The SRNL Technical Assistance Program: Transferring Lessons Learned from Two Decades of Remedial Successes to the DOE Complex – 15438

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ABSTRACT

The Savannah River Site has an established history of developing implementable risk reduction strategies, developing and deploying innovative technological solutions, and collaboratively achieving realistic and protective environmental end states for complex environmental problems. Part of this success results from the strong historical collaboration between site environmental restoration groups and the Savannah River National Laboratory which results in the promulgation of innovative technical approaches and technologies from the laboratory to ongoing remediation campaigns. Much of the underlying research and development effort was funded by DOE's Office on Environmental Management through a series of applied technology demonstration projects (Integrated Demonstration Project, Integrated Programs and the Applied Field Research Site). Concomitant with the research efforts, SRNL has managed a dynamic and efficient national program that provides teams of technical experts with a broad experience base to recommend strategies that reduce risk and/or technical uncertainty for challenging environmental problems at other DOE facilities. At many of these sites, standard remedial approaches (e.g., excavation, pump and treat, soil vapor extraction) have either failed or proved to be too costly, inadequate, or ineffective. Alternatively, other sites struggle with implementation of innovative but less well understood approaches.

The technical assistance teams use a structured process that based on several basic concepts, specifically, development of site specific technical frameworks, and careful matching of remedies to site-specific chemical, geological and physical conditions.

Development of technical frameworks is a key strategy to apply basic science to an applied field problem. When directed toward understanding complex real-world environmental remediation challenges, frameworks are tools that support practical identification and incorporation of the key-controlling scientific processes and principles. Frameworks can also be used to minimize technical risks, encourage efficiency and effectiveness, and provide the basis for innovative and creative solutions.

Efficient and effective environmental cleanup also requires matching the character of remediation and stabilization methods to the nature of the target zone of contamination as the nature of the target zone evolves through the life of the remedial project. A contaminant plume can be divided into the following zones: the source zone, the impact zone, and the transitional zone that then can be used to identify classes of technologies that are appropriate to that zone. For example, physical and chemical methods (e.g., trapping, immobilization, destruction, or isolation) that directly address the source contaminants are often appropriate for the disturbed zone during the remedial process. A variety of methods that include both active treatments (e.g., pump and treat or active bioremediation) and enhanced attenuation technologies (e.g., geochemical manipulation or reactive barriers) are often suitable for the primary contamination zone or impact zone. Various strategies based on natural attenuation processes may be applicable to the primary contamination zone and these methods are typically applied for the transition or baseline portions of the plume.

Careful matching of remedies to site-specific conditions is critical to long-term success in environmental cleanup and restoration. The matching process facilitates selection of technologies with particular strengths that align with real-world needs and constraints, encourages strategic use of multiple or combined technologies to address major plume subdomains, and supports transitioning technologies in space and time as remediation progresses.

Since 2006, the SRNL Technical Assistance program has focused on providing support across the DOE complex. During this time, over 25 teams have visited eleven DOE sites and made recommendations that yielded an estimated cost savings of $100M. Examples will be provided that illustrate key aspects and significant successes of the technical assistance program.

INTRODUCTION

The U.S. Department of Energy (DOE) is responsible for environmental stewardship of sites and facilities in many diverse settings. The DOE Offices of Environmental Management (EM) and Legacy Management (LM) manage contaminated soil and groundwater at most of these sites (Figure1). DOE EM was initially responsible for 107 contaminated sites in 35 states. Of these, major cleanup activities have been completed at 90 DOE sites leaving the current portfolio of active DOE EM sites, 17 DOE sites in 13 states. Some of the challenges at these active EM cleanup sites (e.g., 6.5×10^{12} L of contaminated groundwater and 4×10^{7} m^3 of contaminated soil and debris) are listed in Figure 1. Following major cleanup activities under EM, a number of the completed sites transferred to LM require additional time, active management and (sometimes) additional remedial actions to reach their final environmental remediation goals. Together, the DOE EM and LM efforts represent the largest and most challenging environmental cleanup program in the world.

