Overview of MSE Technology Development for Subsurface Contaminant Applications

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Introduction

MSE Technology Applications, Inc. (MSE) has been performing work in the subsurface contaminant area for more than 7 years. Before that time, MSE was well know for our technology test, evaluation, and development capabilities in support of multiple government organizations, so providing support to DOE in the area of subsurface technology development was a good match for both organizations.

MSE has provided this support for many types of technologies and have capabilities including:

- Resource Recovery
- Subsurface Containment Barriers (grouting and bio)
- Waste Stabilization
- Treatment Barriers
- Subsurface Flushing Technologies
- Phytoremediation and Rhizofiltration
- In Situ Vitrification
- Dense Non-Aqueous Phase Liquids (DNAPL) Cleanup
- Groundwater Sensor Evaluation
- Contaminant Transport Study
- Economic Analysis and Evaluation
- Groundwater Modeling
- Verification and Monitoring
- Vadose Zone Studies
- Long-Term Stewardship
- Laboratory Grout Evaluation and Optimization

As with any technology test and evaluation program, some technology development efforts have been more successful than others, and some have more of a market in the federal complex than others. This paper addresses some of the more current and potentially marketable technologies developed for the DOE. The areas to be discussed are:

- Integrated Economic Analysis
- Interagency DNAPL Consortium
- Viscous Liquid Barrier
- Groundwater Monitoring
- Uranium Transport
- Treatment Barriers

- Non-Traditional In Situ Vitrification
- Mercury Stabilization

For each technology/project area, the subjects addressed include the need for the technology or evaluation, the objective or problem being addressed, the approach or solution, and the project or technology description. The accomplishments achieved, the benefits and applications of the technology/project, and the planned future activities are also discussed.

Technology/Project Discussions

Integrated Economic Analysis and Evaluation

Cost savings and performance analysis have been identified as major contributors for establishing the value of innovative technology development. This established and consistent methodology, when applied to emerging technologies, provides the basis for continued investment in these innovative and first time opportunities. MSE's work includes not only economic analysis, but economic evaluation, including life cycle cost modeling; cost benefit analysis; risk analysis from financial, engineering, development and implementation points of view; and decision analysis. MSE has provided this type of support to the Subsurface Contaminants Focus Area (SCFA), the Accelerated Site Technology Deployment (ASTD) Program, and the Center for Acquisition and Business Excellence (CABE).

MSE typically reviews and performs economic analysis/evaluation on 10 technologies and 10 to 20 deployments per year. Cost savings of $32 and $22 million dollars have been identified for the technologies reviewed on behalf of the ASTD program in FY00 and FY01, respectively.

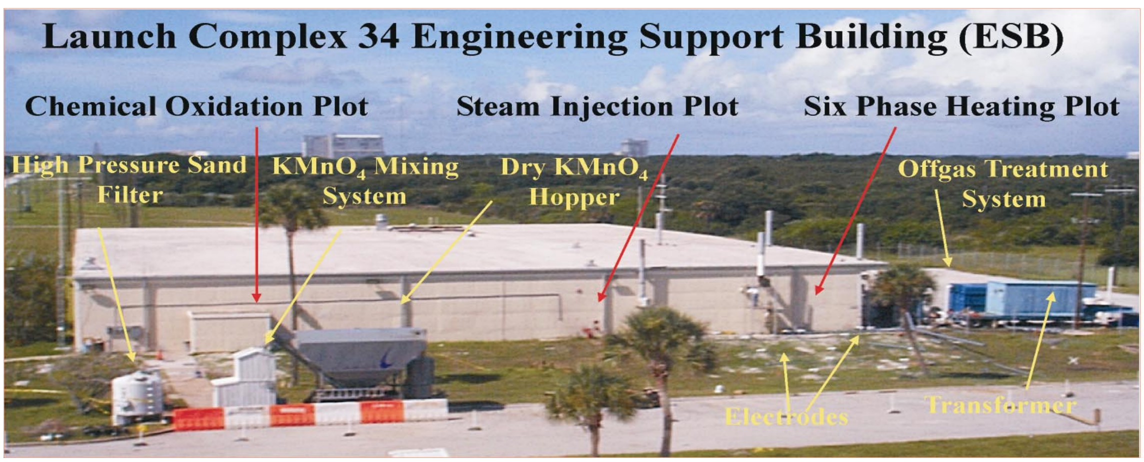
Additionally, MSE was responsible for development and validation of a health monetization module for cost avoidance/saving. This module has been viewed as a potentially controversial and sensitive issue; after all, how does one depict the advantages of a potentially less dangerous innovative technology on medical costs plus the life saving factor, in terms of dollars and cents? The model has now been developed and used for identification of cost avoidance for one technology. The opportunity exists for future use of this module as a method for quantifying the contribution of innovative technologies in minimizing health concerns.

