Novel 3D-Modeling Approach for Sites with Complex, Well-Characterized Geology

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Background/Objectives. At a former landfill site impacted with volatile organic compounds (VOCs), a comprehensive geologic and groundwater model was created to inform the design of a groundwater remedy involving a barrier wall and extensive extraction well network to obtain boundary control of migrating groundwater and soil vapor over several thousand linear feet. The site is underlain by a gently sloping alluvial plain, where hydrogeologic zones consist of mostly fine-grained low permeability units with discontinuous high permeability regions that form a complex heterogeneous and interbedded aquifer system. C Tech's Environmental Visualization Studio (EVS) software was used to develop a comprehensive 3-D geologic model from 233 highly-detailed soil boring logs. The EVS model was imported to MODFLOW using a custom code that the authors developed specifically for this purpose.

Approach/Activities. Initially, a 3-D finite difference grid was constructed using a Hierarchical Kriging method in EVS and imported into MODFLOW USG. This version consisted of 56 layers, each representing a zone of uniform hydraulic conductivity. An attempt was made to simulate the complex geology using the EVS pinch-out feature; however, the discontinuous geology resulted in many challenges in MODFLOW USG with model computation and converging. Ultimately, it was determined that using Hierarchical Kriging and MODFLOW USG was not the best fit for modeling the site's complex geology and hydrogeology.

The final model was constructed in EVS with a 3-D rectilinear grid and using a Geologic Indicator Kriging (GIK) method. The geologic model consists of approximately 120,000 active cells, and the MODLFOW model has 1.2 million active cells, following refinement in the area of interest near the future barrier wall. EVS was used to assign one of four hydrologic conductivity zones (sand with fines, clay, sand, or gravel) to each cell in the model based on imported boring log data. Exporting the grid and hydraulic conductivity zone data from EVS and importing this information into Groundwater Vistas presented particular challenges.

Results/Lessons Learned. Using an external 3-D geologic modeling software package, such as EVS, to simulate a site's complex geologic environment results in an accurate and reliable groundwater model when imported into MODFLOW. However, in order to obtain the best results from MODFLOW, certain considerations must be made during the construction of the geologic model in EVS, primarily concerning the grid construction and kriging methods. The two software packages do not communicate well, and eventually the authors developed a custom code to enable the import. Using the model, the authors identified hydrogeologic data gaps that led to additional investigation and a refinement of both the numerical models and the overall conceptual site model.