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Technical Assistance to Ohio Closure Sites

Technologies to Address Excavated VOC Contaminated Soil from Areas 3A/4A and Plant 6 at Fernald Environmental Management Project, Ohio

Technical Assistance #138

May 29-31, 2002

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EXECUTIVE SUMMARY

On May 29-31, 2002 a technical assistance team met with Fernald Environmental Management Project (FEMP) personnel in Ohio to assess approaches to remediating volatile organic compound (VOC) contaminated soils. The technical assistance team was composed of technical experts from national labs, technology centers, and universities and was assembled in response to a request from the Soil and Disposal Facility Project (SDFP) at FEMP. A list of the technical assistance team members and names and contact information are provided in Appendix A.

The technical assistance request sought evaluation, recommendation, development, and application of a process to treat approximately 1,800 cubic yards of soil/sediment contaminated with organic solvents (TCE, PCE) and with U (treatment process to focus on organics only) in Areas 3A and 4A. FEMP also requested assistance with a strategy for addressing contaminated soils at Plant 6. As part of this request at Areas 3A/4A and Plant 6, FEMP Fernald asked for sustained technical assistance as required to assure successful completion. See Appendix B for the technical assistance request.

This was a two and a half day meeting. The time was used to discuss the primary issues at Areas 3A/4A and Plant 6, brainstorm potential innovative and cost effective solutions, evaluate alternatives, and make general recommendations to SDFP. Since the meeting, the technical assistance team further developed recommendations for the site. The bullet points below summarize the body of this report.

- **Issues.** The selected treatment technology should be timely – feasible to implement and complete by the "end of the year". This will support the overall FEMP closure and restoration activities and help meet the 2006 closure deadline. The technology should treat the target soil to meet FEMP Waste Acceptance Criteria (WAC) thereby enabling disposition at the on-site disposal facility (OSDF) and should be cost effective in comparison to the baseline.

- **Evaluation of Alternatives.** Roughly sorted from least intensive to most intensive, the technologies that were evaluated for Areas 3A/4A and Plant 6 included: direct disposal, passive soil venting, enhanced soil venting, zero-valent iron, anaerobic bioremediation, aerobic bioremediation, thermal desorption, vacuum desorption, chemical oxidation, incineration, and DNAPL removal technologies.

- **Recommendations.** Although ten out of the eleven technologies listed above would work, one technology – enhanced soil venting – stood out as best at meeting all of the requirements at FEMP. Enhanced soil venting is a simple process of removing the VOCs during the storage period using air extraction and available solar heat. This report focuses on design features and recommendations for implementing the enhanced soil venting option in Areas 3A/4A. Generally, our recommendations address technical and functional design requirements (equipment, flow rates, options, issues, cautions, etc.).The design and implementation of an enhanced venting system for excavated VOC contaminated

soil should be straightforward and robust. Any of a number of reasonable and operational conditions should successfully treat the soil and meet FEMP goals. Important issues to be considered include the need for offgas treatment, specific operational cautions associated with carbon absorption (if used), and assuring that the treatment is implemented and accepted by regulatory personnel and stakeholders as meeting environmental stewardship commitments. The recommendations then discuss and generalize the VOC treatment technology matrix in terms of a smart storage concept for Plant 6 soil and any other future VOC contaminated soils generated during FEMP closure activities. As requested, the technical assistance team will continue to assist the FEMP technical staff, as needed, to facilitate implementation and to help assure successful implementation.

I. BACKGROUND

The Department of Energy's Fernald Environmental Management Project (FEMP) in Ohio requested support from the Environmental Management-50 (EM-50) technical assistance team to evaluate cost effective and timely options associated with treating organics in soil. More specifically, the team was tasked to provide technical assistance to the Fernald site to evaluate, recommend, develop, and apply a treatment process to treat approximately 1,800 cubic yards of soil/sediment contaminated with organic solvents (TCE, PCE) and with U (treatment process to focus on organics only) in Areas 3A and 4A. In addition, Fernald requested assistance with a strategy for addressing contaminated soils at Plant 6. Fernald requested sustained technical assistance as required to assure successful completion of the remediation operations at both Areas 3A/4A and Plant 6.

The team assembled to work on this technical assistance request includes the following individuals. Biographies are provided in Appendix A, along with contact information.

Brian Looney, Savannah River Technology Center
Terry Hazen, Lawrence Berkeley National Laboratory
Michael Heitkamp, Savannah River Technology Center
Michael Kuperberg, Florida State University
Laymon Gray, Florida State University
Carol Eddy-Dilek, Westinghouse Savannah River Company
Jim Iwert, Subsurface Contaminants Focus Area
Emily Charoglu, EnviroIssues

The approach to this request for technical assistance involved collecting information on the target problem (including background, site history, environmental conditions, what technologies have been proposed, status), identifying critical FEMP issues to consider in selecting an appropriate technology, identifying potential technologies, and developing a technology matrix designed to qualitatively rate the technologies according to criteria. The team also asked questions to FEMP personnel to determine whether there were site-specific opportunities, benefits of integrating with nearby work, or benefits of integrating technologies, etc. After a two-day assessment, the team began to develop and document recommendations, results of which are provided in this report.

II. ISSUES

Soil/sediment contaminated with organic solvents (TCE, PCE) and with U was excavated during the decommissioning of former FEMP Areas 3A/4A and is currently stockpiled awaiting treatment and/or disposal. Soils are stockpiled in two locations: the Quonset hut and the burrito. Objectives associated with the Quonset hut are to treat organics to pass the Toxicity Characterization Leachate Procedure (TCLP) under Resource Conservation and Recovery Act (RCRA) regulations. The burrito objective is to treat organics to meet the 20X rule. More specific requirements for the technology application are as follows:

Quonset Hut: Stockpiled Soils from Areas 3A/4A

- The treatment technology should be feasible to implement and complete by the "end of the year". This will help meet FEMP staging time guidelines and support overall FEMP closure and restoration activities – helping to achieve the 2006 closure goal.
- The treatment technology should enable soil disposal at the on-site disposal facility (OSDF), meaning that organics need to be treated to meet appropriate guidelines such as OSDF Waste Acceptance Criteria (WAC).
- The technology should be cost effective in comparison to the baseline.

At Plant 6, soils are contaminated with Tc, U, and PCE above OSDF WAC. Similar limitations exist at Plant 6 as those described above. In addition, future activities may generate waste streams with similar technology requirements.

III. EVALUATION OF ALTERNATIVES

At the time of the team visit, the baseline treatment technology for approximately 1,800 yd^3 of excavated and stockpiled VOC contaminated soils from Areas 3A/4A was chemical oxidation. Another candidate technology that had been considered was low temperature thermal desorption (LTTD). FEMP evaluated logistics and feasibility for LTTD after the soils were excavated. FEMP operates rotary kilns that might have been utilized, but the kilns were only permitted for moisture removal and logistics associated with their use for VOC contaminated soil made this approach undesirable. Similarly, bringing in a separate LTTD facility for this small soil volume was not consistent with FEMP goals of minimizing new infrastructure, minimizing future waste, and minimizing future decommissioning activities. Other technologies, such as offsite vacuum thermal desorption had also been examined but these were also proving difficult to implement. Subsequently, the stockpiled soils awaited remediation, FEMP developed a plan to implement chemical oxidation, and requested a technical assistance team to brainstorm alternatives.

After a discussion with site personnel about the technologies previously considered, the team developed a "comprehensive" list of potential technologies to be further evaluated. From least intensive to most intensive, these technologies included: direct disposal, passive soil venting, enhanced soil venting, zero-valent iron, anaerobic bioremediation, aerobic bioremediation, thermal desorption, vacuum desorption, chemical oxidation, incineration, and DNAPL removal technologies. The team evaluated each one of these technologies in terms of effectiveness, regulatory and stakeholder issues, health and safety issues, technology maturity and other factors. Although ten of these technologies would work, one technology – enhanced soil venting – stood out as best at meeting all of the requirements at FEMP. The technology matrix and brief discussions of the technologies are provided below.

