35 percent for total phosphorus (TP)

*Volume Control Calculations*

A LS-VFS does not have the capability for stormwater detention; however, it does provide some volume control for smaller storms via infiltration in the VFS.

## 8.3 Design

### 8.3.1. Siting Issues

Required distances for the LS-VFS from surface waters depend on the applicable rules:
- The entire LS must be placed outside of riparian buffers and stormwater setbacks.
- An engineered filter strip may not be placed within either zone of a riparian buffer. However, it may be placed within a stormwater setback/buffer.
- If a riparian buffer or stormwater setback/buffer exceeds the allowable slope (five or eight percent depending on the vegetation) then an LS may not be used.
- Wetlands will be allowed within the VFS only on a case-by-case basis.

Please refer to the figures below for graphical depictions of LS-VFS siting requirements.

**Figure 8-4:**
Siting for LS with a Riparian Buffer VFS (Winston 2010)

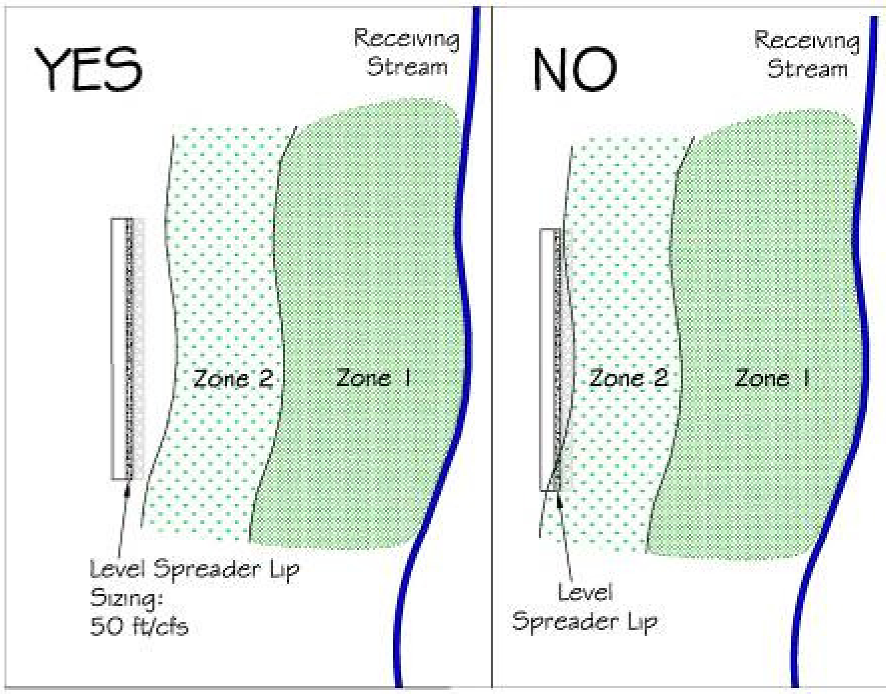



**Figure 8-5:**
Siting for LS-Engineered Filter Strip Adjacent to a Riparian Buffer (Winston 2010)

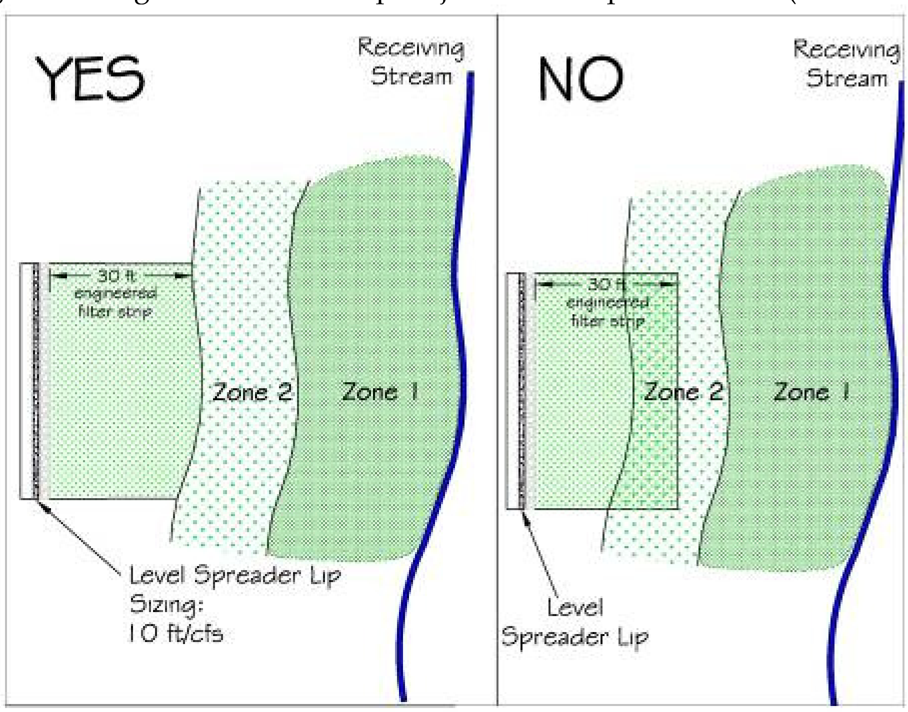
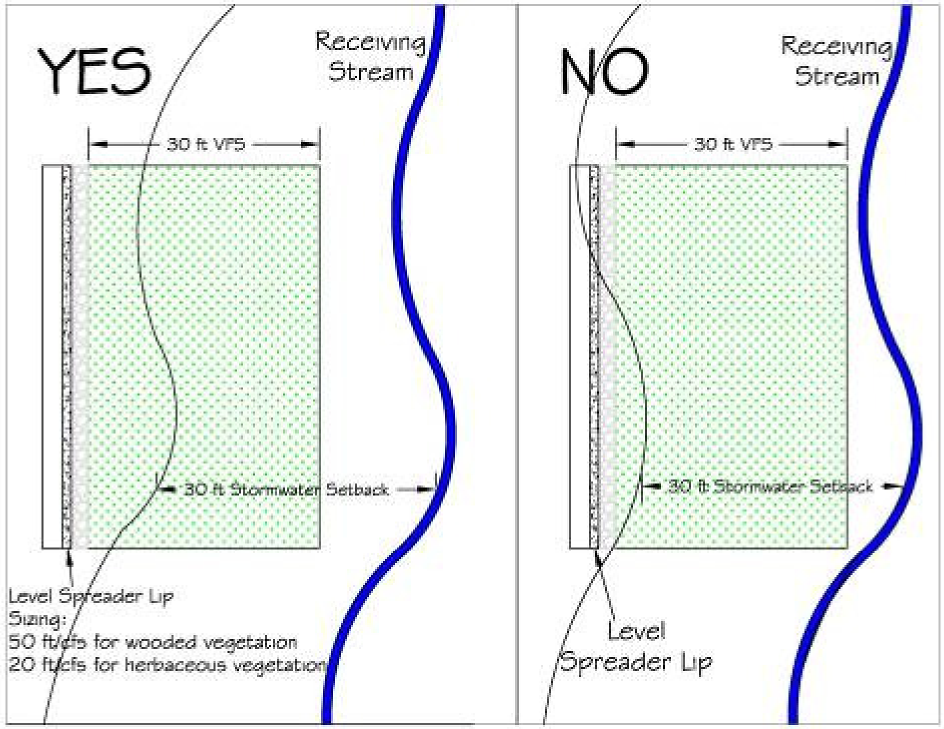


