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Scientific Basis for Monitored Natural Attenuation and Enhanced Passive Remediation for Chlorinated Solvents - DOE Alternative Project for Technology Acceleration Implementation Plan

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Savannah River Site
Aiken, SC 29808

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Scientific Basis for Monitored Natural Attenuation

and

Enhanced Passive Remediation

of Chlorinated Solvents

DOE Alternative Project for Technology Acceleration

Implementation Plan

U.S. Department of Energy Office of Science and Technology
U.S. Department of Energy Savannah River Operations

U.S. Department of Energy
Westinghouse Savannah River Company

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Operated by:

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Acronyms

ASTM	American Society for Testing and Materials
CAB	Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CMP	Chemical, Metals and Pesticides
CMS/FS	Corrective Measures Study/Feasibility Study
Cs-137	cesium 137
DNAPL	Dense Non-Aqueous Phase Liquids
DOD	Department of Defense
DOE	Department of Energy
EMSP	Environmental Management Science Program
EPA	Environmental Protection Agency
EPR	Enhanced Passive Remediation
FRAP	Field Research Advisory Panel
FUSRAP	Formerly Utilized Sited Remedial Action Program
GW	groundwater
HQ	headquarters
ITRC	InterState Technology Regulatory Council
IWG	Interactive Working Group
MCL	maximum contaminant limit
MNA/EPR	monitored natural attenuation/enhanced passive remediation
NABIR	Natural and Accelerated Bioremediation Research
NAS	National Academy of Science
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PCE	tetrachloroethylene
PI	principal investigators
PNNL	Pacific Northwest National Laboratory
RCRA	Resource Conservation and Recovery Act
SC DHEC	South Carolina Department of Health and Environmental Control
SERDP	Strategic Environmental Research and Development Program
SGCP	Soils and Groundwater Closures Project
SR	Savannah River
SREL	Savannah River Ecology Laboratory
SRS	Savannah River Site
SROT	Savannah River Operations Team
SRTC	Savannah River Technology Center
SSEB	Southern States Energy Board
STAR	Science to Achieve Results
SVE	Soil Vapor Extraction
SW	surface water
S&T	Science and Technology
S&T Report	"Critical Science and Technology Targets to Support Monitored Natural Remediation of Chlorinated Organic Solvents" document

TCE	trichloroethylene
TWG	Technical Working Group
UMTRA	Uranium Mill Tailing Remedial Action Program
USEPA	United State Environmental Protection Agency
USGS	United States Geological Survey
VOC	volatile organic compounds
VZ	vadose zone
WSRC	Westinghouse Savannah River Company

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Summary

The overall Monitored Natural Attenuation and Enhanced Passive Remediation (MNA/EPR) Technology Alternative Project is narrowly focused, providing the scientific and policy support to facilitate implementing appropriate passive cleanup and cost effective monitoring strategies leading to responsible completion of active remediation activities at high risk DOE waste sites.

MNA/EPR describe natural processes that mitigate exposure and risk and that are self-sustaining once implemented or require minimal adjustments to maintain functionality. The overall MNA/EPR project effort will be performed as a collaboration between DOE science and operations organizations at the target sites along with regulatory agencies, stakeholders, industry, and universities, as identified in the approved Alternative Project Plan. This plan describes the project initiation activities, individual roles and responsibilities, milestones, and budget for the project. A primary product of this project will be a collaboratively developed MNA/EPR protocol that will facilitate widespread use and acceptance. This technical protocol will be developed in collaboration with regulator agencies as input for regulation updates and guidance documents, as appropriate.

Major Objectives

The major objective of this project is to develop the "next generation" MNA/EPR protocol for chlorinated solvents that will be broadly accepted by regulators, end users, technologists and the public in the states of South Carolina, Tennessee and Washington and EPA Regions IV and X.

The implementation activities and overall structure of this project, along with the specific science selected for systematic deployment and documentation, will support the following key objectives:

- Expand the definition of MNA to include enhanced Natural Attenuation and all forms of sustainable passive natural remediation.
- Gain regulatory concurrence in the states and regions overseeing the Savannah River Site, Hanford, and Oak Ridge sites – work with interstate and national regulatory partners to contribute to national MNA efforts.
- Advance the science and broaden the understanding of natural attenuation and remediation systems.
- Establish and document new monitoring paradigms that provide high levels of performance for reduced costs.

Key considerations in achieving the project objectives include:

- Maintain focus on acceptable end state(s) and the transitional steps that lead to the end state(s).

- Set clear boundaries for expanding MNA concepts and develop consensus with regulators and stakeholders.
- Emphasize a systems approach for both MNA processes and MNA monitoring.

Appendix A provides a historical perspective related to MNA/EPR and provides a synopsis of the information previously included in the approved Alternative Project Plan.

Project Organization

The project will be organized as an Interactive Working Group as shown by the figure in Appendix B. The Interactive Working Group (IWG) is responsible for the successful completion of the development of the "next generation" MNA/EPR protocol for chlorinated solvents. All personnel working on this project are members of the IWG. This Interactive Working Group will have several teams with specific functions. The specific groups to be assembled are summarized below and described in more detail in Appendix B.

Savannah River Operations Team: The SR Operations Team (SROT) will consist of SRS personnel. This team will include the DOE-SR Project Manager, the DOE-ER Waste Area Group Manager, the Technology Integrator (SRTC) and the Soils and Groundwater Closures Project (SGCP) Program Integrator. The SGCP Program Integrator is the Savannah River Site end user. This team will be responsible for day to day management of the project and ensuring the technical direction of the project meets the stated objectives. The specific function of each of these team members is described in Appendix B and in the Alternative Project Plan.

Karen Vangelas, SRTC, will be the Chairperson of the SROT. Karen is a principal engineer with 14 years of experience in deploying environmental characterization, monitoring and remediation technologies. She has coordinated DNAPL technology demonstrations and been the technical lead for the characterization efforts at a large groundwater unit at the SRS.

Technical Working Group: Persons selected as members of the Technical Working Group (TWG) bring to the table experience in MNA, monitoring of subsurface systems and natural systems, risk and regulatory issues, ecological and systems integration, and microbiological sciences. In addition, the members are nationally recognized in their area of expertise and have demonstrated creativity and the ability to participate in collaborative projects. This group includes personnel from DOE, DOD, regulator agencies and the private sector whose technical expertise will allow the project to meet its goal of developing the next generation protocol for monitored natural attenuation and natural remediation of chlorinated solvents. Because this group is critical to the project success – they will specify and document the scientific approaches for MNA/EPR and long-term monitoring that will serve as the foundation of the project – the membership is discussed in more detail below. The members of the Technical Working Group include:

Brian Looney, SRTC, is a senior fellow research engineer with 25 years of experience in developing and deploying environmental characterization, monitoring and remediation technologies. He has coordinated DNAPL and chlorinated VOC projects and serves as a national reviewer for the NABIR Field Research Advisory Panel (FRAP). Brian works closely with the SGCP teams to provide technical assistance and help integrate technology into their programs. Dr. Looney is the technical lead for the alternative project and the chairperson of the Technical Working Group.

Michael Heitkamp, SRTC, is a senior scientist and manager of the environmental biotechnology group in SRTC. He is a recognized expert in applied and environmental microbiology and he was an active participant in past successful ITRC development efforts. Dr. Heitkamp is a key resource for obtaining and critically reviewing the potential for application of new bioassessment tools for characterization and monitoring.

Gary Wein, SGCP, joined the SRS SGCP program from the University of Georgia Savannah River Ecology Laboratory (SREL). Gary leads the WSRC-Bechtel SGCP program to implement MNA and related technologies across SRS and across all of the SGCP project teams. Dr. Wein coordinates and chairs the MNR Technical Working Group (TWG) which shares the results of ongoing activities at the working scientist level in EPA Region IV, SC Department of Health and Environmental Control (DHEC), SRS, and SREL.

Tom Early, ORNL, is a senior scientist at ORNL and served as technical lead for the DNAPL product line of the Subsurface Contaminant Focus Area for eight years. In this capacity, he served on interagency panels to implement characterization, monitoring and remediation technologies (e.g., the Interagency DNAPL Consortium). Dr. Early is familiar with the portfolio of DNAPL and chlorinated VOC related research in the complex and in other federal agencies. Dr. Early is known for his work in organics.

Tyler Gilmore, PNNL, is a senior scientist at PNNL. Tyler is a well known expert on developing and deploying innovative characterization, monitoring and cleanup technologies. He has served in this role for many successful projects at Hanford and he served as a national resource to DOE in providing technical assistance to other sites and in serving on technology panels and peer reviews. Tyler is known for his work in hydrogeology.

Todd Wiedemeier of T. H. Wiedemeier & Associates, LLC, was a principal in the development of the 1998 EPA technical protocol for natural attenuation of chlorinated solvents. Todd brings an understanding of MNA processes and the science to the project. Todd supported DOD during the protocol development. He has published extensively on the subject in the technical literature and provided training on the topic. Todd's participation brings stature and credibility to the project as he is a nationally known expert in the field of MNA.

Jody Waugh, S. M. Stoller supporting the DOE Grand Junction Project Office, is a leading expert in the field of innovative long-term monitoring. Jody has supported the UMTRA and FUSRAP programs and the long-term monitoring research associated with landfills and caps. Dr. Waugh brings the "systems" approach to monitoring theory and a linkage to the history of DOE's applied science development in the field of long-term monitoring to the project.

David Major, of Geosyntec, is a leading expert in the microbiological science of MNA. He worked with John Wilson, of EPA's R. S. Kerr Environmental Research Laboratory, to put together the ITRC guidance for implementing natural attenuation of chlorinated solvents. Dr. Major has taught MNA and accelerated anaerobic degradation classes for the ITRC and has conducted workshops at national meetings on the innovative molecular toolbox of sensors for monitoring MNA processes in the field.

