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**ENHANCING  
TECHNOLOGY ACCEPTANCE:**

**THE ROLE OF THE  
SUBSURFACE CONTAMINANTS  
FOCUS AREA  
EXTERNAL INTEGRATION TEAM**

Prepared by:

H. Kirwan-Taylor  
G.H. McCabe

*Battelle Seattle Research Center*

A. Lesperance

*Pacific Northwest National Laboratory*

J. Kauffman

P. Serie

L. Dressen

*EnviroIssues*

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September 1996

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H. Kirwan-Taylor  
G. H. McCabe  
Battelle Seattle Research Center

A. Lesperance  
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Pacific Northwest National Laboratory  
Richland, Washington 99352

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## Abstract

The U.S. Department of Energy (DOE) is developing and deploying innovative technologies for cleaning-up its contaminated facilities. In Fiscal Year (FY) 1994, DOE set up five focus areas including the Plumes Focus Area (PFA) and the Landfill Stabilization Focus Area (LSFA) for new technology development. In FY 1996, DOE consolidated the PFA and LSFA to form the Subsurface Contaminant Focus Area (SCFA) to combine team efforts, reduce duplication, and reduce costs. The technology end users within DOE are the primary customers of the focus area, but the concerns of the environmental restoration personnel, regulators, and other stakeholders must be addressed. This report describes the efforts of the SCFA External Integration Team (EIT) in defining markets for a portfolio of innovative technologies and associated performance requirements for stakeholder acceptance.

The EIT approach was based on the success of the Volatile Organic Compound Arid Sites Integrated Demonstration (VOC-Arid ID) program at the Hanford Site (FY1993-1995). The VOC-Arid ID demonstrated that a stakeholder involvement process could provide for early, meaningful stakeholder participation in defining, demonstrating, and deploying acceptable technologies for cleaning up volatile organic compounds in soil and groundwater. The program was successful and it was broadened to include other western arid DOE sites. The program expansion demonstrated that even though most stakeholder concerns were common across geographical areas, certain crucial concerns unique to individual sites existed.

The SCFA EIT coordinated site visits with the Site Technology Coordination Groups (STCGs) at DOE field offices to develop an understanding of their site problems and associated technology needs. The information collected became the basis for defining the DOE-wide market for new technologies. EIT also supported the matching of site needs with potentially applicable technologies, communicated potential matches to the STCGs, and requested STCG feedback on the matches and STCG willingness to consider using the technologies for environmental remediation given a successful demonstration.

EIT identified technologies for which addressing stakeholder performance requirements during technology development was essential to ensure broadened acceptance. EIT focused on technologies that were ready or nearly ready for field demonstration or deployment. SCFA product line managers and EIT worked together to prepare an action plan for each high priority technology. Each action plan identified stakeholder issues, site information requirements, and actions that EIT would take to support the technology, from surveying potential end users to coordinating a tour day of a demonstration in progress. EIT facilitated communications between the technology development team and potential end users, regulators and other stakeholders.

Experience in this program has indicated that developing a market-driven program and prioritizing technology needs on a national basis are great challenges. Site problems and needs are complicated and change frequently, while site priorities differ widely. Resources should be focused on those technologies that most need stakeholder involvement to overcome acceptance barriers. Involving stakeholders, including site level end users, in technology development and demonstration is critical and must occur at operable unit, site, and national levels. More extensive multi-site involvement of regulators and other interests can lead to accelerated and broadened deployment. And finally, coordination of the SCFA team on site communication is necessary to maintain credibility.

In the future, it is recommended that maintaining two-way communications between the SCFA and the STCGs, and stakeholder involvement be regarded as top priorities. Focus of communication will help better define market needs. Involvement of regulators with different authorities and missions is critical for clarifying regulatory performance requirements necessary for broadened acceptance of innovative technologies.



## Summary

The U.S. Department of Energy is developing and deploying innovative technologies for cleaning up its contaminated facilities using a market-oriented approach. This report describes the activities of the Subsurface Contaminant Focus Area's (SCFA) External Integration Team (EIT) in supporting DOE's technology development program. The SCFA program for technology development is market-oriented, driven by the needs of end users. The purpose of EIT is to understand the technology needs of the DOE sites and identify technology acceptance criteria from users and other stakeholders to enhance deployment of innovative technologies. Stakeholders include regulators, technology users, Native Americans, and environmental and other interest groups. The success of this national program requires close coordination and communication among technology developers and stakeholders to work through all of the various phases of planning and implementation. Staff involved must be willing to commit significant amounts of time to extended discussions with the various stakeholders.

### *Background*

DOE's Office of Technology Development established the Volatile Organic Compounds Arid Sites Integrated Demonstration (VOC-Arid ID) program at the Hanford site for FY 1993 through FY 1995. A stakeholder involvement process provided for early, meaningful stakeholder participation in defining, demonstrating, and deploying acceptable technologies for cleaning up volatile organic carbons in soil and groundwater. The program was successful and efforts were broadened to include other western arid DOE sites. This effort demonstrated that most stakeholder concerns were common across geographical areas, but that certain crucial concerns unique to individual sites existed.

In Fiscal Year (FY) 1994, DOE set up five focus areas for new technology development: contaminant plumes containment and remediation (plumes focus area), landfill stabilization, mixed waste, high-level waste tanks, and decontamination and decommissioning. These focus areas were directed to design a technology strategy driven by the technology needs in the DOE complex. The technology end users within DOE were to be the primary customers of the focus areas, but the concerns of regulators and other stakeholders also needed to be addressed.

The experience gained in the VOC-Arid ID program was used to develop the External Integration Team (EIT) approach for the Plume Focus Area (PFA) and the Landfill Stabilization Focus Area (LSFA). EIT focused on technologies further along in the development process that were ready for demonstration or deployment. This effort was pursued at all ten DOE field offices. The goal was to enhance communication, cooperation, and collaboration among technology developers, DOE customers, stakeholders, and regulators to implement cost-effective and needs-driven technologies. In FY 1996, DOE consolidated the PFA and the LSFA to form the Subsurface Contaminants Focus Area (SCFA) to combine team efforts, reduce duplication, and reduce costs. The SCFA was directed to demonstrate the capability to contain/stabilize 90 percent of the point-source terms at DOE's contaminated landfills and to control the migration of contaminant plumes at DOE sites by January 1997.

### *EIT's Work*

EIT supported development of a market-oriented SCFA program by working with the sites to develop an understanding of their technology needs and performance requirements. EIT coordinated site visits with the Site Technology Coordination Groups (STCGs) at the ten DOE field offices to develop an understanding of their site problems and associated technology needs. The information collected became

the national needs assessment. EIT developed an investment prioritization process and criteria for the focus area to rank needs across the various operable units, sites, and field offices. The prioritized needs could then be used to develop a technology investment portfolio to address the DOE-wide market.

EIT also supported the matching of site needs with potentially applicable technologies. EIT then communicated potential matches to the STCGs and requested feedback on the matches and their willingness to consider using the technologies in making decisions on environmental restoration projects. EIT provided input to future solicitations for proposals to address site needs that are not being addressed by commercially available technologies or ongoing DOE technology development efforts.

A key EIT effort was identifying stakeholder performance requirements to be addressed during the development, demonstration, and deployment of new technologies. EIT identified technologies for which stakeholder involvement was essential for accelerated and broadened deployment. EIT then helped SCFA product line managers prepare action plans for those high priority technologies. Each action plan identified stakeholder issues, site information requirements, and actions that EIT would take to support the technology, such as coordinating a demonstration site tour day or surveying potential end users. EIT participated in project reviews to monitor project progress and ensure that all stakeholder factors were addressed. EIT also supported product line managers in coordinating partnerships with the sites, leading to commitments by the sites to consider innovative technologies in their environmental restoration decisions. EIT tracked interstate regulatory coordination activities to develop strategies for obtaining multi-state regulatory approval of technologies.

EIT activities facilitated communications between the technology development teams and stakeholders. The goal of these efforts was to develop innovative technologies that are both technically effective and acceptable to end users, regulators, and other stakeholders.

### *Conclusions and Recommendations*

The focus area's vision is market-oriented technology development driven by the needs of end users across the DOE complex. STCGs have been identified as the principal point of contact for the focus areas. However, experience indicates that a need often exists for additional contact with operable unit managers for technical details (e.g. performance requirements) and to obtain firm commitments to consider and use innovative technologies. Additionally, site environmental management priorities differ widely across the DOE complex, and addressing site-specific priorities in a national program is difficult. Each STCG and most sites are involved in prioritizing their environmental restoration problems and technology needs. Each STCG, however, uses a different process and criteria, and often applies different weights to each criterion. A top priority need for one site may not be important to other sites, while another need may be of medium priority to several sites. Defining the DOE-wide market and setting appropriate priorities for focus area investments will be an ongoing challenge for the SCFA.

In addition, the SCFA technology portfolio contains projects that were funded before establishing a needs-driven approach. Matching these technologies to end-user needs at multiple sites has sometimes proven to be difficult. Information on the end users' performance requirements and schedules needs to be factored into technology development planning early in the development process so that the principal investigators' efforts can be better linked to end-user needs. If redirection of a project is not possible, the SCFA should shift funding into technologies that are of higher priority to end users.

Several steps that can be taken to enhance the needs-driven focus of the SCFA are to

- keep site problems and needs information accurate and up to date
- ensure that the SCFA team fully understands these problems and can translate them to technology needs
- follow up with the sites to receive feedback on potential technology matches
- be prepared and offer to explain the relationship of sites' priority-setting processes to SCFA prioritization/portfolio formation and accept site inputs on priorities

Multi-site stakeholder involvement can lead to accelerated and broadened deployment. Consultation with and involvement of stakeholders at a broader levels is a key to encouraging rapid and widespread deployment of innovative technologies. National regulator and stakeholder groups are invaluable in addressing broad issues. Efforts to do so involved both regulators and other interested parties through a variety of organizations, such as the Community Leaders Network, the Interstate Technology and Regulatory Cooperation work group, and on a regional basis, the Southern States Energy Board.

A significant constraint on the effectiveness of the multi-site involvement approach is the operating norm that a technology cannot be deployed at a site until it has been demonstrated there. The regional and national initiatives and many of EIT's activities in FY 1996 were designed to overcome this constraint. EIT examples include the tours for LASAGNA™, in-well vapor stripping, and dense nonaqueous phase liquid treatment technologies, where feedback was solicited from end users, regulators, and other interest groups from many of the potentially applicable sites.

Another lesson that has been learned is that regulators do not all view a technology similarly. It is critical to involve regulators from agencies with different authorities and missions and even divisions within an agency. Forums, such as the technology tours organized by the focus area, have served as excellent opportunities for regulators from these different perspectives to work together, learn from each other, and for the focus area to learn from them.

Understanding the stages of technology development and the increasing commitments from end users at each stage is the key to successful deployment. For example an STCG can easily make a commitment to review information on a technology or the results of a demonstration at another site for applicability to their site's needs. However, obtaining firm commitments from end users (e.g. joint funding of demonstrations) requires more effort and involvement of the SCFA team, site managers, and operable unit managers.

Recommendations include the following:

- The SCFA should appoint site coordinators to facilitate communication by preparing SCFA information tailored to site needs, and by working with the STCGs to design mechanisms to solicit feedback from stakeholders.
- Interactions among the SCFA team, STCGs, and principal investigators should be increased to enhance technology deployment.
- The SCFA should conduct ongoing communication with STCGs and operable unit managers to help forge working relationships, fully understand site problems and needs, and discuss how SCFA technologies can help.

- SCFA should recognize the STCGs and operable unit managers as the focus area's customers and provide timely feedback to them on issues they raise. Feedback from STCGs and operable unit managers should be solicited proactively, and STCG and operable unit managers' requests should be responded to in a timely manner.

Successful demonstration and deployment of innovative technologies require a concerted and coordinated effort of all members of the SCFA team and the sites. Stakeholder involvement strategies for critical technologies should be developed in concert with the SCFA product line managers and principal investigators to ensure that stakeholder issues and end-user perspectives are factored into demonstration planning and deployment decisions. Successful deployment will occur only if a technology is technically effective and meets the performance requirements of regulators, end users, and other stakeholders at all sites where the technology is applicable. The Lead Office, PLMs, technical team, and principal investigators must work closely with the stakeholder coordinator to identify and address site information needs, and stakeholder and regulatory issues and concerns. The SCFA team must coordinate to ensure consistent site communications, and to further ensure that any commitments made are upheld to maintain program credibility.

## Glossary

AC	alternating current
ANL	Argonne National Laboratory
BNL	Brookhaven National Laboratory
CLN	Community Leaders Network
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DOE-RL	DOE-Richland Operations
DOE-SR	DOE-Savannah River
DOIT	Develop On-Site Innovative Technologies
EIT	External Integration Team
EM	Environmental Restoration and Waste Management
EPA	Environmental Protection Agency
ERDF	Environmental Remediation Disposal Facility
INEL	Idaho National Engineering Laboratory
ISRM	<i>In situ</i> redox manipulation
ITRC	Interstate Technology and Regulatory Cooperation
IWVS	In Well Vapor Stripping
LANL	Los Alamos National Laboratory
LEHR	Laboratory for Energy-Related Health Research
LIBS	laser-induced breakdown spectroscopy
LLNL	Lawrence Livermore National Laboratory
LSFA	Landfill Stabilization Focus Area
METC	Morgantown Energy Technology Center
ORNL	Oak Ridge National Laboratory
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PFA	Plumes Focus Area
PGDP	Paducah Gaseous Diffusion Plant
PI	principal investigator
PLM	product line manager
PNNL	Pacific Northwest National Laboratory
PSVE	passive soil vapor extraction
RCRA	Resource Conservation and Recovery Act
RCI	Rapid Commercialization Initiative
RD&D	research, development, and demonstration
RF	radiofrequency
SCFA	Subsurface Contaminants Focus Area
SNL	Sandia National Laboratory
SPSH	Six Phase Soil Heating
SRS	Savannah River Site



SSEB Southern States Energy Board  
STCG Site Technology Coordination Group  
TCE trichloroethylene  
UMTRA uranium mill tailings remedial action  
VOC-Arid ID Volatile Organic Compounds Arid Sites Integrated Demonstration  
WGA Western Governor's Association

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## 1.0 Introduction

This report summarizes the activities of Battelle's External Integration Team (EIT) in supporting the Subsurface Contaminants Focus Area (SCFA) for the U.S. Department of Energy (DOE).

The activities of EIT have encompassed DOE sites nationwide. Experiences gained have indicated that significant time and effort must be spent in personal contact with developers and users of new and innovative technologies to carry out the intended tasks successfully. With sustained effort, EIT staff have been able to

- discover and prioritize needs for new technologies
- provide input for future technology solicitations
- provide input to demonstrations
- evaluate the effectiveness of new technologies and their acceptance by regulators and other stakeholders
- assess their potential for saving time and money.

EIT's work is intended to save DOE users significant time, expense, and duplication of effort by accelerating and broadening technology acceptance.

### 1.1 History

In Fiscal Year (FY) 1994, DOE, desiring to improve technology performance, cut cleanup schedules, and lower cleanup costs, put into place a new approach to develop and deploy innovative technologies to clean up its contaminated facilities. The DOE organized its technology development and application investments nationwide into five focus areas:

- Contaminant Plumes Containment and Remediation (Plume Focus Area)
- Landfill Stabilization
- Mixed Waste
- High-Level Waste Tanks
- Decontamination and Decommissioning

The focus areas were directed to design a technology strategy driven by the technology needs of the sites in the DOE complex. These needs were defined by the technology customers within DOE—Office of Waste Management, EM-30; Office of Environmental Restoration, EM-40; Office of Nuclear Material and Facility Stabilization, EM-60; and Office of Site Management, EM-70. The focus areas were designed to ensure that the technologies being developed were not only useful to and needed by these customers, but also acceptable to environmental restoration personnel, regulators, and other stakeholders.

The foundation for the focus area approach to site and stakeholder involvement was a FY 1993 to 1995 DOE program sponsored by the Office of Technology Development. This program, the Volatile Organic Compounds Arid Sites Integrated Demonstration (VOC-Arid ID), pioneered a stakeholder involvement process that provided for early, meaningful stakeholder participation in defining,

demonstrating, and deploying acceptable technologies for cleanup of VOCs in soil and groundwater at arid sites.

In the VOC-Arid ID, a range of stakeholders were involved initially at the Hanford Site where the technology demonstrations were being conducted. Activities included one-on-one interviews, focus groups, and workshops to integrate the varying range of stakeholder perspectives on the technologies being demonstrated. Stakeholders included regulators, technology users, Native Americans, and environmental and other interest groups. Substantial input was received and incorporated into demonstration test plans and deployment planning.

With a solid base of host-site stakeholder input, the VOC-Arid ID then broadened its efforts to include participation by stakeholders at other western arid DOE sites where the technologies could ultimately be deployed. In this way, acceptability at other locations was assessed and factored into demonstration designs to broaden the applicability of the technologies. While the majority of stakeholder concerns were common across geographic areas and even among stakeholder categories, a significant level of specificity existed that, if ignored, would have placed future decisions at risk.

The VOC-Arid ID approach was used as a starting point for developing the Plume Focus Area (PFA) and later the Landfill Stabilization Focus Area (LSFA) approaches to carrying out the technology development/deployment process. While the VOC-Arid ID model provided insights into the design of an appropriate strategy for the focus areas, this model was limited when applied to a national program. The specific plume and landfill focus area strategies were tailored to the challenges of integrating ten DOE field offices, many with multiple sites, and numerous environmental management and stakeholder needs and programs at each site. Direct stakeholder involvement, including interfacing with regulators, became the responsibility of each field office's Site Technology Coordination Group (STCG).

The PFA's mission was to enhance the deployment of innovative technologies for containing and cleaning up contaminant plumes in groundwater and soil. The LSFA's mission was to enhance the deployment of innovative technologies for stabilizing, containing, and cleaning up buried-waste landfills. The new technologies focused on meeting high-priority needs at DOE facilities nationwide. The PFA and LSFA were directed to enhance communication, cooperation, and collaboration among technology developers, DOE customers, stakeholders, and regulators to enable implementation of cost-effective and environmentally sensitive technologies.

In FY 1996, DOE consolidated and realigned the PFA and LSFA into the Subsurface Contaminants Focus Area (SCFA) to focus and streamline team efforts aimed at technology deployment, identify opportunities to combine the best products of the two focus areas, reduce duplicative efforts, and reduce costs. The SCFA is to demonstrate the capability to contain/stabilize 90 percent of the point-source-terms at DOE's contaminated landfills and to control the migration of contaminant plumes on DOE sites by January 1997. The approaches to working with field office users, STCGs, regulators, and other stakeholders are currently in development.

## 1.2 Mission of External Integration Team

EIT worked with other teams of the focus area to facilitate technology deployment. The outreach function was to

- identify and factor in the stakeholder's values and ideas in identifying and prioritizing cleanup needs at all DOE sites
- evaluate stakeholder acceptability of innovative technologies and provide this information to technology developers and others responsible for choosing innovative technologies to address their problems.

Stakeholders were defined as all individuals or groups that were interested in or felt that they could be affected by some action taken in demonstrating or deploying innovative technologies. Stakeholders included technology users, regulators, environmental and public interest groups, tribal groups, public officials, and other interested parties. Stakeholder acceptance was incorporated into evaluating whether innovative technologies were improvements over current baseline technologies. EIT operated with the assumption that if stakeholders understood the technologies, recognized that their concerns were reflected in the evaluations and demonstrations, and participated in the assessment of how technology performance addressed their concerns, they would be more likely to accept the technologies. This assumption was validated. Additionally, stakeholder input added to the efficiency of the technology evaluation process by, in some cases, identifying obstacles to successful deployment early and, more often, identifying additional information needed to address their concerns about a given technology.

The objectives of EIT included

- coordinating with STCGs to identify site needs and priorities
- assessing and enhancing technology acceptance by ensuring stakeholder involvement
- facilitating interstate regulatory acceptance of innovative technologies.

The major focus of EIT activities is a needs-driven approach. This report includes descriptions on assessing needs, prioritizing needs, soliciting and demonstrating new technologies, summarizing new technologies investigated to meet end-user needs, relating lessons learned, and recommending future actions.



## **2.0 EIT Process—Focus on Technology Needs**

The activities of the focus area fall into several categories that define the work breakdown structure and call on the capabilities of the product line managers (PLMs), Industrial Team, Technical Team, and Support Team, as well as the EIT and the STCGs. Figure 2.1 summarizes the overall basic focus area process, linking EIT activities and products to overall focus area responsibilities. As shown in Figure 2.1, EIT coordinates with the STCGs to support the SCFA team in accomplishing the six tasks listed below:

- identify environmental management problems, technology needs, and schedule requirements at all DOE field offices and sites
- match current technology investments to needs
- solicit new technologies where needs are not met by current investments
- develop and demonstrate new technologies
- evaluate demonstration results to determine whether technologies are appropriate for deployment at DOE sites
- facilitate deployment of successful technologies.

EIT activities associated with each of these tasks are described more fully in subsequent sections of this report.

### **2.1 Identify Site Problems/Technology Needs**

#### **2.1.1 Establish and Maintain STCG Contacts**

An EIT team member was assigned to act as the EIT site coordinator for each of the ten DOE field offices. Each EIT site coordinator was responsible for

- maintaining site contacts
- understanding the field office and site structure
- acting as a liaison between the focus area and the STCG, waste management and environmental restoration operable unit (OU) managers, and other key players at the site/field office
- working to ensure that the field office and site needs, developments, and activities were accurately and fully represented in focus area planning and investments.

The entire EIT team worked together to share information about PFA and LSFA activities, products, site activities and updates, and other factors that support effective external integration.



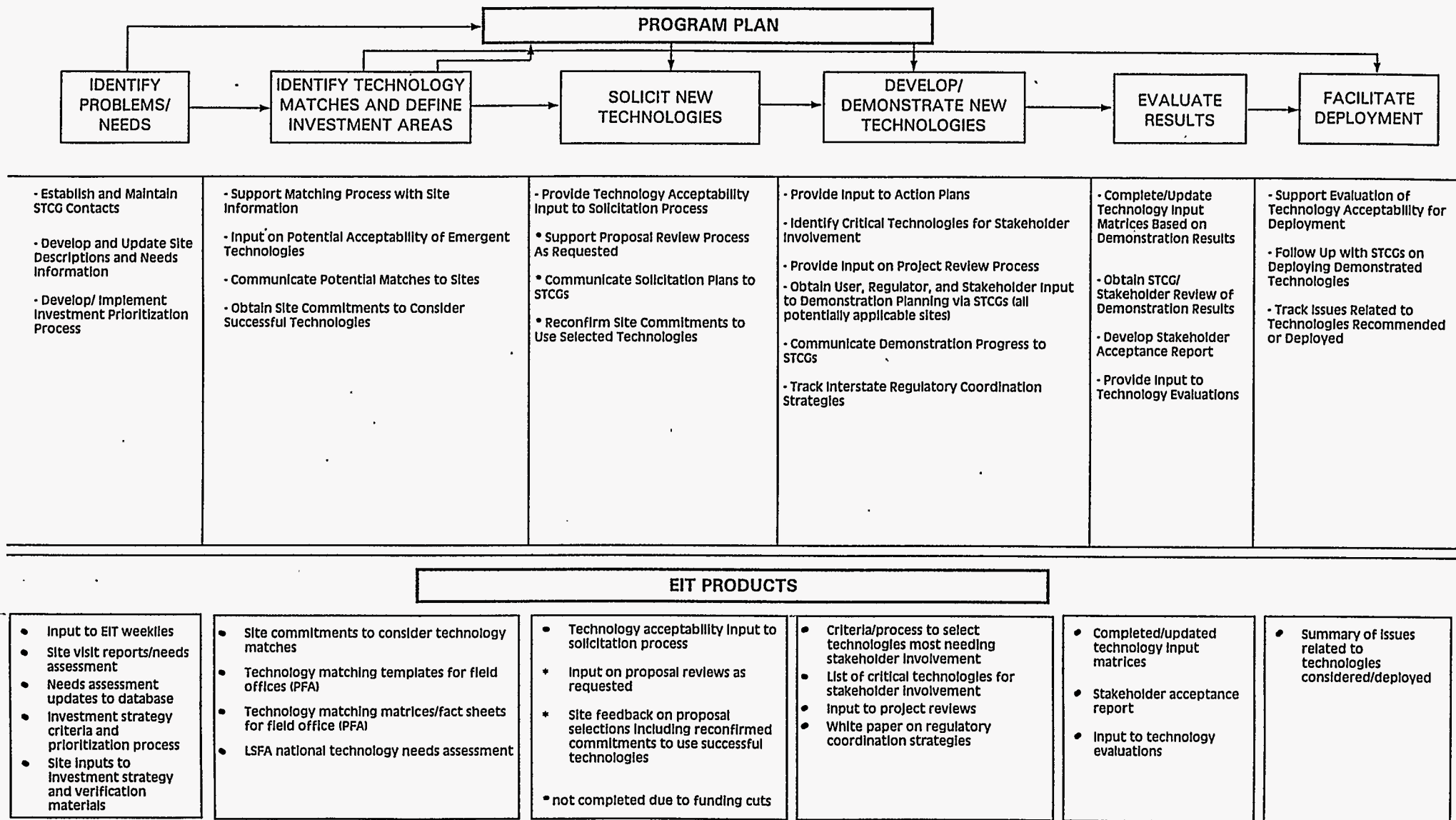


Figure 2.1 EIT Work Plan - Process Diagram

Each EIT site coordinator worked with its respective STCG to establish a network of contacts at each field office, area office, and constituent site. The EIT site coordinators made regular telephone, written, and face-to-face contacts with the STCG chairs and staff contacts to

- obtain information from the STCG to support updating the needs assessment database based on changing field office and site conditions
- update the STCG regarding discussions (meetings, calls) between other LSFA and PFA team members and facility/OU managers to facilitate meeting site needs
- identify actions needed to address specific needs/problems and document actions for tracking by program support function.

Specific products from this task included input to EIT weekly reports to PFA and LSFA to summarize contacts made, issues and actions identified, meetings scheduled, and coordination needs among and outside the teams.

Budget cutbacks during FY 1996 resulted in reduced emphasis on the EIT site coordination activities. Instead, EIT team members shifted their emphasis to LSFA systems engineering work (described in Section 3.2.2) and PFA technology-specific action plans (described in Section 5.0).

### **2.1.2 Develop and Update Site Descriptions and Needs Information**

Critical focus area strategies were to accurately, timely, and completely identify site environmental management problems and associated technology needs to address these problems. Early on, the PFA visited all ten DOE field offices to meet with STCGs, environmental management personnel, and others to begin the process of identifying and understanding site problems and technology needs associated with soil and groundwater plumes. From January through April 1995, each field office was contacted to determine appropriate points of contact for scheduling the visits and for participating in the meetings. Team members from all PFA functional areas (management, Technical Team, Industrial Team, and PLMs) participated. Field office and site participants included DOE and contractor personnel from across the environmental management organizations, with some variations depending on site-specific situations.

Each site visit included an overview presentation on the PFA mission, objectives, and organization. The host field office provided an overview of its environmental management mission, organization, cleanup plans, and priorities, and detailed information was provided at the site and OU level. The meetings were organized informally to allow for dialogue and clarification of information gathered. EIT prepared site-visit reports, including meeting summaries, points of contact, detailed OU-level problem/need descriptions in a standard template format (OU templates), and lists of PFA actions resulting from the discussions. The draft site visit reports were distributed to the sites for review and comment to ensure that the information was captured accurately.

The information in the OU templates formed the basis of the FY 1995 PFA site-needs assessment, which was categorized by PFA product line and technology category and made available to PFA team members.

Specific PFA products from this task included

- site visit reports with templates for PFA site visits to the Albuquerque, Chicago, Idaho, Nevada, Oak Ridge, Oakland, Ohio, Richland, Rocky Flats, and Savannah River field offices (An example site template is provided in Appendix A).
- PFA needs assessment matrices categorized by product line (metals and radionuclides, organics, DNAPLs, and general product lines) and needs categories (characterization, remediation, containment) across all DOE field offices, dated May 1995 (A partial example provided in Appendix C).

From August to November 1995, the LSFA team conducted similar visits, which were coordinated by the EIT, to nine of the ten field offices. Rocky Flats declined to participate in a site visit during that time period. Participants included STCGs, waste management facility and OU managers, and key LSFA team members. A similar overview presentation was provided during the visit, including information on the FY 1996 LSFA program plan. EIT prepared site visit reports including brief meeting summaries, points of contact, lists of LSFA actions resulting from discussions, as well as detailed site templates for each OU and waste management facility. These site templates captured the description of the sites' problems and associated technology needs. Specific LSFA products from this task included site visit reports for LSFA site visits to Albuquerque, Chicago, Idaho, Nevada, Oak Ridge, Oakland, Ohio, Richland, and Savannah River field offices (Example OU and waste management templates provided in Appendix B).

With this base of initial problem/needs information in place, the EIT site coordinators maintained ongoing contacts with the STCGs to learn of changes, additions, or sensitivities related to the needs database.

## **2.2 Prioritize Needs**

### **2.2.1 Develop Investment Prioritization Process**

Because it is critical to prioritize needs and technology development opportunities across the DOE complex so that DOE's investments provide the maximum benefit, EIT worked with PFA and LSFA teams to develop a process and criteria for prioritization. EIT was tasked with developing a user-friendly method for consistently ranking technology needs across the various OUs, sites, and field offices. The prioritized technology needs could then be used to develop an investment portfolio that balanced current and new technology development investments to address the highest priority problems.

In December 1995, the prioritization process was tested to evaluate the proposed process and to determine the ability of the TechInvest database to support the process as designed. To prepare the test run, the group used information provided in the PFA technology need templates from a sampling of 10 OUs and generated 110 technology need statements. If this system were applied complex-wide, as many as 1000 need statements could be generated. The test run (1) reviewed the technology need statements drafted by the TechInvest team; (2) reviewed the information available for the proposed criteria; and

(3) used a statistical approach to develop weights for the criteria. The following describes other findings with regard to the prioritization process.

### **2.2.2 Test Prioritization Process**

The test run revealed that the PFA technology need statements needed a quality check from a technical person to ensure that they were complete. The quality of information from the existing site problem/need templates was inconsistent and incomplete, especially for some of the more critical criteria (i.e., cost, risk, and site priorities).

#### *Criteria*

Reviewing the criteria showed that several people were measuring compound concepts or double counting issues related to riskiness. For example, the criteria measuring risk included risk, schedule flexibility, and regulatory compliance. EIT concluded that the criteria should be reviewed again to determine whether single concept metrics could be found that were acceptable to the focus area. Additionally, the focus area should determine whether the criteria would be solely “fact based” or expanded to include personal judgment. If the choice were the former, involving stakeholders would be expensive to the focus area and unrewarding to stakeholders.

#### *Weighting*

The weighting technique used by the TechInvest team was difficult to explain to participants. The team had to stop the participants several times to remind them about what they were doing. As a result, EIT recommended that a simpler weighting process, such as distributing 100 points among the criteria, be used to facilitate the process. EIT proposed three options on proceeding with the prioritization process. Option 1 (continuing with the process as planned) would require

- finalizing and peer-reviewing the technology needs and templates
- identifying participants from the sites for the prioritization meeting
- agreeing on a process to ensure that TechInvest met the focus area needs to facilitate the evaluation
- preparing for a meeting with STCG members.

The activities under Option 2 (conducting a technical review using only technical information collected and entered into the TechInvest database) included

- developing criteria
- completing the description of technology needs for all of the OUs
- completing a prioritization process with the support of TechInvest.

Option 3 was to continue with the process in place where the PLMs made the decisions based on personal knowledge of the sites, cleanup problems, and technology programs.

Focus area members reported using the prioritization process and found it beneficial. However, because the original team that developed the strategy was not involved in the implementation, the advantages and disadvantages of using the process cannot be addressed here.

### **2.3 Match Technologies to Needs**

Two key strategies of the focus areas are to “buy” technologies from the private sector whenever possible and to ensure that all DOE investments (“make” decisions) are driven by DOE site needs. To accomplish this, matches were identified between the site needs and technologies that were commercially available or already under development or demonstration in industry, other federal agencies, or DOE. Any site problems or technology needs for which neither commercially available technologies nor ongoing DOE technology development programs provided potential solutions were to be addressed through solicitations for proposals (see Section 3.1).

The focus areas’ industrial teams led in identifying commercially available technologies, while the focus areas’ technical teams led in the technology matching process. EIT supported this technology matching process by providing site information and input on whether the technologies were acceptable to potential end users, stakeholders, and regulators, based on information obtained during the needs assessments and subsequent contacts with STCGs and, through them, their stakeholders. EIT also communicated potential technology matches to the STCGs. STCGs were asked to provide feedback on their sites’ potential receptiveness to these matches and their willingness to commit to considering these technologies in making decisions on environmental restoration projects.

EIT site coordinators worked with STCGs and facility/OU managers to ensure that they had adequate information about the technologies to support their decision-making. As described in Section 5.0, EIT also worked with STCGs and facility/OU managers to seek site commitments to consider the technologies identified in the final matches in their feasibility studies and decision making.

The PFA and LSFA took different approaches to technology matching, as described below.

### 2.3.1 Plumes Focus Area

The PFA Technical Team assembled small groups of technical experts to review site needs and evaluate and assess the likelihood that the available technologies would meet the needs. Three groups of experts were convened, each with a particular expertise—characterization, treatment, or containment technologies. Each group held a one- to two-day workshop to identify, evaluate, and assess technology options. An EIT representative participated in each workshop to provide information obtained from the sites during the needs assessments and ensure that all site needs were addressed and grouped appropriately. EIT also provided insights on the potential acceptability of the matched technologies to users, regulators, and other stakeholders. After the workshops ended, each group prepared a draft report that described the results of the matching as well as the information needs, technical issues, technical gaps, etc.

As a follow-up to the workshop, EIT worked with the Technical Team to prepare templates for each OU that described the OU problem and needs, the contaminants of concern, current baseline technology, and the potential characterization, treatment, and/or containment technology matches. The templates were categorized according to whether the STCGs had designated the need as a high, medium, or low priority.

EIT communicated potential technology matches and information on the technologies to STCGs, and through STCGs to facility/OU managers. Matrices were provided to each field office that matched technologies supported by the PFA directly to OU needs at the site. Fact sheets on funded PFA technologies were also provided that described the technology, its advantages, and challenges that remained to be addressed. The field offices were asked to review the matrices and fact sheets and provide feedback through the STCGs on potential interest in any of the technologies and need for additional information.

As described in Section 3.2, EIT worked with product teams to develop action plans for technologies within the PFA portfolio. Many of the action plans called on EIT to identify end users and to contact them to learn more about their performance requirements and schedules. The technology-matching information helped in implementing action plans. STCGs and facility/OU managers were contacted directly in context of the action plans to obtain feedback on technology matches.