To help meet this environmental restoration challenge, DOE has emphasized safety and risk reduction, effectively utilized existing engineering and technology, and incorporated innovative science and emerging methods, as appropriate, to address some of the most difficult "intractable" problems. For soil and groundwater, a small technical assistance program managed by SRNL has proven to be an effective approach to solve environmental challenges (Eddy-Dilek, 2014). In the past decade, 25 technical assistance teams have visited eleven DOE sites and made recommendations that yielded an estimated cost savings over $100M, generating a return on investment of 30:1 for the program [1]. Importantly, innovative technologies have been implemented across the nation to cost-effectively protect and restore the environment. In performing these technical assistance activities, two recurring themes emerged: 1) Development of technical frameworks is a key strategy to apply basic science to an applied field problem, and 2) careful matching of standard and innovative technologies to site specific needs and spatial-temporal conditions is critical for success at difficult sites. A brief description of the development of technical frameworks, and matching process are provided in the following sections.

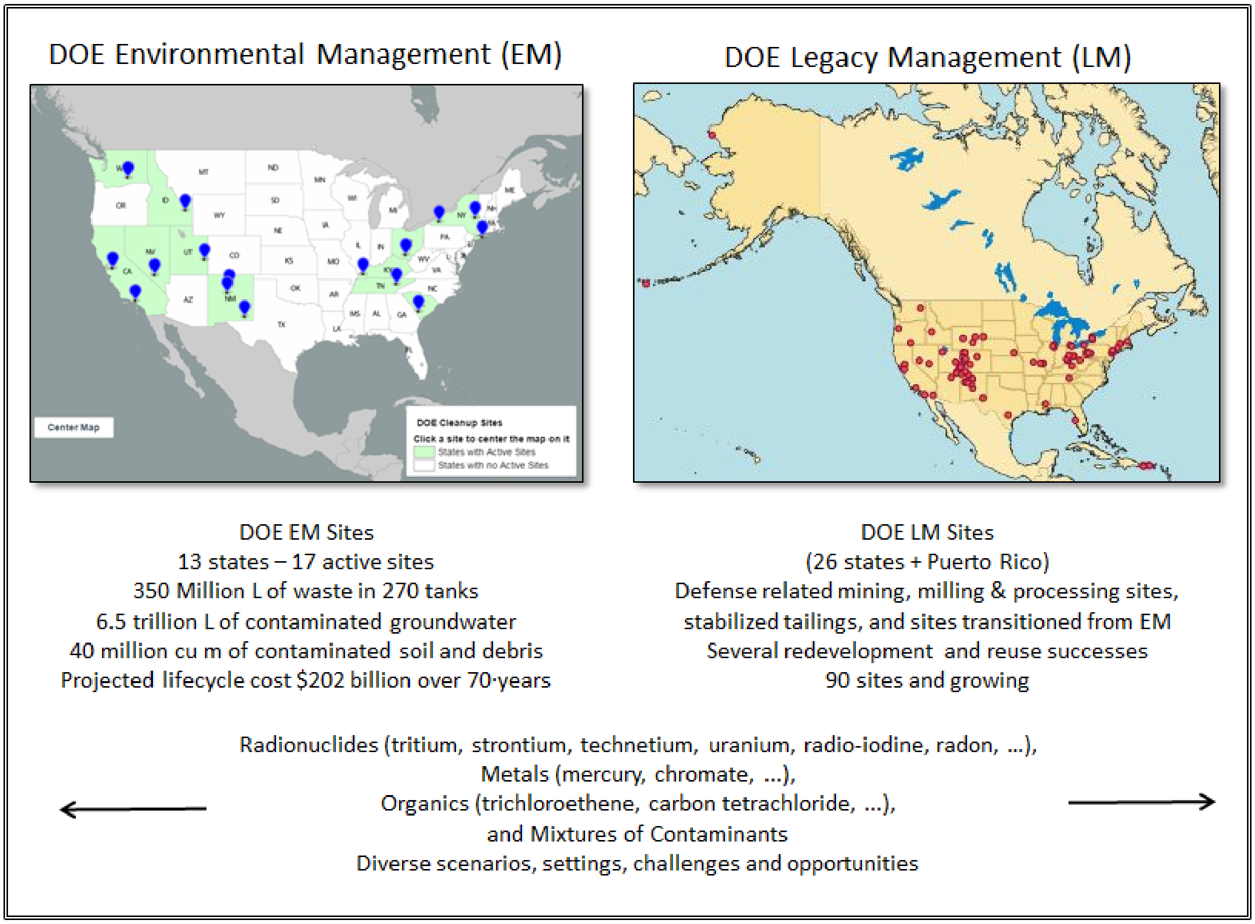

Figure 1. Scope of the U.S. Department of Energy Environmental Management and Legacy Management Challenge

METHODS

Development of Technical Frameworks

Development of technical frameworks is a key strategy to apply basic science to an applied field problem. When directed toward understanding complex real-world environmental remediation challenges, frameworks are tools that support practical identification and strategic incorporation of the key-controlling scientific processes and principles. Technical frameworks provide a consistent way of organizing and interpreting complex data in a manner that supports environmental decision making. They can be used to capture key features at a site in an intuitive manner that supports a practical and actionable understanding. In addition, they can be used to minimize technical risks, encourage efficiency and effectiveness, and provide the basis for innovative and creative solutions.

