Sediment Transfer-Storage Relations for Degrading Alluvial Reservoirs

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The routing of sediment through a drainage system is mediated by transfer-storage relations that are particular to each alluvial reservoir, which contains a channel and floodplain. We propose that sediment transfer rate for a given annual distribution of streamflow is a positive function of sediment storage and examine these relations for degrading reservoirs in which sediment is evacuated by incision and corrasion.

Previous laboratory experiments of sediment-starved channels that model gravel-bed rivers show rapid, linear degradation in initially unarmored beds during non-selective transport, followed by decreasing rates of incision with the onset of selective transport, armoring, and bed structuring. Together, these phases of incision produce nonlinear decreases in sediment output with decreasing bed elevation. A comparison of experimental results and numerical simulations of armoring indicates that the depth of incision achieved at a final low reference transport rate depends on initial transport stage and particle sorting. Typical values of Shields stress for gravel-bed rivers force deep incision in well-sorted material ($\text{sigmaG}<1$) and shallow incision (a few surface layers or less) in poorly sorted material ($\text{sigmaG}>1.5$). This contrast suggests that changes in storage in response to variations in sediment supply are small in river reaches with poor sorting and large in those with superior sorting.

Nakamura and Kikuchi [1996] find that, in the absence of large floods, the annual rate of erosion of floodplain surfaces decreases exponentially with age. We use their model for corrasion in the Saru River, Japan, and arbitrary functions for rates of incision suggested by our previous analysis to simulate degradation over a 40-year period, starting with an initially filled alluvial reservoir. Storage volume decreases more rapidly than exponential regardless of whether or not incision is modeled as exponential with time. This suggests that a general form of sediment transfer-storage relations for degrading alluvial reservoirs is positive and nonlinear.