Advanced Design Study for the Evaluation of Dyed EVO Distribution via Recirculation in a Complex Hydrogeochemical Setting

Anthony Brown (anbrown@trcsolutions.com), Brendan J. Lazar, PE, and Nidal M. Rabah, PhD, PE, LSRP (TRC, New Providence, New Jersey, USA)
Randy St. Germain (Dakota Technologies, Inc.)
Michael Lee (Terra Systems, Inc.)

Background/Objectives.
An extensive trichloroethene (TCE) groundwater plume was identified at a former industrial facility in central New Jersey as previously presented (Battelle, 2012; Battelle, 2017). The impacted unconfined aquifer to depths of 60 feet below ground surface (ft. bgs) is a complex hydrogeochemical setting with highly varying groundwater flow patterns, hydraulic and lithological divides and boundaries, elevated TCE concentrations in both groundwater (5 to >20 mg/L) and soils (100 to 500 mg/kg), and strongly acidic conditions. While an enhanced in situ bioremediation (EISB) interim remedial measure (IRM) was successful in the shallow zone, sustained and increasing concentrations at intermediate zone monitoring wells triggered a detailed pre-design investigation (PDI) identifying additional source areas and an extensive, previously uncharacterized plume between 15 and 35 ft. bgs. The PDI utilized high resolution techniques including direct-sensing, co-located groundwater/soil samples, advanced buffer demand testing, and 3-D visualization models for plume, lithology, and groundwater contours. The PDI and updated conceptual site model indicated numerous hydrogeological boundaries resulting in an elemental volume extending only 50 feet laterally and approximately 5 feet vertically in this highly heterogeneous formation. With data from multiple rounds of temporary injection points, operations utilizing permanent injection wells on a large scale were not well defined and required a detailed field design study to determine distribution trends over time, refine the limitations of the aquifer, and evaluate the overall effectiveness of recirculation with emulsified vegetable oil (EVO).

Approach/Activities. A detailed field design study was completed utilizing a number of injection wells distributed throughout the treatment area, and in a detailed setting, a series of injection, extraction, and monitoring wells under a continuous recirculation pumping regime. Injection step tests were completed before and after a full suite of EISB injections (EVO, buffer, and bioaugmentation) at various locations throughout the treatment area. In the detailed setting, 24/7 tests were sequenced over the course of 5 days such that a standard pumping test featuring a network of transducers and an ideal tracer study were followed by an ideal tracer released under continuous injection-extraction recirculation which was then followed by release of a non-ideal tracer under continuous recirculation at two separate locations, in two different vertical zones. The non-ideal tracer was prepared by Terra Systems, Inc. (TSI) as EVO mixed with Dakota Technologies, Inc. (DTI) proprietary fluorescent hydrophobic dye. Extensive calibration efforts were carried out in the lab and field for DTI's STarGOST high resolution profiling tool in order to assess dyed EVO distribution post-injection. STarGOST profiles and soil samples analyzed for total organic carbon and Fatty Oils and Grease were co-located and collected at a high density surrounding the injection wells.

Results/Lessons Learned.
Various hydrogeological and modeling tools (BIOSCREEN, QTRACER, AquiferTest, and AQTESOLV) were utilized to evaluate the design study results and complete predictive modeling for the design of the full-scale remedy. STarGOST and the FOG samples combined provided a strong qualitative and a defendable quantitative understanding of the distribution of dyed EVO.

This presentation will share practical approaches and lessons learned for EVO distribution in complex sites and insights into the challenges of buffering highly-acidic formations.