**Figure 8-6:**
Siting for LS with a Stormwater Setback VFS (Winston 2010)




## 8.3.2. Contributing Drainage Basin

As explained previously, a LS-VFS can receive stormwater directly from the drainage area or be placed down slope of another BMP. The size of the contributing drainage area will vary based on the application of the LS-VFS:

1. Diffuse Flow per Buffer Rule: The maximum flow that can be handled by an LS installed adjacent to a riparian buffer is 2 cfs. If stormwater is discharged directly from the drainage area that exceeds 2 cfs during the 1 inch/hour storm, then a LS may not be used. Instead, a BMP that removes at least 30% TN and 30% TP must be installed outside the buffer. If stormwater is discharged from a BMP, then the first 2 cfs of the 10-year storm outflow from the BMP should be directed to the LS and the rest should be bypassed to the stream.

2. SW Rule Provisions: A LS-VFS that is installed to meet the requirements of stormwater rules will always receive flow from a BMP. Only the appropriate flow should be discharged to the VFS, the rest must be bypassed. The maximum flow depends on the vegetation in the VFS as follows:
   - Wooded or Riparian Buffer: 2 cfs
   - Herbaceous: 5 cfs
   - Engineered: 10 cfs

3. Pollutant Removal: A LS-VFS system designed for pollutant removal will always have an engineered VFS. Up to 10 cfs can be directed to the LS-VFS and the flows exceeding 10 cfs must be bypassed..

### 8.3.3. High Flow Bypass System

Any flows exceeding the capacity of the VFS must be bypassed through the use of a flow splitter device. See Section 5.3 for more information on designing flow splitters.

