C-9. Level Spreader-Filter Strip (LS-FS)

Design Objective

Aa level spreader-filter strip (LS-FS) consists of an LS that is typically a poured concrete lip and a FS that is graded and grassed that filter and infiltrate stormwater. The LS does not remove pollutants by itself; however, it is an indispensable device needed to bring about pollutant removal in the FS. The vegetation and soils in the FS remove pollutants primarily via filtration and infiltration. The LS-FS is a Secondary SCM.

Design Intensity

The design intensity for an LS-FS is 0.75 inch per hour.

Important Links

Rule 15A NCAC 2H .1059. MDC for Permeable Pavement

SCM Credit Document, C-9. Credit for Level Spreader-Filter Strips

Figure 1: Plan View of an LS-FS Adjacent to a Riparian Buffer

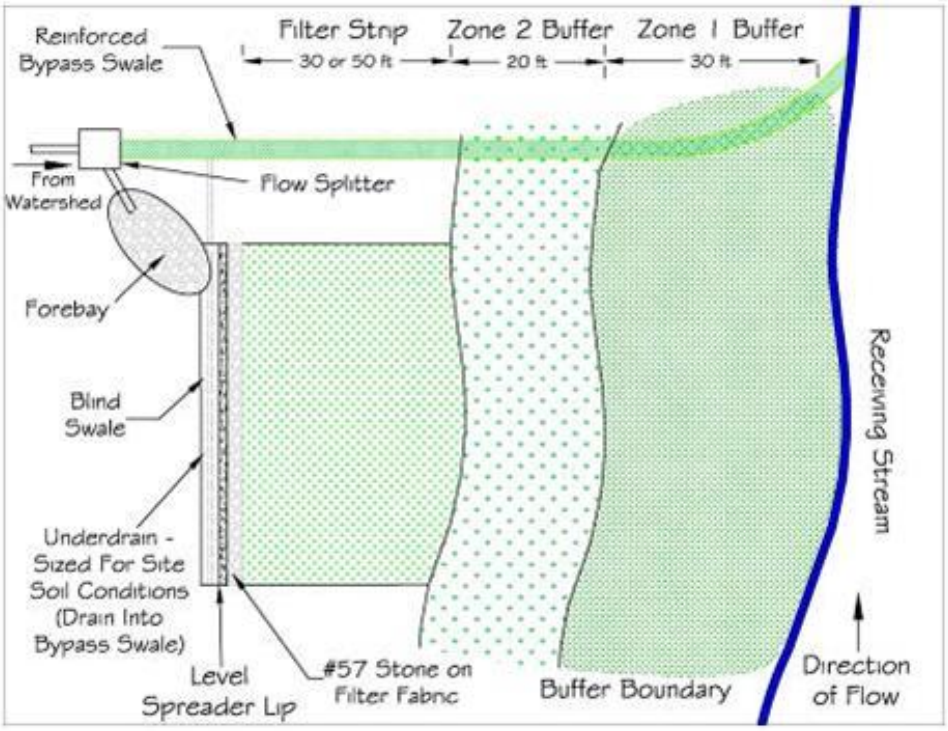
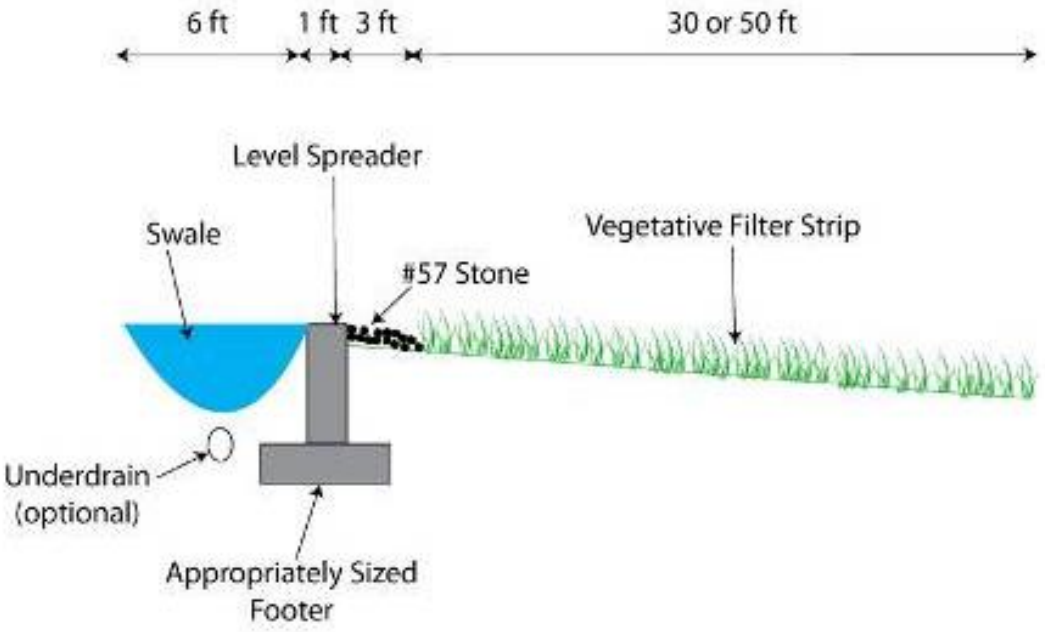


