Geologic Modeling and Data Visualization for Complex Sites: A Contaminant Fate and Transport Fractured Bedrock Case Study

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Background/Objectives. This presentation discusses the value added and lessons learned from using geologic modeling and data visualization tools during site characterization and remediation activities at a complexly fractured bedrock Superfund Site impacted by a 207-acre dissolved phase TCE plume. The site's geologic history (depositional environment, tectonics, and Quaternary geomorphology) produced physical features such as stratigraphic horizons and deformational structures which regulate contaminant fate and transport. Groundwater flow within the pore-cemented siltstone bedrock at the site is predominately through secondary porosity (i.e., fracture flow). Various approaches to evaluate site data were employed through remedial investigation and treatability study phases of the project to date. Geologic modeling and data visualization tools have proved valuable, if not essential, to developing a more accurate conceptual site model and have facilitated additional investigation activities and design of targeted remedial strategies. However, as with any tool, there are limitations and risks that should be considered along with the advantages and benefits provided.

Approach/Activities. During the remedial investigation phase, 32 wells were installed in bedrock to depths of up to 500 feet below ground surface. Downhole geophysical tools were employed in the majority of boreholes producing a large data set. Fractures at the site have variable density of occurrence and several dominant orientations (low-angle bedding plane partings and high-angle joint-set and fault-related tensional fractures). To evaluate fate and transport at the site, the volume of fracture data necessitated several approaches to determine the dominant orientations of bedding and tensional fractures. Preliminary efforts to accomplish this included stereoscopic analysis and spreadsheet-based data reduction and pattern matching exercises. Additionally, site data were loaded into the Rockworks® software program to generate a georeferenced borehole database of features including lithology, stratigraphy, well construction details, geophysical point data, and aqueous geochemistry collected at the site over time. This software, in conjunction with other visualization programs, was used to generate statistical calculations, three-dimensional stratigraphy and plume models, cross-sections, plan-view maps, and other graphical outputs to facilitate data interpretation and presentation. Additionally, a treatability study was completed to evaluate the delivery and performance of bioaugmentation for enhanced reductive dechlorination of TCE in groundwater. During this phase, cross-sectional views of the treatment area were generated to visualize the distribution of contaminants, water quality parameters, and substrate delivery tracers over time. Current and future activities utilizing geologic modeling and data visualization tools include enhanced stratigraphic correlation, additional source zone delineation, targeted monitoring/injection well siting, and evaluation of remedial progress.

Results/Lessons Learned. The use of data visualization tools and geologic modeling software to process complex data sets resulted in a refined conceptual site model, enabled efficient production of numerous cross-sections and other graphics for interpretation and project planning, and facilitated effective presentation of results to stakeholders. While manual data reduction/evaluation and production of cross-sections is possible without these tools, it can be time consuming or cost-prohibitive at large, data-dense sites. Additional examples of added value, potential limitations and risks, and lessons learned will be shared in the presentation.