Combined In Situ Sulfate-Enhanced Bioremediation and Bioventing for Soil and Groundwater Treatment of Petroleum Contamination

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Background/Objectives. Site SS014/SS017 at the Former Galena Forward Operating Location, Alaska has been contaminated by fuel-related releases which have impacted over 2 acres of soil and extends to 40 feet (ft) below ground surface (bgs), including the vadose zone, variably saturated zone (VSZ), and permanently saturated zone (PSZ). Due to its proximity to the Yukon River, the site undergoes large annual water table fluctuations controlled by the freeze/thaw cycle of the river (20 ft increase within 3 weeks of thaw), creating a seasonal VSZ. Site contamination is dominated by diesel-range organics (DRO) and benzene present in soil to approximately 40 ft bgs. A DRO groundwater plume extends approximately 560 ft along the plume axis at concentrations exceeding cleanup levels. The selected remedy includes a three-pronged sustainable bioremediation approach: excavation of shallow soil hot spots with on-site treatment (landfarming of petroleum impacted soil); bioventing treatment of soil within the vadose zone and VSZ; and in situ treatment of non-aqueous phase liquid (NAPL)-contaminated soil source area in the PSZ and lower VSZ by sulfate-enhanced anaerobic bioremediation (SEB). The combined remedy, along with performance monitoring, is intended to address contamination to meet Alaska state human health criteria for unrestricted land use.

Approach/Activities. Approximately 8,500 cubic yards of contaminated soil above 15 ft bgs was removed in 2011 and 2017 to be treated at the landfarm. A bioventing system was installed in 2016 to treat remaining contaminated soil in the vadose zone and VSZ that was not excavated. The 35 vent well bioventing system is equipped with two URAI DSL 36 rotary lobe positive displacement blowers with a combined capacity of 400 standard cubic feet per minute. A gypsum slurry was injected in temporary borings in 2017 to provide a sulfate source for SEB in the NAPL-contaminated soil source area within the 25 to 35 ft bgs interval. Injection materials were emplaced in five 2-ft vertical intervals at each injection location to promote vertical and lateral distribution in the PSZ. The slurry was designed considering the limited solubility of gypsum, with an anticipated five years until fully dissolved, providing a source of passive in situ dosing in the treatment area. A 8.61% (batch average) gypsum slurry was mixed and injected to emplace a total of 72,824 kilograms of gypsum using a total of 243 injection points. Performance monitoring sampling events occur annually to document remedy performance.

Results/Lessons Learned. The results of the first annual performance monitoring event demonstrate that sulfate concentrations in groundwater have increased from background levels (20-40 milligram per liter [mg/L]) to an average of 85 mg/L, with a maximum observed concentration of 1,280 mg/L, indicating that sulfate was successfully delivered to groundwater in the treatment area. Elevated sulfate concentrations were detected 70 ft downgradient of the injection zones. Geochemical monitoring indicates sulfate-reducing geochemical conditions are present in the treatment zone. Biodegradation rates calculated from in situ respiration tests indicate the presence of biological activity in the unsaturated zone, and accelerated petroleum hydrocarbon biodegradation in the subsurface during initial phase of bioventing operation. Soil gas analytical data trends indicate a decrease in total volatile organic compounds (VOCs) concentrations of up to 97% (average of 50%) and benzene concentrations of up to 100% (average of 91%), signifying the degradation of fuel-related contaminants is taking place. The performance monitoring indicates active degradation of contaminants is occurring and soil gas VOC concentrations are anticipated to continue to decline. Results from baseline and two annual monitoring events will be presented.