Reactive Transport Field Experiments at the Hanford IFRC

Hanford IFRC (Principal Investigator: John Zachara)

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The Integrated Field-Scale Subsurface Research Challenge (IFRC) at the Hanford 300 Area addresses multi-scale mass transfer processes controlling U plume dynamics in a complex hydrogeologic setting. The site has 35 instrumented wells, which have been remediated to eliminate the effects of wellbore flow and focus testing on the uppermost portion of the aquifer, and an extensive monitoring system. During CY 2011, several significant, culminating experiments were performed on the revised well field, involving reactive transport. In the spring, an experimental campaign investigated U desorption and reactive transport processes in this uppermost aquifer zone. The experiment involved injecting groundwater containing low U concentrations and a conservative tracer over a two week period. The experimental objective was to create an extended zone of low U concentration groundwater within the IFRC well field that induced desorption of adsorbed U from the aquifer sediments. In the fall, a series of uranium adsorption and desorption experiments were conducted with the objective of providing information about uranium mass transfer processes and kinetics for high concentration U pulses released from the lower vadose zone. The experimental design for the first two injection experiments consisted of two operationally similar injections of groundwater containing elevated uranium concentrations mixed with make-up water of different chemical composition (one groundwater, the other filtered river water with a lower bicarbonate concentration). During each of the injections, the high U test solution (~ 600 μg/L, baseline concentrations within the wellfield were on the order of 100 to 150 μg/L) was spiked with a unique conservative tracer and injected into the uppermost, high permeability portion of the aquifer. These two injection tests were nearly identical except for the makeup water composition and anionic tracer species used. This test configuration made it possible to interrogate the effect of injection solution chemical composition on uranium mass transfer processes. The third experiment, which utilized an injection solution containing elevated uranium concentrations (750 μg/L), filtered river water as the make-up water, and a third unique ionic tracer, targeted a lower permeability intermediate depth interval of the aquifer. These injection experiments have collectively revealed that U retardation is very low in the extremely high permeability aquifer materials comprising the uppermost portion of the aquifer. Although U retardation is relatively small in the high permeability upper zone, a comparison of U transport response for the different solution chemical compositions demonstrated increased mass transfer for the lower bicarbonate concentration river water case. In addition, U adsorption/desorption processes were greatly increased in the lower permeability intermediate zone. The increasingly comprehensive field experimental results, along with the field and laboratory characterization, are leading to a new conceptual model of U flow and transport in the IFRC footprint and the 300 Area in general.