A normalized design procedure to meet sediment TMDL with VFS's

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Outline

1. Motivation
2. Tools: vegetative filter strips and VFSMOD
3. Design Procedure
4. Application: case study
5. Conclusions

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What would be the optimal constructive parameters for a vegetative filter strip (VFS) used as a BMP on a given area to meet certain regulatory standards (i.e. runoff sediment TMDL)?

The TMDL approach

- Setting goals to achieve environmental protection/restoration.
- A complex problem due to numberless interactions (physical, chemical, biological, agronomical, urban).
- Lack of objective tools to achieve results.

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What are Vegetative Filter Strips?

- Research for erosion control date back to the late 1960's in agricultural settings
- Used as a down-slope BMP to reduce sediment transport to off-site waters
- Consist of planted vegetation such as grass, can be natural areas (but these are generally not as effective)
- Can be used in agricultural or urban settings

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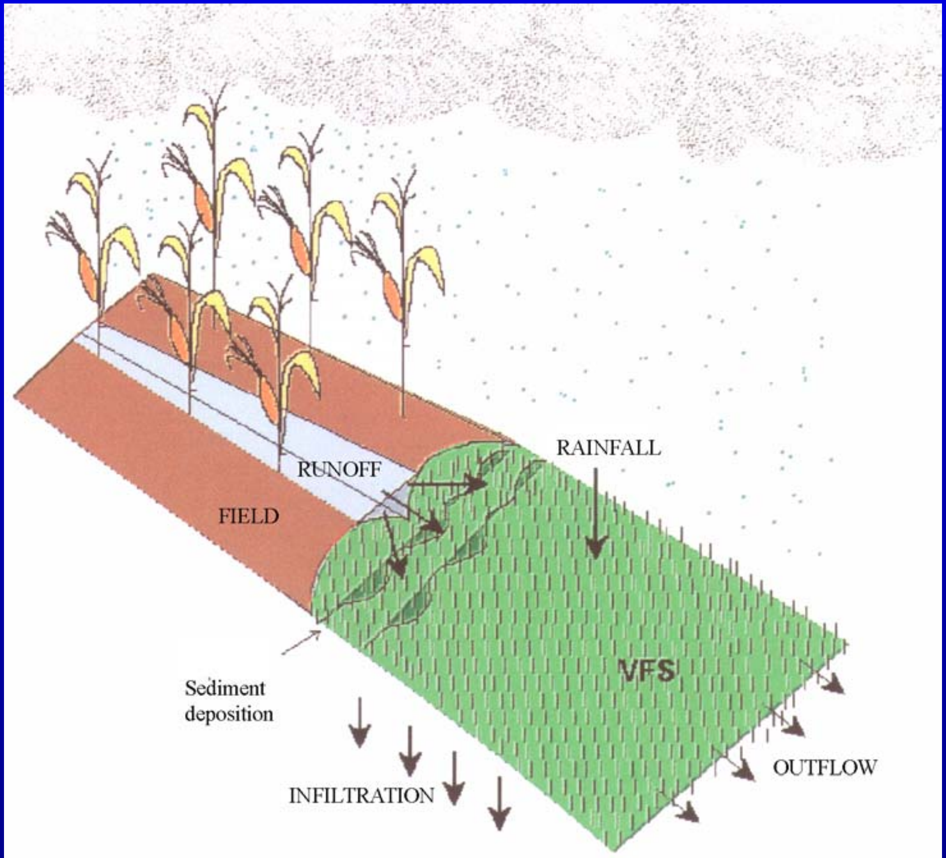
Vegetative Filter Strips: How they work