Figure 2: Cross-Section of an LS-FS



Guidance on the MDC

LS-FS MDC 1: Level Spreader Length
The level spreader shall be a minimum of ten feet in length per one cubic foot per second of stormwater flow that is directed to it.

Figure 3: Level Spreader Lip (NCSU)

The designer should calculate the peak flow during the design intensity (0.75 inches per hour) and multiply that result by 10 feet per cfs to determine the required length of the level spreader.

This length requirement is based on achieving a non-erosive velocity throughout the FS and an overland flow depth of approximately 1.2 inches across the FS. This allows the FS to work effectively in removing TSS, nutrients and other pollutants via filtration and infiltration.

LS-FS MDC 2: Required Storm Intensity and Bypass
The required storm intensity and bypass system shall be based on the source of the stormwater:

(a) A level spreader that receives flow directly from the drainage area shall be sized based on the flow rate during the 0.75 inch per hour storm, with a flow bypass system for larger storm events; or

(b) A level spreader that receives flow from an SCM shall be sized based on the draw down rate of the design volume, with a flow bypass for larger storm events.

Flows exceeding the ten foot per cubic foot per second capacity of the LS shall be bypassed via a flow splitter device. See Part A for more information on designing flow splitters. The flow splitter should direct the excess flows to either:

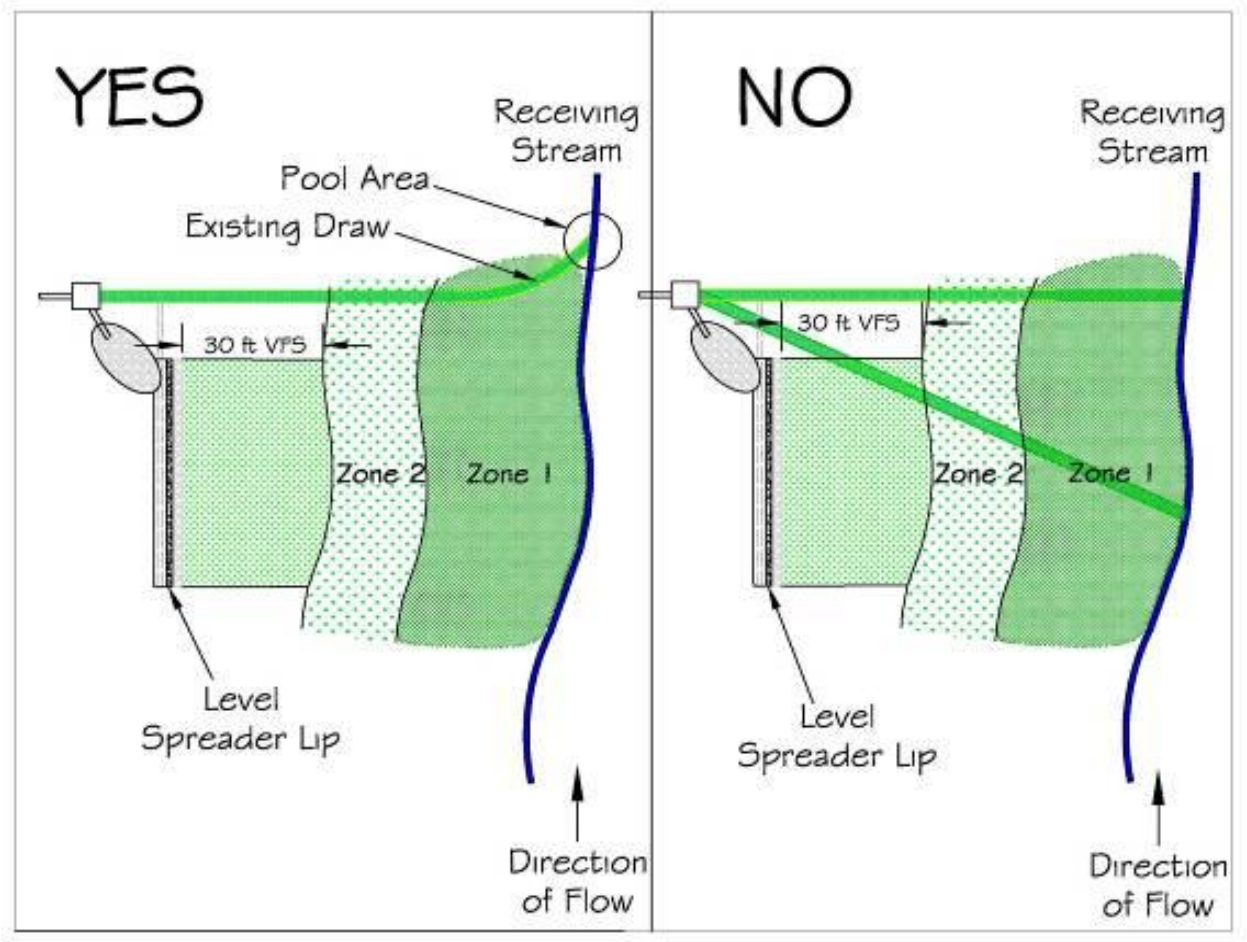
- An existing drainage ditch that is located near the LS-FS,
- A pipe to the receiving stream or storm drainage system, or
- A newly constructed channel to the stream or storm drainage system.

If a bypass channel is being used, then the designer should compute the 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.