A. Direct Disposal

The direct disposal option assumed collection, packaging and transportation of contaminated soils to an off-site disposal facility. The facility would have to be capable of accepting the untreated soils in their current state (e.g., with radionuclides and VOCs). Off-site disposal was recognized as a rapid and complete approach to permanently remove the contaminated soil from the FEMP facility and was evaluated in terms of FEMP closure goals (cost, schedule and utilization of the OSDF). This disposal option was determined to be compatible with FEMP schedule needs; however, cost was estimated to be relatively high based on the assumptions that the soil would need to be packaged at FEMP, transported to the selected disposal facility and disposed as mixed waste. Additionally, this disposal option does not support the stated FEMP objective of utilizing the OSDF for final disposition of this soil. Thus, off-site disposal was determined to be a viable option, but was limited by its high cost and departure from the OSDF disposal strategy.

B. Passive Soil Venting

The passive venting option assumes that soils currently positioned in the Quonset hut and burrito would be left in place and monitored over time for reduction of chlorinated solvents (PCE and TCE). Target concentrations differ for the two soils (TCLP-based for the Quonset hut soils and Final Remediation Levels (FRLs) for the incinerator pad "burrito" soils). When last sampled, TCE was above criteria for both soils. solvents will be removed from the soil piles by passive volatilization over time. Based on the nature (high clay content) and storage method (pile) of the soil, it may be necessary to manually manipulate the pile (i.e., turning) to allow airflow through the entire soil matrix. This may be difficult and costly within the Quonset hut due to spatial limitations. It will be necessary to monitor contaminant concentrations throughout the soil mass and manipulate the soil accordingly to achieve criteria. This technology is low-cost and would utilize the OSDF as the final disposal location. Without additional data, the technical assistance team was not confident that passive venting alone would be able to meet WAC within schedule.

C. Enhanced Soil Venting

Soil venting in an excavated pile is equivalent to soil vapor extraction and has some similarity in operation to biopiles. In unexcavated soils of moderate to high permeability, EPA identifies soil vapor extraction as a presumptive remedy (U.S. EPA, 1991a, U. S. EPA 1993a) for removing VOCs and other volatile contaminants. In fact, for excavated soils that have been physically reworked, soil venting should be more effective than *in situ* soil vapor extraction (U.S. EPA 1992a). In this potential application, the technical assistance team suggests further enhancing the soil venting using passive solar heating of the current storage locations. The enhanced soil venting option assumed that soils currently positioned in the Quonset hut and burrito would be actively vented to increase the volatilization of solvents. Target concentraiotns differ for the two soils (TCLP-based for the Quonset hut soils and FRLs for the incinerator pad soils). When last sampled, PCE was above criteria for both soils. Solvents will be removed by placing perforated pipe(s) into each of the soil piles and extracting air by vacuum. Depending on the concentration in the effluent air stream and regulatory drivers, soil vapor treatment could be implemented if necessary. A secondary, but significant, potential advantage of this enhanced soil venting approach is that active air extraction from the interior of the pile can serve as a collection system for low cost analysis. In this mode, criteria can be developed for the offgas concentrations and rebound to indicate when the process is relatively complete and to reduce and optimize the number of point soil samples for lab analysis.

This approach utilizes the current storage location (Quonset hut) as a passive solar heating system. Elevated ambient temperatures within the building will accelerate the volatilization of solvents. Painting the building black to increase the absorption of solar energy would enhance this process. Once the treatment system is established in the

Quonset hut, future excavated soils that do not meet OSDF WAC for VOCs but are otherwise compatible with OSDF criteria, could be treated and disposed of in the OSDF. Similarly, incinerator pad (burrito) soils, would be covered with a gas permeable black cover to enhance VOC removal by solar heating.

This technology is low-cost, would utilize the OSDF and should meet the FEMP schedule requirements. It would require minimal equipment and soil handling and would not increase the footprint of the two soil piles. In addition, the Quonset hut would be a potentially valuable facility for treating other VOC contaminated soils. This technology was selected as the best alternative for FEMP goals. More details on configuration and implementation are provided in the recommendations section later in the report.

D. Zero-Valent Iron

Addition of zero-valent iron (ZVI) to the soil piles will chemically dechlorinate PCE and related solvents. Granular zero-valent iron would be mixed with existing soil and with water to provide appropriate conditions for the abiotic contaminant destruction. Conditions in the pile would be monitored and optimized to insure complete degradation of the VOCs. ZVI has often been deployed in permeable walls and similar configurations and has been studied by a large number of university/federal laboratories and companies. Researchers from the University of Waterloo in Canada performed early development of the technology – the principal licensee of their work is environmental. Treatment of excavated soils as described herein represents an interesting and appropriate application if better alternatives are not identified. Utilization of this technology would require mobilization of storage and mixing equipment and would expand the footprint of the two soil areas. In addition, spatial limitations within the Quonset hut compound difficulties associated with implementing this technology. This technology could generate intermediates with more stringent WAC than those for PCE. Significant efforts would be required to monitor for the presence of these intermediates and to maintain optimal moisture conditions within the pile to encourage complete degradation. As a potential benefit, ZVI may chemically reduce uranium in the soils and limit the more mobile U (VI). Use of ZVI will increase the volume of materials to be disposed in the OSDF. The core ZVI technology is low-cost and would utilize the OSDF as the final disposal location but implementation for this particular soil at Fernald is limited by the need to mobilize equipment and materials and the associated costs.

E. Thermal Desorption

Low-Temperature Thermal Desorption (LTTD), also known as low-temperature thermal volatilization, thermal stripping, and soil roasting, is an *ex situ* remedial technology that uses heat to physically separate volatile contaminants from excavated soils (Troxler, 1994, U. S. EPA 1992b, U. S. EPA 1993b). Thermal desorbers are designed to heat soils to temperatures sufficient to cause constituents to volatilize and desorb (physically separate) from the soil. They are not designed to decompose organic constituents. The offgas (air containing vaporized contaminants) is treated, if necessary, and discharged to the atmosphere in accordance with applicable permits. Some pre- and post- processing of soil is typical when using LTTD. Excavated soils are screened to remove large objects (2 inch diameter and larger). After leaving the desorber, soils are cooled, re-moistened to control dust, and stabilized (if necessary) to prepare them for disposal/reuse. In the case of the target excavated-soil at Fernald, the soil contains uranium and would be prepared for disposal in the OSDF.

There are several variants of LTTD including rotary dryers, rotary kilns, asphalt plant aggregate dryers, thermal screws and conveyer furnaces. The mode of operation can often be discerned from the name. For example, a rotary dryer typically uses a heated inclined rotating drum - the soil is heated as it moves downward while air moves in a countercurrent direction to remove the contaminants. LTTD was strongly considered for treating the excavated soil at Fernald because rotary kilns are already onsite, but these have not been operated for VOC treatment. Adding the VOC contaminated soil waste stream would require significant planning and permitting, require time in the kiln and soil segregation, require multiple handling operations, and potentially delay the critical routine drying operations that are necessary to ship large volumes of waste pit material to EnviroCare on schedule. Setting up a dedicated unit is not justified for the small target soil volume with unknown future waste volumes of this type. Thus, this approach, while technically feasible may not represent the optimal choice for this treatment activity.

F. Anaerobic Bioremediation

Anaerobic bioremediation is a well-proven technology in which anaerobic microorganisms degrade chlorinated solvents by the mechanism of reductive dehalogenation (Norris et al. 1994). The pathway for this mechanism includes the degradation intermediates dichloroethene, vinyl chloride and ethene. This microbial activity requires strongly anaerobic conditions and the presence of anaerobic microorganisms possessing reductive dehalogenation capability. In cases where natural conditions do not support anaerobic reductive dehalogenation, it is common to deploy biostimulation (addition of carbon sources to produce anaerobic conditions) as well as bioaugmentation (addition of anaerobic halorespiring bacteria) to achieve *in situ* anaerobic biodegradation of chlorinated solvents. Correct conditions and the presence of appropriate biocatalysts will commonly result in complete degradation of chlorinated solvents.

Application of anaerobic bioremediation for *ex situ* treatment of contaminated soils at Fernald would require that strong anaerobic conditions be established and maintained. This could be done by exclusion of oxygen, but more likely by biostimulation with excess organic nutrient supplementation. In general, anaerobic processes are more difficult to implement than aerobic processes for *ex situ* soils. Biostimulation would also result in the reduction of additional electron acceptors, including nitrate and sulfate. Additionally, the bioprocess conditions would need to be held within acceptable ranges for temperature, pH and moisture. Macronutrient additions (primarily nitrogen and phosphorous) may also be required.

