

WORKSHOP REPORT

SERDP and ESTCP Workshop on Investment Strategies to Optimize Research and Demonstration Impacts in Support of DoD Restoration Goals

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TABLE OF CONTENTS

1. INTRODUCTION	1
2. METHOD.....	2
3. CURRENT STATUS OF DOD SITE RESTORATION.....	3
3.1 PROGRESS TO DATE	3
3.2 BARRIERS TO REACHING GOALS.....	3
3.3 POST-RIP ISSUES	4
4. RESEARCH AND DEMONSTRATION NEEDS	7
4.1 SCIENCE NEEDS	7
4.1.1 Quantify Natural Attenuation Capacities (HIGH).....	7
4.1.2 Reduce the Uncertainty in Risk Assessments	8
4.1.3 Assess and Manage the Spatial Variability of Geochemical and Microbiological Conditions	8
4.1.4 Define “Low-Risk Sites”.....	9
4.1.5 Determine the Side Effects of Remediation Technologies.....	9
4.2 REMEDIATION TECHNOLOGY NEEDS	9
4.2.1 Delineation and Treatment of Contaminants in Low-K Zones (HIGH).....	10
4.2.2 Optimization of Existing Technologies (HIGH).....	10
4.2.3 Treatment of Challenging Sites (DNAPLs, Fractured Media and Large Dilute Plumes).....	11
4.2.4 Sediment Restoration	11
4.2.5 Emerging Contaminants	11
4.3 CHARACTERIZATION AND MONITORING TECHNOLOGY NEEDS.....	12
4.3.1 Improved Long-Term Monitoring Methods (HIGH).....	12
4.3.2 Vapor Intrusion.....	13
4.3.3 Characterization and Cleanup of Metals at MMRP Sites.....	13
4.3.4 Advanced Sensors and Algorithms	13
4.3.5 Underwater Sites.....	14
4.3.6 Emerging Contaminants	14
4.3.6 Emerging Contaminants	14
4.4 TECHNOLOGY TRANSFER NEEDS	15
4.4.1 Diagnosis and Optimization of Remediation Systems (HIGH).....	15
4.4.2 Decision-Making Support (HIGH).....	15
4.4.3 Testing and Verifying Conceptual Site Models.....	15
4.4.4 Monitoring Well Guidance.....	16
5. SUMMARY.....	17
APPENDIX A: AGENDA.....	A-1
APPENDIX B: PRESENTATIONS	B-1

1. INTRODUCTION

The Strategic Environmental Research and Development Program ([SERDP](#)) and the Environmental Security Technology Certification Program ([ESTCP](#)) are designed to develop and transition innovative research and technology to help the Department of Defense (DoD) perform its mission in several environmental areas, including cleanup of contaminated sites. Periodically, workshops are held by the Program office to determine future areas of investment. This report summarizes results of a workshop on developing investment strategies to optimize research and demonstration impacts in support of DoD restoration goals.

The DoD's recently updated Defense Environmental Restoration Program (DERP) goals call for achieving Response Complete (RC)¹ at 90% of the Installation Restoration Program (IRP) and Military Munitions Response Program (MMRP) sites at active installations and the IRP sites at Formerly Used Defense Sites (FUDS) properties by the end of FY 2018. There is also a followup goal to achieve RC at 95% of these sites at by the end of FY 2021. The Cost to Complete (CTC)² at IRP sites was calculated at \$12.8 billion in FY 2010. Some of the Services have more aggressive goals, and have proceeded to target site closure, with no long term management liabilities, at many sites within the next 5 to 15 years.

The DoD is responsible for many types of contaminated sites; however, contaminated groundwater has proven to be the cost driver at many military facilities. Substantial progress has been made in the past 20 years in the development of technologies for remediation of contaminated groundwater; however, significant challenges remain (e.g., DNAPLs in fractured media and contaminants in low-permeability materials). The overall CTC is largely driven by these difficult sites. Cleanup to unrestricted use is often desired, but technically difficult to achieve, and sustainable remediation has become an increasingly important goal as well. Given these current DoD restoration goals, there is a need to evaluate the future role of SERDP and ESTCP in supporting environmental restoration, to ensure that future research and demonstration efforts can be useful, timely, and integrated into the current practices and plans.

The workshop described in this document was convened on 16 June 2011, in Salt Lake City UT, to determine future research and demonstration needs to support DoD restoration goals. Specific objectives of the workshop were to (1) review the current cleanup goals and management processes of the different services, (2) evaluate current and potential future issues associated with site closure, particularly under performance based contracts, and (3) identify research and demonstration strategies that, if incorporated into cleanup strategies, can improve remediation approaches, reduce risk, and ultimately reduce the CTC.

¹ RC signifies that the DoD has met the remedial action objectives for a site, documented the determination, and sought regulatory agreement. Further, it signifies that DoD has 1) determined at the end of the Preliminary Assessment/Site Inspection or Remedial Investigation that no additional response action is required, 2) achieved Remedy-in-Place (RIP) and the required Remedial Action Operation (RA-O) has achieved the remedial action objectives, or 3) where there is no RA-O phase, then the Remedial Action Construction (RA-C) has achieved the remedial action objectives. Long-term management may occur after RC is achieved.

² The Cost to Complete is defined as an estimate prepared by each Service that includes, on a current cost basis, all anticipated costs required to effect the restoration of the site, as well as the costs of complying with applicable legal and regulatory requirements. Also included are costs associated with the long-term management phase prior to completion of any response action requirements [ODUSD(I&E), 2001].

2. METHOD

Approximately 20 experts participated in the workshop (see second page of report). The participants were invited with the goal of including knowledgeable experts representing a range of perspectives, including academic researchers, regulators, remedial project managers (RPMs), industry representatives, consultants, and government agency representatives.

The agenda (Appendix A) was designed to identify the most pressing needs in a focused manner, while ensuring that all participants could express their views. The workshop opened with several presentations intended to provide background information on the status of the Service's restoration goals.

The entire group participated in the final discussions and selection of the key issues and the critical and high-priority research and demonstration needs. Several of the participants contributed sections to this report describing specific issues and needs, and/or edited the draft versions.

3. CURRENT STATUS OF DOD SITE RESTORATION

Initial discussions during the workshop focused on a review of the current DoD restoration goals, potential barriers to achieving these goals, and issues that arise once RIP is implemented. The discussion served as a starting point for preliminary identification of research and demonstration needs that would assist the Services with achieving restoration goals and ultimately reducing the CTC for their installations. A summary of some of the key issues addressed is provided in the following sections.

3.1 Progress to Date

The FY10 Defense Environmental Program's Annual Report to Congress provides a summary of program accomplishments during the past year in the Conservation, Compliance, Pollution Prevention, and Restoration Programs. The report is available at <http://www.denix.osd.mil/arc/ARCFY2010.cfm>.

Through FY10, the DERP goals were focused on achieving RIP¹/RC. Specific goals varied within the IRP and MMRP, as well as by active installations, Base Realignment and Closure (BRAC) installations and FUDS properties. A summary of these goals and progress towards them is provided in Table 1.

RIP/RC was achieved at 86% of the IRP sites by FY10 and significant progress has been achieved towards other goals. However, the level of difficulty to remediate sites varies tremendously from relatively simple surface soil contamination to complex contaminated groundwater and contaminated sediment sites. The complex sites tend to drive restoration costs and future efforts should focus on reducing the risk and CTC associated with these sites.

3.2 Barriers to Reaching Goals

A portion of the discussion during the workshop was focused on potential barriers to achieving restoration goals for the most challenging sites. Four key themes emerged during these discussions: unrealistic expectations, technology performance uncertainties, adaptive site management, and innovative tools and guidance.

Unrealistic Expectations. As knowledge of complex groundwater sites grows, it has become increasingly clear that remediation to a drinking water standard is not only impractical, but virtually impossible within a few generations at many sites. Setting such goals is unrealistic and ultimately fails to provide a fiscally responsible solution that is protective of human health and the environment.

Technology Performance Uncertainties. Despite many technology advances, there remain a number of uncertainties regarding technology performance that ultimately impact the ability to achieve performance goals. Technology performance hinges on subsurface site-specific characteristics, and understanding the impact of all permutations of hydrogeology and biogeochemistry is not possible during technology development. Each site is unique, resulting in technologies that perform beyond expectations under certain conditions, but poorly under others.

Even with a technology considered to be proven, amendment delivery continues to be a challenging issue due to site specific characteristics. Further uncertainties exist when scaling up technologies from

¹ RIP is defined as that stage at which a final remedial action has been constructed and implemented and is operating as planned in the remedial design.

relatively small field demonstrations to full site remedial actions. Scale-up issues are difficult to predict and cannot be fully assessed during demonstrations. In truth, technology development continues over the years as lessons learned allow for improved design and operation.

An often unacknowledged area of uncertainty is performance assessment. Performance assessment metrics are likely to vary by technology and perhaps by site; however, guidelines for such metrics are rarely developed. Remedial Program Managers (RPMs) are left with little guidance on how best to assess performance of contractors and technologies beyond traditional construction and operation goals. Reliance on contaminant concentrations only as a performance metric may result in substantial delays before it is recognized that a technology simply does not meet performance objectives.

Inadequate Site Characterization. Site characterization prior to technology implementation is often inadequate (this is a particularly problematic issue in the performance based contract [PBC] framework when several sites are bundled together). Simple tests such as tracer tests and collection of vertically discrete samples often are not performed due to the misconception that conducting the additional work will increase cost or lengthen the schedule. In reality, the lack of initial characterization efforts results in design, implementation, and performance monitoring strategies that are inappropriate or inadequate, increase costs, and extend schedules.

Adaptive Site Management. Adaptive site management allows the flexibility to address unexpected issues associated with site specific factors or technology performance. Unfortunately, implementing such management can be challenging. RPMs have experienced difficulty with including contingency plans written into Records of Decision (RODs). Likewise, inclusion of treatment train approaches has been challenging. Such inflexibility may prevent introduction of alternative approaches with better success rates.

Innovative Tools and Guidance. While not a barrier per se, reluctance on the part of the regulatory community to accept data from new tools and guidance can prevent progress. The DoD has invested substantially into development of innovative tools and improved guidance to increase technology cost effectiveness and reduce risk. Unfortunately, regulatory endorsement of such tools can be a laborious process, yet lack of endorsement results in limited usage.

3.3 Post-RIP Issues

Implementation of RIP is progressing rapidly at military installations. As installations proceed into the Remediation Action Operation (RA-O) phase, issues and questions arise that investments in future research and demonstration could help address. The key questions are briefly discussed below.

1. *What data analysis should be conducted during the RA-O phase?* Often, only routine monitoring reports are generated during the RA-O phase in order to minimize costs. However, critical data may be available that would indicate early issues with technology performance, and at times less useful data continues to be collected simply because it was in the original plan. These data are often not evaluated thoroughly until the 5-year review process is undertaken. This question is related to the issues of performance assessment discussed in the previous section.
2. *How can good engineering and optimization be ensured?* The remediation field has been criticized (perhaps unfairly) for being a “build it and forget about it” practice. Because of the uncertainties in subsurface characterization and design, an iterative or “observational” approach is crucial for effective and efficient remediation projects. RPMs often lack guidance as to how to implement such observational strategies, and have difficulties in

achieving regulatory and/or management acceptance. Guidelines, standard practices, and remediation checklists can provide a structure where good engineering and continual improvement/optimization practices are encouraged. With current contracting strategies, several sites are often bundled together for remediation, with limited third party technical oversight, so it often is difficult to ensure that best current practices for engineering, performance assessment, and optimization are applied. If a problem exists, it may not be detected until several years after implementation, when it becomes obvious that project goals will not be met.

3. *What steps should be taken when asymptotes in performance develop?* Asymptotes in performance are common, but it is often difficult to know what to do when such asymptotes occur. While they may indicate that a given remedial strategy has reached its limits of effectiveness, there is typically uncertainty regarding what to do at that point (i.e., should site closure be pursued, another technology used, or the existing technology be optimized or otherwise modified). Little guidance is available to the RPM to help support these decisions. Better process knowledge, models, and decision tools are needed to diagnose the cause of an asymptote and prescribe the next step.

A “process check” may be required to ensure that the asymptote is not a result of inadequate remediation design and/or poor operational practices. At some sites, asymptotes may be an important signal that the type of source process has changed, such as from a NAPL-dominated source to a diffuse matrix diffusion process. In that event, future remediation efforts should focus on more of a “non-point source” management strategy that employs an appropriate remediation approach. In any case more guidance on how to implement a holistic strategy to take projects beyond initial technology implementation to the point of RC is needed.