If the bypass channel discharges to a stream, then it shall enter the stream at an angle. Perpendicular entry points are likely to cause erosion on the opposite stream bank (see Figure ?). 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. Please note that bypass channels through protected riparian buffers will require a buffer authorization from the DEQ 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 FS, creating channelized flow and reducing the effectiveness of the FS.

Figure 4: Bypass Channel Design (Winston 2010)



LS-FS MDC 3: Exception from Flow Bypass Requirement
A flow bypass system is not needed if the level spreader is sized to handle the flow during 10-year storm event.

A bypass channel is not needed if the LS-FS is designed to handle the entire flow from the 10-year storm event. This will typically be the case only for very small drainage areas.

LS-FS MDC 4: Blind Swale
Immediately upslope of the level spreader, there shall be a blind swale or other method of ponding water. The blind swale shall be designed to provide for uniform overtopping of the level spreader.

Within a blind swale, water rises and falls evenly over the lip of the LS, which distributes the flow evenly to the FS. The blind swale is typically constructed from earth and is covered with turf or possibly lined with rip rap. If the LS-FS is being installed in soils with a low infiltration rate, then an underdrain is recommended. 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.

Whenever practical, stormwater should be conveyed to the blind swale parallel to the LS to avoid short-circuiting the LS. 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. 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.