Increase in hydraulic resistance to flow and soil infiltration

↓

Reduction (infiltration) and delay in overland flow

↓

Decrease in sediment transport capacity of flow

↓

Sediment deposition (and pollutant bonded) in filter

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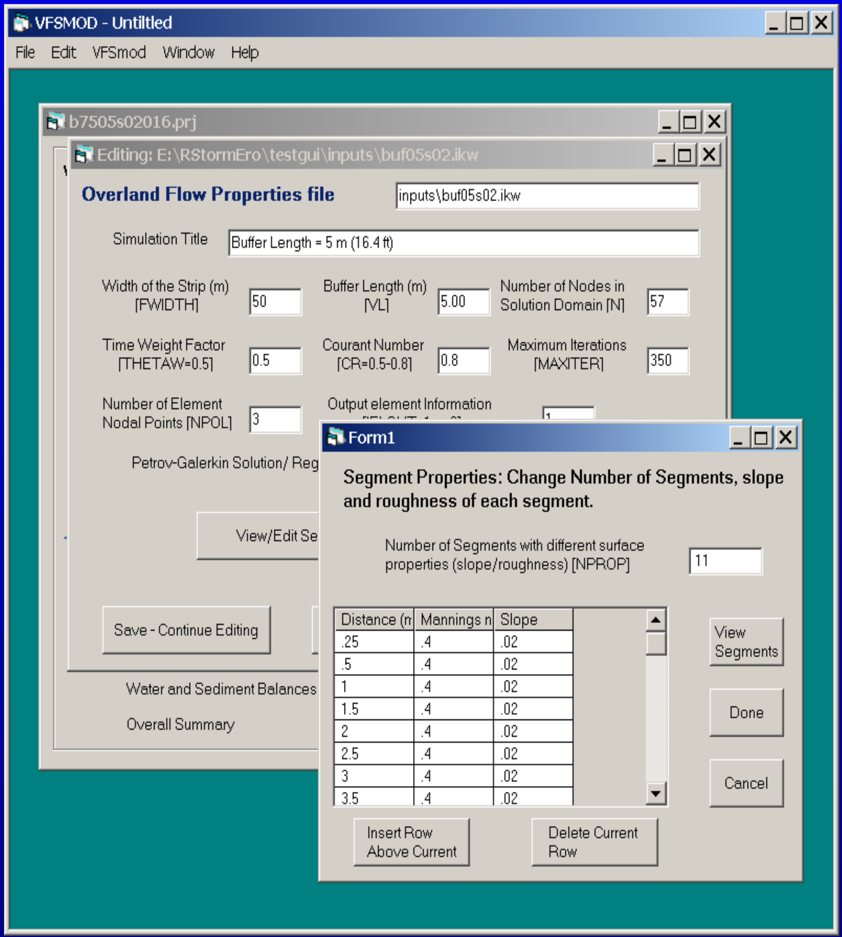
VFSMOD-W a computer system for design

- Targeted at Performance on an Event by Event Basis
- Assist users to determine the relative effectiveness of Filter Strips in a given situation, i.e. for TMDL standards.
- The model inputs are relatively easy to obtain
- A users manual is available
- A visual interactive user-oriented front end program is available.
- Distributed via WWW: http://www3.bae.ncsu.edu/vfsmod/



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The model GUI has two additional built-in tools to help the designer to gain confidence in results:

a) analysis of sensitivity to model inputs

b) Uncertainty analysis of results.

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Design procedure:

Constructive characteristics of VFS:

- Length
- Slope
- Vegetation

Pre-imposed conditions:

- Soil(s)
- Design storm(s) generating runoff
- Management of disturbed area (crop, other)
- Size(s) of contributing area
- Sediment TMDL value to achieve

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Target outputs for analysis are the sediment delivery ratio (SDR) and runoff delivery ratio (RDR) computed as:

SDR = (Mass of Sediment Exiting the Filter)/(Mass of Sediment Entering the Filter)

RDR = (Runoff Exiting the Filter)/(Runoff Entering the Filter)