TABLE 1. DOD RESTORATION GOALS AND PROGRESS^{1*}

Installation Restoration Program	FY06	FY07	FY08	FY09	FY10
Active Installations					
Reduce risk or achieve RIP/RC at all high relative risk IRP sites by the end of FY07†	83%	92%	93%	94%	94%
Reduce risk or achieve RIP/RC at all medium relative risk IRP sites by the end of FY11†	52%	58%	65%	70%	75%
Reduce risk or achieve RIP/RC at all low relative risk IRP sites by the end of FY14†	59%	65%	69%	74%	77%
Achieve RIP/RC at all IRP sites by the end of FY14	85%	89%	90%	86%	86%
BRAC Installations					
Achieve RIP/RC at all Legacy BRAC IRP sites by the end of FY15	86%	86%	87%	88%	88%
Achieve RIP/RC at all BRAC 2005 IRP sites by the end of FY14	66%	62%	47%	54%	61%
FUDS Properties					
Reduce risk or achieve RIP/RC at all high relative risk IRP sites by the end of FY07	48%	50%	54%	55%	59%
Reduce risk or achieve RIP/RC at all medium relative risk IRP sites by the end of FY11	43%	46%	50%	52%	52%
Reduce risk or achieve RIP/RC at all low relative risk IRP sites by the end of FY20	44%	43%	52%	56%	58%
Achieve RIP/RC at all IRP sites by the end of FY20	67%	68%	70%	71%	72%
Military Munitions Response Program					
Active Installations					
Complete PAs at all MRSs by the end of FY07†	70%	96%	95%	97%	96%
Complete SIs at all MRSs by the end of FY10†	24%	29%	51%	72%	97%
Achieve RIP/RC at all MRSs by the end of FY20	17%	23%	34%	43%	38%
BRAC Installations					
Achieve RIP/RC at all Legacy BRAC MRSs by end of FY09	38%	63%	67%	68%	70%
Achieve RIP/RC at all BRAC 2005 MRSs by end of FY17	0%	20%	27%	33%	39%
FUDS Properties					
Complete PAs at all MRSs by the end of FY07	99%	99%	99%	96%	98%
Complete SIs at all MRSs by the end of FY10	34%	45%	58%	67%	84%

¹Data from the FY10 Defense Environmental Program's Annual Report to Congress (<http://www.denix.osd.mil/arc/ARCFY2010.cfm>)

* The DoD considers a goal to be met when it achieves a 95% completion rate.

† New sites added to the inventory after FY08 are not subject to the relative risk reduction or PA and SI completion goals.

MRS = munitions response site; PA = preliminary assessment; SI = site inspection

4. RESEARCH AND DEMONSTRATION NEEDS

The research and demonstration needs identified during the workshop are described below. The needs include improved scientific understanding, new or improved remediation technologies, better characterization and monitoring methods, and technology transfer. These needs inevitably overlap, but this classification is intended to help identify areas of focus for different phases of the technology development and deployment process. The order does not imply any prioritization, although those needs identified as high-priority areas are identified first within each section.

4.1 Science Needs

The information needs reflect the current state of our knowledge and the status of restorations within DoD. For example, DoD clearly has specific needs for information regarding the fate, transport, and risks posed by military unique compounds. Also, many sites have some remedies in place, or are planning to reach those milestones soon, so there is a greater emphasis on understanding natural attenuation and defining acceptable “low-risk” conditions for sites with residual contamination after active treatment. Finally, the major technologies have been demonstrated and deployed, but there remain some concerns regarding their side effects.

4.1.1 Quantify Natural Attenuation Capacities (HIGH)

Quantifying the natural attenuation capacity of an aquifer is critical to understanding if active source treatment is needed, and to determining how much treatment is needed. Natural attenuation is commonly relied upon to manage any residual discharge after source containment or removal, but without confidence in the long-term ability of the aquifer to degrade the continuing discharge, it is difficult to establish treatment objectives. However, despite the considerable amount of work done to date (e.g., see below), there is no accepted definition or solid method to evaluate the “natural attenuation capacity” of an aquifer. Key questions include defining the appropriate metric (for example, no plume length expansion) and assessing any abiotic degradation, quantifying biodegradation rates over time, and ensuring the sustainability of natural attenuation processes. Potentially valuable methods to quantify rates accurately include molecular biological techniques and molecular tools (notably CSIA), as well as perhaps targeted mineralogical analyses to evaluate abiotic degradation potential. As the importance of reservoirs within lower-permeability zones has been recognized, it has become clear that methods are needed to assess degradation rates in both the more and less transmissive zones, and that these methods may differ. In addition, there is a need to evaluate longer term MNA and incorporate slower degradation processes (such as abiotic transformations), as well as dilution/dispersion.

In FY08, ESTCP funded a project titled “Verification of Methods for Assessing the Sustainability of Monitored Natural Attenuation”. Principal investigators on the project are Carmen Lebrón (NAVFAC ESC), Mark Widdowson (Virginia Polytechnic Institute and State University), Frank Chapelle (USGS), and Jack Parker (University of Tennessee). The objective of the project is to demonstrate/validate an integrated methodology for assessing the long-term sustainability of monitored natural attenuation (MNA) that was developed through SERDP project [ER-1349](#) (Integrated Protocol for the Assessment of the Long-Term Sustainability of MNA of Chlorinated Solvent Plumes). The method, which captures the full range of natural attenuation processes (diminishing source mass flux, dilution and dispersion, biological and abiotic transformations, volatilization, and evapotranspiration) was developed as an enhancement to Sequential Electron Acceptor Model, 3D (SEAM3D), also a product of a SERDP-funded project ([ER-1062](#)). The project is nearing completion and is expected to be complete by early 2012.

Results to date are positive and are likely to address the issue of sustainability of natural attenuation discussed during the workshop.

4.1.2 Reduce the Uncertainty in Risk Assessments

Although some uncertainty is inherent in the risk assessment process, the technical uncertainties can be very high, especially for military unique compounds such as munitions. The greatest opportunities for reducing risk uncertainties include improving assessments of bioavailability, understanding the potential for vapor intrusion, and assessing ecological risks.

The bioavailability of contaminants to humans, and other receptors, can vary significantly between sites, and is likely lower than the typical values assumed for many situations. However, methods to establish risk-based criteria for specific compounds or sites remain contentious and expensive. Approved, credible, and cost-effective methods for bioavailability determinations would likely reduce costs and lead to more efficient site management. Research needs associated with bioavailability issues were defined in a 2008 SERDP and ESTCP Workshop report and a suite of projects were initiated to address select research needs. Workshop reports and project descriptions can be found at <http://www.serdp-estcp.org/Featured-Initiatives/Cleanup-Initiatives/Bioavailability>. In particular, cost effective bioavailability tests are needed to develop site-specific criteria for both metals and organics in soil.

Vapor intrusion (VI) is discussed in more detail in Section 4.3.2, but it is currently a significant source of uncertainty in risk assessments that can greatly increase the characterization and remediation costs. Better VI methods such as real-time sensors, better characterization methods and site specific VI pathway evaluations, could reduce the uncertainty and costs at contaminated sites, as well as the regulatory and public concerns. In terms of risk assessments specifically, there is a need for better methods to distinguish background sources from vapors arising from releases to the environment, and there is a need for improvements to exposure models, particularly the existing shower and whole house use models.

Ecological risks have long been a significant uncertainty, especially for military unique compounds. Methods for evaluating ecological risk can be very expensive, and the results often have little impact on the eventual management decisions. Approved, credible, and cost-effective methods are needed to assess the ecological risks of new and existing compounds, and to determine the risks of mixtures of contaminants at specific sites.

There is also a need to reduce the uncertainty associated with direct contact to soil. Specifically, work in four areas is recommended: 1) characterization of outdoor/indoor connections and especially refinements to the models used to estimate the indoor dust contributions from outdoor soil; 2) characterize outdoor soil exposures by children (i.e., the proportions related to actual soil vs. playground covers such as wood chips, sand, etc.); 3) research on exposure frequencies and durations to support sensitivity analyses and to provide better estimates of ranges of exposure; and 4) research designed to reduce the uncertainty associated with dermal exposures to contaminated soils.

Finally, there is a need for toxicological studies of military unique compounds. Such work should include refinements to the life-stage adjustments to the carcinogenic slope factors for chemicals that act via a mutagenic mode of action.

4.1.3 Assess and Manage the Spatial Variability of Geochemical and Microbiological Conditions

Geochemical and microbiological conditions vary tremendously over small distances in the subsurface, but these variations often are not captured well in site characterizations. Better characterization techniques at smaller scales could identify the active and inactive zones within an aquifer, allow targeted delivery of remediation agents to critical regions within a contaminated site, and improve the

interpretation of characterization and monitoring data. For example, a stable isotope analysis of a sample taken from a monitoring well may represent an unknown mixture of groundwater from both active and inactive regions within the screened interval, each having very different isotope ratios, so interpretation is often difficult. It can be important to understand where degradation is occurring and the regions of an aquifer where favorable geochemical conditions occur, but current techniques do not allow sufficient delineation of where such conditions are found.

It is also important to assess how such data could be collected cost-effectively and if the data collected are likely to be of sufficient value to warrant the associated cost. Many DoD sites encompass vast areas, so collection of such data would have to result in improved operations, reduced risk, and reduced life cycle costs to justify the effort. Finally, it is important to recognize that spatial variability can never be fully understood, so tools are needed to help RPMs understand the degree of characterization necessary to implement and optimize a chosen remedial approach.

4.1.4 Define “Low-Risk Sites”

In many cases, DoD and other responsible parties have sites where aggressive treatment has been used, but lingering residual contamination remains, resulting in portions of the site that remain above relevant cleanup criteria. This residual contamination may represent “exhausted” sources and/or contaminants located in low-permeability regions within the source or plume, so that the sustained flux of contaminants to downgradient sites or to a groundwater extraction well may be very low. Although such sites may pose little risk to human health or the environment, significant liabilities and site management costs remain. This situation often presents a disincentive to active treatment or a misallocation of resources. At least one regulatory agency (the San Francisco Regional Water Quality Control Board) has initiated a process to allow “low-threat closure” of such sites. However, there is no clear method to identify these sites. Approved and credible methods to identify sites suitable for some form of low-risk management would lead to more efficient site management.

4.1.5 Determine the Side Effects of Remediation Technologies

Remediation technology side effects have been addressed previously. However, there is still a need to consider the effects in light of new regulations. For example, the possibility of lower chromium (VI) or manganese risk-based concentrations may pose a concern for the use of some technologies (such as oxidation). Alternatively, different technologies may work together to be more effective than either alone.

Research has been initiated recently to address some of these issues. In FY11, SERDP released a Statement of Need (SON) that focused on developing an improved understanding of the near- and long-term impacts to groundwater quality after implementation of common in situ remediation approaches such as enhanced anaerobic remediation, thermal treatment, and in situ chemical oxidation. Final results of the selected research will be available in FY13; a summary of the selected research is available at www.serdp-estcp.org under [ER-2129](#), [ER-2130](#), [ER-2131](#), and [ER-2132](#).

4.2 Remediation Technology Needs

Remediation technologies have been developed and tested for the most pressing legacy problems. These technologies have worked well, especially for the less technically challenging conditions, and they have allowed effective and efficient cleanup of a large fraction of the total DoD sites. Reflecting the rapid progress of cleanups, the current remediation needs emphasize improving treatment under difficult conditions (“high hanging fruit”), treating emerging contaminants (especially those with military unique compounds such as munitions), and optimizing the existing technologies.

4.2.1 Delineation and Treatment of Contaminants in Low-K Zones (HIGH)

Contaminant storage in low-permeability zones may occur over time and these regions may serve as long-term sources of contaminants, limiting the ability to reach groundwater cleanup goals. Storage in low-K (low hydraulic conductivity) zones may occur within sources (both within the saturated and unsaturated zones), resulting in costly and/or incomplete treatment, and within plumes, where the slow back diffusion from such widely dispersed contamination may continue to sustain the plumes for decades or centuries, even after source removal. However, better techniques are needed to identify the locations of NAPL and other contamination within sources and plumes, particularly when characterizing the lower-K zones. One possibility mentioned is the use of tracers specifically designed to mimic contaminant diffusion/back diffusion.

