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Wide-Area Infiltration Delivery of Bioamendments to Treat Energetics Contamination within Tropical Vadose Zone Soils on DoD Live-Fire Ranges

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Background/Objectives. Implementing enhanced biodegradation treatments on former and/or active live-fire training ranges is challenged by dig restrictions preventing the installation of wells and other amendment delivery infrastructure, due to the risk of unexploded ordnance and by the generally wide areal distribution of energetics contamination at such facilities. The Makua Military Reservation (MMR), on the island of O'ahu, Hawai'i, is one such facility that has a 47-year history of use as an artillery and company-scale live-fire infantry maneuvers training area, until operations ended in 2004. As a result of this use, explosives chemical contamination (e.g., hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), octahydro- 1,3,5,7-tetranitro-1,3,5,7-tetrazine (HMX)) exists within the surficial soils and underlying vadose zone, particularly within the 4-acre open burn/open detonation (OB/OD) area used to dispose of undetonated and/or unusable ordnance following training operations wherein concentrations are in excess of U.S. EPA Preliminary Remediation Goals. Following a laboratory treatability study (ESTCP Project: ER-0631), biodegradation utilizing molasses solution as an inexpensive source of carbon was shown to be a promising method of treatment. Likewise, infiltration was selected as the method of delivering the molasses amendment within the surficial soil and underlying vadose zone to a target treatment depth of 20 feet (within which lies the bulk of observed contamination). It is the objective of this work to evaluate the utility of delivering molasses-amended solutions via infiltration to enhance the biodegradation of explosives contaminants within tropical vadose zone soils. Additionally, we will evaluate the feasibility of up-scaling this approach to provide treatment across the whole of the former OB/OD area.

Approach/Activities. The results of a series of pilot-scale studies performed at a demonstration site installed within the MMR facility will be presented. The site utilized two side-by-side infiltration ponds, instrumented with lysimeter pore-water samplers and moisture content sensors between 5 and 31 feet below ground surface, into which molasses and chase water solutions were applied. The results of this study demonstrate the utility and effectiveness of the approach for the MMR. Further, the results of additional in-field infiltration studies will be presented which focused on optimizing implementation design by minimizing the volumes of water and molasses solution needed to maintain bioremediation effectiveness. Finally, the results of a numerical feasibility evaluation will be presented that details the utility of applying infiltration delivery of molasses bioamendments across the larger OB/OD area.

Results/Lessons Learned. Briefly, the initial field study utilized a 1:40 molasses water solution delivered as a single 500 gallon pulse, and repeated seven times over a 9-month period. During each pulse, most of the molasses was consumed by soil microorganisms by about 13.5 feet below ground surface. Likewise, the bulk of RDX/HMX degradation occurred within the 5 to13.5 foot depth interval (e.g., RDX pore-water concentrations were reduced by 90% following the fourth treatment event). Treatment of deeper depths will require greater molasses concentrations and/or an alternative infiltration delivery scenario, which is the focus of the current field effort (in progress at the time of abstract submittal). Alternative infiltration delivery scenarios are being tested at the demonstration site (e.g., alternative pulse frequencies,

volumes, durations, molasses concentrations, and placement of the molasses pulse). The results will be used to assist the up-scaled numerical feasibility evaluation.