These same types of reviews and analyses are applicable for other focus areas and programs trying to identify true cost savings and potential opportunities for cost savings.

Interagency DNAPL Consortium

Through an interagency agreement between DOE, EPA, NASA, and the Air Force, three technologies for treatment of Dense Non-Aqueous Phase Liquids (DNAPL) are being evaluated. Field work for two of the technologies has been completed and deployment of the third remains in progress. MSE has been responsible for the contracting of the technologies, and the collection and development of the cost evaluation and performance comparison.

The technologies are being deployed on a large contaminant plume and DNAPL source area (in excess of 100,000 lbs of Trichloroethylene--TCE) at Launch Complex 34, Cape Canaveral Air Station, Florida. Six-phase soil heating, potassium permanganate oxidation, and dynamic underground stripping/hydrolysis pyrolosis oxidation are the three technologies being tested in this side-by-side configuration.



Cape Canaveral DNAPL Site

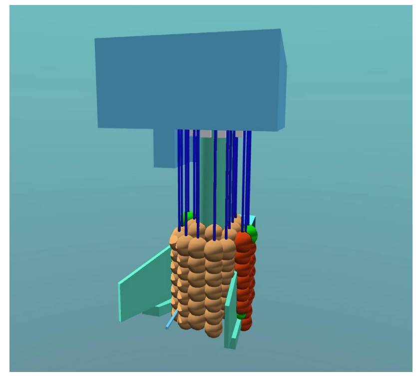
The Permanganate technology removed or destroyed 82% of the DNAPL TCE in place. The Six-phase Heating removed or destroyed 97% of the DNAPL TCE. The Steam Injection deployment began July 2001 and remains in progress. Early results indicated good TCE recovery.

This type of contamination plume was the result of TCE being used to wash down the Saturn I and IB rocket motors without containment. Anywhere chlorinated solvents were used and drained into the subsurface, these types of contamination issues exist. This interagency project was an effort to identify and compare DNAPL cleanup technologies for future use, since DNAPLs have been identified as a challenging cleanup issue. The demonstrated technologies could be applicable for DNAPL remediations throughout the federal complex and private sector.

Viscous Liquid Barrier

MSE has been involved with the Viscous Liquid Barrier (VLB) technology since 1995. Lawrence Berkeley National Laboratory (LBNL) developed the scientific basis for the VLB technology in the early 1990's and conducted early field testing.

Through the years MSE has advanced the technology on behalf of SCFA to the point where a VLB was emplaced at Brookhaven National Laboratory in June 2000. The barrier was designed to control migration of radioactive contamination from the soil into the groundwater.



As-built representation of the VLB at BNL.

Prior to the VLB replacement, rainwater had passed through the contaminated soil and transported contamination down to the groundwater, where it was detected downgradient of the site. The zone of contamination was located directly beneath a building. Approximately 95 cubic feet of contaminated soil located about 22 to 33 feet below grade surrounded a tank and other infrastructure such as a tunnel, piping, concrete walls, and footings. The VLB technology was selected in part due to the ability to inject the grout at low pressures to permeate around the subsurface infrastructure without causing disturbance or affecting the facility operating schedule.

The colloidal silica grout was injected into the soil to fill the large and small pore spaces in the soil matrix; the grout then gelled to form a hydraulic barrier. The barrier isolates contaminated soils or waste materials, preventing the contamination from migrating into the surrounding "clean" soils. At this site, the VLB was emplaced to completely encapsulate the zone of contamination to prevent further migration of the contaminants to the groundwater.