It is possible that indigenous microbial populations under anaerobic conditions may not degrade chlorinated solvents or only partially degrade them. The detection of chlorinated solvent degradation intermediates in soils at Fernald indicates this may be problematic so a treatability study would be required. Partial microbial degradation could result in significant production of degradation intermediates that have more stringent WAC than the original chlorinated solvent(s). Anaerobic microorganisms typically grow slowly and the time required for a treatability study would delay schedule. If sufficient degradation activity was not observed, then bioaugmentation (i.e., the addition of microorganisms as well as nutrients and carbon) would be required. Bioaugmentation would require additional study, increase the cost and time required for bioremediation and result in a more complex approach, which would likely require more time for regulatory approval. Although anaerobic bioremediation of chlorinated solvents is a robust and proven technology, it is not recommended for Fernald primarily due to the time constraint for completion of soil treatment.

G. Aerobic Bioremediation

Aerobic bioremediation is a well-proven technology in which aerobic microorganisms degrade chlorinated solvents by the mechanism of cometabolism (Norris et al. 1994). In this case, enzymatic stimulation by addition of a carbon substrate under aerobic conditions results in fortuitous co-degradation of chlorinated solvents by oxidative mechanisms. Since these microorganisms do not utilize chlorinated solvents directly as a source of carbon or energy, deployment of aerobic bioremediation requires an engineering design to provide oxygen and the presence of degradable organic carbon. In some cases, contaminated soils may contain sufficient levels of degradable carbon and only oxygen addition is required. In other cases, oxygen is provided as well as degradable organic substrates delivered in solid, liquid or gaseous additions. The accumulation of unwanted degradation intermediates does not usually occur with aerobic bioremediation.

Application of aerobic bioremediation for *ex situ* treatment of contaminated soils at Fernald would require that aerobic conditions be established and maintained. This would require engineering an air (or oxygen) supply system into the *ex situ* soil pile. This system could be a relatively simple design, such as perforated PVC piping and a low volume blower. Additionally, the bioprocess conditions would need to be held within acceptable ranges for temperature, pH and moisture. It is likely that a water delivery system would be required to maintain acceptable levels of soil moisture. Macronutrient additions (primarily nitrogen and phosphorous) may also be required.

It is probable that a biotreatability study would be required for aerobic bioremediation of soils at Fernald. This study would demonstrate feasibility and provide an opportunity to optimize the bioprocess for Fernald soils. However, this would increase the cost and time required for regulatory approval. Although aerobic bioremediation of chlorinated solvents is a robust and proven technology, it is not recommended for Fernald primarily due to the time constraint for completion of soil treatment.

H. Vacuum Desorption

Vacuum-enhanced LTTD is a batch treatment that improves the efficiency of treatment over standard LTTD. Historically, the primary criterion for selecting a vacuum enhanced system is to broaden the range of target contaminants that are effectively treated. The addition of vacuum allows treatment of semivolatile contaminants such as pesticides and PCBs. These types of compounds are not present in the VOC contaminated excavated soil so the vacuum process conveys no advantage for the target Fernald need – a standard LTTD or any other physical removal approach would work equally well. A typical system includes a treatment chamber (operated under a vacuum of about 50 mm Hg and using an infrared heat source). By operating under a vacuum, the temperature required to desorb contaminants from the soil and the amount of oxygen present in the treatment chamber are lower than if the unit were operated under atmospheric conditions. This reduces the offgas treatment volume and the potential for formation of oxidized byproducts. Systems can be implemented either on-site (mobile) or at a remote (fixed) facility. For example, Envirocare & TD*X Associates have combined to set up a vacuum LTTD system to support their customers. This technology has been used successfully at several sites (all of which required treatment of semivolatiles). One potential advantage for Fernald would be the benefit from integrating this waste with drummed soil that is currently slated for offsite vacuum desorption and then offsite disposal. Unfortunately, this integration would not reduce costs, would not improve performance and would generate significant schedule risk. Delays associated with the drummed waste (the primary waste that FEMP has slated for this process) might substantially delay treatment of the soil piles. Also, this approach does not meet the Fernald goal of utilizing the OSDF. Vacuum desorption remains the technology of choice for small volumes of soil with widely variable contaminants (i.e., including semivolatiles). Thus, while not optimal for the subject 3A/4A soils, the vacuum desorption process should be pursued as a potentially important technology for other types of soil and waste generated at Fernald.

I. Incineration

This option assumes collection, packaging and transportation of contaminated soils to an off-site incineration facility and subsequent delivery to a disposal site. The incineration facility would have to be capable of accepting the untreated soils in their current state (e.g., with radionuclides and VOCs). Incineration and off-site disposal was recognized as a rapid and complete approach to permanently remove the contaminated soil from the FEMP facility. Incineration and off-site disposal was evaluated in terms of FEMP closure goals (cost, schedule and utilization of the OSDF). This disposal option was determined to be compatible with FEMP schedule needs but cost was estimated to be very high based on the assumptions that the soil would need to be packaged at FEMP, transported to the selected incineration facility for treatment, and then repackaged and transported to the selected disposal facility (U. S. EPA 1993a). Additionally, this disposal option does not support the stated FEMP objective of utilizing the OSDF for final disposition of this soil. Incineration and off-site disposal was judged to be a viable option, but was limited by its high cost and departure from the OSDF disposal route.

J. Chemical Oxidation

Chemical oxidation was identified as a baseline approach for treatment of the target excavated soil piles at Fernald. This technology uses reagents to destroy high concentrations of contaminants (typically non-aqueous phase liquids). Because *in situ* oxidation requires delivery of reagent and requires intimate contact of the reagent with the source solvents, it would work well in an excavated soil system where the geometry and flow characteristics could be carefully controlled. Also, because it is an aggressive and rapid method, such a treatment would be able to meet schedule requirements (assuming that a system could be set up and operations started in a timely fashion). Typical treatment reagents include Fenton’s reagent (hydrogen peroxide and reduced iron) and permanganate solution. These reagents are strong oxidizers that react with the contaminant in a saturated or moist soil setting. As the reagent is added, it reacts vigorously and often induces bubbling and mixing – a process that may enhance contact of the reagent with the target contaminant. Several variants of *in situ* oxidation methods have been deployed commercially. A key element to the success is performing the work rapidly with a minimal volume of reagent. Specific attributes that make this technology promising include: relatively small and well-defined highly contaminated and permeable target soils. The technology uses large volumes of dangerous reagents, is moderately difficult to deploy (i.e., requires expensive infrastructure), requires moving and mixing the soil, and many similar challenges. This technology will also reoxidize reduced forms of uranium, U (IV), chromium (III), and other metals, which are relatively insoluble and make them more soluble U (VI) and Cr (VI), and more toxic in the case of Cr. This increased mobility could become a handling issue during the treatment process and disposal of leachate. Since safer, less-expensive, and effective alternative technologies are available, chemical oxidation is not the optimal candidate for FEMP under the current circumstances.

K. DNAPL Removal Technologies

Several technologies have been developed to accelerate the removal of residual liquid-phase VOCs from soil (see for example Brusseau et al, 1999). As a class, these technologies are intensive and generally rely on significant thermal or chemical driving forces. Similar to *in situ* oxidation and other destruction techniques discussed above, DNAPL removal technologies tend to be relatively high in cost and to have a significant potential for adverse collateral environmental health and safety impacts. Example impacts include those associated with the use of large amounts of energy, the use of large volumes of chemical reagents, undesired mobilization and spread of DNAPL that is not captured. Example technologies in this class include:

- Chemical extraction – Two general technologies are normally included in this category – surfactant flushing and cosolvent extraction. This technology uses reagent solutions to solubilize or mobilize source solvent. Various universities, companies, and government agencies have studied this technology for many years. The process requires rigorous control on the injected and extracted fluids to assure that the source soil is swept by the injected reagent and to assure that the mobilized/solubilized DNAPL is effectively captured. A key element to the success is optimizing the use of the relatively expensive reagents.

- Thermal and other energy based extraction enhancement methods – several technologies have been tested that enhance the removal of residual DNAPL using energy. They are typically deployed in conjunction with a related collection method (e.g., soil vapor extraction, steam collection, DNAPL-water collection) and a treatment or disposal system. These technologies include heat based techniques such as steam flushing, joule heating (e.g., six phase heating), radio frequency heating, microwave heating, conductive heating (i.e., inserting standard heaters into the soil) and a few emerging energy-based technologies (e.g., sonic applicators, electro-osmosis).

