Virtual Site Investigation: Using Perfect Information to Evaluate Strategies for Conceptual Site Model Development at DNAPL Sites

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Background/Objectives. The development of a conceptual site model (CSM) is an essential step in the selection, design and optimization of a remediation approach. There is uncertainty associated with any CSM, including with respect to hydrogeological, chemical and biological conditions. While it is expected that increased investigation efforts will reduce this uncertainty, there is little guidance available concerning decisions on investigation tool selection, sample location, and overall investigation strategy to reduce CSM uncertainty. Evaluation of a CSM, and approaches for CSM development, are complicated by the lack of perfect information. For example, the geological conditions, groundwater flow field, and contaminant distribution at small scales (e.g., a few feet) are not known at every location across a site. Therefore, it is difficult to assess the accuracy of a CSM. However, it is important that relationships between investigation strategies and CSM accuracy be established, with a view towards optimizing those strategies to collect more valuable information at less cost and to support remediation decision making.

Approach/Activities. The SERDP DIVER (Data Information Value to Evaluate Remediation) project has developed a series of three virtual data sets (VSDs), which represent hypothetical DNAPL-impacted sites of varying complexity. Virtual site conditions were established using high-resolution numerical simulations (on the order of 10^0 m horizontally and 10^{-1} m vertically) of DNAPL migration in combination with DNAPL dissolution and reactive transport of the dissolved VOC plume over a period of decades. Four decision maker (DM) teams, made up of some of the most experienced and senior practitioners in the industry, were provided with synthetic Phase I reports containing detailed site history and the results of preliminary site investigation. Each team then conducted a virtual investigation of each of the VSDs, using post-processing algorithms designed to mimic a variety of investigation tools (e.g., borehole logs based on drilling, hydrophobic dye tests, monitoring well installations, MIP profiles, slug tests) and sample types (e.g., soil samples, groundwater samples, Gene-Trac), and administered independently by the project team. The virtual investigations were conducted for the purpose of designing an EISB system with known remediation objectives, and the virtual cost of each investigation was recorded. CSMs developed by the DM teams, based on their virtual investigations, were compared to the true values known from the simulation results on the basis of multiple metrics, including DNAPL mass and location, plume mass and location, and VOC mass discharge.

Results/Lessons Learned. This comparison between known site conditions to CSMs developed by leading practitioners based on realistic, high-resolution information from multiple investigation tools offers a unique opportunity to evaluate the accuracy of CSM development strategies. Various strategies were deployed by the DM teams, with greater variation between teams than between sites of different complexity. These strategies included inside-out and transect approaches, with substantial use of MIP in earlier mobilizations. Results showed good accuracy with respect to plume investigation (e.g., delineation, dissolved VOC mass), but reduced performance for the DNAPL source metrics. The results also highlighted the

importance of both tool location and data analysis in the determination of many quantitative aspects of a CSM (e.g., DNAPL mass). Further analysis will establish optimal relationships between investigation strategies and the value of information obtained in site investigation, and will help to establish expectations for the accuracy of CSMs for DNAPL-impacted sites.