Figure 2 depicts several technical frameworks that have proven useful in guiding environmental decision making at contaminated sites (Looney, 2014). These frameworks, e.g. spatial, temporal, geochemical, hydrological, and other (including risk, ecological, etc.), encourage detailed evaluation of important topic areas using state-of-the-art and state-of-the-practice tools. The results of the different frameworks are integrated and used to develop an updated site conceptual model. Individual frameworks used in various technical assistance activities include:

1) Spatial Framework – places plume data within the spatial context of the sites from source to plume fringe; different locations within the spatial framework require different approaches to characterization, remediation and monitoring

2) Temporal Framework – relates plume data to events in the history of the site, starting with initiation of the processes that caused contamination to remedial action and recovery

3) Hydrological Framework – relates plume data to the physical forces driving plume movement including boundary conditions such as streams and, in arid climates, the capillary fringe

4) Geochemical Framework – describes the interactions of plume constituents with aquifer materials and uncontaminated groundwater, as well as other geochemical process affecting contaminant migration.

As shown (Figure 2, bold border) the spatial and temporal frameworks (when, where and how contaminants were released and how the site evolves over time) are typically important at most all sites. At arid and semi-arid sites, the geochemical and hydrological frameworks (Figure 2, shaded) have proven to be key components that are essential to a reasonable, accurate and effective site conceptual model.

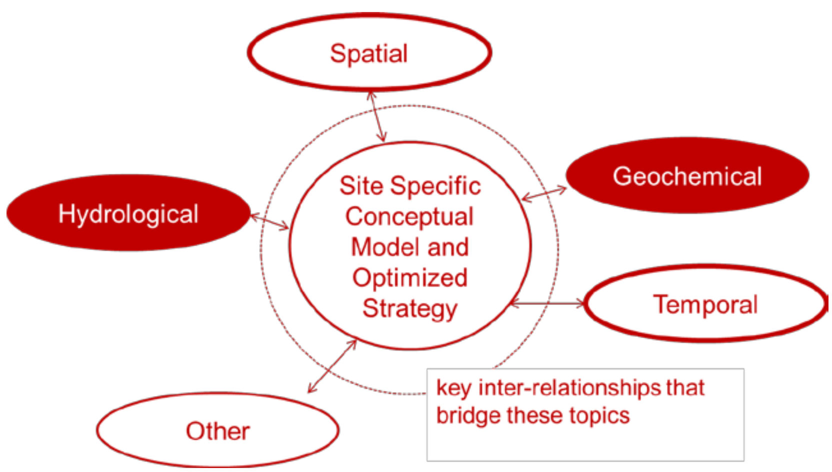

Figure 2. Useful technical frameworks that support optimized environmental and legacy management decisions.