Design objective → TMDL≤ 1-SDR

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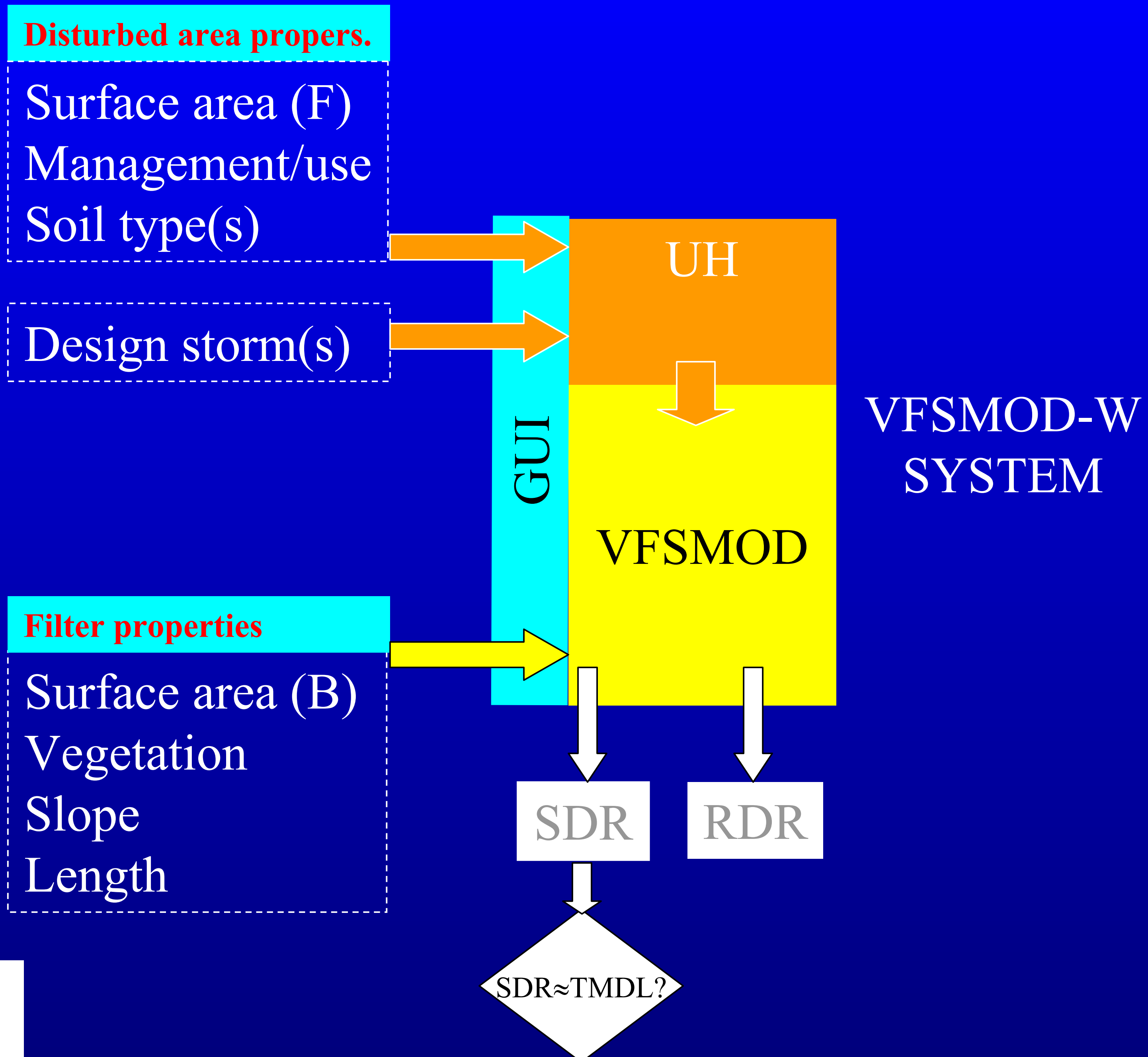

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Background

- The current regulations for the Neuse River Basin (NC) require a total riparian length of 50 feet (15.24 m). Within the riparian zone, there are recommendations that a portion of this should be suitable for trapping sediment.
- A recent ordinance passed by the Town of Cary (2000), NC, requires 100 feet (30.48 m) buffers for stream systems.

Q: Will these regulations meet TMDL requirements?

