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Improving a Streambank Stability Model for Seepage Processes: An Improved River Restoration Tool

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Abstract:

Seepage has been suggested as an important factor in gully and river bank erosion although current streambank stability models neglect such processes. Some of the complexity regarding seepage stems from the fact that seepage can cause hillslope instability through three different but interrelated mechanisms: (1) decrease in soil shear strength due to increased soil pore-water pressure and decreased apparent cohesion, (2) increase in driving forces due to seepage gradient forces, and (3) seepage particle mobilization and undercutting. The objective of this research was to incorporate these interrelated mechanisms into a streambank stability model commonly used for river restoration and demonstrate the importance of each mechanism. Seepage gradient forces were incorporated into a combined Bank Stability and Toe Erosion (BSTEM) model interfaced with a ground water flow code. Improved sediment transport models and geometric headcut relationships were derived for the process of seepage particle mobilization and undercutting using three-dimensional, laboratory soil block experiments. Modeling was performed on three river systems with contrasting soil types and layering and fluvial conditions: Little Topashaw Creek and Goodwin Creek in Mississippi and Cow Creek in Oklahoma. This modeling demonstrated the uniqueness of conditions that can lead to streambank instability by ground water seepage mechanisms.

Impact Statement:

Select erosive events in many areas across the United States lead to high sediment loading in rivers and streams. This sediment loading must be addressed through riparian management. However, the range of possible solutions remains limited until we better understand the surface water/ground water interactions. This research has significantly extended theory on the role of ground water in erosion and provided new tools for multidisciplinary researchers to determine the importance of seepage and erosion undercutting for numerous soils, hydrologic, and environmental conditions. The integration of seepage gradient forces and undercutting into a bank stability model has lead to the development of a dynamic riparian simulation tool which links bank stability with the adjacent, riparian groundwater system, creating a critical tool for stability analyses in river rehabilitation.

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