A key requirement to justify DNAPL removal technologies is the presence in the target soil of significant levels of separate phase residual VOC liquids. Since there is no data to suggest that this key condition is met for the Fernald excavated soil, this technology class is not applicable.

Technology Matrix: Technologies to Address Excavated VOC Contaminated Soil

Remediation Technology	Remediation Strategy	Effectiveness*	Permitting Risk	Implementability	Health and Safety Issues	Cost**	Public Acceptability (Stakeholder)	Long-term Liability	Technical Maturity	Overall
Off Site Disposal	No treatment – waste removal	Rapid and removes soil to facilitate remaining cleanup, but does not meet objective of utilizing OSDF.	Minimal	Moderate - Handling and packaging, utilizing transport and disposal vendors.	Moderate, requires handling and transportation.	High	High	Low but organics remain in soil.	Commercially available, infrastructure already in place.	Viable, but high cost.
Passive Soil Venting	VOC removal from soil	Effective given sufficient time. High uncertainty for treatment duration.	Low	Straightforward – will require significant sampling and/or soil turning.	Minimal – but may require physical manipulation of pile.	Low	High but generates some fugitive emissions of VOCs.	Low	N/A	Viable, but may not meet schedule requirements.
Enhanced Soil Venting	VOC removal from soil	Effective – should meet schedule requirements, PCE removal requirements, and utilizes OSDF. Presumptive EPA remedy in soil.	Low	Straightforward, offgas treatment, if necessary, would eliminate fugitive emissions. Many configurations are possible. Solar heat would accelerate process. Minimal infrastructure required and potential for additional applications.	Minimal – requires insertion of venting infrastructure into soil.	Low to moderate	High	Low	Commercially available and easily implemented by local craft.	Viable, meets all requirements. Best alternative.
Zero-Valent Iron	Destruction – *ex situ*	Reasonable technology for chlorinated solvents, VOCs. Generates intermediate with lower WAC. Requires complete destruction. Increases waste volume to OSDF. Likely to be effective within	Low, need to demonstrate control, conditions and completeness.	Straightforward. Requires soil handling and mixing facility, iron storage and delivery facilities (extending footprint). Probably requiring treatability study.	Moderate, heavy equipment	Medium to high	High	Low	Commercially available – unique application	Potentially viable – but not best alternative.

Remediation Technology	**Remediation Strategy**	**Effectiveness***	**Permitting Risk**	**Implementability**	**Health and Safety Issues**	**Cost****	**Public Acceptability (Stakeholder)**	**Long-term Liability**	**Technical Maturity**	**Overall**
		desired schedule.								
Thermal Desorption	VOC removal from soil	Rapid and controlled, can meet schedule requirements, and treated soil goes to OSDF.	Low but may require additional permits.	Straightforward, off gas treatment, if necessary, would eliminate fugitive emissions. Would require significant equipment infrastructure. May be able to use or modify existing on site equipment.	Moderate – requires significant handling of soil and worker proximity to heat source.	Low with existing equipment - high if new equipment is needed.	High	Low	Commercially available and may be implemented by local personnel.	Viable, may be difficult to implement.
Anaerobic Bioremediation	Destruction that can be *in situ* or *ex situ*	Reasonable technology for VOCs. Generates intermediates with lower WAC. Requires complete destruction.	Low, need to demonstrate control, conditions and completeness. Bio-augmentation would increase permitting risk and extend schedule.	More difficult because soil has been excavated. Unlikely to achieve schedule goals. Requires subcontractor or product supplier. May require bio-augmentation. Requires treatability tests.	Minimal	Medium	High, but bio augmentation could reduce it.	Low	Commercially available	Potentially viable but not best alternative.
Aerobic Bioremediation	Destruction that can be *in situ* or *ex situ*	Reasonable for VOCs (slow for PCE).	Need to document timely PCE destruction.	Requires addition of carbon sources for co-metabolite. May not achieve schedule goals. Requires treatability tests.	Fugitive air emissions, but minimal. Could increase if flammable co-metabolites are used.	Medium may be lower than anaerobic.	High	Low	Commercially available	Potentially viable but not best alternative.
Vacuum Desorption	VOC removal from soil	Rapid and controlled, can meet schedule requirements.	Low	Potential to integrate with drum soil treatment. Shipping to offsite vendor for remote treatment and disposal.	Moderate, requires handling and transportation.	High, given offsite treatment and disposal.	High (treated offsite)	Low	Commercially available, may be difficult to implement. Coordination with drum waste remains an issue.	Viable, not best alternative.

Remediation Technology	Remediation Strategy	Effectiveness*	Permitting Risk	Implementability	Health and Safety Issues	Cost**	Public Acceptability (Stakeholder)	Long-term Liability	Technical Maturity	Overall
Incineration	VOC destruction	Rapid and controlled, can meet schedule requirements.	Minimal	Moderate - Handling and packaging required. Requires separate vendors for incineration and disposal.	Moderate, requires handling and transport.	Very High	High	Low	Commercially available	Viable, not best alternative.
Chemical Oxidation	VOC destruction	Rapid and controllable, can meet schedule requirements and treated soil meets WAC and can go to OSDF.	Low	Requires significant new infrastructure to control reagents (storage and delivery). Requires post treatment drying.	Moderate to high (reagent handling).	Moderate to high	High	Low, but U may be converted to a more mobile state U (VI)	Commercially available	Viable, not best alternative.
DNAPL Removal Technologies	Free product removal	Not appropriate because no significant free product in soil	NA	NA	NA	NA	NA	NA	NA	Not applicable to excavated soil.

*Effectiveness in terms of meeting goals such as schedule, on site disposal, and cost.

**Cost: low < $500,000; moderate > $500,000; high > $1M; very high > $5M

IV. RECOMMENDATIONS

A. Areas 3A/4A

The technical assistance team recommendations for the existing VOC contaminated excavated soil are summarized in the table below. Given the SDFP desire to proceed with a timely and cost effective solution that enables disposal in the OSDF, enhanced soil venting appears to be the best option. As suggested by the table, there are alternative technologies that may not meet all the FEMP objectives and even others that could be viable but that would be ill suited to the soil type at Fernald.

