2023 SECRETARY OF DEFENSE

ENVIRONMENTAL AWARDS

Lake City Army Ammunition Plan, Missouri

Lake City Army Ammunition Plant (LCAAP) is a Department of Defense's (DoD's) small caliber ammunition production plant, producing nearly 1.4 billion rounds of ammunition per year. LCAAP is a government-owned, contractor-operated facility, run by contractor Olin Winchester, LLC (Olin). Under a performance-based acquisition contract with US Army Environmental Command (USAEC), Environmental Chemical Corporation (ECC) provides fence-to-fence environmental restoration services to LCAAP.

LCAAP encompasses 3,935 acres located in Independence, Missouri and was established in 1941 to manufacture and test small caliber ammunition for the US Army (Army). LCAAP is characterized by gently sloping uplands that surround the flat Lake City Valley. The surrounding community is primarily rural, residential, and agricultural. LCAAP has a humid continental climate with cold winters and hot, often rainy, summers.

Background

Historical ammunition manufacturing generated large quantities of potentially hazardous wastes and substances, including oils/greases, solvents, explosives, and metals, some of which were released into the environment. LCAAP established its environmental restoration program in 1980 and was subsequently added to the National Priorities List in 1987. LCAAP is divided into 36 discrete areas of concern (AOCs), and restoration is organized into four Operable Units (OUs) as depicted in Figure 1. Environmental restoration has been occurring at the LCAAP for over 40 years. Remedies for each OU were established by 2008, and the 36 AOCs are in either Remedial Action Operation (RA-O) or long-term management (LTM). Since extensive non-aqueous phase liquids (NAPL) are present at several AOCs, ongoing operations are focusing on optimizing existing remedies, using innovative technology to accelerate restoration of impacted groundwater,

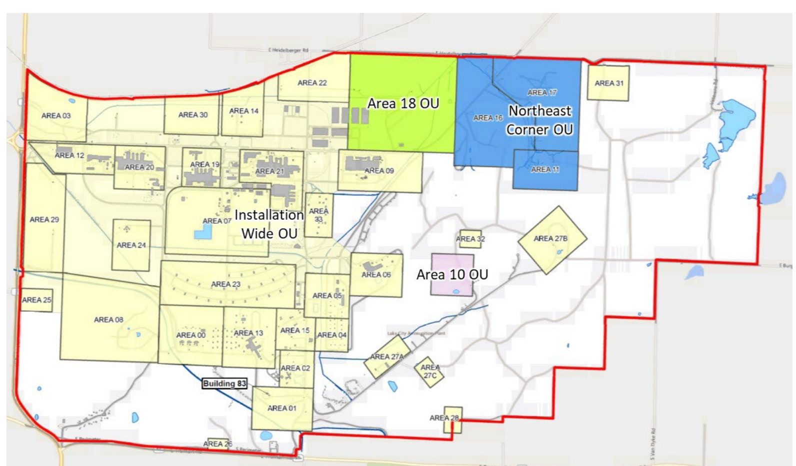

Figure 1. LCAAP is located in Independence, Missouri. Environmental Restoration has been ongoing since 1980. Optimization of protracted RA-O / LTM and ineffectual remedies is the focus of this mature program.

PROGRAM MANAGEMENT | ORIENTATION TO MISSION | IMPACT & OUTCOMES | TECHNICAL MERIT | STAKEHOLDER INTERACTION | TRANSFERABILITY reducing remedial timeframes, decreasing lifecycle costs, using sustainable methods, and increasing energy efficiency. Moreover, the recent 2020 Five-Year Review indicated that restoration timeframes for several AOCs were not reasonable (i.e., over 100+ years) and will require revised or new remedies if technically practical.

