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Silicon Valley Case Study: Applying Environmental Sequence Stratigraphy and HRSC to Confirm Success of In Situ Bio and Manage Commingled Plumes

Mike Shultz (mrshultz@burnsmcd.com) (Burns & McDonnell, Concord, CA, USA)
Rick Cramer (rcramer@burnsmcd.com) (Burns & McDonnell, Brea, CA, USA)
Rebecca Mora (rebecca.mora@aecom.com) (AECOM, Orange, CA, USA)
Linda Niemeyer (laniemeyer@roadrunner.com) (Watermark, Carlsbad, CA, USA)
Herb Levine (levine.herb@epa.gov) (U.S. EPA, San Francisco, CA, USA)

Background/Objectives. This case study documents a site representative of many contaminated groundwater sites in the Santa Clara Valley, or "Silicon Valley" of northern California. Historic contaminant releases related to semiconductor and other electronics manufacturing resulted in extensive groundwater contamination (primarily chlorinated VOCs) in the basin. The groundwater table in the basin is relatively shallow (approximately 10 feet below ground surface), contaminant concentrations in groundwater may be high, and the highly urbanized area is characterized by dense commercial and residential construction. Particularly challenging with respect to groundwater contamination projects are the following:

- Heterogeneous geology that controls complex groundwater flow and contaminant migration.
- Multiple contaminant source areas that result in commingled regional groundwater contamination plumes.

At this site, successful contaminant source elimination (primarily TCE and PCE) had been accomplished over the past 15 years through enhanced reductive dechlorination (ERD) in situ remediation efforts that included injections of cheese whey and emulsified vegetable oil (EVO). As a final source remedy, the remaining impacted source area was excavated during site redevelopment. However, as a result of a recent CERCLA 5-year review, U.S. EPA noted concern for increasing chlorinated VOC concentrations at the downgradient monitoring wells and questioned the efficacy of source treatment.

Approach/Activities. To further evaluate the downgradient increase in contaminant concentrations, we updated the conceptual site model (CSM) by focusing on the geology and the distinctive source area chemical fingerprints resulting from successful on-site in situ ERD (e.g, vinyl chloride daughter product). We applied Environmental Sequence Stratigraphy (ESS) methods to existing data to refine the site stratigraphy and identified specific hydrostratigraphic units (HSUs) that were defined by buried sand channels. With the improved stratigraphic framework, the groundwater monitoring well screens and related groundwater chemistry data were re-analyzed with respect to the differing chemistry of the on-site versus off-site contaminant sources, and this suggested that the downgradient increase in concentrations was in fact coming from the off-site source.

A high resolution site characterization (HRSC) program was developed using direct-push membrane interface probe (MIP), hydraulic profiling tool (HPT), and collection of hydropunch groundwater samples at selected intervals. We also "calibrated" the MIP electronic conductivity (EC) response (as a grain-size indicator) against a continuous core. The purpose of this program was to address data gaps and ambiguous monitoring well data due to screened intervals that penetrated multiple HSUs.

Results/Lessons Learned. Through the combined approach of ESS and HRSC, the CSM was significantly improved as a tool to assess contaminant sources and migration. This solved the

question of the ambiguous downgradient chemistry data and confirmed the effectiveness of on-site source elimination. The lesson learned was that the existing data often have hidden value that can be exploited through improved geology-focused analysis (ESS).