Frank Chapelle, of the South Carolina United States Geologic Survey, is a nationally recognized expert in the field MNA for both petroleum hydrocarbons and for chlorinated organic compounds. Dr. Chapelle has written a SRS specific guidance document and provided training for SRS personnel and SC regulators. He has written national guidance documents and fact sheets for the USGS on bioremediation, innovative sampling methods, and MNA. Dr. Chapelle is currently supporting DOD and SERDP in their efforts to encourage the use of MNA.

DOE HQ and DOE SR project managers are ex officio members of the TWG. Technical subcommittees will be formed within the TWG based on need, as identified by the Technical Working Group in their charter and deliberation. The purpose of the sub-teams will be to focus on specific topic areas identified by the Technical Working Group and to critically evaluate the relevant science and technology and write the related sections of technical reports as identified by the TWG.

Project Budget

The projected annual budget for this project is identified in Table 1. Funding has been approved for the FY03 activities. The FY04, FY05 and FY06 funding is projected based on initial scope of this project. A detailed budget for FY03 and proposed budgets for FY04 through FY06 are provided in the section titled: "Annual Budgets".

Table 1. Projected Annual Budget for the MNA/EPR Alternative Project

Fiscal Year	Funding
FY03	$1.6 M *
FY04	$2.0 M
FY05	$2.0 M
FY06	$0.8 M

* approved funding

Project Start-Up Activities

To efficiently meet the project objectives, an intense period of project initiation activities is planned. The purpose of these activities is to critically evaluate the specific science, technology, implementation, and regulatory concepts that have been proposed for this project and to identify the most promising in terms of potential to accelerate and facilitate the use of MNA/EPR. This evaluation will be performed by the Technical Working Group and the results will be documented in a milestone document, "*Critical Science and Technology Targets to Support Monitored Natural Remediation of Chlorinated Organic Solvents*". This report will serve as the foundation of the project as it moves into the field research and protocol development phases. As shown in Figure 1, the report (hereinafter designated the "S&T Report" will be used as the basis for a detailed research specification, for collaborative and leveraged research.

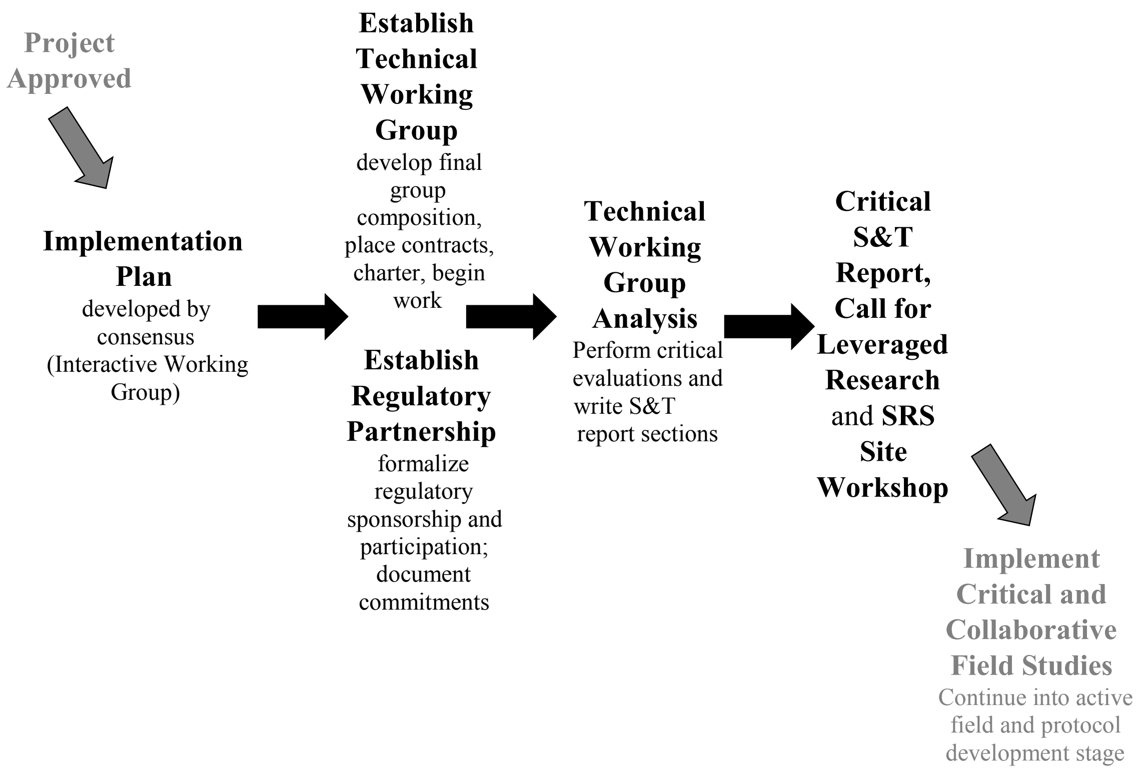


Figure 1. MNA/EPR Alternative Project Start-Up Sequence

The science and technology specification will articulate the specific types of work deemed by the Technical Working Group as having the most impact on future viability and usability of MNA/EPR. The emphasis of this specification will be for field studies. It is anticipated that approximately 90 % of the studies will be field based. The specification will be used as the basis of identifying critical field efforts and opportunities to leverage participation and cooperation with science programs such as EMSP and NABIR in DOE, SERDP in DOD, and STAR in EPA. Further, the science and technology specification process will include a workshop that will provide a forum to document the critical target development process and results, and to provide potential scientific participants with detailed background, regulatory background, and characterization and data on the SRS field sites.

The S&T Report, together with the workshop will also describe the logistics and requirements for the supporting scientific studies and project requirements associated with scientific controls (hypothesis testing, documentation of improved performance, and the like). Short, competitive proposals for work will be solicited and evaluated according to the S&T specification and the information in the S&T Report. A portfolio of critical leveraged research will be selected and leveraged funding allocated to support the work. An example of the type of leveraging anticipated is a subcontract from WSRC to add the specified field work to an existing promising research project. At that time the project initiation phase will be complete and the leveraged research and protocol development efforts will continue as described in the overall project schedule.

This active project initiation phase is essential to achieving the project objectives. It addresses the need to apply limited funding to the most critical items, those that can have the most impact on success. Further, because the proposed schedule is compressed, it provides opportunities to leverage with programs such as EMSP in an accelerated fashion without the delay of the FY federal funding cycle (a cycle that would limit implementation of the required field activities in FY04). The project start-up phase provides a disciplined and steady process to set a strong foundation for the final products and a mechanism to accelerate collaboration with the science community.

Scientific Basis

The Technical Working Group will critically evaluate past MNA/EPR protocols, along with related research. This critical review process will be organized into several lines of inquiry as specified below. The team will document the potential benefits of progress in each line of inquiry and the resulting improvement in the applicability and usability of MNA. For each line of inquiry, the evaluation factors shall include but not be limited to the specific benefits resulting from progress (with the most credit going to items that result in a positive "step change" in MNA/EPR progress); regulatory/stakeholder acceptability; collateral and lifecycle issues; potential cost of the required S&T; and the potential for leveraging existing science efforts.

The historical protocol review, the review of national and international performance history of MNA/EPR for chlorinated solvents, and the critical assessment of the potential value of advancement in the identified lines of inquiry will be included in the milestone S&T Report. The specific titles and the contents of the lines of inquiry will be finalized by the Technical Working Group. The lines of inquiry will, however, align with the conceptual model, approach, and core values described in the approved Alternative Project Plan:

- Processes must be based on natural mechanisms.
- Processes must be sustainable and allow closure of the site from the perspective of active treatment.
- Processes can expand traditional definition of MNA to allow enhancements and reconfiguration (as long as the resulting mechanisms are naturally sustainable).
- New Approaches should build on and link to past MNA protocols.

- New Approaches should focus on the basis for transition from active to passive to MNA/EPR and defining a valid and environmentally protective exit strategy for active remediation.
- New approaches should emphasize the concept of working toward an "agreed" risk-based end state.

The following is a preliminary outline of the potential lines of inquiry and specific examples of science and technology to be evaluated. Importantly, the list includes a relatively comprehensive list of ideas that are being examined in current research programs, but all of these will not be determined to be promising or appropriate to incorporate into the "next generation" protocol. Determination of potential value of any concept will be a primary function of the Technical Working Group and will be the basis for subsequent inclusion in the S&T Report and the leveraged research specification. This critical evaluation process is the primary mechanism for the project to manage costs, maintain schedule, and to assure that the product will provide the best value to DOE.

Lines of inquiry:

- Incorporation of latest research on mechanisms and rates of processes that occur without any enhancement. This includes abiotic degradation, anaerobic biodegradation, aerobic biodegradation, and phytoremediation (either in the rhizosphere or through uptake and subsequent processes). This would also include the latest research on abiotic degradation and consider sorption, dispersion and possibly in-stream processes such as volatilization or other processes that affect contaminant bioavailability.
- Incorporation of latest research on processes that create permanent or semipermanent (sustainable) treatment capacity in the system. This includes the possibility of halorespiring zones, substrates and conditions needed to generate and maintain such zones, etc. This would link to the potential applicability of inexpensive characterization and monitoring of the bulk conditions (a surrogate) or microbial nucleic acids (low-cost bioassessment) as improved documentation techniques. Evaluate how far down this path is appropriate for a MNA/EPR protocol – is fertilization or other periodic maintenance OK with criteria to transition to monitoring only?
- Incorporation of research on the active biological, chemical and physical processes occurring at major system interfaces such as the vadose groundwater interface and the groundwater surface water interface. Examine MNA/EPR potential for NAPL or "near NAPL" environments (as is being studied extensively in DOD).
- Incorporation of research on deployment and enhancements based on large-scale modification of hydrology, reconfiguration of the system, and similar actions. One example is -- expanding existing interfacial zones where treatment is occurring but total treatment is needed to fully address plume delivery (flux). Other examples include deployment of sustainable treatment zones, modification or alteration of plants (community structure and biomass, fertilization), isolation schemes (for deep fractured system for example), and schemes for sustainable large-scale alteration of bulk properties and master geochemical variables (pH, redox, etc.). This work would emphasize study of collateral damage, life-cycle analysis of benefits and costs, systems engineering evaluation, etc.