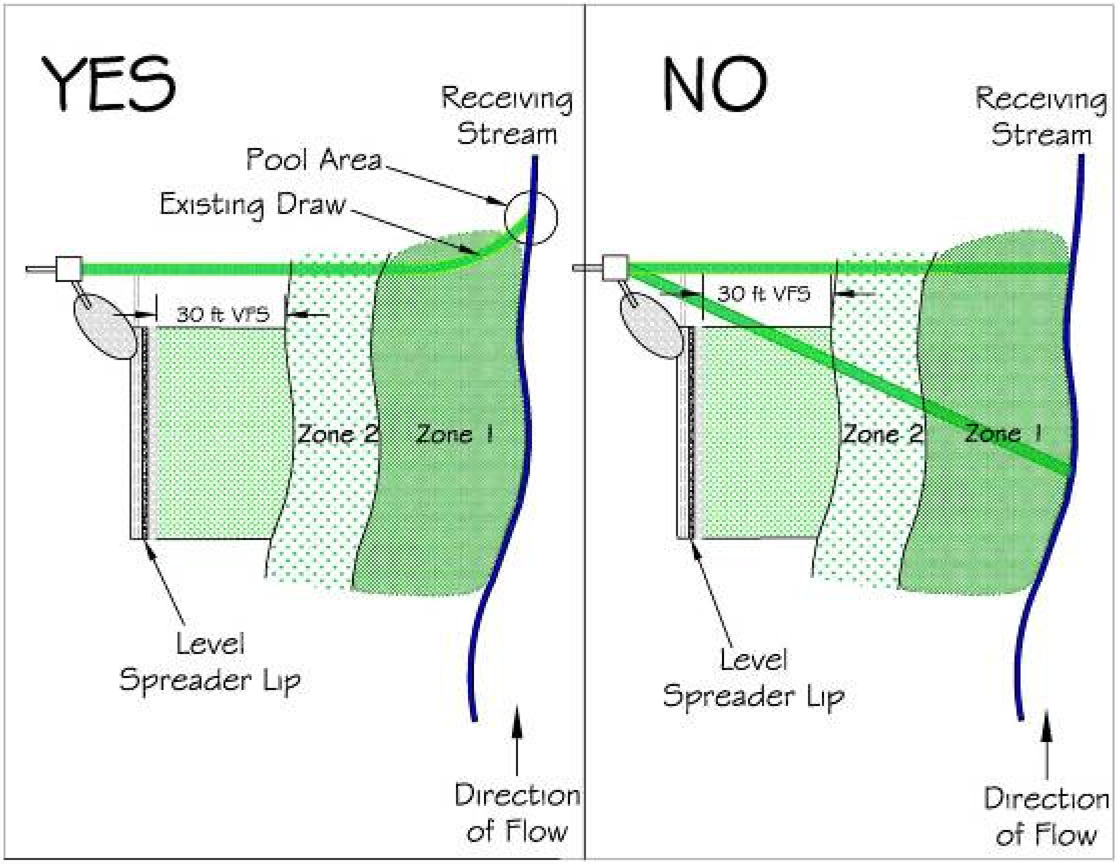
This bypass channel must convey excess flow from the flow splitter to the stream without causing erosion to either the channel itself or to the stream. One option for bypassing flows is to convey the high flows to an existing drainage ditch located near the LS-VFS. Channel calculations should be performed to determine whether rip rap is needed to stabilize the drainage ditch. Another option is to grade a bypass channel to the stream. In either scenario, the designer should compute the flow velocity in the channel and provide appropriate reinforcement if needed. Turf reinforcement is preferred where velocities and erosive forces are not excessive (as on mild slopes) and where sufficient light is available to support turf. However, often these conditions will not exist within a riparian buffer and rip rap will be necessary.

Another option is to use a bypass pipe instead of a bypass channel. This option will eliminate the concern about erosion within the bypass channel.

The outlet of the bypass channel or pipe must be designed to reduce the impacts to the receiving stream. The bypass channel must enter the stream at an angle rather than in a perpendicular manner. Perpendicular entry points are likely to cause erosion on the opposite stream bank. The bypass channel should discharge into a pool (deep section) of the stream. At the point of entry, stream banks may need to be protected with riprap or other engineered solution. If a bypass pipe is being used, it can be discharged to a culvert rather than directly to the stream to minimize erosion issues.

On the "YES" side of Figure 8-7, the bypass channel discharges to a pool section of the stream and the discharge occurs at an angle. This will reduce erosion at the discharge point. It may be necessary to provide some riprap. Please note that bypass channels through protected riparian buffers will require a buffer authorization from the DWQ 401 Permitting Unit. On the "NO" side, both of the bypass channels are poorly designed. One option enters the stream at a right angle, which may cause erosion to the opposite stream bank. In the other option, the bypass channel cuts through the VFS, creating channelized flow and reducing the effectiveness of the VFS.

**Figure 8-7:**
Bypass Channel Design (Winston 2010)



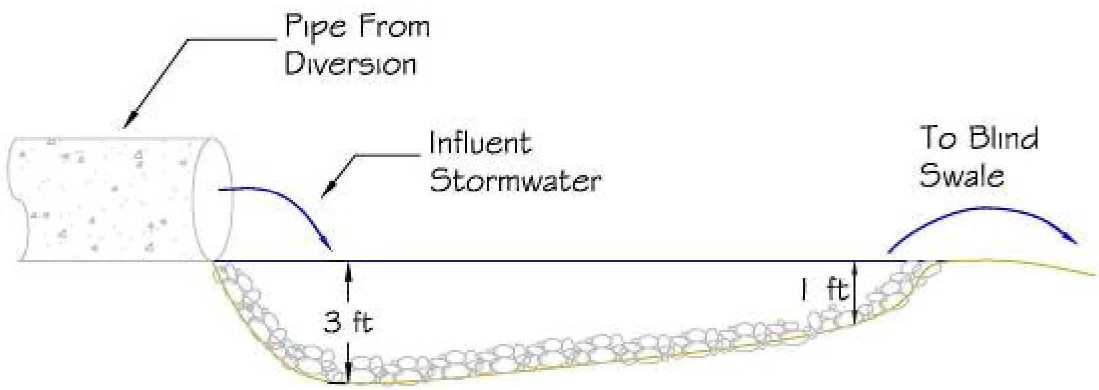

## 8.3.4. Forebay

After passing through the flow bypass system, stormwater should be directed to a forebay (unless the LS-VFS is receiving flow from another BMP, in which case a forebay may not be necessary). The forebay is an excavated, bowl-shaped feature that slows the stormwater and allows sediment and debris to settle out. It is typically lined with Class B riprap.

It is recommended that the forebay be designed so that its surface area is 0.2% of the contributing area's impervious surface. The recommended depth is three feet where the stormwater enters the forebay with the depth sloping up to one foot where the stormwater leaves the forebay. This design promotes settling of sediment and flow dissipation. Figure 8-7 shows a schematic of a forebay specifically designed for use with a LS.

