SOLUTIONS

Vegetative Filter Strips for Open Feedlot Runoff Treatment

Vegetative filter strips (VFS) are areas of either planted or indigenous established vegetation situated down slope from open feedlots and settling basins. that VFS may be used to improve the quality of feedlot runoff. They can be incorporated into pastures, grassed waterways, terraces, or cropland. VFS have been shown to remove up to 60 to 70 percent of the suspended solids load, and up to 70 to 80 percent of nitrogen, phosphorus, and chemical oxygen demand (COD) from settled feedlot runoff when designed and operated properly.

VFS Function

VFS treat runoff through infiltration, settling, adsorption, and aeration. Vegetative filter strips provide an opportunity for runoff and pollutants to infiltrate into the soil profile by spreading the flow over a wide area. They allow deposition settling of total suspended solids by maintaining the runoff velocity at less than 2 feet per second. They enhance filtration of suspended sediment, and adsorption of soluble pollutants by plants and soil by providing numerous adsorption sites on contact with soil and plant surfaces.

A VFS must be preceded by a well-designed, effective and maintained solids settling basin. VFS can be designed either long and narrow like a grassed waterway, or wide and short, similar to buffer strips around cropped fields. Maintaining uniform overland flow may be easier to achieve with narrow strips than very wide ones. While it is sometimes difficult to avoid flow channelization, good design and continued maintenance certainly help. If channelization occurs, the effectiveness of the VFS is severely reduced.

VFS Design

VFS should be designed to provide shallow uniform overland flow, and avoid channelized flow. Overland flow systems allow a uniform loading across the width of the VFS at a shallow depth (<1.5 inches). Uniform depth of flow across the entire width of the VFS results in a slower flow velocity through the system, allowing sediment and nutrients to be trapped for more efficient removal of nutrients and sediment. The keys to designing an overland flow VFS are flat slope, flat bottom, dense uniform vegetation, and initial (and perhaps intermittent) spreading of the flow across the width.

The following design elements apply to all VFS:

- Solid settling should precede VFS
- VFS should have a flat cross section with a slight slope (<4 percent) in the direction of flow.
- VFS should always be as long as possibly practical.
- Outside water should be excluded from the VFS.

For Open Feedlot Operators

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University Extension

PM 1919 September 2002

❒ Using VFS length for design

VFS design can be based on a) length, b) an area ratio, c) hydraulic loading, or d) nutrient loading
Use a minimum width of 30 ft, dead level across the width. Wider is better. Construct berms on both sides of the VFS to exclude outside runoff water. The VFS should carry only settling basin effluent. (Outside drainage water can be reintroduced below the VFS). Use as long a VFS as possibly practical with a minimum of at least 100 feet, or 1 foot of length per animal unit (AU)*, whichever is larger, for lots over 100 AU. Minimum length should increase with increasing VFS slopes, per Natural Resource Conservation Service (NRCS) requirements which range from 100 feet for a 0 to 2 percent slope, up to 300 feet for 6 percent slopes.

Research below both dairy and beef lots shows progressively better removal as VFS lengths increase up to 300 feet on 0 to 2 percent slopes as shown in Figure 1.

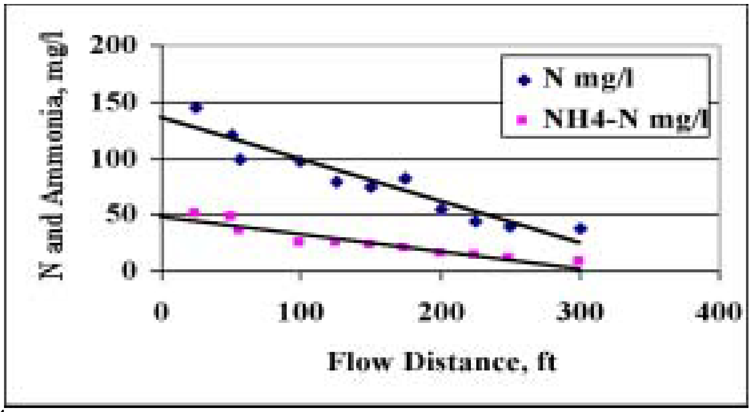


Figure 1. Nitrogen concentration versus VFS length

❒ Using area ratio for design

Use a ratio of VFS are to drainage area of 1:1 (VFS size equals drainage area).

