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Quantifying the uncertainty in riverbank erosion for risk-informed river engineering

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Riverbank erosion is a ubiquitous, natural process. Typically, it occurs during larger flood events when the applied forces exerted by the flowing water on a bank exceed some erosion-resistance threshold. Riverbank protection may be needed when critical infrastructure is present or planned near eroding banks, which requires the quantification of the risk of infrastructure failure by bank erosion. Similarly, renaturalization of many European streams, for example through removal of bank protection measures, necessitates the quantification of expected river width adjustment. Unfortunately, we have been unable to accurately quantify bank erosion rates to date. Limitations exist in characterizing both the applied and resisting forces. For example, bank roughness co-evolves with erosion, which makes it difficult to adequately resolve the forces acting on the bank material. Bank material erosion-resistance of fine-grained soils varies significantly, that is over orders of magnitude, both spatially and temporally. Moreover, existing techniques to measure bank material erosion-resistance do not always produce repeatable results. As a consequence, existing bank erosion models, such as the widely used Bank Stability and Toe Erosion Model (BSTEM), require extensive calibration and validation. This is often unsatisfactory to river engineering professionals that have to make decisions on where to place bank protection measures and the level of protection required. The decision-making process could benefit from a risk-based analysis that quantifies the uncertainty in calculated bank retreat rate. Recent enhancements to the BSTEM model allow users to input probability density functions of (measured) bank roughness and bank material erosion-resistance properties. A Monte Carlo analysis then quantifies the effects of both variability and uncertainty in these parameters on bank retreat. We will present how the shape of different probability density functions affect the probability density function of bank retreat. Results will be further presented of application of the new model to assist in prioritizing riverbank restoration measures along the Lower American and Sacramento Rivers, CA, USA, to prevent failure of levees that protect the City of Sacramento from flooding.