- Examination of need and uncertainties associated with different conditions – notable "outcropping systems" such as those in the east, "vadose systems" as in the west, and fractured/karst systems.
- Incorporation of national and international data on experiences (successes and failures) of MNA/EPR for chlorinated solvents to date.

There have been a number of technology assessment and needs assessments over the past several years that are relevant to MNA/EPR of chlorinated solvents. Notable examples include the NAS review, "*Natural Attenuation for Groundwater Remediation*", and the recent DOE Technical Targets effort, "*Technical Targets: A Tool to Support Strategies Planning in the Subsurface Contaminants Focus Area*". These will be key resources to the team to simplify and streamline their task. Examples of related technical targets that describe science and technology needs related to the basis of MNA/EPR and the Characterization and Monitoring of MNA/EPR are provided in Appendix C.

Characterization and Long-Term Monitoring

The structure and concept for efforts to advance Characterization and Long-Term Monitoring are the same as those for the scientific basis – i.e., (1) review of the state-of-practice and the state-of-science, and (2) critical evaluation of the potential benefits of different types of activity organized into lines of inquiry. As noted above, specific titles and contents of the lines of inquiry will be finalized by the Technical Working Group. They will, however, be aligned with the conceptual model, approach, and core values described in the MNA/EPR Project Plan:

- Develop clear strategies for the distinct needs associated with MNA/EPR characterization and then long-term monitoring.
- Develop responsive characterization and monitoring approaches that beneficially use data to refine and improve decisions and interpretations.
- Emphasize integrating measures, such as flux, remote sensing and other averaging and volumetric methods.
- Refine the idea of "multiple lines of evidence" in current protocols and develop a defensible approach to define a "quorum of evidence" that will be acceptable (given natural variability and uncertainty). The goal is to refine and streamline characterization and monitoring, not to add more parameters to a long list of requirements for MNA/EPR.
- Emphasize large-scale design and monitoring concepts. Document performance and robustness using overall mass balances and MNA process/condition mapping to supplement or replace the traditional requirement of "plume stability."
- Emphasize system and ecosystem monitoring concepts.

The overarching goal of the characterization and monitoring developments will be to facilitate MNA/EPR by reducing costs while maintaining or enhancing the information available to document that the system is protecting the public and the environment.

The following is a preliminary outline of the potential lines of inquiry and specific examples of science and technology to be evaluated. Importantly, the list includes a relatively comprehensive list of ideas that are being examined in current research programs, but all of these will not be determined to be promising or appropriate to incorporate into the "next generation" protocol. Determination of potential value of any concept will be a primary function of the Technical Working Group and will be the basis for subsequent inclusion in the specification.

Lines of inquiry:

- Incorporate latest research and scientific logic to enhance the existing multiple lines of evidence concept. This includes a responsive characterization process based on conditional rules (i.e., no need to measure reduced gases at sites with measurable dissolved oxygen). Develop a paradigm that includes some of the spatial process mapping and other items highlighted in the NAS review of the previous protocol. Lay out a clear "quorum of evidence" concept.
- Incorporate the latest bioassessment tools. These include nucleic acid probes, fatty acid profiles, taxonomy, structure and function screening profile systems, fluorescence methods, and other tools. Many of these technologies have been examined for innovative field deployment in DOE – at ORNL, SRTC, and other labs. Other bioassessment tools include hyperaccumulators (possibly coupled with remote sensing) and macrobioaccumulators (clams, etc.), and biomarkers (ecosystem structure and species composition). These latter tools integrate exposure and may provide a more realistic measure of impact. This is a key topic because there has recently been significant advancements in basic scientific knowledge relative to the microbial biodegradation of chlorinated solvents. For example, it is now widely known that halo-respiring bacteria are primarily responsible for the complete *in situ* anaerobic biodegradation of chlorinated solvents observed at most anaerobic sites. This knowledge has impacted remedial strategies resulting in new efforts to intentionally alter *in situ* conditions to develop and optimize this microbial activity (e.g. biostimulation). In other cases, the absence of *in situ* halo-respiring bacteria has pointed to the need for inoculation of deficient sites with seed cultures of these important chlorinated solvent–degrading bacteria (bioaugmentation). In both cases, bioassessment is a key step in determining the presence, or potential, of a given site for MNA of chlorinated solvents as well as tracking the presence and numbers of key microorganisms during the remediation process.
- Incorporate latest research on remote sensing, geophysics, and flux monitoring. This includes both instrumentation and interpretation and deployment options (horizontal wells, lidar, remote sensing, and others). Examine lessons from agriculture and soil science ("smart farming") and potential for cross over applicability.
- Incorporate the latest research on surrogate measures to reduce costs. These include bulk and master variable properties such as redox potential, as well as indicator species (e.g., Cl^-) and specialized tools such as total halocarbons, degree of chlorination sensors, etc.
- Incorporate latest research on bioinformatics and modeling. This includes data mining, neural networks, incorporating new types of data, integrating diverse types of data, working at sites with large amounts of data and determining the value of data to justify reducing the number and frequency of analyses. Consider the latest progress in both forward and inverse predictive modeling and the potential value of large-scale

mass balance models (i.e. simple balancing delivery and treatment capacity) as an alternative that might be used at many sites.

- Incorporate the latest research on state-of-the-art sensors. Determine the value of sensors in characterization and in monitoring MNA/EPR systems. Examine the need for sensors that provide high frequency data. Examine alternative configurations that use on-off sensor signals rather than concentration signals as a way to reduce costs. Evaluate passive and cumulative sensors that would act similarly to bioconcentration.
- Incorporate the latest research on monitoring system configuration. This includes focusing monitoring on designed or identified monitoring points (weak points that would serve as indicators of performance throughout the system) and focus on interface monitoring.

Selection of Locations for Field Testing

The goal of the project is to develop the "next generation" protocol for monitored natural attenuation and natural remediation of chlorinated solvents. The first step in this process must be to identify both the areas where the science and tools need development, refinement and testing under real conditions and the type interfaces where studies must occur. The TWG will identify the areas needing study and the type interfaces where the studies should occur as part of the development of the S&T report. At that point the TWG and the SROT will select the specific waste site or sites for the field studies. Several waste units have been evaluated to determine the levels of contamination present, the interfaces available and the impact of testing at the waste unit to the regulatory path. The sites under consideration are described in the following paragraphs. Table 2 is a summary table for the four waste sites that are under consideration. Each site offers specific opportunities for testing.

C-Area Reactor Groundwater Operable Unit

Contaminant plumes are associated with historical releases from the C-Area reactor and its support facilities. The unit is well characterized and the flow model is complete for this unit. The plume contains TCE (9,600,000 μg/L (max)) and Tritium (57,000 pCi/mL (max)). TCE is present in source, aqueous and fringe concentrations. Contaminants are present in the vadose zone and throughout plume to the discharge zone. Depth to groundwater is approximately 80 ft at the source. TCE is present at the vadose zone/groundwater interface. Even though sampling of Castor Creek surface water has not detected TCE above the maximum contaminant limit (MCL) of 5 μg/L, the flow model indicates TCE should be present at the surface water/groundwater interface. The Remedial Investigation/Baseline Risk Assessment, revision 0, will be submitted December 2003. The project team is considering several likely response actions including Monitored Natural Attenuation, recirculation wells, permeable treatment walls, air sparge/SVE, phytoremediation (spray irrigation), and dam construction / wetlands management. A potential disadvantage for this site is the difficulty of access to the distal plume and Castor Creek. A portion of Castor Creek is a steep incised channel in the plume discharge

Table 2. Summary Table of Characteristics of Waste Sites to be considered for MNA/EPR Field Studies.

Waste Unit	**C-Area Reactor Groundwater**	**CMP Pits**	**L-Area Southern Groundwater**	**P-Area Reactor Groundwater**
Contaminants (max concentrations)	TCE 9,600,000 µg/L Tritium 57,000 pCi/mL	PCE 18,800 µg/L TCE 4,200 µg/L Lindane 4 µg/L	PCE 165 µg/L TCE 55 µg/L Tritium 26,200 pCi/mL	PCE 365 µg/L TCE 21,000 µg/L Tritium 29,500 pCi/mL
Contaminant Phase(s)	Source Aqueous Fringe	Source Aqueous Fringe	Aqueous Fringe	Source (potential) Aqueous Fringe
Potential Interface(s)	Vadose zone/groundwater (VZ/GW)– aqueous phase Surface water/groundwater (SW/GW) - fringe/distal plume	VZ/GW – Aqueous SW/GW – Aqueous/Fringe	VZ/GW – Aqueous SW/GW – Fringe	VZ/GW – source/aqueous SW/GW – aqueous/fringe
Advantages	Plume well characterized. Groundwater flow understood (flow model complete).	No radionuclides. Plume well characterized. Groundwater flow understood (flow model complete).	Plume well characterized. 3-D understanding of plume structure. Easy access.	Early in RCRA/CERCLA process. TCE identified in creek.
Disadvantages	Access difficult to SW/GW interface	Regulatory process far along. Dense Infrastructure.	Potential contact issue with lake sediments due to Cs-137. Multiple, small point sources. Exact locations of VZ/GW interface not identified.	Source(s) not identified. Potential contact issue with Cs-137 in stream. Access issues – moderate.
Regulatory Status	Remedial Investigation/Baseline Risk Assessment, Rev. 0. Due December 2003.	Corrective Measures Study/Feasibility Study in progress. Submit Proposed Plan in 2004	Remedial Investigation report in progress. Due February 2004.	Initiated pre-Work Plan characterization activities in 2002.

area, limiting the size of the hyporheic zone. In summary, some opportunities exist for site work/studies at the distal end of the plume and discharge area.

