Performance of Vegetative Filter Strips for Highway Pollutant Removal

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NC Guidelines for TSS Removal

BMP	Assumed TSS Removal
Wet detention basins	85%
Extended detention wetlands	85%
Pocket wetlands	35%
Sand filters	85%
Bioretention area	85%
Grassed swales	35%
Extended dry detention	50%
Filter strips	25-40%
Infiltration devices	85%

Filter Strip Design Requirements

- Filter strips are sections of vegetation designed to reduce pollutants in stormwater runoff. They are designed and constructed strips of relatively flat, level land with grasses or other vegetation and some method to spread the storm water runoff into a thin sheet. It is called a grassed filter strip if planted with grass.
- A level spreader is needed along the top edge of the filter strip,e.g. stone-filled shallow trench , concrete berm.
- NC rules require a filter strip to be used to further treat the storm water discharged from wet detention ponds.
- Filter strips are to be used as one of a series of BMPs to reach the 85% TSS removal requirement.

Filter Strip Performace

- Properly constructed forested and grassed field strips can be expected to remove a minimum of 35% solids, 40% nutrients in urban runoff.
- Removal mechanisms include filtering action of vegetation, infiltration of pollutant-carrying water and sediment deposition
- Channelization can drastically reduce pollutant removal.
- Removal rate is affected by runoff velocity, degree of channelization, soil permeability, vegetation type, flow length, slope of the strip etc.
- Filter strips generally do not provide enough runoff storage or infiltration to significantly reduce peak discharges or the volume of storm runoff.
- Cost of establishing filter strips is usually low, requiring only minor grading and vegetation expenses.

Filter Strip Design Criteria

- To prevent concentrated flows from forming, the contributing drainage area should be less than 5 acres and less.
- Filter strips should not be used on slopes greater than 15% or in areas where vegetation cannot be maintained all year.
- Best performance occurs where the slope is 5% or less.
- Filter strips are 50 ft in length along the direction of flow for up to 5% slope of the strip.
- It requires additional 4 ft (added to 50ft) for every 1% increase in slope up to a maximum of 15%.
- Width perpendicular to flow must be 100 ft for each acre of drainage area.

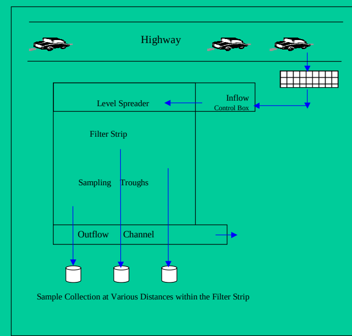
Filter Strip Design Criteria

- Velocity of less than 2 fps is required for the maximum depth resulting from a 10-yr storm.
- Design must include a level spreader to allow runoff to enter the filter strip as sheet flow.
- Pollutant removal credits given to filter strips that meet the design criteria are:
- 45% TSS removal – for filter strips that are primarily natural, woody vegetation
- 30% TSS removal – for filter strips that are planted with primarily woody vegetation
- 25% TSS removal – for filter strips that are planted in grass or legumes.

Table 1. Recommended Design Guidelines for VFS*

Parameter	Criteria
Length	**20 - 25 feet (6.1 – 7.6 meters) minimum. 80 to 100 feet (24.4 – 30.5 meters) optimum**
Slope	**As flat as possible while allowing for drainage, normally in the range of 0.02-0.08.**
Soil Type	**Sandy loam, loamy sand with an infiltration rate of 0.52 inch/hour or better**
Vegetation	**May range from turf and native grasses to herbaceous and woody vegetation, all of which can either be planted or indigenous.**

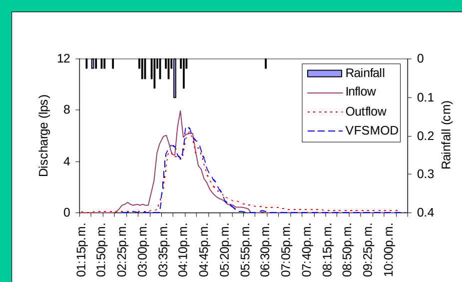
* NJDEP, 2003; VADCR, 1999



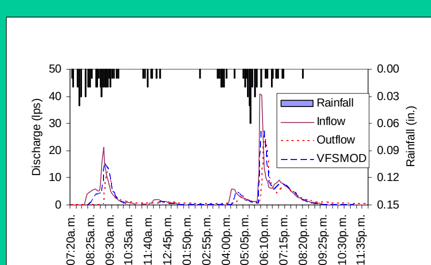
VFS site near Raleigh (Clayton, NC)

