Pacific Northwest National Laboratory SFA: Hydro-Biogeochemical Process Dynamics in the Groundwater-Surface Water Interaction Zone

PNNL SBR SFA (Laboratory Research Manager: Charlette Geffen)

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The PNNL SFA is developing a predictive understanding of the groundwater-surface water interaction zone (termed the subsurface interaction zone, SIZ). The SIZ is a ubiquitous and biogeochemically active domain within river corridor systems that controls contaminant, nutrient, and biogenic gas releases to surface waters. It is hydrologically dynamic, vulnerable to the effects of climate change, and includes but is not limited to the hyporheic zone where gradients in water composition and dissolved oxygen drive complex biogeochemical processes. Active carbon and nitrogen cycling occurs within the SIZ that are key to surface water quality and gas exchanges with the atmosphere. Using the 75 km Hanford Reach of the Columbia River as our research domain, overarching science questions on the function and impact of subsurface interaction zone are driven down from the reach scale to focus lower-scale scientific hypotheses and comprehensive field studies at the kilometer scale and below on essential system attributes, behaviors, and mechanisms for robust process model development. These questions relate to: i) hyporheic exchange flows and groundwater-surface water mixing, ii) residence times and pathways of different water sources, and biogeochemical processes and fluxes, iii) the composition and biogeochemical function of microbial communities across geochemical and temperature gradients, and iv) the nature, speciation, and energetics of organic carbon driving biogeochemical processes. A facies-based, multiscale simulation framework is being established to connect biogeochemical transport models across scales while preserving robust process descriptions derived at local field sites along the Hanford Reach and with field derived sediments in the laboratory. New microbial ecological models are being formulated and tested to translate microbial community composition and function into biogeochemical process rates controlled by environmental conditions. Our research on the subsurface interaction zone will provide essential knowledge and relevant models for rivers worldwide that flow through glacio-fluvial aquifers and for catchments with coarse-grained sediments that are vulnerable to climate change.