Multi-Scale Mass Transfer Processes Controlling Natural Attenuation and Engineered Remediation: An IFRC Focused on Hanford's 300 Area Uranium Plume

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The Integrated Field Research Challenge (IFRC) at the Hanford Site 300 Area uranium (U) plume addresses multi-scale mass transfer processes in a complex and dynamic subsurface biogeochemical setting where groundwater and river-water interact. The site has 35 instrumented wells that are screened in the upper layer of the unconfined, near-river aquifer. It has a deep borehole for microbiologic and biogeochemical research that is screened in the lower, semi-confined region of the aquifer.

Significant, impactful progress has been made in CY 2011 and early CY 2012 including: i.) geophysical monitoring of winter precipitation infiltration through the U-contaminated vadose zone and spring river water intrusion 150 m inland to the IFRC site, ii.) injection experimentation to probe the lower vadose zone and to evaluate the transport behavior of high U concentrations released from the smear zone in the spring, iii.) extended passive monitoring before, during, and after the period of water table rise and fall, and iv.) collaborative down-hole experimentation with the PNNL SFA on the biogeochemistry of the Hanford-Ringold contact and the underlying redox transition zone. Collaborative microbiologic studies with the PNNL SFA have established a census of microorganism types present with the IFRC, with research now evolving to investigations of in-situ function and activity. Beyond these experimental efforts, geostatistical models of hydrologic and geochemical properties and adsorbed U distribution, and new hydrologic characterization measurements of the upper aquifer have been integrated into our site-wide reactive transport models (PFLOTRAN and eSTOMP). These increasingly robust models are being used to simulate past and recent U desorption-adsorption experiments performed under different hydrologic conditions, and to perform heuristic modeling to understand the complex functioning of the smear zone under dynamic hydroloigic conditions. Ongoing efforts to assimilate geophysical logging and 3D ERT characterization data into our site wide hydrophysical model have been successful, yielding a recently submitted manuscript

Our increasingly comprehensive field experimental results and robust reactive transport simulators, along with multi-scale field and laboratory characterization, are leading to a new conceptual model of U(VI) flow and transport in the IFRC footprint and the 300 Area in general Important insights have resulted on the microbiological community and associated biogeochemical processes influencing N, S, C, Mn, and Fe under the highly varied redox conditions present at the site. Collectively, these findings and higher scale models are providing a unique and unparalleled system-scale understanding of the biogeochemical function of the groundwater-river interaction zone.