In 1989, the Army, the Missouri Department of Natural Resources (MoDNR), and the United States Environmental Protection Agency (USEPA) signed a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 120 Federal Facility Agreement (FFA) to jointly manage the LCAAP restoration program. The FFA partners work closely together by continually interacting via e-mails, conference calls, monthly project manager (PM) meetings and semi-annual Restoration Advisory Board (RAB) meetings. The monthly PM meetings are managed by ECC and attended by the FFA partners, Omaha US Corps of Engineers Center of Excellence (USACE-CX), USAEC, Olin, ECC's teaming partners Arcadis and Environmental Works Incorporated (EWI), and various restoration specialty subcontractor as needed. USACE-CX provides an independent technical review of all ECC deliverables to the Army prior to submittal to the FFA partners.

ECC conducts each monthly PM meeting via Microsoft Teams or in person at LCAAP to facilitate interactive discussions and dynamically share maps, recent data, and other content for streamlined decision making by the FFA partners. The long standing and ongoing PM meetings have built a highly functional and efficient LCAAP environmental restoration team, built on trust, that allows the Army to not only prepare the CERCLA-required deliverables, but also to propose and implement numerous optimizations through streamlined plans and meeting action items. ECC also conducts an internal Army alignment meeting prior to each monthly PM meeting to ensure a unified Army position with the FFA partners.

LCAAP established its RAB in 1997 and has continuously hosted semi-annual meeting to involve the community in the environmental restoration activities taking place at LCAAP. The RAB meetings are announced through public advertisements, social media postings and direct mailings. The RAB includes over 300 invites to the FFA partners, local citizens, various environmental activists, and City and County government officials. Despite COVID restrictions, LCAAP continued to conduct its semi-annual RAB meetings using Zoom, Facebook Live, or outdoor locations with appropriate masking and social distancing. The Army and ECC also maintain an administrative repository of over 1,100 electronic documents at the local library for the public to review, conducted community interviews for the 2020 Five-Year Review, and updated the Community Involvement Plan.

Summary of Accomplishments

In addition to performing RA-O / LTM at LCAAP in complete compliance with regulatory requirements and decision documents, LCAAP has implemented multiple innovative and important optimizations to resolve the issues / recommendations from the 2020 Five-Year Review and reduce Army lifecycle costs, restoration timeframes and DOD's resources expended on environmental restoration. The goals of these optimizations are to achieve environmental restoration objectives in a more environmentally sound, green and cost-effective manner while protecting the community and in complete compliance with regulatory requirements and decision documents. These optimizations have utilized the latest innovative and state-of-art technologies to achieve the stated goals. Specific optimizations and performance outcomes include:

Area 17B Waste Pits High-Resolution Site Assessment and Insitu Thermal Remediation

The Area 17B Waste Pits consisted of three historical disposal pits that received large volumes of liquid hazardous waste (petroleum hydrocarbons and chlorinated solvents) from 1960s to 1979 that resulted in groundwater contamination and NAPL in a low permeability silty clay up to 35 feet thick. The contaminated mass was estimated to be nearly 2 million pounds.

The selected remedy for Area 17B was implemented in 2007 and included limited zero valent iron (ZVI) mixing at the waste disposal pits and enhanced reductive dechlorination (ERD) downgradient of the pits via insitu reactive barriers (IRZs). LCAAP previously optimized the downgradient IRZs through hydraulic fracturing in 2015. However, based on the 2020 Five-Year Review, the restoration timeframe for Area 17B remained over 700 years and alternative remedies are needed.