CMP (Chemical, Metals and Pesticides) Pits

Vadose and groundwater contamination is associated with the CMP disposal pits. Characterization of this unit is complete. The Corrective Measures Study/Feasibility Study (CMS/FS) is in preparation with the Proposed Plan being submitted in April 2004. This is a major disadvantage for this unit because the decision making process for the remedial action is very far along. At present an interim action of SVE and air sparging is in operation. The preferred final remedial option is a small-scale phytoremediation (pump and treat and treatment of surface soils) and a mixing zone. PCE, TCE and Lindane are present in the upper aquifer system. PCE concentrations range from 18,800 μg/L to <1 μg/L and TCE concentrations range from 4,200 μg/L to <1 μg/L. PCE and TCE are present at both the vadose zone/groundwater interface and the surface water/groundwater interface. PCE and TCE are present in the aqueous phase at the vadose zone/groundwater interface. Depth to groundwater ranges from approximately 100 ft to 20 ft below ground surface. The vadose zone - groundwater interface is important at the CMP Pits and is a good resource for science studies. However, the infrastructure for the air sparging and SVE units is located on the surface of the vadose zone/groundwater interface area and makes access very difficult. Characterization data does not indicate PCE and TCE are discharging to Pen Branch from the main plume. A small plume to the north of the main plume contains low levels of PCE that is discharging to Pen Branch. There are no access issues at the surface water/groundwater interface. Because of topography, hyporheic zone is limited in extent in the groundwater discharge downgradient of CMP Pits. The plume is well characterized and standard flow modeling is complete. In summary, this is a promising site for study but the OU is far along in the RCRA/CERCLA process. There is little opportunity for immediate use of the technical protocol at this OU. The technical protocol will need to be applied as a long-term strategy.

L-Area Southern Groundwater Operable Unit

Contaminant plumes are associated with historical releases from the L Reactor and its support facilities. Characterization of the unit began in 1999. The post-characterization scoping meeting was held on January 28, 2003. Tritium, PCE and TCE are present in the upper aquifer system. Concentrations of PCE and TCE are low, ranging from a high of 155 μg/L to a low of < 1μg/L. PCE and TCE are present at both the vadose zone/groundwater interface and the surface water/groundwater interface. Depth to groundwater ranges from approximately 50 ft to 8 ft below ground surface. Both interfaces are easily accessible. The contamination is from multiple point sources ranging in size from direct discharge of drums/buckets of spent cleaning solutions to seepage basins. The locations where the PCE and TCE are present at the vadose zone/groundwater interface are not identified. The concentrations would be in the aqueous phase. The surface water/groundwater interface occurs at the boundary of L Lake. This is a classic MNA setting with PCE and TCE concentrations being in the fringe range. L Lake sediments are contaminated to varying degrees with cesium-137. Thus, there may be contact issues for working in the sediments. The Remedial

Investigation Report for the unit is scheduled for submittal in February 2004. Overall this unit is a promising site for studies at the surface water/groundwater interface.

P-Reactor Groundwater Operable Unit

Contaminant plumes are associated with historical releases from the P-Area Reactor and its support facilities. Pre-characterization activities at this unit began in 2002. To date, TCE, PCE and tritium have been identified in the upper aquifer system. Concentrations of TCE range from 21,100 ug/L to <1 ug/L with much lower concentrations of PCE (range 365 ug/L to <1 ug/L). TCE and PCE are present at both the vadose zone/groundwater interface and the surface water/groundwater interface. Depth to groundwater is approximately 50 ft below ground surface. Both interfaces are accessible. The surface water/groundwater interface that occurs on the eastern bank of Steel Creek will present some access issues, but they can be managed. There may be contact issues related to Cs-137 present in the sediments of Steel Creek. The source(s) of the contamination have not been identified at this time. The early characterization work indicates the potential for a DNAPL source near the reactor facilities. In summary this unit presents a good opportunity for field studies due to accessibility, contaminant concentrations at the surface water/groundwater interface and the unit being in the very early phase of the regulatory process. Because of its regulatory status, accessibility, and lack of conflicting activities, the IWG considers this site as potentially serving as the principal "Field Test Bed for MNA/EPR of chlorinated solvents."

Interagency and Regulatory Interface

One objective of this project is to have the technical protocol developed by the Interactive Working Group gain broad-based acceptance as the protocol for MNA/EPR. In order to accomplish this objective, an early partnership will be established that formalizes the collaboration and the related expectations and commitments. Toward this goal, the SR Operations Team (SROT) will work with the Interstate Technology Regulatory Council (ITRC) to develop a working relationship for acceptance of the protocol by the ITRC. The ITRC training platform could be a major vehicle in providing training for regulators, end users and technologists in using the new protocol.

The Interactive Working Group (IWG) proposes working in partnership with the ITRC in developing and disseminating the protocol. DOE will provide the technical and operational support for the development of the protocol and the science and technology needs. The IWG will work closely with the ITRC throughout the three-year decision-making process to ensure the technical protocol developed will support both DOE and ITRC needs for implementation and acceptance. Upon completion of the technical protocol, the ITRC training platform is proposed as the method of disseminating the technical protocol and its application to other regulators and end users.

Initial contacts with two ITRC members, one who is the vice chair of the council, show interest in the development of the "next generation" protocol for MNA/EPR for chlorinated solvents. The SROT has committed to provide additional information to the ITRC for discussion at their board meeting on February 26, 2003. If the board expresses interest to partner with DOE on this project, the SROT has requested ITRC to document their interest in a letter to DOE.

Assuming ITRC decides to partner with DOE on this project, ITRC will bring this work to their July 2003 planning meeting for further development. The July meeting is where they make their strategic decisions and update the five-year plan for the ITRC.

If ITRC decides they will not partner with DOE on this project, the SROT will make contacts with other appropriate agencies such as the Southern States Energy Board (SSEB), ASTM International and/or other regulatory and consensus standards organizations.

Upon DOE acceptance of "*Critical S&T Development Targets for MNA/EPR*", representatives of the IWG will make a presentation to the ITRC (or other identified partner), EPA-Regions IV & X and state regulators from South Carolina, Tennessee and Washington obtain buy-in of the project objectives and approach. During this same period, a presentation of the project objectives and approach will be made to stakeholder organizations (such as the Hanford, Oak Ridge and Savannah River Citizens Advisory Boards (CABs)) and to the Western Governors Association and SSEB, as appropriate. The information will also be scheduled for presentation at the Federal Remediation Roundtable Meeting.

The exact form of interactions for the remaining two years of the project will be defined by the outcome of the July 2003 ITRC planning meeting and follow on efforts to adjust and align, as needed, to implement cooperation.

End User Interface

An important factor in developing this "next generation" MNA/EPR protocol is to work towards having it embraced by the end user community. This means the protocol must provide a methodology to allow the end users to implement the protocol in an efficient, cost-effective process that will meet the requirements of the environmental regulations. To this end, the IWG includes members of the end user community at Savannah River (the SGCP organization managed by Bechtel Savannah River Inc.). The IWG through the ORNL and PNNL representatives will communicate the goals and objectives of this project as well as providing information on the scientific/technical process to end users at the Oak Ridge Reservation and Hanford Site. In addition to communicating information to these organizations, input and feedback will be requested from these organizations to aid the Technical Working Group in identifying issues the end users are faced with in implementing MNA/EPR type remediations. One avenue to having a continuing dialog with the end users at the three DOE sites involved in this project is through the Bechtel National Incorporated Environmental Management Technology Panel. This panel includes the technical end users from Bechtel Savannah River, Bechtel Jacobs and Bechtel Hanford. The IWG will communicate on a regular basis with the Bechtel Technology Panel to ensure their inputs and issues are considered and addressed. It is the intent of the IWG to have continuing dialog with end users throughout the life of this project.

Strategy for Obtaining Services

This project requires the expertise of persons from many agencies and organizations across the United States. The chair of the SROT will be responsible for initiating all new procurements and managing all new subcontracts placed for this project. The main contracting need over the first year of this project will be obtaining the services of the Technical Working Group. One additional contracting need for FY03 activities is the service to provide a comprehensive review of the historical base of work on MNA/EPR and related processes (characterization and long-term monitoring related to MNA/EPR). FY04 and FY05 contracting will concentrate on the field studies and support thereof. The SROT will provide support services as necessary to support the PIs. These services may include such things as clearing/constructing access to field study location; installing wells, piezometers, trenches, test beds, etc. These services will require the placement of new subcontracts or use of existing SRS subcontracts where available. The funding mechanism for the field studies will be contracts to the selected PIs to leverage funding they have in place for related research projects that can be extended or enhanced to meet the technical specification for the MNA/EPR project.

Obtaining services for the Technical Working Group will occur through three basic mechanisms. These mechanisms are a Memorandum Purchase Order, an Interagency Work Request and a consultant subcontract. The services of personnel employed by DOE organizations, such as PNNL and ORNL, will be obtained via the appropriate contracting mechanism, such as a Memorandum Purchase Order, placed between SRS and the subject organization. The services of personnel employed by government organizations other than DOE, such as DOD and USGS, will be obtained via an Interagency Work Request placed between SRS and the subject organization. The services of non-government organizations will be obtained via a consulting subcontract placed between WSRC and the subject organization. All three mechanisms require a purchase requisition, technical statement of work and a criteria sheet to justify obtaining the services of specific individuals.

The SR Operations Team will work with the WSRC Procurement and Material Management Department to place the needed subcontracts for this project.

