Title: Influence of Hyporheic Exchange on Coupled S-Fe-C biogeochemical cycling and Microbial Community Function in Riparian Wetlands at the Savannah River Site

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Project Abstract: Riparian wetland hyporheic zones where oxic surface water and anoxic groundwater mix, drive steep redox gradients and promote hotspots and hot-moments of biogeochemical processes. In freshwater wetland and stream sediments, carbon (C) turnover and fate is heavily influenced by the biogeochemical cycling of iron (Fe). "Hidden" or "cryptic" sulfur (S) redox processes may be further coupled to these Fe and C cycles. S biogeochemical cycling is not well constrained in freshwater systems but can include the production of reactive intermediate S species that promote further biotic and abiotic redox reactions (including those coupled with Fe reduction and methane oxidation), thus supporting higher rates of sulfur biogeochemical cycling than otherwise expected in these low sulfate environments. The overall goal of this project is to develop a mechanistic understanding of how hydrologic flow influences coupled abiotic-biotic Fe-S-methane cycles in riparian wetlands.

In the uncontaminated area of Tims Branch at the Savannah River Site, we set up several sites with continuous surface- and ground-water level and flux measurements and seasonal sampling of water and sediments. Specifically, we examined the primary Tims Branch stream, a hydrologically dynamic stream tributary containing Fe oxide-encrusted microbial mats or "Fe flocs", a large wetland with abundant "Fe flocs", and a small sulfide-enriched pond of water connected to the wetland. Microbiome analyses revealed the microbial community was highly similar between sites regardless of season, except for changes in the relative abundance of phyla with depth. Quantitative PCR revealed that both dissimilatory sulfite reduction (dsr) and adenylylsulfate reductase (apr) genes were enriched in gaining stream sites (e.g., wetland, tributary), indicating that sulfate reduction is an important process despite relatively low sulfate levels and below-detection porewater sulfide concentrations. In support of a cryptic sulfur cycle, shotgun metagenome sequencing revealed a greater abundance of sulfur oxidation and thiosulfate oxidation genes in anoxic sediments in the gaining environments relative to the primary losing stream. Despite the reduction environment, porewater geochemical analysis measured high aqueous or colloidal Fe(III) concentrations, which could fuel this cryptic S cycle.