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Pacific Northwest National Laboratory SFA: Influences of Hydrologic Exchange Flows on River Corridor and Watershed Biogeochemical Function

Tim Scheibe[1*] (PI), Xingyuan Chen[1], James Stegen[1], Maoyi Huang[1], Jie Bao[1], Yilin Fang[1], Tim Johnson[1], Hyun-Seob Song[1], Chris Strickland[1], Gautam Bisht[1], Jesus Gomez- Velez[2], Glenn Hammond[3], Heping Liu[4], and the SFA Team

[1] Pacific Northwest National Laboratory, Richland, WA
[2] Vanderbilt University, Nashville, TN
[3] Sandia National Laboratories, Albuquerque, NM
[4] Washington State University, Pullman, WA

Contact: tim.scheibe@pnnl.gov

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The PNNL SFA is developing predictive understanding of processes that govern influences of hydrologic exchange flows on water quality, nutrient dynamics, and ecosystem health in dynamic river corridor and watershed systems. Exchange of water between rivers and subsurface environments (hydrologic exchange flows or HEFs) are a vital aspect of watershed function.

HEFs enhance biogeochemical activity and modulate water temperatures, thus playing a key role in water quality, nutrient dynamics, and ecosystem health. However, these complex processes are not well understood in the context of large managed rivers with highly variable discharge, and are poorly represented in system-scale quantitative models. The PNNL SFA is studying the biogeochemical and ecological impacts of hydrologic exchange flows and their cumulative impacts at reach to watershed scales. Using the 70-km Hanford Reach of the Columbia River as our primary research domain, the project emphasizes three integrated elements:

1. *Development of fundamental understanding of the effects of river dynamics and organic carbon character on biogeochemical processes.* We performed laboratory and field studies, including development of new sensor technologies, to characterize organic matter in diverse river systems and understand its impact on biogeochemical and ecological processes. We developed the WHONDRS network as an exemplar of community science to extend understanding beyond our own testbed site.

2. *Incorporation of new understanding into mechanistic models of coupled hydrologic and biogeochemical processes in the river corridor.* We constructed new biogeochemical networks based on metagenomic and metabolomic information. We developed and tested a framework for modeling coupled river-subsurface processes, then applied it to a 7-km segment of the Hanford Reach encompassing multiple hydromorphic classes to quantify residence time distributions.

3. *Use of mechanistic models to develop reduced-order representations of the function of large-scale systems (reach to watershed) with emphasis on interactions between energy, water, and ecological subsystems.* We developed a reach-scale (70-km) model of subsurface flow linked to river stage variations and used it to study spatiotemporal variations in HEFs and temperature. We have used field observations and coupled subsurface-land surface models to evaluate the impacts of HEFs on land surface fluxes (e.g., through eddy covariance stations that recently joined the AmeriFlux network). We are also developing new field observations including geophysical sensing of riverbed characteristics and water quality monitoring, and have assimilated field observations into reach- and watershed-scale models to quantify cumulative impacts of local processes on watershed function.