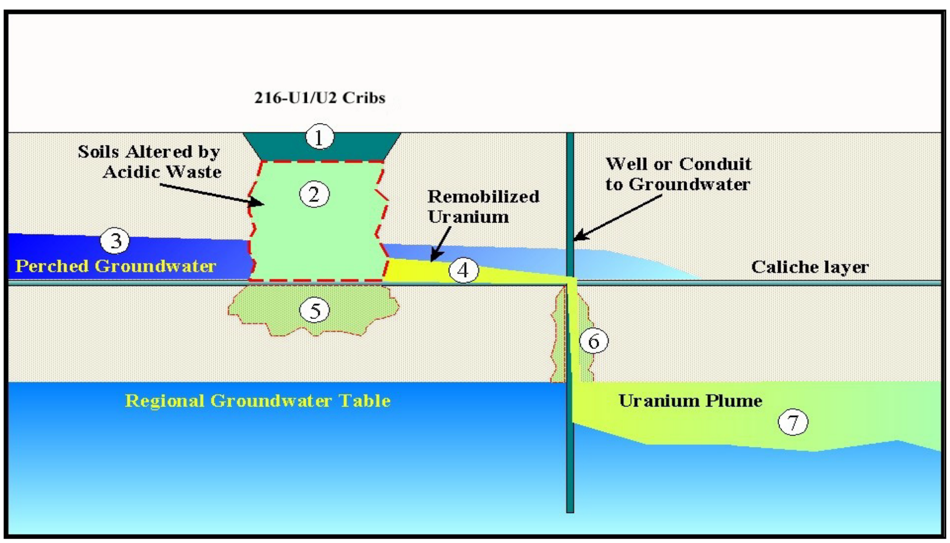
The deployment of the VLB technology was successfully completed in June 2000 and final testing and reporting was completed in 2001. The technology is now ready for implementation at other sites where operating facilities and infrastructure make cleanup through removal impractical.

Groundwater Monitoring

Long-term monitoring of contaminants is required throughout the federal complex. Manual sampling and laboratory analysis are time consuming and labor intensive, so MSE has been evaluating more automated approaches, along with looking at effectiveness of sample collection, data management, and data presentation. The project was initiated in FY01 and tasks have included identification in situ groundwater sensors for Strontium-90, Tritium, Hexavalent Chromium (Cr-VI), Carbon Tetrachloride (CCl_4), and Technetium-99. Potential sites where this work could also be applicable include Hanford, Nevada Test Site, and others. Sensors that are already in existence for these contaminants and sensors in the development phase are being evaluated for retrofit for downhole use. Methods for remote data collection, management and presentation will also be evaluated and/or enhanced to meet the site user needs. In FY02, the recommended sensor(s) will be the focus of bench testing, enhancement/retrofit, and evaluation for real time sensors use in further field testing.

Uranium Transport

Currently, a pump and treat system is in place at the site to reduce the uranium contaminant mass within the plume. Data indicates the system is not effectively removing enough uranium to meet the compliance requirements for the site. This project focuses on the uranium and how it interacts with the soil, in terms of adsorption to the soil matrix. This task is intended to improve the understanding of uranium transport in the vadose zone and groundwater to feed into the development/selection of a remedial solution for the uranium plume at a Hanford site. The identification of factors affecting uranium migration in soils and aquifer through laboratory and/or field-testing has been in progress during FY01. The project is intended to refine the conceptual model of the soils associated with the 216-U1/U2 Cribs in the 200 West Area. This will be accomplished through sampling and lab analyses, obtaining additional subsurface characterization data, developing and validating a geochemical model to quantify the mobility of uranium in the unsaturated and saturated soils, and producing an updated conceptual model.



Baseline Conceptual Model of Uranium Contamination from 216–U1/U2 Cribs

Once the site conceptual model has been developed, recommendations for the most appropriate and effective methods for cleanup are to be identified.

Innovative technologies/systems are being employed to assess the uranium transport mechanisms, which will be used for the geochemical surface complexation model. Two such technologies/systems include a follow-on deployment of the CPT cone sipper developed by ARA and a first time deployment of the Subsurface CO_2 Sampling System developed by MSE. As with the use of any other innovative technology, there were advantages for using these two. The cone sipper provides in situ real time measurements for CO_2 concentration, soil moisture and lithology for shallow depths.

The Subsurface CO_2 Sampling System was somewhat of a different story—the baseline technique for collecting CO_2 concentration in the formation-gas is by discrete sampling and laboratory analysis. Use of the baseline technique requires expensive delays in drilling due to the turn-around time for laboratory analysis. Additionally, data quality cannot be determined until laboratory results are known. The innovative Subsurface CO_2 Sampling System was developed in response to the need for obtaining high quality formation gas CO_2 measurements in the field during Hanford ERC-funded drilling of a groundwater monitoring/extraction well. The system extracts formation-gas through a borehole from which the CO_2 concentration in the formation can be measured. With this information, the pH of soil moisture in the unsaturated zone can be determined. This information will be used in the geochemical model to evaluate the mobility of uranium.