Figure 5: Blind Swale Entrance Angles

YES

Credit: Jessica Bolin, Town of Apex

NO

Credit: Ryan Winston, NCSU

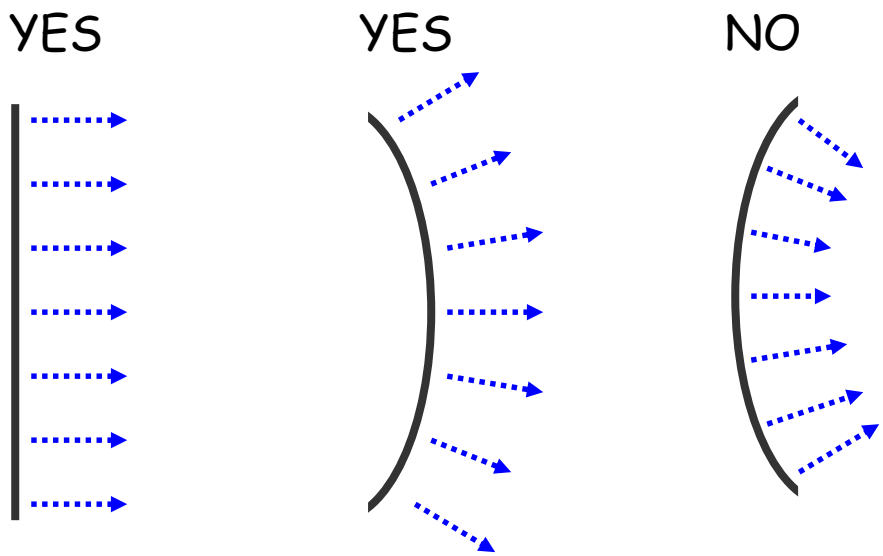
LS-FS MDC 5: Level Spreader Specifications
The lip of the level spreader shall be at a uniform elevation with a construction tolerance of plus or minus 0.25 inch at any point along its length. The level spreader shall be constructed of concrete or other stable material.

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.

LS-FS MDC 6: Level Spreader Shape
The level spreader shall 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 6 below. To minimize the grading needed to install the LS, it should be sited such that it is approximately parallel to contour lines.

Figure 6: Level Spreader Configurations



Required distances for the LS-FS from surface waters depend on the applicable rules:

- The entire LS must be placed outside of riparian buffers and stormwater setbacks.
- An FS 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 FS only on a case-by-case basis.

LS-FS MDC 7: Transition Zone
Immediately downslope of the level spreader, there shall be a one to three-inch drop followed by a transition zone that is protected from erosion via aggregate or high performance turf reinforcement matting. The transition zone shall be a minimum of 12 inches wide.

The transition zone downslope of the LS provides erosion protection and flow dissipation. If aggregate is used, then the recommended depth is three to four inches. If geotextile fabric is used, then it should be selected based on the soil type (sand, silt or clay).