Models and calculation tools are needed to estimate the contaminant mass in low-K zones when little or no sampling data are available from these zones. Partitioning relationships, 1-D diffusion equations, and simple analytical models, if packaged in simple-to-use formats, have significant potential to help site managers estimate the nature and the future impact of the mass in low-K zones. Better models and tools may promote the increased use of important new low-K site management paradigms such as the “14-compartment model” developed as part of ESTCP project ER-0530 and now being promoted in the upcoming Interstate Technology and Regulatory (ITRC) guidance for chlorinated solvent sites.

Treatment of low-K zones also will require effective delivery techniques. Some methods have been proposed, including widespread thermal treatment, use of large augurs to deliver reagents, and electrokinetic techniques combined with bioremediation or chemical treatment. Also, hydraulic fracturing has gained considerable attention as a method to improve delivery of amendments into low-K zones. However, demonstration and adoption of effective and cost-effective techniques are needed, and in particular, methods to target delivery of remedial agents to low-K zones and to effectively treat and/or contain the contaminants in these regions are needed, to prevent continued back-diffusion of contaminants. Inexpensive and effective treatment within the low-K zones, or at the interfaces along permeability contrasts, could allow closure of sites with persistent residual contamination or more cost-effective site remediation strategies.

Delineation and treatment of contaminants in low permeability zones was recognized as an area of concern within the last few years. In FY10, SERDP released an SON to address contaminant storage in low-permeability zones. Specifically, the SON sought to improve our understanding of how low-permeability zone storage of contaminants occurs, the hydrogeochemical conditions that contribute to this process, and how the contaminants within these zones respond to standard treatment approaches. In addition, approaches were sought for improving our ability to measure and predict the performance of standard treatment approaches for dissolved-phase plumes that are sustained through storage of contaminants in low-permeability zones. Final results of the selected research will be available in FY12; a summary of the selected research is available at www.serdp-estcp.org under [ER-1737](#), [ER-1738](#), [ER-1739](#), and [ER-1740](#). To address vadose zone sources, gaseous amendment delivery technologies have been tested (notably the GEDIT process for perchlorate treatment (ER-0511), and the HT2 process to deliver hydrogen to low-permeability regions (ER-1027).

4.2.2 Optimization of Existing Technologies (HIGH)

The general consensus was that existing technologies are largely sufficient for treating many contaminated sites, particularly those with fuel hydrocarbons or relatively homogeneous and simple subsurface conditions, but optimization of these technologies is needed to be more cost-efficient and sustainable. In other cases, particularly the munitions constituents present at MMRP sites, improvements in existing technologies are recommended (discussed further in Section 4.4.3).

Two specific optimization issues were discussed. Given the aggressive deadlines in cleanup contracts and site closure plans, improving existing technologies to work more rapidly was of interest. In addition, improvements are needed to existing technologies that would effectively treat the low-level residual contamination that often persists even after aggressive treatment. Better information is needed to ascertain the value of certain treatment trains, particularly when dealing with low-level residual contamination.

4.2.3 Treatment of Challenging Sites (DNAPLs, Fractured Media and Large Dilute Plumes)

Managing chlorinated solvent DNAPL sites remain one of DoD's most prevalent, expensive, and difficult environmental problems. For example, persistent chloroethene plumes are a significant issue at FUDs sites, due to residual sources (especially in the vadose zone) and secondary sources within lower-K regions that cause many sites to be "stuck" in the RA-O phase.

Fractured bedrock sites also represent a particularly difficult and costly problem for remediation. Characterizing and treating contaminants in fractured media can be very challenging, and as many of the less challenging sites have been addressed, these sites have become an increasing fraction of the remaining DoD liabilities. Despite ongoing work to address the issues involved in characterizing and remediating large dilute plumes, these also remain a significant challenge because of the high costs.

SERDP and ESTCP have substantial investments into treatment of the more challenging sites. Expert panel workshops were held by SERDP and ESTCP in 2001 and 2006 to address the issue of chlorinated solvents and DNAPL contamination and several projects are currently underway to tackle these issues. Current projects and research workshop reports on DNAPL site restoration are available at: <http://www.serdp-estcp.org/Featured-Initiatives/Cleanup-Initiatives/DNAPL-Source-Zones>. Large dilute plumes were the subject of a SERDP statement of need (ERSON-09-01), and relevant projects include ER-1026 (ESTCP) and ER-1683, -1684 and -1685 (SERDP).

4.2.4 Sediment Restoration

Sediment contamination remains a significant liability for DoD. In particular, the Navy has 500 sediment sites, with an estimated CTC of over \$800M. Development of technologies for treatment of contaminated sediments lags behind those available for contaminated groundwater. Improved or new technologies are needed for more effective and accurate identification and characterization of the environmental impacts associated with sediment contamination, as well as more cost-effective restoration. In particular, methods for delivery or placement of amendments and caps must be developed to advance successful sediment restoration. In addition, while substantial research has been conducted to improve our understanding of contaminant bioavailability, these concepts are utilized sporadically in sediment restoration decisions. Progress in utilizing bioavailability concepts is needed to truly reduce risk at contaminated sediment sites.

SERDP and ESTCP convened an Expert Panel Workshop in 2004 to address the issue of contaminated sediment management, and in 2008 convened a workshop to address the issue of contaminant bioavailability in soils and sediments. Descriptions of current sediment research and demonstration projects, and workshop reports on sediment restoration and bioavailability in soils and sediments are available at: <http://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Sediments>.

4.2.5 Emerging Contaminants

DoD regularly tracks emerging contaminants that could result in a need for new or improved technologies. Emerging contaminants include new compounds of concern, as well as regulatory changes that could lower cleanup criteria. The official definition adopted by DoD includes contaminants that have a reasonably possible pathway to enter the environment, with real or perceived threats to human health and the environment, and that do not have regulatory standards based on peer-reviewed science or the

regulatory standards are evolving due to new science, detection capabilities or pathways. DoD also prioritizes emerging contaminants based on their prevalence and potential impacts to DoD's operations. Several emerging contaminants appear to be particularly difficult to remediate using conventional technologies, including perfluorinated compounds (PFCs) and 1,4-dioxane, as well as possibly some munitions compounds (depleted uranium, advanced explosives). New regulatory standards may require development of new technologies or improvements to existing technologies.

Currently, the most important potential changes in regulatory standards include lowering the criteria for trichloroethene (TCE), perchlorate, naphthalene, benzo(a)pyrene and chromium (VI). In each case, lowered risk-based criteria could make restoration more difficult, expand or re-open sites, and require changes to cleanup methods. The continued emergence of new contaminants and cleanup requirements led some participants to suggest a need for new aboveground treatment technologies, or combinations of technologies, capable of treating virtually any contaminant, even those that are currently unknown or undetected.

The issue of some of the emerging contaminants has been addressed over the years. In 2000, research efforts were initiated through SERDP to investigate bioremediation of perchlorate contaminated groundwater. These early efforts led to successful demonstrations of in situ bioremediation of perchlorate in the field and it is now considered a proven technology. Reports from these efforts can be found at <http://www.serdp-estcp.org/Featured-Initiatives/Cleanup-Initiatives/Perchlorate>. In 2005, SERDP released an SON to investigate remediation of 1,4-dioxane, N-nitrosodimethylamine (NDMA), and 1,2,3-trichloropropane (TCP). Project reports can be found at www.serdp-estcp.org under [ER-1417](#), [ER-1421](#), and [ER-1422](#).

More recently (in FY11) SERDP released an SON to develop cost effective in situ treatment technologies for perfluoroalkyl-contaminated groundwater. Specifically, the SON sought to improve our understanding of fate and transport properties of perfluoroalkyl contaminants in groundwater, as well as to gain a basic understanding of the mechanisms involved in contaminant destruction in order to develop cost-effective remedial technologies. Final results of the selected research will be available in FY14; a summary of the selected research is available at www.serdp-estcp.org under [ER-2126](#), [ER-2127](#), and [ER-2128](#).

4.3 Characterization and Monitoring Technology Needs

Characterization and monitoring continue to be important, despite the progress being made towards remediation and closure. Arguments are frequently made that the need for characterization technologies is limited given that the investigation phase is complete or near complete at the majority of sites. However, it is unfortunately the case that further characterization is often needed at sites where technologies fail to meet their performance objectives. This characterization becomes part of the technology optimization and improvements in this area are a critical need. The following sections discuss several issues associated with characterization and monitoring needs.

4.3.1 Improved Long-Term Monitoring Methods (HIGH)

Long-term monitoring (LTM) continues to represent an increasing proportion of the total environmental restoration costs for DoD. LTM methods need to be less expensive, and monitoring plans should allow optimal location of wells and timing of sampling events. Advanced sensors that do not require site visits for sampling would reduce costs. Less frequent, but perhaps more intensive, sampling events could increase the value of the LTM data in decision-making.

LTM issues have been addressed by SERDP and ESTCP through the development of monitoring techniques that can be conducted in the field utilizing less labor, as well as through research to improve

our understanding of sampling issues. In 2008, SERDP released an SON for applied research leading to reductions in the costs of LTM at sites with contaminated groundwater. Not only were new methods and tools sought, but also improved practices or guidance that would lead to more cost-efficient monitoring programs was of interest. This SON was followed by an additional SON in 2009 that focused on improving our understanding and prediction of which environmental parameters and sampling methods will provide accurate groundwater contaminant measurements for compliance sampling. Specifically, the SON sought to gain a better understanding and predictive capability of how measured contaminant concentrations vary as a function of parameters such as hydrogeological conditions, geochemistry, well type, sampling method, contaminant type and concentration, or other key parameters. The goal was to ultimately decrease LTM costs by improving our ability to utilize in-well field sensors, while maintaining an accurate representation of contaminant concentrations. Research projects are nearing completion; a summary of the selected research is available at <http://www.serdp-estcp.org/Featured-Initiatives/Cleanup-Initiatives/Long-Term-Monitoring>.

4.3.2 Vapor Intrusion

Vapor intrusion is not well understood, and yet it can be the most important pathway of concern at contaminated sites. There often is considerable regulatory and public concern regarding the potential for vapor intrusion, but the costs for assessing vapor intrusion potential can be very high and the uncertainties involved can lead to highly conservative risk assessments. Technical solutions that could improve this situation include inexpensive sensors capable of measuring vapors over extended timeframes and improved predictive models or assessment procedures (such as encouraging sampling while depressurizing) that could reduce the uncertainty surrounding this issue.

In FY09, SERDP released an SON to develop a better understanding of natural spatial and temporal variations in vapor intrusion measurements and how to account for such variability in pathway assessment, as well as to improve our ability to obtain accurate and cost-effective characterization of key site parameters that impact the vapor intrusion pathway. Final results of the selected research will be available in FY12; a summary of the selected research is available at www.serdp-estcp.org under [ER-1686](#) and [ER-1687](#). Additional projects under ESTCP have been funded to validate new sensors and methodologies for measurement and assessment of vapor intrusion. Summaries of these projects can be found at <http://www.serdp-estcp.org/Featured-Initiatives/Cleanup-Initiatives/Vapor-Intrusion>.

4.3.3 Characterization and Cleanup of Metals at MMRP Sites

The MMRP sites represent a large fraction of the total CTC estimates for DoD sites. Metals, especially lead, are prevalent contaminants, and both the cleanup and characterization of these sites are costly and challenging. In addition to improved cleanup methods, the characterization of MMRP sites requires research and development. Extending incremental sampling and analysis to metals (and other contaminants) could reduce costs and improve risk assessment. Advanced metal analyses (such as use of synchrotrons) could better determine site-specific risks.

Development and validation of the incremental sampling methodology for energetic residues was funded by SERDP and ESTCP, resulting in the development and posting of USEPA method 8330B. Recent efforts are focused on extending the incremental sampling methodology to metals under ESTCP project ER-200918. Additional information about these efforts can be found at <http://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminants-on-Ranges/Identifying-and-Evaluating-Sources>.

4.3.4 Advanced Sensors and Algorithms

Advanced sensors for evaluating groundwater, air, sediments and surface waters could reduce labor costs for site characterization and monitoring, as well as reduce the uncertainties involved. Such field-based sensors may not be designed for regulatory compliance monitoring, at least not initially, but may be

valuable for assessing remediation progress or providing early warning of altered conditions as part of the LTM framework. In particular, the development and deployment of small maneuverable sensors could greatly improve the speed and accuracy of underwater munitions investigations, which can be very costly using conventional methods.