Specific products from this task included

- technology matching templates for medium-priority needs for Albuquerque, Chicago, Idaho, Nevada, Oak Ridge, Oakland, Ohio, Richland, Rocky Flats, and Savannah River field offices, August 1995
- technology matching templates for high-priority needs for Albuquerque, Chicago, Nevada, Oak Ridge, Oakland, Ohio, Richland, Rocky Flats, and Savannah River field offices, August 1995

- technology matching matrices/fact sheets transmitted to field offices (Albuquerque, Chicago, Idaho, Nevada, Oak Ridge, Oakland, Ohio, Richland, Rocky Flats, and Savannah River), January 12, 1996 (example provided in Appendix D).

### 2.3.2 Landfill Stabilization Focus Area

The LSFA technology matching process began with processing the information contained in the site visit reports and site templates. First, the needs reported by the sites on each template were entered into a database. In some instances, the description of the need was expanded to include contaminant types and other information contained in the problem description. Next, the LSFA Technical Team developed and defined technology-needs categories and subcategories. Six major categories were defined: assessment, containment, disposal, removal, *in situ* treatment, and treatment. These major categories were further divided into subcategories. The Technical Team then assigned a technology-need category and subcategory to each need contained in the database. The database was sorted by category and subcategory, resulting in a list of sorted needs across the DOE complex. The needs for each category and subcategory were “rolled up” on a national basis. That is, needs that were common to multiple sites were compiled to present a picture of how pervasive a given need was across the DOE complex.

EIT supported this process by (1) compiling the site needs database, (2) facilitating a 2-day workshop with the LSFA Technical Team to assign the needs to technology categories and subcategories (3) updating the database to incorporate the results of the Technical Team workshop; (4) sorting the needs by category and subcategory and preparing a “roll up” on a national basis. EIT then prepared a report that summarized all the work. The LSFA national needs assessment report was distributed to the STCGs for review and comment. The report was also used by the LSFA team to support the systems engineering work (described in Section 3.2.2) and PLM activities.

In March 1996, the LSFA received a refined and updated list of technology needs from the Hanford STCG. The Hanford STCG asked for feedback on potential technology matches for each of their identified needs. EIT worked with the LSFA Technical Team and PLMs to prepare a formal response to this request. EIT also facilitated communication between STCGs and PLMs to identify end users for technologies in the LSFA portfolio.

Specific products from this task included

- LSFA, *National Technology Needs Assessment*, Working Draft Rev. 1, January 31, 1996.
- LSFA, Letter and table from LSFA to Hanford STCG relating the Hanford site technology needs to potential DOE technologies to address those needs, April 5, 1996.

## **3.0 EIT Process—Enhance New Technology Development, Demonstration and Deployment**

### **3.1 Solicit New Technologies**

The technology matching process discussed in Section 2.3 identified technology gaps: site needs that were not being addressed by commercially available technologies or ongoing DOE technology development efforts. The focus areas planned to issue solicitations for proposals to develop technologies that would address those needs and satisfy criteria relating to technical performance, protection of public and worker health and safety, cost, schedule, regulatory compliance, and stakeholder acceptability. The Morgantown Energy Technology Center (METC) representative to the focus area led the solicitation process and developed solicitation packages for efficient separation processes, metal and radionuclide technologies, and dense nonaqueous phase liquid (DNAPL) technologies. The planned EIT activities included support for developing the solicitation process, reviewing proposals, and obtaining site feedback on proposal selections.

EIT provided input to the METC representative on the solicitation package to ensure that proposers addressed stakeholder acceptance issues. EIT's input included specific stakeholder factors and criteria to be considered during the proposal evaluation process. Due to funding cuts, the focus areas were unable to issue a call for proposals during FY 1996. Thus, proposals were not received or reviewed, so site feedback on the proposal selections was not needed.

A product of this task was a letter dated October 5, 1995, to the PFA METC representative. This letter included stakeholder acceptance factors/criteria for inclusion in future solicitations.

### **3.2 Support Development, Demonstration, and Deployment of New Technologies**

The key strategy of the focus areas was to leverage resources using a focus area collaborative approach to facilitate broad deployment. The EIT was responsible for working with the principal investigators (PIs) and PLMs to develop a plan for developing and implementing the technologies, factoring in the needs and issues of the sites, potential end users, regulators, and other stakeholders where a technology was potentially applicable.

#### **3.2.1 Plumes**

Selected technologies underwent project reviews (gated reviews) to monitor project progress and performance based on a standard set of criteria and to define actions necessary to advance the technology. EIT was involved in the project reviews to ensure that end user, stakeholder, and regulatory factors were addressed. Six "gates" or steps were defined for the technology development and demonstration process, as follows:

- Gate 1 - Readiness to move from basic research to applied research, based on knowledge of similar efforts.



- Gate 2 - Readiness to move into exploratory development, based on whether it addressed a priority DOE need.
- Gate 3 - Readiness to move into advanced development, based on whether it showed a clear advantage over available technology.
- Gate 4 - Readiness to move into engineering development, based on whether it met cost/benefit requirements.
- Gate 5 - Readiness to move into demonstration.
- Gate 6 - Readiness for deployment.

A number of technologies were already under development and demonstration in the PFA and were at various points in the technology development process. One of the early efforts assessed the place of each technology in the process and applied criteria to evaluate whether the technology was ready to proceed through the gate to the next step of development or whether additional information was needed before the criteria could be applied.

EIT evaluated how well a technology met the stakeholder acceptance criteria and provided this input to help determine whether the technology was ready to pass through a gate to the next phase of development or demonstration. The primary EIT focus was on technologies undergoing Gates 4 through 6 evaluations. During Gate 4 evaluations, EIT largely used its professional experience from past projects, including the VOC-Arid ID and stakeholder reactions detailed in the literature, to make a determination. During the Gate 5 and 6 evaluations, obtaining site-specific input from STCGs and facility/OU managers on user, regulator, and other stakeholder perspectives was particularly important.

As described in Section 5.0, EIT also supported the PLMs in coordinating partnerships with the sites for technology development and demonstration, leading to commitments by the sites to consider the technologies in the decision processes for their environmental restoration projects. A critical part of the strategy was to ensure that technology demonstrations provided the information needed for users, regulators, and other stakeholders to make reasoned judgments regarding the acceptability of the technologies. For selected technologies, EIT worked through the STCGs and facility/OU managers to obtain input from users, regulators, and other stakeholders into the development of the demonstration test plans. Once demonstration test plans were approved, EIT tracked the progress of the demonstrations and observed/participated as appropriate. EIT also worked with STCGs and facility/OU managers to ensure that they obtained appropriate site and stakeholder involvement in the demonstrations as they proceeded.

In addition, EIT tracked interstate regulatory coordination activities by helping to develop strategies and protocols for obtaining multi-state regulatory agency approvals of technologies or specific categories of technologies. EIT tasks in support of this phase of the program are described in more detail below.

### *Identify Critical Technologies for Stakeholder Involvement*

EIT identified technologies for which stakeholder involvement was essential to ensure that stakeholder concerns were addressed while technologies were being developed. To identify these technologies, EIT first developed a list of factors and criteria to make the determination of those technologies likely to benefit from stakeholder involvement.

Criteria included performance, cost, environmental/safety/health, regulatory, and socio-political factors. EIT defined these general stakeholder acceptability factors based on extensive previous work (VOC-Arid ID) with regulators and other stakeholders in the technology development field. These general acceptability factors can be considered by the PFA team and other technology development personnel in the further development of technologies to improve their acceptance. The acceptability factors helped identify areas of public and regulatory sensitivity or concern and allowed for appropriate involvement of regulators and stakeholders at different stages in a technology's development.

An EIT team member was assigned to each of the technologies in the plume portfolio. Not every technology funded under the focus area was of significant interest to stakeholders. In addition, some technologies were too far advanced in the demonstration phase to benefit optimally from broad stakeholder involvement, such as influencing the design of the demonstration plan. Consequently, EIT developed draft criteria to identify critical technologies for stakeholder involvement (see Figure 3.1 and 3.2). Technologies were then assigned to one of the following lists (see Figure 3.3):

- A list: technologies of high stakeholder interest where it was possible to affect the demonstration test plan
- B list: technologies of high stakeholder interest, but not broadly applicable
- C list: technologies of high stakeholder interest, where demonstration plans were not compatible with stakeholder involvement
- D list: technologies of little stakeholder interest
- E list: technologies with potential stakeholder interest, but with no demonstrations planned or sites selected.

Based on the letter assigned to a technology, EIT developed technology action plans with the support of the PLMs. The technology action plans identified stakeholder issues, site information requirements, and actions that EIT would undertake to support the technology, such as coordinating a tour day or surveying potential users. EIT helped the PLM prepare an action plan for technologies in the PFA portfolio. EIT was responsible for providing input to the PLM and PI on the EIT scope, decision points, and schedules for the technology action plans. Section 5.0 discusses activities for implementing the technology action plans in more detail.

Specific products from this task included

- report on *Factors for Regulator and Stakeholder Acceptance of Innovative Technologies within the Plume Focus Area Portfolio*, dated December 22, 1995 (Appendix E).
- letter report evaluating PFA portfolio technologies for stakeholder involvement - a draft approach, dated October 17, 1995 (Appendix F)

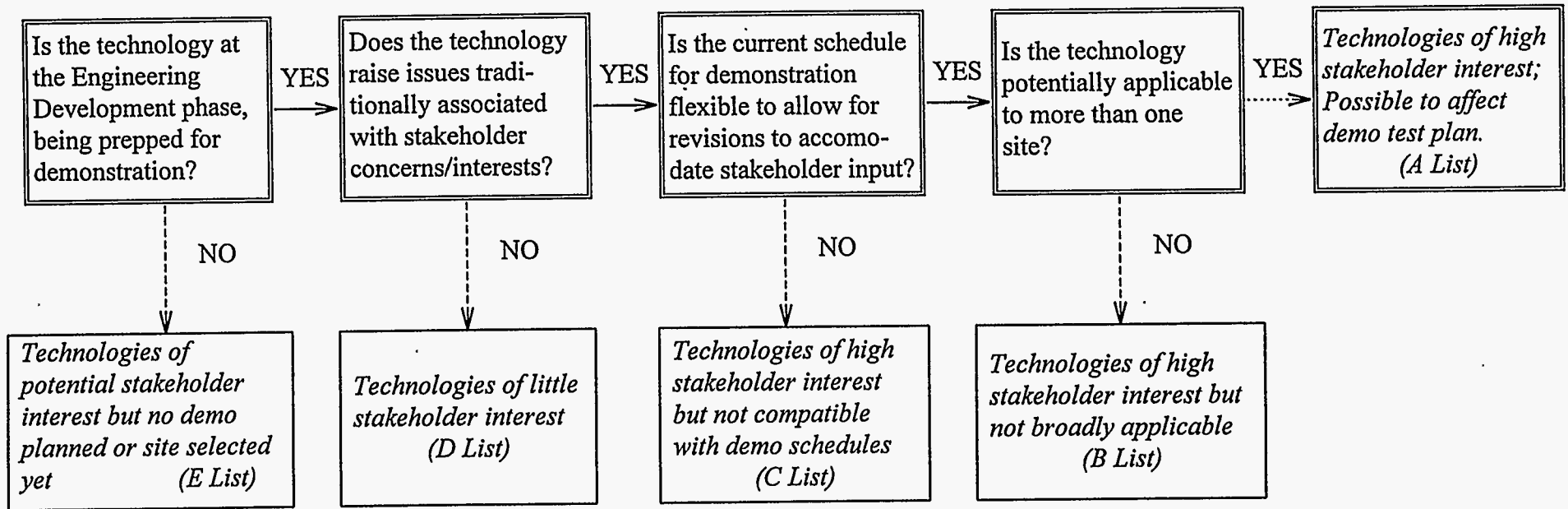


Figure 3.1 Evaluating Portfolio Technologies for Stakeholder Involvement

FACTORS/CRITERIA	MEASURE
PERFORMANCE	
<ul style="list-style-type: none"> <li>• Potential to adversely increase contaminant mobility **</li> <li>• Requires subsurface injection **</li> <li>• Transfers contaminants from one medium to another</li> <li>• Unable to address co-contaminants *</li> <li>• Type, volume, toxicity, or recyclability of process waste worse than baseline *</li> <li>• Not versatile (broad range of contaminants, conditions)</li> <li>• Complex technology</li> <li>• Unusual maintenance/expertise required</li> <li>• Auxiliary technologies required for whole solution and not yet identified</li> <li>• Requires offsite transport/treatment</li> <li>• Slower than baseline</li> </ul>	<p>YES/NO  YES/NO  YES/NO; H/M/L  YES/NO  YES/NO  YES/NO; H/M/L  YES/NO; H/M/L  YES/NO  YES/NO  YES/NO  YES/NO</p>
COST	
<ul style="list-style-type: none"> <li>• Cost greater than baseline</li> </ul>	<p>YES/NO</p>
ENVIRONMENTAL, SAFETY & HEALTH	
<ul style="list-style-type: none"> <li>• Potential failure impact ** (environment, public or worker health)</li> <li>• Produces emissions or releases **</li> <li>• Energy demands greater than baseline</li> </ul>	<p>YES/NO; H/M/L  YES/NO; H/M/L  YES/NO</p>
REGULATORY	
<ul style="list-style-type: none"> <li>• Regulatory infrastructure/track record</li> </ul>	<p>YES/NO</p>
SOCIO-POLITICAL	
<ul style="list-style-type: none"> <li>• Forecloses future options</li> <li>• Potential to impact key cultural or socio-economic resources (e.g., tribal resources, scenic vistas, drinking water supplies, open space)</li> </ul>	<p>YES/NO  YES/NO</p>

\*\* of highest stakeholder concern  
\* of high stakeholder concern

Figure 3.2 Technology-Specific Stakeholder Involvement Factors and Criteria

TECHNOLOGY SUBSET	EIT APPROACH (BASED ON RESOURCE AVAILABILITY)
<p><b>A List:</b></p> <p>High interest, affect test plan</p>	<ul style="list-style-type: none"> <li>- Multi-site STCG involvement</li> </ul>
<p><b>B List:</b></p> <p>High interest, but not broadly applicable</p>	<ul style="list-style-type: none"> <li>- Host-STCG focus (for single applicable site)</li> <li>- Stakeholder lessons learned</li> </ul>
<p><b>C List:</b></p> <p>High interest, but not schedule compatible</p>	<ul style="list-style-type: none"> <li>- Suggest revising demo schedule</li> <li>- Modified multi-site STCG approach</li> <li>- Stakeholder lessons learned</li> </ul>
<p><b>D List:</b></p> <p>Little interest</p>	<ul style="list-style-type: none"> <li>- Information sharing (telephone/paper)</li> </ul>
<p><b>E List:</b></p> <p>Pre Engineering Development Phase (prior to demonstration planned) technologies</p> <ul style="list-style-type: none"> <li>• technologies of little interest</li> <li>• technologies of potential high interest</li> </ul>	<ul style="list-style-type: none"> <li>- Information sharing</li> <li>- Coordination with Product Line Manager and PI to alert them of potential stakeholder acceptance issues and concerns</li> </ul>

Figure 3.3 Stakeholder Involvement Approaches

### *Input on Project Review Process*

The PFA Technical Team selected technologies to be included in the project review process. EIT's list of critical technologies for stakeholder involvement was used to determine which project reviews required EIT input. Input was provided for technologies undergoing evaluations for Gates 4 through 6. EIT provided input on potential end users throughout the DOE complex and their performance requirements. EIT also identified critical stakeholder and regulatory issues that would have to be addressed in future demonstration activities. EIT provided input to gate reviews for the following technologies:

- Biomass Remediation System - Worked with the Technical Team to develop criteria to define potential end users for rhizofiltration and phytoextraction. Identified and contacted potential end users to determine their interest and performance requirements. Prepared letter report and summary of potential end user interest. Participated in project review in Butte, Montana, presenting findings and developing recommendations for future work.
- In Situ Remediation by Electrokinetics, Uranium Removal from Soil - Completed potential end user review and preliminary baseline cost analysis, focusing on determining if the technology was ready to advance to a field demonstration at Oak Ridge National Laboratory (ORNL). Provided this input to the review team. Refined end user analysis and assisted Sciencetech with cost/investment return study following project review.
- Mound Selentec - Contacted Mound to determine end-user interest in deploying the technology and how well the technology addressed the site's performance requirements. Summarized findings for the project review team. Submitted list of other potential end users to PLM.

These activities and the resulting products are described in detail in Section 5.0.

#### *User, Regulator, and Stakeholder Input to Demonstration Planning via STCGs*

In the context of implementing action plans, EIT coordinated with STCGs and facility/OU managers to obtain user, regulator, and other stakeholder input into demonstration planning. Demonstration planning is the point where direct stakeholder input is most useful. Draft demonstration test plans were prepared by the PI and were subject to the review and approval of other SCFA representatives to ensure that technical, regulatory, and other stakeholder interests were considered. A demonstration test plan defined the objectives and parameters for the demonstration and questions and hypotheses that the demonstration intended to test. EIT obtained site-specific evaluation criteria and data requirements for the technologies from the host site STCGs and potential end users. They worked to ensure that these issues were addressed in the demonstration plans and results.

EIT also identified other sites where technologies that were being demonstrated were potentially applicable. These sites were contacted to obtain input on their specific issues and concerns, and this input was summarized to be considered by the PLM and PI.

Input to demonstration planning was obtained for the following PFA projects:

- *In Situ Redox Manipulation* - Worked with DOE-Richland Operations (DOE-RL) STCG to obtain endorsement of the technology and review of the demonstration test plan for the 100-H Area at Hanford.
- *Chemically-Enhanced Barriers* - Worked with DOE-RL STCG to develop an approach to address the Yakama Indian Nation's concerns over the demonstration, and to obtain stakeholder review of the demonstration plan. Worked with STCG as it addressed stakeholder issues in the demonstration plan.
- *Electrokinetics* - Obtained input from potential end users on the demonstration planned at ORNL. Identified end user issues, including removal of co-contaminants, that were not being addressed by the demonstration plan.
- *Magnetic Separation* - Identified sites where this technology could potentially be used and obtained site input to determine end user performance requirements for the Mag\*Sep project review. Contacted thirteen sites to collect information on performance requirements related to *ex situ* treatment of metals and rads in groundwater. Provided information to the PIs to help focus their future research to address the performance requirements that must be met by the sites.

In the case below, EIT set up a tour of a demonstration site to obtain end-user and stakeholder input. Input before the demonstration was not possible because of insufficient time, but the technology was of high interest to stakeholders.

- *DNAPL Treatment Technologies* (Deep Soil Mixing and *In Situ* Oxidation using Potassium Permanganate) - Conducted a tour of a demonstration site at the Kansas City Plant for potential end users, regulators, and stakeholders. During the tour, facilitated discussions among the participants on the issues to be addressed during future field tests and demonstration of the technologies and prepared a report on the issues raised so they can be addressed during future work.

These activities and the resulting products are described in more detail in Section 5.0.

#### *Communicate Demonstration Progress to STCGs*

After approvals were obtained, the technologies were demonstrated according to their demonstration test plans. EIT tracked the demonstration progress and was responsible for communicating demonstration progress to STCGs and facility/OU managers and providing feedback from them to the Product Team.



### *Track Interstate Regulatory Coordination Strategies*

EIT tracked interstate regulatory coordination strategies and technology certification/validation programs, focusing on identifying and resolving regulatory issues. This was accomplished by evaluating regional efforts for regulatory involvement in technology development and demonstration, and identifying lessons learned in overcoming barriers by promoting multi-state regulatory cooperation and accelerated regulatory acceptance of innovative technologies.

Information derived and lessons learned from these programs can assist focus area PLMs and PIs by identifying (1) specific technology acceptance criteria, (2) technology demonstration or deployment protocols, and (3) protocols for determining adequate levels of remediation that are important to regulators within and across states.

The product for this task was the white paper *Accelerating Regulatory Acceptance of Innovative Environmental Technologies: Lessons Learned from Selected Interstate Regulatory Cooperation Programs and Technology Certification/Validation Programs*, by Brad Brockbank, PNNL, January 1996.

#### *Evaluate Demonstration Results*

EIT helped evaluate demonstration results by summarizing performance data in a manner stakeholders could understand and by obtaining stakeholder input on the acceptability of the results. EIT also prepared a stakeholder acceptance report to support decisions on future work and deployment of the technologies. EIT completed the evaluation of demonstration results for two technologies: *in situ* bioremediation and in-well vapor stripping. The demonstration of *in situ* bioremediation was completed in January 1996. This technology received stakeholder input (regulators, users, environmental groups, and other interested parties) throughout the technology development process. A technology profile was distributed to stakeholders to help them understand the technology. The stakeholders were contacted to obtain input on issues and concerns, based on the profile. EIT summarized this input on a technology input matrix and asked the PI to document demonstration test plan commitments on the matrix to ensure that stakeholder issues were addressed. EIT summarized the demonstration results on the technology input matrix in a manner that stakeholders could understand and review. EIT went back to the stakeholders and interviewed them about the technology's acceptability based on the demonstration results. Based on the interviews, EIT developed a stakeholder acceptance report. The stakeholder acceptance report will be provided to the PI and PLM for incorporation into a more comprehensive technology evaluation report. The stakeholder acceptance report will also be provided to potential users to support decisions on deploying this innovative technology.

The in-well vapor stripping demonstration was evaluated following the same basic process. Again, the technology had received stakeholder input throughout the technology development process. A profile and input matrix were prepared. However, because of budget cuts, stakeholders evaluated demonstration results informally during a tour of the demonstration site in December 1995. This input was documented, but because of budget cuts, a formal stakeholder acceptance report was not completed.

Completed technology input matrices and a stakeholder acceptance report were products from this task. These products are described in more detail in Section 5.0.

### *Facilitate Deployment*

EIT supported the deployment of successful technologies by helping the SCFA in evaluating the acceptability of the successful technologies. EIT worked with the STCGs and facility/OU managers to identify potential sites for deployment and potential regulator and other stakeholder issues for each identified deployment site. This input was used by SCFA in developing deployment recommendations. In addition, EIT supported the SCFA in developing strategies for expanded application of the technologies and transferring the technologies to the private sector. EIT also worked with STCGs and facility/OU managers to track whether the sites considered and deployed successful technologies.

Facilitation of deployment of successful technologies was completed for the following projects:

- In-Well Vapor Stripping - EIT conducted a tour of demonstration site at Edwards AFB for potential end users, regulators, and other stakeholders. EIT provided stakeholder acceptance input to support decisions on deployment of this technology.
- LASAGNA™ - EIT conducted a tour of the LASAGNA™ demonstration site at Paducah, Kentucky for potential end users, regulators, and other stakeholders. Participants discussed issues related to the deployment of the technology, which was summarized for consideration in deployment decisions.
- DNAPL Treatment by Bioaugmentation - EIT conducted a tour of the demonstration site at the Kansas City Plant for potential end users, regulators, and other stakeholders. Participants discussed issues related to deployment of the technology, which EIT summarized for consideration in future deployment decisions.
- Smart Sampling - EIT tracked deployment of the technology at the Mound and Fernald sites, and developed strategies for obtaining broad regulator acceptance.

The specific products from this task are described in more detail in Section 5.0.

### **3.2.2 Landfills**

As described earlier, EIT support of the LSFA included identification of site problems/technology needs (Section 2.1.2), technology matching (Section 2.3) and solicitation process development (Section 3.1). However, EIT support to the LSFA in technology development, demonstration and deployment took a different path than it followed for the PFA. Rather than focusing on support for individual technologies, EIT support to the LSFA emphasized programmatic support in three major categories: systems analysis; workshop on long-term performance of *in situ* stabilization systems; and support to PLMs. Each of these activities is described in this section.

#### *Systems Analysis Support*

The goal of the LSFA systems analysis was to support technology investment decision-making and provide a means to quantify the net benefits of LSFA technology investments to the DOE complex. The

systems analysis effort was led by Idaho National Engineering Laboratory (INEL), through its contractor, LITCO. The systems analysis effort was divided into short-term and long-term goals. The short-term goals, addressed during FY 1996, were to evaluate DOE's ability to treat retrieved buried waste and identify potential technology gaps and to evaluate DOE's ability to contain and/or stabilize 90 percent of the waste in the DOE complex by January 1997. The long-term goal was to develop a process for making technology investment decisions supported by traceable requirements and consistent criteria.

To support the short-term goals, EIT gathered additional information on LSFA site problems/technology needs to fill data gaps identified by the LITCO systems engineers. The systems engineers reviewed the site templates and developed OU-specific questions on waste volume and area, waste matrix, and constituent types and concentrations for landfill wastes to be contained and/or retrieved. These questions were addressed by the EIT team through STCG and OU contacts at each site. The responses were recorded on a standard form that showed both the questions asked and the responses of the OU contacts. After the data were collected, forms containing a summary of the results were completed. Upon completion, data packages containing the completed questionnaires and summary forms were submitted by the EIT team to LITCO. Followup information was collected by EIT from the sites based on additional information requests by LITCO. Copies of all data packages provided to LITCO were also submitted by the EIT team to DOE-Savannah River (DOE-SR) in February and March 1996.

Using this data and the LSFA national technology needs assessment report prepared by EIT in January 1996, a systems engineering draft report was prepared and issued by LITCO on March 25, 1996. The report assessed treatment capabilities for retrieved landfill waste and containment/stabilization capabilities for buried landfill waste. The report concluded that

- DOE's ability to contain and/or stabilize 90 percent of buried waste can be demonstrated by January 1997 if funding of applicable technologies is continued and specific requirements associated with identified technology gaps are satisfied.
- DOE can treat over 90 percent of the retrieved landfill waste by integrating retrieved landfill waste streams with waste streams being addressed by the Mixed Waste Focus Area.
- Specific requirements and performance measures, models, and databases need to be developed to refine conclusions and formulate decisions on technology development and investment.

Once the LSFA and PFA were combined into the SCFA, the systems engineers began to define data fields to expand their LSFA database to include soil and groundwater plumes problems. EIT developed a database for plumes problems for the SCFA to support the systems analysis effort. EIT prepared Excel spreadsheets for all field offices/sites with plumes problems. The spreadsheets summarized information gathered from the PFA site visit reports plus additional information that EIT had collected since that time through interactions with STCGs and OU managers in support of the PLMs. The database contained better information than the site visit reports, including new information on soil plumes and other OUs, and better, updated information on site problems. Data shown on the spreadsheets included OU, plume type and source, future land use, indication if plume is offsite, contaminant type and concentration, depth to groundwater, depth of plume, areal extent, indication if offsite migration direction and timing is an issue, time until regulatory driver, schedule, baseline technology, and comments.

Because of budget constraints, EIT did not fill all the gaps in the plumes database. Site contacts will be required to fill remaining information gaps, and data must be converted to common units. In addition, complete data were not collected during FY 1996 to support the systems analysis long-term goal of supporting technology investment decisions. Lack of funding limited data collection for both the plumes and landfill areas for risk to the population, cost, implementability, and effectiveness.

Specific products from this task included

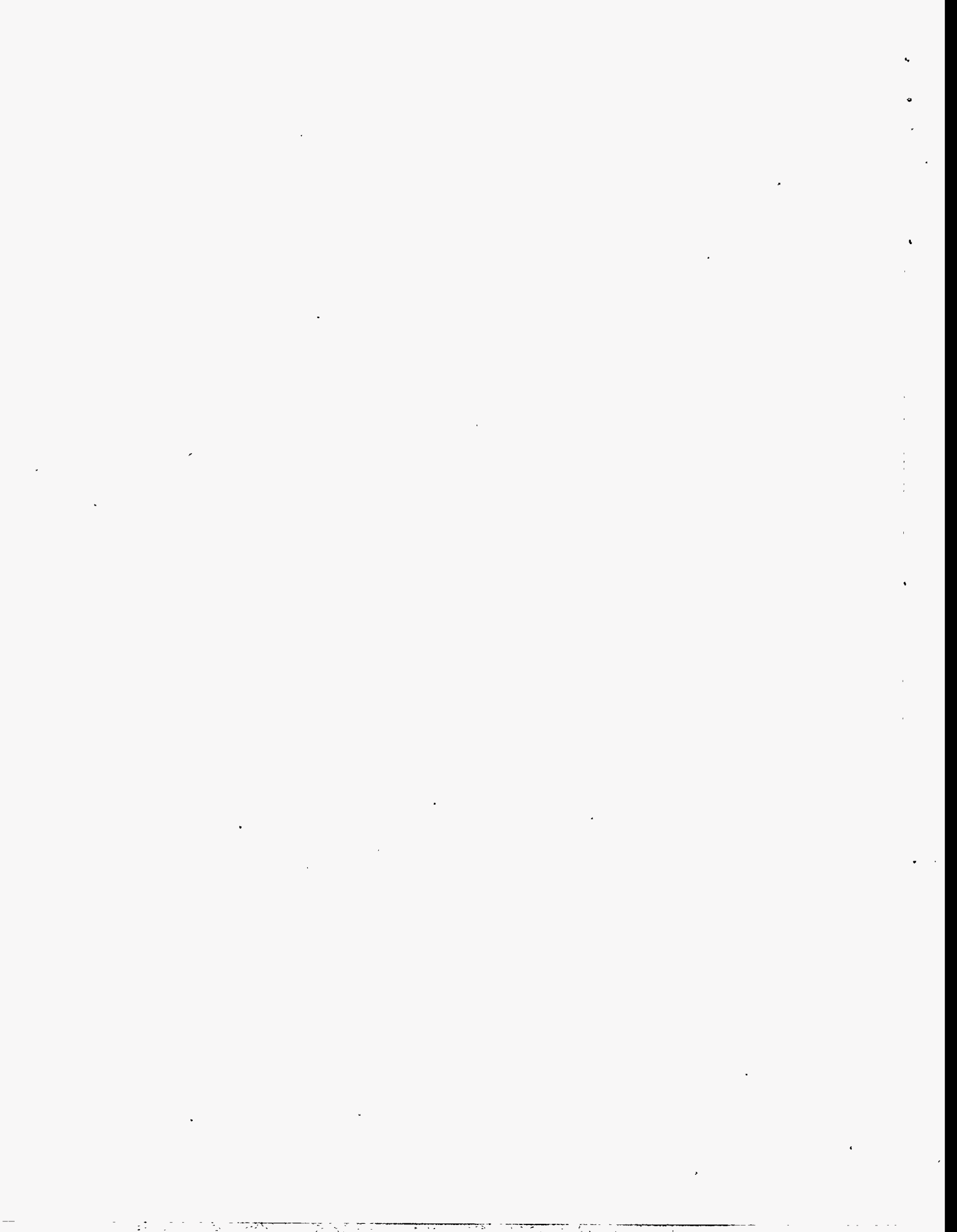
- Input to LITCO incorporated into Systems Engineering Draft Report, March 25, 1996. *Assessment of Treatment Capabilities for LSFA Retrieval Waste, Assessment of Containment/Stabilization Capabilities for LSFA*, TTP No. ID 7-6-LF-12.
- Letters with disks to LITCO transmitting plumes database, dated May 1996.

#### *Long-Term Performance Monitoring of In Situ Stabilization Systems Workshop*

EIT provided workshop design and facilitation support for the LSFA's long-term performance monitoring of the *in situ* stabilization systems workshop conducted in Park City, Utah, on June 26-27, 1996. The workshop objectives were to define long-term performance issues, recommend a path forward to address the issues, and implement a systems approach for identifying solutions for long-term performance. EIT supported the design of the workshops, which included presentations, a panel of regulators and end users, working group/brainstorming sessions, and large group discussions. EIT facilitated the panel discussion of end users and regulators to set the stage for the working groups. EIT also participated in two working groups at the workshop, one on covers and one on improved communications during technology deployment and implementation. The results of the workshop will be summarized into an overall report and working group white papers that will be used to support decisions on future technology development efforts.

#### *EIT Support to Product Line Managers/Development Sector Managers*

The LSFA site visits, described in Section 2.1, resulted in lists of action items to be completed by the PLMs and other members of the LSFA team. EIT followed up to ensure the actions were completed. EIT also facilitated communications between the PLMs and the sites and assisted in setting up visits to discuss site-specific issues and facilitate technology demonstration and deployment. EIT also worked with PLMs to identify potential end users for landfill technologies. As described in Section 2.3.2, EIT developed the LSFA national technology needs assessment, which compiled needs across the DOE complex. The assessment was used by PLMs to help identify potential end users for LSFA technologies. EIT also conducted more-detailed analysis of site needs and schedule requirements (e.g., containment technologies) to support strategic investment decisions. EIT prepared a letter report in May 1996 that compiled the LSFA sites that have *in situ* containment/stabilization needs and categorized the urgency of these needs based on site schedules.





## 4.0 Lessons Learned

The main lessons learned from this multi-year effort to enhance the acceptance of innovative technologies supported by DOE are listed below (discussed in more detail afterwards):

- Developing a needs driven program and prioritizing technology needs are great challenges.
- Resources should be focused on those technologies that most need stakeholder involvement to overcome acceptance barriers.
- Clear, timely summaries of technology development and demonstration activities and results are critical communication tools.
- Stakeholder involvement, including site-level end users, in technology development and demonstration is critical and must occur at multiple levels.
- Broader, multi-site involvement of regulators and other interests can lead to accelerated and broadened deployment.
- Coordination of the SCFA team on site communications is necessary to maintain credibility.

### 4.1 Developing a Needs-Driven Program and Prioritizing Technology Needs Are Great Challenges

The focus area's vision is technology development driven by the needs of end users across the DOE complex. In practice, several challenges have faced this vision.

First, collecting and updating information regarding field office technology needs is difficult, given rapidly changing budgets and regulatory climates being faced by the sites. Operable units may be combined, schedules delayed, and priorities shifted in a rapid manner.

Second, ensuring that the SCFA team fully understands site problems and associated technology needs is difficult. This understanding is critical to the process of matching technologies to the identified needs. To compile needs on a national basis, the SCFA must consistently translate site environmental restoration *problems* (e.g., DNAPLs in low-permeability soil) into *technology needs* (e.g., need for a technology for *in situ* treatment of DNAPL to a depth of 45 feet). The SCFA faces the challenge of understanding the problems well enough so that this translation is accurate and complete.

Third, site environmental management priorities differ widely across the DOE complex. Addressing site-specific priorities in a national program is difficult. Each STCG and most sites are involved in prioritizing their environmental restoration problems and technology needs. Each STCG, however, uses a different process and criteria, and often applies different weights to each criterion. The SCFA has designed its own priority-setting process to support technology investment decisions that takes into account site-specific priorities and input and aggregates them on a national basis. A top priority need for one site may not be important to other sites, while another need may be of medium priority to several sites. Taking the national view and appropriately setting priorities for focus area investments will be an ongoing challenge for the SCFA.