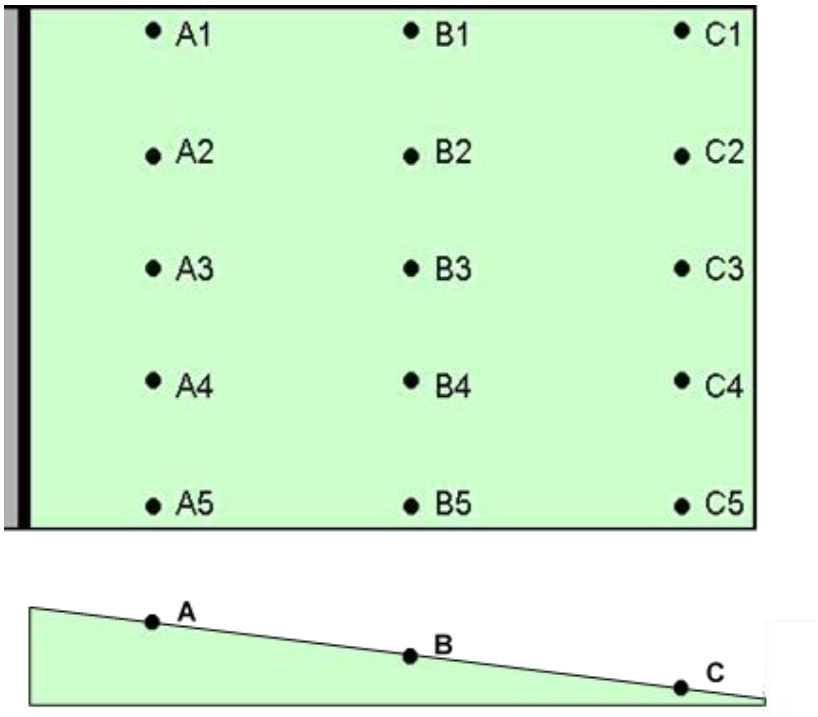
LS-FS MDC 8: Minimum Width of the Filter Strip
The minimum width of the filter strip shall be 30 feet, measured perpendicular to the level spreader lip.

For new projects, the minimum width of the filter strip is 30 feet; however, there is a design variant below that allows for widths of less than 30 feet for retrofit projects if a longer LS is provided. See Design Variant 1 below for more information.

LS-FS MDC 9: No Draws or Channels in the Filter Strip
The filter strip shall not contain draws or channels.

The FS should have uniform slope (equal elevations at A1, A2, A3, A4 and A5). In addition, the elevations at B1-B5 should be equal and the elevations at C1-C5 should be equal. Furthermore, the slope between the LS and the end of the filter strip will be uniform and constant.

Figure 7: FS with Uniform Slope (Plan and Profile Views)

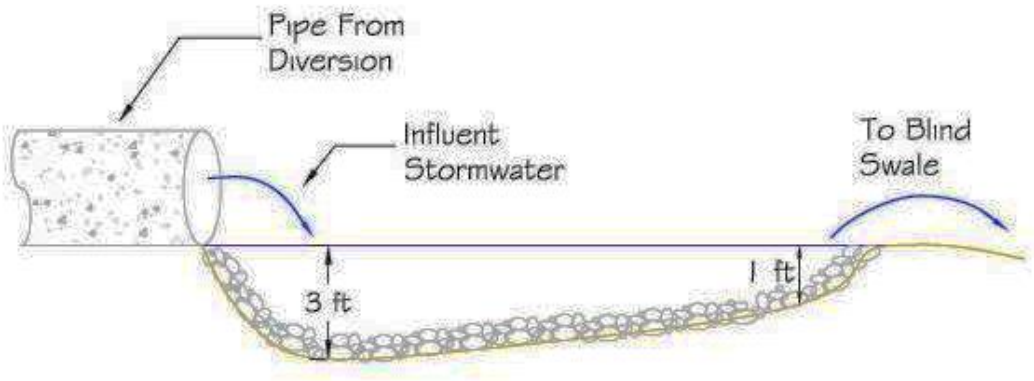


LS-FS Recommendation 1: Pretreatment
Pretreatment via the use of a forebay is recommended when the LS-FS receives flow from the drainage area.

It recommended that stormwater directly from the drainage area be directed to an excavated, bowl-shaped forebay that slows the stormwater and allows sediment and debris to settle out. It is typically lined with Class B riprap. The surface area of the forebay should be equivalent to 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 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. Lining the blind swale with riprap may more cost-effective for a relatively short LS.

Figure 8: Schematic of a Forebay (Hathaway and Hunt 2006)



LS-FS Recommendation 2: Soil Amendment
It is recommended to amend the soil in the FS to promote plant growth.

The FS and side slopes should be covered with at least six inches of stockpiled topsoil, imported topsoil or a combination of the two. It is recommended to test the soil and amended it according or otherwise to follow the general amendment requirements given below. If possible, mix 1 to 2 cubic yards of peat moss or compost per 1,000 square feet into the topsoil to increase soil fertility. In addition, a one-time fertilizer application to the topsoil should be specified. See Table 1 for guidance on the start-up fertilization of FS topsoil.