Peer Reviews

Peer reviews of the project will be scheduled at critical points in the process. The purpose will be to ensure the project team has developed and is working towards a scientifically and technically defensible end product. The DOE HQ Program Manager of this Alternative Project will manage the peer review activities. The initial peer review will be of the approved MNA/EPR Technology Alternative Project. Documents to be provided for the peer review panels review will be the Alternative Project Plan and the approved Implementation Plan.

Criteria for the peer reviews is as follows:

- Will be conducted in collaboration with SC-75.
- Will be modeled after the Office of Science approach.
- Each major deliverable will be reviewed when complete.
- Reviewers will provide written comments via e-mail to the DOE HQ Program Manager and the Chair of the Technical Working Group.
- DOE Program Manager will run each peer review.

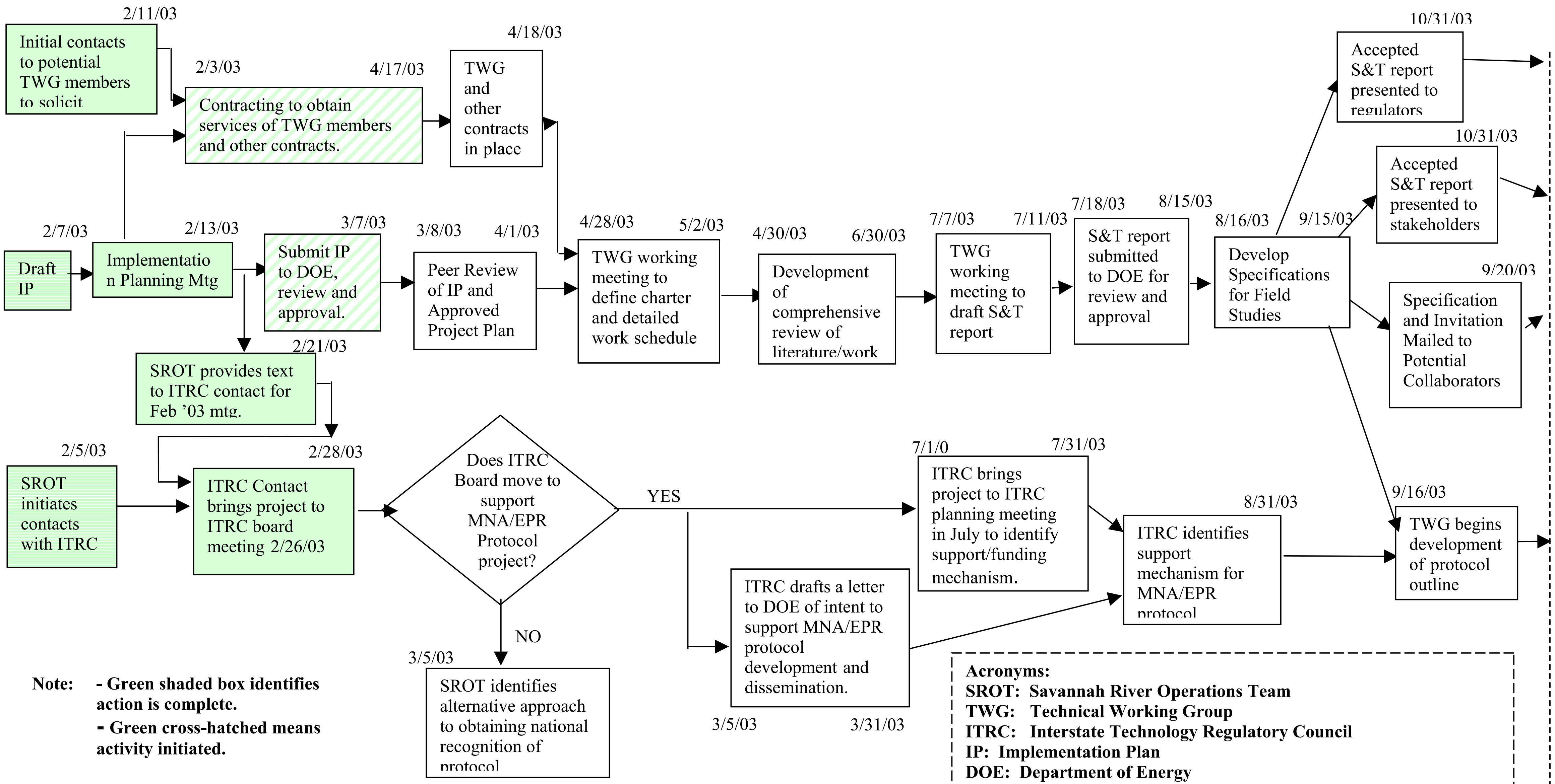
Implementation Schedule

The project will be implemented in an organized manner, but will be structured to be responsive to opportunities for leveraging related science and technology developments (e.g., promising research in EMSP, NABIR, SERDP, EPA STAR, and the like). The project will be conducted over a three-year period (FYs 03 – 06). In brief, the first year is planning the project, identifying the scientific and technology needs, and selecting the field studies. The second and half of the third year are conducting the field studies. The last half of the third year is analyzing the results of the field studies and writing the MNA/EPR technical protocol, and disseminating the information. Figure 2 is a logic diagram of the FY03 activities. Figure 3 is a schedule over the life of the project. Table 3 is a summary table of major milestones. Table 4 is a summary table of deliverables.

The documents defining this project and documenting the process for the remaining years of work will be prepared in FY03. As part of FY03, regulator partners will be identified, the scientific and technology needs will be identified, a workshop planned for potential collaborators (PIs) for the field studies and a workshop planned for Oak Ridge, Hanford and their respective regulators and technical end users.

In the first quarter of FY04, the workshops for potential PIs for the field studies and the Oak Ridge/Hanford personnel will be held and the field studies to be implemented will be selected. After the field studies are selected the SROT will place the contracts to the PIs, work with the PIs to prepare all needed permits and complete all field preparation activities. The PIs will mobilize to the field test sites in the second quarter of FY04. The field studies will begin in the second quarter of FY04 and continue through the last quarter of FY05. The PIs for the field studies will document and submit their results in the first quarter of FY06.

The technical protocol for MNA/EPR will be drafted from the last quarter of FY05 into the second quarter of FY06. The technical protocol will be peer reviewed during the second quarter of FY06. The peer reviewed technical protocol will be published at the end of the second quarter of FY06. Also during the last quarter of FY05 into the third quarter of FY06, the IWG will work with the ITRC to develop and finalize training on



Note: **- Green shaded box identifies action is complete.**
- Green cross-hatched means activity initiated.

Figure 2. Logic Diagram of FY03 Activities for MNA/EPR Alternative Project

Acronyms:
SROT: Savannah River Operations Team
TWG: Technical Working Group
ITRC: Interstate Technology Regulatory Council
IP: Implementation Plan
DOE: Department of Energy
MNA/EPR: Monitored Natural Attenuation/Enhanced Passive Remediation
S&T Report: Critical S&T Development Targets for MNA/EPR

Task	Dates
Technical team identified and put in place.	1/20/03 – 4/18/03
Science and Technology needs defined and S&T report to address needs written.	4/28/03 – 8/15/03
Specifications for Field Studies developed. Workshop with prospective PIs conducted	8/16/03 – 10/15/03
Interagency partners identified and working relationship developed.	2/1/03 – 9/30/03
Research studies selected and leveraged funding organized.	10/16/03 – 12/1/03
Placement of Contracts for Field Studies	12/2/03 – 1/2/04
Conduct Workshops for Oak Ridge and Hanford DOE, Regulators and End Users	11/1/03 – 12/1/03
Mobilization of Field studies (includes permitting and site preparation)	12/2/03 – 3/1/04
Conduct Field Studies	3/1/04 – 8/30/05
Document Field Studies and Submit to TWG	9/1/05 – 11/30/05
Develop Draft Technical Protocol	7/1/05 – 1/30/06
DOE approval of draft technical protocol followed by Peer Review	2/1/06 – 2/14/06
Publish Technical Protocol	2/15/06 – 3/15/06
Work with ITRC to develop and finalize training on technical protocol	7/1/05 – 4/1/06
Plan and Conduct workshop at a national meeting to present results of MNA/EPR Alternative Project	9/1/05 – 6/30/06
Support ITRC in training program of technical protocol	4/2/06 – 6/30/06

