Facies-based mapping of hydro-biogeochemical attributes to subsurface and surface water interaction zone at the Hanford site

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Abstract: A facies conceptualization can be employed in a complex multiscale hydro-biogeochemical (HBGC) modeling system as a vehicle for reducing system complexity and analyzing inter-scale relationships. In this study, we aimed to identify hydrogeological facies at the Hanford Reach for both river bed (i.e., recent alluvium) and older subsurface strata (i.e., Hanford and Ringold formations, both inland and beneath the recent alluvium), develop reliable relationships linking facies to HBGC attributes, and eventually assign HBGC properties to the modeling domain in terms of multiple field realizations at multiple scales as required inputs for multiscale modeling and uncertainty quantification of subsurface-surface water interaction processes. For the river facies definition, the Folk-Wentworth classification and hybrid hierarchical clustering approaches were applied to particle size data from freeze-core sediment samples collected from several campaigns. The lithofacies developed from the particle size data are then compared to the river bathymetry data and thermal imagery data with a much larger extent and spatial coverage, for extension of the facies definition to larger scales covering areas with few sediment samples. Supplementary constraints for the river facies definition are derived from geophysical measurements and geologic mapping along the river bank. For example, surface-based 3D time-lapse electrical resistivity tomography (ERT) helps identify the preferential flow paths and illuminate the shape of the lower confining unit of the aquifer; while induced polarization measurements are being used to map mud layer thickness along the river bed (see poster by Johnson et al.). HBGC properties are then mapped using geostatistical methods to the river bed layer by sampling from the property distributions for each facies using options such as locally varying mean. Subsurface facies are being defined separately for the high-permeability Hanford and low-permeability Ringold formations, using existing particle size data. The Hanford–Ringold contact, a key hydrologic feature, is being mapped stochastically, and will be extended beneath the river. The transition probability indicator simulation method will be used to map lithofacies in the subsurface modeling domain. HBGC properties will then be mapped to the lithofacies using geostatistical methods. The approach for development of an integrated lithofacies model of the river bed and older subsurface strata over multiple scales will initially be developed in the 300 Area, where relatively dense data can be used to test the stratigraphic and lithofacies models. The approach will then be extended to the larger domain of the Hanford Reach following refinement and optimization.