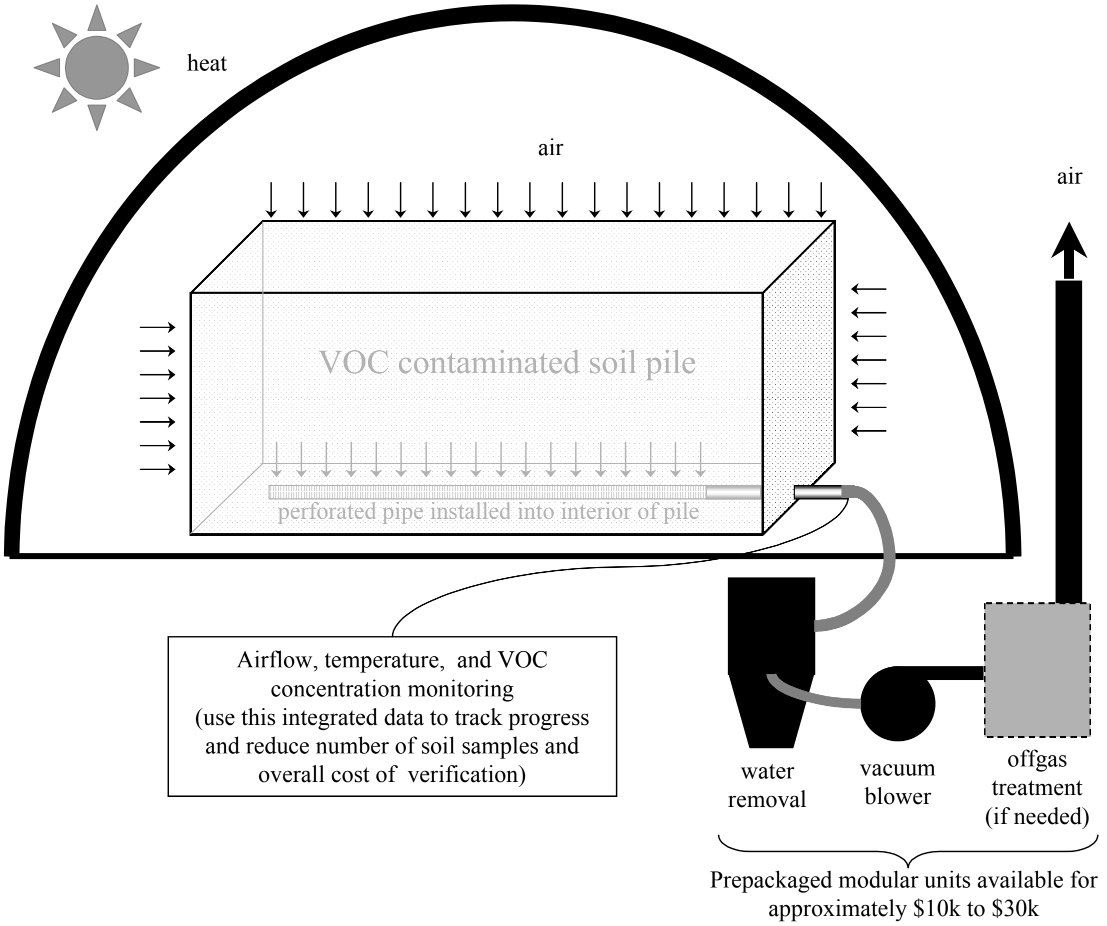
Best Technology	
Enhanced Soil Venting	Meets all FEMP objectives. Inexpensive and rapid to implement and provides potential sampling and analysis cost reduction. Presumptive remedy for VOC contaminated soil.
Alternative Technologies	
Passive Soil Venting	Good choice but may require too long to reach concentration goals and may be difficult and/or expensive to monitor and document progress.
Zero-Valent Iron	Relatively expensive. Requires significant infrastructure and potential schedule delay associated with implementation.
Chemical Oxidation	Relatively expensive. Health and safety issues. Requires significant infrastructure and potential schedule delay associated with implementation.
Low Temperature Thermal Desorption	Requires significant coordination, permitting, and infrastructure. Potential schedule delay associated with implementation.
Viable but Potentially Undesirable Technologies for This Soil	
Aerobic Bioremediation	Relatively expensive. Requires treatability tests, significant infrastructure and almost certain schedule delay associated with implementation.
Anaerobic Bioremediation	Relatively expensive. Requires treatability tests, significant infrastructure, and almost certain schedule delay associated with implementation.
Vacuum Thermal Desorption	Requires significant coordination, permitting, and infrastructure. Almost certain schedule delay for these soil piles because the primary waste stream for this treatment is drummed soil. Does not use OSDF.
Incineration	Very expensive. Requires significant coordination, permitting, and infrastructure. Almost certain schedule delay. Does not use OSDF.
Direct (offsite) disposal	Very expensive. Requires significant coordination, permitting, and infrastructure. Almost certain schedule delay. Does not use OSDF.
Not Applicable Technology Class	
DNAPL Removal Technologies	No significant DNAPL in soil.

Enhanced soil venting (the best identified option) is relatively simple to implement and has proven to be robust in similar and related implementations. There is a large body of literature related to the design and performance of *in situ* (unexcavated) soil vapor extraction – specifically on soil vapor extraction design (Johnson et al. 1990, U. S. EPA 1991a-1991c, U. S. EPA 1993a, U. S. EPA 2001) on the performance of biopiles (Norris et al. 1994). Reworking the soil during excavation, transport, and stacking is expected to have enhanced the permeability and efficiency of the venting, or vapor extraction, process. Ready access to the soil pile and the addition of solar heat would provide further enhancement opportunities and would further accelerate cleanup. Thus, the proposed enhanced soil venting process provides a high level of performance with minimal investment, low energy use, minimal operational complexity, and minimal health and safety risk. As discussed below, this technology essentially provides "complete" removal of VOCs from excavated soils during a brief period of storage or staging prior to disposal or reuse. The technology is aligned with the DOE Technical Target that advocates integrated storage and treatment as an important strategy in meeting environmental cleanup goals (Appendix C).

Implementation of enhanced soil venting for the excavated soils from Areas 3A/4A could be successfully performed using any of a large number of configurations. We recommend that the configuration approach and design be developed and finalized in cooperation with local personnel (technical and operations staff, crafts, etc) and with support of the technical assistance team as needed. The implementation can be roughly divided into four activities:

- Installation of venting pipe(s) into soil pile(s)
- Installation and operation of the venting system(s)
- Offgas treatment (if needed)
- Monitoring and documenting performance

The figure on the next page shows an example implementation to assist in describing these steps. In this case, the venting pipe is installed near the bottom interior of the pile so that air must pass relatively evenly and completely through the contaminated soil prior to collection. The diagram documents the thermal enhancement from solar energy and the general configuration of the equipment for air extraction and monitoring. A potential variation on this figure might involve installation of venting pipes at an angle into the pile (e.g., by hand). Many logistical choices are possible, such as treating the Quonset hut soil first and then the treating the burrito soil in the Quonset hut after the first batch is removed. Alternatively, separate systems could be set up in both locations or a single treatment unit could be piped to both locations (within engineering limits). In either case, the Quonset hut, if set up properly could be a future resource to efficiently remove VOCs from contaminated soils of this type while they were being staged for disposal. Each of the implementation phases is described in more detail below for an example near-term activity to meet FEMP objectives.



Schematic Diagram of Example Implementation of Enhanced Soil Venting

1. Installation of Venting Pipes into Soil

Installation of venting pipes into a soil pile is readily accomplished with inexpensive power equipment, or even by hand. Examples of power equipment include hydraulic ram or power auger. Examples of hand equipment include sliding hammer or small soil auger. To install a horizontal venting pipe as shown in the example figure, industry standard residential utility installation equipment would be ideal. Such equipment is commonly used to install cable, wire or pipe under roads. A hydraulic ram or hammer (ideally a model that does not use water for cutting or hole stability) is pushed through the soil and the material to be installed is pulled back though the hole. Appropriate equipment may be already available at Fernald or could be supplied by local residential utility installation contractors. Specific equipment that would work for horizontal venting pipe installation would include the Ditch Witch Models P40 or P80 Rod Pushers or the Ditch Witch PT20, PT30 or PT40 Piercing Tools. Other brands and models are available. For installation of venting pipe, the work could be done by pulling back through or by pushing with rod through the middle of the vent pipe on a tip in the leading end and then removing the push rod. The push rod could be covered by a plastic sheath to avoid any potential contamination by uranium or other soil constituents. The job would require planning because it is an unusual application (normally holes are made from pit to pit across a road or other surface obstruction) but there are no technical barriers to safe and simple operation. Installation of angle holes into the pile by hand would also be simple and straightforward.

2. Installation and Operation of Venting System

A standard packaged soil vapor extraction unit mounted on a cart or a skid would be ideal for this application. Based on the soil pile size, a large pilot test size unit (circa 100 scfm) or small commercial unit (circa 200 to 300 scfm) would be appropriate. These flow numbers can be refined, if needed, based on additional data. A normal packaged unit comprises a water separator, a vacuum blower, a silencer (muffler), offgas treatment (if needed), a stack and appropriate controls. Often, the particular type of vacuum pump (standard blower, rotary lobe blower, liquid ring pump, etc.) is a significant decision to meet vacuum-flow-backpressure requirements. This application should be amenable to any of the various pump types as long as backpressure from any offgas treatment is minimal. Many brands and models of equipment are available for sale (both new and used) and systems can be supplied and serviced by a large number of local environmental service companies. Example vendors include NSS Environmental (Louisville, KY), W.E.S Inc. (Sarasota, FL), Carbonair (New Hope, MN), NEEP Systems (West Lebanon, NH), and others. Prices for reasonable systems would range from about $10K to about $30K (depending on the flow rate selected, the sophistication of control systems, and offgas treatment). Solar heat would be colllected by the Quonset hut or by the burrito covering. For the burrito, this covering could be a gas permeable UV resistant material, or an impermeable UV resistant cover installed in a overlapping fashion to allow vapor transport while shedding water.

