Concurrent arsenic mobilization to levels as high as 9 μM at the U.S. Department of Energy’s Integrated Field Research Challenge (IFRC) site in Rifle, Colorado highlights one of the challenges to widespread use of biostimulation for uranium immobilization. The addition of acetate to this shallow alluvial aquifer results in a shift from iron to sulfate reducing conditions. Arsenic release correlates with sulfate reduction and is characterized by a dominance of soluble arsenic-sulfur species (thioarsenics). To further explore this phenomenon, laboratory sediment columns derived from the site were seeded with Geobacter sulfurreducens and fed a synthetic groundwater containing 19 ± 2 mM acetate for ~135 days. After achieving iron-reducing conditions, columns were differentiated by three treatments: high sulfate (10 mM SO$_4^{2-}$), low sulfate (1mM SO$_4^{2-}$) and inhibition of sulfate reduction (10mM SO$_4^{2-}$ + 1.5 mM molybdate). The ‘high sulfate’ column is most analogous to field conditions at the Rifle IFRC, which had 8-10 mM SO$_4^{2-}$ in groundwater pre- and post-stimulation. In each case, column effluent showed an initial increase in soluble arsenic to approximately 1 μM, presumably associated with reductive dissolution of Fe- and Mn-solid phases, followed by a slow decline over the remainder of the experiment. While significant quantities of thioarsenic species could be formed in the laboratory by combining sulfide and arsenite at circumneutral pH in aqueous batch, arsenic breakthrough in the three flow through-columns was independent of sulfate-reduction. Similarly low concentrations of thioarsenics formed in the high sulfate, low sulfate and the sulfate-reduction-inhibition column which, by the end of the experiment, were evolving ~8,000 μM, ~300 μM, and ~10 μM sulfide, respectively. For comparison, sulfide concentrations reached ~300 μM in the field during peak sulfate reduction. Furthermore, the introduction of a pulse of soluble As(III) to the columns resulted in >85% of total arsenic being immobilized, presumably due to sorption or formation of FeS species, rather than significant thioarsenic evolution. Analysis of the microbial community by 16S rRNA gene 454 pyrosequencing indicates dominance by the orders of Clostridiales, Rhodospirillales, Burkholderiales, and Pseudomonadales with C. delftia as the most prevalent species. To further deconstruct the role of different microorganisms and geochemical conditions in these flow-through systems, work is transitioning to the mineral-microbe interface using sediment and mineral thin section (~60 um) coupons sorbed with As(V). By colonizing the coupons with axenic bacteria that are selected for iron, sulfate and arsenic respiratory processes, we can monitor for alterations in geochemical and biofilm properties associated with microbial colonization. Through ongoing biofilm visualization development pairing fluorescence in situ hybridization (FISH) with quantitative evaluation of minerals by scanning electron microscopy (QEMSCAN) new possibilities for visualizing these types of microbe-metal interactions is evolving. In addition a protocol for species-specific metallo-labeling of microbial cells for subsequent SEM and synchrotron-based micro-XAS analysis is currently being optimized in order to concurrently monitor elemental redox, mineralogical associations and microbial processes at the micron scale. This novel approach exploits the versatility and cost-efficiency of in situ hybridization-based methods without the limitations of fluorescence-based detection of cells in complex environmental samples. Collectively this work has importance in merging existing molecular and geochemical toolsets to investigate complex mineral-microbe processes relevant to metal fate and transport.