# Integrating Geologic Investigations into Remedial Design to Enhance Amendment Delivery to Solvents in Bedrock

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**Background/Objectives.** In situ injection into bedrock is one of the most challenging issues facing groundwater remediation practitioners. Although there is a wide understanding that bedrock remediation is and a conceptual model is needed, there is a gap between this understanding and generating a workable in situ injection plan that will meet remedial objectives of a site. This presentation will present on two sites in New England where site-specific bedrock investigations were performed to design and implement an injection plan. At both sites, bioremediation using enhanced reductive dechlorination (ERD) was performed to treat tetrachloroethene (PCE) in bedrock.

**Approach/Activities.** At Site 1, a former industrial site, traditional borehole geophysical tools, packer sampling, and fracture interconnectivity pump tests were utilized to revise the bedrock conceptual site model and locate fractures containing PCE. The bedrock investigation identified a bifurcated plume based on fracture orientation. The injection plan was designed to use straddle packers to deliver amendments for treatment of isolated fractures PCE in bedrock as deep as 120 feet below ground surface. Approximately 9,000 gallons of amendments, bioaugmentation culture, and chase water were injected into 17 boreholes.

Site 2, a wooded site, contained multi-acre PCE plumes with PCE at concentrations greater than 10 mg/L in overburden and bedrock. The Remedial Design Investigation identified weathered bedrock zones containing PCE, and higher PCE concentrations in weathered bedrock groundwater were observed than overburden in portions of the site. Given the large area of the PCE plume in weathered bedrock, a site-wide approach to weathered bedrock treatment was designed and implemented consisting of source area injection points and a series of weathered bedrock permeable reactive barriers (PRBs). Approximately 7,500 gallons of amendments, bioaugmentation culture, and chase water were injected into 51 weathered bedrock injection wells using screen lengths selected based on identified weathered bedrock characteristics in each area.

**Results/Lessons Learned.** Post-remediation sampling at both sites has observed PCE concentration reduction and evidence of reductive dechlorination in bedrock monitoring wells at both sites. Coupling investigation of bedrock geology and PCE distribution, Remedial Design incorporating those investigations, and a field approach to deliver amendments to the PCE was critical to successful in situ remediation of PCE in bedrock. At Site 1 the bedrock characterization greatly improved amendment delivery compared with earlier injection events. The presentation will share the lessons learned from bedrock investigation and characterization, remediation design, and implementation of injections.