Real-Time Identification and Characterization Approaches to Perched Water Zones

Ankit Gupta (ankit.gupta@arcadis.com) (Arcadis, Washington, DC, USA), Christopher Shepherd (Arcadis, Phoenix, AZ, USA), Jason Nail (Arcadis, Portland, OR, USA) and Wesley McCall (Geoprobe, Salina, KS, USA)

Background/Objectives. Perched water zones can act as significant sources of sustained recharge and resulting contaminant loading from vadose zone contaminant sources into underlying water table aquifers. Identifying and characterizing perched water zones and their associated hydraulics is critical in understanding vadose zone source areas of emerging contaminants like PFAS or energetic compounds like TNT that have high sorption potential to soil matrices, or naturally occurring metals and anions that can be mobilized by perched water into water table aquifer. If not properly characterized, one might miss the opportunity to either optimize the remedy in the best case, or implement a remedy that cannot address the source effectively in the worst case. Since the water table aquifer is often evaluated as the first water encountered in borings, the presence of a perched water zone may go unnoticed by traditional site characterization methodologies and can complicate the conceptual site model (CSM) due to incorrect interpretation of groundwater flow conditions. Temporal (seasonal) and lateral (geological) variations in the presence and absence of perched water zones can further confound traditional site characterization methods that are reliant on visual observations of wet soil cores (not usually reliable) or accumulation of groundwater within soil borings which may not be targeted at the right depth interval to intercept the perched water zone. With the advancement of high resolution site characterization (HRSC) techniques available in the market today, real-time approaches can be tailored for detection and characterization of perched water zones. The application of these technologies can provide significant benefits in understanding (1) the extent and depth of perched water zones, (2) the nature of underlying geology that leads to the pooling of water above it, (3) the degree of saturation in the underlying materials and (4) hydraulic connectivity between the perched water and the water table aquifer.

Approach/Activities. A careful evaluation of multiple real-time HRSC technologies (geophysical technologies like nuclear magnetic resonance [NMR], electrical resistivity imaging [ERI] and electromagnetic induction [EM], cone penetrometer testing [CPT], electrical conductivity [EC], hydraulic profiling tool [HPT], etc.) was undertaken to identify their specific applicability and their individual advantages and limitations relative to detecting and characterizing perched water zones. Following the review of HRSC technologies, a case study is presented involving potential chemical impacts from a perched water zone at a confidential site in Arizona where a combination of CPT and HPT in tandem was selected for evaluation of the perched zone.

Results/Lessons Learned. A review of the available real-time HRSC technologies with the specific advantages/disadvantages and limitations of each with respect to detection and characterization of perched water zones is presented. The criteria and rationale behind selection of CPT-HPT in tandem as the best suited tool is discussed, along with the nuances of using each individually and in tandem. The presentation will close with a discussion of the challenges faced and lessons learned with regards to regulatory approval, real-time data interpretation and field decisions, the sensitivity and precision of the technology as well as implications of the technology for evaluating vadose zone and aquifer hydraulics (gradients, degree of saturation, water levels, permeability, etc.) at a high resolution.