If the entire blind swale is lined with rip rap, then a forebay is not required. This option may be more cost-effective for relatively short level spreaders.

**Figure 8-8:**
**S**chematic of a Forebay for Use with a Level Spreader (Hathaway and Hunt 2006)




### 8.3.5. The Blind Swale

Immediately upslope of the LS, stormwater is discharged into a "blind swale" (the term "blind" is used because the swale terminates at either end). Within the blind swale, water rises and falls evenly over the lip of the LS, which distributes the flow evenly over its length. Whenever practical, stormwater should be conveyed to the blind swale parallel to the LS to avoid short-circuiting the LS.

*Credit: Jessica Bolin, Town of Apex*

**Figure 8-9:** Poor Entrance Angle to a Blind Swale

This photo shows a LS receiving concentrated flow from a pipe, and dispersing it across its length. However, if this pipe were flowing closer to capacity, water would easily overtop the LS prior to flow being spread across its length. Also, a larger forebay than that shown is needed to still flow before it enters the blind swale.

*Credit: Ryan Winston, NCSU*

**Figure 8-10:** Appropriate Entrance Angle to a Blind Swale

Ideally, the designer should force flow to enter the blind swale parallel to the LS to provide the best chance for diffuse flow as shown.

The blind swale will most commonly be constructed from earth and will be covered with turf or possibly lined with rip rap. If the LS-VFS is being installed in soils with a low infiltration rate (less than 2 in/hr), then an underdrain should be provided. The underdrain will drain the blind swale between storms to provide capacity for the next storm, prevent turf from dying and avoid mosquito risk. The underdrain should discharge into the bypass channel.

Another option is to construct the blind swale as a linear wetland. This option is especially useful in areas with Triassic Basin soils that have extremely low infiltration rates that are not conducive to proper functioning of an underdrain.

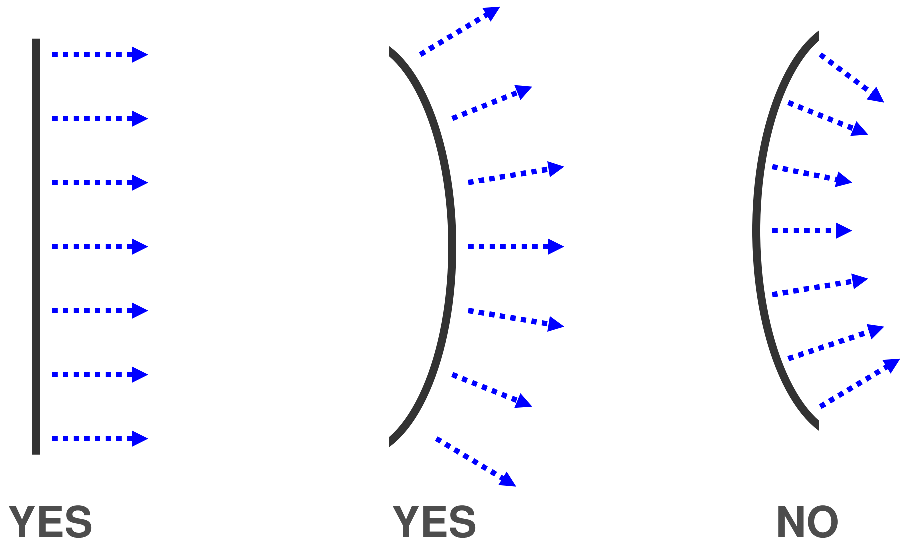
### 8.3.6. Level Spreader

The LS consists of a poured concrete weir. Level spreaders may not be constructed from lumber, PVC pipe or earth. The lip of the LS should be 3 inches higher than the existing ground (downslope side) and anchored into the soil with an appropriately-sized concrete footer. Earthen or concrete berms may be placed at each end of the LS to prevent bypass of runoff.

Immediately downslope of the LS, there should be a three-foot wide area for flow dissipation. The DWQ recommends this area be covered with a geotextile fabric that is overlain with a 3-4 inch layer of aggregate stone (with average diameter not exceeding one inch). The geotextile fabric should be selected based on the soil type (sand, silt or clay).

The LS must be straight or convex in plan view. Level spreaders may not be concave in plan view because this concentrates flow downslope of the LS. This is illustrated in Figure 8-10 below. To minimize the grading needed to install the LS, it should be sited such that it is approximately parallel to contour lines.

**Figure 8-11:**
Level Spreader Configurations




The LS length must comply with the standards in Table 8-1 depending on the purpose of the LS-VFS and the type of vegetation in the VFS.

