**Effects of Vegetated Buffer Strips on Flow Hydraulics and Sediment Deposition and Delivery**

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**Introduction**

Grass buffer strips impact overland flow hydraulics and consequently sediment delivery from hillslopes. Mathematical models facilitate the evaluation of performance of grass strips in reducing sediment delivery by simulating and predicting flow characteristics and sediment transport adjacent to and within grass strips. This paper summarizes some of the recent studies and modelling approaches by our research group to explain and simulate the physical processes in and around grass strips.

Following Rose et al. (2002) study, Akram et al. (2014) used vetiver grass in controlled conditions and the profile of water surface was recorded upstream and within narrow and stiff hedges for different slope length and steepness, and for different flow rates. The results showed that water surface profiles in stiff hedges no longer follow the classic $M_r$ water surface profile and the friction slope can be quite high within the narrow hedges. A model was developed to simulate the water surface profile upstream and within grass strips. Simulated water surface profiles compare well with observations, and this study re-confirms the non-linear relationship between the Manning’s n and Froude number in densely vegetated areas. As water approaches the downstream end of stiff hedges, the reduction in water depth leads to flow acceleration, and an increase in friction slope and stream power, and as a consequence net deposition of sediment is unlikely to occur. Stream power is the rate of working of the mutual shear stress between the surface and the flow, and is equal to:

$$\Omega = pqS_yg$$

where $\rho$ is the density of water, $q$ is the unit discharge, $S_y$ is friction slope, and $g$ is acceleration due to gravity. Figure 4 shows the variations in the stream power upstream and within the 30 cm hedge grass strip for 5% slope and different flow rates. This clearly shows and explains the reason that erosion rather than net deposition has been observed around the downslope end of grass strips in some previous studies.

**Methods, Results, & Discussion**

In order to justify and predict the physical processes in and around grass strips, the surface water profile should be correctly simulated. Rose et al. (2002) developed a model for porous resistive elements of beds of nails of various densities to simulate the hydraulic resistance offered by grass strips. In 14 experiments, the hydraulic consequences were measured for steady flows through nail beds of various densities at various flume slopes. Spatial variation in water depth to and through the resistive element was measured. Provided that the nail density was not too low or slope too high, the maximum depth of water occurred as flow entered the nail bed. In such cases, the momentum theory was able to provide a reasonably good prediction, both of the shape of water profile within the nail bed, and of the slope and extent of the region of hydraulic adjustment formed upslope of the resistive element.

In another study, Hussein et al. (2007) developed a new model which couples the hydraulics, sediment deposition and subsequent adjustment to topography in order to predict water and sediment profiles upslope of a grass strip with time.

**Conclusions**

The momentum theory was found to provide a good prediction of water depth throughout the resistive element. Also a simple model was developed using the gradually varied flow equation, which recognized the variation in Manning’s coefficient within the hedges.

A process-based model was developed in order to simulate and predict the fate of water and sediment in and around grass strips. As the size of sediment particles is very important in the use of the model for water pollution predictions, the model calculates the concentration and mass of sediment in the outlet for different particle size classes separately.

The sensitivity analysis showed that the initial soil moisture of the grass buffer strip is the most sensitive parameter in predicting runoff loss. Increase in slope steepness and flow rate dramatically decreases the efficiency of grass strips in reducing sediment concentration and sediment delivery. The efficiency of grass strips reduces over time during the runoff events.

**References**