Fourth, the SCFA technology portfolio contains projects that were funded before establishing a needs-driven approach. Matching these technologies to end-user needs at multiple sites has sometimes proven to be difficult. In some cases, end users have been more interested in having research dollars come to their sites than in making a commitment to use a technology to address a site need. In at least one case, SCFA delayed an expensive demonstration that was planned in order to further evaluate the site's commitment. Information on the end users' performance requirements and schedules needs to be factored into technology development planning early in the development process so that the principal investigators' efforts can be better linked to end-user needs. If redirection of a project is not possible, the SCFA should shift funding into technologies that are of higher priority to end users.

Several steps that can be taken to enhance the needs-driven focus of the SCFA are to

- keep site problems and needs information accurate and up to date
- ensure that the SCFA team fully understands these problems and can translate them to technology needs
- follow up with the sites to receive feedback on potential technology matches
- be prepared and offer to explain the relationship of sites' priority-setting processes to SCFA prioritization/portfolio formation and to accept site inputs on priorities.

#### **4.2 Resources Should Be Focused on Those Technologies That Most Need Stakeholder Involvement to Overcome Acceptance Barriers**

The stakeholder issues that are likely to be relevant to a given technology vary substantially. Not every technology being funded by the SCFA will be of significant interest or concern to stakeholders. In addition, some projects are too early in the research stage or too far advanced toward deployment to benefit from broad stakeholder involvement. Available resources and funding also limit the number of projects that can be addressed. Therefore, it is necessary to identify and apply a process to prioritize the projects in the SCFA portfolio and design an appropriate stakeholder involvement approach tailored to each project. As described in Section 2.2, EIT developed a process and criteria for the identification of technologies for which stakeholder involvement is critical. Stakeholder involvement strategies for those technologies should be developed in concert with the SCFA product line managers and principal investigators to ensure that stakeholder issues and end-user perspectives are factored into demonstration planning and deployment decisions.

#### **4.3 Tailor Technology Development and Demonstration Information for Stakeholders**

Technical test plans and project reports produced by SCFA principal investigators are typically not in suitable formats or levels of detail for informing and involving a range of stakeholders in technology demonstrations. A lesson learned is that brief summaries of technology development or demonstration projects are critical tools that can be used to solicit feedback from STCGs, OU managers, regulators, and other stakeholders on their interest in a particular technology. Such a summary should be prepared in conjunction with the principal investigators for each technology that can most benefit from stakeholder input. For demonstrations, this summary should include a brief description of the technology, the objectives of the demonstration, and a description of the demonstration site. A similar summary can be developed for technologies that are not ready to be demonstrated or still need a demonstration site. Such summaries should

describe the status and intent of the technology and the challenges associated with a demonstration. The summaries can be used to help identify potentially interested end users who can be contacted to solicit input into the demonstration plan to enhance technology acceptance and broaden deployment.

#### **4.4 Stakeholder Involvement Is Critical and Must Occur at Multiple Levels**

The STCGs have been identified as the principal point of contact for the focus areas. However, experience indicates that OU managers often need to be contacted for technical details and to obtain firm commitments to use innovative technologies. In addition, national regulator and stakeholder groups are invaluable in addressing broad issues in technology development/deployment.

Understanding the stages of technology development and the increasing commitments from end users at each stage are keys to successful deployment. For example, an STCG can easily make a commitment to review information on a technology or the results of a demonstration at another site for applicability to their site's needs. However, obtaining firm commitments from end users (e.g., joint funding of demonstrations) requires more effort and involvement of the SCFA team, STCGs, site managers, and OU managers.

Due to funding cuts, EIT interactions with STCGs were limited to specific technologies and to collecting information for the systems engineering effort versus efforts at the national level to address broad issues in technology development/deployment. Value was gained through the principal investigator, SCFA, and STCG interactions. However, the EIT had only an indirect role in stakeholder involvement.

##### **4.4.1. Stakeholder Technology Coordination Groups**

The EIT worked through the STCGs to obtain input from site regulators and stakeholders. STCGs are responsible for identifying and prioritizing their cleanup problems and translating these problems into technology needs. STCGs at the ten DOE field offices vary in organization and composition. Some sites included regulators, tribes, and other interest groups, while others limit their representation to DOE staff. The defined roles and level of maturity of the STCGs differ also. Thus, one approach or method of interaction does not work for every STCG.

The effectiveness of the interactions was variable. Recognizing the differences among the STCGs, and understanding and respecting their meeting schedules and involvement preferences proved to be the best way to facilitate effective interactions. STCGs with more diverse representation asked more questions about the technologies and identified a range of issues that needed to be addressed to enhance technology acceptance and facilitate deployment. Some STCGs expressed the opinion that the flow of information from the sites to the SCFA was only one way. The SCFA did not provide regular briefings or updates on the program or on investment decisions. On the other hand, interactions among the principal investigators, STCGs, and SCFA team that were focused on specific technologies proved to be valuable. The SCFA needed to be proactive to obtain feedback from STCGs on potential technology matches or commitments to consider or use portfolio technologies. Facilitating communications among the principal investigators of technologies, the STCGs, and SCFA team led to an increased STCG understanding of a technology's capabilities and provided the SCFA with an opportunity to understand the STCG's issues associated with deployment.



The STCGs were also invaluable in linking OU managers to the SCFA team. The OU managers, as potential end users, are critical to technology demonstration and deployment.

Recommendations include the following:

- The SCFA should appoint site coordinators to facilitate communications by preparing SCFA information tailored to site needs and by working with the STCGs to design mechanisms to solicit input from stakeholders. Work with STCGs to (1) help identify needed technologies for addressing cleanup problems (2) identify performance requirements of candidate technologies, and (3) factor end-user performance requirements should be factored into technology development and demonstration planning.
- Interactions among the SCFA team, STCGs, and principal investigators should be increased to enhance technology deployment. SCFA site coordinators should set up meetings with STCGs to provide opportunities for the principal investigators to describe the intent of their planned demonstrations and to obtain STCG input. The site coordinator can then work with the principal investigators to design demonstrations to address site needs. Following a demonstration, feedback on the demonstration results should be provided to the STCGs.

#### **4.4.2 Operable Unit Manager Interface**

STCGs were the SCFA's principal point of contact at each site. However, once a potential match between a site need and SCFA technology was identified, it often became necessary to contact the end users, usually OU managers, to obtain more detailed technical information. The STCGs found that it was more productive to have SCFA representatives contact the OU managers directly and report findings back to the STCGs. At the same time, it did not damage the ability of the STCGs to speak for the site as a whole. In some cases, information provided by the OU manager helped the STCG validate technology matches. This approach improved the speed of communications and enabled the EIT to develop a network that linked OU managers with principal investigators.

Recommendations include the following:

- Conduct ongoing communication with STCGs and OU managers to help forge working relationships, fully understand site problems and needs, and discuss how SCFA technologies can help.
- Recognize the STCGs and OU managers as the focus area's customers and provide timely feedback to them on issues they raise. Proactively solicit STCG and OU feedback and respond to STCG and OU requests in a timely manner.
- Coordinate the interactions that various SCFA team members have with a site so the SCFA team has one voice when it interacts with a site.

### 4.4.3 National Stakeholder Groups

National regulator and stakeholder groups provide an opportunity to obtain multi-site input on issues critical to broad technology deployment. Lessons learned from interactions with these groups are summarized in Section 4.5.

## 4.5 Multi-Site Involvement Can Lead to Accelerated and Broadened Deployment

Consultation with and involvement of stakeholders at a broader level (non-site specific) is also key to encouraging rapid and widespread development of innovative technologies. Efforts to do so involved both regulators and other interested parties through a variety of organizations and mechanisms. When the PFA was created, EIT presented the strategy for interacting with DOE sites and soliciting feedback from stakeholders to the Community Leaders Network (CLN). The CLN supported EIT's commitment to involve stakeholders (via the STCGs) in developing and demonstrating innovative technologies. They supported the lessons learned earlier regarding early and substantial involvement of a broad range of stakeholders.

As described in Section 3.2.1.1, EIT developed a report summarizing all of the multi-site technology demonstration initiatives where regulators, and in some cases other stakeholders from various sites, were involved in the planning and demonstration to accelerate and broaden technology acceptability and deployment.<sup>(a)</sup> Many of these initiatives have focused on involving regulators from various states to develop demonstration protocols. Then the states can agree on a set of data to validate technology performance and thus reduce the duplication of collecting data from one site to another site within a state and from one state to another state. Although most of these initiatives are fairly new in their creation, it is clear that multi-site involvement has and will lead to accelerated and broadened deployment.

One visible multi-site effort is the Federal Advisory Committee to Develop On-Site Innovative Technologies (DOIT). Four federal agencies participated in DOIT: DOE, EPA, Department of Defense, and Department of Interior. DOIT's goal was to expedite the cleanup of federal waste sites by commercializing promising new technologies in a manner acceptable to all stakeholders. Representatives of EIT have been involved from the beginning in DOIT.

During the tenure of the focus area, EIT's role with DOIT has primarily been focused on its Interstate Technology and Regulatory Cooperation (ITRC) work group, whose goal is to speed the efficient, safe, and effective cleanup of federal waste sites by accelerating the regulatory acceptance and commercial use of innovative characterization and remediation technologies. ITRC hopes to do this by improving the inter- and intrastate technology regulatory acceptance process. EIT participated in ITRC meetings to ensure that our efforts were not duplicative but collaborative. Relevant protocols developed by ITRC were transferred to the focus area for its use. This experience demonstrated the importance of substantive, early regulatory input to technology development.

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(a) Brad Brockbank, *Accelerating Regulatory Acceptance of Innovative Environmental Technologies, Lessons Learned from Selected Interstate Regulatory Cooperation Programs and Technology Certification/Validation Programs*, white paper draft, prepared for DOE/EM Plumes and Landfill Stabilization Focus Area Teams, January 1996.

The focus area has also worked with the Southern States Energy Board (SSEB), whose goal is to overcome regulatory barriers to technology deployment by working with state regulators on a regional basis to harmonize state regulations relative to specific technologies. SSEB has, for example, been involved in a focus area tour to encourage the attendance of regulators from various states that have sites that could benefit from the use of an innovative technology. The interaction and feedback from these regulators supports the focus area's goal to broaden technology deployment by involving stakeholders and, in this case, regulators from various states in the demonstration process.

A significant constraint on the effectiveness of the multi-site involvement approach is the operating norm that a technology cannot be deployed at a site until it has been demonstrated there. The initiatives described above and many of EIT's activities in FY 1996 were designed to overcome this constraint. EIT examples include the tours for LASAGNA™, in-well vapor stripping, and DNAPL treatment technologies, where feedback was solicited from end users, regulators, and other interest groups from many of the potentially applicable sites.

Another lesson that has been learned is that regulators do not all view a technology similarly. It is critical to involve regulators from agencies with different authorities and missions and even from divisions within an agency with different authorities and missions. Forums such as the technology tours organized by the focus area have served as excellent opportunities for regulators from these different perspectives to work together and learn from each other, and for the focus area to learn from them.

#### **4.6 Coordination of the SCFA Team on Site Communications Establishes Credibility**

Successful demonstration and deployment of innovative technologies require a concerted and coordinated effort of all members of the SCFA team and the sites. Successful deployment will occur only if a technology is technically effective and acceptable to regulators and the public. The Lead Office, PLMs, technical team, and PIs must work closely with the stakeholder coordinator to identify and address site information needs and stakeholder and regulatory issues and concerns. The SCFA team must coordinate to ensure consistent site communications and to ensure that any commitments made are upheld to maintain program credibility.

## 5.0 Support New Technologies to Meet Plumes Needs

The following section includes the technologies in the former PFA portfolio and selected METC technologies categorized first by product line and second by type of technology. For each technology, a brief description has been provided, followed by the stakeholder involvement ranking, EIT activities undertaken to support the technology, and an evaluation of the current level of stakeholder acceptance and recommendations.<sup>(a)</sup> The table below summarizes EIT actions to support of the technology.

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(a) The PLMs felt that the Tritium Analysis System, the Passive Treatment Barrier, and the RTDF Bioremediation Activities Recycling of Surfactants Used in DNAPL Remediation Methods were of low priority and did not need EIT support.

Technology	Gate	Stakeholder Score	EIT Actions						
			Develop/Demonstrate New Technologies					Evaluate Results	Facilitate Deployment
			Identify Potential End Users	Input to Project Review Process	Obtain User/Regulator/Stakeholder Input to Demo Planning	Communicate Demo Progress to STCG and/or End Users	Conduct Demo Site Tour	Prepare Stakeholder Acceptance Report	
<b>Metals and Radionuclides</b>									
<b>Characterization</b>									
Smart Sampling™	5	D	X					X	
On-Line Real Time Measurement of Liquid Streams	3	D	X						
Fiber Optic Cone Penetrometer for Heavy Metals	3	D	X						
<b>Removal</b>									
Electrokinetics System	5	C	X	X	X				
Solution Mining	5	B	X						
Biomass Remediation	3	C/D	X	X					
<b>Treatment and Stabilization</b>									
Gaseous Reduction of Chrome/In- Situ Chemical Treatment System	5	A	X		X				
In-Situ Redox Manipulation	5	C	X		X	X		X	
<b>Passive Treatment</b>									
Chemically Enhanced Barriers (Permeable Strontium Sorptive Barrier)	5	C	X		X	X		X	

Technology	Gate	Stakeholder Score	EIT Actions						
			Develop/Demonstrate New Technologies					Evaluate Results	Facilitate Deployment
			Identify Potential End Users	Input to Project Review Process	Obtain User/Regulator/Stakeholder Input to Demo Planning	Communicate Demo Progress to STCG and/or End Users	Conduct Demo Site Tour	Prepare Stakeholder Acceptance Report	
<b>Secondary Waste Treatment</b>									
MAG*SEP <sup>SM</sup>	3	C/D	X		X				
Mound Selentec Treatability Study	4	C	X	X					
Polymer Separation	4	E	X						
<b>DNAPL and Organic Technologies</b>									
<b>Characterization</b>									
Alcohol Injection	4	C	X						
Gas Tracer	5	C	X						
In-Situ Permeable Flow Sensor	5	D	X			X	X		
<b>Removal</b>									
Evaluation of DNAPL Mobilization Potential	3	E	X						
Six-Phase Soil Heating	5	C	X			X			
Thermally Enhanced Vapor Extraction System	6	C							
In-Well Vapor Stripping	5	A	X		V	X	X	X	
Passive Soil Vapor Extraction	6	C	X	X					
Barometric Pumping Using Surface Flux	5-6	C	X						



Technology	Gate	Stakeholder Score	EIT Actions						
			Develop/Demonstrate New Technologies					Evaluate Results	Facilitate Deployment
			Identify Potential End Users	Input to Project Review Process	Obtain User/Regulator/Stakeholder Input to Demo Planning	Communicate Demo Progress to STCG and/or End Users	Conduct Demo Site Tour	Prepare Stakeholder Acceptance Report	
Recirculating Well	5	C							
<b>Destruction</b>									
Remediation in Low-Permeability Media	5	A	X						
In-Situ Chemical Oxidation of Contaminated Soils	5	C/A	X				X		
Adsorption/Desorption Relative to DNAPLs	5	C/A	X				X		
In-Situ Bioremediation of Chlorinated Solvent NAPLs	4	E							
DNAPL Remediation by Electro-Osmosis (LASAGNA™)	5	C	X			X	X		X
Arid Engineering System for In-Situ Bioprocessing	5	A			V	X		X	
<b>Access</b>									
Resonant Sonic Drilling	6	C			V	V		V	

V: Stakeholder Involvement Activities under VOC-Arid Site Integration Demonstration.

## 5.1 Metals and Radionuclides

### 5.1.1 Characterization

#### 5.1.1.1 Smart Sampling™ (Cost/Risk Performance Assessment)

##### *Technology Description and Objectives*

Researchers at Sandia National Laboratory (SNL) and ORNL, in association with multiple sponsors, are applying newly developed geostatistical and modeling techniques to minimize costs of characterization or remediation. The Smart Sampling™ technology calculates and maps the probability that any location exceeds a specified concentration of contaminants, given a particular set of sample data, and evaluates the risk associated with a given decision. Instead of a site map that shows contamination levels, the Smart Sampling™ geostatistical method displays the probability that contamination is greater than a specific threshold value. The probability levels reflect the degree of risk that a parcel left untreated is actually contaminated.

Probability mapping is used in economic decision models to help select a risk-adjusted, least-cost approach to contaminant excavation decisions and confirmation sampling. The costs of further characterization are therefore balanced against the cost of excavation and disposal and the penalties for failure, and the available funds are invested in cleaning up the problem rather than carrying out exhaustive characterization studies.

Smart Sampling™ technology is being demonstrated at DOE's Fernald Plant near Cincinnati, Ohio, and at the Miami-Erie Canal at the DOE Mound Site in Miamisburg, Ohio. At Fernald and Mound, Smart Sampling™ is being used to reduce the volume of soil sent offsite for disposal and the number of verification samples. The end result will be cost savings. Potential applications for Smart Sampling™ are also being evaluated at Site-91, an environmental restoration site in New Mexico managed by SNL. The DOE Portsmouth Gaseous Diffusion Plant in Ohio is also considering application of Smart Sampling™ probabilistic approaches to sampling of a groundwater trichloroethylene (TCE) plume and its associated DNAPL source.

The goal of the demonstrations is to deploy Smart Sampling™ to the sites and to the regulatory agencies responsible for oversight, if desired. Another goal is to obtain customer feedback on the value of this approach and issues for broader deployment.

##### *Stakeholder Interest Ranking*

Stakeholder interest scoring for the Smart Sampling™ technology was D (of little interest) because it is a decision support tool. However, because the tool may lead to remediation cost savings, it has been supported by regulators (Ohio Environmental Protection Agency [EPA] and U.S. EPA), and may be of interest to other stakeholders (e.g., end users, other regulators, and other interest groups.)



### *EIT Actions*

EIT contacted the PIs to obtain the work products created for the Mound effort to use in promoting the technology to other potential end users.

EIT identified DOE end users where near-term soil excavation efforts were planned that were most likely to benefit from the results of the current demonstration activities. These end users included Hanford, INEL, ORNL, and the Savannah River Site (SRS). EIT developed a recommended set of follow-up actions that were not implemented due to a change in direction from the lead office.

### *Evaluation of Current Level of Stakeholder Acceptance*

The technology had been well-received by regulators from the Ohio EPA and U.S. EPA Region V, and these regulators were actively involved in demonstration activities. Because probabilistic approaches are difficult for stakeholders to understand, a need existed to develop an information package and/or conduct an interactive workshop. The Southern States Energy Board (SSEB) interstate regulatory cooperation project had already conducted a data management and integration systems pilot program to explore systems that could provide data needed by regulators. Preliminary contacts with SSEB indicated that Smart Sampling™ might be of interest for future follow-on work.

### *Recommended Future EIT Support*

EIT recommendations for future work included the following:

- Contact potential end users to verify their plans/schedules and determine their interest in receiving demonstration results from Mound and Fernald
- Prepare a simple fact sheet/briefing package describing the benefits of this complex geostatistical technology to potential end users; include results from the Mound and Fernald demonstrations
- Distribute the fact sheet/briefing sheet to all STCGs and conduct follow-up calls to priority STCGs (Richland, INEL, ORNL, and Savannah River) to determine their interest in a follow-up presentation by the PI and/or a workshop for potential end users, regulators, and stakeholders co-sponsored by the SSEB
- If appropriate, design a workshop that 1) provides an opportunity for end users to participate in a hands-on, interactive session with the Smart Sampling™ tool, 2) identifies issues associated with broad deployment, and 3) documents input for consideration in future deployment decisions.

#### **5.1.1.2 Online Real Time Measuring Instrument for Liquid Streams**

### *Technology Description and Objectives*

The Online Real-Time Monitoring instrument involves a patent-pending *in situ* method of collecting and concentrating dissolved radioactive species on a solid surface, allowing a solid state detector to quantify specific

alpha-emitting species rapidly. Initially, this technique simultaneously collected and quantified radioisotopes directly on the silicon detector, providing an energy resolution equivalent to conventional electroplating. This technology has been proven in field tests with both natural and transuranic alpha emitters. This technology is a METC-funded technology.

#### *Stakeholder Interest Ranking*

This technology was ranked D (of little interest).

#### *EIT Actions*

The PLM asked EIT to summarize input from potential end users of this technology. The PLM requested specific information with regard to specific sites, types of contaminants, and to the extent possible, depth and areal extent of the contamination. On May 2, 1996, a final report was transmitted to the PLM.

#### *Evaluation of Current Level of Stakeholder Acceptance*

Discussions with site personnel revealed that

- Of the sites contacted, two expressed an interest in the On-Line, Real-Time Alpha Radiation Measuring Instrument for Liquid Streams—SRS and ORNL (Portsmouth).
- Several site personnel said that they needed a comprehensive understanding of all characterization technologies so they can have integrated solutions to their problems. They need to be able to detect radionuclides, metals/radionuclides, or DNAPLs. If an integrated package of possible tools were available, they could better assess the applicability of technologies to meet their needs.
- Two specific questions with regard to this technology were “Does this technology perform equal to or better than EPA methodologies (SW 846 Methods)?” and “Can the technology be used for solids?”

#### *Recommended Future EIT Support*

Follow-up contact should be made with potential end users to assess their interest in deploying the technology at their sites and to identify acceptance and performance issues.

### **5.1.1.3 Fiber Optic Cone Penetrometer for Heavy Metals**

#### *Technology Description and Objectives*

This is a METC-funded technology. This technology analyzes the heavy metals content of the subsurface through an integrated fiber optic sensor/cone penetrometer system. This site characterization tool will use the penetrometer to deploy an optical fiber chemical sensor, which is based on laser-induced breakdown spectroscopy (LIBS). In LIBS, an optical fiber delivers a high-energy laser pulse to the soil sample. The soil sample will absorb the laser pulse, heat rapidly, reduce to elemental form, and become electronically excited.

When the input pulse is removed, the excited electrons drop to lower energy levels with the emission of characteristic photons. The plasma emission is returned from the sample via the second filter. Elemental analysis is conducted by observing the wavelength and intensities of the emission lines, which will depend upon the type and amount of material with the plasma.

### *Stakeholder Interest Ranking*

This technology was ranked D (of little interest).

### *EIT Actions*

EIT was asked by the PLM to identify DOE end users' interest in the technology with regard to specific sites. Additionally, information on site specifics regarding types of contaminants and, to the extent possible, depth and areal extent of the contamination was also collected. A final report was sent to the PLM on April 2, 1996.

### *Evaluation of Current Level of Stakeholder Acceptance*

Discussions with site personnel revealed that

- Several sites expressed a willingness to use the Fiber Optic/Cone Penetrometer System for Subsurface Heavy Metal Detection. These sites include SRS (MWMF Burial Ground Complex, F/H Inactive Sewer Line), Hanford (100 Area - 100-D, 100-H, 200 Area, 300 potential future uses), Nevada Test Site (Off-Site Muck Pits), and WETO Site (Silver Bow Creek).
- Additional sites indicated their use would depend upon specific performance parameters of the technology (i.e., ability to detect organics and radionuclides in addition to metals, high resolution and detection capability, and ability to penetrate a significant depth through rock or cobble).
- Several sites were willing to participate in a demonstration project if desired.

### *Recommended Future EIT Support*

EIT recommends that future work include continued contact with potential end users who are interested in information on the following issues:

- performing this technology in a radiological area and its performance in "hot spot" detection
- achieving detection limits of Pb - 15 MCL, Cd - less than 50 and more than 15, Hg - 2 MCL
- achieving detection limits of 4 mg/kg for Cr ( This is the cleanup goal for concentration of Cr in soil.)
- collecting analyte-specific samples
- reaching 30-foot depth
- penetrating through river bed cobbles, rock, and construction debris.

## 5.1.2 Removal

### 5.1.2.1 Electrokinetics Systems

#### *Technology Description and Objectives*

Electrokinetic remediation technology creates an electrical field in soil to force negatively charged radionuclides and ionic metal contaminants toward *in situ* electrodes. Electrokinetics is based on the principle that high-voltage electricity, passed through contaminated soil, will carry negatively charged (anionic) mobile contaminants through the soil to a place where they can be captured and removed. A solubilizer (e.g., water or citric acid) is introduced to enhance contaminant mobility. An array of electrode assemblies is installed in the contaminated ground and connected to a high-voltage power supply. When the high voltage is turned on, current is passed through the soil, and contaminants are carried to the electrode site for removal.

EIT activities addressed two electrokinetic systems: remediation of chromium-contaminated soils and remediation of uranium-contaminated soils.

Remediation Of Chromium-Contaminated Soils: Early in FY 1996, unsaturated-zone electrokinetic remediation of chromium in soil was at Gate 5, ready to move from engineering development into the demonstration phase. A 9-month field demonstration began in May 1996 using water to mobilize extractable chromate in the unsaturated zone at the Sandia Chemical Waste Landfill, which is an unlined chromic acid plating solution disposal pit under the auspices of a Resource Conservation and Recovery Act (RCRA) research, development, and demonstration (RD&D) permit. Technical issues to be addressed by the demonstration included the management of water balance and electric field strength to optimize the rate of contaminant removal. The progress of the test was monitored by using periodic soil samples and soil-resistivity data collection.

Electrokinetic Remediation Of Uranium-Contaminated Soil: Early in FY 1996, electrokinetic remediation of uranium-contaminated soil was in the engineering development stage and ready to move into field demonstration (Gate 5). Laboratory and pilot-scale studies performed by Isotron Corporation, a private contractor, for electrokinetic removal of uranium from ORNL K-25 soils showed that uranium could be effectively removed from K-25 soils using *in situ* application of electrokinetics and carbonate and citrate solubilizer solutions. Based on the results of those studies, a field-scale demonstration was planned for uranium-contaminated soils in the Building 311 Area at the K-25 site in February 1996. The demonstration was designed to introduce citric acid and DC current into the soil to solubilize and mobilize the uranium toward an anode at 2 cm per day for capture in ion-permeable barriers containing bead resins. The goal of the demonstration was to demonstrate in the field that uranium contamination levels could be reduced to the point that restrictive barriers could be removed, consistent with the K-25 site's current industrial land use. The demonstration was delayed until FY 1997 pending further evaluation of end user interest and the availability of funds.

#### *Stakeholder Interest Ranking*

Stakeholder interest scoring for electrokinetic remediation of both chromium- and uranium-contaminated soils was C (high stakeholder interest, but not compatible with demonstration schedules).

### *EIT Actions*

Chromium: EIT efforts for unsaturated-zone electrokinetic remediation of chromium-contaminated soils were to support a gate review for the field-scale demonstration at the Chemical Waste Landfill. Planned EIT activities were to identify and then contact potential EM-40 end users to invite viable end user candidates to attend the demonstration site visit at the Chemical Waste Landfill. However, because of the delay in the demonstration startup, actual EIT activities consisted of compiling a preliminary list of sites with chromium contamination in preparation for an end user analysis. No further evaluation was done on these sites.

The primary product developed by EIT to support chromium removal from soils using electrokinetics was a working draft list of sites with chromium-contaminated soils.

Uranium: EIT efforts for electrokinetic removal of uranium-contaminated soils were to support a gate review for the proposed demonstration at the K-25 Site. The gate review was to determine if the technology was ready to advance to the field demonstration stage. EIT evaluated potential DOE end users and stakeholder issues and worked with the Industrial Team to support a return-on-investment analysis and provide input to the gate review decision for the field demonstration.

EIT submitted a letter report to J. Phelan on January 22, 1996, that reviewed potential DOE end user interest and stakeholder issues and provided a preliminary baseline cost analysis, in advance of the planned February gate review on the advisability of funding the demonstration at ORNL. In a subsequent letter report to J. Phelan dated March 4, 1996, EIT provided an expanded evaluation of potential DOE end users, with an emphasis on DOE-Ohio sites, and presented a brief survey of non-Ohio sites with uranium contamination. It was determined that end user interest was minimal unless the technology could also remove co-contaminants, a question that the demonstration was not designed to answer. The demonstration was delayed until FY 1997, pending verification of end user interest and funding availability. EIT also assisted Scientech in the preparation of a March 1996 cost/investment return study following the gate review.

### *Evaluation of Current Level of Stakeholder Acceptance*

Chromium: Because of demonstration schedule delays, no evaluation of stakeholder acceptance of chromium removal from soils using electrokinetics was performed by EIT.

Uranium: EIT found that near-term cleanup of the uranium-contaminated soils using electrokinetics at the K-25 site was not a regulatory priority or of stakeholder interest at ORNL. At the Fernald OU 5 site, EIT learned that electrokinetics for uranium contamination had been considered and rejected based on stakeholder concerns related to mobilizing contaminants over a sole-source aquifer and prior decisions to cost-effectively dispose of the soil in an on-site disposal cell without such treatment.

### *Recommended Future EIT Support*

Chromium: EIT recommends that future work on electrokinetic remediation of chromium-contaminated soils include identifying and contacting potential EM-40 end users and subsequently inviting viable end-user candidates to attend a demonstration site visit.

Uranium: EIT recommends that future work on electrokinetic remediation of uranium-contaminated soils include

- monitoring the gate review outcome
- responding to potential future inquiries on the completed analyses
- monitoring the status of possible bench/pilot tests at Ashtabula to address co-contaminant issues and other demonstration redirection issues as they affect end-user interest if the gate review outcome is positive.

### **5.1.2.2 Solution Mining (Enhanced Uranium Recovery from Groundwater)**

#### *Technology Description and Objectives*

Solution mining for uranium-contaminated groundwater applies proven commercial technology used in the mining industry for improved recovery of uranium from groundwater. Treated groundwater is re-injected via upgradient injection wells to sweep the contaminants toward recovery wells that pump the groundwater to the surface for treatment. This process shortens the remediation time compared to baseline pump and treat. For Fernald, this could mean reducing the time required for groundwater cleanup from an estimated 27 years to as few as 10 years. Chemical additives (lixivants) can be introduced if the uranium is adsorbed onto aquifer sediments and must be mobilized into solution. The well fields are extensively monitored to ensure that contamination does not spread.

In FY 1996, Solution mining technology was at Gate 5, and a field demonstration was planned at Fernald, Ohio. The goal of the Fernald demonstration was to perform an injection demonstration to assess the benefits of remediating the uranium-contaminated Great Miami Aquifer and to determine the remediation effectiveness over baseline pump and treat. Because injection wells would not be installed until the end of FY 1996, demonstration results will not be available until 1997.

#### *Stakeholder Interest Ranking*

Stakeholder interest scoring for solution mining was B (high interest, but not broadly applicable).

#### *EIT Actions*

At the request of the PLM, EIT identified potential end users (other than Fernald) that might be interested in the technology and provided this information to the PI.

In February 1996, EIT contacted the PI to discuss the technology's capabilities. EIT then reviewed the needs assessment data base and identified five OUs at three sites that needed to remediate uranium contamination in groundwater. The three sites were SRS (MWMF, TNX, and D Areas), INEL (WAG 3 - ICPP), and Hanford (200 Area UP-1). On February 20, 1996, EIT faxed the PI a list of the applicable OUs and copies of the OU templates for these sites. No additional support was requested from the PLM.

#### *Evaluation of Current Level of Stakeholder Acceptance*

Groundwater injection technology had high stakeholder and regulator interest. Issues of concern included the potential to increase contaminant mobility, requirement for subsurface injection, and the complexity of the process (from a geochemical standpoint). The Fernald STCG worked closely with the Fernald Citizens Task

Force. Fernald regulators and stakeholders had been involved in the demonstration and were very supportive because of the potential to reduce the time required for groundwater remediation. EIT was not asked to review stakeholder acceptance.

#### *Recommended Future EIT Support*

EIT recommendations for future work include the following:

- follow up contacts with potential end users to determine performance requirements
- summarize/share results of Fernald demonstration with other potential end users
- determine if there is interest in a demonstration site tour
- evaluate issues identified by potential end users, regulators, and stakeholders so they can be addressed in future technology development activities.

#### **5.1.2.3 Biomass Remediation**

##### *Technology Description and Objectives*

Biomass remediation uses the natural ability of terrestrial and aquatic plants to accumulate, and in some instances concentrate, heavy metals and radionuclides from soil and water. Biomass remediation cultivates and harvests plant species that hyperaccumulate contaminants. Phytoextraction, which is biomass remediation of surface soils, generally applies to heavy-metal and radionuclide contamination in the top 30 cm of soil (the rooting zone of annuals). Rhizofiltration, which is a surface or groundwater biomass treatment process for low levels of contamination, uses hydroponically-grown plants, such as sunflowers, to transport contaminants from the water into the plant roots. After harvesting, the biomass (e.g., leaves, stalks, stems, roots) is processed by various methods, including composting and/or thermal ashing, to substantially reduce the volume and to extract and/or stabilize the toxic components.

Biomass remediation technology is in the exploratory development stage. In FY 1996, protocols for evaluating biomass remediation performance at DOE site cleanups were developed and implemented, hyperaccumulator species were identified, and field tests that began in FY 1995 were completed. A Gate 3 review of the project was conducted on March 19, 1996, to determine if this technology had applicability at DOE sites and to evaluate the future direction of the project. The primary objective of the gate review was to determine if the technology could be used at DOE sites to remediate soils, sediments, groundwater, and surface water contaminated with heavy metals and radionuclides. The review identified 1) DOE OUs where this technology could be practically used, 2) the range of contaminants and concentrations over which this technology could be economically applied, 3) the technical merit of the studies that had been completed to date, and 4) cost and performance advantages of the technology over baseline technologies.

The primary focus of the remainder of FY 1996 to prepare work plans, scope, schedule, and budget for treatability testing of cesium-contaminated soils at Brookhaven National Laboratory (BNL). To date, phytoextraction studies have included field tests at INEL and a Superfund site at Silver Bow Creek, Montana. Laboratory evaluation of cesium-contaminated soils from BNL OU1 is continuing, and testing of uranium-contaminated soils from the RMI site in Ashtabula, Ohio, is underway. An INEL field test summary was prepared for the March gate review; follow-on development work focused on methods availability to increase available cesium in soil to accelerate plant uptake. Summary results of the Silver Bow Creek field test data and greenhouse tests were also included in the gate review package.

Rhizofiltration field tests are ongoing at the RMI/Ashtabula site in waste-water effluent containing low levels of uranium and technicium, and tests are also being conducted at the ORNL Y-12 Bear Creek Valley site. Work continues on the preparation of comparative cost and performance data for both soils and water cleanup technologies. Potential test sites at several UMTRA sites and other DOE facilities are being evaluated.

### *Stakeholder Interest Ranking*

Stakeholder interest scoring for biomass remediation was C/D (of high interest but not schedule compatible; i.e., not enough time to affect demonstration test plans), primarily because of process waste issues. Using soil additives to increase the availability of contaminants (e.g., cesium) for plant uptake may raise stakeholder interest.