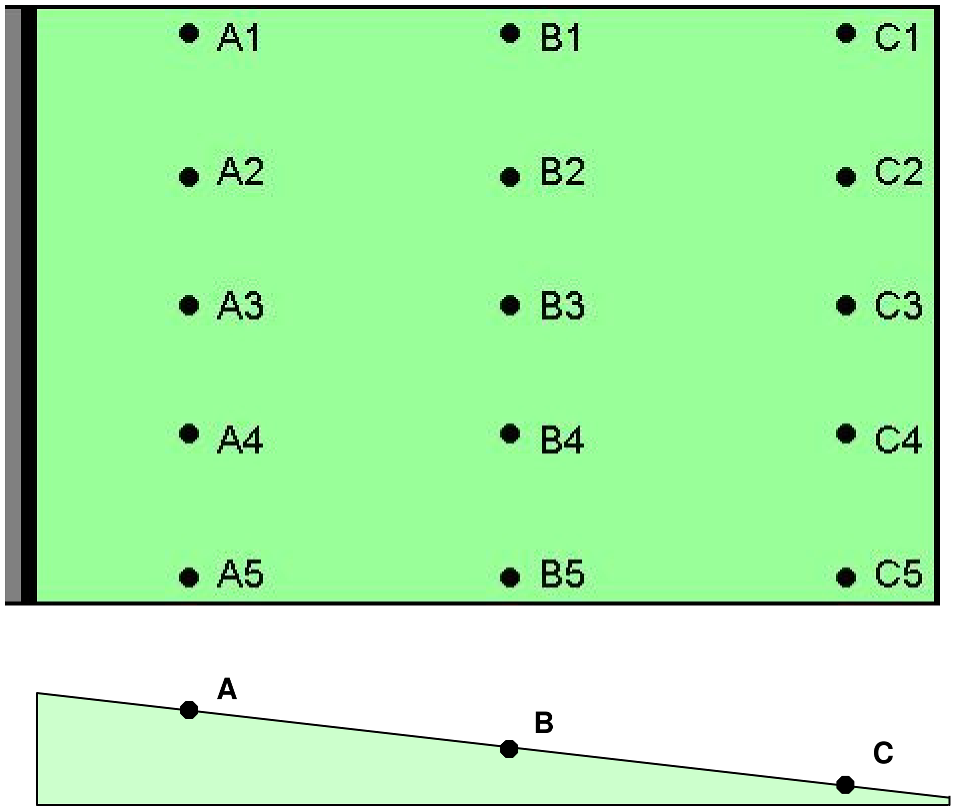
### 8.3.7. Vegetative Filter Strip

If the VFS is an existing riparian buffer, herbaceous setback/buffer or wooded setback/buffer, then an engineered design is not required for the VFS. However, it is crucial that the slope and vegetation of the proposed VFS be surveyed in the field to ensure that slopes comply with those given in Table 8-1. Also, a natural buffer or setback should not be used as a VFS if any natural draws or channels are present. If the setback is herbaceous in nature but does not contain a thick stand of vegetation, then additional plantings should be added to stabilize the ground surface. A list of suggested plant species can be found in the *Ecosystem Enhancement Program's Guidelines for Riparian Buffer Restoration*, available at on the DWQ web site.

If the VFS is an engineered filter strip, then it will be required to be graded so that it has a uniform slope of less than eight percent slope (in accordance with NCSU's design protocol). Filter strips that are located down slope of BMPs are required to have a uniform slope of less than five percent (in accordance with state stormwater rules).

A VFS with uniform slope will have equal elevations at A1, A2, A3, A4 and A5. In addition, the elevations at B1-B5 will be equal and the elevations at C1-C5 will be equal. Furthermore, the slope between the LS and the end of the filter strip will be uniform and constant. Any cut slopes that are created by the grading may not exceed 3:1 and 4:1 is preferred. All grading must be clearly depicted on plan sheets that tie proposed topographical contours with existing ones.

**Figure 8-12:**
VFS with Uniform Slope (Plan and Profile Views)




For an effective VFS, it is essential to prepare the soils properly and plant and maintain a dense, vigorous stand of turf. The side slopes created by any grading should receive the same attention to soils and vegetation as the VFS.

At a minimum, the VFS and any side slopes should be covered with six inches of topsoil. It can be stockpiled topsoil, imported topsoil or a combination of the two. The soil can be tested and amended accordingly or the general amendment requirements given below can be followed. If possible, mix 1 to 2 cubic yards of peat moss or compost per 1,000 sq ft into the topsoil to increase soil fertility. In addition, a one-time fertilizer application to the topsoil should be specified. See Table 8-4 for guidance on the start-up fertilization of VFS topsoil.

**Table 8-4:**
Start-up Fertilizer Application to the Engineered Filter Strip Topsoil
(from NCSU Cooperative Extension Service 2008)

| If Obtaining a Soil Test | If No Soil Test is Obtained |
|---|---|
| Send approximately 1 cup of the air-dried soil sample to the NCDA & CS Agronomic Division Soil Testing Services, 1040 Mail Service Center, Raleigh NC 27607. Boxes and forms can be obtained at your county Cooperative Extension center or at the Agronomic Division office in Raleigh. Allow several weeks for the results to be returned.<br><br>Apply the amount of lime and fertilizer recommended for your soil by the soil testing laboratory. For additional information about interpreting a soil test, visit this Web site: http://www.ncagr.com/agronomi/uyrst.htm | Apply the following for grasses other than centipede[1]:<br>• 75 lbs of ground limestone per 1,000 sq ft.<br>• A starter type fertilizer (one that is high in phosphorus) based on the type of grass and the planting method. Fertilizer bags have a three-number system indicating the primary nutrients, such as 8-8-8 or 5-10-10. These numbers denote the N-P-K ratio—the percentage of each nutrient in a fertilizer. The percentages are noted in the following order:<br>N Nitrogen for green color and growth.<br>$P_2O_5$ Phosphorus for good rooting.<br>$K_2O$ Potassium to enhance pest and environmental stress tolerance.<br><br>Common examples of starter fertilizers required for a 1,000 sq ft area include 40 lbs of 5-10-10, 20 lbs of 10-20-20, or 16 lbs of 18-24-6. For sandy soils, typical to the Coastal Plain and Sandhills, fertilizer rates should be increased by 20 percent. |

[1] For centipede grass, apply ½ lb of nitrogen per 1,000 square feet. Too much fertilizer will kill centipede.