Based on data from 10 separate studies conducted over the last 25 years, Figures 2 and 3 show that over 80 percent reductions of total kjeldahl nitrogen (TKN), and phosphorus (P) are achievable if the VFS surface area is large enough compared to the feedlot drainage area (DA). The figures show that a VFS:DA ratio of 1 can be expected to provide approximately a 70 percent reduction in both N and P. This system can be used to size short, wide VFS.

❒ Using hydraulic performance for design

Designs can be based on providing a specified transit time for the flow to traverse from the top to the bottom of pass through the VFS. Typically a 2 hour passage time has been used. This is a sophisticated design process requiring the services of an agricultural engineer, and will result in pollutant reductions similar to those discussed above.

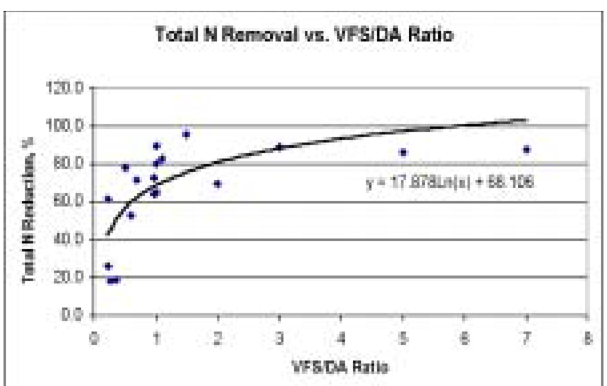


Figure 2. Total N removal by VFS

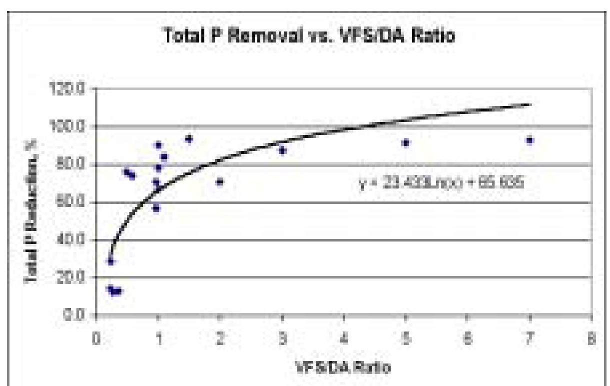


Figure 3. Total P removal by VFS

❒ Using nutrient removal for design

Designing a VFS based on the nutrient removal of the VFS plants is another method. If beef feedlot runoff contains 5 pounds of N per year per head (from Extension publication PM-1811, Managing Manure Nutrients for Crop Production) the VFS can be sized to utilize those nutrients. For example, assume a smooth brome VFS utilizes 40 pounds of N per ton of harvested grass and yields 4 tons per acre. With plant removal of 160 pounds/acre, the each VFS acre would carry remove the nitrogen from 32 head/acre, so the VFS size should be an acre for every 32 head. This conservative design results in a VFS larger than the feedlots they it serves.

Figure 4. Serpentine vegetative filter strip design.