### *EIT Actions*

For the gate review, EIT determined potential end-user interest in rhizofiltration and phytoextraction technologies and DOE Ous where these technologies could be practically used. EIT performed the following actions:

- contacted sites involved in recent laboratory and field tests to determine their interest and the practicality of large-scale biomass remediation at their locations
- with the PFA Technical Team, developed criteria to screen for additional potential end users
- contacted those additional potential end users to update site information/status and performance requirements and to determine their interest
- participated in the March 1996 gate review in Butte, Montana, and made a presentation on the results of the EIT findings and recommendations for follow-up
- reviewed and commented on the draft Biomass Project Review Report.

EIT submitted a letter report to H. Freeman, PNNL, on March 4, 1996, that presented initial EIT input for the gate review, including

- Rhizofiltration - Identified 7 potential end users; using screening criteria, also identified 17 sites with shallow metal and/or radionuclide groundwater contamination with little or no potential for rhizofiltration (because of co-contaminants, schedule constraints), and 3 sites for which information was currently inadequate. Determined through an interview that RMI/Ashtabula, the site involved in a field test, is not interested in full-scale implementation of rhizofiltration because they already had an on-site waste water treatment plant that was meeting discharge limits.



- Phytoextraction - Identified 3 potential end users; using screening criteria, also identified 18 sites with metal and/or radionuclide soil contamination with little or no potential for phytoextraction (because of co-contaminants, depth of contaminants, schedule), and 12 sites for which information was currently inadequate. Discussed results of site contacts at BNL, Silver Bow Creek, and RMI/Ashtabula regarding potential end user interest in the technology.

EIT performed follow-up data collection and submitted both detailed and summary letter reports to H. Freeman on March 15, 1996, that presented EIT's final input for the gate review:

- Rhizofiltration - Described results of interviews with 6 potential end users and identified issues that needed to be addressed at potentially interested sites. With the possible exception of ORNL and several UMTRA sites, the evaluation showed little end user interest in rhizofiltration. The advantages of rhizofiltration over conventional technologies was not apparent.
- Phytoextraction - Described results of interviews with 10 potential end users and identified issues that need to be addressed at potentially interested sites. The evaluation showed that the Chicago, Nevada, Oak Ridge, and Ohio field offices were somewhat interested in phytoextraction; however, most sites that expressed interest had not yet made cleanup decisions or needed further information about the technology.

On April 4, 1996, EIT sent a letter to J. Phelan that listed sites that did not meet the criteria for rhizofiltration or phytoextraction and appeared to have little or no potential for applying these technologies. On April 24, 1996, EIT submitted a letter to H. Freeman with review comments on the draft Biomass Project Review Report, which summarized gate review results.

#### *Evaluation of Current Level of Stakeholder Acceptance*

Stakeholder and regulatory concerns about phytoextraction included the effects of using chelating agents to enhance the uptake of contaminants into the plants, food chain uptake of contaminated biomass, exposure to dust generated during tilling and harvesting of contaminated crops, contaminant movement by crop irrigation, and biomass disposal operations (e.g., incineration). Also, the 5- to 10-year cleanup schedule (multiple growing seasons) was of concern.

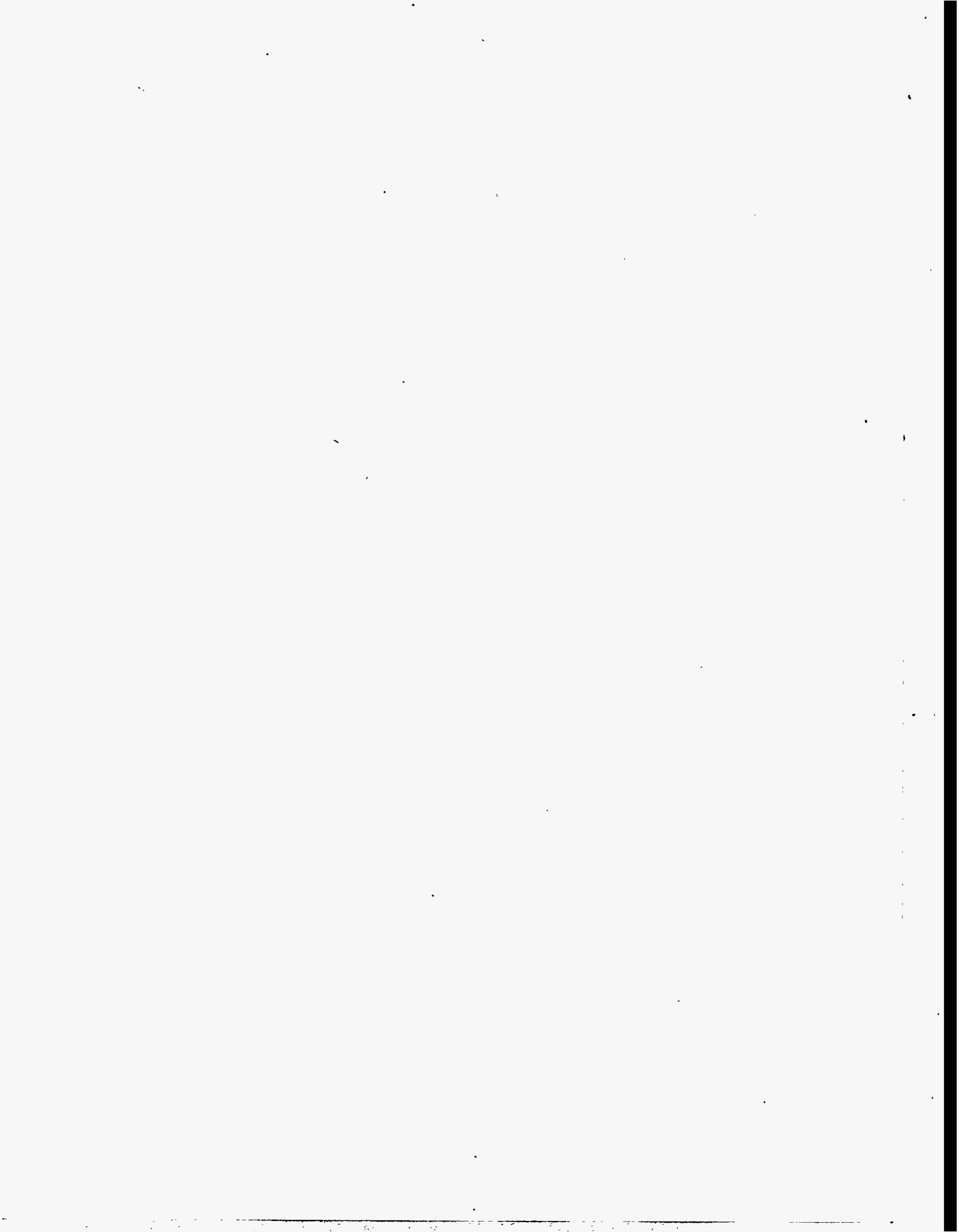
Stakeholder and regulator concerns about rhizofiltration included land requirements for greenhouses, worker exposure, and biomass handling/disposal.

#### *Recommended Future EIT Support*

EIT recommends the following future work:

- More-detailed information (including performance data) needs to be developed on the technologies for dissemination to potential end users and stakeholders.

- Principal investigators should schedule presentations to STCGs and OU Managers at selected sites, including ORNL, INEL, Nevada, and Richland, to further evaluate the potential of the technologies.
- The PLM and EIT should work with the PIs to define the scope and approach for further DOE market analysis.
- Any follow-up contacts with potential end users should focus on determining end user performance requirements so that input can help focus future research to meet end user needs.



### 5.1.3 Treatment and Stabilization

#### 5.1.3.1 Gaseous Reduction of Chrome/*In Situ* Chemical Treatment System

##### *Technology Description and Objectives*

This technology uses reactive gases, such as hydrogen sulfide, to treat and immobilize heavy metals and radionuclides in soil. This approach to *in situ* remediation of soils uses a well-field network to inject gas into the subsurface and direct the gas flow through a zone of contamination to reduce the solubility and mobility of contaminants. The approach may be particularly valuable in treating soils contaminated with hexavalent chromium, which is highly soluble and toxic. Laboratory tests have shown that hydrogen sulfide can reduce hexavalent chromium to a state that is immobile and essentially nontoxic. By altering the state of contaminants to a nontoxic form, the need for removal is eliminated. Hydrogen sulfide, however, is a chemical asphyxiant. Using the technology requires extra safety procedures, such as a breathing apparatus for workers. Fugitive emission tracer tests were planned in FY 1996 to assess gas movement and recovery. Consideration of less-toxic gases (e.g., ethylene/nitrogen mixture) was also underway.

Gaseous reduction of chrome/*in situ* chemical treatment technology was at Gate 5, ready to move from engineering development into the demonstration stage. Laboratory testing activities had confirmed that chromium in a waste soil site at SNL could be significantly immobilized by gas treatment. A field demonstration of unsaturated soil treatment of chromium contamination by hydrogen sulfide gas is planned for FY 1997. The field demonstration location was originally identified as SNL Chemical Waste Landfill; however, state regulatory agency permitting requirements led to consideration of other sites. Other potential demonstration sites included the Pantex facility and the U.S. Air Force's White Sands Missile Range in New Mexico.

Permits were obtained in April 1996 to perform characterization drilling activities at a chromium spill site at the White Sands Missile Range in preparation for a FY 1997 field demonstration. The objective of the gaseous reduction of chrome field demonstration is to demonstrate unsaturated soil treatment of chromium contamination by hydrogen sulfide gas in conjunction with supplemental laboratory studies to evaluate the treatment efficacy for other metals and radionuclides. The demonstration will conduct a full-system test of a subsurface injection and extraction array and the gas treatment system with a tracer gas, to validate model predictions and to verify that engineered controls can completely contain all gas streams. The demonstration will provide an assessment of the engineering issues of gas perfusion into heterogeneous porous soils that identify optimum configurations and maximize treatment efficiency.

##### *Stakeholder Interest Ranking*

Stakeholder interest scoring for gaseous reduction of chrome/*in situ* chemical treatment was A (of high stakeholder interest, with the possibility to affect the demonstration test plan).

##### *EIT Actions*

EIT supported the planned demonstration by evaluating the extent of stakeholder/end user concern for use of hydrogen sulfide gas at a proposed demonstration at the Pantex facility and recommended methods to mitigate poisonous gas migration/safety/worker training issues, based on mining industry experience. to

support product line decisions on further development of the technology This input supported product line decisions about developing the technology further.

EIT submitted a letter report to J. Phelan on February 13, 1996, that 1) confirmed that Pantex was not a suitable demonstration location (concern was raised by Pantex on the use of poisonous gas within a secured area and the lack of written safety protocols), 2) described concerns and perspective on the potential application of the technology at the Pantex facility if positive demonstration results were obtained at an alternate site, and 3) presented information on the use of hydrogen sulfide gas in mining industry applications, as well as worker safety precautions taken with respect to fugitive emissions.

#### *Evaluation of Current Level of Stakeholder Acceptance*

Significant end-user and stakeholder concerns exist over using toxic hydrogen sulfide gas as a treatment medium. Specifically at the Pantex facility, where EIT focused its evaluation, concerns included potential migration of fugitive emissions into buildings, the possibility that trace amounts of gas could trigger false alarms or evacuation, and the need for written safety protocols and procedures. However, Pantex did not completely rule out the technology if positive demonstration results were obtained elsewhere and their safety and security concerns were satisfactorily addressed.

#### *Recommended Future EIT Support*

EIT recommends that future work include

- confirm the tentative plan to conduct the demonstration at the U.S. Air Force White Sands Missile Range
- assess potential DOE end user interest based on earlier work and on a list of chrome-contaminated sites
- identify and contact EM-40 at sites to determine technology "match" viability in consultation with the PLM
- provide demonstration status information and establish PI contact with viable end-user candidates.

#### **5.1.3.2 *In Situ* Redox Manipulation**

##### *Technology Description and Objectives*

*In situ* redox manipulation (ISRM) creates a permeable treatment zone in the subsurface, within or just down-gradient of groundwater contaminated with chromium, carbon tetrachloride, uranium, and/or other radionuclides. The technology targets contaminants that are mobile under oxidizing conditions. If the oxidation-reduction (redox) potential can be changed to be reducing, contaminants can be made less soluble and less mobile. The treatment zone is created by injecting reagents and/or microbial nutrients in the subsurface to alter the redox potential of the aquifer fluids and sediments. Contaminant plumes migrating through the treatment zone under natural gradients are destroyed or immobilized.

The ISRM technology was in the demonstration phase for application to chromium (Gate 5). FY 1996 activities consisted of the following subtasks: finish analyzing the ISRM field demonstration performed in August and September 1995 at the Hanford 100-H site, plan with EM-40 for a pilot-scale demonstration at the Hanford 100-D Area, and develop biotic redox-manipulation methods for anaerobic destruction of carbon tetrachloride and immobilization of soluble uranium and chromium on a bench scale. A 200-foot-long by 50-foot-wide pilot-scale demonstration barrier was planned within a chromium plume at the Hanford 100-D Area. If the demonstration were successful, it was anticipated that the ISRM technology would be deployed at full scale in future years to remediate the chromate plume at the Hanford 100-DR-3 OU.

### *Stakeholder Interest Ranking*

Stakeholder interest scoring for *in situ* redox manipulation was C (of high interest, but not schedule compatible). However, funding issues delayed the demonstration enough that this score may need to be re-evaluated.

### *EIT Actions*

EIT performed the following activities to support the ISRM technology:

- enlisted DOE-RL STCG support to reinstate EM-40 support for the demonstration at Richland
- arranged for the PI to present the demonstration test plan and results of the 100-H field test to the STCG and discuss stakeholder concerns to be addressed in the demonstration
- contacted Oakland and Albuquerque to determine interest in the technology.

The DOE-RL STCG Subgroup had expressed strong interest in this technology, but wanted to hear the results of the field tests before endorsing it. The STCG is currently reviewing the report on the 100-H field test. A decision about supporting the demonstration is on hold, pending resolution of funding issues. The state regulator has expressed support for the technology and urged additional EM-50 funding. However, the major issue is the joint funding to come from EM-40, which is currently on hold. EM-40 identified a budget underrun that would have allowed funding of the demonstration in FY 1996; however, as of June 1996, EM-40 had put this on hold while it reviewed the location of the demonstration and its priority for the 100 Areas.

The Oakland field office's Lawrence Livermore National Laboratory (LLNL) and Laboratory for Energy-Related Health Research (LEHR) sites and the Albuquerque field office's Pantex site were contacted in January 1996 by EIT to determine their interest in the technology. On January 29, 1996, EIT sent to J. Cormier, DOE Albuquerque office, and E. Reber, DOE Oakland office, letters that provided additional information on the technology and requested input on their site's performance requirements for the technology for input to the test plan. LLNL responded that the technology was not applicable to them. LEHR is very interested, and the PI is in contact with them. Pantex has not yet responded on their interest in the technology, despite several follow-up calls.

### *Evaluation of Current Level of Stakeholder Acceptance*

The DOE-RL STCG has expressed support for the technology demonstration to address several critical issues before a position on deployment can be determined. The Nez Perce Tribe has many concerns with this technology:

- potential for mobilization of contaminants other than Cr
- timing for groundwater re-oxidation and extent of Cr remobilization
- impact of anoxic groundwater conditions on salmon beds in the Columbia River
- length of time that the reducing environment lasts to address Cr entering from the vadose zone, and what can be done to eliminate the Cr source in the vadose zone
- the need to add still more chemicals (i.e., sulfate) to the groundwater.

### *Recommended Future EIT Support*

EIT recommends that future work

- continue to obtain DOE-RL STCG endorsement of the technology and review of the test plan
- contact the DOE-AL STCG to follow up on Pantex interest in the technology
- provide demonstration results and photos of the demonstration to LEHR and Pantex.

## 5.1.4 Passive Treatment

### 5.1.4.1 Chemically Enhanced Barriers (Permeable Strontium Sorptive Barrier)

#### *Technology Description and Objectives*

The chemically enhanced barrier technology for strontium in shallow groundwater uses *in situ* permeable reactive barriers in aquifer sediments to minimize contaminant migration. Sequestering agents (e.g., zeolite or other adsorbents, and organic chelates) form *in situ* barriers that minimize the transport of strontium-90. The technique is passive in that it relies on the natural hydraulic gradient and does not require a continuous energy source for pumping nor continuous maintenance. The barrier can be left in place to immobilize strontium-90 until it decays to innocuous levels.

The permeable strontium sorptive barrier was in the field demonstration stage (Gate 5). The FY 1996 focus was on the use of clinoptilolite, a zeolite mineral, to form a reactive, semi-permeable barrier to capture strontium-90 in shallow groundwater. A proof-of-principle test is planned at the 100-Area of the Hanford Site near the 1301-N and 1325-N (N Springs) liquid waste disposal facilities where large quantities of radioactive waste water were allowed to percolate through the vadose zone into the unconfined aquifer.

The objectives of the treatability test are to 1) verify laboratory-scale testing of the *in situ* treatment zone technology under actual field conditions as a pilot study, 2) provide data to scale up to a full-scale treatment phase, 3) support remediation activities in the evaluation of alternatives for the Corrective Measures Study, and 4) provide information on the effectiveness as a long-term remedial action. The field treatability test will consist of a 100-foot long, 30- to 40-foot deep trench, excavated on the down-gradient end of the plume, that is backfilled with material containing clinoptilolite. The groundwater will be monitored to evaluate the migration rate of strontium-90 through the barrier. Primary issues to be addressed in the demonstration are constructability and the potential for plugging of the barrier. Based on stakeholder comments received in a workshop, a revised test plan that addressed regulator and stakeholder concerns was issued for public review in August 1996.

#### *Stakeholder Interest Ranking*

Stakeholder interest scoring for chemically enhanced barriers was C (of high interest, but not schedule compatible). However, because of high interest, the project has been delayed to allow for enhanced stakeholder involvement.

#### *EIT Actions*

EIT's support to the planned treatability test included the following activities:

- informed DOE-RL STCG about the project and encouraged their participation
- worked with EM-40 and the PI to develop an approach to addressing stakeholder concerns
- identified and contacted other potentially applicable sites to assess interest in the technology.



In February 1996, EIT arranged for the PI to present the demonstration test plan to the DOE-RL STCG Subgroup. Subsequently, EIT obtained an endorsement of the technology from the DOE-RL STCG and statements from both the STCG and EM-40 that, if the demonstration were successful, the technology would likely be deployed at Hanford N-Springs. Additional presentations were made at the June and July 1996 meetings of the STCG Subgroup to discuss outstanding stakeholder issues. EIT also worked with the PI and EM-40 personnel to develop an approach to address the concerns of the Yakama Indian Nation over the demonstration. DOE-RL agreed to remove the barrier at the end of the demonstration to address at least some of the Yakama concerns.

EIT submitted a letter report to J. Phelan on July 3, 1996, that assessed potential end user interest in the *in situ* chemically enhanced barrier technology for strontium in shallow groundwater. A preliminary list of 24 OUs was identified from the Technical Team's technology matching matrix. This list was narrowed to five sites at four field offices by focusing on those sites where strontium-90 was the major contaminant and the plume was less than 30 to 40 feet deep. These field offices were contacted to confirm whether strontium was a primary contaminant in shallow groundwater and to assess potential interest in the technology. Two sites (West Valley and ORNL WAGs 4 and 5) were interested in the technology and requested further information and reports on the planned demonstration. Operable units at ORNL Y-12 S-3 Ponds, Hanford 100-Area, and SRS H-Area Tank Farm had no interest because strontium is a secondary contaminant at these sites.

On July 12, 1996, information on the use of clinoptilolite as an *in situ* permeable barrier at Hanford was sent by EIT to R. Kettelle and H. Moore at ORNL and West Valley, respectively, and on July 17, EIT sent the draft treatability test plan for the treatment test zone at Hanford N-Springs to these two sites.

#### *Evaluation of Current Level of Stakeholder Acceptance*

The state and the Yakama Nation have expressed concerns about several major issues:

- Excavating the trench for the barrier will result in a large spoils pile. The state wants this moved to the top of the hill behind the demonstration location or even to the Environmental Remediation Disposal Facility (ERDF), since it may be contaminated soil.
- Constructing the barrier could be hindered or prevented by boulders, cementation, maintenance of the walls with casing or shoring, and the potential for clogging of fine soils in the barrier.
- Excavating the trench may disturb Native American burial grounds and bring bones to the surface.
- The barrier will concentrate Sr and create a potential for a major release if Grand Coulee dam fails and floods the area.
- The barrier will not meet the 15-foot depth requirement for protection from intruders (this is applicable only to Class C wastes, but the Sr concentrations in the barrier should be below Class C limits).
- The Yakamas prefer to use cryogenics, coupled with solution mining.

These issues have caused DOE-RL to revise the test plan and provide another public review period. This has delayed the demonstration until February 1997.

*Recommended Future EIT Support*

EIT recommends that future work include the following:

- Support should continue to be provided to the DOE-RL STCG as it considers the significance of stakeholder issues to its support of the technology.
- Follow-up contacts to West Valley and ORNL should be continued to provide them with ongoing information, including photos of the demonstration (no tour is planned) and the reports on results.

## 5.1.5 Secondary Waste Treatment

### 5.1.5.1 MAG\*SEP<sup>SM</sup> (Groundwater Treatment Using Magnetic Separation)

#### *Technology Description and Objectives*

The MAG\*SEP<sup>SM</sup> process is an *ex situ* remediation technology that is designed to remove metals and radionuclides from groundwater. Groundwater is mixed with magnetic particles coated with a resin. The metal contaminants in the groundwater adsorb to the resin. This mixture then passes through a chamber that houses a magnet. The magnetic particles, to which the metal contaminants have adsorbed, are separated from the groundwater in the chamber, and the treated groundwater is discharged from the process. The contaminants are chemically removed from the magnetic particles, and the particles are recycled.

The MAG\*SEP<sup>SM</sup> technology was in the exploratory development stage (Gate 3). A pilot-scale demonstration of the technology was performed at SRS during the fall of 1995. In January 1996, additional system optimization tests were performed at SRS, and initial resin particle testing was done in the field. A Gate 3 project review planned for early June 1996 was postponed to allow time to complete additional technical work.

The purpose of the proposed MAG\*SEP<sup>SM</sup> demonstration project was to conduct a field test of the system at the D-Area Coal Pile Runoff Basin at the SRS where contaminated groundwater contained metals above drinking water standards. Nickel and chromium were targeted for removal during the demonstration.

#### *Stakeholder Interest Ranking*

Stakeholder interest scoring for MAG\*SEP<sup>SM</sup> treatment was C/D (of high interest - but not schedule compatible, to of little interest).

#### *EIT Actions*

EIT supported the MAG\*SEP<sup>SM</sup> project by performing the following actions:

- In conjunction with the Technical Team, identified DOE sites with metal and radionuclide groundwater plumes above action levels that currently pump and treat or plan to install an *ex situ* treatment system.
- Collected information from STCGs and OU managers on the performance requirements related to *ex situ* groundwater treatment at 13 sites at the Idaho, Ohio, Oakland, Oak Ridge, Richland, and Savannah River field offices.
- Gauged the sites' interest in the technology.

EIT was not trying to obtain end-user commitment to use the technology, but rather was assisting the PIs in focusing their technology development efforts on meeting the performance requirements of potential end users.

EIT submitted a letter report to J. Phelan on June 7, 1996, that summarized the findings resulting from contacts with 13 DOE sites identified as needing *ex situ* treatment of groundwater to remove metals and radionuclides. The report provided detailed information on the sites' problems, performance requirements and issues, and current status. The issues and conditions at each site and OU related to *ex situ* treatment were found to be variable and unique. Site-specific conditions that were identified that could impact the MAG\*SEP<sup>SM</sup> technology included the geologic/hydrologic system (karst, clay, and groundwater flow conditions) and competing ions (e.g., Fe, Ca, Mg).

The information collected by EIT for MAG\*SEP<sup>SM</sup> is also being used to help identify end users for polymer separations, another *ex situ* treatment technology that adsorbs metals and radionuclides from groundwater (see Section 5.1.5.3).

#### *Evaluation of Current Level of Stakeholder Acceptance*

From talking with potential end users, the complexity and unusual maintenance/expertise required to operate this technology may be an issue. The inability to remove co-contaminants, treatment and disposal of secondary waste, and the lack of a regulatory track record may also be issues.

#### *Recommended Future EIT Support*

MAG\*SEP<sup>SM</sup> is also being evaluated as a potential *in situ* treatment technology. Other potential end users may need to be investigated to identify those that are interested in *in situ* technologies.

### **5.1.5.2 Mound-Selentec Treatability Study**

#### *Technology Description and Objectives*

The Mound Selentec technology is being evaluated for the remediating low-level plutonium-238 contamination of soils in the Miami-Erie Canal at the DOE Mound site at Miamisburg, Ohio. This *ex situ* soil-treatment technology encompasses two processes: 1) washing the sediments with a proprietary solution (ACT\*DE\*CON<sup>SM</sup>) to dissolve the contaminant, followed by 2) extracting the solution and using the MAG\*SEP<sup>SM</sup> process to concentrate the contaminant and allow reuse of the ACT\*DE\*CON<sup>SM</sup> solution. The MAG\*SEP<sup>SM</sup> process adsorbs the plutonium onto magnetic particles that can eventually be recycled or stabilized and properly disposed of. Alternatives to MAG\*SEP<sup>SM</sup> may also be available for secondary waste recycling.

The technology was in the advanced development stage (Gate 4), and laboratory work had been performed to optimize the process for a pilot-scale demonstration. A project/gate review was held in April 1996 to evaluate the readiness to proceed to pilot-scale demonstration.

The purpose of the pilot-scale demonstration at Mound was to demonstrate the recycling of the wash solution, demonstrate that the MAG\*SEP<sup>SM</sup> particles could be regenerated, assess the process to be used to produce an acceptable waste form, and evaluate the potential for volume reduction and stabilizing the liquid waste.

### *Stakeholder Interest Ranking*

Stakeholder interest scoring for the Mound Selentec treatability study was C (of high interest, but not schedule compatible). The technology may only be applicable to the Mound Site and possibly to Rocky Flats.

### *EIT Actions*

In support of the April 1996 gate review, EIT contacted Mound to evaluate end-user interest in the technology and associated performance requirements and to define site-specific issues. EIT also identified other potential end users.

On February 1, 1996, EIT submitted a letter report to J. Phelan that provided input on Mound end-user interest in the technology, along with some information on site-specific issues, the baseline technology, and associated costs. Names of Mound end user representatives who were interested in participating in the project review were also provided. Mound OU 4 (Miami-Erie Canal) and OU 9 were interested in the technology if they could achieve a 25 pCi/g cleanup level and a 30 percent cost reduction over their baseline plan. The pilot test was switched from OU 4 to OU 9 because the soils at OU 9 contained less fine silt and clay and were more amenable to the Mound-Selentec process. A follow-up memo was submitted to J. Phelan on February 8, 1996, that identified other potential end users, based on a review of the PFA needs database and site visit templates. These sites included the Chicago, Nevada, Richland, and Rocky Flats field offices, although the technology may not be directly applicable to all of these sites.

### *Evaluation of Current Level of Stakeholder Acceptance*

Mound stakeholders are involved in making decisions on cleanup priorities and are aware that innovative technologies are being explored. These end users appear interested in the technology. However, cost and performance advantages over the baseline technology (excavation and off-site disposal) must be demonstrated. Processing time and reduction of large volumes of secondary wastes are issues that need to be addressed to ensure stakeholder acceptance.

### *Recommended Future EIT Support*

EIT recommends that future work include

- Share results of pilot testing with Mound regulators and stakeholders so their input can be incorporated into future test plan(s). This is necessary to facilitate stakeholder acceptance.
- Evaluate the applicability of the Mound-Selentec process to other soils/contaminants/sites. If appropriate, share results of Mound pilot test with other potential end users and their STCGs.

- Contact other potential end users to determine their interest, site conditions, and performance requirements and factor these into future technology development activities.

### 5.1.5.3 Polymer Separation

#### *Technology Description and Objectives*

Polymer separation is an advanced *ex situ* (pump and treat) technology that may be capable of treating a wide variety of heavy metal and radionuclide contaminants in groundwater. The technology is based on the use of specially designed water-soluble polymers that selectively bind with target radioactive or metal ions. The polymers have such large molecular weights that they can be physically separated from groundwater using available ultrafiltration technology. The polymers are too large to pass through the ultrafilter, but water and ions that are not captured by the polymers pass through freely.

Polymer separation technology was in the advanced (pre-engineering) development stage (Gate 4). Polymer separation materials that were originally developed for efficient separation of metals, cesium, and other radionuclides from aqueous waste streams were being evaluated for ground-water treatment applications. A report was issued in May 1996 that compared the performance and cost parameters of recently developed polymers that could selectively adsorb metal and radionuclide contaminants in the presence of competing anions and cations. Selective polymer separation materials from the Efficient Separations and Processing Cross-Cutting Focus Area were being evaluated for groundwater treatment applications. Issues being addressed included selectivity, capacity, concentration, and other factors.

#### *Stakeholder Interest Ranking*

Stakeholder interest scoring for the polymer separation technology was E (pre-engineering development phase), because no demonstration is currently planned.

#### *EIT Actions*

EIT obtained background information on the technology and the Efficient Separations and Processing Cross-Cutting Program. Potential end users were identified as a result of EIT's identification of end users for the MAG\*SEP<sup>SM</sup> technology, another *ex situ* treatment technology that adsorbs metals and radionuclides from groundwater.

EIT submitted a letter report to J. Phelan on June 7, 1996, in support of the MAG\*SEP<sup>SM</sup> technology (see Section 5.1.5.1), which summarized the findings resulting from contacts with 13 DOE sites identified as needing *ex situ* treatment of groundwater to remove metals and radionuclides. Detailed information on the sites' problems, performance requirements and issues, and current status was included. The information collected by EIT for MAG\*SEP will also be used to help identify end users for the polymer separation technology.

### *Evaluation of Current Level of Stakeholder Acceptance*

Because the polymer separation technology was in the pre-engineering development stage, no EIT activities were performed relevant to stakeholder acceptance.

### *Recommended Future EIT Support*

Assuming that funds become available for future laboratory and field testing, EIT recommendations for future work include

- providing a briefing package (prepared by the Technical Team) to the STCGs that may have an interest in the technology, based on potential end users identified for MAG\*SEP
- contacting STCGs to determine their interest and provide them with additional information and contacts, as appropriate.

## **5.2 DNAPL and Organic Technologies**

### **5.2.1 Characterization**

#### **5.2.1.1 Alcohol Injection/Extraction**

##### *Technology Description and Objectives*

This technology detects DNAPL in the vicinity of monitoring wells. Clean water is injected and withdrawn, and then an alcohol-water solution is injected and withdrawn. The clean water injection cycle is for baseline data, and the alcohol-water injectant is to solubilize DNAPL within the injected volume. The difference in the time-concentration response of the well effluent between water injection-extraction and the solution injection-extraction confirms the presence of DNAPL at the suspect location.

##### *Stakeholder Interest Ranking*

This technology ranked a C (of stakeholder interest, but not enough time to effect the demonstration plans). The principal issue was anticipated stakeholder concern over the injection of materials into subsurface.

##### *EIT Actions*

The PLM requested that EIT assist with identifying information to enhance the deployment of the technology and identify potential end users and their issues. Several sites were interviewed with regard to their interest in the Alcohol Injection/Extraction of DNAPL.

##### *Evaluation of Current Level of Stakeholder Acceptance*

Idaho-TAN (Technical Area North) and Oak Ridge-Paducah are interested in this technology.

One potential end-user was unsure of the quality of the DNAPLs at his site, so he did not know how he would be able to gauge the success of this technique.

##### *Recommended Future EIT Support*

Follow-up contact should be made with potential end users to assess their interest in deploying the technology at their sites and to identify acceptance and performance issues.

#### **5.2.1.2 Differential Gas Tracer Test**

##### *Technology Description and Objectives*

This technology uses different tracers to assess mass-transfer characterizations of DNAPL in the vadose zone. Differential gas tracers, after being injected into the subsurface, dissolve to a different extent into any DNAPL that is present. This results in the tracers arriving at different times at an extraction well.



The arrival time delay exhibited by the hydrophobic tracers is related to both the amount of the residual DNAPL encountered and the mass transfer of the tracer gas into the DNAPL.

#### *Stakeholder Interest Ranking*

EIT ranked this technology a C (of high stakeholder interest, but no time to have stakeholder input in the demonstration plan), primarily because of the plan to inject a substance into the subsurface.

#### *EIT Actions*

The PLM requested that EIT assist with identifying information to enhance the deployment of the technology and identify potential end users and their issues with regard to this technology. EIT interviewed OU managers at sites with suspected DNAPL problems about their interest in the technology, the status of characterization at their site, and their geology. The results were delivered to the PLM in a report in May 1996.

#### *Evaluation of Current Level of Stakeholder Acceptance*

Several sites were interviewed with regard to their interest in the Gas Tracer Test. The Sandia-Chemical Waste Landfill site, Idaho-TAN, Oak Ridge-Paducah, and Richland were interested. Potential end users were concerned whether this technology could be used in fractured rock.

#### *Recommended Future EIT Support*

Follow up contact should be made with potential end users to assess their interest in deploying the technology at their site and to identify acceptance and performance issues.

### **5.2.1.3 *In Situ* Permeable Flow Sensor**

#### *Technology Description and Objectives*

Two instruments under development will assist with characterization and monitoring. The first instrument directly measures the direction and magnitude of the 3D groundwater flow velocity vector in saturated, unconsolidated porous media. The tool is a thin heated cylindrical element that is buried in the ground. The pattern and magnitude of temperature distribution over the surface of the cylinder reveal the direction and magnitude of the groundwater flow velocity. The second instrument directly measures gas-flow velocity in unsaturated subsurface sediments.

Both tools were designed to demonstrate accurate information on flow. The gas flowmeter was field tested at an air-sparging unit in late FY 1995, and results were recorded in winter FY 1996. In 1996, the groundwater flow instrument technology was demonstrated in conjunction with the In Well Vapor Stripping (IWVS) demonstration at the Edwards Air Force Base. The data showed a clear correlation with activation of the pumping. The results were used to help determine the radius of influence and the overall hydrologic behavior of IWVS.

### *Stakeholder Interest Ranking*

The instrument ranked D (of limited stakeholder interest). The principal issue was lack of regulatory track record.. Although many new technologies have to establish a track record with regulators, this technology may be more difficult for regulators to accept because it operates out of sight.

### *EIT Actions*

Even though the instrument was ranked D, the PLM requested that potential end-users be contacted about their interest in the technology because of its potential application to IWVS and Passive Soil Vapor Extraction (PSVE).

The survey of approximately 30 potential users from across the DOE complex revealed a high degree of interest in the technology. One potential user reported that he hoped the tool could be applied to avoid drilling bad wells, thus saving money. EIT submitted a letter report in November. EIT later provided the PI with the list of attendees from the IWVS technology tour to assist the PI identify additional potential users.

