MODELING SEDIMENT TRANSPORT DURING OVERBANK FLOW IN THE RIO PUERCO, NEW MEXICO

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Abstract: Reach-averaged in-channel flow within an 81-km segment of the lower Rio Puerco, New Mexico, has been modeled successfully using a physically based model for steady, horizontally uniform flow applied to reach-average channel shapes, bed gradients, and shrub characteristics. These characteristics were determined from survey data obtained in April 2002. Long segments of this channel have dense shrub willows or tamarisks growing on the banks and floodplain. Model results for three specific flows that left silt lines on the stream banks were found to be accurate as long as the shrubs on the stream banks were included, and they indicate rates of infiltration into the upper banks are high.

Prior to flow going overbank, the bed of the Rio Puerco is coated with a clayey silt, but once the flow reaches a bankfull depth, the cohesive layer of clayey silt is broken and the sand beneath goes into suspension. During overbank flows, form drag on the shrubs reduces flow velocities so that fine to very fine sand in suspension is deposited on the channel levees, and silt and clay are deposited on the floodplain, rather than sediment being carried back into the channel. As a result, the channel bed and floodplain have been aggrading since the 1970s, and the average annual sediment loads carried from the Rio Puerco into the Rio Grande have been reduced by about one-half. In contrast, prior to the 1970s the stream channel was wider and braided, and there were few shrubs along the banks, allowing much larger sediment loads to pass through the system into the Rio Grande. During this period, large amounts of sediment from the Rio Puerco ended up in Elephant Butte Reservoir.

In order to investigate the effectiveness of the riparian shrubs in promoting levee deposition and, thereby, maintaining a stable single channel morphology, we have added overbank flows to the above-described, in-channel flow model. The first step in this effort was the quantitative examination of weak overbank flows. Details of channel and floodplain stratigraphy mapped at two trench sites located at the upstream and downstream ends of a 27-km reach show that an overbank flow in August 1999 deposited very fine sand on the levee surfaces next to the channel to average depths of about 0.24 m. Flow discharge, suspended sediment concentration, volume of sediment scoured from the channel bed and volume of sediment deposited on the levees through the 27-km reach have been calculated for that overbank flow.

When sand is in suspension, a concentration gradient often exists in the water column, with concentrations decreasing away from the bed. Effects of density stratification due to the suspended sediment concentration gradient are included in the calculations. Woody vegetation on channel banks reduces near-bank flow velocities and boundary shear stresses, resulting in a lateral suspended sediment concentration gradient, with decreasing concentrations toward the edges of the channel. Turbulent diffusion of sand from the center of the channel into the near-bank area with shrubs causes a high rate of sand deposition on the steep (~30º) channel banks. Our hypothesis is that this results in mass movement of sediment down the bank toward the center of the channel, driving a secondary circulation that is toward the center of the channel at the bed, vertical (upward) near the center of the channel, and toward the banks near the surface. Velocities calculated for the secondary current using the rates of sand deposition initiated from lateral diffusion indicate that sand in the upper part of the flow is advected overbank onto the levees and deposited on levee surfaces next to the channel. Our calculations show that sand deposition on the levees is substantially enhanced by the presence of the shrubs. Efforts to remove riparian shrubs along the Rio Puerco currently are underway. Once the riparian shrubs are removed from the lower reaches, pre-1970 sediment transport rates are likely to resume.