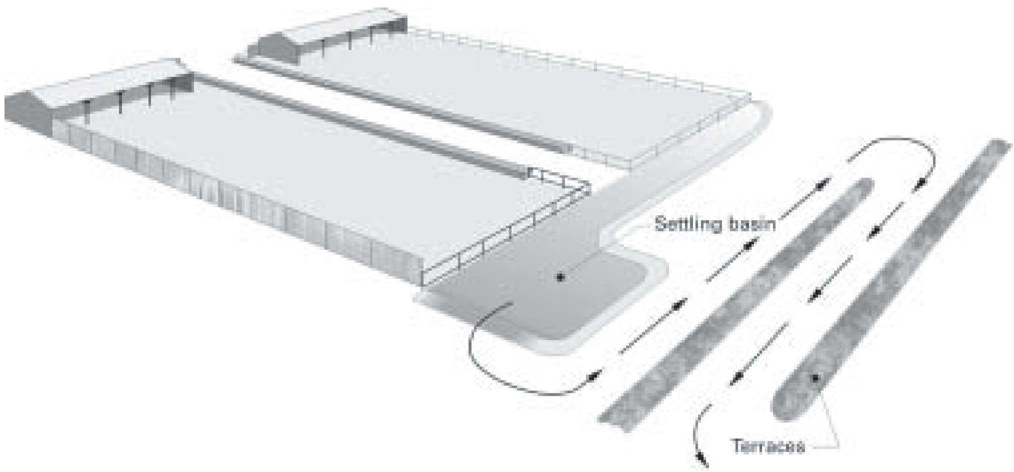
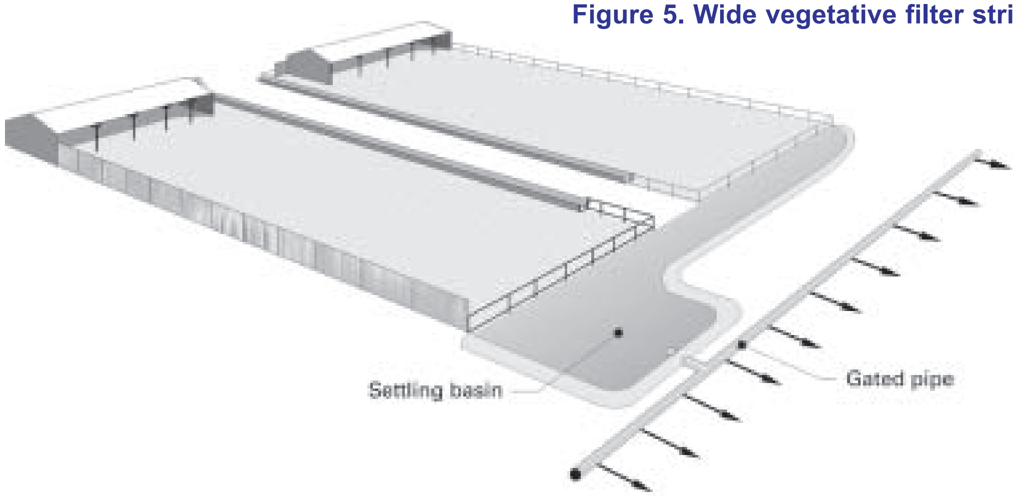


Figure 5. Wide vegetative filter strip desgin.



** An animal unit is a unit of measurement used to determine the animal capacity of a feeding operation based upon the product of multiplying the number of animals in each species by a predetermined multiplier. A rule of thumb is one beef feedlot steer is equal to one animal unit.*

VFS Maintenance

VFS maintenance is extremely important to the proper functioning of the treatment system. Effective VFS require a dense, vigorous stand of a grass that can tolerate wet conditions such as Reeds Canary or Brome grass. A good stand of vegetation will lead to uniform filtration. Uniform flow, minimal soil disturbances, and proper harvesting of vegetation are all important (Ikenberry and Mankin, 2000). Minimize traffic to reduce soil compaction. Keep all traffic off, both vehicles & animals, when soil is soft to avoid tracks and/or ruts that will cause channelization. Good vegetative cover helps to slow the flow, prevent soil erosion, and helps minimize the formation of gullies. Grass should not be allowed to grow tall enough that it will lay down when overland flow occurs. Harvesting should be done periodically during dry conditions to not only remove nutrient accumulation, but to and help in maintaining a healthy stand. If channels begin to develop, they should be filled and/or tilled out to maintain smooth flow. If flow spreaders are used, they must be maintained level so they can do their jobs well.

Summary

Properly designed and maintained VFS provide excellent removal of feedlot runoff contaminants as shown in Figure 6. Although VFS are passive treatment systems, they still need occasional attention, and require good management in order to function satisfactorily. Good design, proper sizing, and good management are all required for effective VFS treatment to result.

Figure 6. Summary of VFS contaminant removal

	Percent Removal		
	Average	Maximum	Minimum
Total Solids	64.5	87.0	23.6
COD	74.8	92.1	15.0
Total N	71.5	95.3	18.0
Total P	68.7	97.0	12.0
NH_4-N	69.4	99.2	18.6
Fecal Coliform	76.6	100.0	31.0

SOLUTIONS

File: Environmental 4-1

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