### *Evaluation of Current Level of Stakeholder Acceptance*

Sites interested in the technology included Argonne National Laboratory (ANL), Hanford, Ashtabula, BNL, and SRS. The questions raised about the instrument focused on ease-of-use aspects, cost, and regulatory acceptability. Stakeholders were concerned about whether the instrument would be difficult to install. Another user wanted to know the geologic conditions where the tool was applicable. A second concern was whether the tool was cost effective at greater depths. The last concern was what it would take to show regulators that the tool worked as intended.

### *Recommended Future EIT Support*

The concerns could be addressed by documenting the demonstration results. The following information should be included in the technology profile:

- Detailed steps describing the installation process at the demonstration. Discuss variations in the installation process based on different geology. Identify geology where the tool is most applicable and where it is not applicable.
- Cost information detailing the conditions that existed at the demonstration. Extrapolate to consider other depths. Discuss the limits of applicability.

To address the concern about regulatory acceptability, EIT recommends working with the regulators involved in the California demonstration to ensure that their questions were answered. EIT also suggests documenting the questions and the answers in a report. Another step would be to secure the regulator's permission to be used as a contact in the future.

## 5.2.2 Removal

### 5.2.2.1 Evaluation of DNAPL Mobilization Potential

#### *Technology Description and Objectives*

Alcohol and surfactants can increase DNAPL solubility in water, enhancing its recoverability by pump-and-treat methods and result in a decrease in remediation time. These technologies, however, also reduce the capillary force that resists their further migration as a separate phase. If the capillary force is reduced too far, residual DNAPL can begin to flow, potentially magnifying a contamination problem. This research is designed to help understand the processes better that are associated with enhanced DNAPL remediation by surfactant dissolution and provide guidance for site-specific system design that will minimize the risk to remobilizing DNAPL. High-energy synchrotron x-rays are used to nondestructively monitor DNAPL saturation in experimental porous media. The large x-ray flux allows relatively rapid monitoring of changes in DNAPL saturation characteristic of separate phase flow. Surfactant concentration is determined *in situ* using a tracer (e.g., iodine). This technology is in the bench-scale phase, and the FY1996 objective was to develop a modeling tool.

#### *Stakeholder Interest Ranking*

This technology ranked an E (of stakeholder interest, but no demonstration site had been identified). The anticipated issue of concern was the injection of materials into the subsurface.

#### *EIT Actions*

The PLM requested assistance in determining potential end-user interest in the technology. EIT faxed a description of the technology to all sites with a suspected DNAPL contamination problem. EIT then followed up with a call to each site to determine interest and information needs about the technology. These results were compiled in a report to Tom Early in May 1996. Additionally, EIT contacted the PI to explain the results of the experiments should they be made available to interested sites.

#### *Evaluation of Current Level of Stakeholder Acceptance*

As the technology is only in the bench-scale phase, it is too early to conduct a stakeholder acceptance evaluation.

#### *Recommended Future EIT Support*

EIT recommends that the results of mobilization experiments at the synchrotron should be distributed to interested end-users.

### 5.2.2.2 Six-Phase Soil Heating

#### *Technology Description and Objectives*

Six Phase Soil Heating (SPSH) was developed to remediate soils contaminated with volatile and semi-volatile organic compounds. SPSH is designed to enhance the removal of contaminants from the

subsurface during soil vapor extraction. The innovation combines emerging technology, that of six-phase electrical heating, with a baseline technology, soil vapor extraction, to produce a more efficient *in situ* remediation system for difficult soil and/or contaminant applications.

#### *Stakeholder Interest Ranking*

Stakeholder interest scoring for that technology was C (of high stakeholder interest, but not compatible with demonstration schedule.)

#### *EIT Actions*

Several potential DOE end-users were contacted and asked about their interest in using SPSH at their site.

#### *Evaluation of Current Level of Stakeholder Acceptance*

The Albuquerque-Chemical Waste Landfill site, the Kansas City Plant, and Oak Ridge-Portsmouth are interested in this technology.

Potential end users would be interested in learning more about the following issues:

- the impact moisture has on the performance of the technology
- effectiveness of the technology in volatilizing DNAPLs that contain polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbon PAHs, and chlorinated compounds
- cost of energy use
- ability of the technology to work under buildings.

#### *Recommended Future EIT Support*

Several SPSH demonstrations are planned. One of these is to occur at Dover AFB, which will test the technology in the saturated zone. This demonstration may be a good candidate for a technology tour. The PLM has requested that updated information be sent to potential end users. Before conducting a technology tour, the latest SPSH performance information should be sent to interested attendees. If a tour does not occur, an updated report (update of the Innovative Technology Summary Report) should be sent to potential end users and stakeholders.

### **5.2.2.3 Thermally Enhanced Vapor Extraction System**

#### *Technology Description and Objectives*

Volatile organics, semi-volatile organics, and non-aqueous phase liquids (e.g., DNAPLs) can be removed better by using soil heating combined with traditional vacuum vapor extraction. Heating subsurface soils by alternating current (AC) and by radiofrequency (RF) methods will significantly increase the mass removal rates of soil contamination because of the exponential increase in vapor pressure of the chemical contaminants with temperature. The technology uses either AC heating or RF heating or both, depending on the soil's physical properties and contaminant properties. The system can be combined

with traditional or innovative off-gas treatment to complete the system. This technology was demonstrated in 1995, and a performance report was to be developed in 1996.

#### *Stakeholder Interest Ranking*

This technology was ranked a C (of high stakeholder interest, but not compatible with demonstration schedule) because the demonstration had been completed in 1995.

#### *EIT Actions*

This technology was a low priority to the PLM with respect to EIT support. No specific requests were made in FY 1996.

#### *Evaluation of Current Level of Stakeholder Acceptance*

Materials such as performance reports, required by stakeholders to evaluate the technology, were not available in time to receive stakeholder input.

#### *Recommended Future EIT Support*

Follow up contact should be made with potential end users to provide them the performance report and to assess their interest in deploying the technology at their site

### **5.2.2.4 In-Well Vapor Stripping**

#### *Technology Description and Objectives*

This system is designed to change the VOCs in the groundwater from the dissolved phase into the vapor phase and transport these vapors to the surface for treatment or release. EIT inherited this technology from the former VOC-Arid ID, which conducted an extensive stakeholder program in support of developing this technology. Consequently, the test plan incorporated the questions and concerns of 75 stakeholders at four arid sites. In FY 1996, the technology was demonstrated at Edwards Air Force Base and a performance report was prepared.

#### *Stakeholder Interest Ranking*

EIT gave this technology a C (of high interest, but limited time to affect the content of the demonstration) . The factors drawing attention are that it will

- potentially increase contaminant mobility adversely
- transfer contaminants from one medium to another
- be unable to address co-contaminants
- be too complex
- produce emissions or releases.

### *EIT Actions*

To meet the PLM's goal to increase awareness of the technology among potential sites, EIT planned a technology tour. The invitees included potential users identified in the technology needs template, regulators associated with those sites, and stakeholders involved in the VOC-Arid Site ID. Thirty stakeholders attended, representing four sites and a variety of stakeholder interests. The sites were Oak Ridge-Paducah, ORNL, Westinghouse Savannah River, and Mound. The tour agenda included presentations on the technology, the site, and the demonstration. The demonstration addressed the issues that stakeholders identified during the 3-year development phase. Additionally, attendees were given the opportunity to visit the actual demonstration for a visual representation of the technology. EIT facilitated a discussion of stakeholders' acceptance of the technology and took notes at the tour. EIT followed up with the attendees to make sure they had the information they needed to evaluate the technology.

### *Evaluation of Current Level of Stakeholder Acceptance*

The VOC-Arid Site ID program's last evaluation of the technology occurred before the technology's demonstration.<sup>(a)</sup> VOC-Arid Site ID stakeholders had the following issues with the technology:

- environmental risk associated with the technology's impact on aquifer's flow (such as mounding, changes in water chemistry, clogging)
- ability to handle other types and concentrations of organics, metals, and radionuclides
- lack of regulatory track record for technologies that may change the groundwater level
- the technology's capability to work as intended.

The PI addressed all of the above issues in discussions during the tour. He included an explicit discussion of the demonstration's problems with clogging and the steps he took to overcome the problem. The new issues raised during the tour included

- whether the technology was viewed by regulators as a recirculating technology or an injection technology and the implications of each
- whether appropriate off-gas systems for the system are available
- whether it has the capability to handle co-contaminants
- what is appropriate geology for cost-effective cleanup?

The regulators discussed the pros and cons of viewing the technology as a recirculating technology or an injection technology. They agreed that permitting a recirculating well was simpler, which was the approach California used. Following the tour, Paducah expressed interest in deploying the technology.

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(a) T.S. Peterson, *Stakeholder Acceptance Analysis: In-Well Vapor Stripping, In-situ Bioremediation, and Gas Membrane Separation System*, prepared for the U.S. Department of Energy's Office of Technology Development under contract DE-AC06-76RLO 1830, PNNL-10912, December 1995.

### *Recommended Future EIT Support*

EIT recommends the following:

- EIT provide regulatory contacts who had viewed the technology as recirculating to those sites interested in the technology. The emphasis on contacting regulators came from potential users who expressed an interest in putting their regulators in touch with those who attended the tour.
- Potential end users should receive both the performance report and the Stakeholder Acceptance Analysis report on the technology to illustrate the extensive stakeholder involvement.

#### **5.2.2.5 Passive Soil Vapor Extraction**

##### *Technology Description and Objectives*

This technology takes advantage of natural changes in the atmospheric pressure to capture escaping VOC vapors from boreholes. The technology is, by design, slower than active soil vapor extraction (the baseline technology), which will reduce its acceptability in conditions where speed is important. Much of the FY 1996 research was focused on enhancing the atmospheric flow through the use of valved well heads. The technology was not intended to be applicable to all cases where VOC gases need to be removed from the vadose zone.

##### *Stakeholder Interest Ranking*

EIT ranked this technology a C (of high stakeholder interest, but limited time for stakeholder input into a demonstration plan). The issues surrounding this technology include its inability to handle co-contaminants, requirement of offsite transport/treatment, and production of emissions or releases.

##### *EIT Actions*

The PLM requested that EIT assist with 1) identifying information to enhance the deployment of the technology and 2) identifying the most feasible DOE sites for deployment opportunities.

EIT conducted a user survey designed to determine 1) if the sites were interested in using the technology and 2) what information they needed to evaluate the technology, thus facilitating deployment.

##### *Evaluation of Current Level of Stakeholder Acceptance*

Three issues were expressed repeatedly during the interviews and were presented in a report to the PSVE Working Group in November.

*Effectiveness of Technology.* All potential users included a number of effectiveness issues in their responses. Ranking the responses, requests for information centered around how PSVE works, its practicality, and its cost. Several mentioned that cost or time were their primary drivers in evaluating technologies. Three OU managers interviewed had extensive knowledge about the technology, including very specific criteria for determining site suitability.

*Regulatory and stakeholder acceptance.* The predominant response about regulatory information was that an established track record of regulatory acceptance is essential. One manager also requested stakeholder acceptance. Since the technology was in the demonstration phase, many managers wanted to know that potential regulatory issues had been addressed. Only one site felt that their regulators were amenable to providing some leeway for using innovative technologies. However, the site also felt that the technology would be closely monitored for quantifiable remediation results.

*Other information needs.* PSVE did not elicit much need for information on either worker safety or public health and safety. Two managers wanted to know both the amount of emissions and the volatilization of the contaminant during the construction phase and during operation. As for contaminant handling, many of the managers felt that fugitive airborne emissions were not a significant issue at their site. However, if the situation changed, they wanted to know what treatment options were available for the contaminant and the costs associated. The quality of monitoring equipment was a concern to another manager. In his experience, the equipment has not been designed to adequately handle field conditions. At one particular site, the printout of the recording equipment faded away before it was collected.

#### *Recommended Future EIT Support*

The survey results indicated that

- A wide audience was unfamiliar with the technology
- The criteria developed by the VOC-Arid Site ID reflected the information needs identified by the potential users.
- The information desired by the users was consistent across sites, with PSVE's effectiveness and regulatory acceptance receiving the most emphasis.

Consequently, EIT felt additional data sharing to preparing the workbook was required. EIT recommends developing case studies using the demonstration sites. Specifically, the information to be included in the case studies is

- Contaminant Handling: which contaminants were addressed, what was left behind, what is the removal rate, and what treatment is used, if any?
- Site Suitability: soil conductivity, soil permeability, vapor pressure, depth to groundwater, radius of influence, the hydrogeology, and climate.
- Cost: cost of set-up and operation, as well as an estimate of costs over time.

Given that both cost and maintenance needs are of concern to potential users, the workbook should highlight low cost and maintenance as advantages of PSVE. Lastly, the limitations and operational envelope of the technology should be clearly articulated so that potential users would be made aware of where and when the technology would and would not be applicable.



A review of a broad range of stakeholders' level of acceptance was prepared in the Stakeholder Analysis Acceptance Report.<sup>(a)</sup> This report provides details on how users, regulators, environmental interest groups, and tribal groups viewed the technology after it had completed a field demonstration in FY 1995. EIT recommends that this report be made available to interested sites.

### **5.2.2.7 Barometric Pumping with Surface Flux**

#### *Technology Description and Objectives*

Like the PSVE system with boreholes, this technology controls VOC gas releases occurring through atmospheric pressure changes. However, this technology does not require boreholes, off-gas treatment, or site power. The system uses a surface seal, collection plenum, and one way relief valve to pull the gas to the surface. The amounts released are low and thus are released directly into the atmosphere. This is a METC funded technology. In FY 1996, the PI was identifying sites interested in hosting a demonstration in FY 1997.

#### *Stakeholder Interest Ranking*

This technology was not ranked, but as it shares many of the same characteristics as PSVE with boreholes, it could also be considered a C. The issues with surface enhancements are that it is slower than baseline, it cannot handle co-contaminants, and it produces emissions/releases.

#### *EIT Actions*

The PLM requested that EIT work with the PI to identify sites interested in hosting the demonstration. EIT asked the PI to provide a description of the technology that could be provided to the sites. EIT used the site visit reports to identify sites with a VOC contamination problem in the unsaturated zone. EIT then called all of these sites to confirm (1) whether their geology was a fit for the technology, (2) the site's contaminants and levels of concentration, (3) the site's cleanup objectives, and (4) whether the site was interested in hosting a demonstration. The results were provided to the PI in a memo on June 20, 1996.

#### *Evaluation of Current Level of Stakeholder Acceptance*

Several potential users expressed an interest in hosting a demonstration. Of the 16 sites identified as potential users, ANL, INEL, and Princeton Plasma Physics Lab were interested in the demonstration. Three additional sites, Los Alamos National Laboratory (LANL), Portsmouth Gas Diffusion Plant, and Y-12: Chestnut Ridge at Oak Ridge, were good matches. Messages were left with these sites, but they did not contact EIT.

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(a) T.S. Peterson, *Stakeholder Acceptance Analysis: Passive Soil Vapor Extraction Using Borehole Flux*, prepared for the U.S. Department of Energy's Office of Technology Development under Contract DE-AC06-76RLO 1830. PNNL-10915, December 1995.

Information on other stakeholders' acceptance of the technology, such as regulators and the general public acceptance, can be extrapolated from the Stakeholder Acceptance Analysis report prepared in December 1995 on PSVE with boreholes.<sup>(a)</sup>

#### *Recommended Future EIT Support*

EIT recommends that the four-column matrix completed for the PSVE technology be incorporated in the test plan for the upcoming demonstration to address the issues identified by a wide range of stakeholders. The PI should stay in contact with interested sites and provide details of the demonstration. Lastly, the PSVE stakeholder acceptance analysis report should be provided to sites along with information on the demonstration to illustrate a track record of extensive stakeholder involvement that could facilitate acceptance.

### **5.2.2.8 Recirculating Well**

#### *Technology Description and Objectives*

Recirculating wells are multi-screened groundwater wells that can pump and recirculate groundwater without the cost of above-ground treatment. Groundwater was treated below ground in treatment modules that separate, destroy, or immobilize the contaminants. This technology works similarly to the In-Well Vapor Stripping System (IWVS) in that it can remove VOCs; however, it can also collect technetium-99, a radionuclide, with the use of palladized bimetallic substrate material. The system requires a pair of parallel horizontal wells. One well is for extracting groundwater, and the second well is for injecting treated groundwater. Treatment canisters in the wells capture the contaminants as the groundwater circulates through the system.

A demonstration was planned at Portsmouth in FY 1996. During the previous year, the PI had demonstrated the recirculating system at a cold site at the facility. The goal of the FY 1996 demonstration was to measure the dechlorination of trichloroethylene (TCE) and the sorption of technetium-99 attributed to the palladized bimetallic substrate material.

#### *Stakeholder Interest Ranking*

EIT ranked this technology a C (of high stakeholder interest, but limited time for a demonstration), primarily because of the potential to adversely increase contaminant mobility and the need for offsite transportation/treatment.

#### *EIT Actions*

The PLM requested that EIT work with the PI on information exchange to enhance future deployment. The funding was on hold for this project for several months, which short-circuited EIT's action plan. To provide the PI with information on stakeholder issues on a technology that had similar characteristics, EIT provided the three-column matrix created for the IWVS system.

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(a) T.S. Peterson, *Stakeholder Acceptance Analysis: Passive Soil Vapor Extraction Using Borehole Flux*, prepared for the U.S. Department of Energy's Office of Technology Development under Contract DE-AC06-76RLO 1830. PNNL-10915, December 1995.

### *Current Evaluation of Level of Stakeholder Acceptance*

Some of the findings from the IWVS system stakeholder tour were applied to the horizontal recirculating system because of the similarities between the two systems. Stakeholders were pleased that water can be treated without having to remove it from the aquifer and that treating the water in place would cost less. The horizontal recirculation system had the additional advantages of (1) destroying VOCs instead of transferring the contaminant from dissolved form to vapor form and (2) being able to handle co-contaminants.

### *Recommended Future EIT Support*

The questions asked about IWVS could also be asked of the horizontal system. Future demonstrations should address the following issues:

- Does the technology cause secondary contamination as it moves groundwater from one level to another within the subsurface?
- For what aquifer conditions is the technology well-suited? Ill-suited?
- Under what geologic conditions does the technology operate well? Poorly?
- What is the zone of influence?

## 5.2.3 Destruction

### 5.2.3.1 Remediation in Low Permeability Media

#### *Technology Description and Objectives*

Two technologies were designed to accelerate removal or *in situ* destruction of DNAPLs in silts and clays, a particularly difficult problem.

Hydraulic fracturing and hot fluid injection, the first technology, enhance the rate and extent of DNAPL mass removal by soil vapor extraction. The fractures are placed horizontally to assist in the delivery of pressurized hot air and/or steam, which in turn raises the temperature of the subsurface and mobilizes the DNAPL.

The multipoint injection system coupled with permeation dispersal of chemical agents, the second technology, enhances the in-place destruction of DNAPLs. The chemical agent (either Fenton's reagent or potassium permanganate) is delivered through porous lances that are dug into the soil.

FY 1996 focused on preparing for a full-scale demonstration at a site contaminated with TCE. The objectives of the upcoming demonstration include 1) determining and comparing the operational features of multiple technologies under full-scale conditions, 2) determining the extent and distribution of *in situ* treatment effects, 3) determining the fluid agent interaction with the soil and any resulting beneficial modifications to the transport and/or reaction properties of the soil deposit, and 4) assessing the capability of each technology to rapidly achieve cost-effective remediation to risk levels that are acceptably low.

#### *Stakeholder Interest Ranking*

EIT evaluated this technology as an A (of high stakeholder interest with the time to effect the demonstration). The issues EIT identified included concern about the potential to drive the contaminant into an unwanted area by hydro-fracturing the subsurface followed by chemical injection, ability to accurately measure and control the process, the injection of foreign materials into the subsurface, and the lack of regulatory track record.

#### *EIT Actions*

The PLM requested assistance in coordinating visits to the demonstration sites by interested site representatives. To determine other sites interest in the technology, EIT faxed a description of the technology and planned demonstration to sites with clay soils or other low permeability media. EIT then followed-up to determine their interest. EIT asked these potential users about their site's contaminants and concentrations, their geology, the cleanup schedule, and their interest in the technology.

#### *Evaluation of Current Level of Stakeholder Acceptance*

Among potential end users, two sites expressed interest in the technology. Portsmouth, the host of the demonstration, is one site interested in deploying the technology if the demonstration is successful. The Kansas City plant is interested in the performance results. However, the site has invested in demonstrations of several DNAPL treatment technologies that have provided sufficient remediation to

warrant no further action. A third site where the technology could have been applicable, Rocky Flats, was concerned about fracturing the soil and injecting hot fluids because of the potential to mobilize plutonium, a co-contaminant at the site. Additionally, the site was concerned about the public perception of fracturing more generally.

Other stakeholder groups have not been approached to evaluate the technology.

#### *Recommended Future EIT Support*

Based on stakeholder feedback, this technology will require extensive stakeholder involvement before deployment. Fracturing conveys a sense that the technology is hard to control and could result in unintended consequences, such as driving the contaminants beyond an area where they can be controlled. One step to overcome this perception would be to include in the performance report explicit discussion of the sequence of steps that the contaminant takes throughout the process. Given Rocky Flats' concern about the impact on co-contaminants, future test plans should include a radioactive proxy to measure the impact. Lastly, EIT expects that developing regulatory acceptance will be challenging. The PIs need to contact regulators at applicable sites early in the process and keep them informed on the technology's development.

#### **5.2.3.2 *In Situ* Chemical Oxidation of Contaminated Soils**

##### *Technology Description and Objectives*

This system uses strong oxidizing agents (e.g., potassium permanganate) to treat soils contaminated with a range of organic chemicals, such as TCE. The oxidizing agents take the contaminant out of solution so that it can be degraded. The applicability of the technology to treat metals and radionuclides, including oxidizing and immobilizing uranium, is also being investigated.

The FY 1996 objective was to test and evaluate the soil mixing and reagent injection apparatus to deliver a 5 percent potassium permanganate solution at different depths. The demonstration measured the contaminant concentration, oxidant concentration, and physical, chemical, and biological properties of the site.

##### *Stakeholder Interest Ranking*

EIT ranked this tech C/A (of high stakeholder interest, not enough time available to influence current demonstration, but can influence future demonstrations). As with many of the DNAPL technologies, EIT believes that stakeholders would be concerned about the injection of materials into the subsurface. In this particular case, stakeholders were concerned that the technology would negatively affect the permeability of the soil, thus hindering treatment. They were also concerned that the injected agents would drive the contaminant offsite (into an aquifer, or into a region that is more difficult to access).

##### *EIT Actions*

The PLM requested that EIT coordinate visits to the demonstration site by potential users. EIT faxed a description of the technology to potentially interested sites and followed up. Several sites were interested in the chemical oxidation project that was demonstrated at the Allied-Signal Kansas City Plant. The results of the calls were provided to the PLM in a report on May 6, 1996.

Based on the level of interest, a tour was coordinated. To prepare for the tour, EIT used the list of interested sites to identify regulators and other interested stakeholders in the same areas. The sites interested in the technology included ANL, Savannah River, LANL, and the Corps of Engineers. EIT prepared a memo for the PI on stakeholder issues to incorporate into the presentation to be given on the tour day. EIT attended the tour day and facilitated a discussion on stakeholder issues and information needs. EIT also prepared notes on the tour day. Following the tour, EIT distributed presentations to the attendees and those who were interested in the technology, but were unable to attend the tour..

#### *Evaluation of Current Level of Stakeholder Acceptance*

Based on stakeholder feedback, unresolved issues need to be addressed before deployment. Questions raised by the attendees were

- What are the by-products?
- What are the impacts on co-contaminants?
- How does this compare to rotary steam stripping?
- How do you handle the potential to mobilize metals?

Although regulators and potential users were well represented at the tour, other stakeholder groups were absent. No evaluation of stakeholder acceptance can be made for public interest groups, environmental groups, or tribal groups.

#### *Recommended Future EIT Support*

Future demonstrations should address the questions raised at the tour. For example, the Kansas City demonstration was not funded to look at intermediate products. However, stakeholders are very concerned about the possibility of an intermediate product having a toxic effect. Another example is the question about co-contaminants. No metals were present at the Kansas City site, but this could be an issue at other sites. The Kansas City tour participants should be kept informed of the technology's progress by distributing the performance report and given the opportunity to ask questions of those involved in the demonstration.

### **5.2.3.3 Adsorption/Desorption Relative to DNAPLs**

#### *Technology Description and Objectives*

This research is developing the potential to greatly increase the efficiency of bioremediation at hazardous waste sites by 1) selectively stimulating indigenous micro-organisms, 2) introducing highly active and mobile bacteria, and 3) using surfactants to desorb contaminants so that they are available to be degraded.

The FY 1996 activity was a full-scale demonstration at the Allied-Signal Kansas City Plant. The demonstration used a TCE degrading, non-genetically engineered bacterium for *in situ* degradation of TCE contaminated soil and groundwater. The bacterium was introduced into the subsurface through deep soil mixing.

### *Stakeholder Interest Ranking*

EIT ranked this technology a C/A (of interest to stakeholders, no time to affect current demonstration, but the potential to influence future demonstrations.) The same stakeholder issues and concerns for the *in situ* bioremediation would apply to this technology. In particular, this demonstration used non-indigenous bacteria, which raises stakeholders' concerns. Additionally, EIT anticipated that stakeholders would have performance questions, specifically related to measuring destruction efficiency. Lastly, use of micro-organisms raises the concern of not being able to control microbial growth.

### *EIT Actions*

The PLM requested that EIT determine the level of interest among sites where the technology may be applicable. EIT included this technology in a survey of potential OUs and found significant interest in it. The results of the survey were presented in a report to the PLM on May 6, 1996. Because of the concentration of DNAPL technologies being demonstrated at the Kansas City Plant, EIT recommended that a tour of these technologies be arranged. EIT preparation and activities at the Kansas City tour were described above.

### *Evaluation of Current Level of Stakeholder Objectives*

Stakeholders felt that many of their issues were addressed by the PI of this technology. The PI delivered a presentation that included answering the questions that were asked during the survey and other stakeholder issues that EIT had anticipated. Additionally, she answered demonstration-specific questions, including the following:

- What problems had been encountered?
- What permits were needed?
- Was the mixing complete?

The following additional questions about the technology were not addressed:

- Could the organisms be coupled with other physical or chemical processes?
- Were any plans made to bio-stimulate?
- Could the organisms perform at depths of 120 feet?

The attendees of the tour did not include representative of public interest groups, environmental groups, or tribal groups, so their level of stakeholder acceptance was not known.

### *Recommended Future EIT Support*

Future demonstrations should address the additional issues presented at the tour. The specific questions concerning the demonstration should be answered in the performance report. Issues uncovered during other bioremediation technology demonstration should be monitored. Additionally, the attendees of the tour should receive the performance report and other information pertaining to the development of the

technology. To develop a preliminary view of likely stakeholder issues from regulators, EIT recommends reading stakeholder reports on other bioremediation technologies.<sup>(a)</sup>

#### 5.2.3.4 *In Situ* Bioremediation of Chlorinated Solvent NAPLs

##### *Technology Description and Objectives*

This technology uses dehalogenating and iron-reducing bacteria, which can handle near-saturated conditions of chlorinated solvents and degrade them, as a long-term plume management technique for aquifers with these contaminants.

The research in FY 1996 was at the proposal phase. Preliminary tests were performed on anaerobic microbial growth, substrate consumption, and contaminant destruction rates to measure both direct dehalogenation and bacterial iron-reduction mechanisms. The results of the tests were used to develop kinetic models and cost estimates.

##### *Stakeholder Interest Ranking*

EIT ranked this technology an E (no demonstration site identified yet.) The issues that the technology raised were that it required subsurface injection and that it was slower than the baseline.

##### *EIT Actions*

The PLM asked that EIT track potential stakeholder issues as the technology developed. EIT used the stakeholder issues expressed in other in-situ bioremediation demonstrations as issues likely to affect the stakeholder acceptance of this technology.

##### *Evaluation of Current Level of Stakeholder Acceptance*

The technology's stage of development inhibited a meaningful evaluation of stakeholder acceptance.

##### *Recommendation for Future Work*

In planning upcoming demonstrations, EIT recommends that the following questions be addressed:

- Where should the technology be applied, given its slow pace?
- Under what conditions is the technology economically viable?
- Are the bacteria predictable and controllable?
- What are auxiliary technologies that should be matched with this system?

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(a) Reports include T.S. Peterson, *Stakeholder Acceptance Analysis: In-well Vapor Stripping, In-situ Bioremediation, and Gas Membrane Separation System* and G. R. Bilyard, G. H. McCabe, T. F. Grant, S.W. Gajewski, P.L. Hendrickson, J.A. Jaksch, H.A. Kirwan-Taylor, and M.D. McKinney, F.B. Metting, F.A. Morris, M. Skumanich, L.A. Stevenson, *Ethical, Legal and Social Issues to Consider During the Development of Microbial Bioremediation Technologies*, PNNL-11301, September 1996, prepared for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.



Additionally, as with the other bioremediation technologies discussed above, developing regulatory support was recommended. EIT anticipates that the technology will benefit from the bioremediation technologies that are further ahead in the development cycle. These technologies are likely to establish a track record with regulators and increase familiarity with bioremediation which should reduce barriers to acceptance.

### 5.2.3.5 DNAPL Remediation by Electro-Osmosis (LASAGNA™)

#### *Technology Description and Objectives*

The LASAGNA™ technology is an integrated, *in situ* treatment process for contaminants in low-permeability, clay-type soils. The LASAGNA™ process involves three components: 1) the creation of vertical or horizontal layered treatment zones within the low-permeability contaminated soil, 2) the injection of materials into the treatment zones to break down or trap contaminants, and 3) the use of continuous low-voltage electrical current generated between electrodes to move contaminated water trapped in pore spaces through the treatment zones, in a process called electro-osmosis. The LASAGNA™ process is named for the layered structure of the treatment zones.

In FY 1995, a pilot-scale demonstration at the Paducah Gaseous Diffusion Plant (PGDP) removed TCE from groundwater, collecting it on granular activated-carbon media for disposal. The initial test was very successful, achieving a contaminant removal efficiency (by adsorption) of 98%. A five month full-scale field demonstration using iron filings for the treatment zones began in July 1996 at the PGDP. The area to be remediated measures approximately 20 ft by 30 ft by 45 ft deep. In the current demonstration, the focus is on creating vertical treatment zones using vibrational-drive methods to a depth of 45 feet. The treatment zones will consist of a mixture of iron filings and clay to break down DNAPL and dissolved chlorinated solvents.

Commercialization of this technology has been a public-private partnership through the Rapid Commercialization Initiative (RCI). The consortium of private industry representatives includes Monsanto, Du Pont, and General Electric; public participants include U.S. Department of Commerce, U.S. Department of Defense, DOE and EPA. The Western Governors' Association, SSEB, and California EPA are state and regional members.

The full-scale demonstration at the PGDP will determine the most effective way to configure, install, and operate the system at low cost and whether the system components are reliable. If successful, this demonstration will be followed by complete remediation of the site.

#### *Stakeholder Interest Ranking*

Stakeholder interest scoring for the LASAGNA™ process was C (of high interest, but not schedule compatible). Although the input of other potential end users, regulators, and other stakeholders could not be incorporated into the FY 1996 demonstration test plan because of insufficient time, it was determined that a tour of the demonstration site would be beneficial. The tour would facilitate the identification of issues to be addressed to facilitate deployment of the technology at other sites. This effort was conducted in conjunction with the RCI.

### *EIT Actions*

EIT actions to support the LASAGNA™ technology included identifying and contacting potential end users to determine their interest in the technology and designing and facilitating a demonstration tour held in mid-September 1996. EIT support of the tour included planning and designing the tour, mailing invitations and handling tour registration, facilitating the tour, and preparing tour documentation.

EIT identified potential DOE end users with DNAPL problems that may benefit from the LASAGNA™ technology and potential parties interested in the tour. EIT worked with the SSEB, RCI team, and DOE headquarters to solicit input on the tour date, design, and format and worked with the DOE stakeholder coordinator, the PLM, PI, and contacts at PGDP to develop logistics for the tour. In July and August, 1996, EIT facilitated communications with the tour planning team to achieve consensus on the tour logistics, agenda, speakers, and visuals. EIT also submitted a list of potential attendees and a draft participant information package (including invitation letters tailored to various groups of attendees, a draft agenda, registration form, technology information, and logistics) for review by the planning team.

In August 1996, EIT developed a 260-person mailing list and mailed the invitation and information package. EIT handled all incoming registrations, sent out confirmation packages, developed a list of persons interested in more information but unable to attend the tour, prepared draft news releases and provided advice on media relations strategies, verified attendance and coordinated with the site, and worked with the planning team to develop final logistics based on registrations.

In September 1996, EIT participated in the site tour, and supported facilitation and last-minute logistical changes. Following the tour, EIT prepared a report summary that fully documented the tour to capture participant input on issues to be addressed in future technology work and listed action items.

### *Evaluation of Current Level of Stakeholder Acceptance*

Through the tour, potential end users, stakeholders, and regulators become more familiar with the technology. However, stakeholders may be concerned about the potential for the water to adversely increase contaminant mobility, the ability to treat co-contaminants, and the complexity of the technology.

### *Recommended Future EIT Support*

EIT recommendations for future work include the following:

- Contact DOE STCGs and end users with DNAPL problems to obtain more detailed information on their site problems, technology performance requirements, and schedules.
  - Begin with the sites represented at the tour (Portsmouth, Savannah River, ORNL Y-12).
  - Contact other end users who may be interested (ORNL K-25, ANL E, LLNL, Lawrence Berkeley Lab, Stanford Linear Accelerator Center).
- Work with RCI and technology developers to develop a summary-level information package on the technology and its applicability and performance for dissemination to regulators and stakeholders. Involve Community Leaders Network in developing the information package, based on their input during the tour.

- Develop a strategy for involving regulators from states that are not participating in the RCI and soliciting their input into future demonstration planning. Consider the following options:
  - Provide an opportunity for regulators from the Paducah site (U.S. EPA Region IV and Kentucky Department for Environmental Protection) to meet with other regulators to exchange perspectives and ideas.
  - Work with RCI and SSEB to design and facilitate a process for obtaining regulator input.
  - Disseminate information through the Association of State and Territorial Solid Waste Management Officials.

### 5.2.3.6 Arid Engineering System for *In Situ* Bioprocessing

#### *Technology Description and Objectives*

This system injects nutrients into the soil that can co-metabolically destroy contaminants. The primary commercial product of this technology is a design tool (including designing the approach, testing plans, and modeling plans) to use in assessing the applicability of and operational parameters of bioremediation systems.