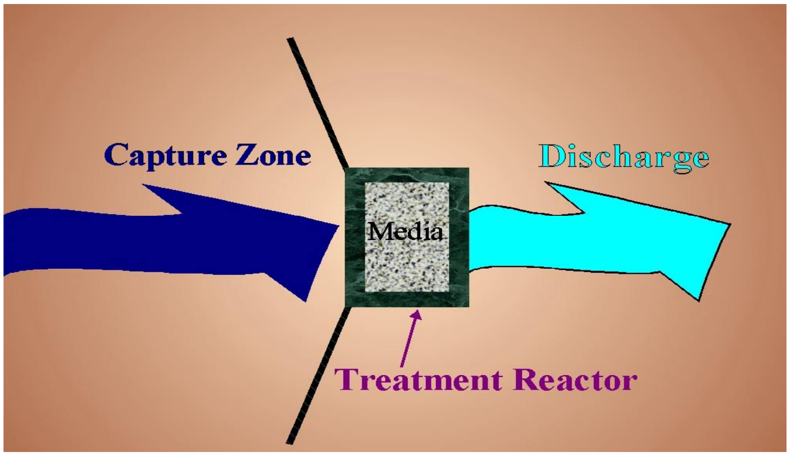
Subsurface CO_2 Sampling System

In FY02, the data taken in FY01 will be used to develop a surface complexation model to support the refinement of the site conceptual model and eventually to support the decision for remediation alternatives. The innovative technologies for characterization/sampling and the process for evaluating uranium transport through the subsurface are applicable to sites where subsurface evaluation is critical to the remediation decision and costly alternatives.

Treatment Barriers

Treatment barriers were developed to allow groundwater to be remediated in the subsurface without the cost of bringing the water to the surface or the issue of clean water reinjection. MSE has worked with treatment barriers for several years in the areas of design, installation, evaluation, and media advancement. Our focus has been on all areas of the barrier, including the capture—collecting the water underground, treatment—both the reactor design and the treatment media to be used for the contaminants, and release—the discharge zones and their design.

The most recent area of advancement for SCFA by MSE has been the laboratory and field-scale development of reactive media for cleanup of uranium and heavy metal contaminants in groundwater at the DOE Oak Ridge, TN, Y-12 Plant. Successful laboratory testing was completed in FY00. Performance and environmental stability of organic "apatite" media was confirmed at bench-scale. Field demonstration/deployment of the technology was initiated at the Oak Ridge, TN, Y-12 Plant during FY01 and remains in progress. Apatite, as an alternative to zero valent iron, has the potential for treating additional contaminants with the advantage of less remobilization issues.



Treatment Barrier Schematic

There are potential opportunities for full-scale deployment of this technology at Oak Ridge, TN, other DOE and non-DOE sites.

Non-Traditional In Situ Vitrification

In situ vitrification is a mobile, thermal treatment process that involves the in situ electric melting of contaminated soils, sludges, or other earthen materials and debris for the purpose of permanently destroying, removing, and/or immobilizing hazardous and radioactive contaminants.

Conventional ISV involves processing the soil/waste matrix in a top-down fashion. A horizontally oriented melt is established between four electrodes. The continued application of electrical power through the melt causes the melt to grow downward and outward until such time that the melt has encompassed the entire treatment volume from grade down to the desired depth.

When electrical power is shut off, the molten mass solidifies into a vitreous and crystalline rock-like monolith with unequaled physical, chemical and weathering properties, compared to alternative solidification/stabilization technologies. Off gases generated by the process are contained under a steel hood covering the treatment area and are drawn to an off-gas treatment system.

The process destroys organic contaminants such as dioxins, pesticides, and PCBs. Heavy metals and radionuclides are retained in the melt and immobilized in the resulting product.

The NTISV technology used was an advanced technology, termed GeoMelt Planar ISV, which involves joule-heated melting within the subsurface. In this process, two vertically oriented planar melts are established in the subsurface between pairs of electrodes. The planar melts can be initiated at the desired depth and separation within the subsurface. The process results in two independent vertically oriented planar melts during the initial stages of the process. Because the melts are initially separated and grow horizontally together late during the treatment process, the potential for restricting the flow of gases generated below the melts is significantly reduced compared to conventional ISV.   Melt temperature ranges from 1400-2000 degree C and the batch process operates with rates up to 100 tons/day of melt.

The non-radioactive demonstration was successfully completed at Los Alamos in 1999 using the planar melt ISV technology. A full-scale deployment of the technology was completed at a Los Alamos National Laboratory mixed-waste site in FY00. It resulted in a 500 ton vitrified monolith. Analysis and reporting, with minor exceptions, were completed in FY01.