Non-clumping, native, deep-rooted grasses, such as Blue Grass or Bermuda, should be specified in VFS design. Recommended grasses for the Mountains, Piedmont, and Coastal Plain are identified in Table 8-5. These grasses should require little maintenance. Sod grown in non-clayey soils or washed sod should be specified in the VFS. It is crucial to specify frequent watering for the first three weeks of sod installation so that the first 1.5 inches of soil is kept moist.

**Table 8-5:**
Appropriate Grasses for Engineered Filter Strips by Region (Winston and Hunt 2009)

| Region | Appropriate Grasses |
|---|---|
| Mountains | Blue Grass, Tall Fescue |
| Piedmont | Tall Fescue, Common Bermuda |
| Coastal Plain | Centipede, Common Bermuda |

## 8.4 Construction

Immediately before the LS is constructed, the designer should verify that proposed ground contours are approximately parallel to the LS location called for in the plans. If not, the LS should be re-oriented to minimize grading. The designer should also verify in the field that the appropriate width (30 or 50 feet) is available for the VFS and that the LS-VFS is fully 50 feet away from the stream if an Engineered Filter Strip is being installed in an area covered by a buffer rule.

During the pre-construction site visit, the designer should also verify that the VFS does not include any unaccounted for wetland areas. Wetland areas may not be graded without an appropriate permit. If the VFS is intended to include a wetland, then the designer should verify that 0.5 to 5.0 percent slopes and a dense stand of primarily herbaceous vegetation is present. If not, the location of the LS-VFS should be relocated to an area that can be graded and vegetated appropriately.

Proper construction sequencing will ensure that the LS-VFS is functioning as designed to improve water quality. The LS-VFS must be protected from sediment and stormwater flows during construction. A temporary stormwater diversion will likely be necessary until the drainage area and the LS-VFS have fully stabilized.

The remainder of this section has been excerpted from Winston and Hunt 2009.

Grading of the Engineered Filter Strip (if required) should be the first step in the construction sequence. Grade the site to the design slope using a box blade or similar equipment. Care should be taken to avoid driving heavy equipment through the Engineered Filter Strip to prevent compaction. After the Engineered Filter Strip is graded, then proceed with constructing the blind swale and LS as shown in Figures 8-13 through 8-17 below.

*Credit: Ryan Winston, NCSU*

**Figure 8-13:** Excavating the Blind Swale

The blind swale and LS should be constructed next. Using a small excavator (or back hoe), dig a rectangular hole large enough for the "blind" swale and LS. It should nominally be dug to a depth of 1 ft, or the design depth of the LS.

Credit: *Ryan Winston, NCSU*

**Figure 8-14:** Construction of Forms for the LS

The LS should be constructed on undisturbed soil whenever possible. If the use of fill is unavoidable, compact the soil to 95% of standard proctor test prior to construction. A LS to date is more easily cast in place rather than pre-cast (although pre-cast options may become more commonly used). If cast in place, forms will be built for the LS. ***It is critical that the top of the forms are level.***

*Credit: Ryan Winston, NCSU*

**Figure 8-15:** Side View of Forms for the LS

The LS should be placed at the far downslope end of the excavated area, and the forms should be approximately 3" higher than the soil downslope to allow for diffuse flow to occur.

*Credit: Ryan Winston, NCSU*

**Figure 8-16:** Pouring Concrete for the LS

Concrete is poured to the top of the forms. Depending on the length of the LS, this can be done by mixing concrete onsite or by having concrete delivered. Once the concrete is poured, ensure that the top surface of the concrete is level by using a wooden dowel (or similar) to screed excess concrete from above the top of the forms.

*Credit: Ryan Winston, NCSU*

**Figure 8-17:** LS and Blind Swale Post-Construction

Concrete should be allowed to set overnight. The wooden forms can then be removed to reveal the finished LS. If the underlying soil is poorly drained, install an underdrain upslope of the LS to drain the blind swale. Place soil around the LS, and sod the swale. Sod is strongly preferred for the blind swale. In urban applications, the blind swale may be concrete. An advantage of a concrete channel is the relative ease in accumulated debris removal (maintenance).

Following construction of the LS and blind swale, the forebay should be constructed using a small excavator. The forebay should be lined with riprap to dissipate flows and protect against erosion. Consider placing an underdrain under the forebay if the underlying soils are high in clay or silt content. Construct an overflow swale adjoining the VFS using a small excavator. Sod should be used to vegetate the swale if low velocities and high sunlight are expected. If stormwater is expected to reach highly erosive velocities or if sunlight penetration is not expected, class B rip-rap should be used to line the swale. A diversion box may then be installed. This structure should be installed at the outlet of the watershed, to split flow between the forebay and the overflow swale as determined by the engineering designs.