ECC designed, constructed, and operated an insitu thermal remediation system (ISTR) that treated over 28,000 bank cubic yards (bcy) of the Area 17B Waste Pits impacted with NAPL. The ISTR design was based on gas thermal conduction and a high-resolution site assessment (HRSA) conducted by ECC using dye-enhanced laser induced fluorescence (DyeLIF). DyeLIF provided high resolution, real-time data on the presence of NAPL in the subsurface using a probe advanced via direct-push technology (DPT) drilling. Standard LIF is often used for investigation of petroleum hydrocarbon NAPLs that readily fluoresce when exposed to ultraviolet light. DyeLIF is a modification of standard LIF to enable identification of chlorinated solvent NAPL that lack natural fluorescence by injecting a hydrophobic dye during probe advancement. While continuously advancing the DyeLIF tooling, a fluorescence dye is injected from the ground surface through tubing in the DPT rods and through the screen in the downhole DyeLIF tooling. Simultaneously, laser pulses travel through fiber-optic lines in the DPT rods, which are then deflected through the exit window in the DyeLIF tooling. The resulting fluorescence response from dyed NAPL is recorded by the laser energy at the LIF sapphire window, generating a response data point approximately every 0.5 centimeter that the DyeLIF tooling is advanced. The DyeLIF system provided real-time NAPL results, which allowed ECC to use a dynamic and adaptive strategy to characterize the site. In addition to determining the presence of NAPL, the DyeLIF tool simultaneously mapped relative permeability by measuring the relative pressure and flow response during injection of the dye solution.

ECC dynamically completed 4,300 linear feet of DyeLIF and whole-core soil borings with continuous soil sampling to quantify the contaminant mass (see Figure 2). Over 300+ soil samples and 103,000+ DyeLIF readings were used to generate 3D renderings of site lithology, contaminant concentrations, and DyeLIF responses. The 3D model was utilized to estimate NAPL extent and mass that formed the basis for the ISTR design.

Figure 2. LCAAP conducted a high-resolution site assessment (HRSA) using cutting edge dye-enhanced laser induced fluorescence (DyeLIF) that generated over 103,000 readings to create a precise 3D model of the non-aqueous phase liquid (NAPL) contamination within Area 17B waste pits.

ECC submitted three versions of the ISTR design and documented responses to FFA partner comments for approval. Based on the approved design, ECC installed the ISTR well field, which included 253 locations (over 11,000 vertical feet completed to the top of the bedrock) for thermal conduction heating (TCH), multi-phase extraction (MPE), soil vapor extraction (SVE), groundwater monitoring and temperature and pressure monitoring wells. All drilling investigation derived waste (IDW) was containerized for proper offsite disposal. Due to the presence of explosive vapors in the subsurface, each well location required vacuum abatement during welding of downhole well components. The ISTR wellfield (see Figure 3) was then covered in a 12-inch thick thermal insulating cap comprised of gravel, perlite and high-temperature grout.

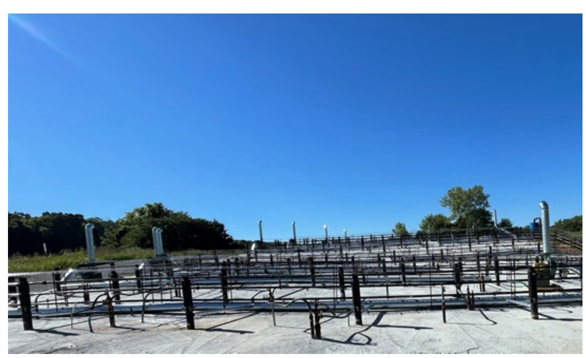

Figure 3. The innovative Area 17B insitu thermal remediation (ISTR) system will heat soil, groundwater and non-aqueous phase liquids (NAPL) within the waste pits to the boiling point of water (~100ºC) for effective extraction and treatment that will optimize restoration timeframes.

The ISTR system heats soil, groundwater and NAPL indirectly through conduction to the boiler point of water (~100°C). Mobilized contaminants are collected from the MPE and SVE wells that are routed to the above ground treatment system. Extracted fluids are cooled to condense contaminants and the NAPL, groundwater and non-condensable vapors are separated for treatment. Groundwater is treated through the pump-and-treat system and non-condensable vapors are treated through granular activated carbon (GAC) prior to discharge. NAPL is disposed offsite at a permitted hazardous waste facility. The construction of the ISTR system was conducted in extreme cold weather (temperatures below 0°F with 6-inches of snow) to maintain project schedules without a single safety incident (over 10,000 work hours).