Level Spreader for inflow to VFS

Inflow to Level Spreader

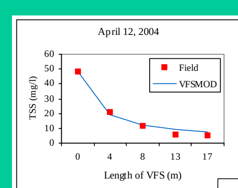


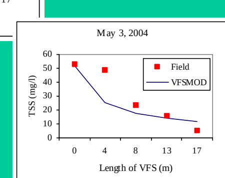
4-12-04, 0.33", ADD 10 days



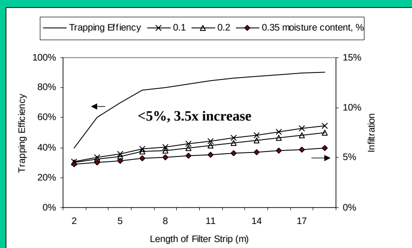
5-2-04, 0.93", ADD 5.4 days

TSS Removal Along Filter Strip



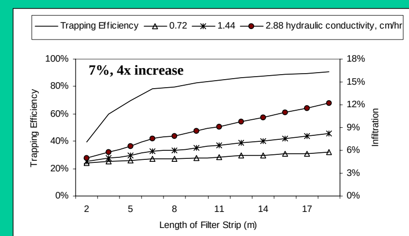


VFSMOD Simulation Initial Water Content



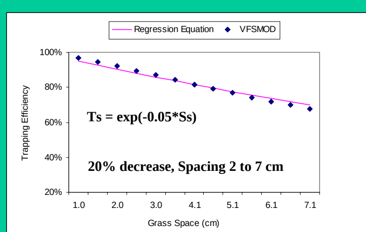
(d_{50} = 8 µm, VKS = 1.44 cm/hr, Grass Spacing = 2 cm)
Figure 6. Effect of Initial Water Content on VFS

VFSMOD Simulation Hydraulic Conductivity



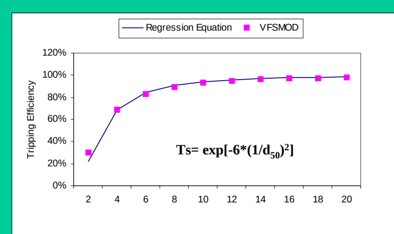
(d_{50} = 8 µm, Initial Water Content = 0.1%, Grass Spacing = 2cm)
Figure7. Effect of Soil Saturated Hydraulic Conductivity on VFS

VFSMOD Simulation Grass Spacing

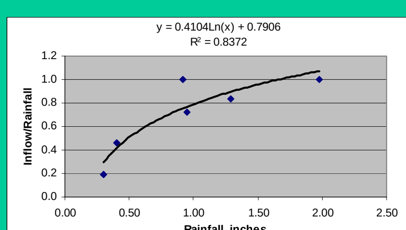


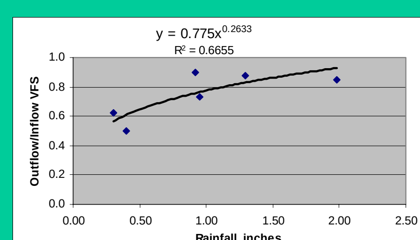
(d_{50} = 8 µm, Length = 16.7 m)
Figure 8. Effect of Grass Spacing on VFS

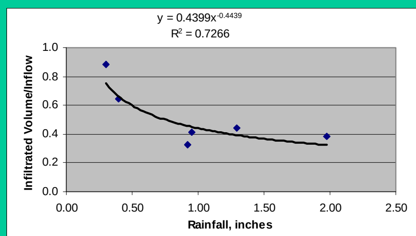
VFSMOD Simulation Particle Size



(Grass Spacing = 2 cm, Length = 17.6 m)
Figure 9. Effect of Particle Size (d_{50}) of Inflow Suspended Sediment on VFS







TSS

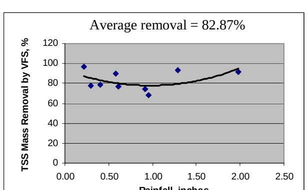
	VFS	Mass
Rain, in	Rem.,%	Rem.,%
0.40	56.52	78.25
0.92	70.79	73.83
0.30	64.35	77.72
1.98	90.31	91.75
0.95	80.27	67.92
1.29	92.18	93.16
0.22	94.05	96.90
0.61	65.73	76.68
0.58	84.53	89.61
	77.64	82.87

TN

	VFS	Mass
Rain, in	Rem.,%	Rem.,%
0.40	-26.52	36.72
0.92	45.45	51.14
0.30	11.34	44.58
1.98	19.75	31.70
0.95	-5.95	24.19
1.29	-4.00	9.10
0.22	7.00	51.62
0.61	5.43	35.66
0.58	18.89	45.54
	7.93	36.69

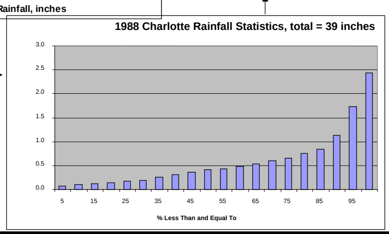
TP

	VFS	Mass
Rain, in	Rem.,%	Rem.,%
0.40	-100.00	-0.04
0.92	19.05	27.48
0.30	35.48	59.67
1.98	21.12	32.86
0.95	-160.40	-91.48
1.29	-17.16	-2.40
0.22	100.00	100.00
0.61	15.41	42.44
0.58	26.69	50.78
	-6.65	22.11



Long-Term TSS removal = 84.36%

X



The End

TC

Rain, in	VFS Rem.,%	Mass Rem.,%
0.40	-37.41	31.27
0.92	3.59	13.63
0.30	4.98	40.61
1.98	5.77	19.79
0.95	-50.07	0.88
1.29	-13.88	0.01
0.22	-18.68	38.27
0.61	-4.55	28.86
0.58	32.26	54.52
	-7.41	25.32