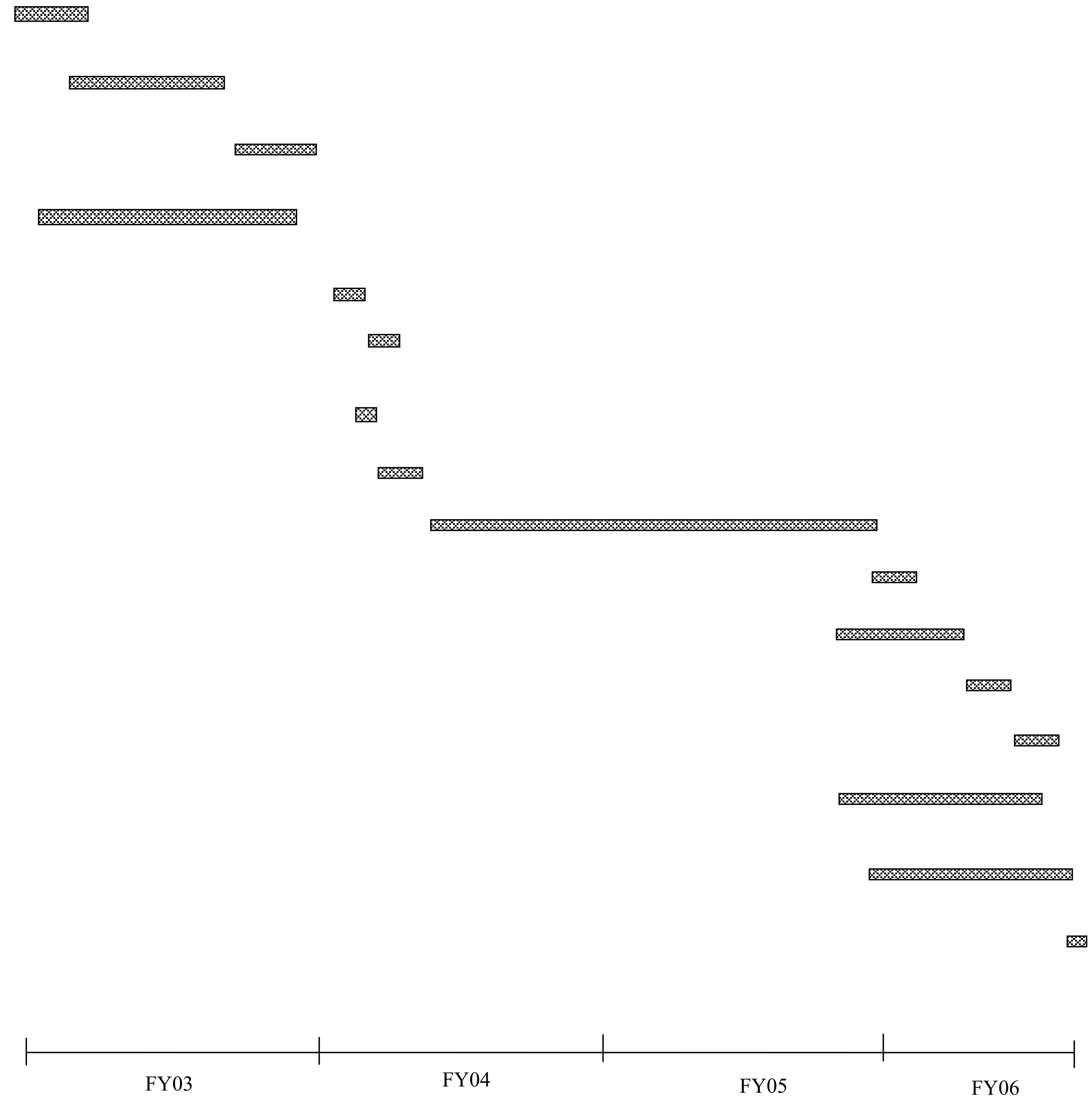


Figure 3. MNA/EPR Alternative Project Schedule

Table 3. Summary Table of Major Milestones for MNA/EPR Alternative Project

Milestone	Due Date
ITRC makes decision on whether to partner with the IWG on development of the "next generation" technical protocol for MNA/EPR.	3/31/03
TWG members are in place.	4/18/03
Field studies are selected.	11/15/03
Conduct workshop for Oak Ridge and Hanford DOE personnel and their respective regulators and technical end users.	12/01/03
Funding in place for field studies	1/02/04
Start field studies. (This does not include the permitting and field preparation activities. The permitting and field preparation activities occur from 11/15/03 through 3/1/04.)	3/1/04
Final technical protocol for MNA/EPR published.	5/1/06
Results of MNA/EPR Alternative Project presented in a workshop at a national meeting.	6/30/06

Table 4. Summary Table of Deliverables for MNA/EPA Alternative Project

Deliverable	Due Date
Submit to DOE for review the Draft Implementation plan	2/28/03
Submit to DOE for review the draft "Critical S&T Development Targets for MNA/EPR" report.	7/17/03
Researchers (PIs) submit documented results of field studies to TWG.	11/30/05
Submit to DOE for review the draft technical protocol for MNA/EPR	1/30/06

the technical protocol. The IWG will support the ITRC with the training classes for the technical protocol, as requested.

Between the period beginning the last quarter of FY05 and ending during the third quarter of FY06, the IWG will conduct a workshop at a national meeting to present the results of the MNA/EPR Alternative Project. This workshop will be the communication tool for disseminating the results to end users and regulators for the Oak Ridge and Hanford Sites.

Milestones:

- ITRC makes decision on whether or not to partner with the IWG on development of the "next generation" technical protocol for MNA/EPR. Date: 3/31/03.

- TWG members are in place. Date: 4/18/03.

- Field studies are selected. Date: 11/15/03.

- Funding is in place for field studies. Date: 1/2/04

- Conduct workshop for Oak Ridge and Hanford DOE personnel and their respective regulators and technical end users. Date: 12/01/03.

- Start field studies. Date: 3/1/04. (This does not include contracting, permitting and all field preparation which will begin November 15, 2003.)

- Final technical protocol for MNA/EPR published. Date: 5/1/06.

- Results of MNA/EPR Alternative Project presented in a workshop at a national meeting. Date: 6/30/06

Deliverables:

- Submit to DOE for review the final implementation plan. Date: 2/28/03.

- Submit to DOE for review the final "*Critical S&T Development Targets for MNA/EPR*" report. Date: 7/17/03.

- Researchers submit documented results of field studies to TWG. Date: 11/30/05.

- Submit to DOE for review the draft technical protocol for MNA/EPR. Date: 1/30/06

Summary of Project Activities by Year

<u>Year 1</u>

The first year of the project will develop the project and documentation that will define the process for the following two years of work, prepare a specification describing the field studies needed and to select the field studies to be conducted.

Included in the first year will be three documents and one peer review. The first document and deliverable is the draft implementation plan. This plan describes the key areas of work for the project and defines the structure, schedule, deliverables and milestones. A peer review will be conducted on the approved project plan and the approved implementation plan.

The S&T report is the second document to be prepared. This foundational document is the second deliverable for the project. The basis for the report will be the critical evaluations and identified technical activities as described in this plan. The S&T report will be written by the TWG and document the specific scientific and technical needs to be addressed in the project.

The third document will be the S&T Specification for critical field studies. This specification document will be the document provided to potential collaborators for the field studies. In October 2003, a workshop to be conducted by the IWG will be held at Savannah River for potential collaborators on the field studies. This will be a three-day meeting discussing the field studies needed based on the science and technology assessment of the TWG. A tour of the units to be the field test sites will be part of this workshop.

The S&T report will document in detail the scientific areas needing further development to enable successful implementation of MNA and enhanced passive remediation techniques and the field methods for characterization (both problem identification and long-term monitoring) and remediation that would improve efficiency and minimize long-term implementation and operation costs.

A parallel path during the first year of the project is identifying a regulator policy body to partner with on this technical protocol development and obtaining their agreement to partner. The organization identified by the IWG as a potential partner is the ITRC. Discussions will be held will key members of the ITRC to solicit input on interest. Assuming the ITRC would like to partner, the IWG will work with ITRC personnel to identify a mutually acceptable working relationship.

To more easily accomplish information sharing with Oak Ridge and Hanford sites, ORNL and PNNL personnel who are on the TWG are members of the IWG, as well. They will act as the liaisons for this project with their respective DOE sites and state and EPA regulators. They will be required to participate in all workshops and meetings of the full IWG and TWG in the first year of the project as well as the following two years.

<u>Year 2</u>

The second year of the project will emphasize the field testing of tools and technologies identified as necessary to advance the scientific basis of MNA/EPR, characterization and remediation methods. Important activities this year will include briefings to Savannah River Site, Oak Ridge Reservation and Hanford Site stakeholders (such as citizen’s advisory boards, Western Governors Association and Southern States Energy Board), State regulators (SC, TN, WA), EPA regulators (regions IV and X), end users and interagency partners. Greater detail of activities for this year will be defined in the S&T report. Until the level of field activities is defined and projects identified, the detailed schedules for the field activities can not be provided.

<u>Year 3</u>

The third year of the project will emphasize the writing of the technical protocol followed by a peer review. The field activities will be completed in the first half of the third year with the PIs documenting their results. Additional activities to finish the project will be to publish the technical protocol, work with ITRC to prepare a training course on use of the protocol and to present a workshop at a national meeting describing the results of the work conducted as part of the development of the protocol.

The submission of the field study results to the TWG is the third major deliverable for this project. The results of the field studies will be used on this project by the TWG in completing the technical protocol. The final major deliverable for this project is the draft technical protocol for MNA/EPR. This technical protocol will document the process for identifying the use of MNA/EPR as a remedial option for the closure of waste units.

Assuming ITRC is interested in partnering on this project, one member of the TWG will be a member of the ITRC committee identified to collaborate on this project. Tom Early of ORNL has been identified as the TWG representative, if the ITRC requests our team's participation.

Details of Calendar Year 2003

Following funding, the project enters an implementation phase during which the project management structure and project layout are developed and documented. Once documented, the technical team is assembled and the critical science and technology needs to develop the "next generation" technical protocol are identified and documented. The first year of the project will close with the PIs selected for the field studies and field preparation activities initiated.

February 2003

- Initial contact with ITRC members (Ken Taylor, Carl Froede, Ken Feely). Complete by February 11, 2003. (Completed Feb. 5, 2003)
- IWG meets February 11 through 13 to finalize input for implementation plan. (completed Feb. 12, 2003)
- SR Operations Team to submit draft Implementation Plan to DOE, Feb. 21, 2003. (completed Feb. 21, 2003)
- Provide Ken Taylor, ITRC, and Blaine Rowley, DOE-HQ, with information packet on project to be discussed at ITRC board meeting on February 26, 2003. Submit information on February 21, 2003. (completed Feb. 21, 2003)
- Identify and make initial contacts with potential TWG members. These members will be identified from other DOE facilities, government agencies, industry and academia. Complete February 21, 2003. (activity completed Feb. 20, 2003)
- DOE approval of draft Implementation Plan received by SR Operations Team on March 7, 2003.
- Based on response of interest by the potential TWG members, initiate procurement process to access the selected persons. This will involve meeting with procurement to identify the appropriate contracting mechanism for each individual. Purchase requisition to be initiated February 21, 2003. (activity initiated January 31, 2003)
- Initiate procurement to obtain services of consultant to prepare a comprehensive review of all documents/literature associated with MNA/EPR activities and science and associated areas such as long-term monitoring and characterization related to MNA/EPR. Initiate purchase requisition February 21, 2003.