4.3.5 Underwater Sites

Underwater sites require significant technology advancements in several areas. As indicated earlier, investigating munitions releases at underwater sites is expensive and uncertain. Further, recovery and disposal of munitions from these sites is costly and difficult. For example, the Navy MMRP has 320 terrestrial sites and only 28 marine sites, yet the estimated CTC for all of the marine sites (\$1.1 B) is almost twice as large as the combined CTC for all of the terrestrial sites. Specific needs include: 1) greater use of wide area assessment technologies; 2) improved discrimination of munitions and munitions constituents; 3) improved platforms for underwater equipment; 4) better understanding and characterization of underwater conditions; and 5) cost-effective recovery and disposal techniques.

Some of these issues are currently being addressed by SERDP and ESTCP and descriptions can be found at <http://www.serdp-estcp.org/Program-Areas/Munitions-Response/Underwater-Environments>. In addition, the threat of chemical constituents in the underwater environment is being addressed and descriptions of such efforts are available at <http://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminants-on-Ranges>.

4.3.6 Emerging Contaminants

The production of new materials and renewed regulatory interest in older ones require ongoing research to evaluate risks and investigate impacted sites. PFCs and insensitive munitions are two recent examples of this ongoing need, and depleted uranium may represent another. Greater use of computational chemistry to predict chemical properties and environmental risks would streamline the process and save time and costs. In addition, changes in the regulatory status of existing contaminants of concern also require ongoing research to improve analytical methods and characterization methods. For example, lowering TCE or perchlorate criteria could greatly expand investigations of low-concentration plumes.

Efforts continue under SERDP to develop methods for assessing the risk of new munitions compounds. In 2010, an SON was released to develop methods to utilize advanced, predictive techniques to improve the assessment of the environmental fate and transport of new, military-unique munition compounds. Summaries of these projects are available at www.serdp-estcp.org under [ER-1734](#), [ER-1735](#), and [ER-1736](#). In 2012, an additional SON was released seek research to develop an improved understanding of the environmental impacts associated with the use of insensitive munition compositions in munitions on DoD training and testing ranges. The selection process for these projects will be finalized in the Fall 2011.

4.3.7 Distinguishing Between DNAPL and Back Diffusion Sources

New paradigms are being tested at chlorinated solvent sites that focus on the aging process, where it is hypothesized that some or perhaps many sites may be in a “Late Stage” category defined as when little or no DNAPL remains but a plume is sustained largely by back diffusion from low-K zones. Better tools, protocols, and decision guides are needed to distinguish between plumes primarily sustained by DNAPL and plumes primarily sustained by back diffusion, as the appropriate remedial response, regulatory status, and applicability of inexpensive low-risk site management techniques may hinge on this distinction.

4.4 Technology Transfer Needs

Participants strongly supported technology transfer. SERDP/ESTCP has produced a wealth of valuable information, much of which has had limited use by practitioners. Some participants recommended that ESTCP establish a “study group” to evaluate the best methods to use to better transfer this information.

In particular, participants stressed the need for decision-making support tools and guidance on diagnosing and optimizing existing remediation systems. Participants also felt that remediation practitioners need help in two specific areas: verifying conceptual site models and interpreting monitoring well results.

4.4.1 Diagnosis and Optimization of Remediation Systems (HIGH)

An increasing number of sites have entered (or will soon enter) the RIP phase, and therefore cost-effective diagnostic techniques and remedy optimization processes are necessary. Diagnostic tools such as high-resolution monitoring, push-pull tests and tracer tests continue to be developed and promoted, but there is little guidance available on their use. In addition, an increasingly important consideration in the optimization process is the focus on green and sustainable remediation. Participants felt that optimization is often poorly thought-out; for example, there seems to be an emphasis on reducing the number of treatment and monitoring wells, even though it may also reduce treatment performance and thereby actually increase the life-cycle costs and overall liability. “Best practices” for diagnosing and optimizing remediation systems are needed to help site managers minimize the ongoing costs for restoration, while ensuring that performance problems are detected and corrected as soon as possible. Rules of thumb for remedy optimization would be particularly useful. Participants also noted that the diagnosis and optimization guidance should be provided in a focused manner, to avoid the perceived information overload common in technology transfer materials.

4.4.2 Decision-Making Support (HIGH)

Several participants expressed a desire for better decision-making support that both incorporates applicable regulatory guidance (e.g., CERCLA remedy selection guidance at NPL sites) and assists site managers with operational and optimization decisions. Cost/benefit analysis tools are particularly needed, so that decision-makers fully consider the potential costs and benefits of differing strategies in a realistic and thorough manner. Typical questions include: 1) How to decide when to transition between technologies or to stop active treatment; 2) How to efficiently combine remedies; 3) How to incorporate the risks of having to implement contingency actions; 4) How to scale-up from laboratory- and pilot-scale tests to full-scale designs and cost estimates; and 5) When to stop a technology that is not working? Guidance on adaptive management approaches also would be helpful in some situations. As noted above, brief and targeted guidance is preferred.

4.4.3 Testing and Verifying Conceptual Site Models

Accurate and updated conceptual site models (CSMs) are critical to effective site management, but it is common to have incomplete or even inaccurate conceptual models. Often, the existing data is not sufficient to discriminate between varying possible conceptual models, or the available characterization efforts were not focused on providing the information needed to make management decisions or to design specific remedial alternatives. Assumptions underlying the CSM often are not explicitly questioned, multiple hypotheses are not identified, and unexpected surprises are common. As a result, there is a need for guidance on how to test and refine existing CSMs. Such evaluations should be done in a strategic and surgical manner. Questions to be addressed in these evaluations include: 1) What features should be included in an adequate CSM; 2) How can managers test the CSM to verify its adequacy and accuracy; 3) What methods are available to address deficiencies in an existing CSM; and 4) How can managers differentiate between multiple possible interpretations of existing characterization data?

4.4.4 Monitoring Well Guidance

Monitoring wells have several limitations that often are not recognized. Wells generally sample a very small fraction of the total groundwater in aquifers generally characterized by a high degree of heterogeneity. Further, wells can intersect multiple strata with highly varying groundwater and solute fluxes. A well may create unrepresentative geochemical and microbiological conditions in and around the borehole, and there often is a high degree of temporal variability in monitoring well data, due to changes in groundwater velocity, direction, temperature gradients or elevation. Long-term trends, typical of natural attenuation or post-treatment re-equilibration, can be difficult to discern using typical monitoring well deployments. Alternative strategies, including “high resolution” monitoring, use of transects, and less frequent but more spatially-intense monitoring, have been proposed to overcome some of these challenges. However, there is a need for guidance on the use and interpretation of monitoring wells. Such guidance should cover the potential limitations of monitoring wells, the best practices for designing and sampling monitoring wells for different conditions and purposes, and the issues to consider when interpreting monitoring well data.

5. SUMMARY

The workshop highlighted the progress that all of the DoD components have made over the last 15 years. Nearly 90% of the IRP sites at active installations have achieved RIP or RC status. The BRAC installations and FUDS properties are not as advanced, with 61% and 72% at the RIP/RC stage by FY10. The CTC estimates have declined significantly for the IRP sites as well, and optimization programs have led to increasing cost-efficiency in the management of contaminated sites.

However, there are several remaining challenges in achieving RIP/RC for all sites. The MMRP programs are not as far along as the IRP, and the estimated costs associated with the MMRP sites have increased over the last decade. Most of the remaining IRP sites are technically challenging (especially the fractured bedrock and underwater sites). In addition, some more recent contaminant issues have arisen, notably dioxane and PFCs, as well as some contaminants for which the existing risk-based standards may be lowered (e.g., TCE, Cr). Finally, even after achieving RIP, many of the sites seem to be “stuck” in the RA-O phase, even if the site is low-risk.

Research and development have contributed to the past success, but still are needed to address the future challenges. The characterization and monitoring of large MMRP sites and underwater sites will require technology advances. Restoration of contaminated groundwater at fractured bedrock sites remains extremely challenging. Vapor intrusion has become a highly contentious and costly issue at many sites. Research on emerging and military-unique contaminants will continue to be needed.

In addition, all of the representatives agreed that technology transfer was an important priority. Improved guidance and decision-making support for RPMs, consultants and regulators is needed. Guidance on several issues was recommended, including remedial system optimization, CSM development, and the use of monitoring wells. Decision-making support was considered a high priority, particularly for performing cost/benefit analyses of management options. Technology transfer tools should be web-based, and focused on specific issues, so that RPMs can find relevant information quickly and easily.

APPENDIX A
AGENDA



Environmental Restoration Workshop

**Investment Strategies to Optimize Research and Demonstration Impacts in Support of
DoD Restoration Goals**

Peery Hotel, Salt Lake City, UT 84101

THURSDAY, JUNE 16, 2011		
0730	Registration/Continental Breakfast	
0830	Welcome and Introduction Workshop Objectives and Structure	Andrea Leeson SERDP/ESTCP
0845	US Army Perspectives on Meeting Restoration Goals	Laurie Haines Army Environmental Command
0910	USAF Perspectives on Meeting Restoration Goals	Hunter Anderson AFCEE
0935	Navy Perspectives on Meeting Restoration Goals	Kim Parker Brown US Navy
1000	An Overview of the FUDS Program and Perspectives on Meeting FUDS Program Goals	Chuck Coyle US Army Corps of Engineers
1020 Break		
1035	Application of Innovative Solutions to Meet Site Closure Goals from a Contractor's Perspective	Lynn Kessler HGL
1100	Discussion: <ul style="list-style-type: none"> • DoD Goals: Progress and Barriers to Attainment • Post-RIP Issues at Contaminated Sites • Current and Future Roles for Innovative Technologies 	Group
1200 Lunch (on your own)		
1245	Discussion: <ul style="list-style-type: none"> • Identifying Knowledge and Technology Gaps • Rationale for Specific Research Needs 	Group
1515 Break		
1530	Prioritization of Research Needs	Group
1645	Closing Summary and Remarks	Andrea Leeson
1700 Adjourn		

APPENDIX B
PRESENTATIONS

SERDP/ESTCP Strategy Meeting

**SERDP/ESTCP Strategy Meeting
Army Active Sites Cleanup Program Update**

16 June 2011

Laurie Haines
USAEC Cleanup & Munitions Response Division

Our mission is to lead and execute environmental programs and provide expertise that enables Army training, operations, acquisition and sustainable military communities.
ENABLING MISSION READINESS

Laurie Haines/BAE/CD/10401-810 / laurie.haines@us.army.mil UNCLASSIFIED 16JUN11

SERDP/ESTCP Strategy Meeting

Briefing Outline

- Overview of the Army's cleanup goals
- Army Active Sites Cleanup Program Status
- Barriers to meeting the goals
- Use of innovative tools and technologies in the cleanup program

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SERDP/ESTCP Strategy Meeting

DoD/Army Cleanup Goals

- **DoD/Army Goals**
 - Remedy in Place/Response Complete (RIP/RC) on all Installation Restoration Program (IRP) sites by 2014
 - RIP/RC on all Munitions Response Sites by 2020
 - RIP/RC at each CR site within 7 years of site identification
- **Army Cleanup Program**
 - Active Installations
 - Installation Restoration Program (IRP) Sites
 - Military Munitions Response Program (MMRP) Sites
 - Compliance Related Cleanup (CR) Sites
 - BRAC Installations (IRP and MMRP)
 - FUDS Properties (IRP and MMRP)

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SERDP/ESTCP Strategy Meeting

Definitions

- **Remedy in Place (RIP)** – remedy has been constructed and is operating effectively.
- **Response Complete (RC)** - all cleanup objectives specified in the site's ROD or decision document have been met.
- **Long-term Management (LTM)** - activities to ensure the implemented remedy remains effective. Includes activities such as environmental monitoring, review of site conditions, and/or maintenance of a remedial action to ensure that the established remedy continues to meet the objectives prescribed in the ROD.