FY 1996 projects included completing a demonstration of nutrient injection and performing post-demonstration well production testing, chemical sampling, and biological sampling.

#### *Stakeholder Interest Ranking*

EIT ranked this technology an A to reflect the stakeholder involvement efforts begun under the VOC-Arid Site ID. The issues with this technology were the degree of regulatory concern, the accurate measurement of performance, the control of the technology, and the link between stakeholders' understanding of the technology and the impact on acceptability.

#### *EIT Actions*

As the demonstration was completed early in FY 1996, the PLM asked that EIT write a report on the current state of acceptance. EIT worked with the PI to complete the four-column matrix on stakeholder issues. The matrix was then provided to stakeholders, who were interviewed on their acceptance of the technology. Based on the results of the interviews, the stakeholder acceptance report was prepared.

#### *Evaluation of Current Level of Stakeholder Acceptance*

Following the demonstration, the technology received a mixed review from stakeholders.

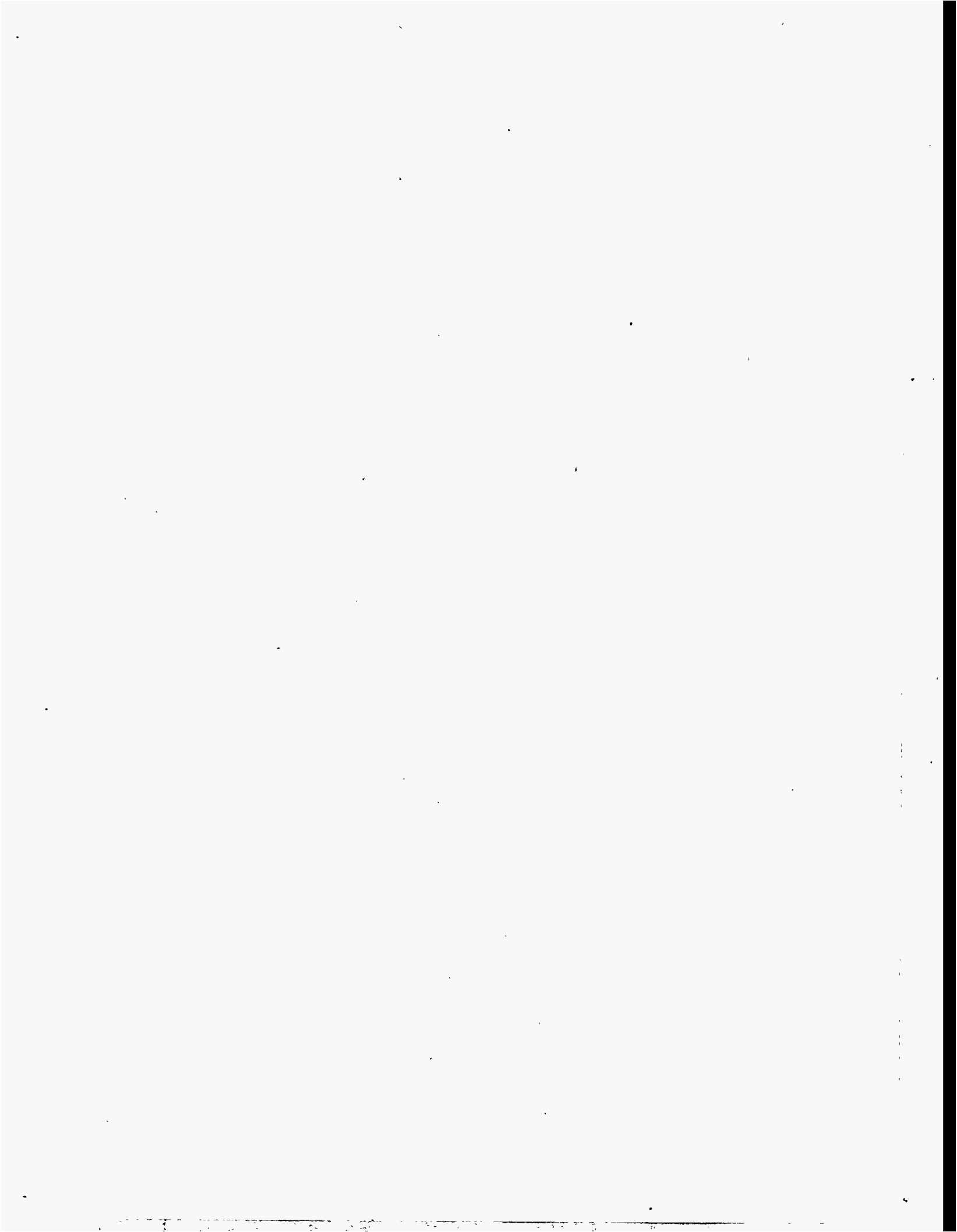
Conceptually, stakeholders were comfortable with *in situ* bioremediation. They saw advantages to the technology's ability to handle the contamination without bringing the water to the surface and the long-term remedial abilities. However, some stakeholders felt that the demonstration did not adequately test the technology and consequently have not developed confidence in it. Several stakeholders felt that well spacing was the critical parameter driving cost and effectiveness. A future demonstration should examine the trade-off between cost and effectiveness. Additionally, stakeholders would like more explicit cost information about the technology. In particular, they want a side-by-side demonstration with pump and treat, and cost information that discussed the long-term operational costs, such as labor requirements in the

monitoring costs. The design tool was viewed favorably by most stakeholders. Those who expressed reservations suggested providing increased access to the tool by demonstrating it at conferences and other forums that stakeholders attend.

*Recommended Future EIT Support*

EIT recommends that future work include the following:

- Identify potential end users
- Distribute the stakeholder acceptance report to potential end users
- Provide the stakeholder acceptance report to the PIs of other bioremediation technologies so that the likely stakeholder issues are understood
- Facilitate discussions among PIs about stakeholder issues they have addressed.



## 5.2.4 Access

### 5.2.4.1 Resonant Sonic Drilling

#### *Technology Description and Objectives*

This technology uses counter-rotating weights to generate energy that causes the drill pipe to vibrate elastically along its entire length, creating forces of up to 200,000 pounds and thus creating a cutting action. The resonant energy causes sands, gravels, cobbles and even clays to relax into the adjacent formation just enough to permit the drill pipe to advance freely. The technology completed a demonstration in FY 1995 under the former VOC-Arid Site ID program. FY 1996 activities focused on completing the performance report and identifying new sites for deployment.

#### *Stakeholder Interest Ranking*

EIT ranked this technology a C because of its stakeholder interest, but no time is available to influence the design of the demonstration.

#### *EIT Actions*

The PLM did not request any additional EIT involvement in FY 1996.

#### *Evaluation of Current Level of Stakeholder Acceptance*

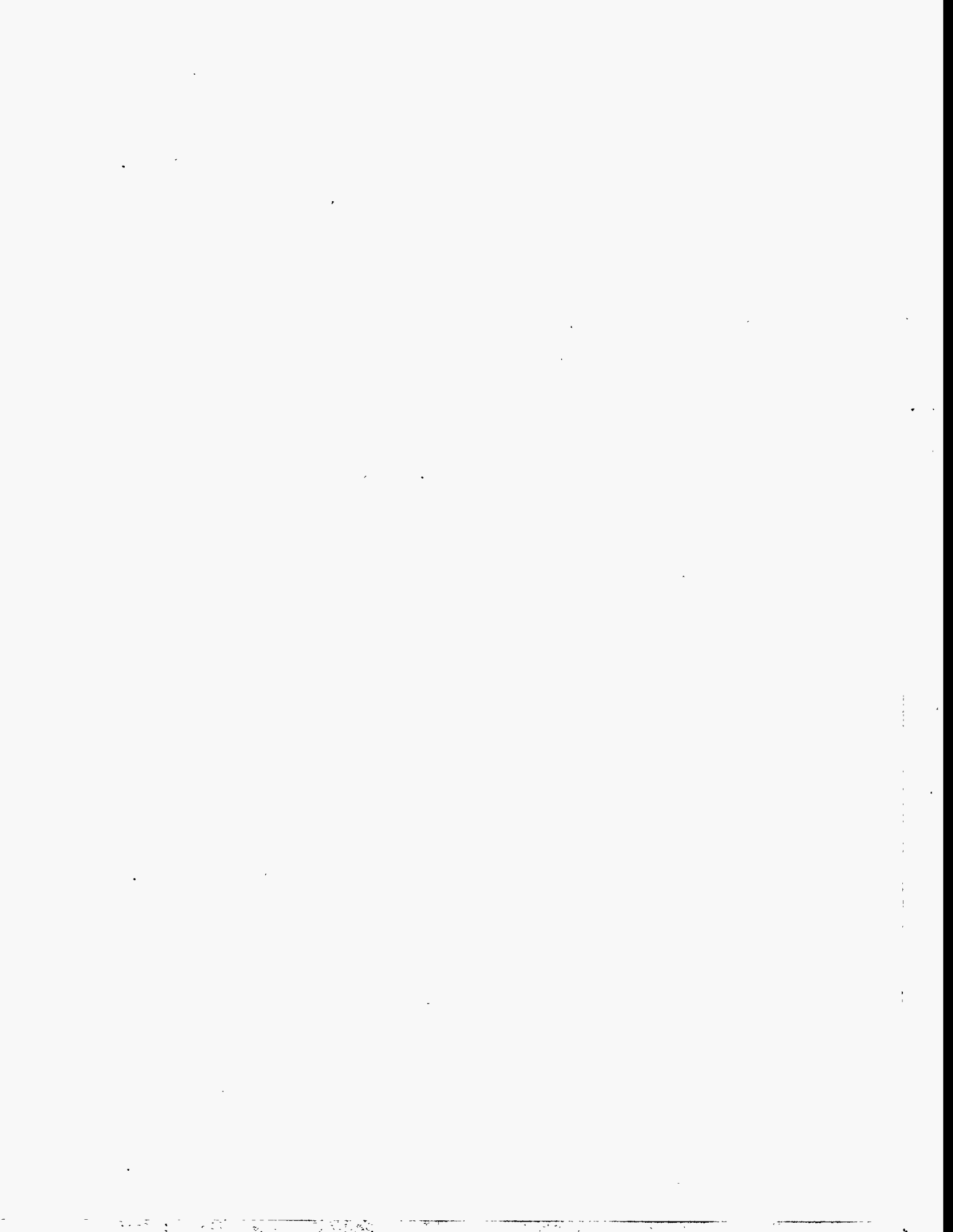
EIT concluded that the technology is ready for deployment; however, it is critical that its marketing be accurate. Questions that have been raised about this technology include 1) its cost under different conditions, 2) its effectiveness under different conditions, and 3) its reliability. Some stakeholders expressed doubt about the technology's ability to operate in a broad range of conditions. In one application of the technology, production well development yielded poor flow in the saturated zone due to possible clogging from drilling. A stakeholder acceptance report was published in December 1995.<sup>(a)</sup>

#### *Recommended Future EIT Support*

The questions raised during the demonstration centered around performance promises that the technology was not designed to keep. Future opportunities should clearly state where the technology should and should not be applied. For example, the technology is better suited to complex geology than geology with granular soils. Additionally, when documenting results, the operating parameters of the demonstration should also be clearly defined. The stakeholder acceptance report should be provided to potential end users.

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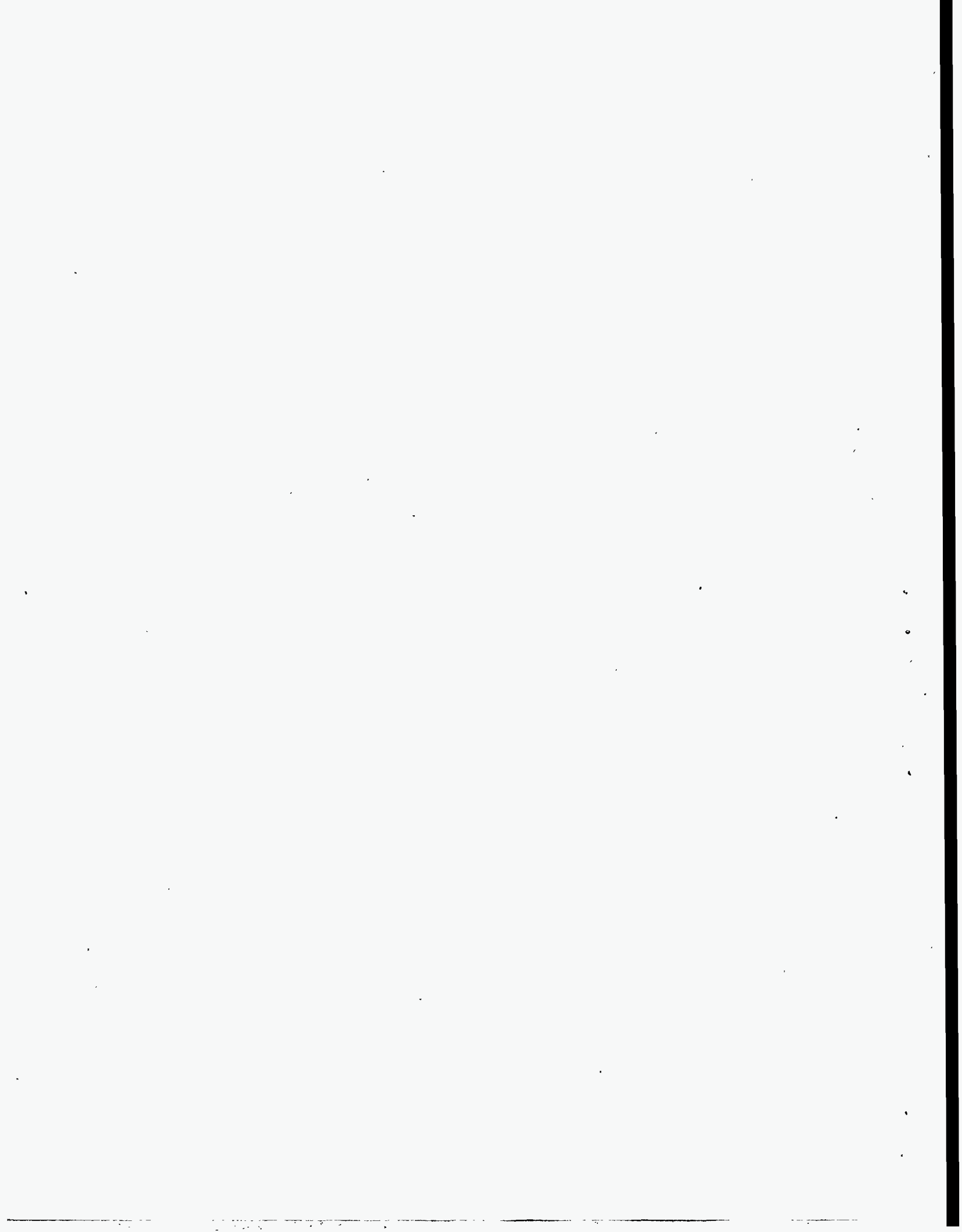
(a) T.S. Peterson *Stakeholder Acceptance Analysis: Resonant Sonic Drilling*, prepared for the U.S. Department of Energy's Office of Technology Development under Contract DE-AC06-76RLO 1830, PNNL - 10914, December 1995.



## **Appendix A**

### **PFA Example Site Template**





# Appendix A: PFA Example Site Template

## 1.0 Items Addressed During Site Visit

**Field Office:** Richland

**Date:** 2/7/95

**Recorder:** Mary Peterson/Pat Serie

**Site/Operable Unit Designation:** Hanford - 200 Areas - General

**General Priority Level:** No priorities provided because of renegotiations.

**Operable Unit Manager:** Jerry Chiaramon (200 Area Remedial Action)

**Telephone:** (509) 376-2539  
**Address:** Bechtel Hanford, Inc.  
P.O. Box 969  
Richland, WA 99352

### **Regulatory and Other Drivers:**

The plan for FY 1996 is not to do anything in the 200 areas, though soil vapor extraction will continue. Pump and treat will be stopped even for containment. Actions at ZP-1 and UP-1 will be stopped. An interim ROD was expected in March 1995 with a preferred option of pump and treat.

### **Schedule and Milestones:**

The schedule is currently being renegotiated. The site wide groundwater strategy should be approved in June 1995. The current milestones are:

#### ZP-1 Groundwater:

Initiate pilot scale pump and treat treatability test 30 days following issuance of interim record of decision (Note: Treatability test was initiated on 8/24/94; interim record of decision yet to be issued.)

#### BP-5/Groundwater (BY Cribs):

Initiate pilot scale treatability test for Tc-99 and Co-60 by 8/31/94  
Issue treatability test report by 5/31/95  
Issue Interim Remedial Measure (IRM) proposed plan by 10/30/95  
EPA tentatively scheduled to issue interim record of decision by 4/30/96

**BP-5/Groundwater (216-B-5 Reverse Well):**

Initiate pilot scale treatability test by 8/31/94  
Issue treatability test report by 5/31/95  
Issue Interim Remedial Measure (IRM) proposed plan by 10/30/95  
EPA tentatively scheduled to issue interim record of decision by 4/30/96

**UP-1/Groundwater:**

Pilot scale treatability test (U and Tc-99 only) initiated in March 1994  
Issue treatability test report by 10/31/94  
Issue Interim Remedial Measure (IRM) proposed plan by 3/31/95  
Initiation of interim remedial measure by 10/1/95 (tentative)

**Overall Cleanup Objective:**

The site wide strategy for groundwater is containment of plumes and mass reduction. This strategy will exceed ARARs. The groundwater strategy should be approved in June 1995.

**Technical Performance Requirements and Goals:**

Containment only for the 200 Area groundwater plumes.

**Current Baseline Approach/Technologies:**

**BP-5/Groundwater (216-B-5 Reverse Well):** The baseline is pump and treat using ion exchange for radiological contaminants. No treatment technology currently identified for the co-contaminants. The pump and treat system has not been successful. The well is at 200-250 ft. with Pu present at this level. If they can not pump and treat at that depth, they may have to extract and then inject a reagent to mobilize the contaminant. The contaminant is not moving very fast, so there is little risk. The strontium and cesium will be gone before they leave the central plateau. No risk assessment has been done to date. A no action ROD is expected.

**ZP-1 Groundwater:** The baseline is pump and treat using granular activated carbon and UV/OX to extract VOCs from aqueous phase. No treatment technology currently identified for co-contaminants.

**BP-5/Groundwater (BY Cribs):** The baseline is pump and treat using ion exchange for radiological contaminants. No treatment technology currently identified for cyanide or other co-contaminants.

**UP-1/Groundwater:** The baseline is pump and treat using ion exchange for radiological contaminants. No treatment technology currently identified for co-contaminants.

The cost for pump and treat with GAC at ZP-2 is \$1.8 M. The concentrations were lower than expected so the costs have gone up. They are hoping to continue operation of this pump and treat system in FY 1996.

## **Geologic Setting:**

ZP-1 Groundwater: Unconfined (water table) aquifer composed of unconsolidated, poorly stratified glacio-fluvial sand and gravel deposits (Hanford Formation), and poor to well consolidated fluvial-lacustrine deposits of the Ringold Formation. Depth to groundwater varies from 175 ft. to 250 ft. below ground surface. Hydraulic conductivity of unconfined aquifer ranges from 0.06 to >1,000 ft/day. Radial groundwater flow dominates central portion of OU due to development of groundwater mound beneath active liquid waste disposal facilities.

BP-5/Groundwater (BY Cribs): Unconfined (water table) aquifer composed of unconsolidated, poorly stratified glacio-fluvial sand and gravel deposits (Hanford Formation). Elephant Mountain Basalt Member forms base of unconfined aquifer. Basalt surface is scoured and eroded through in some localities. Depth to GW 130-150 ft; hydraulic conductivity 500 to 5000 ft/d; thickness of aquifer 1 ft to >100 ft. Minimal hydraulic gradient throughout plume area.

BP-5/Groundwater (216-B-5 Reverse Well): Unconfined (water table) aquifer composed of unconsolidated, poorly stratified glacio-fluvial sand and gravel deposits (Hanford Formation), and poor to well consolidated fluvial-lacustrine deposits of the Ringold Formation. Depth to GW is 250 ft. Hydraulic conductivity 5,000 ft/d to 10,000ft/d. Minimal hydraulic gradient through plume area.

UP-1/Groundwater: Unconfined (water table) aquifer contained in poor to well consolidated fluvial-lacustrine deposits of the Ringold Formation. Hydraulic gradient averages 0.004 throughout plume area with flow generally to the east-southeast. Depth to groundwater is 165 to 262 ft. Hydraulic conductivity 20 to 51,000 ft/d.

## **Contaminant Types, Concentrations, Volumes, and Areal Extent:**

ZP-1/Groundwater: VOC contamination in saturated zone are primarily CCl<sub>4</sub>, CHCl<sub>3</sub>, TCE (max. avg conc =7000, 1595, 24.3 ug/L, respectively). Secondary contaminants include As, F, I-129, Cr, NO<sub>3</sub>, Pu, Se, tritium, and U. Areal extent of contamination is 10E06-10E07 m<sup>2</sup>.

BP-5/Groundwater (BY Cribs): Radionuclide/Metal contamination in saturated Zone is primarily Tc-99 (4310 pCi/L); Co-60 (74.3 pCi/L); and cyanide (241 ug/L). Secondary contaminants are H-3 and Nitrate.

Hanford/200-BP-5/Groundwater (216-B-5 Reverse Well): Radionuclide/Metal contamination in saturated zone are primarily Pu-239/240 (51 pCi/L), Sr-90 (5028 pCi/L), and Cs-137 (1564 pCi/L). Secondary contaminants include H-3 and I-129. The areal extent varies with contaminants.

Hanford/200-UP-1/Groundwater: Radionuclide/Metal contamination in the Saturated zone is primarily U (1560 pCi/L), Tc-99 (28262 pCi/L), and nitrate (1.3E6 ug/L). Secondary contaminants include Carbon tetrachloride; chloroform; TCE, arsenic, cadmium, chromium, selenium, fluoride, I-129; plutonium, K-40; and Sr-90. The areal extent in saturated zone is 7E5 m<sup>2</sup>.

## **Issues and Concerns:**

The remediation activities and schedules are being renegotiated. The proposal is to defer soil remediation in the 200 Areas by 3 years and only contain the groundwater plumes.

## **Technology Needs:**

In general, ZP-2 could use technologies in the short term. ZP-1 could use technologies in the short to mid-term. They are looking at a I-129 plume in TPA milestone M-15-81B. There was also an interest in surface barriers.

In addition, we reviewed the previous needs that had been submitted and the revised needs are provided below:

### **Needs for 200 BP-5:**

#### **Characterization**

Rapid, accurate and inexpensive methods for analyzing and locating Sr-90, Tc-99, Co-60 and cyanide groundwater contamination

Methods to determine whether contaminants are present in dissolved or particulate form

Technologies that permit cost effective determination of unconfined saturated aquifer thickness on a large scale

Cost effective drilling and subsurface access technologies

On-line methods for measuring alpha, beta and gamma radiation during groundwater extraction

Cost-effective groundwater monitoring and field screening techniques

Better analytical techniques for cyanide (a minor need)

#### **Remediation**

More selective ion exchange resins or alternate treatment processes for radionuclides

Cost effective methods for deep in situ mining of soils contaminated with transuranics and fission products

In situ stabilization of radionuclides in groundwater

Technologies to install cost effective deep groundwater flow barriers such as a barrier for across Gable Gap

Cost effective treatment processes for nitrates

## **Needs for UP-1:**

### **Characterization**

Rapid, accurate and inexpensive methods for analyzing and locating Tc-99 groundwater contamination

Cost effective drilling and subsurface access technologies

In Situ methods for determining and monitoring aquifer hydraulic conditions and properties

Cost-effective groundwater monitoring and field screening techniques

### **Remediation**

More selective ion exchange resins or alternate treatment processes for radionuclides

Cost effective treatment processes for nitrates

## **Needs for ZP-1:**

### **Characterization**

Cost effective technologies or methods for determining the vertical and horizontal extent of contamination

Cost effective technologies or methods for determining the location, extent and volume of DNAPL zones

Fate and transport models capable of modeling multi-phase organic contaminants

Cost effective drilling and subsurface access technologies

In Situ methods for determining and monitoring aquifer hydraulic conditions and properties

Cost-effective groundwater monitoring and field screening techniques.

## **Remediation**

Cost effective treatment processes for nitrates

Cost effective in situ methods for long term control of the carbon tetrachloride plume

Cost effective alternative to GAC for organic removal

Methods or technologies for isolating or removing DNAPL

Cost-effective groundwater monitoring and field screening techniques.

## **Needs for ZP-2:**

### **Characterization**

Fate and transport models capable of modeling multi-phase organic contaminants

Cost effective drilling and subsurface access technologies

Methods for characterizing large-scale atmospheric losses of carbon tetrachloride from the vadose zone

Rapid broad-range compound-specific automated field screening technologies

Methods and technologies for locating immiscible phase liquids in the vadose zone

### **Remediation**

Capability to regenerate activated carbon on-site

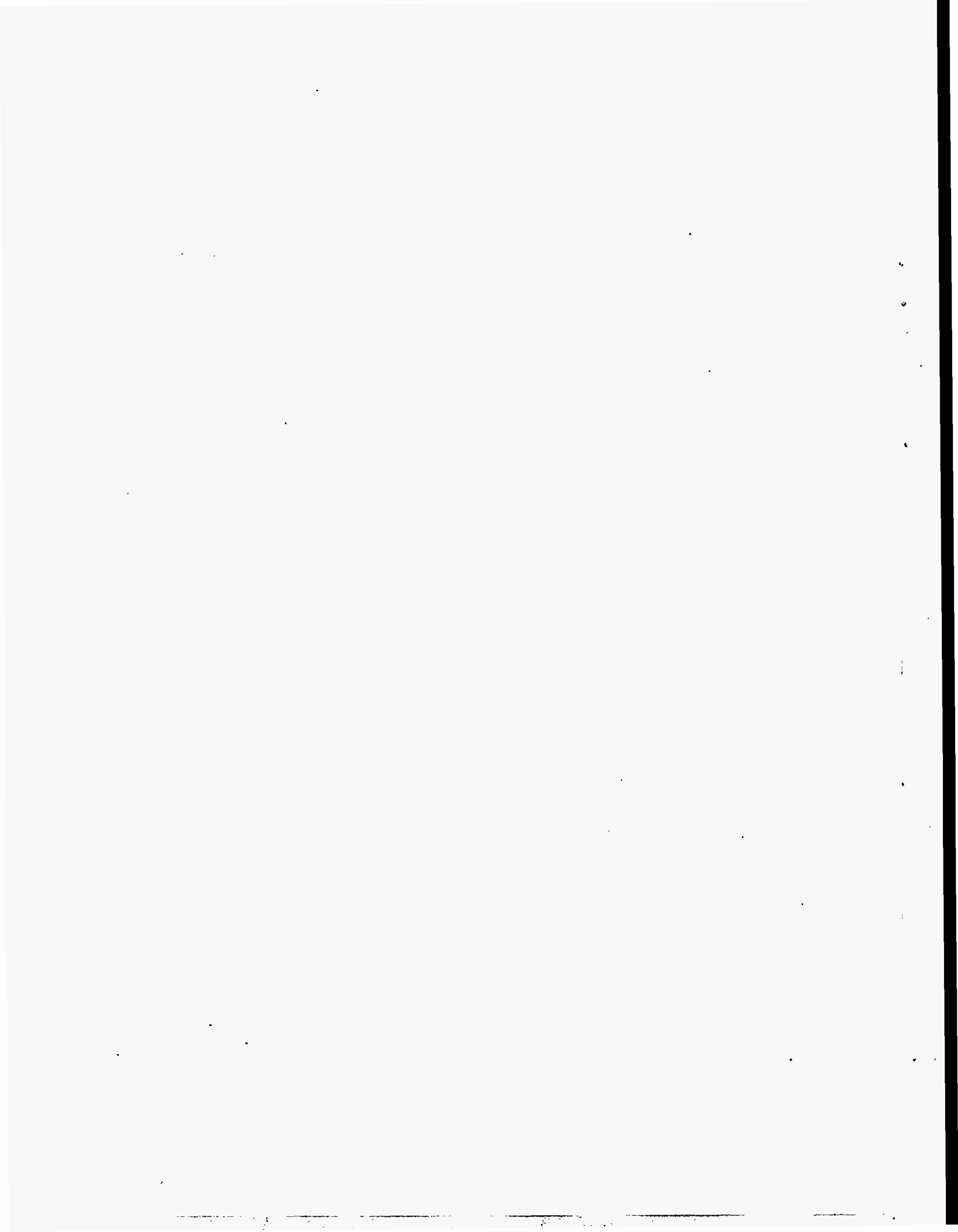
Methods to destroy carbon tetrachloride on site

Methods for enhancing vapor extraction well field and removal rates

## **Appendix B**

### **LSFA Example OU Template**





# Appendix B: LSFA Example OU Template

## 1.0 Template for Operable Unit Information

**Field Office:** Savannah River Field Office

**Date:** 10/10/95

**Recorder:** S. Hauth, J. Kauffman

**Site/Need Designation:** Radiologically Contaminated Basins: F, R, K, Old F Area Basins; H Retention Basins.  
Radiologically Contaminated/Mixed Waste Basins: L Oil/Chemical, Ford Bldg., Old TNX Basin.  
ASCAD grouping #3 (part)

### General Priority Level:

ASCAD groupings were not ranked. However, technology needs for this unit are top 3 identified for SRS-ERD overall (see Table 3).

### Operable Unit Manager:

**Telephone:**

**Address:**

### Regulatory and Other Drivers:

FFCA Agreement is the main driver for the site. Milestones renegotiated every 2 years.

### Schedule and Milestones:

Radiologically Contaminated Basins (F, R, K, Old F):	FS (earliest): 1Q FY 1996 ROD (earliest): 4Q FY 1996
Radiologically Contaminated Basins (H Retention):	FS (earliest): 3Q FY 1997 ROD (earliest): 2Q FY 1998
Radiologically/Mixed Contaminated Basins:	FS (earliest): 3Q FY 1996 ROD (earliest): 2Q FY 1997

### Overall Objective:

**Technical Performance Requirements and Goals:**

Current Baseline Approach/Technologies	Site's Evaluation		
	Cost	Effectiveness	Implementation
<u>Baseline</u> - <i>In situ</i> soil mixing/grouting/stabilization and capping	Med/Low	Med	High
<u>Options Considered</u> - Vitrification - Stabilization - Plasma Arc or Torch - <i>In situ</i> soil mixing/grouting - <i>In situ</i> chemical treatment - Capping	High High High Med/Low Med/Low Med/Low	High Med Med Med Low Med	Med Med Low High High High

**Geologic Setting:**

**Contaminant Types, Concentrations, and Volumes:**

- Radiologically Contaminated Basins (F, R, K, Old F Area): These sites have depths of contamination ranging from 10 feet to 20 feet.
- Radiologically Contaminated Basins (H Retention): This site has depth of contamination of 3 feet. Interim Action using a soil cover is being considered. Also looking at a viscous barrier to isolate the basin bottom or act as a groundwater diversion. Groundwater is flowing on-site and comes up in the basin. Runoff goes into a wetland, and vegetation has radioactive contamination. Worker safety is a major concern.
- Radiologically/Mixed Contaminated Basins (L Oil Chemical, Ford Bldg., Old TNX): These sites have depths of contamination ranging from 2 feet to 13 feet.

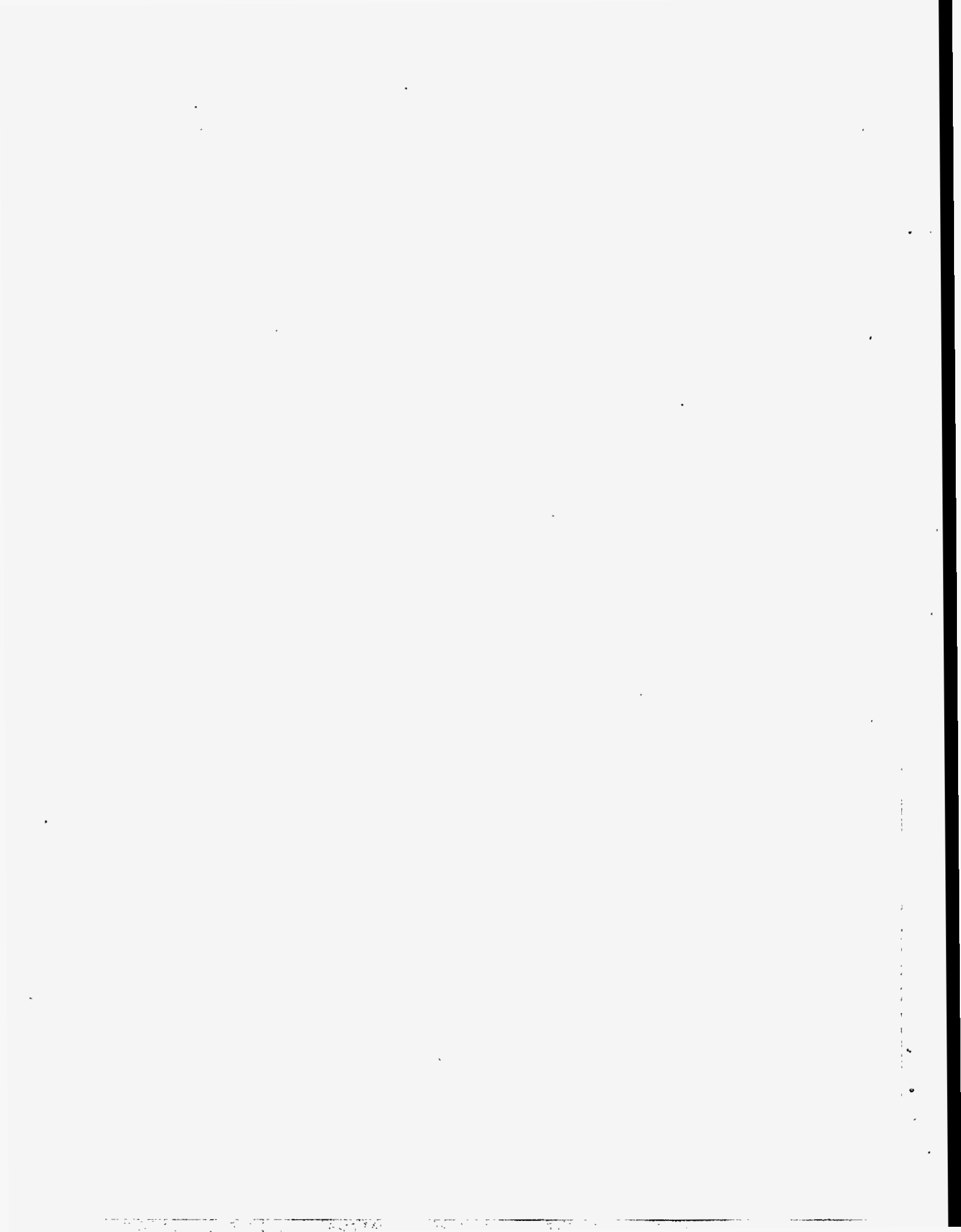
The Old F Seepage basin is a .1 acre site, with a horseshoe-shape, that has standing water in it. A treatability study to evaluate grout combinations for in-place stabilization is underway. Cs, Sr, I-129 and small amounts of other radionuclides (Eu, Pu, Tc) are contained in the vegetation. There is radioactive contamination in the groundwater and vegetation.