March – April 2003

- Hold initial meeting with ITRC members (Ken Taylor and Carl Froede and/or other appropriate members). Complete by March 21, 2003.
- Peer review of approved Alternative Project Plan and Implementation Plan to be convened by DOE-HQ. End date: April 1, 2003.
- Complete procurement process to put in place the TWG, April 18, 2003. The TWG members will be assigned to review relevant basic science research documents/papers and be prepared to discuss the status and applicability to this project at the first meeting of the Technical Working Group.
- Complete procurement process to put in place the subcontract for the comprehensive review and documentation of national and international MNA/EPR results. End Date: April 18, 2003.
- The TWG will meet at Savannah River Site to define the elements of the project. The project objectives and deliverables will be documented at this meeting. The meeting will be held the week of April 28, 2003. This will be a 5-day meeting.
- IWG responds to peer review comments on Implementation Plan. End Date: April 30, 2003.

May-June 2003

- TWG to identify subcommittees, as needed to provide support for protocol development. End Date: May 31, 2003.
- Upon receipt of peer review acceptance, brief Interagency Federal Remediation Technologies Roundtable. Complete prior to June 30, 2003.
- Comprehensive review of MNA/EPR related documents to be complete and submitted by June 30, 2003.
- Upon receipt of peer review acceptance, the TWG will finalize subcommittees needed and identify participants to subcommittees. Complete prior to June 30, 2003. Sub-committee leads to initiate work with subcommittees to prepare for TWG meeting week of July 7 for drafting the S&T report.

July-August 2003

- TWG meets to develop S&T report to define the scope of the project and establish goals for the technical protocol. This document focuses on the scientific studies and how they support the ultimate objectives. A draft of the S&T report will be complete at the end of the 5-day meeting. The meeting will be held the week of July 7, 2003.
- Submit draft S&T report to DOE for review on July 18, 2003.
- DOE review and approval of S&T report. Approval received by SRS on August 15, 2003.
- TWG develops specifications for field studies. Start Date: August, 16, 2003. End Date: September 15, 2003.

September 2003

- SROT sends out the specification for field studies and an invitation to attend the workshop that will focus on the scientific and technology needs for the field studies. End Date: September 20, 2003.

- IWG prepares for workshop with potential collaborators (PIs) on the field studies to support the MNA/EPR protocol development. Start Date: September 1, 2003. End Date: October 3, 2003.

October – November 2003

- Hold workshop for potential collaborators (PIs) on the field studies to support the MNA/EPR protocol development. End Date: October 15, 2003.
- Potential collaborators submit proposals to TWG for review. End Date: October 31, 2003.
- Conduct briefings to stakeholders on project objectives, goals and scientific/technical basis. End Date: October 31, 2003.
- Conduct briefings for regulators on project objectives, goals and scientific/technical basis. End Date: October 31,2003.
- Proposals for implementation are selected. End Date: November 15, 2003.
- PIs are notified and leverage funding organized. End Date: December 1, 2003.
- Conduct a workshop with Savannah River Site, Oak Ridge Reservation and Hanford Site DOE personnel and end users, state regulators (SC, TN, WA), EPA regulators (regions IV and X), stakeholders (such as Citizens Advisory Boards, Western Governors Association and Southern States Energy Board), and interagency partners. End Date: December 1, 2003.

December 2003

- The SROT meets with each PI to discuss logistics of each study. End Date: December 14, 2003.

Details of Calendar Year 2004

The emphasis of year 2004 will be the field studies. A more detailed schedule of activities will be developed after field studies have been selected. The IWG desires to provide the PIs with sufficient testing time to develop meaningful data. Thus, the schedule below is built around that premise. Throughout the field testing period, all regulators and stakeholders are welcome to visit the field sites to observe the work in progress. However, access to the test facilities may be limited due to the Homeland Security Threat Level in place at the time of the visit. Anyone wishing to visit the field test sites should contact the SROT Chairperson to determine if the sites will be accessible and to arrange for badging, if appropriate.

January - December 2004

- Contracts for Field Studies are in place. End Date: January 2, 2004.
- Revise project schedule to include details of field studies and associated support. End Date: January 5, 2004.
- SROT to work closely with SGCP to prepare selected site for the field tests. SROT will work closely with organizations selected to conduct tests and SGCP to ensure permits are prepared correctly. All permit requests (onsite and offsite) will be written and submitted by January 15, 2004.
- Receive approval of permits. End Date: March 1, 2004.
- Begin field deployment on February 20, 2004.

- Conduct field studies. Window for this activity is March 1, 2004 through August 30, 2005. Exact duration of deployment, testing and demobilization will be defined by the test(s) to be conducted. The SROT chairperson will manage the subcontracts for the field studies.
- Briefings for regulators and stakeholders will be conducted as appropriate throughout the field testing to provide updates on the activities. End Date: June 30, 2005.
- The TWG will monitor the progress of the field studies and work on the technical protocol development throughout 2004.

Details of Calendar Year 2005

The emphasis of year 2005 is evaluating the data from the field studies and writing the final technical protocol for MNA/EPR. The field studies will conclude this year and the PIs will document their results.

January 2005 through December 2005

- Continue field testing to completion. Field studies to be complete by end of August 30, 2005.
- PIs to evaluate and document field results. Reports due to TWG. End Date: November 30, 2005.
- Write draft technical protocol. End Date: January 30, 2006.

Details of Calendar Year 2006

The emphasis of year 2006 is the peer review of the technical protocol, publishing the protocol, developing training on implementation of the protocol and conducting a workshop at a national meeting to present the results of the research conducted as part of this project.

- Peer Review of the final technical protocol for MNA/EPR. End Date: March 15, 2006
- The IWG will support ITRC in development of a training course for implementation of the technical protocol. End Date: April 1, 2006.
- Publish technical protocol for MNA/EPR. End Date: May 1, 2006.
- Conduct workshop at national meeting to disseminate the results of the research conducted as part of this project and to introduce the technical protocol. DOE and end user personnel from Savannah River Site, Oak Ridge Reservation and Hanford Site, state regulators (SC, TN, WA), EPA regulators (regions IV and X) and stakeholders will be invited to this workshop. End Date: June 30, 2006.
- The IWG will support the ITRC, as requested, in teaching training classes on the MNA/EPR technical protocol and methodologies. End Date: June 30, 2006.

Annual Budgets

A summary of the annual budgets showing the organization breakout of funds is provided in Table 5. A detailed budget for FY03 is provided in Table 6 and a proposed budget for FYs 04 through 06 is provided in Table 7. The FY03 budget provides funding for the work the Interactive Working Group must accomplish to identify and document the scientific and technical objectives and details for the final 2 years of the project. Table 6 identifies the details of the FY03 budget. Personnel from ORNL and PNNL will be members of the Interactive Working Group and specifically the Technical Working Group. Based on the activities described for FY03, both ORNL and PNNL will each receive $100K in funding for their participation. The FY04 through FY06 budgets will be refined as work for those years becomes better defined. The scientific and technical field-based studies to be accomplished in FY04 and FY05 will be identified and specific field studies selected in early FY04. The collective experience of the SROT in field tests provides the basis for a proposed budget for the field activities to be conducted in FY04 and FY05. The collective experience of the Interactive Working Group provides the basis for the proposed budget for the protocol development activities to be conducted in FY04 through FY06. These budgets will be refined and additional detail provided as the specifics of the field studies are identified in early FY04.

Table 5. Summary Table of Annual Budgets with Organizational Breakouts for MNA/EPR Alternative Project

FY	Description	SRS Labor	SRS Contracts	ORNL	PNNL
'03	TWG	$350K	$800K	$60K	$70K
	IWG	$30K		$10K	$20K
	SROT	$210K			
	Regulator Interface	$10K		$10K	$10K
	ITRC Membership			$20K	
	FY03 TOTAL	**$600K**	**$800K**	**$100K**	**$100K**
'04	TWG	$100K	$240K	$25K	$35K
	IWG	$120K		$35K	$45K
	SROT	$150K			
	Regulator Interface	$10K		$10K	$10K
	ITRC Membership			$20K	
	Field Studies		$800K		
	SROT Field Support	$100K	$300K		
	FY04 TOTAL	**$480K**	**$1340K**	**$90K**	**$90K**
'05	TWG	$350K	$400K	$70K	$80K
	IWG	$120K		$35K	$45K
	SROT	$190K			
	Regulator Interface	$10K		$10K	$10K
	ITRC Membership			$20K	
	Field Studies		$550K		
	SROT Field Support	$40K	$70K		
	FY05 TOTAL	**$710K**	**$1020K**	**$135K**	**$135K**
'06	TWG	$145K	$200K	$45K	$55K
	IWG	$60K		$18K	$22K
	SROT	$95K			
	Regulator Interface	$5K		$5K	$5K
	ITRC Membership			$20K	
	Field Studies		$100K		
	FY06 TOTAL	**$305K**	**$300K**	**$88K**	**$82K**

Table 6. Detailed FY03 Budget for MNA/EPR Alternative Project

FY03 Activity	Description/Detail	Cost
Implementation Planning Mtg.	2.5 days at SRS of the IWG to review and input to the draft Implementation Plan	$45K
Technical Working Group Mtg. –1	5 days at SRS to draft project objectives and deliverables. This is the first meeting of the TWG and will initiate assignments towards the writing of the S&T plan.	$100K
Technical Working Group Mtg. –2	5 day meeting at SRS to draft the S&T document. A draft document will be prepared by the close of the meeting.	$100K
Weekly Meeting of TWG/Bi-Weekly Meeting of IWG	Conference call. The TWG will conduct a conference call weekly. Every second week the meeting will be expanded to include the entire IWG.	$70K
Writing/Reviewing, etc. for Technical Working Group members	This item is for activities performed by the TWG members to prepare and support the development of the protocol. The work in FY03 will support the development of the IP, objectives, deliverables, S&T document and the workshop at SRS	$825K
Historical Review	This is a subcontract for a comprehensive review of documentation/literature of MNA/EPR and associated technologies policy, implementation, success and failure.	$100K
SROT	• Interface with ITRC, SCDHEC, EPA • Interface with DOE-HQ • Interface with SGCP project teams • Manage contracts, day to day activities • Work with TWG to ensure milestones, deliverables are on schedule and met. • Coordinate planning activities for Workshops to be held at SRS in Oct. and Nov. 2003. • Support DOE-HQ, as requested, in preparing for peer review. • Prepare final version of all documents.	$220K
PNNL (activities as TWG member not included)	Interface with Washington state regulators, EPA Region X and Hanford management	$10K
ORNL (activities as TWG member not included)	Interface with Tennessee state regulators and Oak Ridge Reservation management	$10K

FY03 Activity	Description/Detail	Cost
ITRC committee membership	If requested by ITRC to provide a member(s) to an ITRC committee, 10% of the person(s) time must be committed. Will assume 1 person at this time.	$20K
Quarterly Meetings of IWG, as needed*	The IWG will meet quarterly as necessary. This decision will be made jointly by the DOE HQ project manager, DOE SR project manager, SROT chairperson and TWG chairperson.	$100K
	FY03 TOTAL	**$1600K**

*note: First quarterly meeting held in February (implementation planning meeting). Will assume 2 additional meetings held in FY03.