Careful Matching of Technical Approaches to Site Specific Conditions

Figure 3 provides a simplified conceptual plan view diagram of a facility that has impacted the surrounding environment (Looney, 2013). The three ovals – the disturbed zone, the impact zone, and the transition/baseline zone – represent different portions of the impacted environment. Each of these zones has a different character and provides opportunities for technology matching. The disturbed zone received relatively high levels of contaminant. The impact zone often manifests as a primary contaminant plume that contains lower levels of pollutants than the disturbed zone but still represents a potentially significant present or future risk. The transition/baseline zone contains contamination at relatively low concentrations but impacts relatively large volumes of water (or air or soil). For a real-world target problem, the contaminated areas are not simple ovals. Instead, contamination occupies a complex three-dimensional geometry and encounters multiple geochemical conditions and geological materials as it travels through the subsurface (vadose zone and groundwater), surface water (e.g., wetlands and streams), and/or the atmosphere. A site-specific technology assessment process considers these multiple levels of complexity to identify areas of opportunity.

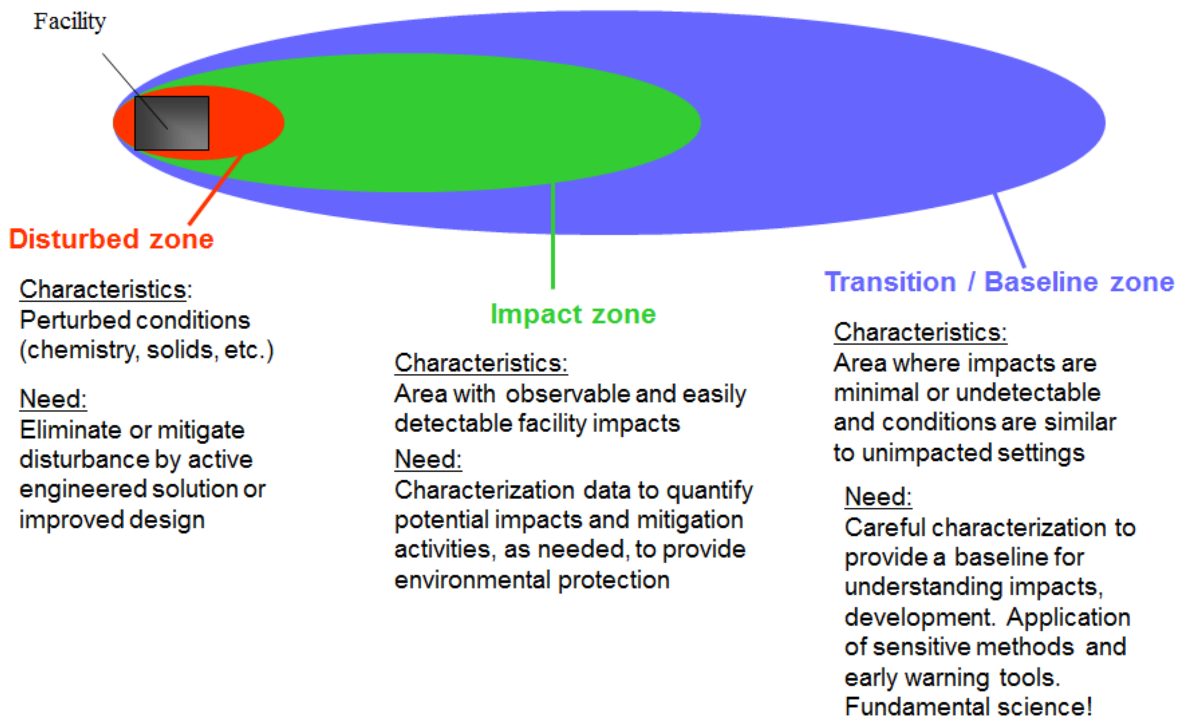

Figure 3. Simplified conceptualization of facility impacts on the surrounding environment and technology matching principles developed by SRNL