3. Offgas Treatment (if needed)

Based on the highest concentrations measured in the limited VOC data in the soil, total residual VOC content should be less than approximately 1500 Kg (this would be equivalent to about six 55 gallon drums of original solvent). In fact, depending on the amount of volatilization during the current staging period, the VOC residual may be significantly less. Offgas treatment decisions and design should be based on soil and soil gas samples collected from the interior of the soil pile. These could be collected using a hammer driven lance sampler and/or a small vacuum pump. A secondary benefit of this sampling is the potential to determine that the soils have already been decontaminated by passive venting during previous handling and the current period of storage. If sampling documents that the soils easily meet OSDF WAC for VOCs and radionuclides, additional active treatment may not be needed. The team also suggests sampling for moisture content, if possible, during this screening activity. If moisture content of the interior soils were collected, improved specifications for the water removal system could be developed. If offgas treatment is needed, standard carbon could be used and procured as part of the packaged treatment system. There are risks and difficulties associated with carbon based offgas treatment so that it should not be implemented if it is not needed. Particular common problems (all of which can be handled by proper operating procedures and care) include: 1) carbon concentrates radon gas from the soil gas leading to potential radiation measurements/exposure for short periods (circa days) during radioactive decay, 2) carbon overheating during shutdown if high VOC concentrations are present due to an autocatalytic reaction and high heat of absorption, 3) increased operating complexity, and 4) generating an additional waste stream to handle and transportation of the carbon to the vendor.

4. Monitoring and Documenting Performance

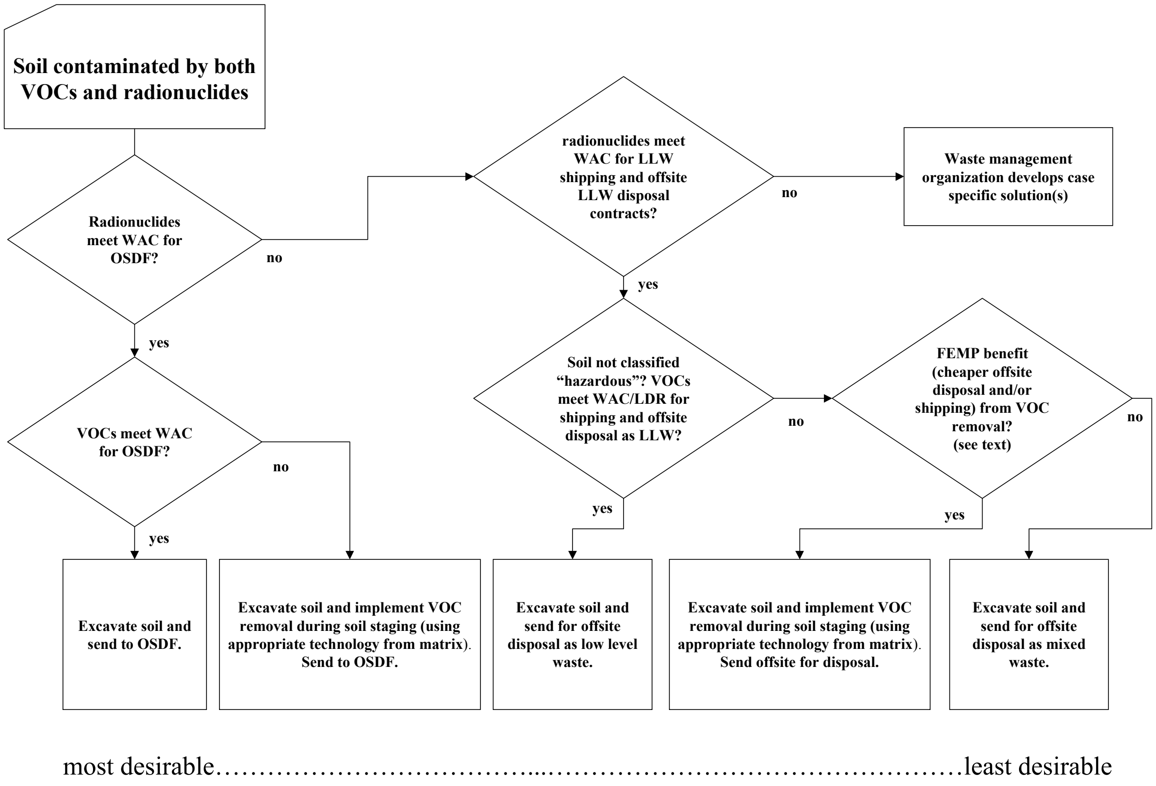
There is a significant opportunity to optimize the overall action by implementing creative monitoring and documentation approaches. A particular advantage of this approach is that the system itself provides an integrated measurement of the presence of VOCs in the pile. Simple measurements of concentration, temperature and flow during operation, concentration rebound (total rebound and rate) can all be related to residual VOC levels in the soil and help determine when the process is complete. Because the measure is integrated it is unlikely to miss a “hot spot” of VOC. This integrated measure will still need to be confirmed by direct soil sampling once the concentration/rebound criteria are met. In this case, however, we would propose much fewer soil samples than would be necessary if the screening data were not available. In addition, it may be reasonable to sample the unbroken “clods” of soil from the interior of the pile for the documentation phase since these represent a worst case for mass transfer and cleanup speed. All of these ideas can be further developed and quantified in a sampling and monitoring plan.

B. Plant 6

Based on the FEMP presentations, the technology matrix developed for VOC treatment of the 3A/4A soils is equally applicable to removing VOCs from potential new soil waste excavated from Area 6 or any future soil contaminated with moderate levels of VOCs and radionuclides. Thus, the technical assistance team advocates the same technology (ies) and strongly urges implementing treatment via a smart storage or staging concept (see Appendix C for details). The most important issue for FEMP in such scenario is determining the value of removing/treating the organics in a soil that still must be disposed in a protected landfill (either onsite or offsite).

The decision tree on the following page assumes that the target soil is contaminated with both VOCs and radionuclides and that the soil is slated to be removed for permitted disposal either to the OSDF or to an offsite facility (i.e., the waste is not slated to be stabilized and left in place). Under this scenario, *in situ* technologies that would simultaneously stabilize radionuclides (as relatively insoluble minerals) and destroy VOCs are not applicable. Similarly, technologies that treat organics *in situ* and address the radionuclide(s) by excavation and disposal would not be ideal. Soil can be treated much more efficiently after it has been excavated because of improved access, better process control and more efficient mass transfer. This overall improved efficiency holds true for virtually all technologies, even if the treatment is something as standard as soil venting. A second assumption associated with the decision tree is that the soil does not contain significant quantities of either residual DNAPL VOC or semivolatile co-contaminants. Such conditions would violate the underlying assumptions of the technology matrix as presented. Within these constraints, the decision tree lays out the various decision points and the resulting options with the most rapid and lowest cost options on the left moving to more complex and expensive options on the right. In general, the most desirable options for the subject wastes are those on the left and left center of the diagram. These options can often be implemented as a smart storage concept where the waste can be prepared for its ultimate disposal during a staging/decision making period.

Ultimately, for waste that will be shipped offsite, the appropriateness of any treatment is contingent upon an acceptance by the transporter and/or disposal facility that the waste can be appropriately designated as not containing VOCs. In the case of rail shipment to EnviroCare, this might entail agreement by all parties that a designation of low-level waste is appropriate. This would simplify transportation because the soil would be covered by existing rail contracts and would reduce the disposal cost approximately in half. A key element in the sequence is generating a soil that is well below the offsite vendor's waste acceptance criteria. In the case of typical FEMP VOC contaminated soil sent to facilities such as EnviroCare, the offsite WAC is often set to the concentrations listed in the Land Disposal Restriction (LDR) Guidelines of 40 CFR 268. LDRs for typical FEMP VOCs in soil range from 6 µg /g for (PCE, TCE and 1,1-DCE) to 30 µg /g (1,2-DCE). These levels can safely and easily be achieved by smart storage options. As documented by the decision tree, if the soil cannot be designated as non-hazardous after VOC removal during staging, then the technology matrix developed for the 3A/4A soils will not be applicable. Initial data suggests that some of the soil wastes from Plant 6 may be an interesting test case for this decision tree and the potential applicability of smart storage in optimizing FEMP activities.



Flowchart "decision-tree" for soils containing both radionuclides and VOCs

V. CONTINUED INVOLVEMENT

One element in the Technical Assistance Request was the need for the team to provide "sustained support" to assure that any appropriate recommendations can be successfully implemented. The following paragraphs outline the team's concept of the approach to providing this sustained support.