Design criteria

- NC Piedmont region is selected (i.e. soils, crop, filter vegetation, design storms).
- The length of the filter strips will be our design factor in analysis.
- TMDL set to achieve a 75% reduction in sediment output (SDR=0.25) from the disturbed area (field crop).

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Analysis:

Fixed:

- Same source area in all cases (0.5 ha, crop type and management)
- Filter vegetation recommended in area
- 2% slope in all cases

Variable:

- 4 Design storms (6-hour, T=1, 2, 5, 10 yrs)
- 2 Soils (clay, sandy-clay, 1% OM)
- 8 Filter lengths (5-100 m)

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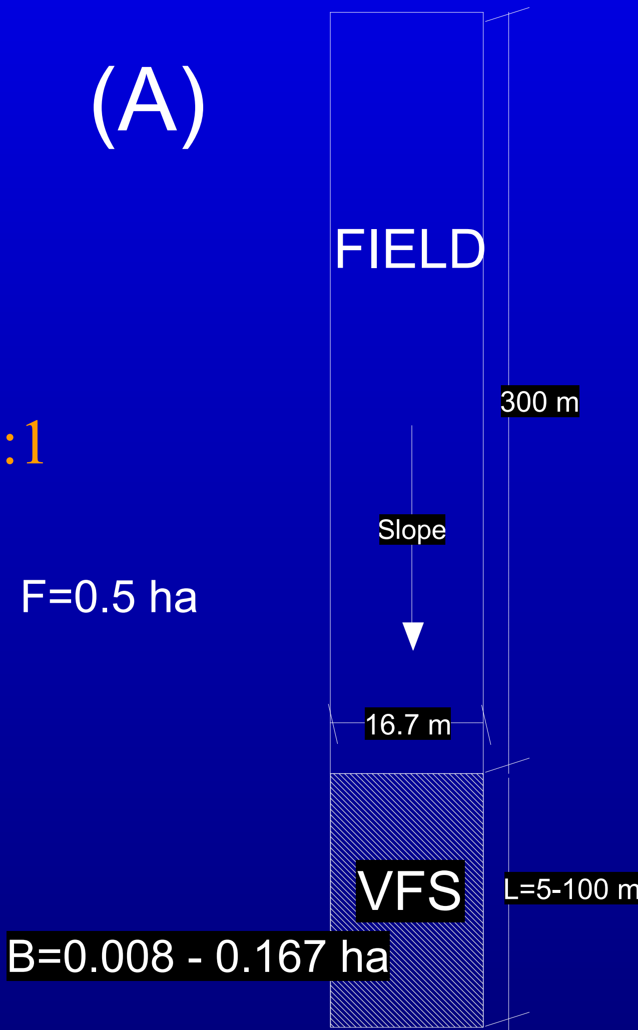
- Two filter to source area ratios (F/B):

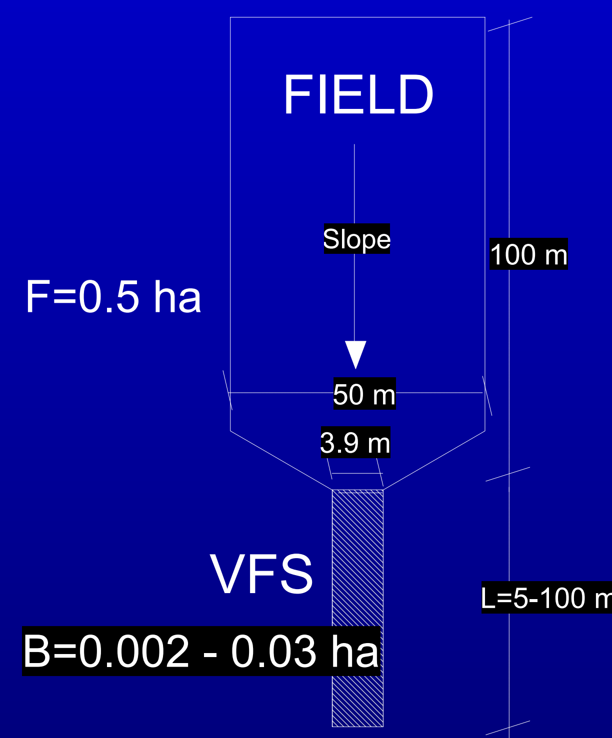
F/B_A 3-60:1

F/B_B 13-258:1

(A)



