Lessons Learned from Direct-Push Injection of In Situ Reagents

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Background/Objectives. The direct-push injection process is an adaptive fluid delivery method for in-situ reactive zones. This approach typically involves the advancement of small diameter down-hole rods followed by deployment of either a retractable sleeve point or pressure-activated nozzle point to a target depth. The down-hole rods displace and compact soils outside the borehole during advancement. Consequently, the direct-push injection process may require greater initial injection pressure to both overcome localized permeability reductions and advance the reagent solution into the formation, although the amount of applied pressure varies based on the lithology and reagent. Solution-based reagents (such as organic carbon amendments and liquid sulfate blends) are injected using a retractable sleeve point. Applied pressure is required to initially fracture the compacted soils around the injection point. Afterward, the injection process typically continues at lower pressures through these engineered intervals of soil weakness. Slurry reagents (such as oxygen-release materials and zero-valent iron blends) require special considerations to achieve meaningful distribution. Specifically, slurries require small continuously-agitated mixing, short conveyance piping and injection via pressure-activated nozzle point, requiring the use of fracturing to create subsurface fissures to allow propagation of the slurry. This presentation will discuss the advantages and limitations of direct-push injection methods for different soil reagents and lithologies as well as share lessons learned across a portfolio of direct-push injection projects.

Approach/Activities. Common questions considered when evaluating the applicability of the direct-push injection process as a fluid delivery method include: (1) What is the best procedure for effectively distributing the reagent throughout the vertical and lateral target injection area? (2) What is a reasonable direct-push injection point spacing for a reagent/lithology? (3) What is the best direct-push tooling for the reagent/lithology/target interval? (4) Could the presence of utilities or other subsurface features lead to short-circuiting or poor reagent distribution? (5) Will nearby monitoring wells still be viable long-term monitoring points? and (6) What is the likelihood that contaminated groundwater or injection reagents will surface during the injection event? Over two dozen direct-push projects for a representative number of solution and slurry based reagents were evaluated to better understand the effectiveness and safety of direct-push injection methods. Treatment results were also reviewed relative to baseline concentrations and to assess the overall viability of these methods for achieving stringent cleanup objectives.

Results/Lessons Learned. Direct-push reagent injections may result in order of magnitude concentration reductions; however, the overall success of this approach is often dependent on the remedial objectives including the target end-point concentrations. When less effective performance was observed, root causes were attributed to: (1) failure to adequately consider fluid delivery options until after the site remedy was selected; (2) targeting an overly large direct-push injection spacing leading to ineffective distribution between injection locations. These observations suggest that fluid delivery options should be considered during remedy selection to pre-screen reagents or applications that may lead to poor performance. Reagent distribution via direct-push can be improved by making more conservative assumptions about injection point spacing or by conducting an injection test, when feasible, to confirm the injection hydraulics.

Last, practitioners must account and plan for the likelihood of reagent daylighting at sites with lower permeability soils and/or with very shallow water tables where injection is less feasible.