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SERDPI/ESTCP Strategy Meeting

Army IRP Status

- *Initial:* 1083 Installations/10501 Sites
- *As of FY11:* 47 Installations/407 Sites not at RIP/RC
 - Progress is slowing; complicated sites remain
 - All but 4 installation RIPs expected by end of FY15
 - Last installation RIP expected 2030
- ~ 93 installations will require RA(O) and/or LTM at one or more sites
- Army has ~ \$1.7B (un-inflated, FY09) in liabilities associated primarily with RA(O)/LTM at Active sites

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SERDPI/ESTCP Strategy Meeting

Army MMRP and CR Status

MMRP

- *Initial:* 158 installations/631 sites were evaluated (SI)
- *As of FY11:* 89 Installations/311 Sites not at RIP/RC

CR

- *Initial:* 417 CR Sites
- *As of FY11:* 345 CR Sites not at RIP/RC

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SERDP/ESTCP Strategy Meeting

IRP Challenges

- **Groundwater restoration**
 - DNAPL
 - Complex hydrogeologic environments
 - Tools to make remediation decisions
- **Vapor Intrusion**
- **Long term monitoring/Long term management**
 - Reduce groundwater monitoring costs
 - Life Cycle Cost analysis/Optimize asset management
- **Remedial Action Optimization**
 - Decision Tools - when to stop active remediation or when to transition to a different technology

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SERDP/ESTCP Strategy Meeting

MMRP Challenges

- Definition of adequate characterization
- Discrimination between MEC and munitions debris
- MEC risk assessment tools
- Decision tools – MEC management versus clearance

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SERDP/ESTCP Strategy Meeting

END OF PRESENTATION

INSTALLATION MANAGEMENT COMMAND



IMCOM
SUSTAIN • SUPPORT • DEFEND

“Sustain, Support and Defend”

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Air Force Center for Engineering and the Environment

Integrity - Service - Excellence



Overview of Technology Needs to Support the Air Force Environmental Restoration Program

June 16, 2011

Hunter Anderson
AFCEE/TDV

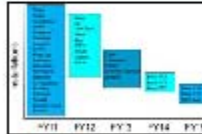


Big Picture Restoration Goals

U.S. AIR FORCE

Objective 1: ENVIRONMENTAL

Reduce Liability and Close Sites
Design a strategy to obtain the Highest ROI for each dollar



Objective 2: MISSION

Invest to Enhance the Mission
Identify opportunities to enhance the mission and strategically invest to clear land of constraints



Objective 3: ASSETS

Leverage Assets to Create Value
Identify opportunities in hot markets and leverage the asset to offset liabilities or create value for the installation



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1



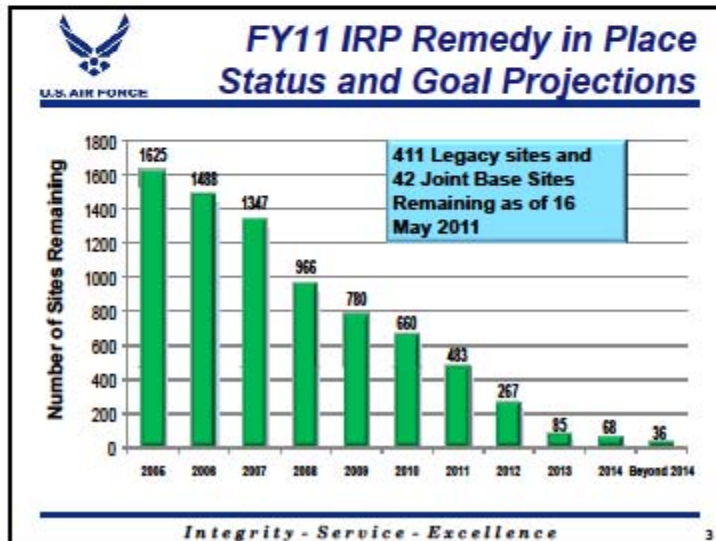
Environmental Restoration Program (ERP) Goals

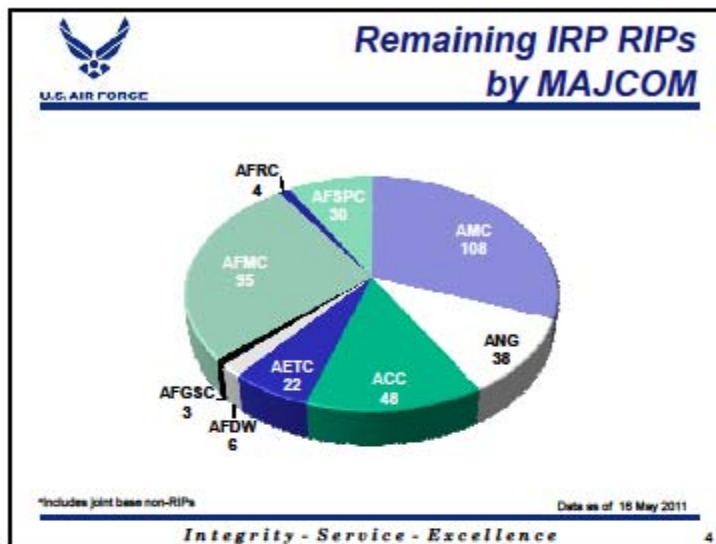
U.S. AIR FORCE

<p>Installation Restoration Program (IRP)</p> <ul style="list-style-type: none"> ■ Cleanup of pre-1986 contaminated sites ■ Achieve Remedy-in-Place (RIP) at most sites by 2012 ■ Total Sites: 6622 (1753 Open, 4869 Closed) 	<p>Munitions Response Program (MMRP)</p> <ul style="list-style-type: none"> ■ Cleanup of closed, non-operational ranges ■ Complete Site Investigations at all sites by 2010 ■ Total sites: 865 (679 Open, 186 Closed)
<p>Compliance Restoration Program (CRP)</p> <ul style="list-style-type: none"> ■ "Compliance cleanup sites" (post-1986 releases) ■ Began In 2011; Program goals under development ■ Total Sites: 955 (953 Open, 2 Closed) 	

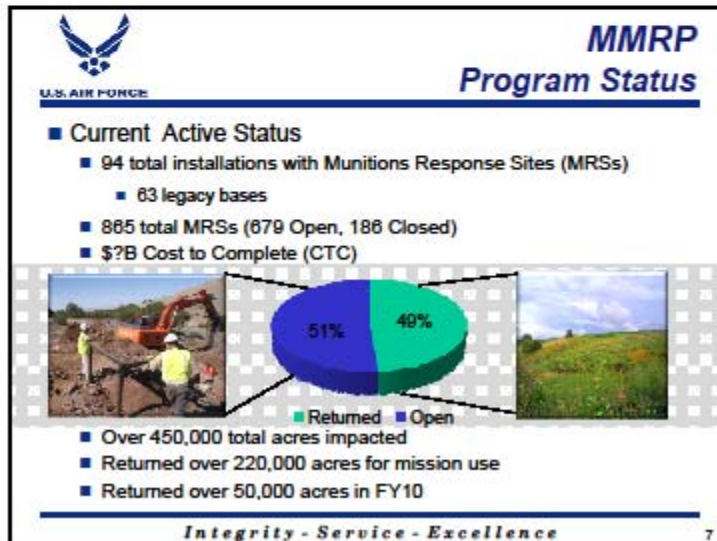
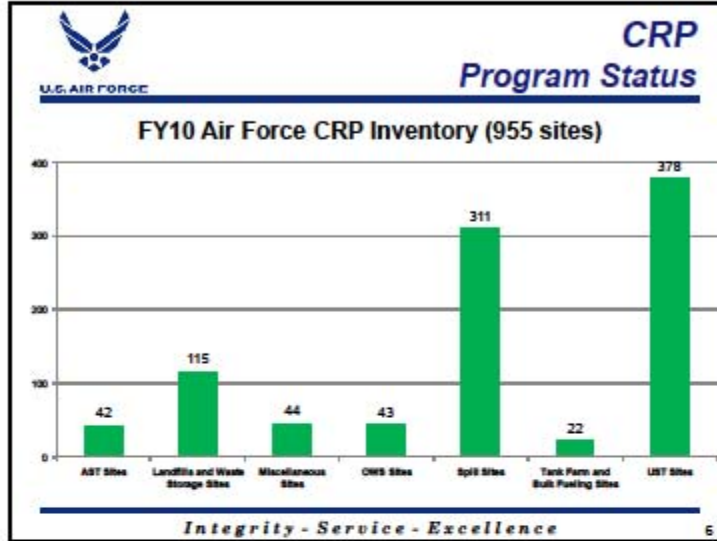
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2





- CRP
Program Status**
- **Snapshot**
 - Created in response to DUSD(IE) and AF/A7CAN policy
 - ERA sole funding source for most cleanup activities
 - ERA funding for eligible sites authorized beginning in FY11
 - FY09 Air Force CRP Inventory (913 sites) validated as of 30 Sep 09
 - FY10 Air Force CRP Inventory (955 sites)
 - Validated as ERA eligible as of 30 Sep 10
 - Transitioned to Air Force CRP on 1 Oct 10
 - Expect total number of sites to change with FY11 Joint Basing transitions and ongoing oil-water separator sampling efforts
 - **Future Emphasis**
 - Aggressively execute FY11 Program
 - CRP sites included in fence-to-fence PBCs
- Integrity - Service - Excellence*
- 5






MMRP Program Status


- Majority of AF MMRP sites are small arms ranges, open burning/open detonation areas, and disposal pits
 - 60% of AF program – Continue to focus on closure!
- The “Big Eight”—Large munitions/mixed use ranges will drive the long-term program
 - Bombing Ranges
 - Air-to-Ground Ranges
 - Historic Artillery Ranges

The Big Eight Air Force Installations:

• Barksdale AFB	• Kirtland AFB
• Edwards AFB	• Luke AFB/Barry M Goldwater Range
• Eglin AFB	• Nellis AFB
• Hill AFB	• Vandenberg AFB




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Paradigm Shift in the AF ERP

- Continued protection of human health and the environment; and maintain compliance with all laws and regulations
- Focus shift from RIP to SC (Residential Levels)
- Installation scope vs site-specific approach
- Life cycle cost considerations
- Performance-Based Contracts as primary vehicle
 - Multi-year, Fence to fence or multi base
- Anticipated Outcomes
 - Reach site closure faster
 - Minimize life-cycle costs



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Take Home Message

U.S. AIR FORCE

IRP:

- "High Hanging Fruit"
- Existing Remedial Options/Technologies are Probably Sufficient
- Issue is with Characterization (CSM) and Engineering Remedial Systems

CRP:

- Mostly Fuels-Related Contamination
- Existing Remedial Technologies are Probably Sufficient
- Need for optimized (and efficient) in-situ applications of Current Technologies

MMRP:

- Metals, MEC, and UXO
- Existing Remedial Technologies are Probably Insufficient
- Need for Better Risk and Site Characterization Methods
 - Discrimination Technology
 - Fate and Transport
 - Exposure

EMERGING ISSUES AND CONTAMINANTS!!

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12



AF Emerging Issues and Contaminants Program

U.S. AIR FORCE

Overview

- Complements DoD Hazardous Chemical and Material Risk Management Directorate Emerging Chemicals Program
- Air Force Environmental Restoration focused
- Promotes state-of-the-science remediation actions within AFCEE
- Identify and reduce AF Environmental Liability

Challenges

- Evolving technology; new clean-up remedies
- Evolving detection capabilities
- New toxicology information – new effects and new pathways = new clean-up standards
- regulatory changes likely result in lower clean-up values and higher costs
- Data-driven documentation of Environmental Liabilities

Initiatives

- Provide technical expertise regarding emerging issues for AFCEE
- Identify/anticipate chemicals and scientific issues that may impact AFCEE ER
- Utilize a standardized, data-driven protocol for evaluation and assessment
- Proactive risk management from emerging issues/contaminants
- Validated technology and research linked to EIs

Impact

- Standardized process, file of record & reports
 - Quarterly Surveillance Reports
 - Issue-specific background papers
- Standardized Stakeholder involvement
- Technology & research initiatives address emerging issues/chemicals
 - AFCEE BAA & OSD SERDP/ESTCP Proposal solicitations include EIs
- Data-driven documentation of Environmental Liabilities

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13



U.S. AIR FORCE

AF Emerging Issues and Contaminants Program

Emerging Issue/Contaminant	Reason Emerging	Current Status in EI Process
PFCs (PFOA/PFOS)	Regulatory interest, high AF impact	RL3- Decision Support; BAA proposals for remediation tech.
Perchlorate	Change in regulatory status	RL1- Background paper, stay in monitor status
1,4-dioxane	Change in regulatory status	Screening- BAA proposals for remediation tech.
Chromium 6+	Change in regulatory status	Screening
Benzo-a-pyrene	Change in regulatory status	Screening
Naphthalene	Change in regulatory status	Screening
PAH Mixtures	Change in science/methods	Screening
Manganese	Change in science and regulatory interest (Mn in soil/inhalation)	Screening
Chlorinated Pesticides	Change in political and regulatory issues	Screening

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14

MISSION

Environmental Restoration delivers sustainable, innovative, cost effective remediation solutions with stakeholder engagement, to protect human health and the environment, maintain regulatory compliance, and maximize reuse of DON assets to support the warfighter.