**Issues and Concerns:**

- Refer to other templates for OUs in ASCAD grouping #3 for related information.

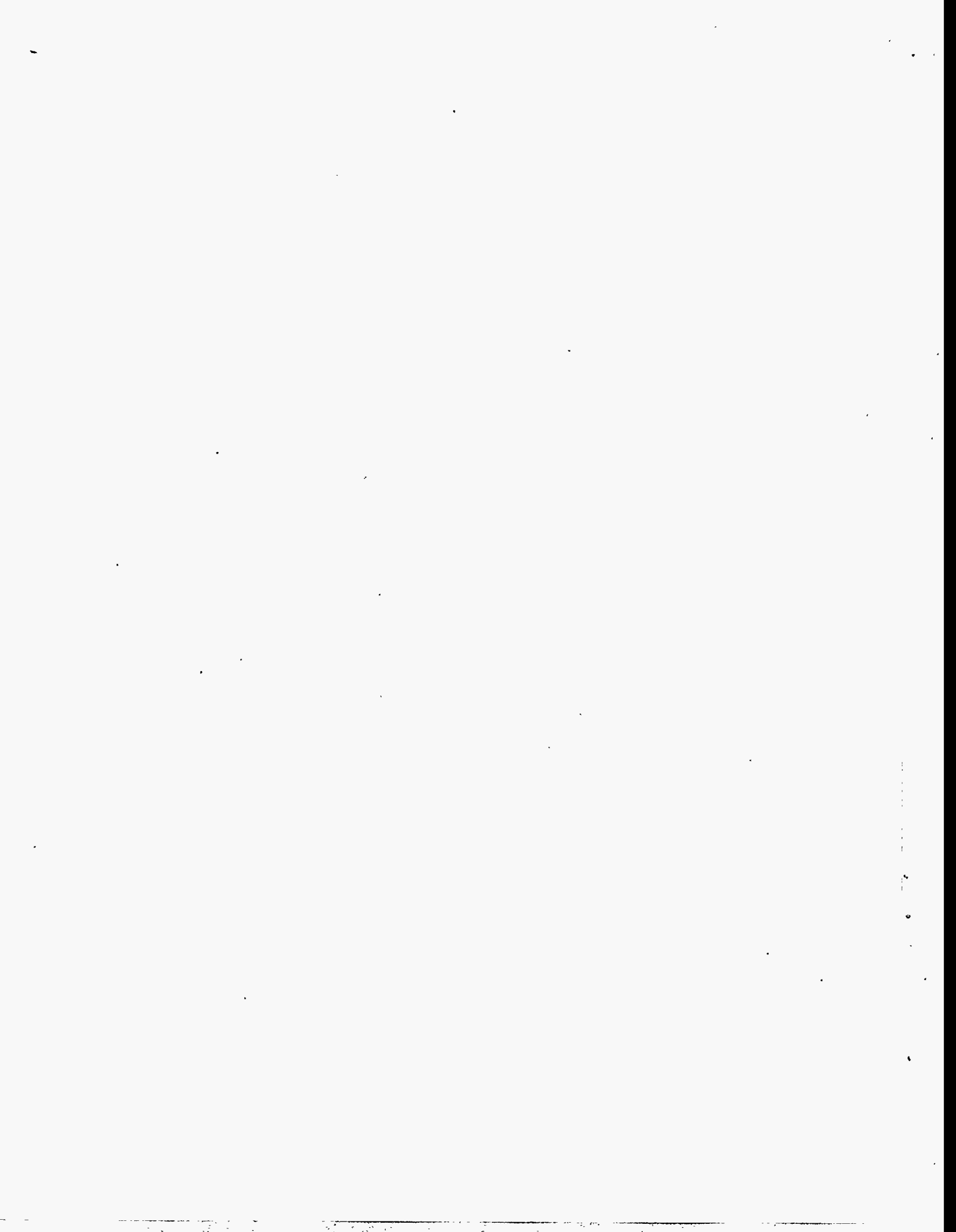
**Technology Needs:**

- Grout formulations for soil stabilization.
- Rad vegetation handling.
- Rad vegetation grout formulation and disposal.



## **Appendix C**

### **PFA Needs Assessment Matrices—Partial Example**



TECHNOLOGIES	PROBLEM/NEED CATEGORIES	FIELD OFFICE	SITES/OU's	PROBLEM	SCHEDULE
<b>METALS &amp; RADIONUCLIDES</b>					
	<ul style="list-style-type: none"> <li>Assessment/characterization</li> </ul>	<p>Albuquerque</p> <p>Albuquerque</p> <p>Albuquerque</p> <p>Albuquerque</p> <p>Albuquerque</p> <p>Albuquerque</p> <p>Albuquerque</p>	<p>LANL: In general</p> <p>LANL-Field Unit 4 - Tech Area 33</p> <p>LANL-Field Unit 5 Material Disposal Area G</p> <p>LANL-Field Unit 5 - Tech Area 33</p> <p>LANL-Field Unit 5 - Material Disposal Area C</p> <p>PANTEX - Zone 12 Groundwater - OU6 (ADS 1230)</p>	<p>Soil: Want low maintenance, continuous monitoring, unmanned method to measure tritium.</p> <p>Soil: Want methods for detecting low &amp; remote concentrations of tritium and/or methods to minimize boreholes &amp; samples required to establish plume.</p> <p>Soil: Have tritium water vapor plume but it is not well characterized.</p> <p>Soil: Have tritium water vapor plume but it is not well characterized.</p> <p>Tritium &amp; possibly fission products &amp; VOCs.</p> <p>Groundwater: Unexplained absence of chromium; HMX (explosive) between surface soils and in groundwater.</p>	<p>No specific schedule.</p> <p>Have two field seasons to complete characterization, corrective measure study will follow. But EPA doesn't regulate rad.</p> <p>Have two field seasons to complete characterization, corrective measure study will follow. But EPA doesn't regulate rad.</p> <p>Have two field seasons to complete characterization, corrective measure study will follow. But EPA doesn't regulate rad.</p> <p>Starting field work - characterization summer 95. Two field sessions to complete CMS study to follow.</p> <p>Characterization complete, treatability design and RFI Report due FY 1995, but still an issue.</p>





TECHNOLOGIES	PROBLEM/NEED CATEGORIES	FIELD OFFICE	SITES/OU's	PROBLEM	SCHEDULE
<b>METALS &amp; RADIONUCLIDES</b>					
	<ul style="list-style-type: none"> <li>● <i>Ex situ</i> separation/ extraction</li> </ul>	<p>Ohio</p> <p>Ohio</p> <p>Ohio</p> <p>Ohio</p>	<p>Fernald OU5</p> <p>Mound OU5 (SM/PP Hill and "New" property area); and OU6</p> <p>Mound OU4 (Miami Erie Canal)</p> <p>Mound OU2 Seeps</p>	<p>Soil and groundwater (on- and off-site): Uranium in soil (&gt;10,000 mg/kg), perched aquifer (&gt;100,000 ppb), and Great Miami Aquifer (&gt;1,000 ppb). Need to reinject GMA water and optimize pumping.</p> <p>Soil: Primarily Pu and Th, with other mostly radiogenic materials. In OU6, soils are under D&amp;D sites. Need technology to remove Pu from soil.</p> <p>Soil off-site: Pu (up to several thousand pCi/l) along sides and bottom of ~1 mile reach of canal.</p> <p>Groundwater: Discharging through seeps. Tritium (maximum concentration ~20,000 pCi/l at seeps - near drinking water standard).</p>	<p>Final ROD by 10/31/95. Start remediation 1/31/97.</p> <p>OU5 New properties: draft FS/proposed plan by end FY 1995. OU5 SM/PP: draft FS/proposed plan mid FY-2004. OU6: draft FS/proposed plan due FY 2005.</p> <p>Complete design and begin removal action: 4/96. Complete removal: FY 1998.</p> <p>Draft RI report FY 1998. Draft FS/proposed plan FY 1999.</p>

TECHNOLOGIES	PROBLEM/NEED CATEGORIES	FIELD OFFICE	SITES/OU's	PROBLEM	SCHEDULE
<b>METALS &amp; RADIONUCLIDES</b>					
	<ul style="list-style-type: none"> <li>Subsurface containment/stabilization</li> </ul>	<p>Chicago</p> <p>Chicago</p>	<p>Brookhaven National Lab. OU4</p> <p>Brookhaven National Lab. OU5</p>	<p>Soils: Rad concentration Cs-137, Sr-90, U, Pu, and Eu detected. Permeable barriers are of interest. Soil washing not promising.</p> <p>Concerns related to river basin area with trace concentrations of rad in the river...Offsite tritium plume not characterized.</p>	<p>Draft ROD (air sparging unit) will be signed this year.</p> <p>FS-12/95 ROD-7/95</p> <p>FS/EA/PRAP reports - 2/26/97 ROD - 11/4/97</p>
		Idaho	WAG 3, OU 3-13 (ICPP Perched Water Contaminants)	Groundwater: Sr-90 (peak 516,000 pCi/l); Np-237 (4 pCi/l); Tc-99 (592 pCi/l); tritium (32,600 pCi/l)	RI/FS 9/97; ROD 7/98
		<p>Ohio</p> <p>Ohio</p> <p>Ohio</p>	<p>West Valley Demonstration Project</p> <p>Fernald OU5</p> <p>Mound OU2 Seeps</p>	<p>Groundwater: Primarily Sr-90 (maximum concentration 1 M pCi/l). Need permeable and impermeable barriers, hydraulic control methods, and long-term monitoring.</p> <p>Groundwater on- and off-site: U in perched aquifer (&gt;100,000 ppb) and Great Miami Aquifer (&gt;1,000 ppb). Low permeability soils. Need permeable and impermeable barriers, hydraulic control methods, and long-term monitoring.</p> <p>Groundwater: Discharging through seeps. Tritium (maximum concentration ~20,000 pCi/l at seeps - near drinking water standard). Other contaminants may include VOCs. Impermeable barriers to tritium and surface barriers to water infiltration needed.</p>	<p>Design zeolite barrier wall 5/95; construct wall by end of 1995.</p> <p>Final ROD by 10/31/95.</p> <p>Draft RI report FY 1998. Draft FS/proposed plan FY 1999.</p>

## **Appendix D**

### **PFA Example Technology Matching Matrices/Fact Sheets**



## **Appendix D: PFA Example Technology Matching Matrices/Fact Sheets**

12 January 1996

Rod Warner  
U.S. Department of Energy  
Fernald Area Office  
Administrative Building  
P.O. Box 538705  
Cincinnati, Ohio 45253-8705

**Subject:** Technology Matching Information for Plume Focus Area Followup

Dear Mr. Warner:

Thank you for your help over the last few months in identifying and clarifying aspects of your sites' environmental management program that may benefit from the application of innovative technologies. The Plume Focus Area (PFA) has examined the information available on site problems and technology needs in relation to the current investment portfolio. Enclosed is a matrix that represents the PFA's first cut at relating the technologies supported by the PFA directly to operable units at your site. We have also provided information on those technologies under development in the PFA that appear to be matches with your site needs; these descriptions are intended to supplement STCG and OU manager knowledge of these potentially applicable technologies. You should note, however, that this information does not address technologies under development in other programs or that are no longer funded by the PFA.

Our hope is that you will distribute copies of the enclosed material to relevant people at your site for review and discussion. We would like feedback, through the STCG, on the following questions:

- Which, if any, of the matched technologies appear to offer a benefit to solving your sites' problems, and are you willing to enter into further discussion about their potential applicability?
- Would you like additional, more detailed information about these technologies and their development and demonstration plans in order to incorporate them into your EM planning?

We would appreciate your feedback on the potential applicability of these technologies by February 15, 1996. Please contact me at 206-528-3340 or the External Integration Team site coordinator, Jennifer Kauffman, at (206) 343-7701 if you have any questions, or if this timing is a problem.

Sincerely,

Steven L. Stein  
Lead, PFA External Integration Team

cc (w/enclosures):

J. Kauffman  
G. McCabe  
J. Wright  
K. Gerdes  
P. Beam  
J. Steele  
T. Walton

T. Early  
J. Phelan  
T. Brouns  
T. French  
D. Ridenour

## PFA Funded Projects Applicable to Ohio

12-Jan-96

<u>MATCHING TECHNOLOGY</u>	<u>PRODUCT LINE</u>	<u>ACTION</u>	<u>NEED</u>	<u>RELEVANT OUs</u>
Chemically Enhanced Barriers to Minimize Contaminant Migration	Rads and Metals - Saturated Zone	Treatment	Permeable barriers to treat/contain Sr-90 groundwater plumes	West Valley
	Rads and Metals - Saturated Zone	Treatment	Permeable barriers to treat/contain Uranium groundwater plume	Fernald OU5
Cost Risk Performance Assessment	Rads and Metals - Vadose Zone	Other	Decision support systems	Fernald OU5
Environmental Measurement While Drilling System	Rads and Metals - Saturated Zone	Characterization	Real-time monitoring of U in soil and groundwater to support remediation, post-closure monitoring, and process monitoring	Fernald OU5
	Rads and Metals - Vadose Zone	Characterization	Real-time monitoring of Pu-238 in soil at levels of 75 pCi/g. Also need to monitor other radionuclides to 25 pCi/g or lower, depending on radionuclide	Mound OU4, OU5, OU6
	Rads and Metals - Vadose Zone	Characterization	Real-time monitoring of U in soil and groundwater to support remediation, post-closure monitoring, and process monitoring	Fernald OU5



<b>MATCHING TECHNOLOGY</b>	<b>PRODUCT LINE</b>	<b>ACTION</b>	<b>NEED</b>	<b>RELEVANT OUs</b>
Permeable Treatment Barriers	Rads and Metals - Saturated Zone	Treatment	Permeable barriers to treat/contain Sr-90 ground water plumes	West Valley
Mound Bradtec (Selentec) Treatability Study	Rads and Metals - Saturated Zone	Treatment	Permeable barriers to treat/contain Uranium groundwater plume	Fernald OU5

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## FACT SHEET: CHEMICALLY ENHANCED BARRIER TECHNOLOGY

### NEED:

Much of DOE's hazardous waste has been disposed to the ground as liquid waste that remains in the sediments above aquifers. These contamination points within sediments and near-surface burial grounds can provide contaminants that migrate through the unsaturated zone to groundwater. Although conventional pump-and-treat or dig-and-treat methods can be used to remove the contamination, these methods are expensive and produce secondary wastes. Permeable reactive barriers that do not significantly restrict the flow of groundwater, but selectively remove hazardous components, may be a cost-effective substitute for conventional treatment methods. Selective barriers are needed for a range of contaminants, including organic solvents, radionuclides, and toxic metals.

### DESCRIPTION:

The chemically enhanced barrier technology uses permeable reactive barriers in aquifer

sediments or the unsaturated zone to minimize contaminant migration. Sequestering agents (e.g., zeolite adsorbents, other adsorbents, and organic chelates for strontium; metallic iron colloids for mixed waste; phosphate coprecipitation and hydrotalcite barriers for chromate; and granulated rubber tire for chlorinated organic compounds) form in-situ barriers that minimize the transport of mobile contaminants. The current focus is on the use of clinoptilolite, a zeolite mineral, to remove strontium-90 from groundwater. Technologies being evaluated in detail for emplacement of the barriers include excavation and filling of a trench with the sequestering agent and injection of chemical barriers using an injection well.

### ADVANTAGES:

The advantages of chemically enhanced permeable barriers to minimize contaminant migration include:

- The installation cost is relatively inexpensive.
- No need for continuous maintenance or a continuous energy source for pumping exists for this technology.
- During operation, there is no need for management of large volumes of water containing low concentrations of contaminants, management of secondary waste, discharge permits, or purchase of groundwater rights.
- The barrier can be left in place to immobilize contaminants.
- Human exposure to potentially hazardous materials is greatly diminished because neither contaminated groundwater nor matrix material are brought above ground.
- No permanent external treatment or pumping systems are required.
- If groundwater monitoring indicates it is necessary, another layer of barrier material could be installed or replenished.

#### **CHALLENGES:**

One potential disadvantage of the chemically enhanced impermeable vertical barrier method is that it will require disposal of some contaminated sediments brought to the surface during installation of the trench barrier. Other issues to be addressed include the constructability of the in-situ treatment zone, the ability of the barrier to remain permeable to the flow of groundwater, and regulatory acceptability.

#### **PRINCIPAL INVESTIGATOR:**

Dr. Jonathan Fruchter, PNL  
(509) 375-2532

## **FACT SHEET: COST-RISK PERFORMANCE ASSESSMENT**

### **NEED**

The time and money spent on characterization of contaminated hazardous, radioactive, and/or mixed waste sites within the DOE complex is considerable. The programmatic concerns of the site owner, the regulator and the local community result in a complex and expensive decision making process. Uncertainties in characterizing the distribution of contaminants in the subsurface and the geologic framework make it difficult to evaluate alternative remedial and economic strategies. In addition, the complexity of resolving a problem that has technical, legal, and political components requires a systematic approach to collection, evaluation, and use of data in the decision-making process. Improved decision making using information management systems, advanced geostatistical models, and economic risk-based decision analysis can reduce costs and time spent on site characterization.

### **DESCRIPTION**

To meet the complex and uncertain factors in characterizing a contaminated site (i.e., complexity and uncertainty in site conditions, legal and regulatory atmosphere, and involvement of many different stakeholders), information management and visualization, advanced geostatistical models, and economic risk-based decision analysis methods have been developed. This model and method provide a framework for decision-makers to see the big picture by integrating site conditions, engineering, and economics into a coherent picture; providing a way of documenting how decisions are made; and communicating reasons behind decisions to involved stakeholders. The process works within a framework of geological decision analysis that quantifies the uncertainties inherent when sampling natural materials and incorporates these uncertainties in a decision model. The framework is based on a risk-based philosophy of engineering decision that couples the uncertainty of geologic information with a

decision model seeking to optimize a cost-risk-benefit objective function. The probabilistic framework in which the characterization and decision making take place allows for quantitative estimates of uncertainty. The end product is an honest evaluation of the risks and benefits of alternative decision making strategies.

### **ADVANTAGES**

The economic benefits are an order-of-magnitude decrease in information management and analysis time; technically defensible, state-of-the-art site characterization and decision strategies; documentable and defensible basis for programmatic decisions; and stakeholder participation and acceptance.

### **CHALLENGES**

Key issues still to be addressed during additional research include regulatory acceptance at the regional, state, and local levels; fast, cost-effective generation and visualization of complex three-dimensional models; and acceptance of the methods used to generate quantitative estimates of uncertainty.

## **FACT SHEET: ENVIRONMENTAL MEASUREMENT WHILE DRILLING**

### **NEED**

The use of drilling equipment can result in delays in waiting for lab results on the type, extent, and location of radionuclide, heavy metal, and organic contaminants and hazardous conditions when drilling in areas where the contaminants are unknown. Thus, there is a need for a characterization technology with subsurface access and sampling abilities with which workers at the drilling site can quickly and easily identify the contaminants they are drilling into and distinguish between contaminated and noncontaminated areas.

### **DESCRIPTION**

The objective of this technology is to distinguish contaminated from non-contaminated areas in real time while drilling in soil beneath a hazardous waste site. Measurement-while-drilling includes a downhole sensor which is embedded in drilling equipment and linked by a fast data transmission system to a computer at the surface. As drilling is conducted, data are collected on the nature and extent of contamination in real time, enabling on-the-spot decisions to be made regarding drilling and sampling strategies. The initial system for radionuclide contamination includes a simple downhole gamma radiation detector (Geiger Mueller tube), and voltage and temperature detectors. The end product will be a multisensor (gamma, heavy metals, and/or VOCs) detector and data transmission system with real-time data gathering and data reduction capabilities.

### **ADVANTAGES**

Measurement-while-drilling offers several advantages which make it a cost-effective, time-saving, and safe technology. Data on the nature of contamination will be obtained in minutes, as opposed to weeks or months from an

off-site laboratory. Substantial cost savings will be achieved by minimizing the number of samples requiring off-site confirmatory analyses. Worker safety will be enhanced as a result of no waste generation, and also by instantly alerting field personnel of hazardous conditions. This on-site knowledge of contaminants also allows for more accurate placement of directionally drilled wells. Energy requirements are minimal and no secondary wastes are produced.

### **CHALLENGES**

Measurement-while-drilling provides less-sensitive detection than conventional instruments and more restricted capabilities in identifying specific radionuclides due to the use of a gross gamma radiation sensor. Several technical challenges remain, such as developing a data transmission linkage within the borehole that is sensitive and has sufficient bandwidth to transmit data to the surface in real time, and developing a total system that is compatible and does not interfere with current drilling practices. The system will be field tested during Fiscal Year 1996. As much of the system is based on pre-existing technologies, field testing is expected to be successful. Issues still to be decided include technical success during field demonstrations, achieving a data transmission system rate of at least 300 bits per second while drilling, achieving regulatory acceptance, commercialization, and increasing the flexibility of the system by adding other real-time sensors.

### **PRINCIPAL INVESTIGATOR:**

Cecelia Williams, SNL  
(505) 844-5722

## FACT SHEET: MOUND BRADTEC TREATABILITY STUDY

### NEED

The U.S. Department of Energy has identified a treatment of contaminated sediments as a major problem at several government sites. Mound Laboratory, a former plutonium-processing facility at Miamisburg, Ohio, is one such site, with an estimated four million cubic feet of plutonium-contaminated soil/sediment in the Miami-Erie Canal.

### DESCRIPTION

The technology being evaluated for the remediation of the low-level plutonium-238 contamination of the sediment at the Mound site encompasses two process: (1) washing the sediments with a proprietary (ACT\*DE\*CON<sup>SM</sup>) solution to dissolve the contaminant, followed by (2) extraction of the solution and processing with the MAG\*SEP<sup>SM</sup> process to concentrate the contaminant and allow reuse of the ACT\*DE\*CON<sup>SM</sup> solution. The MAG\*SEP<sup>SM</sup> process would adsorb the plutonium onto magnetic particles which can eventually be recycled or stabilized and properly disposed. Alternatives to MAG\*SEP<sup>SM</sup> may also be available for secondary waste recycling.

This technology is in the advanced development stage, and laboratory work has been performed to optimize the processes for pilot-scale demonstration. A project/gate review is planned to assess the value of the technology prior to proceeding to pilot-scale demonstration.

### ADVANTAGES

The potential benefit of this technology is reduction of the volume of contaminated sediments that require off-site disposal, thereby reducing waste packaging, transportation, and disposal costs.

### CHALLENGES

The technical feasibility of secondary waste treatment/recycling is a major technical challenge that needs to be addressed. Specific issues that need to be addressed include the feasibility of: (1) recycling of the wash solution; (2) regenerating the MAG\*SEP<sup>SM</sup> particles; (3) producing an acceptable waste form; and (4) reducing the volume and stabilizing the liquid waste that results from the washing process.

# FACT SHEET: PERMEABLE SUBSURFACE BARRIER TECHNOLOGY

## NEED:

The groundwater at several DOE and industrial sites is contaminated with metals, mixed metals/organics, and radionuclides. These contaminants include strontium-90, chromium, cobalt-60, uranium, technetium-99, and chlorinated hydrocarbons. Until recently, costly pump-and-treat systems, which require long-term intervention and are not always effective, were used to remediate groundwater plumes containing these contaminants. A new approach is needed that offers multiple long-term, low-cost, passive options to pump-and-treat for treating groundwater contaminated with metals and radionuclides. A viable alternative approach to pump and treat systems is an in-situ reactive barrier treatment.

## DESCRIPTION:

The permeable barrier technology creates a subsurface treatment zone through which groundwater moves. The permeable treatment zones include reactive materials that can immobilize metals and radionuclides or destroy nitrates and organic contaminants. The treatment zone is created by either excavating and filling a trench with the reactive material or injection of the reagent using an injection well.

Most research on permeable barriers has been directed toward the remediation of organic waste. However, laboratory/bench scale studies have proven that some metals, radionuclides, and mixed metals/organic waste problems have great potential to be addressed by this innovative technology.

A variety of permeable barrier materials that could be suitable for removing metals and radionuclides from groundwater have been identified, but need to be tested in the field. These may include zeolite and other adsorbents, organic chelates, iron chemicals/filings, phosphates, hydrotalcites, granulated rubber tires, and others.

## ADVANTAGES:

The primary advantage of the permeable barrier design is that a large contaminated groundwater plume can be treated in a cost-effective manner relative to traditional pump-and-treat. Pump-and-treat systems will generally have a lower initial cost (capital investment) than a permeable barrier system, but the savings from the permeable system come later as the active pump-and-treat system continues to accrue steady costs, while the passive permeable treatment barrier has minimal costs for operation and maintenance. The time required for the permeable barrier to become the economically beneficial choice depends on the actual emplacement costs.

Laboratory tests have shown excellent treatment results and have improved upon the results achieved with pump-and-treat technologies. In addition, many difficult-to-treat contaminants reagents can be treated with this approach at lower cost and improved worker safety because the treatment is below the ground surface.

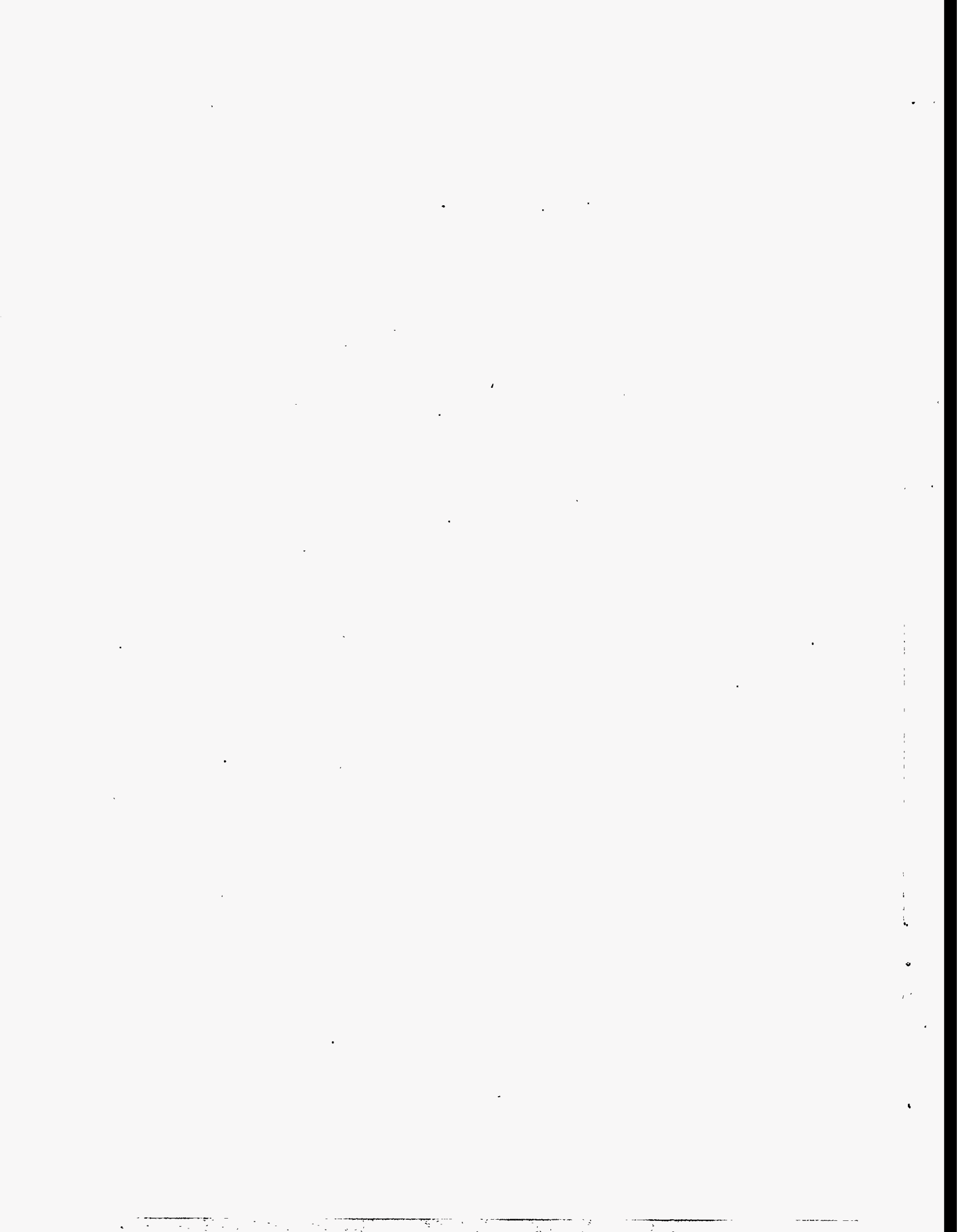
## CHALLENGES:

The potential for the permeable barriers technology has been established through laboratory testing, but field studies are needed to extrapolate to actual field conditions and larger-scale operations. Issues to be addressed include the constructability of the permeable barriers, the ability to address co-contaminants, and the ability to maintain flow permeability through the reactive treatment zone to avoid plugging of the aquifer.

## **Appendix E**

### **Report on Factors for Regulators and Stakeholders Acceptance of Innovative Technologies**





# **Appendix E: Report on Factors for Regulators and Stakeholders Acceptance of Innovative Technologies**

## **FACTORS FOR AND STAKEHOLDER ACCEPTANCE OF INNOVATIVE TECHNOLOGIES WITHIN THE PLUMES FOCUS AREA PORTFOLIO**

**Gretchen H. McCabe, Battelle Seattle Research Center  
Helene Kirwan-Taylor, Battelle Seattle Research Center  
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Patricia Serie, EnviroIssues  
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## 1.0 OVERVIEW OF TECHNOLOGY ACCEPTABILITY ASSESSMENT

To enhance deployability of innovative soil and groundwater cleanup technologies, the U.S. Department of Energy's (DOE's) Contaminant Plume Containment and Remediation Focus Area (PFA) is involving users, regulators, and other stakeholders in the technology development process through Site Technology Coordination Groups (STCGs) at the field office level. As specific technologies being sponsored by the PFA are developed, their acceptability for application at various DOE sites will be evaluated based on input from STCGs and their stakeholders.

It is possible at this time, however, to define general acceptability factors based on previous work with regulators and other stakeholders in the technology development field.<sup>(a)</sup> These general acceptability factors, described in this deliverable, can be considered by technology development personnel (e.g., PFA team personnel, technology development principal investigators, environmental management personnel at sites where the innovative technologies may be applied) in the further development of their technology to improve its acceptance. These acceptability factors will alert those parties involved in technology development to the questions and areas of public and regulatory sensitivity, or concern, and allow for appropriate involvement of regulators and stakeholders at different stages in a specific technology's development.

Based on application of these acceptability factors to the projects receiving PFA investments, the team is designing technology- or project-specific action plans for interacting with STCGs and, through them, with their stakeholders. In that way, each technology's concept, demonstration plan, and operating parameters can be tailored to provide the information or protections needed to facilitate stakeholder acceptance of the technology.<sup>(b)</sup>

The technologies used in investigating and remediating DOE's contaminated sites nationwide fall into several categories, including:

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- (a) Peterson, T.S., G.H. McCabe, B.R. Brockbank, P.J. Serie, and K.A. Niesen, *Arid Sites Stakeholder Participation in Evaluation Innovative Technologies: VOC-Arid Site Integrated Demonstration*. Prepared for the U.S. Department of Energy, Office of Technology Development, PNL 10524, May 1995. See also forthcoming reports on Final Evaluation of Passive Soil Vapor Extraction, Sonic Drilling, and Tunable Hybrid Plasma.
  - (b) Several organics treatment technologies that were originally included in the PFA portfolio, including tunable hybrid plasma, recirculating well treatment, borehole freezing, and soda lime destruction, have been deleted from the program due to funding constraints. They are not addressed in this document.

- Characterization
- Access
- Treatment and Remediation
- Secondary Waste Management

Appendix 1 lists the stakeholder acceptability factors and criteria developed earlier in the PFA process, and relates them to the categories of technologies to which they are generally applicable. Cost is an important issue with all technologies. However, there is often insufficient data on cost to assess whether or not it is a problem for a technology. The following sections of this report describe the issues and criteria that relate to the four categories and to the specific technologies included in the PFA portfolio.

It should be noted that all of these considerations are postulated on input received from a variety of stakeholders in assessing the acceptability of previous DOE environmental restoration work. As the PFA proceeds with matching technologies to site needs and working with those sites' STCGs to enhance acceptability of the technologies, greater certainty will be achieved about technology-specific acceptance factors.

## 2.0 ACCEPTABILITY FACTORS RELATED TO CHARACTERIZATION TECHNOLOGIES

Characterization of site contamination problems has been the focus of DOE activities for several years. Characterization techniques for many contaminants and site conditions have been developed, but have often proved to be costly, time-consuming, and not necessarily accurate enough to support cost-effective remediation that meets regulatory requirements. In some cases, for example methods to accurately locate and characterize Dense Non-Aqueous Phase Liquids (DNAPLs) are not currently available in industry or within the DOE system.

The most desirable attribute of characterization technologies is the ability to operate in real time in field conditions, producing immediately- available information to support field decisions on how deep to excavate, how much water to pump, or other remediation decisions. The ability to monitor effectiveness of the remediation in the field is also a major objective. Through use of technologies that allow for real-time results, significant cost and time savings can be achieved.

In addition to those basic elements of a preferable characterization technology, characterization approaches that have the potential to adversely affect contaminant mobility or that require subsurface injection of characterization agents will likely raise stakeholder concerns. The ability of a characterization technology to identify and measure multiple contaminants is of significant interest, as well as the versatility of the technology -- its suitability for use in a broad range of site conditions. Simple, easy to maintain characterization technologies are preferred over complex or high-technology systems.

The characterization technologies included in the current PFA portfolio can be expected to raise the following stakeholder issues:

- **DNAPL Location/Distribution:** Methods being assessed under this topic include injection extraction tests using alcohol and surfactant solutions to determine the presence or absence of DNAPL near existing monitoring wells. Other methods to locate and characterize the presence of

DNAPLs include differential tracer tests, borehole geophysical logging and cross-hole seismic or electrical tomography, cone penetrometer measurements, and enhanced access techniques. The alcohol and surfactant solution injections will likely be of greatest interest and potential concern to stakeholders. They may be afraid that the injected substance will increase the contaminant's mobility and drive it into an unwanted area (e.g., offsite, into an aquifer, or into a more difficult to access region). Stakeholders may also be concerned about the level of expertise required to conduct the work. The lack of a regulatory track record may be an issue for some of these methods.