(B)



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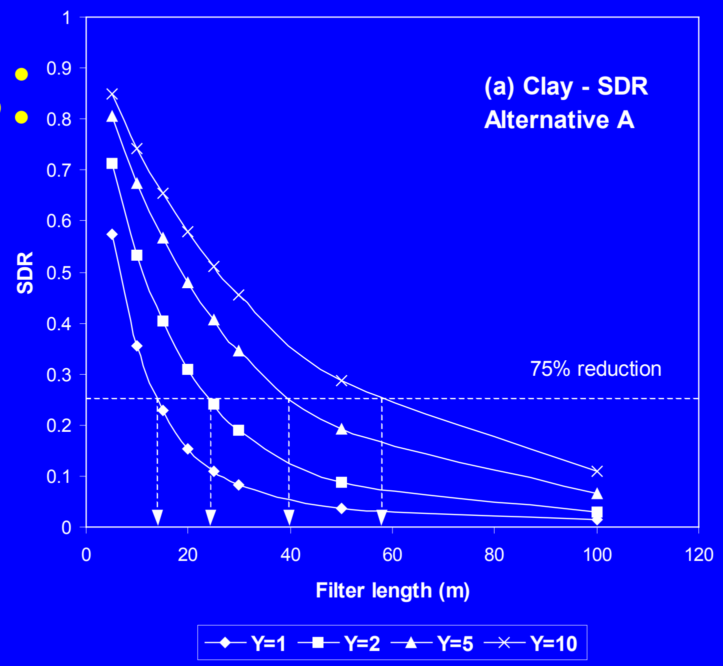
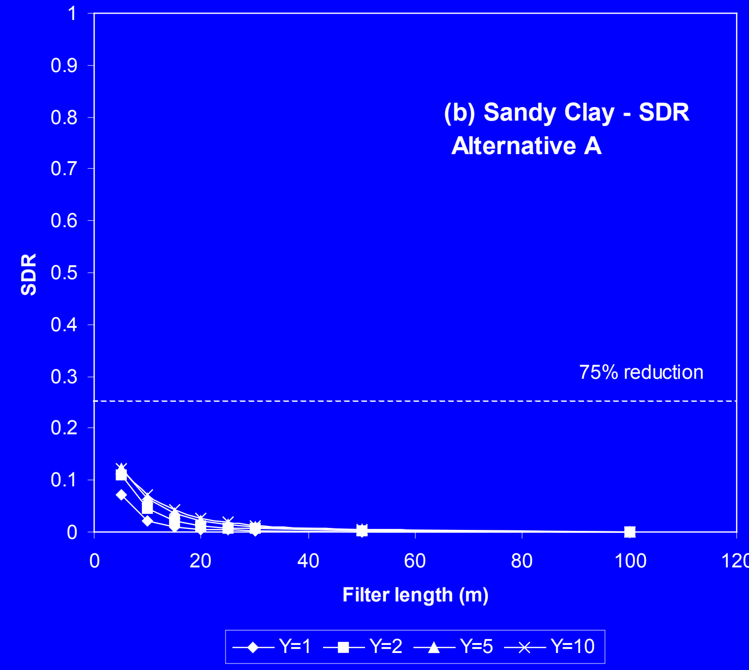
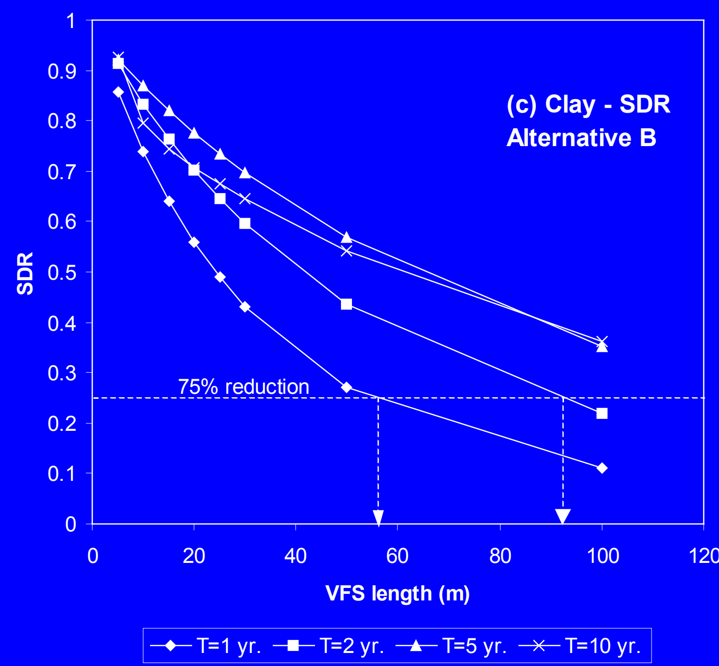
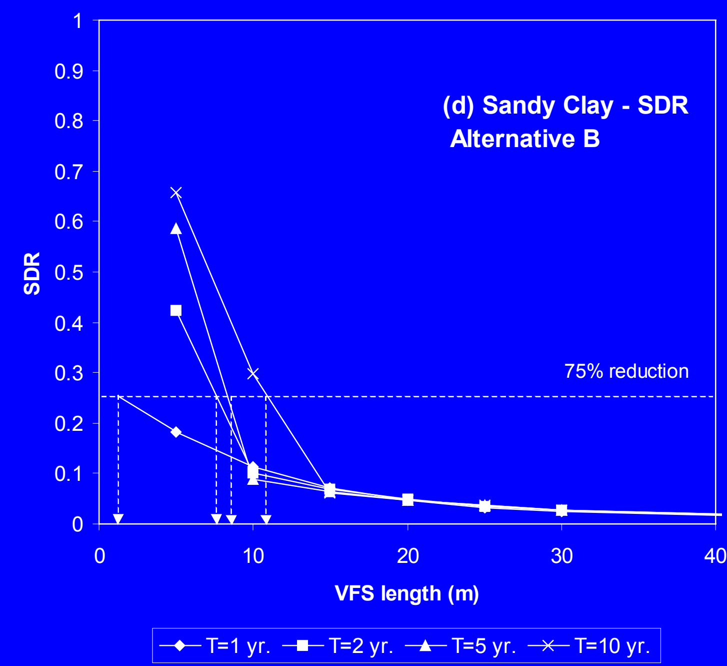
Results:









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Summary of analysis results

Soil type (USDA)	Optimal filter length (m) to achieve the desired TDML			
	T= 1 yr.	T= 2 yr.	T= 5 yr.	T= 10 yr.
Design alternative (A)				
Clay	14	24	40	57
Sandy-clay	<5	<5	<5	<5
Design alternative (B)				
Clay	58	93	>100	>>100
Sandy-clay	1	8	9	11

Fails Town of Cary ordinance

Fails Neuse River and Cary

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- A procedure for design of vegetative filter strips is presented using an event-based mechanistic graphical modeling system (VFSMOD-W)
- A desired TMDL (expressed in terms of % reduction of sediment from a disturbed source area) is used as objective function for the design method
- The procedure is both flexible and comprehensive since a wide range of design parameters can be utilized in the procedure

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- An application on the method in the Piedmont region of North Carolina shows the potential of this tool
- It is also worth noticing that for the conditions studied in this scenario, although intended only for illustration purposes, the current regulations would not hold for one of the two soils present in the area and design storm return periods greater than 5 years.
- This illustrates the limitations of this type of regulations and the need for a mechanistic approach

Research needs

- Extension of model to predict sediment-bound pollutants and fecal pathogen transport in VFS.
- Incorporate design procedure in GUI

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