In the case of groundwater contamination, the changing size and structure of a contaminant plume is a dynamic process with conditions that change in both space and time. Figure 4 schematically depicts the general trends of plume expansion stabilization and shrinkage and overlays the examples of potential matches of remedial technologies for application – this approach is used to help apply appropriate technologies and to transition technologies (e.g., from active to passive) at appropriate times.

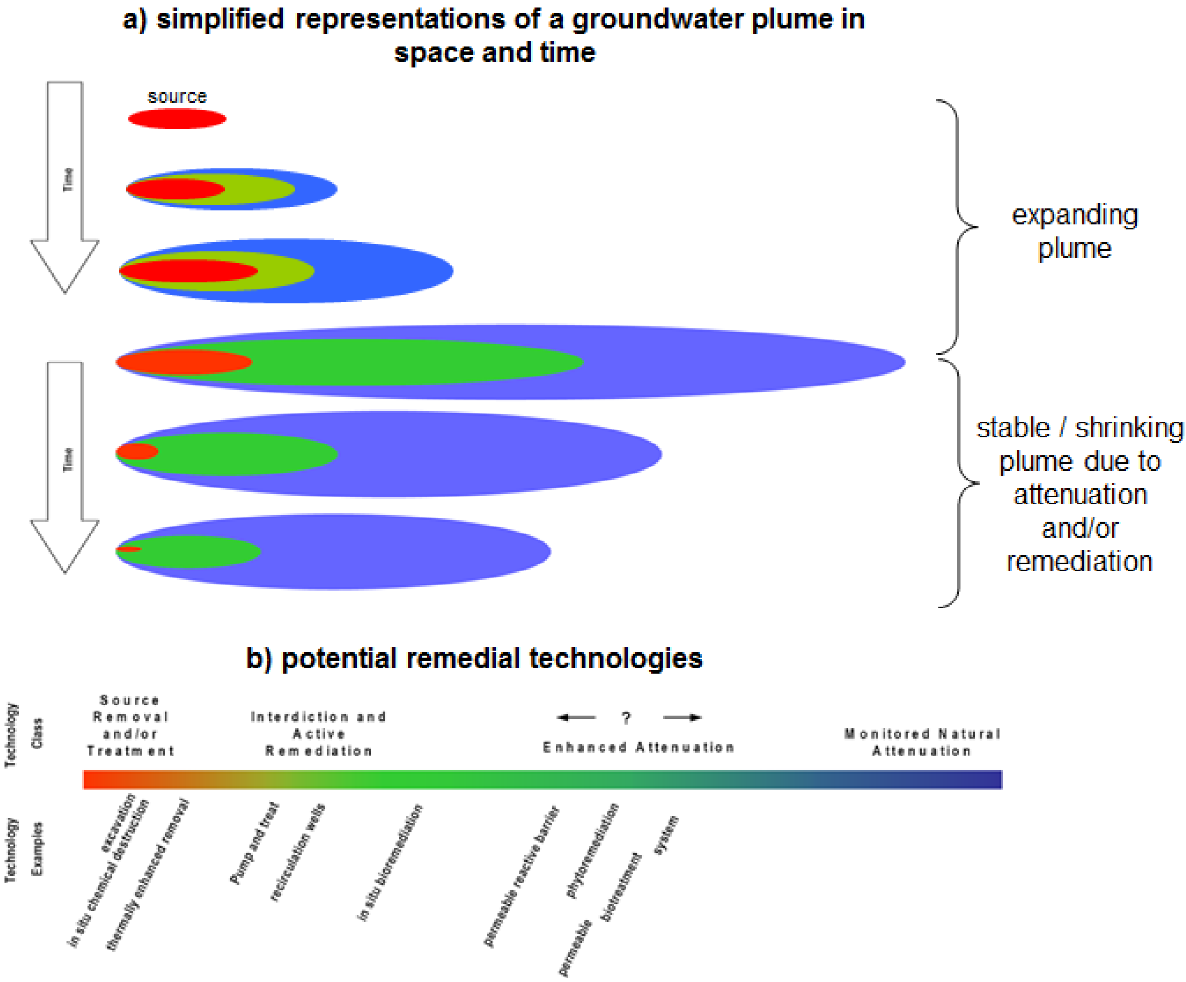

Figure 4. Simplified depiction of plume structure over time and the matching of potential remediation technologies

The DOE technical assistance teams have applied the general matching concepts described above at numerous sites throughout the United States – generating technology matrices that are generally binned into several key categories such as: “viable and recommended”, “viable but not recommended”, or “not viable”. Viable technologies are generally those that would physically work at the target site. Those viable technologies that were “recommended” are well matched to site conditions so that they would be expected to be relatively efficient and effective compared to those that are “not recommended”. Those technologies that are designated “not viable” typically will not work at the site due to some type of physical, chemical or hydrological constraint (e.g., technologies that require injecting liquid reagents into a clay zone). In most cases, there is more than one technology in each bin providing flexibility for the DOE-contractor-regulators-stakeholder team to further evaluate options in the context of local conditions and needs. Past technical assistance results highlighted the need for aggressive technologies such as steam enhanced extraction or excavation in the red (disturbed) zone, mass removal, in-situ stabilization and enhanced attenuation in the green (impact) zone, and natural or enhanced attenuation in the blue (transition) zone.

ENABLING/ACCESS

Technology/Approach	Description	Objective	Positives	Negatives	Technical Maturity	LANL Specific Issues (Interim Action / Access / etc.)	OVERALL
Boundary Condition Modification (infiltration reduction)	Modify surface or process water inputs to the subsurface using infiltration reduction or relocation	Reduce the "driving force" of water through a contaminated system, minimize contact of clean water with contamination, or shift water to a desired location to change flow patterns.	Standard geotechnical and civil engineering methods coupled with minimal subsurface access can provide benefit. Impacts can be predicted and measured using standard approaches. Simple O&M (often passive). Cost for some variants (e.g., weirs and infiltration control) are relatively low.	Strategy is limited to the boundaries of the subsurface flow system, the impacts to the plume are lagged and damped, particularly in distal portions of the plume.	Mature	An engineered system to stabilize and limit erosion in the headwater wetlands in Sandia Canyon, maintain protective biogeochemical conditions, and reduce the flow has been developed by LANL. Implementation requires modeling of capture zones and plume behavior (attenuation and effects on migration) in response to extraction to support that objectives will be met. Cost = $ with multiple benefits.	May not impact the plume boundary within the time frame of an interim remedy. Flow reduction viable and recommended for application in headwater wetlands for both IM and CME actions. Infiltration relocation potentially viable for both IM and CME actions if evaluation indicates that the action reduces migration through contaminated sediments. Other actions such as shifting infiltration between canyons should be evaluated.
