

## Introduction

According to the U.S. Environmental Protection Agency, sediment is the fourth leading cause of water quality impairment. Studies have shown sediment from streambanks can account for as much as 85% of watershed sediment yields and bank retreat rates of 1.5 m/year have been documented (Simon et al., 2000). Monitoring and modeling techniques to assess the contribution of channel sediment to overall sediment load are needed to determine the reductions necessary to meet water quality standards. This research focused on testing the ability of watershed- and reach-scale models to predict stream channel degradation. Model predictions were compared to estimates developed from a system of erosion pins and scour chains.

## Objectives

The goal of this study was to compare stream channel erosion predictions from three models; GWLF, SWAT, and CONCEPTS. The project had two main objectives:

1. Summarize current methods of estimating channel erosion at the watershed scale.
2. Compare three models with varying levels of complexity to field measurements of bank retreat.

## Study Site

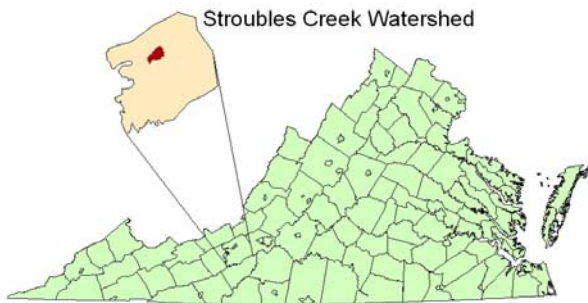


Figure 1. Location of the Stroubles Creek watershed in Blacksburg, Virginia, USA.

Model predictions were compared with actual streambank retreat rates measured using a system of erosion pins along Stroubles Creek, Blacksburg, Virginia, USA (Figure 1). In 1998, the Virginia Department of Environmental Quality (DEQ) included a 4.87-mile segment of Stroubles Creek downstream of the Virginia Tech Duck Pond on Virginia's Section 303(d) list, due to impairment of the stream benthic macroinvertebrate community (VADEQ, 1998). A TMDL study by the Biological Systems Engineering Department at Virginia Tech cited sediment, originating largely from construction activities and streambank erosion, as the major cause of the water quality impairment (Mostaghimi et al., 2003). Streambank erosion at the Heth Farm is particularly severe due to past stream channelization, increased flows from upstream urban development, and livestock damage (Figure 2).

## Methods

A 500-m experimental reach was selected as the focus of channel degradation monitoring and modeling efforts (Figure 2). A series of over 250 erosion pins and scour chains were installed systematically throughout the experimental reach. A monthly monitoring program measured channel degradation for the period from July 2005 – June 2006. Point data were interpolated across individual bank segments to produce an estimate of soil erosion volume. Measured soil bulk densities were then used to calculate the estimated mass loading to Stroubles Creek from channel degradation.

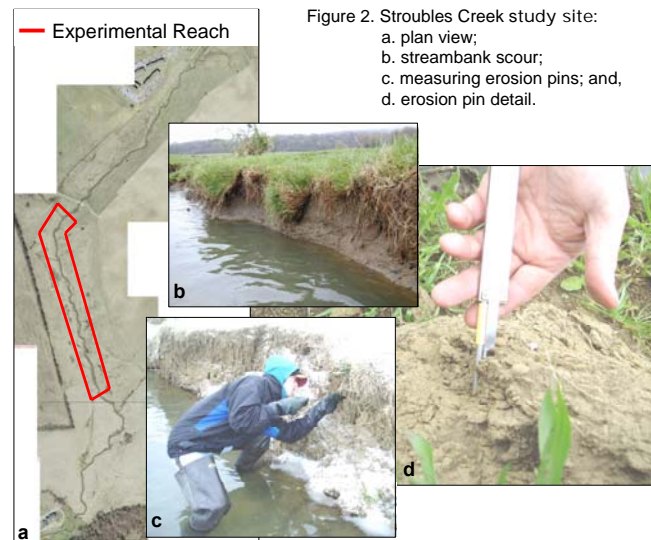


Figure 2. Stroubles Creek study site:  
a. plan view;  
b. streambank scour;  
c. measuring erosion pins; and,  
d. erosion pin detail.

Two watershed models and one reach-scale model were developed to predict sediment loading to the stream channel from channel degradation. The Generalized Watershed Loading Function (GWLF) was selected to represent watershed models with limited channel degradation process detail; the Soil and Water Assessment Tool (SWAT) represented the level of channel degradation detail seen in the majority of watershed models; and the CONSERVATION Channel Evolution and Pollutant Transport System (CONCEPTS) reach-scale model was used to evaluate the effectiveness of a detailed process model. To simulate a typical TMDL study, the models were not calibrated. Monthly model predictions were compared to retreat rates measured using the erosion pin and scour chain network.

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### References:

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- Simon, A., A. Curini, S. E. Darby, and E. J. Langendoen. 2000. Bank and near-bank processes in an incised channel. *Geomorphology*, 35(3-4):193-217.
- VADEQ. 1998. Virginia 303(d) Total Maximum Daily Load Priority List and Report. Virginia Departments of Environmental Quality and Conservation and Recreation: Richmond, VA.

## Results

- Measured sediment loading to the stream from bank retreat was 41 t/yr. GWLF, SWAT, and CONCEPTS predicted stream channel sediment contributions of 8 t/yr, 1500 t/yr and 4 t/yr, respectively.
- No significant agreement was found between any model predictions and measured retreat ( $\alpha = 0.2$ ).

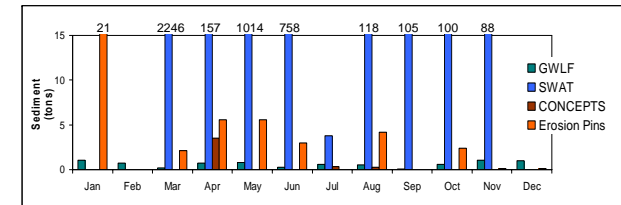


Figure 3. Comparison of model predictions and measured streambank erosion rates.

- GWLF underpredicted channel degradation, but most closely simulated observed data, likely due to similarities in climate and watershed characteristics between the study watershed and the Pennsylvania watersheds used for the bank model development.
- SWAT-predicted retreat rates exceeded measured values by two orders of magnitude
  - Daily flow and sediment discharge predictions were poor
  - Highly sensitive channel degradation parameters and the lack of calibration data also contributed to SWAT simulation error.
- CONCEPTS predicted erosion rates slightly less than GWLF.
  - Error resulted from limited input data availability and error in daily discharge predictions from SWAT
  - Underpredictions also resulted from poor estimation of sensitive sediment input parameters
- Screening-level watershed models are useful in channel degradation prediction
- Flow and sediment time series discharge data are important for detailed process-based simulation; SWAT and CONCEPTS should only be used for evaluation if appropriate input data are available.
- The limited flexibility of the GWLF channel degradation algorithm makes it unsuitable for evaluating the effects of stream restoration.

## Future Work

- Future research will focus on the development of a long-term flow and sediment monitoring data to allow more accurate modeling and better assessment of channel restoration impacts on channel degradation.
- Further modeling with GWLF in geographic regions outside the eastern United States is needed to determine the range of applicability of the empirical GWLF channel degradation relationship.
- Additional research should also focus on the significance of subaerial processes for watersheds of various sizes and on the development of algorithms to simulate these processes.