Precipitating Success; A Solution to Heavy Metals in Groundwater

Jeffrey McDonough (Jeffrey.McDonough@arcadis.com) (Arcadis, Portland, ME)
Richard Royer (Richard.Royer@arcadis.com) (Arcadis, Clifton Park, NY)
Greg Sitomer (Greg.Sitomer@arcadis.com) (Arcadis, Plantation, FL)
Richard Murphy (Richard.Murphy@arcadis.com) (Arcadis, Highlands Ranch, CO)

Background/Objectives. The toxicity and mobility of heavy metals in groundwater require a reliable and predictable in situ groundwater remediation approach to achieve regulatory objectives. The physical properties of heavy metals preclude treatment using destruction or volatilization: the primary treatment mechanism for heavy metals-impacted groundwater is the formation of low-solubility compounds and the resultant precipitation. Contaminant heavy metals in groundwater typically speciate as soluble cations under natural geochemical conditions, and are often associated with acidic pH. Therefore, the permanence of the precipitation strategy is contingent upon the solubility constant (k_{sp}) of the targeted precipitated compound and acidity neutralization as necessary. Metal sulfides present an attractive form of precipitation because they are predicted to be up to four orders of magnitude less soluble than other metal precipitates (i.e., metal hydroxides and metal carbonates). Metal sulfide precipitation can be induced chemically using sulfide rich reagents (i.e., polysulfide) or indirectly through biological sulfate-reduction.

Approach/Activities. A former galvanizing facility will be discussed that represents surficial groundwater from Tampa, Florida impacted with tens to hundreds of milligrams per liter (mg/L) nickel and thousands of mg/L zinc (with a variety of other heavy metals slightly exceeding relevant regulatory criteria) at pH 3.0 to 5.0. Two rounds of bench-scale treatability testing were conducted to evaluate heavy metal removal from the groundwater using sodium polysulfide, and the results were used to design a field-scale remedy inclusive of more than 800 direct-push injection points within two distinct hydrostratigraphic units. A total injection volume of approximately 1.87 million gallons, including approximately 65,000 gallons of concentrated sodium polysulfide and approximately 4,500 gallons of concentration sodium hydroxide, was completed over an approximate one-year period.

Results/Lessons Learned. The groundwater results, including dose response of the injected reagent, the achieved engineered geochemistry, and heavy metals concentrations, will be discussed. Targeted Performance Standards for many of the monitoring wells at the site were achieved after the single injection, with recalcitrant metals concentrations measured in monitoring wells attributed to challenging distribution of the sodium polysulfide. For example, the highest exceedance observed onsite was for zinc (1,140 mg/L versus a targeted 10 mg/L). After injection, the zinc concentration at this location was 0.9 mg/L, coincident with a sustained pH increase of approximately four standard units, an increase in specific conductivity and reactive sulfide, and numerous qualitative field observations of dose response. The permanence of the remedy is continually evaluated through a robust quarterly monitoring program and approximately one year's worth of data will be available to discuss. Lastly, optimization measures for injecting polysulfide at the field-scale using large volume injections will be discussed with respect to equipment, manipulating solution chemistry, and reagent staging.