Analysis of variations in channel width and sediment supply on riffle pool dynamics, before and after dam removal

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Abstract. Many gravel-bed rivers feature quasi-regular alternations of deep and shallow areas known as riffle-pool sequences, which in straight reaches are often forced by variations in channel width. The mechanisms responsible for the formation and maintenance of riffle-pool sequences are still poorly understood. There is also much uncertainty in the basic understanding of how fluvial systems respond and readjust to large sediment fluxes through time (i.e. dam removal). Here we present physical experiments, numerical modeling, and field observations aimed at improving our understanding of how downstream variations in channel width affect bed morphology and influence riffle-pool development, and how these features respond to changes in sediment supply. A two-dimensional morphodynamic model, Nays2D, is being used to explore interactions between the flow field, the sediment transport field, and the bed morphology for a channel with sinusoidal variations in width. Model predictions suggest that riffles form in wide sections of the channel while pools develop in channel constrictions, and these model results are being used to guide ongoing mobile-bed experiments we are conducting in a 21-cm wide, 9-m long flume. Artificial walls imposing a sinusoidal width variation have been installed in the flume, and during the experiments it is supplied with a constant water discharge and a sediment mixture of coarse sand and fine gravel. After riffles and pools develop under these equilibrium conditions, the sediment supply is increased to simulate dam removal. These physical and numerical experiments are complemented by observations from a natural experiment on the Elwha River in Washington State, where the largest dam-removal project in history is providing riffle-pool sequences with greatly increased sediment supply. Analysis of aerial imagery and repeat bathymetric measurements indicate that prior to dam removal, pools on the Elwha were co-located with local decreases in bankfull width. During dam removal, a pulse of sediment temporarily filled in the pools and increased the overall sediment transport capacity of the river, but eventually most of the pools re-emerged at their prior location, suggesting that width imposes an important and long-term control on bed morphology.

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