VISION

NAVFAC Environmental Restoration is the recognized Federal leader for responsive, best value, and sustainable remediation solutions.

Department of Navy

*Environmental Restoration Program
Goals and R&D Needs*

Kim Parker Brown, M.S., P.E.

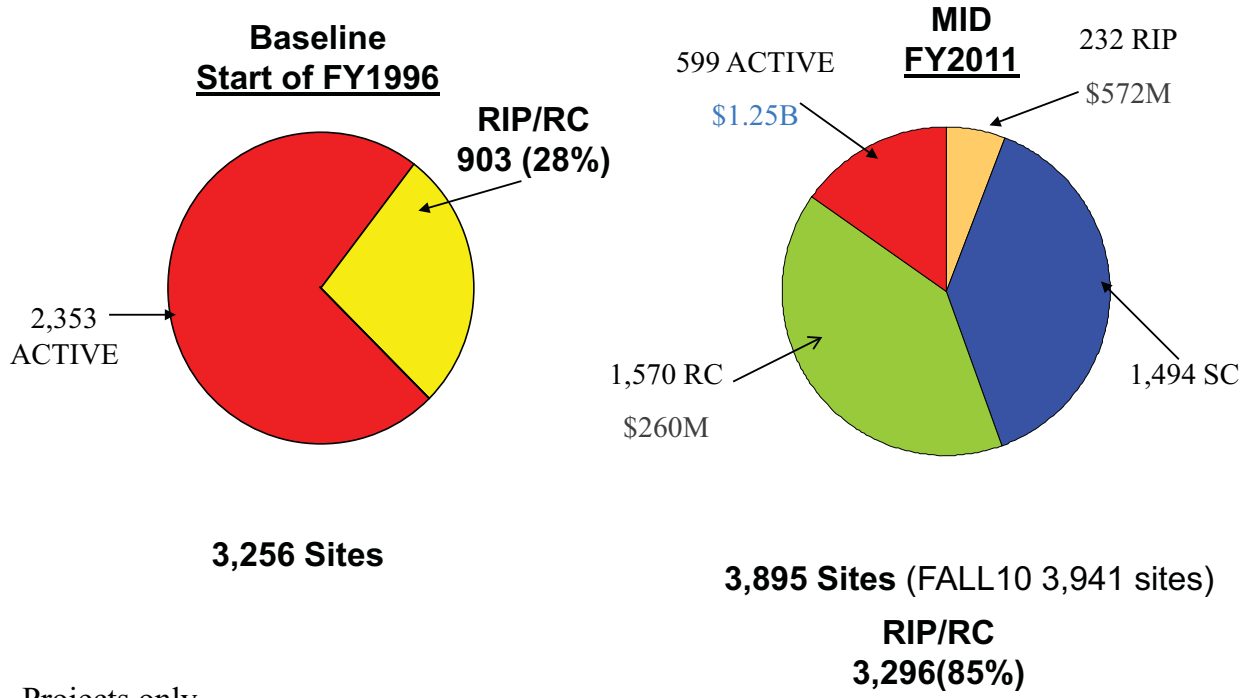
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AGENDA



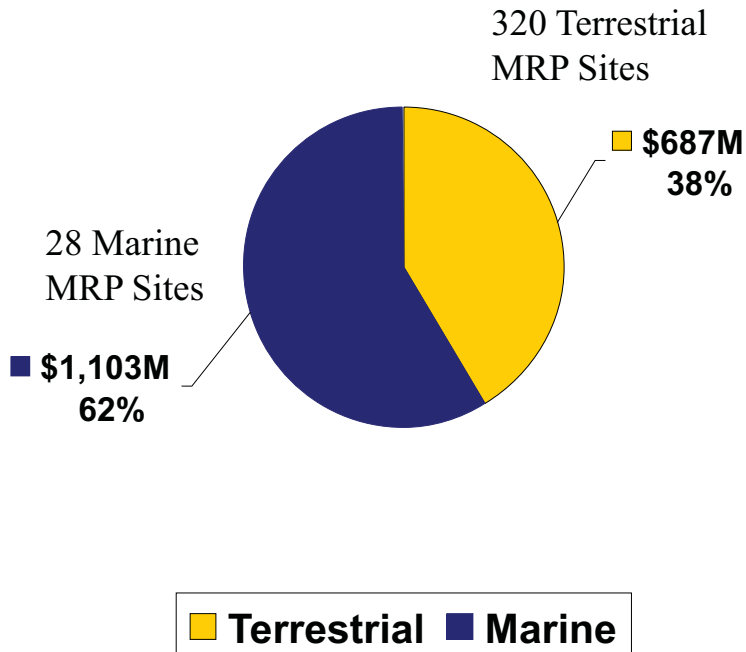
- PROGRAM OVERVIEW
- IR PROGRAM GOALS
- MR PROGRAM GOALS
- IR & MR PROGRAM FOCUS AREAS
 - OPTIMIZATION/GREEN AND SUSTAINABLE REMEDIATION
 - SEDIMENT REMEDIATION
 - STRATEGY FOR VAPOR INTRUSION
 - ADVANCED SENSORS AND ALGORITHMS
 - UNDERWATER SITES
- PROGRAM CHALLENGES
- SUMMARY

Snapshot Of The ER,N IR Program



3

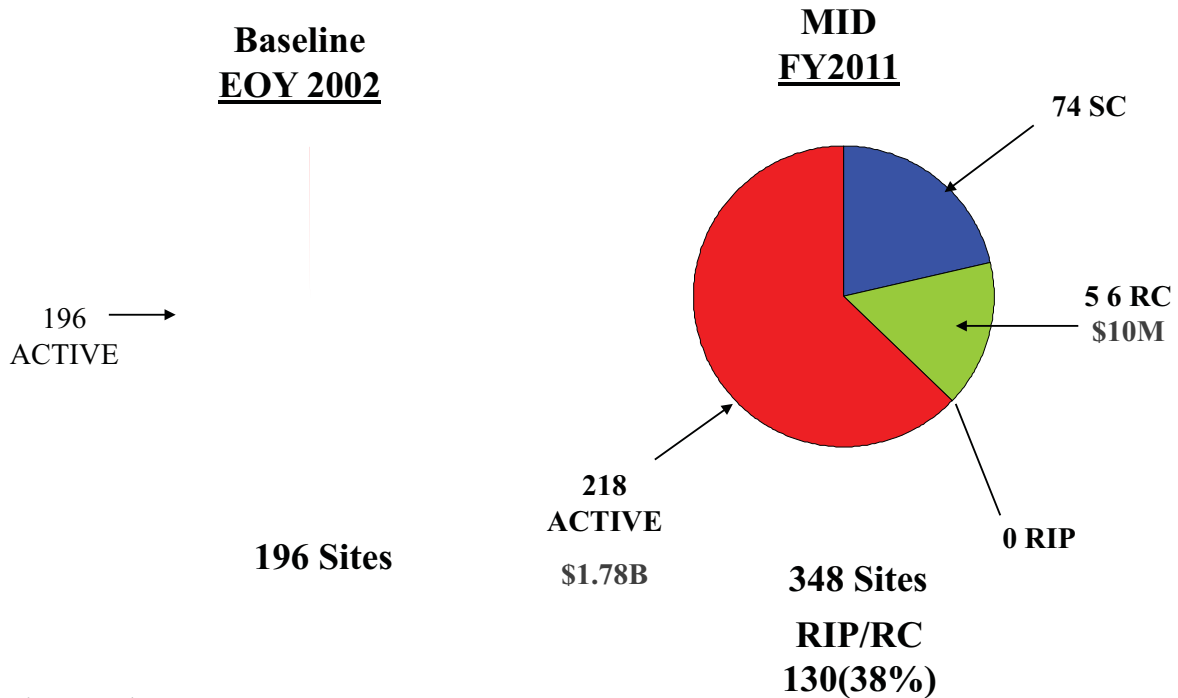
MRP Breakdown Terrestrial and Marine



Projects only

4

Snapshot Of The ER,N MRP Program



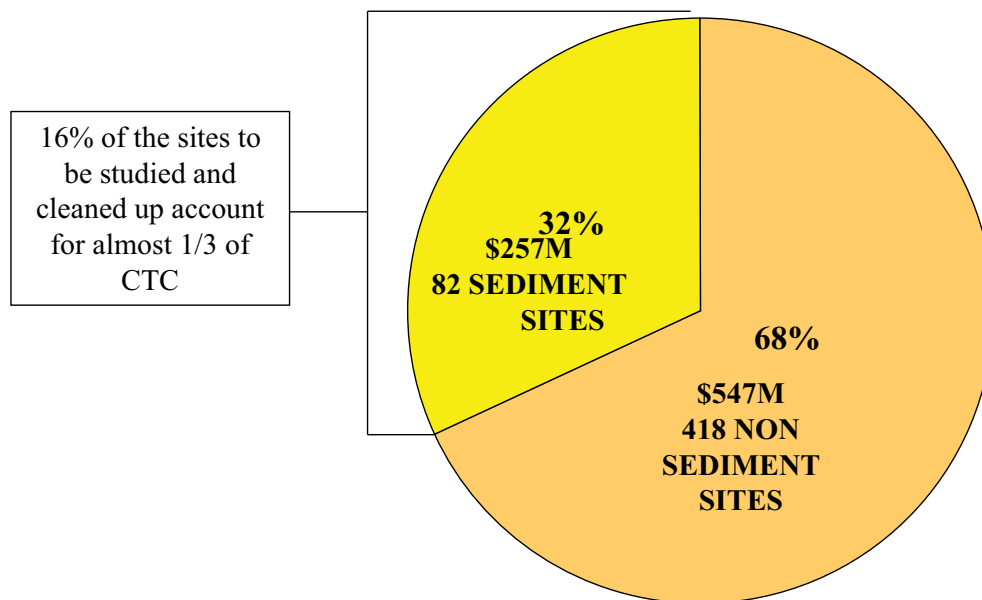
Projects only

5

ER,N IRP Focus Areas Study and Cleanup of Sediment Sites



Total of \$804M on 500 sites



6



- **Long-Term Monitoring - 1**
 - Cost-effective technologies
 - Real-time sensors for contaminant monitoring
 - In-field collection, storage, and retrieval of electronic data
- **VOCs Plumes - 6**
 - Application methods – better ways to distribute (inject) reagents
 - Vapor intrusion issues
- **Sediments - 4**
 - Remedy or containment approaches
 - Long-term monitoring
- **DNAPLs - 5**
 - Characterization and remediation of source zone areas
- **Munitions Constituents (MC) - 3**
 - Toxicity of MC in marine environment
 - Impact of MC on coral reefs
 - In situ treatment of MCs
- **Optimization - 2**
 - Methods/technologies for optimizing long-term monitoring
- **Emerging Contaminants - 7**
 - Additional data on chemical behavior, transport properties, and toxicological characteristics to support decision making
 - Better analytical methods and tools to address exposure pathways and scenarios

IR Program Focus Areas – Optimization/Green and Sustainable Remediation (GSR) Efforts



- **Implementing as part of NAVFAC’s existing optimization program**
 - Optimization reviews (required by NAVFAC Policy) are opportune times to evaluate green/sustainable methods
- **Emphasized in NAVFAC Technology Transfer Plan for Environmental Restoration 2010 – 2014**
 - “Incorporating Optimization and Sustainable Environmental Remediation Practices” is one of the top 8 technical challenges
- **Optimization Workgroup tasked to develop and promote Navy’s GSR approach, implementation, and information**
- **Communicating efforts through FRTR, ITRC, and SuRF**

IR Program Focus Areas - Green and Sustainable Remediation (GSR) Efforts



- NORM Optimization Module to be updated by EOY to track GSR metrics
- Optimization/GSR Module will ultimately track the following sustainable actions:
 - Minimized energy usage and increased energy efficiency
 - Maximized recycling, reuse and reduction of materials, including waste
 - Preserved natural resources
 - Minimized emissions, including greenhouse gases
- Optimization/GSR Module will ultimately track the following sustainable remedial technologies:
 - Monitored natural attenuation
 - In-situ bioremediation
 - Engineered Wetlands
 - Permeable reactive barriers, including biowalls
 - Stabilization/solidification using soil amendments

9

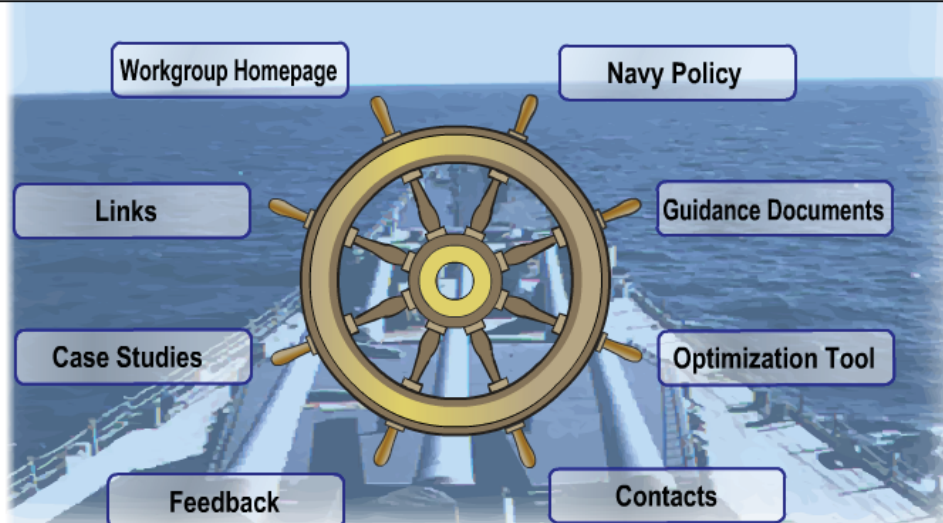
T2 Optimization Web Page



www.ert2.org

Welcome to Technology Transfer Optimization Portal!

