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INTEGRATED FIELD RESEARCH CHALLENGE SITE
Hanford 300 Area

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Placing the Hanford 300 Area IFRC Site in Perspective: Plume Scale Modeling of Uranium Attenuation and Its Flux to the Columbia River

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Hanford 300 Area Plume Scale Conceptual Model

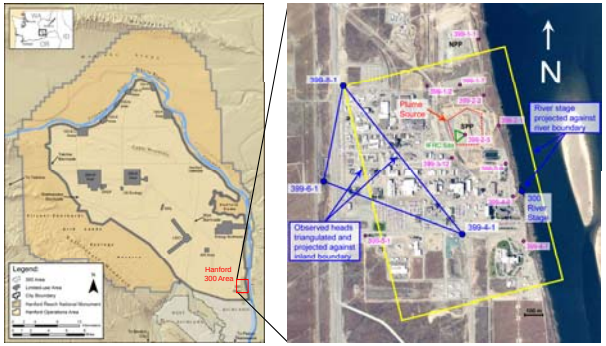

Figure 1. Computational domain (yellow) showing the locations of the North and South Process Ponds (NPP & SPP), IFRC field site, and observation wells. The transient inland boundary condition at the western edge is constructed by projecting head data obtained from wells 399-8-1, 399-6-1 and 399-4-1 onto the western boundary. Transient Columbia River stage is projected onto the river boundary to the east. U(VI) initial condition representative of current *in situ* concentrations with a hypothetical continuous source term.

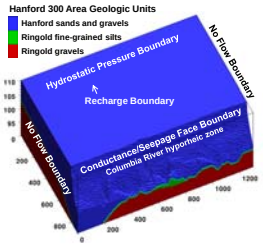

Figure 2. Plume scale model material types and boundary conditions. The vertical axis is magnified by 36x.

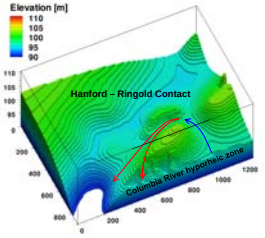

Figure 3. Undulating Hanford-Ringold contact. During high river stage groundwater flow is westerly through gap while southeasterly through valley at low stage.

Uranium Plume in October Time Frame

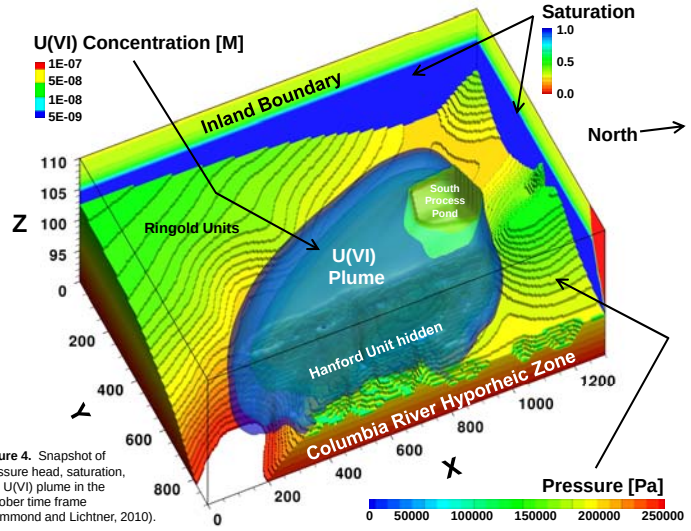

Figure 4. Snapshot of pressure head, saturation, and U(VI) plume in the October time frame (Hammond and Lichtner, 2010).

PFLOTRAN Simulations

Problem domain: 900×1300×20 meters
Grid resolution: $\Delta x = \Delta y = 5$ meters, $\Delta z = 0.5$ meters
Grid size: 180×260×40 grid cells
chemical species: 15 primary, 88 secondary, 2 minerals (metatorbernite k = 2e-17 mol/cm^3/s), 2 surface complexes
Total # of degrees of freedom (unknowns): ~28M
Supercomputer: ORNL NCCS Jaguar Cray XT4/XT5
Computing: 4096 cores (single realization), 40960 (multi)

Acknowledgements

This research is supported under the U.S. Department of Energy SciDAC-2 program with funding provided by DOE Offices of Biological & Environmental Research (BER) and Advanced Scientific Computing Research (ASCR). Supercomputing resources were provided by the DOE Office of Science Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program through an allocation on NCCS Jaguar at Oak Ridge National.

References

Hammond, G.E. and P.C. Lichtner (2010, under review) Field-Scale Modeling for the Natural Attenuation of Uranium at the Hanford 300 Area using High Performance Computing, submitted to *Water Resources Research*.
Hammond, G.E., P.C. Lichtner and M.L. Rockhold (2010, accepted) Stochastic Simulation of Uranium Migration at the Hanford 300 Area, submitted to the *Journal of Contaminant Hydrology*.

Key Findings and Observations

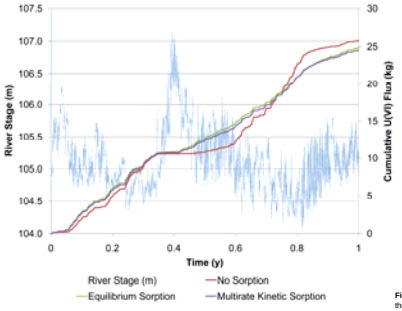

Figure 5. Columbia River stage and cumulative U(IV) flux to the Columbia River for equilibrium sorption, multirate kinetic sorption and no sorption with a continuous release of non-labile U(VI) from the source zone (Hammond and Lichtner, 2010).

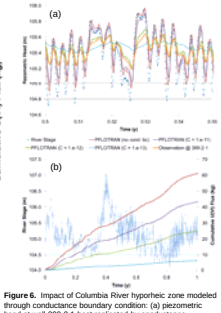

Figure 6. Impact of Columbia River hyporheic zone modeled through conductance boundary condition: (a) piezometric head at well 399-2-1 best replicated by conductance coefficient C = 10^{-2} (dots represent temporal resolution of river stage data set); (b) cumulative U(VI) flux to river as a function of conductance coefficient C.

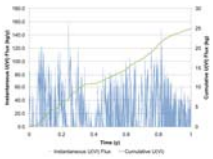

Figure 7. Comparison of cumulative versus instantaneous U(VI) flux for equilibrium sorption.

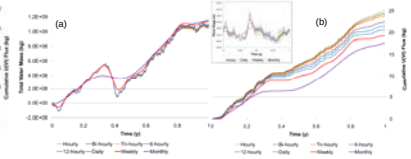

Figure 8. Comparison of cumulative (a) water and (b) U(VI) flux to Columbia River versus smoothing interval. To perform smoothing, a convolution integral was applied to the inland well and river stage data. The smoothed river stage is shown in the inset of (b).

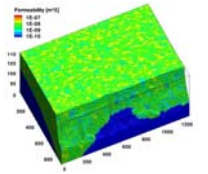

Figure 9. Representative realization of permeability generated from IFRC characterization data.

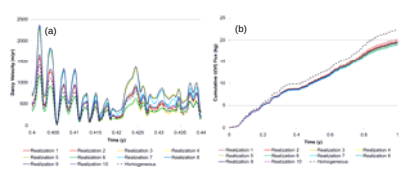

Figure 10. Comparison of (a) Darcy flow velocity and (b) cumulative U(VI) flux for ten realizations of heterogeneous permeability and a homogeneous permeability data set based on the mean of the random fields (Hammond et al., 2010).

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