Table 1: Start-up Fertilizer Application (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. 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]: • 75 lbs of ground limestone per 1,000 sq ft. • 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: N Nitrogen for green color and growth. P_2O_5 Phosphorus for good rooting. K_2O Potassium to enhance pest and environmental stress tolerance. 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 pound of nitrogen per 1,000 square feet. Too much fertilizer will kill centipede.

LS-FS Recommendation 3: Grass Specification for FS
Non-clumping, native, deep-rooted grasses should be specified in the FS.

Non-clumping, native, deep-rooted grasses, such as Blue Grass or Bermuda, should be specified in FS design. Recommended grasses for the Mountains, Piedmont, and Coastal Plain are identified in Table 2. These grasses should require little maintenance. Sod grown in non-clayey soils or washed sod should be specified in the FS. 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 2: Appropriate Grasses for FS by Region (Winston and Hunt 2009)

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

Construction

In the field prior to construction, 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 appropriate width (30 feet) is available for the FS.
- The FS does not include any unaccounted for wetland areas. Wetland areas may not be graded without an appropriate permit.

The LS-FS should be protected from sediment and stormwater flows during construction. A temporary stormwater diversion will likely be necessary until the drainage area and the LS-FS have fully stabilized.

Grading the FS is 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 FS is graded, then proceed with constructing the blind swale and LS as shown in Figures 9 through 11 below. 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. 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.***

Figure 9: Excavating the Blind Swale (NCSU-BAE)

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. 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.

Figure 10: Forming the Level Lip (NCSU-BAE)

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, consider installing an underdrain upslope of the LS to drain the blind 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.

Figure 11: LS and Blind Swale Post-Construction

Construct an overflow swale adjoining the FS 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

The FS soils must be left "loose" – this can be achieved by raking, tilling or using a field cultivator. After the FS soils have been loosened, six inches of topsoil should be added to the FS 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 Table 2, 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. 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 FS (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.

Maintenance

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

Maintenance of an FS 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-FS from achieving diffuse flow. Figures 12 through 14 show a number of common maintenance issues with LS-FS systems.

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-FS 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. 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 12: Clogged Forebay (left) and Unmaintained Blind Swale (right)

During the mowing season, the FS should be mowed at least every other week. The mowing allows an opportunity for the FS to be inspected and also helps to prevent clumping of grass. This is a view upslope of the same FS at right. The clumping of the unmown grasses and resulting channelization of flow is evident from this view. The eroding areas in this FS need to be filled in and revegetated before the problem becomes worse.

Figure 13: Unmaintained Blind Swale and Unmown FS

Figure 14: Erosion in the FS

Important maintenance procedures:

- Immediately after the FS is established, grass will be watered twice weekly if needed until the plants become established (commonly six weeks).
- Stable groundcover will be maintained in the drainage area to reduce the sediment to the LS-FS.
- Every two weeks during the growing season, the FS will be mowed. Turf grass should not be cut shorter than 4-6 inches and may be allowed to grow as tall as 12 inches depending on aesthetic requirements (NIPC, 1993).
- Once a year, the soil will be aerated if necessary and the FS will be reseeded to maintain a dense growth of vegetation.
- Once a year, soil pH will be tested and lime will be added if necessary.

For the first two years after the LS-FS 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-FS 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 FS 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 and maintenance shall be performed per Table 3 below.

Table 3: Sample Operation and Maintenance Provisions for LS-FS

SCM element	Potential problem	How to remediate the problem
The entire LS-FS	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 swale is overgrown with vegetation.	Mow vegetation. Re-grade and vegetate if the swale has become silted in.
The LS	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 damaged or ripap is rolling downhill.	Study the site to see if a larger bypass channel is needed (enlarge if necessary). After this, reestablish the erosion control material.
The FS	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.	Contact the NC Division of Water Resources.