Welcome to NAVFAC's interactive case studies and training tool. The primary objective of optimization efforts is to maximize the effectiveness of remedial and removal actions while minimizing the cost to achieve site closeout. This Web page is a link to the optimization Web tool and also focuses on the case studies associated with the tool.

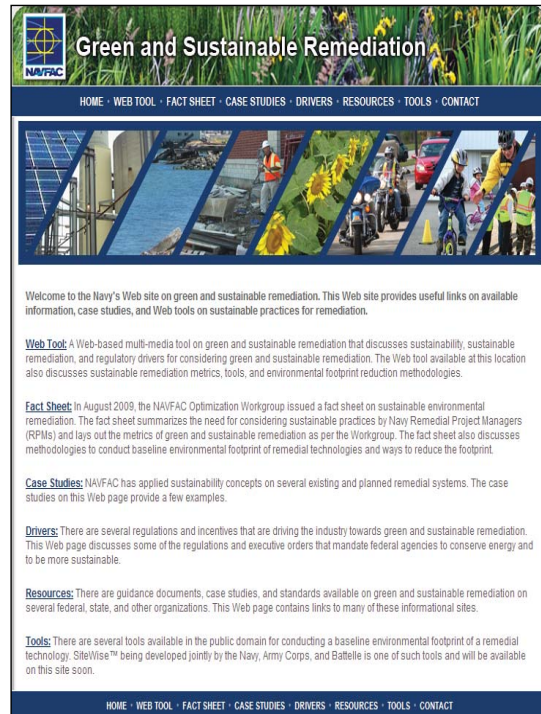




Resources such as:

- **Guidance documents and standards available on green and sustainable remediation**
- **GSR Fact sheet**
- **Case Studies**
- **Drivers**
- **Tools**
- **Links Federal, State & other organizations related to GSR.**

Access from: www.ert2.org



11

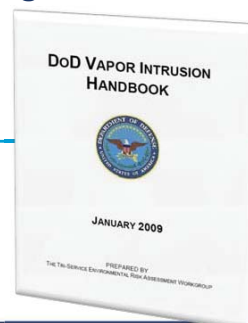
IR Program Focus Areas - Navy Strategy to Meet Vapor Intrusion Challenges



- **Web-based Vapor Intrusion Decision Tool On Schedule, Beta Testing Underway**
- **EPA Enthusiastic about Tool and Participating in Beta Testing**
- **Developing Industrial Attenuation Factor to be More Representative of DON Buildings/Structures**

Item	MILITARY		CIVILIAN		REMARKS
	STATUS	COMPLETION DATE	STATUS	COMPLETION DATE	
1. Vapor Intrusion Decision Tool (VIDT) Development	Complete	2009	Complete	2009	Tool is available for beta testing.
2. EPA Participation in Beta Testing	In Progress	2009	In Progress	2009	EPA is currently testing the tool.
3. Industrial Attenuation Factor Development	In Progress	2009	In Progress	2009	Factor is being developed for DON buildings.
4. Passive Samplers Development	Complete	2009	Complete	2009	Samplers are available for use.

Passive Samplers



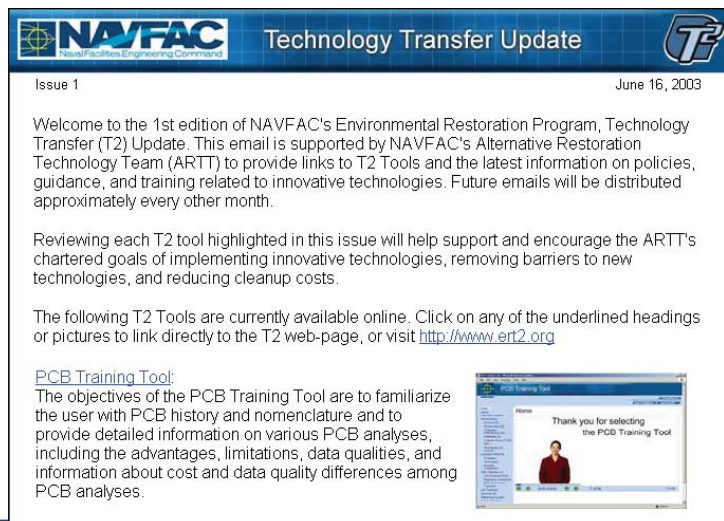
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- Amphibians Risk Assessment
- Benthic Flux Sampling Device
- Biodegradation of DNAPL Through Bioaugmentation
- Charleston Web Portal
- Chemical Fingerprinting
- DCE Stall
- Degradation of Ordnance Constituents in Marine Sediments
- Direct Push
- DNAPL Detection and Characterization
- DNAPL Management Overview
- Electrical Resistive Heating Case Study
- Electromagnetic Surveys
- Encapco Stabilization
- Environmental Background Analysis
- Groundwater Sampling
- In Situ Chemical Oxidation
- In Situ Reactive Zones (IRZ)
- Land Use Controls
- Molecular Biological Tools
- MTBE Training
- Munitions Response Web Portal
- Nanoscale Zero Valent Iron
- Navy Sediment Investigation
- Optimization Web Portal
- Passive Diffusion Sampler
- Perchlorate Treatment Technologies
- Permeable Reactive Barrier (PRB)
- Polychlorinated Biphenyls (PCBs)
- Pulsed Elemental Analysis with Neutrons (PELAN)
- Remedial Action Performance Objectives
- Site Closeout Tool
- Sediment Guide₁₃

T2 Email Updates and Technical Insight and Problem Solving (TIPS) Forum



- T2 Updates distributed once per month
- Succinct, addresses 1 – 3 topics, provides hyperlinks for further information
- Announces new T2 web tools, guidance documents, or other new information to support RPMs
- TIPS calls held monthly by HQ w/Field (FECs)




Issue 1 June 16, 2003

Welcome to the 1st edition of NAVFAC's Environmental Restoration Program, Technology Transfer (T2) Update. This email is supported by NAVFAC's Alternative Restoration Technology Team (ARTT) to provide links to T2 Tools and the latest information on policies, guidance, and training related to innovative technologies. Future emails will be distributed approximately every other month.

Reviewing each T2 tool highlighted in this issue will help support and encourage the ARTT's chartered goals of implementing innovative technologies, removing barriers to new technologies, and reducing cleanup costs.

The following T2 Tools are currently available online. Click on any of the underlined headings or pictures to link directly to the T2 web-page, or visit <http://www.ert2.org>

PCB Training Tool:
The objectives of the PCB Training Tool are to familiarize the user with PCB history and nomenclature and to provide detailed information on various PCB analyses, including the advantages, limitations, data qualities, and information about cost and data quality differences among PCB analyses.





- Provides training on new and innovative technologies, methodologies, and guidance under Navy's IR Program and MRP
- Topics identified by ER Managers and developed by NFESC with input from ARTT and other workgroups
- Held twice yearly as one-day seminars at each Field Engineering Command (7 locations)
- Targeted to Navy RPMs, but available to other DoD personnel, the Navy's environmental cleanup contractors, and environmental regulators
- Current RITS registration and past RITS presentations available at <https://portal.navfac.navy.mil/go/erb>

15

15

MRP Focus Area: *Requirements and Prioritization*



- Development of New Requirements
 - Areas of Concern from completed SI's leading to new sites
 - Sea Defense Areas
 - Recent range closures included under new DERP eligibility
- Navy applying Munitions Response Site Prioritization Protocol
 - MRSP provides foundation of site sequencing decisions
 - Scores currently being updated to reflect latest SI information
 - Updated scores will be utilized to prioritize follow-on RI's and cleanup actions
 - Sequencing considerations include application of "risk-plus" factors
- Continued Cleanup at high risk and political sites
 - Vieques
 - Jacksons Park
 - Cat Island, NC

16

MRP Focus Area: *Technology*



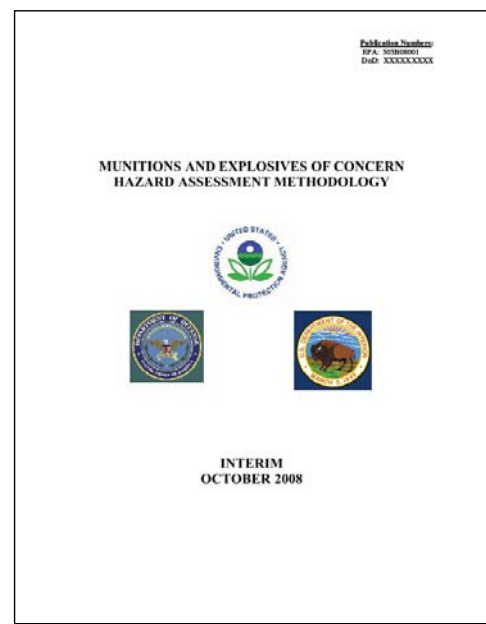
- **Remedial Investigation focus over next several years**
 - **Must begin technology transfer of new advanced sensors and algorithms into mainstream use in RI's**
- **Underwater sites require significant technology advancement**
 - **Wide Area Assessments**
 - **Improved discrimination**
 - **Improved platforms**
 - **Underwater phenomenology**
 - **Cost effective recovery and disposal**

17

MRP Focus Area: *Risk Assessment*



- **MEC Hazard Assessment (MEC HA)**
 - **Developed by a Technical Working Group EPA, DoD, DOI, States, and Tribes**
 - **NCP requirement to conduct site-specific risk assessments**
 - **Navy has agreed to evaluate over a two year trial period**
- **Navy interest in developing and evaluating other methodologies**
 - **MEC HA does not address underwater**
 - **MEC HA provides only qualitative assessment**
 - **Desire more probabilistic and quantitative risk assessment**



18

ER,N Program Challenges



- Incorporating more in-house design to the program
- Reducing program overhead

- IRP
 - Sediment Remediation Technologies
 - Radiological Site Identification
 - Compliance Cleanup Sites
 - Sites closed with limited information during IAS
 - Vapor Intrusion /PFOAs
 - Policy on Asbestos and Lead Base Paint
- MRP
 - Need for Advanced Sensors (Terrestrial Side) – Better Maneuverability
 - Marine UXO cleanup
 - Sea Defense Areas
 - New Sites
 - Vieques (Trespassing, Burn)

19

DON ER Program Summary



- Continue steady progress towards reaching DoD goals. Late funding impacting RIP/RC progress.
- Forty sites not making FY 14 RIP/RC goal due to technical challenges, increased requirements/cost, new sites added late that will need additional time to go through the process.
- Refocusing our optimization efforts with positive results (ROI of 5.5).
- Progressing on green and sustainable remediation by incorporating with our optimization strategy and developing metrics.
- Ramping up ER program to address MRP Technology Needs

20

FUDS Overview and Perspective on DOD Research & Development Needs for Environmental Restoration

Charles Coyle, P.E.
Environmental & Munitions Center of
Expertise
US Army Engineering and Support
Center, Huntsville

June 2011



US Army Corps of Engineers
BUILDING STRONG_®



FUDS Overview & Perspective

- **Purpose:**
 - ▶ Communicate FUDS Program Goals and FUDS Perspective on Environmental Restoration (ER) R&D Needs
- **Objective:**
 - ▶ To ensure that FUDS ER R&D needs are taken into consideration by SERDP / ESTCP



