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

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The PNNL SFA is developing predictive understanding of the processes that govern influences of hydrologic exchange flows on water quality, nutrient dynamics, and ecosystem health in dynamic river corridor systems. Exchange of water between rivers and the surrounding subsurface environments (hydrologic exchange flows or HEFs) are a vital aspect of watershed function. HEFs lead to enhanced biogeochemical activity (accounting for up to 96% of respiration within river ecosystems) 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, particularly in the context of large managed rivers with highly variable discharge, and are poorly represented in system-scale quantitative models. Using the 75 km Hanford Reach of the Columbia River as our research domain, we have developed fundamental understanding in several areas including i) effects of groundwater-surface water mixing on ecological assembly processes, biogeochemical rates, and balance among metabolic pathways, ii) river water pathways and impacts on contaminant plume mobility, iii) physical controls on HEFs at kilometer scales, iv) impacts of microbial regulation processes on biogeochemical rates in response to changing environmental conditions, and v) the nature, speciation, and energetics of organic carbon driving biogeochemical processes. We established a facies-based multiscale simulation approach to incorporate new understanding into predictive models. Proposed research will build on this foundation to develop a fundamental and comprehensive scientific understanding of the influences of HEFs (in particular as driven by river discharge variations) on river corridor biogeochemical and ecological functions and to integrate this new-found scientific understanding into a first-of-kind hydrobiogeochemical model of the river corridor, linked as a critical component of watershed systems models. Accordingly, we will pursue the resolution of fundamental scientific hypotheses designed to advance understanding of coupled hydrobiogeochemical processes. At the same time, we will develop a hierarchical multiscale modeling framework that will integrate scientific understanding into a predictive watershed modeling capability with wide applicability. New predictive understanding of HEFs and biogeochemistry in the river corridor will play a key role in reduction of uncertainties associated with major Earth system biogeochemical fluxes, improving predictions of environmental and human impacts on water quality and riverine ecosystems, and supporting environmentally responsible management of linked energy-water systems.