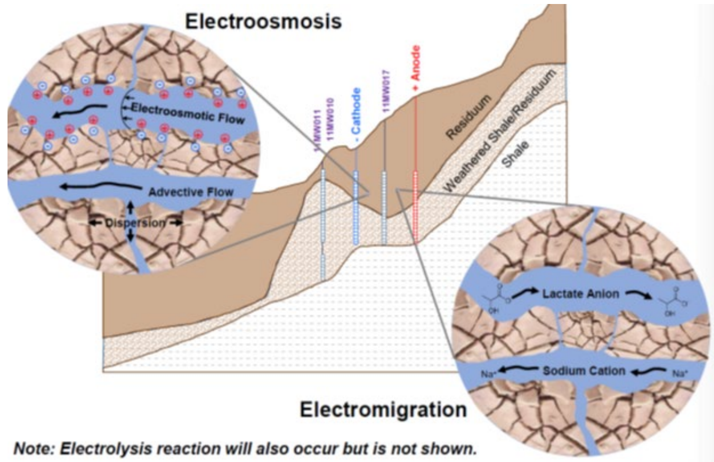

Figure 4. Electrokinetic-enhance bioremediation will enhance ionic bioremediation amendment distribution within a treatment area through electromigration, electroosmosis and electrophoresis.

Monitoring results from the Area 17B ISTR system operation will be used to evaluate the effectiveness of thermal remediation for other NAPL source areas at LCAAP and to perform a remedial alternatives analysis in a Feasibility Study (FS) Addendum that will determine the optimal remedy for Area 17B.

Area 11 Burning Grounds Solar Powered Electrokinetic-Enhanced Bioremediation

Area 11 encompasses ~0.7 acres and was used between 1957 and 1985 for the open burning and detonation of waste propellant, explosive, and pyrotechnic materials on burn pads. The Area 11 soils were excavated and closed, and the selected remedy for groundwater was monitored natural attenuation (MNA). Area 11 groundwater was impacted with low levels of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and perchlorate.

After 10 years of monitoring, RDX groundwater concentrations were increasing, and restoration timeframes could not be estimated in the 2020 Five-Year Review. Peak RDX concentrations were only 10.0 micrograms per liter (µg/L) (May 2018) versus a cleanup goal of 2.6 µg/L. Using the monthly PM meetings, a dynamic groundwater investigation was proposed, approved by the FFA partners, and conducted to identify potential hotspots of residual RDX contamination. A total of 12 DPT points were installed by March 2019 and four soil samples, 13 groundwater samples and one surface water sample were collected and analyzed for RDX and perchlorate. Soil samples were non-detect for RDX and perchlorate but an upgradient groundwater source was identified. Based upon the results of the DPT investigations, one additional groundwater monitoring well was installed and sampled multiple times that identified an upgradient source of elevated RDX contamination at a peak of 234 ug/L. Again using the PM meeting as a forum to expediate optimizations, a solar-powered electrokinetic-enhanced bioremediation (EK-bio) pilot study was proposed, approved, and subsequently constructed (September 2020). RDX will rapidly degrade anaerobically if sufficient bioremediation amendments are distributed in the source area. However, the permeability of Area 11 saturated soils was exceptionally low (~5×10^{-5} centimeters / second) that inhibited traditional injections and distribution of bioremediation amendments. By applying a low voltage current through electrodes installed within the treatment zone, EK-bio will enhance the distribution of ionic bioremediation amendments like sodium lactate in low permeability soils through electromigration (ion migration), electroosmosis (electroosmotic advection), and electrophoresis (movement of charged particles) as depicted in Figure 4. While EK-bio has been used for restoration of chlorinated solvents, LCAAP's deployment at Area 11 was the first ever application for explosives. With design support from Dr. David Gent of the USACE Engineering Research and Development Center, the EK-bio treatment zone consisted of 12 electrodes, 6 injection wells, 2 observational piezometers and a gravity fed injection system (see Figure 5). Each electrode well consisted of three tubular anodes (titanium rods with a mixed metal oxide coating) evenly spaced vertically within the well screen (~5-20 feet below ground surface). The electrodes were powered by solar panels with batteries for nighttime operation, controllers, and associated wiring for a green remediation approach. The electrodes consumed ~45 amps of solar power at 55V DC, 24 hours a day. Concurrent with the applied electrokinetic field, ~12,500 gallons of dilute 3 weight percent (wt.%) sodium lactate solution was gravity feed into the treatment zone by March 2021. The 3 wt.% sodium lactate solution was gravity-fed through individual injection lines from a 1,550-gallon supply tank to the individual injection wells.