- **Cost/Risk Performance Assessment:** This is an assessment of a collection of decision support tools to help field personnel expedite characterization work. One tool under evaluation is a software program that uses a probabilistic framework to reduce the chance of collecting unnecessary data either because the area under consideration for sampling is clean or because sufficient data has already been collected in the area. It is believed that by using this performance assessment, the user will have higher confidence that his or her characterization activities have obtained the truly important information which can be used in decision making, and avoid the expensive often extraneous information. Since probabilistic approaches are often difficult for stakeholders to understand, stakeholders may not have the necessary confidence in this performance assessment. They may have an additional concern about the level of expertise needed by the user to operate the decision support tools.
- **Environmental Measurement While Drilling:** This system uses a simple, general purpose gamma ray detector which measures gross gamma-ray counts to distinguish between contaminated and non-contaminated soils in real time. Since the tool operates *in situ*, stakeholders may be concerned about verifying the accuracy of the information.
- **Tritium Analysis System:** This technology is a rapid monitoring device for portable, automated field sampling of water samples containing low levels of tritium contamination. As with the above characterization technologies, reliability may be a concern to stakeholders.
- ***In Situ* Permeable Flow Sensor:** This instrument directly measures the direction and magnitude of the 3D groundwater flow velocity vector in saturated, unconsolidated porous media. There may be potential regulatory issues related to assurance that the technology works as intended.

### 3.0 ACCEPTABILITY FACTORS RELATED TO TECHNOLOGIES FOR GAINING ACCESS TO CONTAMINANTS

There are a number of stakeholder concerns that can be expected for technologies that address gaining access to contaminants (e.g., drilling). Speed of operation, and hence completion of the access task, is of primary importance. Also important, and related to speed of operation, is the cost of the technology versus today's baseline life-cycle cost. Developers and demonstration teams must be able to show that an access technology does not adversely affect contaminant mobility, such as allowing cross contamination across geologic media.

Technologies that do not require addition of substances below ground (e.g., drilling muds) are preferred. Versatility of the access technologies is an important criterion, with preference for methods that can be used in a variety of media, depths, borehole sizes, and other factors. Simplicity, ease of maintenance and operation, safety and reliability, and production of secondary waste (e.g., drill cuttings) are important factors in acceptability of access technologies. If regulators are experienced or familiar with the technology, regulatory uncertainty may be reduced. Access technologies that change the physical nature of the land, possibly damaging natural or man-made structures or altering geologic or topographic characteristics, can be expected to raise issues and concerns.

Within the PFA portfolio, only one access technology is currently under development. It is:

- **Sonic Drilling:** The technology uses counter-rotating weights to generate energy that causes the drill pipe to vibrate elastically along its entire length creating forces of up to 200,000 pounds and thus creating a cutting action. The resonant energy causes sands, gravels, cobbles and even clays to relax into the adjacent formation just enough to permit drill pipe to advance freely. The cost of this technology is of particular importance and potentially of concern to stakeholders. Sonic drilling is expensive, but offers both speed and angled drilling as benefits to offset cost. However, the versatility of the technology is being questioned, given recent difficulty of drilling production wells in the saturated zone. The technology is now under review to determine where it is applicable and where it has limitations.

## 4.0 ACCEPTABILITY FACTORS RELATED TO TREATMENT AND REMEDIATION TECHNOLOGIES

By far technologies for containment, treatment, and remediation are expected to raise the greatest number of regulatory and stakeholder issues. This broad category includes technologies designed to remove contaminants from their host medium; treat and destroy contaminants in place; and passively treat contaminants using a variety of permeable barriers.

All of the criteria related to technology performance, as described in Appendix 1, come into play in evaluating treatment and remediation technologies. Most important are those technical elements that may be perceived to increase risks or damages, such as increasing contaminant mobility, subsurface injection, the potential for technology failure and resulting human or environmental impacts, and production of dangerous emissions or releases. Also of major stakeholder concern are issues of cost, ability to address co-contaminants, and process waste management issues such as concerns about waste characteristics and volumes; storage, treatment and disposal options and availability on-site and offsite, as well as cost; and the ability to recycle the secondary waste. Other issues that support cost-effective cleanup that should be evaluated include the timeliness of the technology, technology versatility, simplicity and ease of maintenance and operation, and regulatory track record and infrastructure. Stakeholders also prefer technologies that do not transfer the contaminant from one environmental medium to another. In cases where the contaminant is removed and pulled to the surface, stakeholders want to know that the auxiliary technologies needed to effect the treatment or remediation are in place, and do not raise additional concerns of their own.

There are a large number of technologies in development to address removal, *in situ* destruction, and permeable barrier needs. These are explained in the following sections.

### 4.1 REMOVAL

The following technologies remove contaminants from either the vadose zone or the saturated zone. Contaminants require further treatment and possibly disposal once they are above ground. Some stakeholders may see this as simply transferring the contaminants from one environmental medium to another. The concern associated with this is that costs may be higher, because of the added expense of treating the contaminant once it is above ground, including the potential need to ship the contaminant off-site for further treatment or disposal. This management of secondary or process waste is seen as posing more risks to human health and the environment. Stakeholders may also view removal technologies as more likely to include emissions or releases of contaminants, both intentionally and unintentionally. In cases of the latter incident, under some failure scenario, stakeholders fear that the environment and human health will be harmed.

- **In-Well Vapor Stripping:** This system is designed to change the VOCs in the groundwater from the dissolved phase into the vapor phase and transport these vapors to the surface for treatment or release. Some stakeholders are concerned about how the technology will be classified by the regulatory community -- as either a reinjection or recirculating system. The former could be problematic. Stakeholders have expressed concern over whether the recirculating cell would push contaminants out of the treatment zone. It is important to stakeholders to know what auxiliary technologies (e.g., off-gas system) are planned to be used with the technology. The technology

can only address VOCs, therefore would not be capable of handling non-VOC co-contaminants in cases where they are present.

- **Passive Soil Vapor Extraction:** This technology takes advantage of natural changes in the atmospheric pressure to capture escaping VOC vapors from both boreholes and surface area. Additionally, much of the FY96 research is focused on enhancing the atmospheric flow through use of valved well heads, wind turbines, and surface modifications. The technology is not intended to be applicable to all cases where VOC gases need to be removed from the vadose zone. The technology is, by design, slower than active soil vapor extraction (the baseline) which will reduce its acceptability in conditions where speed is important. Stakeholders may be concerned about the release of the gases in cases where they are not captured and be concerned about offsite treatment/transportation of the contaminant in cases where they are captured. The technology may be viewed by stakeholders as having a narrow range of applicability, given the limited plume size it can remediate. Some stakeholders may feel that the technology is also limited in the degree to which it cannot control the movement of a plume. Some stakeholders may feel that the technology is not effective enough to be worth the expense, even though it is not as expensive as active soil vapor extraction. The surface modifications of passive soil vapor extraction may raise aesthetic concerns given that they will alter the terrain. Finally, there may be an issue about the lack of a regulatory track record in using the technology.
- **Thermally Enhanced Vapor Extraction System:** This technology is a thermally enhanced soil vapor extraction system that uses ohmic and radio frequency heating. The soil acts as a resistor and is therefore resistive/powerline type heating in that the soil serves as the conduit for electric current. In contrast, radio frequency heating uses electromagnetic heating. VOCs in the vadose zone are volatilized using this technology. It is well documented that thermal technologies are generally of great concern to stakeholders. They generally find technologies acceptable that solely transfer contaminants from soil to air where they are released. Stakeholders may see this technology as closely related to incineration and, therefore, be opposed to it. Stakeholders will want to know about auxiliary technologies required for the whole system to operate (e.g., whether an off-gas system is planned and its design). The cost of this technology could be an issue. Finally, under a failure scenario, if significant emissions could result, stakeholders would likely oppose the technology.
- **Six-Phase Soil Heating:** This method increases the removal of volatile and semi-volatile contaminants from soils by resistance heating. Heating contaminated soil volatilizes the contaminants for extraction using conventional soil vapor extraction equipment. The system requires fairly large amounts of energy and produces emissions, which require subsequent treatment (often offsite). Some stakeholders may see the technology as transferring contaminants from one medium to another. An auxiliary technology would need to be identified for handling the off gas. Finally, the lack of a regulatory track record may be an issue.
- **Evaluation/Demonstration of DNAPL Remediation Methods:** The methods in this project focus on making contaminants available for mass removal, not destroying them. This can be seen by stakeholders as simply transferring the contaminant from one medium to another. Stakeholders would want to know what auxiliary methods are being planned to destroy or recycle the contaminant and whether or not these methods would require offsite transport and treatment.



Some of the methods under this topic will include using alcohol and surfactant flushing. Stakeholders may be concerned about the injection of those substances and the potential for them to accelerate the mobility of the contaminant (a target of these methods but unintentionally driving them to unwanted areas). Again, failure control may be an issue.

- **Evaluation of DNAPL Mobilization Potential:** Under this activity, quantitative models are developed and tested to improve the understanding of DNAPL behavior in porous media. Of primary interest is determining the critical interfacial tension values that can be tolerated to prevent DNAPL mobilization in the subsurface during remediation when surfactants and alcohol are used. This work aims at improving the design of remediation plans. This approach is only applicable to sites that have actually detected DNAPL. Stakeholders may be concerned about the limited versatility of the research, given that the majority of sites are inferring the presence of DNAPL and have not actually located it.
- **Enhanced Uranium Recovery from Groundwater Plumes:** Solution-mining water injection methods are being used to reduce the time necessary to pump and treat groundwater to remove uranium from an aquifer. An ion-exchange facility is part of the system to extract the uranium from the solution. Stakeholder concerns may focus on the need to inject a substance into the subsurface and the fear that it may somehow adversely increase contaminant mobility. Because this is not an *in situ* technology, there is the need to manage the uranium once it has been separated from the groundwater. This may pose some concern to stakeholders. They will likely want to know what off-site treatment and transportation requirements there will be.
- **Biomass Remediation:** This system uses plants that have the natural ability to take up stable radioactive metals from contaminated soils and aqueous waste streams as a means to remove contaminants from a site. Such an approach is applicable to sites with shallow contamination. Stakeholders may be concerned about how the plants will be destroyed once they have accumulated the contaminants and the potential for that destruction process to result in re-releasing the contaminants back into the environment. Stakeholders will likely want to know what auxiliary technologies are planned for this bio-waste (e.g., some form of incineration or burial). Some may see this technology as simply transferring the contaminant from one environmental media to another since the secondary waste will have to be managed. Some stakeholders may question the need for this technology given the various other ion-exchange type of technologies to remove contaminants. Full-cycle costs of this technology may be an issue in comparison with other baseline technologies.
- **Electrokinetics System:** There are two technologies in the electrokinetic category. The first one creates an electric field in soil to force radionuclide and metal contaminants in low-permeability soils toward *in situ* electrodes. The contaminants are then removed with minimal excavation required. Since some unsaturated soils do not contain sufficient moisture for effective electrokinetic remediation, development of a moisture-addition method is underway. Secondary waste management of removed chromium is through off-site treatment and disposal. The second technology uses the electrokinetic phenomenon to pull surface soil contaminants through a water-permeable ion exchange barrier that captures uranium for disposal. Extractants are used to enhance metal solubility. A leaching solution (e.g., carbonate, citrate flood) is used to extract the uranium. In this later case, electric field strengths have caused high soil temperatures that have

been sufficient to disassociate uranium complexes and limit electrokinetic remediation success. Temperatures have reached 60° C. With both of these technologies, stakeholders may view them as transferring contaminants from one environmental medium to another since removal is required following the use of the technologies. Both of the technologies require the injection of a liquid which could be viewed by stakeholders as a means to drive contaminants down into the groundwater. Identifying failure scenarios, predicting the possible environmental and human health impacts, and knowing what responses would be taken to prevent and, if ever needed, rectify such situations may be another concern. Increased energy demand and the high temperatures needed for the second version of an electrokinetic technology may also be raised as concerns by stakeholders. Thermal technologies are generally viewed very negatively by stakeholders. Much of the fear is centered around emissions that can result and the impossibility of capturing harmful emissions once they are airborne. Stakeholders will likely want to know what auxiliary technologies are planned to be used with these technologies to remove the contaminants.

#### 4.2 *IN SITU* DESTRUCTION

The following technologies destroy contaminants underground, removing the need to bring them to the surface and treat them. In all cases some substance such as water, surfactants, nutrients, non-indigenous bacteria, oxidizing agents, and chemicals are injected into the subsurface (vadose zone or unsaturated zone) to isolate and destroy the contaminants. In addition, heat and force (e.g., hydraulic fracturing) are used to support the remediation. Stakeholders will support seeing these contaminants treated *in situ* but will likely have concerns about the means to destroy them. Specifically, the injection of substances (particularly in cases where they are toxic) will likely be feared by stakeholders. They will worry that the substances will increase the mobility of the contaminants (a goal of many of the DNAPL technologies) but to unwanted areas such as offsite, into an aquifer, or into an area that is difficult to access. Moreover, they will likely be worried about the use of heat and hydraulic fracturing to further the remediation process. Failure scenarios will need to be identified, explained, and planned for. Stakeholders will likely want assurance that the technologies are operating as expected, which will require defensible monitoring plans. Many of these technologies are seen as overly complicated and requiring high experienced personnel to operate which may be of concern to stakeholders. Finally, cost and regulatory track record are likely issues that will be raised. Many of these technologies hold the greatest promise for making a substantial improvement in environmental restoration, but with such great changes and the use of more sophisticated technology come risks.

- **Arid Engineering System for *In Situ* Bioprocessing:** The primary commercial product of this technology is a design tool (including designing the approach, testing plans, and modeling plans) to use in assessing the applicability of and operational parameters of bioremediation systems. These systems inject nutrients into the soil that can co-metabolically destroy contaminants. Regulators have historically had some concern about injecting substances into the subsurface. Stakeholder concern will likely depend on the make-up of the substance being injected. Non-toxic substances, like acetate, will be of much less concern than toxic substances (nothing toxic was injected as part of the demonstration). Stakeholder concern would also elevate if non-indigenous microbes or genetically-engineered microbes were to be injected (not part of this demonstration). The other primary concerns about bioremediation are the ability to accurately measure the performance of the technology and to control it. Potential failure impact may be one of the greatest fears of stakeholders. They may question how easy it will be to detect a failure and how feasible it will be to rectify any resulting problems. Bioremediation is not a complex technology,

but the science behind how the technology operates is not necessarily well understood by stakeholders.

- **RTDF Bioremediation Activities:** This effort is focused on both active anaerobic bioremediation and intrinsic bioremediation (natural attenuation) of trichlorethylene (TCE) at the same site. The goal is to develop protocols for assessing and deploying bioremediation systems, have these protocols approved broadly by regulatory agencies, and then disseminate the protocols. With respect to active anaerobic bioremediation, stakeholder concern will likely mirror that described above for the Arid Engineering System for *In Situ* Bioprocessing. The task to develop a reaction kinetic tool is at the bench scale phase and would, therefore, be of less concern to stakeholders. Nonetheless, the same concerns listed above would likely be relevant to later development and deployment stages of this tool.
- ***In Situ* Bioremediation of Chlorinated Solvent NAPLs:** This technology uses dehalogenating and iron-reducing bacteria, which can handle near-saturated conditions of chlorinated solvents and degrade them, as a long-term plume management technique for aquifers with these contaminants. The technology is in an early stage of development. Nonetheless, stakeholder concern will likely center around the same issues as raised for the other bioremediation technologies. Some may feel that this long-term management technology is not appropriate for NAPL plumes and needs to be used more aggressively.
- **Adsorption/Desorption Relative to DNAPL:** This research is developing the potential to greatly increase the efficiency of bioremediation at hazardous waste sites by 1) selectively stimulating indigenous microorganisms, 2) introducing highly active and mobile bacteria, and 3) using surfactants to desorb contaminants so that they are available to be degraded. The same stakeholder issues and concerns raised above for *in situ* bioremediation methods would apply to this technology. If non-indigenous or bio-engineered organisms are planned as the "highly active and mobile bacteria" to be used, stakeholders will likely have great concern. In addition, stakeholders may be concerned that the surfactants will increase the spread of the contaminants. They will likely want confirmation that the technology is working as planned -- performance can be measured real time. Furthermore, they will want the technology to be controllable so that if an accident occurs, users can bring the system under control. Since the treatment of DNAPL is fairly new, there may be an issue of regulatory track record associated with this technology.
- **DNAPL Remediation by Electro-osmosis:** Electro-osmosis is the movement of water through soil matrices induced by an applied electric field. For remediation in clays and other low-permeability soils, this method introduces water that flows under electro-osmosis through the contaminated soil, flushing the contaminant to an area for further treatment or disposal above ground. Stakeholders may be concerned about the potential for the water to drive contaminants into unwanted areas as described above. The technology may be seen by stakeholders as rather complex and requiring high expertise on the part of the users, which could lead to lower stakeholder acceptance. Finally, the regulatory track record may be an issue at some sites even though the technology is being supported by the regulators at the host demonstration site.
- **Remediation of DNAPL in Low-Permeability Media:** *In situ* remediation methods are being evaluated for both source control and mass removal of DNAPL compounds in silts and clays using

thermal enhancement and fracturing methods. This technology hits high on most of the factors driving stakeholder concern. Some methods require the injection of surfactants and alcohol to flush out the DNAPL in these tight media so that it may be degraded. Such action could concern stakeholders about the probability of increasing contaminant mobility (the aim of the method), driving the contaminant into an unwanted area (e.g., offsite or into a aquifer), and not being able to degrade it. The same concerns, if not more so, apply to the hydraulic fracturing techniques. Stakeholders will be worried that performance cannot be accurately measured and that the techniques are not controllable. This concern is also captured in the stakeholder acceptability factor of potential failure impact. As mentioned, the treatment of DNAPL is fairly new; consequently there may be an issue about the lack of a regulatory track record associated with this technology.

- ***In Situ* Chemical Oxidation of Contaminated Soils:** This system uses strong oxidizing agents (e.g., potassium permanganates) to treat soils contaminated with a range of organic chemicals, such as TCE. The oxidizing agents take the contaminant out of solution so that it can be degraded. The applicability of the technology to treat metals and radionuclides, including oxidizing and immobilizing uranium, is also being investigated. As with many of the DNAPL technologies, stakeholders will likely be concerned about injecting a substance into the subsurface. In this case, there is concern that the potassium permanganate may negatively affect the permeability of the soil and, thus, hinder the treatment process. There is also the concern that the injected agents may increase the mobility of the contaminant and drive it into an unwanted area (offsite, into an aquifer, or into an even more difficult region to access). Again, the lack of a regulatory track record may be an issue.
- **Gaseous Reduction of Chrome / *In Situ* Chemical Treatment System:** A gas reagent (hydrogen sulfide) is used to treat unsaturated soils contaminated with chromium and potentially other contaminants. Injecting a toxic gas into the subsurface will likely raise significant concerns with stakeholders. Their concerns would likely focus on the degree to which the gas can be controlled, once it is released into the ground, and understanding and preparing for potential failure scenarios where both the environment and humans could be harmed. Lastly, securing regulatory approval is likely to present challenges. Will the resulting state of the chrome (given it is to be altered to a more stable form) be viewed as safe enough to leave in place?

#### 4.3 PERMEABLE BARRIERS

Reactive permeable barriers are being evaluated for containing and treating metals and radionuclide contaminated groundwater. As groundwater flows through an injected wall of a material, such as zeolite, the contaminants are either bonded chemically to the barrier material or incorporated into its matrix, thereby immobilizing them. Barriers require the subsurface injection of some substance to form the barrier which could be of some concern to stakeholders in that they may see it as adding foreign substances to the subsurface. Moreover, they may fear a mass failure of the barrier that leads to the further mobilization of the contaminant. Stakeholders will likely prefer that a barrier address co-contaminants so that additional technologies are not needed to cleanup the zone. Barriers requiring some type of unusual maintenance may also be of concern to stakeholders. They will want assurance that the barrier is working as intended. Finally, regulatory track record may be an issue in some cases. Both of the barriers described below



require subsurface injection which could be seen by stakeholders as potentially adversely increasing contaminant mobility which could lead to harmful environmental or human health impacts.

- **Groundwater Permeable Strontium Sorptive Barrier:** This project uses a clinotololite (zeolite) sorptive barrier to target strontium-90 in the groundwater. The stakeholder concerns likely associated with this barrier are described above.
- ***In Situ* Redox Manipulation:** This technology creates a permeable subsurface treatment zone to immobilize and in some cases destroy contaminants. A sulfur compound, which is chemically reducing, is injected to create the permeable barrier. As groundwater moves through the zone, the injected materials change the contaminants' oxidation state, either partially or completely immobilizing them. The stakeholder concerns likely associated with this barrier are described above.

## 5.0 ACCEPTABILITY FACTORS RELATED TO SECONDARY WASTE MANAGEMENT TECHNOLOGIES

While the production or suppression of secondary or process waste using the technologies above is a major stakeholder concern, the PFA portfolio also contains technologies aiming at effective management of those wastes when they are produced. In this case, issues related to other treatment technologies are applicable. Specific to the PFA technologies, concerns include:

- **Recycling of Surfactants Used in DNAPL Remediation Methods:** This activity is part of a larger effort under another task. The focus is to determine the capability of recycling surfactants that will be used in great volume in remediation efforts. The interest in recycling is primarily motivated by cost. An obvious question that will likely be raised by stakeholders is to determine how clean is clean enough for the recycled surfactants. Stakeholders would also want to know about the process planned to separate the contaminant from the extracted surfactants (an auxiliary technology) and how these contaminants will be managed. Information will be needed on the appropriate operational life of a surfactant. The regulatory track record will likely be an additional issue associated with this activity, including whether states will allow the interstate shipment of recycled surfactants.
- **MAG\*SEP:** This technology removes the inorganic contaminants from groundwater through an ion-exchange process that adsorbs contaminants onto resin-coated magnetic particles. Magnetic particles are to adsorb targeted contaminants which together are collected by a magnetic filter. Contaminants can be chemically removed from the magnetic particles and the particles can be recycled. The complexity of and unusual maintenance/expertise required to operate this technology may be an issue to stakeholders. Cost of this technology versus other competing, available technologies could also be important to stakeholders. The versatility of the technology to operate in different conditions and on various contaminants may also be an issue. Stakeholders may also want to know what plans there are for handling (e.g., offsite treatment and transportation needs) the removed contaminants. Finally, the lack of a regulatory track record may be an issue.

- **Mound Selentec Treatability Study:** Under this work, an *ex situ* soil treatment process is being developed to extract Pu from clay soils. An extraction solution is used followed by a magnetic separation process to remove the Pu from the extracted solution. Stakeholders may be concerned about what plans there are to manage the process waste from using this technology. They may want to know how the Pu will be managed, once it is extracted. Off-site transportation and treatment may be an issue.

## **Appendix F**

### **Evaluating Portfolio Technologies for Stakeholder Involvement -- a Draft Approach**

## Appendix F: Evaluating Portfolio Technologies for Stakeholder Involvement -- a Draft Approach

The Contaminant Plume Containment and Remediation Focus Area (PFA) has been formed to facilitate the development and deployment of innovative cleanup technologies across the U.S. Department of Energy (DOE) complex. A key PFA strategy is to enhance deployability of innovative technologies by involving relevant stakeholders -- users, regulators, and tribal and public interests -- in technology development. The goal is to fully understand the needs of potential technology users and obtain the acceptance of those users, as well as regulators and other stakeholders, for deploying new, improved technologies to meet their needs. This is referred to as stakeholder involvement, reflecting the broad range of potentially interested parties that can constructively participate in the development and demonstration of a technology to meet a particular site need.

As a national program, the PFA will make the majority of investments in technologies that will meet multiple site/field office needs, maximizing the benefit from the investment of research and development dollars. To this end, the PFA is identifying the full set of site problems that may be addressed by a given technology in the investment portfolio. Where appropriate, potential users and stakeholders from all sites where a technology may be applicable will be involved in that technology's development and demonstration. This is referred to as the multi-site stakeholder involvement approach.

To this end, the PFA External Integration Team works closely with Site Technology Coordination Groups (STCGs) at each DOE field office. The STCGs facilitate interactions and communication between the PFA team and their site personnel and stakeholders. This relationship is critical to achieving stakeholder involvement in PFA technology investments, and the PFA team works closely with STCGs to ensure that the interests of their users and other stakeholders are accurately represented in PFA activities.

Not every technology that is being funded within the PFA portfolio will be of significant interest or concern to stakeholders, however. In addition, because of the ongoing nature of some of the investments, some projects are too far advanced toward demonstration to benefit optimally from broad stakeholder involvement (e.g., affecting pre-demonstration planning). Available resources and funding also define the number of projects that can be addressed. Therefore it is necessary for the PFA to identify criteria to prioritize the projects in the investment portfolio, and design appropriate stakeholder involvement approaches that are tailored to each project. This will be done in conjunction with the product team's action plans for each investment technology, which will guide PFA activities in relation to each project.

This document describes proposed factors and criteria to be considered in assessing the need for stakeholder involvement, and an approach for analyzing the portfolio technologies and defining an appropriate level of stakeholder involvement. Figure 1 on the following page reflects the questions to be asked about each technology, using the set of factors and criteria presented in Figure 2 in conjunction with information on project plans (e.g., demonstration schedules, descriptions of technology attributes), compilations of site problems and technology needs, and understanding of issues traditionally associated with stakeholder concerns and interests. If a technology triggers several of the criteria, especially those that are more heavily weighted as being of major stakeholder concern, that technology ranks high on the stakeholder interest scale. (See Attachment 1 for definitions of the factors and criteria.) Then, considering the development and demonstration schedules, as well as breadth of potential applicability (multi-site potential), a judgement can be reached about what level of stakeholder involvement should be applied to that technology/project.



Based on those results, there are five categories of stakeholder involvement that may be appropriate. They are shown in Figure 3, linked to the results of the process shown in Figure 1 (A List, B List, etc.). Those variations on the stakeholder approach consist of the following:

- **Multi-site STCG involvement** -- This is essentially the full, start-to-finish stakeholder involvement approach warranted by a technology of high stakeholder interest according to several criteria, especially those weighted most highly (e.g., increasing contaminant mobility, requiring subsurface injection) and those that are capable of being carried out within the demonstration schedule for the project. This approach will include early, substantive stakeholder involvement via the STCGs (including stakeholders at the host demonstration site as well as from all other potentially applicable and interested sites) in defining demonstration requirements. With broad input represented in the demonstration test plans, the PFA team will continue to involve STCGs and other interested stakeholders as appropriate throughout demonstration planning and fine-tuning, through demonstration progress, and in reviewing and evaluating demonstration results to assess technology acceptability.
- **Host-site STCG focus** -- For a technology that is of significant stakeholder interest, but that is only applicable at the demonstration site (no multi-site applicability), stakeholder involvement will focus on the host-site STCG. This group will be asked to provide input to demonstration planning, track and monitor the demonstration, and evaluate the results to affirm the technology's suitability to meet their site's needs. The PFA team will provide general information based on lessons learned from stakeholder involvement in similar technologies, and will share related information as appropriate, but will not undertake a multi-site involvement approach.
- **Modified multi-site STCG approach** -- For those technologies that are of high stakeholder interest, but for which the demonstration schedule is too far along (e.g., less than one year to demonstration, the time required for developing and finalizing the demonstration test plan), a reduced multi-site effort will take place. If it appears that the stakeholder concerns may be serious enough to jeopardize the acceptability of the technology, EIT will recommend a schedule modification to accommodate stakeholder involvement in planning. If a change in schedule is not possible, potential users and stakeholders at other sites (in addition to the host site) will still receive information about the demonstration, though they will not be able to affect the demonstration, and they will be asked to review results and provide their thoughts on acceptability.
- **Information sharing** -- For those technologies that do not appear to trigger significant stakeholder interest (e.g., meet few or none of the criteria in Figure 2), little direct stakeholder involvement will be sought. Information about the technologies will be distributed to STCGs at the host site and other potentially applicable sites, and stakeholder interest will be addressed if it arises during or after the demonstrations. This will take place primarily by mail and telephone.
- **Coordination and issue identification** -- For situations where full-blown stakeholder involvement is not appropriate, the PFA team will take into consideration the potential stakeholder issues that may come into play with types or classes of technologies, based on past experience, literature review, or other sources of general information.

## ATTACHMENT 1 -- FACTOR/CRITERIA DEFINITIONS

### Factor 1: PERFORMANCE

Most stakeholder questions and concerns relate to a technology's ability to perform in positive ways, and not to create problems during that performance. Within this factor category, the following specific criteria are defined:

Potential to Adversely Increase Contaminant Mobility -- Use of a technology may add to the likelihood that a contaminant or contaminants will become mobilized and create further areas of contamination or increased risk. For a technology that demonstrates the potential to increase mobility, there would likely be significant stakeholder concern.

Requires Subsurface Injection -- Some technologies call for the injection in the subsurface of various substances, ranging from water to biological organisms. This can be expected to raise stakeholder concerns related to regulatory requirements (e.g., Washington State's non-degradation standards for groundwater), effects on groundwater levels and fluctuations, environmental impacts, or generalized concern about injecting anything into the subsurface environment.

Transfers Contaminants from One Medium to Another -- Stakeholders often express concern about removing contamination from an area, and merely moving it to another place (e.g., ground water or the air). Technologies that do not destroy or immobilize contaminants will tend to raise these issues, and thus present concerns.

Unable to Address Co-Contaminants -- Stakeholders have expressed major concern about investing in technologies that may remediate one or more contaminants, but do not take care of the entire problem, leaving other types of contamination in place. This is especially true for mixed radioactive and hazardous contaminants and particularly important for in-situ technologies, as the remaining co-contaminants would be left in place. Therefore, a technology's ability to address only some of the constituent contaminants will be an important stakeholder issue.

Type, Volume, Toxicity, or Recyclability of Process Waste -- Although almost all remediation technologies produce some type and level of process waste, there is significant stakeholder concern about how that waste must be treated, stored, disposed, transported, or otherwise managed. Therefore, any technology that produces process waste that is higher in volume or toxicity, or more difficult to dispose of or recycle, in comparison with a baseline technology, will create concern.

Not Versatile -- Stakeholders prefer technologies that are able to address a broad range of contaminants and that can be used in varying soil, groundwater, chemical, temperature, and other site conditions. A technology that is narrow in its applicability will raise issues related to its priority for investment.

Complex Technology -- A technology's complexity of design, and operation raises questions with stakeholders. There is a common belief that a more complex technology is more expensive, more likely to fail, and more costly to maintain.

Unusual Maintenance/Expertise Required -- A technology that requires frequent, high-tech, expensive, or off-site maintenance in order to operate raises concerns with stakeholders. They prefer technologies that

can be operated with existing labor forces, without extensive training, and that can be maintained and repaired if necessary using onsite resources.

Auxiliary Technologies Not Yet Identified -- Stakeholders prefer to consider a technology in the context of the entire system in which it will operate. For example, an in-situ treatment technology will need an access technology (drilling), an injection and removal method, and a monitoring system. In order to assess the impacts of one element, it is necessary to consider the impacts or benefits of the entire system. Technologies that require auxiliary technologies in order to effect a solution raise issues if the supporting technologies are not yet concretely identified or understood.

Requires Offsite Transport/Treatment -- Technologies that call for offsite transport of material for treatment or disposal raise issues with many stakeholders. Sending process waste or remediation materials offsite also raises issues. These include transport across jurisdictions, with potential impacts of exposure and accident, as well as concerns about treatment or disposal facilities off the site that may impact their site locations.

Slower than Baseline -- A technology may have significant benefits in terms of effectiveness, cost, or other factors, but may operate more slowly and/or be slower to complete its objective than an existing baseline technology. These factors, rate of performance and time required to complete the job, are of concern to stakeholders.

## **Factor 2: COST**

Cost is a factor that has been broadly important to stakeholders, though not to the detriment of other factors, especially health and safety. For purposes of determining stakeholder involvement in technology development, cost is defined as follows:

Cost Greater than Baseline -- If a new technology will be more costly to develop, construct, operate, or decommission, than the baseline technology, stakeholders are likely to raise issues about it. Areas of interest include total life-cycle cost, including startup, operations, maintenance, and decommissioning. This is a factor that will be affected by other factors, but is nevertheless a high-visibility stakeholder issue.

### **Factor 3: ENVIRONMENTAL, SAFETY AND HEALTH**

Any projected effects of a new technology on the environment, or on the safety and health of workers and the public, will raise significant stakeholder concerns. Specific criteria to address stakeholder involvement in technology development include:

Potential Failure Impact -- This can be expected to be a very critical criterion with many stakeholders. Effects on the environment, the public, or on workers from the unexpected failure of an innovative technology -- which may range from release of contaminants to mechanical failure and injury -- must be carefully considered. The ability to control and mitigate for the failure is key. The more catastrophic the potential failure scenario, the greater the likelihood of stakeholder concerns in this area.

Produces Emissions or Releases -- Any uncontrolled emissions or releases of contaminants or other hazardous materials from installation, operation, or removal of a technology, whether to the air, surface, soil, or groundwater, are cause for significant stakeholder concern. These can be equated to environmental impacts on wildlife, vegetation, air, water, soil, and people.

Energy Demands Greater than Baseline -- Use of large amounts of energy (e.g., electricity) to construct, operate, or remove and decommission a technology is of stakeholder concern. If projected energy use is greater than the baseline technology, this can be expected to raise at least some level of concern. Use or damage to natural resources is another flag.

### **Factor 4: REGULATORY ISSUES**

There is really only one regulatory criterion relevant to evaluating the need for stakeholder involvement in technology development. It is described below.

Regulatory Infrastructure/Track Record -- A technology that has no precedent of approval within the regulatory system (federal, state, or local) will raise stakeholder concerns. Infrastructure primarily means the regulations and regulatory guidance needed to evaluate a technology's compliance. If regulators are experienced or familiar with the technology, it may reduce regulatory uncertainty. A technology that requires many complex regulatory approvals will also raise issues.

### **Factor 5: SOCIO-POLITICAL**

Forecloses Future Options -- The ability to pursue unlimited future land uses, as well as to undertake alternative remediation approaches if indicated in the future, are both key parts of this criterion. Spiritual, traditional, and practical uses all come into play. Technologies that change the physical nature of the land itself, or create an environment that will not be amenable to further processing or remediation, are of concern.

Potential to Impact Cultural or Socioeconomic Resources -- Any potential impacts from the technology on resources that are valued by a community will raise significant concern. This may include tribal resources, scenic vistas and landmarks, drinking water supplies and important habitats, open space or other special land uses, etc. The potential for these types of impacts must be carefully evaluated in designing stakeholder approaches for such a technology.

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