INTRODUCTION

The Swift Creek landslide is a large active landslide located west of Everson in northwest Whatcom County, WA (Figure 1). The slide produces large quantities of asbestos laden sediment that flows down Swift Creek into the Sumas River, which flows north into British Columbia, Canada. This is problematic because the asbestos fibers pose a risk to human health (Bayer, 2006; EPA, 2006). Knowledge of what factors affect the amount of sediment being eroded from the slide and an accurate quantification of the sediment discharge into the south fork of Swift Creek (Figure 2) is crucial to develop remediation plans.

Swift Creek Watershed

Watershed Characteristics
- Washed Area ~ 0.5 km²
- Elevation range from 35 m to 1040 m

Swift Creek Landslide

The slide is classified as slow moving and deep seated (McAnaney-Johnson, 2004) (Figure 3). There are three basic zones defined by their characteristic morphology and motion: the zone of depletion, the neutral zone, and the zone of accumulation (Figure 4). Small failures frequently initiate on the toe and release turbidity flows into the stream. These small superficial failures have been recorded by time lapse photography as part of the Western Washington Landscape Observatory (Linneman and Clark, 2006). In addition to small failures on the toe, abundant surface erosion results from rainfall on the unvegetated surface.

GIS Input Grids

- 10 m x 10 m DEM (Figure 7)
- STATSGO Soil type (Figure 8)
- Stream network (Figure 9)

Research Objectives

We have used the Distributed Hydrology-Soil-Vegetation Model (DHSVM) to model the stream discharge and DHSVM turbidity model to model the suspended sediment concentration of Swift Creek. The model is intended to provide insight to the primary hydrologic parameters that are causing erosion from the landside and to quantify a volume of suspended asbestos sediment that is being transported and deposited downstream. Preliminary modeling results are shown on this poster.

The steps to accomplish my research objectives include the following tasks:
- develop the grid-based DHSVM input for the Swift Creek watershed
- collect stream discharge data for Swift Creek and calibrate the DHSVM stream flow output to the measured data
- collect and format the meteorological time series for the model
- measure sediment concentrations in the creek at various flow rates and calibrate the DHSVM to the measured sediment load
- perform numerical experiments on the model outputs and analyze the results

Calibration Problems

- Limited discharge data and rapidly changing stream-bed morphology
- Unconstrained soil hydrometric and mechanical properties for the landslide material

MODELING METHODS

Distributed Hydrology-Soil-Vegetation Model and Sediment Module

DHSVM is a physically based, distributed hydrology model that simulates a water and energy balance at the pixel scale of a digital elevation model (DEM). It has been applied predominantly to mountainous watersheds in the Pacific Northwest to simulate hydrologic responses to weather and land use conditions (Wigmosta et al. 1994). The turbidity model predicts mass wasting and hill slope erosion (Figure 6). The sediment module is coupled with DHSVM and relies on the soil moisture, surface water, and stream flow as inputs for predicting mass wasting and erosion in order to quantify sediment yield (Dolen and Lettenmaier, 2004). The model captures the major events but seems to over predict the latter sampling dates. Discharge measurements were collected quarterly and the stream gauge was unable to function properly due to rapidly changing stream bed and turbulent flow that would occasionally derail the collection device.

DHSVM Sediment Module

Preliminary calibration efforts focused on the first major storm (Jan 6, 09 to Jan 9, 09) where water samples were collected for suspended sediment concentration (SSC) analysis. Although the simulated series has an obvious point at the leading edge of the SSC curve, the magnitude of simulated and measured concentration coincides. This was accomplished by increasing the soil cohesion and decreasing the angle of internal friction of the landslide portion of the basin. We believe this reflects the conditions of the toe because of the highly disturbed setting and the ability of the material to rapidly fluctuate, even in energetic water.

Field Methods

Stream Data

A stream gauging station mounted on the Goodwin Road bridge crossing Swift Creek (Figures 2 and 11) was designed to continuously record stream stage and turbidity using the Turbidity Threshold Sampling (TTS) method. This method is commonly used by the Pacific Southwest Research Station of the United States Forest Service (Leaves and Eads, 2008). Physical water samples are drawn by an SSC water sampler when triggered by rising or falling turbidity passing specified thresholds. The samples were analyzed for suspended sediment concentration (SSC). The stream gauge survived the erratic and turbulent nature of the stream, but a site with more consistent flow and constant bed shape would improve the data quality. Also, a polyethylene type stage recorder is unsuitable for this stream because of the changing stream bottom and turbulent water.

Meteorological Data

Meteorological inputs required by DHSVM:
- Precipitation (m)
- Relative Humidity (%)
- Temperature (°C)
- Longwave Radiation (W/m²)
- Wind Speed (m/s)
- Shortwave Radiation (W/m²)

Meteorological data were obtained from nearby climate stations in Whatcom County, WA (Figure 1). The Swift Creek Watershed is equipped to measure precipitation and temperature (Figure 12).

Discussion

The turbidity data that was recorded during this storm has no correlation to measured SSC that can be determined with only two SSC measurements. However, over the entire sampling season there are time periods that had a visible correlation with discharge, usually found during times of mid-low flow.

Water samples were collected on each site visit. The SSC sampler worked well once the appropriate threshold values were incorporated into the turbidity data logger sampling program. Other times the hose and sensor were either resting on the bottom, buried, or frozen causing erroneous or no data to be collected.

Preliminary Data

Discharge and Suspended Sediment Concentration

REFERENCES


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