Figure 5. The first ever application of electrokinetic-enhanced bioremediation (EK-bio) for explosives using solar power at LCAAP Area 11. The treatment reduced RDX groundwater contamination over 96% in less than 3-years. This was achieved from problem identification through implementation and confirmation monitoring for a sustainable green remediation approach to optimize restoration timeframes.

After 18 months of post treatment monitoring, perchlorate concentrations are below the cleanup goal and RDX concentrations remain near the cleanup goals with a concentration of 9.2 µg/L (April 2022), which is a 96% reduction in the source zone groundwater concentrations. The remaining groundwater restoration timeframes for Area 11 likewise were reduced from unreasonable (i.e., over 100+ years) to a projected 12 years with MNA.

High-Resolution Site Assessment (HRSA) for Unknown Source Areas at Area 5 and Area 17D

The 2020 Five-Year Review also identified unreasonable restoration timeframes (i.e., over 100+ years) at Area 5 and Area 17D. Since monitoring began in 1981, Area 5 groundwater concentrations for trichloroethylene (TCE) have not declined, which indicated an unknown source of groundwater contamination. Similarly, groundwater modeling for Area 17D projected TCE restoration timeframes over 475 years due to residual NAPL.

To identify and quantify these sources of groundwater contamination for restoration optimization, ECC proposed to the FFA partners in September 2021 an expediated and dynamic characterization using an innovative combination of whole core soil sampling (WCSS), onsite direct sampling ion trap mass spectrometry (DSITMS) laboratory using USEPA Method 8265 and offsite confirmatory laboratory analysis. In comparison to traditional mobile laboratories, the onsite DSITMS allowed for rapid sample analysis (<15-minutes) and significantly higher daily analytical volumes (60-80 analytical samples per day) for real time decision making in the field. Moreover, expediated and dynamic characterization approach based on membrane interface probes (MIP) was rejected since the MIP response is qualitative, detection limits were not capable of meeting the data quality objectives (DQOs) for the low TCE concentrations at Area 5 and could not differentiate the separate DQOs for NAPL mass (<100 mg/kg) versus residual TCE mass (>1mg/kg) at Area 17D.

Figure 6. An expediated and dynamic characterization of Area 5 and Area 17D using whole-core soil sampling (WCSS) with an onsite direct sampling ion trap mass spectrometry (DSITMS) laboratory allowed LCAAP to identify an unknown groundwater source and establish detailed contamination assessment for targeted remediation that will optimize restoration timeframes.

By December 2021, ECC completed 18 borings (810 vertical feet) at Area 5 and analyzed 256 onsite samples; completed 36 borings (1,200 vertical feet) at Area 17D and analyzed 567 onsite samples to meet the proposed characterization DQOs (see Figure 6). ECC collected an additional 51 split samples for offsite laboratory analysis and validation of the DSITMS data. Based on this HRSA, an unknow, upgradient groundwater source was identified at Area 5 that will be targeted for ERD injections. In addition, a detailed 3D assessment of the NAPL and residual TCE contamination sources at Area 17D was generated that will form the basis for targeted remediation to optimize restoration timeframes.