Deployment Site at Los Alamos National Laboratory

MSE continues to work with AMEC (the technology owner) to identify follow-on opportunities to apply this technology at other DOE sites.

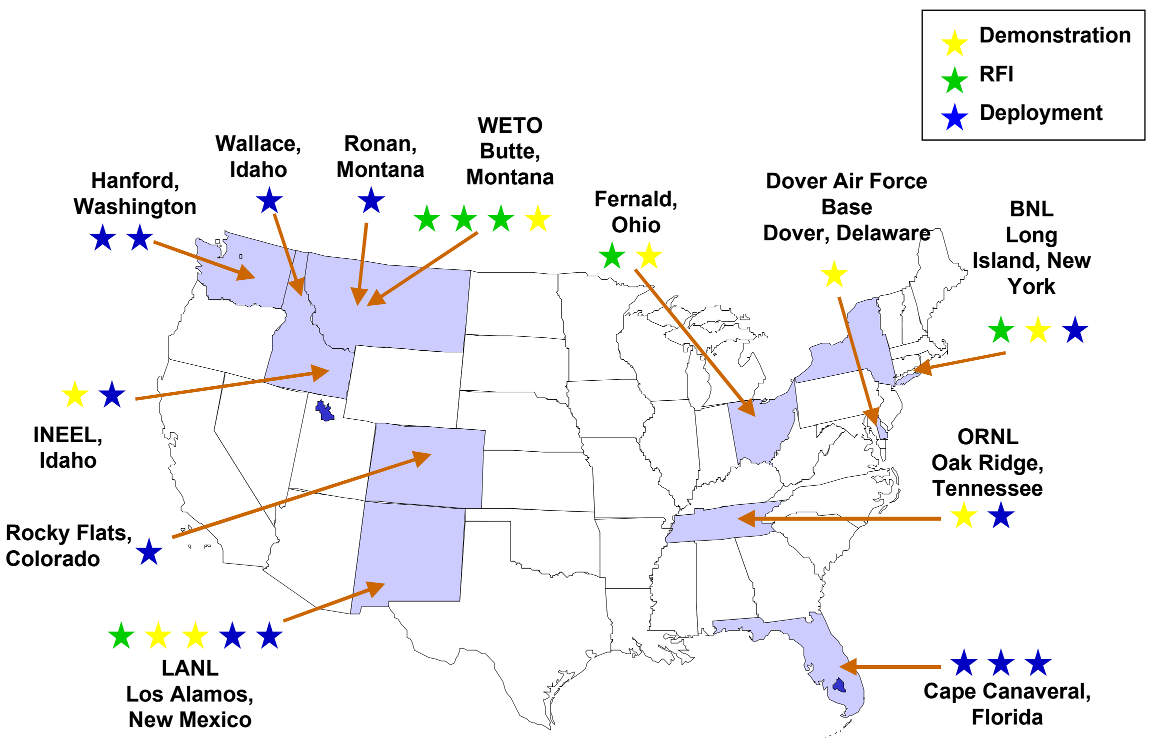
Mercury Stabilization

Mercury contamination in the subsurface continues to be a problem in the federal complex. MSE has been chartered with evaluating technologies for in situ stabilization of mercury in soils at the Oak Ridge, TN, DOE Site. The stabilization technologies have been focused on grout materials coupled with emplacement methods. Because many of the contaminated sites at the Oak Ridge facility are operating facilities, subsurface infrastructure makes in situ treatment attractive. Many grout materials developed in the past have not been advanced with the stabilization of mercury contamination in mind.

MSE has been performing bench-scale testing of selected technologies as part of a CERCLA treatability study for mitigation of mercury contaminated soils near and under buildings at the Oak Ridge Y-12 Plant. Field demonstration and deployment of a mercury stabilization technology is scheduled at Oak Ridge during FY02-03. MSE will continue to pursue opportunities for application of mercury stabilization technology at Oak Ridge and other sites with similar needs.

Closing

These and many other technologies are being developed by MSE through the DOE for subsurface contaminant application throughout the federal complex. Among the many challenges we face, the principal ones are transferring these technologies and finding opportunities to deploy them. Our past work, performed through the DOE Western Environmental Technology Office under contract to the National Environmental Technology Laboratory and in collaboration with the SCFA, has been performed throughout the United States. It has resulted in many technologies demonstrated, deployed, and ready for implementation.



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