PFAS FTA Source Zone In Situ Stabilization: Long-Term, Field-Scale Leachability Evaluation

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Background/Objectives. Firefighting training areas (FTAs) are one of the most widespread point sources of per- and polyfluoroalkyl substances (PFAS) due to frequent application of Class B foams (e.g., aqueous film-forming foam [AFFF]) over a prolonged period. PFAS site characterization studies conducted so far have demonstrated that long-chain PFAS preferably adsorb to shallow subsurface soils, with sorption governed by numerous individual PFAS-specific parameters (e.g., octanol-carbon partitioning coefficient [K_{oc}], PFAS chain length and functional group, and net molecular charge) and site soil specific parameters (e.g., cation/anion exchange capacities [CEC/AEC], pH, fraction of organic carbon (f_{oc}) and mineral content). For FTA remediation, in situ stabilization (ISS) of shallow soil source area presents a useful remedial alternative to excavation. ISS consists of the use of common construction equipment (excavators with rotary tools) to mix soil, water, and fixants in the vadose and saturated zones. ISS can be a highly-effective method for accessing source mass because it homogenizes soil, reduces geological anisotropy, and provides immediate access to soluble PFAS stored in low-permeability strata. ISS reduces PFAS leachability through stabilization via hydrophobic and electrostatic adsorptive mechanisms and through solidification with portland cement (PC) via reduction of vertical infiltration and lateral groundwater flow. Studies that evaluate the long-term leachability of PFAS from stabilized source areas are sparse. As part of the Air Force Civil Engineering Center's Fiscal Year 2017 Broad Agency Announcement, Arcadis was selected to perform the first ever demonstration project to evaluate the permanence of reduced PFAS leachability at the field scale. The project began with a treatability study (TS) program designed to evaluate the viability and dosage of various commercially-available fixants.

Approach/Activities. Soil and groundwater samples were collected from a FTA site as part of pre-design source zone characterization, and shipped to the Arcadis Treatability Lab in Durham, North Carolina. The baseline samples were homogenized and analyzed for various parameters including PFAS precursors via the total oxidizable precursor (TOP) assay. Three commercially available fixants were selected for evaluation: a proprietary formulation of aluminum hydroxide, kaolinite clay, and activated carbon (AlOH/KC/AC); Modified Clay (MC); and Hydrotalcite. Batch reactors evaluated dosing and efficacy to stabilize PFAS. For select doses of each fixant, monoliths were created with varied PC to evaluate unconfined compressive strength (UCS) development. The monoliths were subjected to long-term leaching evaluation via US Environmental Protection Agency's (USEPA's) Leaching Environmental Assessment Framework (LEAF) Method 1315 at circumneutral pH to evaluate worst-case leaching. Based on the treatability lab results, two fixants were selected for field test pit implementation with different fixant and PC concentrations along with a PC-only control. Four performance monitoring events are planned over two years, which will involve collection of monoliths from test pits and evaluation of leachability via USEPA's LEAF 1315 method.

Results/Lessons Learned. Of the three fixants evaluated during the TS, two (AlOH/KC/AC and MC) demonstrated greater than 98% reduction in long-chain PFAS. The strongly hydrophobic

Hydrotalcite failed to similarly reduce PFAS leachability and was difficult to handle. Notably, MC demonstrated higher relative reduction of short-chain perfluorobutanoic acid, and better UCS strength development with lower percentage dosage of PC. The AlOH/KC/AC demonstrated a significant reduction in UCS strength when combined with PC versus the PC only control or the MC monoliths. These TS results will be presented in addition to long-term performance monitoring data from the field test pits collected prior to the April 2019 conference.