Hydrologic Modification (interception of upgradient flow or supplemental injection of clean water)	Modify water input to a groundwater system by pumping (intercepting) clean water upgradient or by injecting supplemental clean water	Shift flow patterns (e.g., to protect receptors).	For interception systems, eliminates the need to treat pumped water (compared to pump and treat system). Impacts can be predicted and measured using low cost standard methods.	Interception systems require installation of wells and a reasonable means to disposition or use water. Large and deep hydrologic systems may require large flow volumes to achieve objectives. Active system that requires O&M.	Mature	Requires installation and continuous operation of several deep wells. Cost = $$	Viable but not recommended for IM. Viable but not recommended for CME based on current understanding of site specific issues.
Well Drilling Modifications and Access Optimization	A variety of technical, engineering and contracting strategies are described in the text. These include alternative drilling/contracting methods/strategies, repurposing wells, and PRB concepts.	Control costs while maintaining or improving the quality and performance of drilling and subsurface access activities at LANL	Generally use existing technologies.	Significant depth is a challenge and limits options for subsurface access. Repurposing wells (e.g., using existing monitoring wells for remediation) may be appropriate in limited cases but should be done carefully to avoid loss of expensive infrastructure. Required depths are beyond the reach of trench based PRBs but injectable PRB zones may be viable (see geochemical treatments below).	Mature	Primary focus should be cost reduction while maintaining quality -- costs for access will remain relatively high even if the recommendations are implemented due to the required depths and subsurface heterogeneity at LANL	Several of the technologies and strategies are viable and recommended (as described in text) for an IM and a CME
Depth Discrete Sampling	Collect samples in the lower vadose zone and upper portion of the regional aquifer during drilling or using multilevel sampling in existing wells	Provide improved information to refine the conceptual model of Cr(VI) distribution and transport processes	Would improve and assist in optimization of remediation design	Retrieval of samples from these depths is complex and time consuming -- i.e. expensive. Multilevel sampling in existing wells is also expensive and subject to problems and inaccuracies associated with well construction (gravel pack, differences in screened intervals)	Moderate to Mature	The ability to get meaningful depth profiles using existing wells is particularly challenging at LANL due to the relatively short screens and the depth of the wells.	Viable and recommended (as feasible) for an IM and CME. The best strategies are as an adjunct to planned future drilling in key locations and for use in profiling in existing wells if a cost effective method can be developed.