Engineered Filter Strip soils must be left "loose" – this can be achieved by raking, tilling or using a field cultivator. After the VFS soils have been loosened, six inches of topsoil should be added to the VFS and any adjacent side slopes created by grading. The topsoil can be obtained from a stockpile, off-site area or a combination of the two. Based on the soil test report recommendations or the fertilization guidelines in Section 8.3.6, incorporate lime and fertilizer into the topsoil using a disk or rototiller. Regardless of the region, a deeper root system is able to extract more moisture and nutrients from the soil, improving drought tolerance and overall health of the plant.

An appropriate species of grass should be planted at the correct planting time per Section 8.3.6. Before planting, water the area to enhance settling. Fill areas that settle unevenly to avoid standing water.

Follow these steps to install the sod in an Engineered Filter Strip (NCSU Cooperative Extension Service 2008):

1. Make sure the soil is moist (but not overly wet) before laying sod. Irrigating the soil several days before delivery is often adequate.
2. Install the sod within 24 hours of delivery. Plan to unstack and unroll the sod if it cannot be laid within 48 hours.
3. While installing, keep sod in the shade to lessen the chance of heat buildup.
4. Start sodding from a straight edge (driveway or sidewalk), and butt strips together, staggering them in a bricklike pattern (See Figure 5).
5. Avoid stretching sod. Use a knife or sharp spade for trimming to fit irregularly shaped areas.
6. Lay sod lengthwise across the face of slopes, and peg or stake the pieces to prevent slippage.
7. After the sod has been placed, roll the lawn to ensure good sod-to-soil contact. Then begin watering.

For a complete list of North Carolina sod producers and the varieties they carry, visit the North Carolina Sod Producers Association Web site: http://www.ncsod.org. Again, to ensure high quality and better chance for success, it is highly recommended that certified sod be used. A list of producers growing certified sod can be found on the NCCIA Web site: http://www.nccia.ncsu.edu/.

After the sod is planted, keep the top 1.5 inches of the soil moist. This may require light watering several times a week for 7 to 21 days.

## 8.5 Maintenance

### 8.5.1. Common Maintenance Issues

A LS-VFS that is not maintained properly may become a source of pollution rather than a pollutant removal mechanism. During the first two years after construction, LS-VFS should be inspected after every moderate to major storm event for proper distribution of flows and signs of erosion. After the first two years, the LS-VFS may be inspected quarterly. If evidence of erosion exists, the eroded areas should be filled in and reseeded. The cause of the erosion should then be determined and eliminated.

Maintenance of an Engineered Filter Strip involves routine mowing and replanting grass when necessary. Strips that receive excessive sediment may require periodic regrading and reseeding of their upslope edge because deposited sediment can kill grass and prevent the LS-VFS from achieving diffuse flow.

Figures 8-18 through 8-21 below show a number of common maintenance issues with LS-VFS systems.

**Figure 8-18:** Clogged Forebay

The job of a forebay is to collect leaves, trash and sediment before stormwater is discharged to the blind swale. Therefore, this is the part of the LS-VFS that needs the most frequent maintenance. The forebay must be checked frequently and will need to be cleaned out throughout the year, particularly in the fall.

**Figure 8-19:** Unmaintained Blind Swale

In case you can't see the LS, it is immediately to the left of the yellow line. The vegetation in the blind swale has become overgrown and taken up nearly all the capacity of the blind swale. The blind swale was likely undersized in its design.

**Figure 8-20:** Unmown VFS

During the mowing season, the VFS should be mowed at least every other week. The mowing allows an opportunity for the VFS to be inspected and also helps to prevent clumping of grass.

**Figure 8-20:** Looking Upslope at the Same VFS

This is a view upslope of the same VFS shown in Figure 8-19. The clumping of the unmown grasses and resulting channelization of flow is evident from this view.

**Figure 8-21:** Erosion in the VFS

The eroding areas in this VFS need to be filled in and revegetated before the problem becomes worse.

### 8.5.2. Sample Operation and Maintenance Provisions

Important maintenance procedures:

- Immediately after the Engineered Filter Strip is established, grass will be watered twice weekly if needed until the plants become established (commonly six weeks).
- Once a year, the Engineered Filter Strip will be reseeded to maintain a dense growth of vegetation
- Stable groundcover will be maintained in the drainage area to reduce the sediment load to the vegetation.
- Every two weeks during the growing season, the Engineered Filter Strip will be mowed. Turf grass should not be cut shorter than 3 to 5 inches and may be allowed to grow as tall as 12 inches depending on aesthetic requirements (NIPC, 1993). Forested filter strips do not require this type of maintenance.
- Once a year, the soil will be aerated if necessary.
- Once a year, soil pH will be tested and lime will be added if necessary.

For the first two years after the LS-VFS is established, it will be inspected **quarterly and within 24 hours after every storm event greater than 1.0 inch (or 1.5 inches if in a Coastal County)**. After two years of successful performance, the LS-VFS will be inspected quarterly. Records of operation and maintenance will be kept in a known set location and will be available upon request.

If the soil in the Engineered Filter Strip becomes compacted, consider coring to alleviate this condition. Use a device that removes soil cores. Coring should be accomplished when the lawn is actively growing so that it can recover from any injury. Core cool-season grasses in fall or early spring. Core warm-season grasses in late spring or early summer. Some lawn care and landscape companies offer coring service if rental equipment is not available.

Inspection activities shall be performed as follows. Any problems that are found shall be repaired immediately.

**Table 8-6:**
Sample Operation and Maintenance Provisions for LS-VFS

| BMP element: | Potential problem: | How to remediate the problem: |
|---|---|---|
| **The entire LS-VFS system** | Trash/debris is present. | Remove the trash/debris. |
| **The flow splitter device (if applicable)** | The flow splitter device is clogged. | Unclog the conveyance and dispose of any sediment off-site. |
| | The flow splitter device is damaged. | Make any necessary repairs or replace if damage is too large for repair. |
| **The blind swale** | The swale is clogged with sediment. | Remove the sediment and dispose of it off-site. |
| **The LS** | The swale is overgrown with vegetation. | Mow vegetation. Re-grade and vegetate if the swale has become silted in. |
| | The level lip is cracked, settled, undercut, eroded or otherwise damaged. | Repair or replace lip. |
| | There is erosion around the end of the level spreader that shows stormwater has bypassed it. | Regrade the soil to create a berm that is higher than the level lip, and then plant a ground cover and water until it is established. Provide lime and a one-time fertilizer application. |
| | Trees or shrubs have begun to grow on the swale or just downslope of the level lip. | Remove them. |
| **The bypass channel** | Areas of bare soil and/or erosive gullies have formed. | Regrade the soil if necessary to remove the gully, and then reestablish proper erosion control. |
| | Turf reinforcement is | Study the site to see if a larger |

| | | |
|---|---|---|
| | damaged or ripap is rolling downhill. | bypass channel is needed (enlarge if necessary). After this, reestablish the erosion control material. |
| **The VFS/Engineered Filter Strip** | Grass is too short or too long (if applicable). | Maintain grass at a height of approximately three to six inches. |
| | Areas of bare soil and/or erosive gullies have formed. | Regrade the soil if necessary to remove the gully, and then plant a ground cover and water until it is established. Provide lime and a one-time fertilizer application. |
| | Sediment is building up on the filter strip. | Remove the sediment and restabilize the soil with vegetation if necessary. Provide lime and a one-time fertilizer application. |
| | Grass is dead, diseased or dying. | Determine the source of the problem: soils, hydrology, disease, etc. Remedy the problem and replace plants. Provide a one-time fertilizer application. |
| | Nuisance vegetation is choking out grass. | Remove vegetation by hand if possible. If pesticide is used, do not allow it to get into the receiving water. |
| **The receiving water** | Erosion or other signs of damage have occurred at the outlet. | Contact the NC Division of Water Quality local Regional Office, or the 401 Oversight Unit at 919-733-1786. |

<u>September 28, 2007 Changes:</u>

1. Major Design Elements:
   i. Reformatted to include numbered requirements.
   ii. Specified concrete for the level spreader material.
2. 13.1: The Administrative Code refers to "vegetative filters", but they are commonly referred to as "filter strips" in practice. Added the following statement for clarification, "Filter strips are often referred to as vegetative filters."
3. 13.3.5: Clarified requirements for filter strips following wet ponds that are designed for 85% and 90% TSS removal. Requirement now reads, "…the discharge of a wet detention basin must flow through a companion VFS for ponds designed to treat 85% TSS. Ponds designed to treat 90% do not require a level spreader/filter strip."
4. Figure 13-1: Altered for clarification.
5. Figure 13-2: Altered for clarification.

<u>May 20, 2009 Changes:</u>

1. Various terminology and clarification changes made throughout the chapter.

<u>March 9, 2010 Changes:</u>

A complete re-write of the entire chapter was done. Main changes include:

1. The Level Spreader and Vegetative Filter Strip Chapters were combined to reflect that these two devices should be used together as two indispensible parts of a single system.

2. The types of VFS were categorized as follows: Riparian Buffer, Wooded Stormwater Buffer/Setback, Herbaceous Stormwater Buffer/Setback, and Engineered Filter Strip.
3. The regulatory credits awarded to LS-VFS have been increased based on recent research done by NCSU. The VFS now must be an Engineered Filter Strip in order for the system to be awarded pollutant removal credit.
4. A definition of "diffuse flow" was added.
5. The term "blind swale" has been coined to describe the swale immediately upslope of the level lip.
6. A requirement to include an underdrain beneath the blind swale in clayey soils has been added. This increases capacity of the swale, protects the swale vegetation and reduces the mosquito risk.
7. The length requirement for the LS has been modified based on hydraulic calculations associated with the various ground covers.
8. LS length and slope requirements have been tiered based on the vegetation in the VFS.
9. The maximum LS length has been reduced from 130 to 100 feet to reduce the chance of an unlevel LS lip. The minimum length has been reduced from 13 to 10 feet.
10. LS are no longer allowed to be "concave" because of the tendency of this design to concentrate flow.
11. A requirement for a bypass around the level lip downslope of BMPs that discharge more than the allowable flow based on the vegetation in the VFS during the 10-year storm has been added.
12. A new requirement to discharge to the blind swale in a manner parallel with the LS has been added.
13. A requirement for uniform transverse slope has been added.
14. For the Engineered Filter Strip, a requirement to cover the VFS and adjacent cut slopes with six inches of topsoil before vegetating has been added. A requirement to amend this topsoil appropriately has also been added.
15. Scour holes are no longer allowed on shallow slopes as a means of achieving diffuse flow.
16. Many photos and diagrams have been added to assist in understanding this device.
17. The construction and maintenance section has been enhanced.