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FUDS is a Different Animal

- The FUDS Program is separate from the Army IRP Program
- The FUDS Program cleans up only DoD generated pollution which occurred before transfer of property to private owners, or federal, state or local government owners
- The Department of Defense does not own the property that FUDS is cleaning up
- We do not certify that the property is clean
- We rarely have a project office on site
- We work hand in hand with current property owners and regulators on cleanup efforts



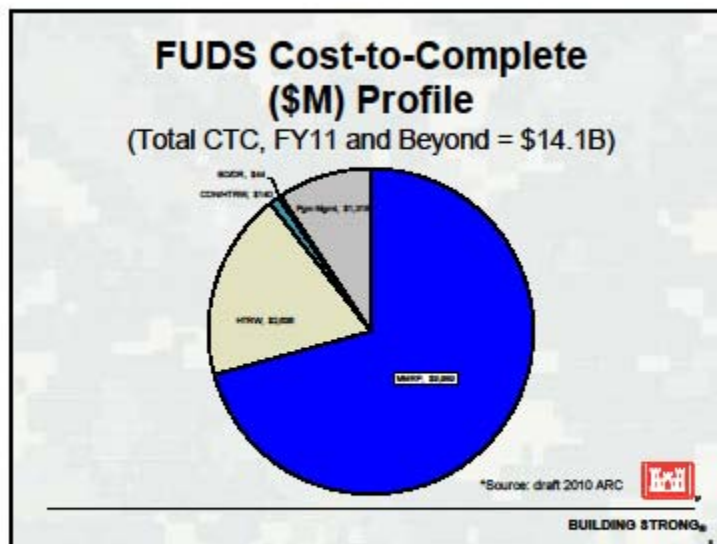
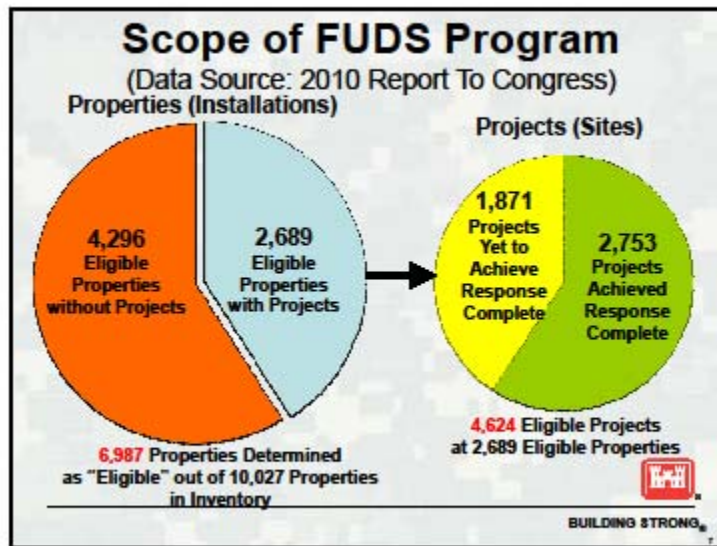
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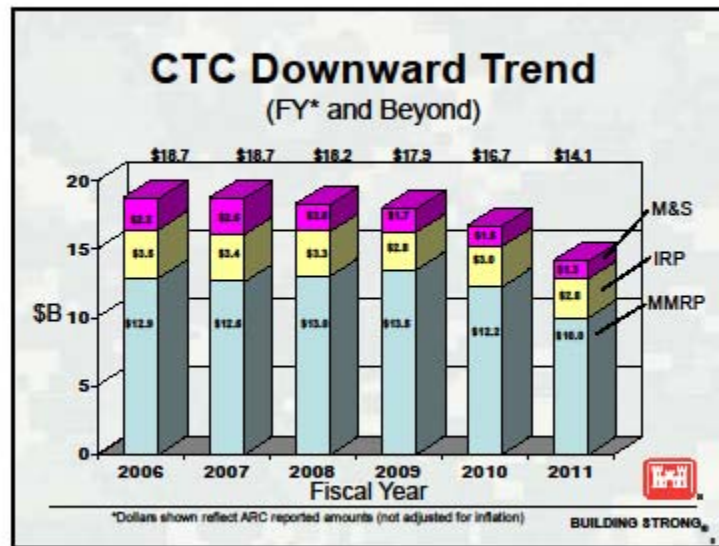
FUDS Property Eligibility

- For a Property to be FUDS eligible:
 - ▶ Under the jurisdiction of the Secretary, **AND**
 - ▶ One of the following:
 - Owned by;
 - Leased to; or
 - Otherwise possessed by.
- Transferred from DoD prior to 17 October 1986
- Meeting eligibility criteria makes the property eligible for DERA funding



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- ### PBC Goals
- **FUDS funding goal for PBC**
 - ▶ Currently at 25% & being achieved

 - **Use of innovative technologies within PBCs continues to be encouraged, but can pose challenges**
- BUILDING STRONG**

MMRP Characterization Data Summary



- ▶ So far, Pb appears to be the most prevalent MC that has been identified in soils from FUDS MMRP properties
- ▶ At least 42 former Small Arms Ranges (SARs) have been identified on FUDS MMRP project sites,
- ▶ A large number of the Pb exceedances in soils are believed to be associated with SARs
- ▶ Sidenote: There is significant uncertainty regarding the timing of when former SARs on FUDS MMRP properties will move forward into remedial design stage – will probably depend on scoring from Munitions Response Site Priority Protocol (MRSP)



13

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Common IPR issues

- ▶ **Persistent chloroethene plumes are prevalent on FUDS projects**
- ▶ Many of these sites appear to have high-concentrations of chloroethenes that are “hung-up” in the vadose zone, & functioning as continuing sources
- ▶ Secondary sources also appear to be common (i.e., back-diffusion from low permeability zones)
- ▶ RIP has been achieved on many of these sites by installing ex-situ groundwater treatment systems; but we don't seem to be making much progress toward RC (i.e., many sites appear to be “stuck” in RA-O).



14

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Maturity of the Program

- RC on >59% of all projects; all but a “hand-full” expected to achieve RIP by 2020
- Current estimated cost to achieve RIP / RC for FUDS IRP projects (HTRW & CON/HTRW) : \$2.1B (total cost to complete estimate \$2.8B). FY11 funding profile for FUDS IRP projects ~\$262M (including plus-up & reprogrammed funds)
- Approx 130 FUDS IRP projects scheduled to enter RI stage after FY2011
- The list of FUDS-eligible properties may still increase, but the number of new properties coming into the program is decreasing (average of ~20/yr, over the last 3 years)



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Preliminary List of R&D Needs

- Development of better sensors / field instruments & methods to reduce long term monitoring (LTM) costs
- Renewed emphasis on LTMO & Optimization of Remedies already In Place, with Green & Sustainable Remediation attributes
- Research to reduce uncertainty in Risk Assessment
- Continue to fund a modest level of remediation technology development, including fractured rock applications
- Extension of Incremental Sampling & Analysis methods to metals & other organics
- Improvements in technologies for cleanup of MC (e.g., metals) from small arms ranges on MMRP sites



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**Application of Innovative Solutions to
Meet Site Closure Goals:
Contractor's Perspective**

**ESTCP Environmental Restoration
Workshop**

June 16, 2011

Presentation Outline

- ▼ To What Extent Are Innovative Technologies Being Used In PBCs?
- ▼ Keys To Evaluating Use Of Innovative Technologies When Bidding PBCs
- ▼ How Can Innovative Technologies Help Meet Restoration Goals and Reduce CTC?
- ▼ What Issues Remain At Sites After Attaining RIP and RC?
- ▼ Role Of ESTCP

2



To What Extent Are Innovative Technologies Being Used In PBCs?

- ▼ Contracts issued before PBC initiatives often included a "Pilot Study" to select the better remediation technology.
 - Current PBC scopes are only focused on achieving objectives within the slated timeframe. Proposing a science based "Pilot Study" to select the better technology adds additional costs and increases the schedule.
 - A failed remedy falls back on contractor to fix at their own cost.
- ▼ Not all agencies/programs promote use of innovative technologies equally - examples of HTRW PBC contract language that limit use of unproven technologies:
 - "Preferable option is to apply technologies which are "proven" (i.e., reduce uncertainty with technology application and associated cost)."
 - "Goal is for Contractor to meet the Project Specific "Performance Objectives" & they bear the risk for unknown site conditions etc."

3



To What Extent Are Innovative Technologies Being Used In PBCs (cont)?

Examples of HTRW PBC contract language that limit use of unproven technologies (cont.)

- "Where the proposed performance objective for a site is Optimized Exit Strategy, include a performance model (i.e., a quantitative performance metric) that illustrates the anticipated progress towards achieving the remedial action objectives by year during the POP. The performance model shall illustrate what monitoring results will look like through the POP, by year, if the strategy is successful. Actual monitoring data will be compared with the model as the metric for determining success."
- "Innovative technologies shall be approved by the client and regulatory agencies prior to initiating site work"
- "Structure the milestone payment plan so that at least 15% of the total contract price (base) remains for the final milestone." generally site closure or achievement of MCLs

4



To What Extent Are Innovative Technologies Being Used In PBCs (cont)?

▼ Certain MMRP contracts are promoting the use of innovation-example SOW language:

- "Optional Task, Implement Innovative Technology: This task is a Firm Fixed Price task.
 - Objective: Propose, utilize and evaluate effectiveness of innovative technology selected by the contractor.
 - Specific Task Requirements: The contractor shall select an innovative technology to demonstrate during the implementation. The contractor shall provide in its proposal how the technology will be used, how it will evaluate the technology, and how it will document the effectiveness of the technology."

5



To What Extent Are Innovative Technologies Being Used In PBCs (cont)?

▼ Savvy contractors will include innovative technologies in proposal if two conditions are met:

- Engineers can be convinced that the technology has a reasonable chance of effectively meeting performance milestones (unlikely without multiple successful demonstration studies, and preferably studies that show attainment of MCLs)
- Technology is inexpensive enough that contractor can include contingency costs if the technology does not work and still have a cost-competitive proposal.

▼ Some ESTCP technologies that have been proposed and used:

- PRBs
- ISCO
- Passive Flux Meters

8



Keys To Evaluating Use Of Innovative Technologies When Bidding PBCs

- ▼ Are there studies that demonstrate the technology can meet performance goals under the known site conditions?
 - Note – often PBC sites are not well characterized, and lack sufficient geochemical, hydraulic, or lithologic data to support a remedial design.
- ▼ Can the technology be inexpensively and quickly field tested to determine its effectiveness, allowing contractor time to change the remedial approach and still meet the POP if the technology is not successful?
- ▼ Will the innovative technology be accepted by the regulators and clients?
- ▼ Is there a feasibility study (FS) or Record of Decision (ROD) in place? If so, does it include the innovative technology, or will the contractor need to revise the FS or ROD?

7



How Can Innovative Technologies Help Meet Restoration Goals And Reduce CTC?

- ▼ Innovative technologies that work rapidly would be beneficial.
 - Even with proven technologies, it is difficult to attain the remedial goals within the timeframe required for the PBCs to achieve response complete (note - timeframe must include monitoring period).
- ▼ Technologies that are effective on residual, low-level contamination would be beneficial.
 - Even with a proven technology, it can be difficult to remediate the residual contamination to the MCLs or other cleanup goals.
- ▼ Innovative technologies or approaches that are effective in remediating the most complex and challenging sites
 - DNAPL in fractured rock
 - DNAPL in karst
- ▼ Innovative technologies that address emerging contaminants would reduce future costs.
- ▼ Continued development of vapor intrusion sampling techniques will minimize long-term remediation on sites to support that they pose no health risk

8



What Issues Remain At Sites After Attaining RIP and RC?

- ▼ Legacy Costs
 - Ongoing LTO/M and remedial process optimization
 - Life cycle costs associated with Five Year Reviews
 - LUC/IC Inspections
- ▼ Regulator DSMOA Funding



9

Role of ESTCP

- ▼ Develop investigation tools to better delineate, quicker, cheaper, faster, and more completely – not just chemical data but the input (geochemical, hydraulic, and other data) needed to properly design remedies
- ▼ Additional testing in multiple environments/sites
- ▼ Comprehensive guide/design tool on successful technology application, metrics, costing, etc.
- ▼ Educate
- ▼ Regulatory collaboration (ITRC)



10