Personnel at FEMP will review this report and select their strategy for remediation at Areas 3A/A and Plant 6. Specifically, the FEMP technical and operations staff will identify the technology(ies) to be deployed, the general deployment sequence and schedule, and the particular activities that would benefit from sustained technical assistance activities. During this FEMP strategy development period, the technical assistance team is available for general support (e.g., clarification of initial recommendations, and assistance in addressing issues or overcoming barriers encountered). Depending on the FEMP selected course of action, the technical assistance team will provide further detailed assistance and, if needed, return to the site for specific support actions. Examples of additional assistance that might be provided include drafting sampling strategies and plans, defining conceptual designs, developing technical functional requirements, and providing implementation assistance. The specific type(s) of technical assistance desired will be proposed by FEMP following their strategy development process. The technical assistance activities will then will be formalized and approved by the DOE Headquarters Ohio Field Office Technical Assistance Coordinator or his/her designee.

As part of this sustained technical assistance effort, there may be a need for routine communications in the way of conference calls, one-on-one conversations, and potential site visits. Members of the technical assistance team will continue to be available for consultation. Importantly, the assistance effort is limited to technical support – Ohio Field Office Technical Assistance is not intended as staff augmentation does not replace the need for local technical staff. The recommendations and supporting information developed by the team were developed rapidly, using a technical triage approach, and is based on a limited visit and rapid review of data and conditions. Thus, the results are recommendations to the local support staff and managers and FEMP should not be bound by the recommendations coming from the technical assistance team but rather view them as a resource.

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APPENDIX A:
TECHNICAL ASSISTANCE TEAM BIOGRAPHIES/CONTACT INFORMATION

Brief biographies of the assembled technical assistance team are provided below.

Brian Looney, Savannah River Technology Center. Dr. Looney has a B.S. in Environmental Science and a Ph. D. in Environmental Engineering and is a fellow research engineer at the Savannah River Technology Center. In this position for the past 15 years, he has coordinated development and deployment of environmental characterization and clean-up technologies. Dr. Looney has successfully performed environmental projects on a wide range of topics. For example, he was principal investigator responsible for the first large scale application of horizontal drilling to environmental remediation. Other successful research efforts include: soil gas survey techniques for hazardous waste sites, barometric pumping for vadose zone clean up. gas phase nutrient addition to stimulate bioremediation, and various topics associated with modeling and risk assessment. Dr. Looney currently holds five U.S. and one foreign patent for environmental technologies. Most of these are licensed to environmental engineering companies and are in use throughout the U.S. Dr. Looney, in collaboration with others, contributed to recent field studies at the Mayak Site (a former nuclear production facility) in Russia. Recently, Dr. Looney co-edited the book "Vadose Zone Science and Technology Solutions". He also led the successful efforts to redefine the Subsurface Contaminants Focus Area technical program in terms of technical targets within which R&D programs could be developed.

Terry Hazen, Lawrence Berkeley National Laboratory. Dr. Hazen received his B.S. and M.S. degrees in Interdepartmental Biology from Michigan State University. His Ph.D. is from Wake Forest University in Microbial Ecology. His dissertation research was done at the DOE Savannah River Site on the effects of nuclear reactor cooling waters on bacteria, alligators and fish. Dr. Hazen was Professor, Chairman of Biology and Director of Graduate Studies at the University of Puerto Rico for 8 years. He was Fellow Scientist at the Savannah River Site 11 years, the last 5 as manager of the Biotechnology Group within the Savannah River Technology Center. In early 1998, Dr. Hazen joined the LBNL Earth Sciences Division as Head of the Microbial Ecology and Environmental Engineering Department and Lead Scientist for the Environmental Remediation Technology Program. Since September 1999 he has also been head of the Center for Environmental Biotechnology. He is a fellow of the American Academy of Microbiology and has authored more than 149 scientific publications, not including more than 341 abstracts and chapters in several books. He has also given more than 580 scientific presentations, 75% of them invited. Dr. Hazen received the 1995 R&D 100 Award, 1996 R&D 100 Award, and the 1996 Federal Laboratory Consortium Excellence in Technology Transfer for bioremediation technologies. He has patents on 5 bioremediation processes that are being used in 15 states; these technologies have been licensed to more than 30 companies. Dr. Hazen has acted as an expert reviewer for 25 different scientific journals and 14 federal research granting agencies. He has supervised and consulted on the implementation of bioremediation at more than 50 sites. He is currently the LBNL representative to the DOE EM50 Strategic Lab Council, the DOE Natural and Accelerated Bioremediation Research Program Field Research Center, the EM50 Subsurface Contaminant Focus Area Lead Lab POC, and the EM50 lead for LBNL. He was recently appointed to the United Nations Global Water Quality Task Force, one of only two US scientists. His area of specialty is environmental microbiology, especially as it relates to bioremediation. His current research is focused on aerobic bioremediation of landfills, PAH contaminated soil, solvent contaminated soil and groundwater, and actinide biogeochemistry.

Michael Heitkamp, Savannah River Technology Center. Dr. Heitkamp has a Ph.D. in Interdisciplinary Toxicology; a M.S. in Microbiology, and a B.S. in Biological Sciences and has over 25 years of experience in environmental microbiology and biotechnology. He is currently Manager of the Environmental Biotechnology Section, a multi-disciplinary research team whose mission is the discovery, development and deployment of environmental biotechnology at the Savannah River Site and other sites within the DOE complex. The primary focus areas include biodegradation, bioremediation, biocorrosion, biofouling, biodetection, molecular biology and microbial ecology. Dr. Heitkamp has training and experience spanning microbial ecology; microbial toxicology; microbial physiology; isolation of novel chemical-degrading microorganisms; microbial nutrient cycling and chemical degradation; technology innovation; and the laboratory, pilot-scale and field testing of novel microbial technologies for biotreatment of water, air and soils. He also developed new molecular biology technologies to investigate survival, movement and genetic exchange of recombinant microorganisms. Dr. Heitkamp has over 40 publications and four U.S. Patents.

Michael Kuperberg, Florida State University. Dr. Kuperberg is the project manager for a multi-year, U.S. DOE-funded project to evaluate innovative international environmental remediation technologies for potential application within the DOE complex. This project is currently involved in activities in Russia, Poland, Hungary, and the Czech Republic. Many of the innovative technologies under evaluation in this project are biologically based (e.g., phytorememdiation and bioremediation) or are tools that support such technologies. His research interests include environmental toxicology with an emphasis on pesticide toxicology, ecological risk assessment and biologically based environmental remediation systems.

Laymon Gray, Florida State University. Mr. Gray has a B.S. in Civil Engineering from Florida State University. He has a diverse professional background in the environmental engineering field including managing externally-funded research programs, and international programs involving research and development, and deployment of new and emerging remedial technologies for environmental contamination in the United States and Central and Eastern Europe. Mr. Gray currently provides management and oversight for the Interagency DNAPL Consortium field demonstrations. This role has allowed Mr. Gray to obtain first hand implementation and operational knowledge of innovative DNAPL cleanup technologies. As part of the Consortium's technical team, Mr. Gray is integrally involved with site characterization, technology selection and design review, construction and operation, and cost and performance evaluations.

Carol Eddy-Dilek, Westinghouse Savannah River Company. Carol Eddy-Dilek is a research scientist in the Environmental Restoration Technology Section at the Savannah River Technology Center, the research and development laboratory supporting SRS. Her responsibilities have included many aspects of applied research related to characterization of hazardous waste sites and monitoring and performance assessment of remedial technologies. This work has a strong geotechnical, geological, and geohydrologic basis. For the last four years, she has been the lead investigator for the DOE's cone penetrometer sensor testing and evaluation program and has been actively involved in the development, evaluation, and application of new sensors and approaches for site characterization and monitoring. During 1998–99, she led the site characterization efforts for the Interagency DNAPL Consortium Program at the Cape Canaveral Air Station, Florida, a joint EPA-NASA-DoD-DOE program for evaluation of innovative technologies for DNAPL remediation.

Jim Iwert, Subsurface Contaminants Focus Area. James W. Iwert is assigned to the Savannah River Technology Center and is responsible for identification of technical resources to support the Subsurface Contaminant Focus Area Lead Laboratory Technical Assistance Program. This Program has dispositioned over 100 requests for technical support from DOE sites across the complex during the past 2 years. In this capacity, Jim receives requests for assistance on environmental problems from the sites and assures that the scopes of work clearly define the objective. Working with the National Laboratories, technical expertise is selected and mobilized to develop the most cost effective technical solution. Jim has a B.S. degree in Civil Engineering from the University of Wisconsin and over 30 years experience primarily in the areas of project and program management.