Revised Area 18 Pump-and-Treat Discharge

In March 1997, the Area 18 pump-and-treat system started operation to provide hydraulic control of the contaminated groundwater plumes. The pump-and-treat system discharges ~130 million gallons of treated groundwater per year to the sanitary sewer and is projected to operate across the next 100+ years. In 2021, the sewer discharge fees cost the Army ~$340,000 annually with an anticipated annual escalation of 3.5% per year. The pump-and-treat system removed influent VOCs to non-detect levels through an air stripper prior to discharge. Since the treated effluent was non-detect for VOCs, ECC proposed to divert the treated effluent to an on-site surface water ditch that flowed to Fire Prairie Creek, thus eliminating the sewer discharge fees. However, while naturally occurring metals in the treated groundwater were below surface water discharge criteria, the metal concentrations were above the background concentrations in Fire Prairie Creek and required an anti-degradation assessment prior to discharge.

To achieve approval from the FFA partners for the surface water discharge, ECC conducted an extensive baseline characterization of the treated effluent and the surface water within Fire Prairie Creek, then prepared an Optimization Plan, Explanation of Significant Difference (ESD), Anti-Degradation Assessment and Metal Translator Study to ensure the treated effluent discharge was compliant with appropriate Applicable Relevant and Appropriate Requirements (ARAR), specifically the substantive requirements of promulgated Missouri code and the National Pollutant Discharge Elimination System (NPDES). The key to the approval from the FFA partners was the Metal Translator Study, which was a first ever conducted for a DoD facility in Missouri.

The Metal Translator Study involved twenty rounds of sampling across two years, which included the pump-and-treat influent and effluent, upstream receiving waters of Fire Prairie Creek, simulated mixing zone water, and the downstream Fire Prairie Creek outfall as it existed LCAAP. The sampling program included total and dissolved metals, alkalinity, hardness, dissolved organic carbon, total suspended solids, oxidation reduction potential (ORP), pH, temperature, whole effluent toxicity (chronic and acute) and water flows. A total of 5,200 analytical data points were collected, assessed for usability, and statistically evaluated to determine the metal translator value for each metal species per USEPA guidance.

With concurrence from the FFA partners, the discharge ditch was constructed (see Figure 7) and the treated effluent was diverted in January 2022 to the surface water ditch. The revised discharge of the treated groundwater from the pump-and-treat system will save the Army over $340,000.00 annually across the life of the remedy (i.e., over 100+ years).

The performance, costs and lessons learned from these various LCAAP's optimization efforts were disseminated to other DoD installations and environmental industry through USACE-CX guidance documents, newsletters and presentations; environmental industry conference presentations including Battelle, REMTEC, and JETC; and ECC's and its teaming partners various internal remediation community-of-practice meetings.

The general approach used at the LCAAP of implementing optimization through monthly PM meeting action items and streamlined plans is directly transferable to other sites of mature environmental restoration sites around the country. Additionally, specific optimization concepts implemented at the LCAAP are directly applicable to many other sites. These concepts include application of cutting-edge technology for high-resolution site assessment, aggressive NAPL source zone treatment, and increasing community involvement.

The environmental restoration program is a key component of the mission at the LCAAP. The health and safety of personnel at the LCAAP, as well as the surrounding community is paramount. The environmental restoration program continues a robust monitoring program for vapor intrusion, surface water and sentry boundary groundwater monitoring across the entire installation to ensure that LCAAP's staff and local community receptors are not adversely impacted from legacy contaminants.

Figure 8. Some of LCAAP's fuzzier community members! One of our Environmental goals is to enrich and protect the health of the deer by maintaining Land Use Controls of the AOCs. The deer on the installation are part of a dynamic hunting program that engages team members to get out in nature and teach the next generation conservation.

Figure 7. Through an extensive baseline characterization, metal translator values were generated that allowed the treated effluent from the pump-and-treat system to be diverted from the sanitary sewer to a newly constructed surface water discharge ditch, which saved the Army ~$340,000 annual.

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