Air, Water and Aquatic Environments
Science Program
Rocky Mountain Research Station

Focus: Hyporheic Exchange in Gravel Bed Rivers with Pool-Riffle Morphology

Research | Technology Transfer | Science Application

Key Findings:

- Lab experiments show that hyporheic exchange in pool-riffle channels is driven by interactions between stream flow and local channel topography; it varies with discharge.
- A three-dimensional model was developed that successfully predicts observed hyporheic exchange.
- Predicted patterns of hyporheic flow are spatially and temporally complex, creating a highly diverse environment that may cause benthic species to adapt to seasonal variations in stream flow.
- Two consecutive stages of mixing characterized by fast and slow rates of exchange produce two volumes in the hyporheic zone: a shallow one due to fast rates of exchange, and a deeper layer that experiences slower rates of exchange and therefore is less coupled with the in-stream water.

Challenge

Hyporheic exchange (the mixing of stream flow and shallow groundwater) in gravel-bed rivers is poorly understood. These channels are particularly important habitat for salmonids, which incubate their offspring within the hyporheic zone, and are currently at risk worldwide.

Context

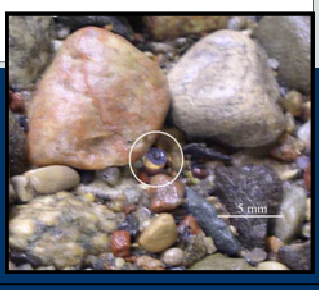
The hyporheic zone is a band of permeable, saturated sediment surrounding a river, where stream flow and shallow groundwater mix. It includes riverbeds (shallow hyporheic zone), riverbanks, saturated sediments under dry bars (parafluvial hyporheic zone), and riparian and floodplain areas (floodplain hyporheic zone). It is characterized by intense physical and chemical gradients due to the mixing of groundwater and surface water by upwelling and down welling fluxes.

Actions

We conducted a series of laboratory experiments to explore physical controls on hyporheic exchange in gravel-bed channels, and used these results to test a three-dimensional model for predicting hyporheic exchange.

Results

Pool-riffle channels not only have complex surface hydraulics with spatially varying flow depths and velocities that change with discharge, but they also have corresponding spatial and temporal complexity of hyporheic flow, creating a highly diverse environment that may cause benthic species to adapt to seasonal variations in flow. Because of these physical heterogeneities, it is important to have a holistic perspective that links in-stream and hyporheic flows in studies of solute transport and aquatic habitat in pool-riffle channels. A companion study examines the effects of salmon spawning activity on hyporheic exchange and consequences for survival of salmon eggs buried within streambed gravels (Tonina 2005; Tonina and Buffington 2007).



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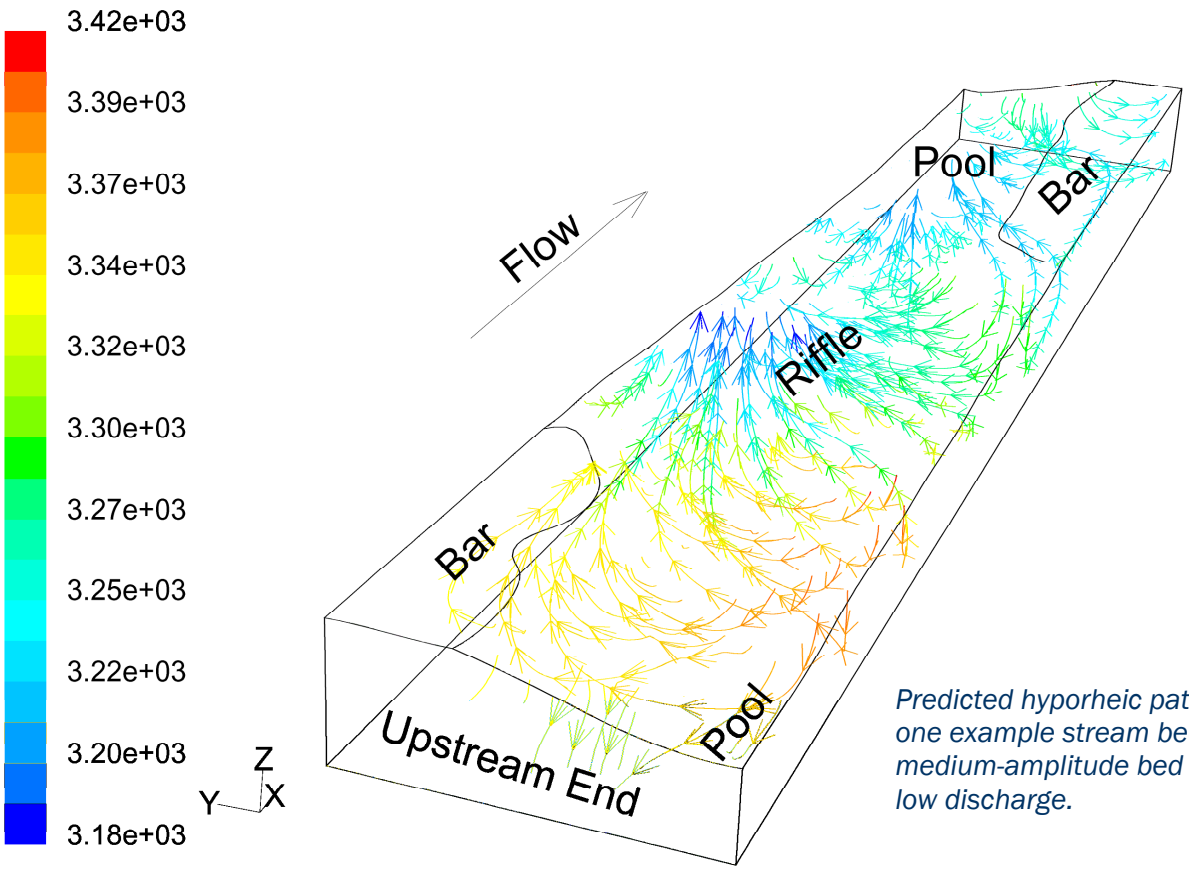
Products: Hyporheic Exchange in Gravel Bed Rivers with Pool-Riffle Morphology



Predicted hyporheic path lines for one example stream bed with medium-amplitude bed forms and low discharge.

Project Publications

Tonina, Daniele; Buffington, John M. 2007. Hyporheic exchange in gravel bed rivers with pool-riffle morphology: Laboratory experiments and three-dimensional modeling. Water Resources Research, 43: W01421, doi:10.1029/2005WR004328.

Related Publications

Tonina, D. (2005). Interaction between river morphology and intra-gravel flow paths within the hyporheic zone. Ph.D. dissertation. Boise: University of Idaho. 129 p.

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