Emily Charoglu, EnviroIssues. Emily Charoglu has nearly a decade of work experience, two graduate degrees in environmental science and public affairs from Indiana University, and an undergraduate degree in economics from Emory University. In the past several years, Emily's work experience includes working with the Department of Energy (DOE) Subsurface Contaminants Focus Area and well as other focus areas. She has focused on facilitating issues such as deployment of innovative technology, strategic planning, and response to both long-term and short-term needs across the DOE Complex. Moreover, she has coordinated entities in cleanup response efforts, developed technical analyses to determine the future direction of policy, developed environmental assessments, planned processes to effectively communicate information, and managed community assistance programs.

CONTACT INFORMATION

The table below identifies contact information for the technical assistance team assembled for FEMP.

Name	Organization	E-Mail	Phone	Fax
Charoglu, Emily	EnviroIssues	echaroglu@enviroissues.com	208-336-2505	208-336-3570
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Gray, Laymon	Florida State University	lgray@ispa.fsu.edu	850-644-5516	850-574-6704
Hazen, Terry	Lawrence Berkeley National Laboratory	TCHazen@lbl.gov	510-486-6223	510-486-7152
Heitkamp, Michael	Savannah River Technology Center	Michael.Heitkamp@srs.gov	803-819-8404	803-819-8432
Iwert, Jim	Subsurface Contaminants Focus Area	james.iwert@srs.gov	803-725-9548	803-725-4129
Kuperberg, Michael	Florida State University	mkupe@mailer.fsu.edu	850-644-5516	850-574-6704
Looney, Brian	SRTC	Brian02.looney@srs.gov	803-725-3692	803-725-7673

APPENDIX B:
TEHCNICAL ASSISTANCE REQUEST

ATTACHMENT 1

TECHNICAL ASSISTANCE BASELINE

(E-mail to susan.meyer@srs.gov, fax to Susan Meyer at 803-725-4129, for the Lead Laboratory)

Tracking Number:	138
Request Title:	Treatment and Beneficial Use of Fernald Organically Contaminated Soil
Contact Individual:	Carol Eddy-Dilek
Requesting Organization:	DOE Fernald
E-Mail Address:	Carol.eddy-dilek@srs.gov
Phone Number:	513-529-3218
Fax Number:	513-529-1542

Scope of Work:

Provide technical assistance to the Fernald site to evaluate, recommend, develop, and apply a treatment process to treat approximately 5,400 cubic yards of soil/sediment contaminated with organic solvents (TCE, PCE) and with U (treatment process to focus on organics only). Provide sustained technical assistance as required to assure successful completion of the remediation operations. Approximately 3,000 cubic yards of soil has been excavated and stockpiled and treatment of the soils must be initiated by October 2002. Other source areas have not been excavated and an *in situ* treatment method is preferred. Once the organic contamination has been removed from the soils, the soils will be disposed of in the Fernald On-Site Disposal Facility.

Support:

What resource(s) have been selected?

Dr. Terry Hazen, LBNL
Dr. Michael Kuperberg, Florida State University
Dr. Michael Heitkamp, SRTC

What resources were offered, but not selected?

Requested Start Date:	**May 28 2002**
Requested Completion Date:	**October 2002**
Estimated Cost:	

Submitted By: Carol Eddy-Dilek

APPENDIX C:
NATIONAL DOE ENVIRONMENTAL STRATEGY ADVOCATING INTEGRATED STORAGE AND TREATMENT

EXCERPT FROM: ***Technical Targets – A Tool to Support Strategic Planning in the Subsurface Contaminants Focus Area,*** WSRC-RP-2002-00077, U.S. Department of Energy, Savannah River Site, Aiken SC 29808.

Integrated Containment-Treatment Concepts – "Smart Containment"

Team: Brian Looney, Terry Hazen, Tyler Gilmore, Jody Waugh

Summary of Need (s):

A new "smart containment" approach that incorporates modifications so that solid hazardous and/or radioactive waste is stabilized or detoxified during a period of containment or isolation is needed. To support such a strategic development, potential treatment processes (delivery systems and their compatibility with the isolation systems) must be evaluated, as well as methods to monitor treatment progress and document when the waste containment is no longer needed.

Relevance:

The relevance, and potential benefits, from addressing this target are exemplified by recent technical assistance activities throughout the DOE complex. In complex situations where technical assistance has been requested, the SCFA Lead Lab has routinely identified a smart storage option that provided a high level of performance at a significantly reduced cost. Specific examples include the Lead Lab Technical assistance reports to Sandia National Laboratory (PCB contaminated soil), to Lawrence Livermore National Laboratory (site 300), to Brookhaven National Laboratory (viscous barrier), and others. The significant potential value for smart containment has also been highlighted in other technical reports such as the technical evaluations of detritiation and tritium management strategies (both at Savannah River Site and Hanford). These highlight the potential for eliminating tritium risks by recycling highly contaminated water for use in cements and grouts for tank closure. The potential relevance for smart containment is supported by the fact that there are over 3500 municipal and solid waste landfills in the United States, with over 100 lined and unlined landfills in DOE. These are currently slated to receive large volumes of solid waste generated by environmental restoration activities.

This concept is valuable in part because it eliminates inefficiencies associated with traditional administrative boundaries (e.g., ER, WM, D&D) and encourages closure of the WM-ER-WM cycle. The primary benefit of this target strategy is elimination of the need for maintaining and documenting the performance of containment and isolation systems for 100s to 1000s of years. Integrated smart containment provides a highly desirable option that meets end-user needs in both the short and long term.

Status:

Traditional response actions for solid radioactive and hazardous waste in the environment fall into four categories: containment by emplacement of engineered barriers, in-situ stabilization or destruction, removal followed by ex-situ treatment, and removal followed by storage and disposal. Ex-situ treatment generally consists of separation methods for volume reduction and/or engineered stabilization/detoxification facilities (normally "expensive" thermal, chemical or biological treatment systems). An important strategic target is development of a new option, a modified "smart containment" concept. Such systems are designed to make technically based modifications to the storage/disposal environment to integrate low cost "passive" natural treatment. The value of this concept is that the treatment process built into the smart containment system would eliminate the need for "permanent" monitoring and maintenance. Indeed, this concept represents a critical step to improve long-term stewardship by eliminating future hazards. The potential benefit of this general class of action is indicated by several historical efforts:

- Success of biopiles as an example where the treatment occurs rapidly and completely versus attempts to treat in situ or by shipment to landfills (many EPA reports)
- Information on emerging municipal landfill research/concepts (see, for example, LBL reports related to T2ALF model)
- A growing body of potentially applicable scientific literature on compounds that will degrade slowly under appropriate conditions (e.g., PAHs, PCBs, pesticides, and the like)
- Many past examples – efforts to isolate short-lived radionuclides to allow time for decay

This target moves beyond the artificial and regulatory dichotomy currently in place that allows either "permanent" containment or expensive hazardous waste treatment facilities. The "dry tomb" concept implicit in most containment and landfill storage forecloses the technical opportunity for an optimal integrated solution because these typically require the presence of water, reagents, or gases and possibly delivery or recirculation activities.

Vital Scientific and Technical Objectives:

Demonstrate "smart containment" options for solid hazardous and radioactive wastes associated with environmental restoration activities. Develop protocols for candidate "end-user" waste streams in DOE (as defined by STCG needs statements and other resources). The protocol should identify and consider waste types that are not suited to the concept, such as long-lived radionuclides. The protocols should also recognize and develop a technical basis to overcome regulatory concerns and other challenges. Potentially useful treatment technologies have the following characteristics:

- they have a clear scientific-theoretical basis,
- they exhibit low energy and/or resource use,
- they are compatible with the isolation system,
- they are effective within the projected life of the isolation system, and

- their progress is measurable so that performance can be documented in a cost effective manner.

Importantly, the “smart containment” configuration is not limited to in ground (landfill style) implementation but could also be applied to above ground storage buildings. Above ground storage is often designed to simply house waste containers for extended periods while final disposition is negotiated. Smart containment would provide an option for waste treatment to be underway while the remainder of the decision making process was underway.

Additional work to provide data to facilitate crossover of existing treatment processes, monitoring tools such as sensors, and other required technical elements to support this new concept are required. Development of technically defensible protocols, configurations and monitoring approaches for “smart containment” will facilitate deployment and use of this new and promising strategy.