Figure 5. Example technology matrix that includes Technology Description, Site Specific Objective, Evaluation of Technology Positives and Negatives, Technical Maturity, and Summary Recommendation of technologies recommended as viable for the specific project (Looney, 2012).

CONCLUSIONS

For over two decades, SRNL has managed a dynamic and efficient national program that provides teams of technical experts with a broad experience base to recommend strategies to address DOE's challenging environmental problems when standard approaches haven't worked. These experiences have resulted in the development of a structured process that based in part on the development of site specific technical frameworks to support the development and refinement of the site specific conceptual site model that incorporates key technical uncertainties, and development of technology choices that are matched to the site-specific chemical, geological and physical conditions at the sites.

Examples of successful technical assistance efforts include:

Issue: A deep groundwater plume contaminated with metals impinging the DOE site boundary.
Recommended Approach: Technical assistance team identified technical strategies including treatment and hydraulic control options that may provide pathways to address contamination and avoid

implementation of costly pump and treat remedial strategy.
Impact: Significant cost savings associated with optimization of pump and treat system. Improved credibility with state regulators and stakeholders.

Issue: Depleted uranium present in shallow soils and sediments where site regulatory groups favored soil washing as the preferred remedial alternative.
Recommended Approach: The team determined that soil washing would not clean-up to desired levels and instead recommended an alternative phased remediation approach that included a radiological surface survey, strategic excavation, and off-site disposal of highly contaminated material.
Impact: Proposed strategy resulted in significant cost savings and reduced impacts to sensitive ecological habitats.

Issue: Characterization and remediation of industrial solvent contamination and associated large groundwater plume has proved challenging in the complex geohydrologic setting
Approach: The technical team identified opportunities for improvement of source zone thermal treatment operation, and recommended phased remediation to allow opportunities for changes in strategy to address areas where performance is inefficient or ineffective.
Impact: Based on the current plans, cost savings resulting from the team efforts are projected at $18 million with additional savings in the future resulting from the natural attenuation science support.

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ACKNOWLEDGEMENTS

The authors acknowledge the support of DOE-EM and DOE-LM, as well as to the various site contractors who provided open communication of data and information. This document was prepared in conjunction with work under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy.