Long-Term Performance of a Carbon Barrier Evaluated through Integrated Use of Aspect Ratio, Passive Flux and Modelling Analytical Tools

Jeremy Birnstingl (jbirnstingl@regenesis.com) (REGENESIS, Bath, UK)
Chris Lee (clee@regenesis.com) (REGENESIS, Kenosha, WI, USA)
Craig Sandefur (csandefur@regenesis.com) (REGENESIS, San Clemente, CA, USA)

Background/Objectives. Injectable colloidal activated carbon (CAC) barriers are increasingly used in plume management. Their purpose can be to retard plume migration *per se* as in the case of non-degradable species such as PFAS, or to increase residence time of degradable species in a treatment zone. Historic solvent releases on a site in the eastern US have resulted in a solvent plume extending 1,700 feet (500 m). The plume principally comprises TCE at concentrations exceeding 10,000 µg/L. Migration of the plume has been mitigated by a sequence of CAC barriers co-applied with an electron donor to combine retardation and biodegradation. The full-scale application was preceded by a pilot study in 2014, conducted in an area of the plume spatially separate from the full-scale barrier application that followed. This has allowed long-term performance without subsequent intervention to be evaluated.

Approach/Activities. Barrier performance is determined by the combined contributions of contaminant retardation and destruction. A CAC barrier represents a localized adjustment of the soil adsorption coefficient (Kd) which is typically increased by several orders of magnitude. This results in plume retardation to a corresponding degree. Since Kd is fundamental to all fate and transport models, CAC applications naturally lend themselves to modelling. The PlumeForce™ modelling software was used to unwrap and interrogate field performance data over the period 2014 to present. The software accommodates mass-conservative dialog between multiple compartments, dynamic competitive interactions of mixed solutes, and biotic and abiotic transformations of amenable species. Model inputs were supported by velocity estimation by plume aspect-ratio analysis and deployment of passive flux measurement devices. In addition to barrier performance evaluation, the overall exercise served as a means of cross checking the respective tools to evaluate consistency.

Results/Lessons Learned. Initial model fits suggested the presence of significant TCE mass in lower transmissivity 'storage' units. These represented the largest component of plume mass pre-application and a source of anticipated back-diffusion. Aspect ratio analysis of plume dimension indicated the governing seepage velocity to be significantly faster than the 60 ft/year (18 m/year) estimated at the time of design. Based on the known plume history and its measured present extent, the natural retardation of the TCE was calculated from the new velocity estimate. The magnitude of the storage compartments indicated by modelling closely matched the overall matrix Kd (taken as immobile/mobile mass) inferred by the calculated retardation. The desktop estimates were then confirmed by direct measurement of contaminant and Darcy flux by passive flux units. Convergence of independent lines of evidence from the three approaches supports confidence in their individual use. Collectively, their integrated application can be of great value to the establishment of a robust conceptual site model. Suitable modelling, calibrated to field performance using combined lines of evidence, can be used to project barrier longevity under different management scenarios including 'leave-alone', donor-based bio-regeneration (as employed) and ZVI-based ferro-regeneration. The merits and efficacy of different approaches or combinations can therefore be explored such that a strategy optimal for the project may be identified, refined and communicated.