Table 7. Proposed Budget for FY04, FY05 and FY06 for MNA/EPR Alternative Project

Activity	Description/Detail	Cost
Workshop at SRS with PIs	Potential collaborators and IWG will meet to discuss research opportunities in relation to scientific and technical needs of protocol development	$100K (FY04)
Workshop at SRS for SRS, Oak Ridge and Hanford	Workshop to discuss objectives, goals and field studies of this project. Invitees include DOE and end users from the 3 sites, their respective state and EPA regulators, and stakeholders.	$50K (FY04)
Funding of Field Studies	Funding to PIs for field testing and writing of final report documenting test results	$800K (FY04) $550K (FY05) $100K (FY06)
SROT Field Support	Permitting, site preparation, contracts to support field studies, interface with SGCP projects, demobilization assistance	$400K (FY04) $110K (FY05)
TWG	Support as required for field studies and regulator/stakeholder contacts	$330K (FY04) $330K (FY05)
Technical Protocol Development	TWG prepares technical protocol. Results of field studies will be input to the technical protocol.	$500K (FY05) $300K (FY06)
Peer Review	IWG, as requested, will participate in peer review. Assume select members of TWG will participate if this peer review is conducted as a panel meeting.	$50K (FY06)
Workshop at National Meeting	IWG will conduct a workshop at a national meeting to present results of the MNA/EPR Alternative Project	$75K (FY06)
SROT	• Interface with ITRC, SCDHEC, EPA • Interface with DOE-HQ • Interface with SGCP project teams • Manage contracts, day to day activities • Work with TWG to ensure milestones, deliverables are on schedule and met.	$160K (FY04) $200K (FY05) $100K (FY06)

Activity	Description/Detail	Cost
SROT (continued)	• Support DOE-HQ, as requested, in preparing for peer review (FY06). • Prepare final version of all documents (FY06).	
PNNL	Interface with Washington State regulators, EPA Region X and Hanford management	$10K (FY04) $10K (FY05) $ 5K (FY06)
ORNL	Interface with Tennessee State regulators and Oak Ridge Reservation management	$10K (FY04) $10K (FY05) $ 5K (FY06)
ITRC committee membership	If requested by ITRC to provide a member(s) to an ITRC committee, 10% of the person(s) time must be committed. Will assume 1 person at this time.	$20K (FY04) $20K (FY05) $20K (FY06)
Weekly Meeting of TWG/Bi-weekly Meeting of IWG	Conference call. The TWG will conduct a conference call weekly. Every second week the meeting will be expanded to include the entire IWG.	$70K (FY04) $70K (FY05) $20K (FY06)
Quarterly Meeting of IWG, as needed.	The IWG will meet quarterly as necessary. This decision will be made jointly by the DOE HQ project manager, DOE SR project manager, SROT chairperson and TWG chairperson.	$200K (FY04) $200K (FY05) $100K (FY06)
	TOTAL FY Budgets	**$2000K (FY04)** **$2000K (FY05)** **$775K (FY06)**

References

National Academy of Sciences, 2000. *Natural Attenuation for Groundwater Remediation*, National Research Council, Committee on Intrinsic Remediation, National Academy Press, Washington, D.C. 2000.

U. S. Department of Energy, 2002. *Technical Targets: A Tool to Support Strategic Planning in the Subsurface Contaminants Focus Area*. B. B. Looney (ed.), Westinghouse Savannah River Company, Aiken SC 29808.

Appendix A
Baseline and Purpose of Technology Acceleration

Historical Baseline

The historical baseline vis-à-vis MNA/EPR includes: (1) continued active treatment until all contaminant is removed (often to levels based on direct water use and exposure), or (2) development of alternate endpoints based primarily on dilution or mixing. The former option results in high costs and the need for semi-permanent remediation at virtually every site, while the latter option has not been widely accepted as protective and final by stakeholders and regulators. These baseline approaches do not appropriately focus on long-term effectiveness and overall protection of the environment.

Synopsis of the Status and Usability of Monitored Natural Attenuation and Natural Remediation

In 2001, the National Research Council of the National Academy of Sciences (NAS) published a book that provided a comprehensive synopsis of the status and usability of MNA -- *Natural Attenuation for Groundwater Remediation*, National Research Council, Committee on Intrinsic Remediation, National Academy Press, Washington, D.C. 2000. This book was a follow-up to their 1993 report: *In-Situ Bioremediation: When Does It Work?* The earlier report focused on the potential significance of in situ biological degradation, while the recent book advocated general policies to support selecting remedies that rely on natural attenuation processes. As documented in the MNA/EPR Technology Acceleration Project Proposal, many such MNA/EPR development efforts have recently been completed or are underway. Examples include the ASTM Standard Guide for Remediation by Natural Attenuation (ASTM), the EPA Science Advisory Board (SAB) review of the Agency's Program for Monitored Natural Attenuation (EPA, May 2001), and various other policy and guidance documents by EPA, DOD, USGS, DOE and industry. As discussed below, these existing policy documents, while valuable, have not lead to widespread use or acceptance of natural remediation based systems. Existing protocols are generally similar in structure and approach and the standard paradigm contains key requirements that discourage use of natural remediation. The central purpose of this project is to provide the scientific basis to extend, modify and shift the standard paradigm and provide an alternative that will support widespread-appropriate implementation. Particular elements of the alternative that are critical to the future include using more integrated systematic monitoring, emphasizing processes occurring at interfaces, and implementing engineering enhancements to maximize robustness and sustainability. This approach views the cleanup as an ecosystem with the goal of maximizing environmental performance acceptability and documentation while controlling monitoring costs.

To support an understanding of the proposed alternative, the primary features of the baseline protocol are discussed below (using the NAS book as a key exemplar) and an analogy is presented that depicts the required science and technology enhancements.

The principal findings of the NAS report were:

- natural attenuation and natural remediation are established remedies for only a few types of contaminants (such as petroleum hydrocarbons) but not for chlorinated solvents, metals, radionuclides, …
- rigorous protocols are required to ensure that natural attenuation and natural remediation are properly implemented, and
- natural attenuation and natural remediation should be accepted as a remedy only when the processes are documented in detail, can be monitored to be working at all times, and are sustainable.

The NAS committee examined public concerns about natural attenuation, the scientific bases for natural attenuation, and the criteria for evaluating the potential success or failure of natural attenuation as a remedial action. They dedicated a large amount of text to discussions of community concerns, and included recommendations for increasing the level of stakeholder participation. The committee acknowledged that affected communities and regulators are often skeptical of remedies that are perceived as low-cost, that require a long time, or that rely on underlying processes are not understood in complete detail. This perception that "remediation based primarily on natural processes is often used by industry as a 'do-nothing' alternative" is a major factor that generated the rigorous requirements in the rest of the paradigm.

Based on stakeholder and regulator skepticism, NAS advocated a cautious technical stance, and recommended that multiple lines of evidence be used for remedial decisions that incorporate and rely on natural processes. The committee rejected systems that are based on a "primary" line of evidence, such as plume stability. They reasoned that since monitoring networks can generate inaccurate or ambiguous information, such monitoring data need to be supplemented with other lines of evidence. They also cited the need to ensure that natural attenuation is sustainable. They stressed the importance of explaining detailed cause/ effect relationships, and the need to quantitatively understand the importance of each attenuation process in order to assure reliability and sustainability. The committee advocated the use of site-specific conceptual models combined with the use of chemical mass balances and "footprints" of attenuation reactions. These footprints and similar spatial patterns of chemicals indicate the presence of specific biogeochemical reactions that destroy or immobilize contaminants. The committee recommended abandoning simple scoring systems as tools for deciding when natural attenuation may be appropriate, because attenuation processes are too site-specific, and therefore require a level of flexibility, expertise, and professional judgment that is inconsistent with the use of simple scoring systems.

Importantly, the NAS committee advocated a much higher standard of care for remedies that rely on natural attenuation than for active remedies that rely on engineered systems. For example, protocols for evaluating engineered remedial measures are rare, and it is even rarer still to require multiple lines of evidence. The authors justified this higher standard of care as necessary, given the long time frames often required, coupled with widespread public skepticism, and a general lack of training among agencies, responsible parties, consultants, and other stakeholders. The committee reviewed more than a dozen published protocols and policy statements regarding the use of natural attenuation, and compared these to a list of desirable attributes. They found most of the existing protocols adequate in some respects, but none of the protocols met all of the characteristics defined by the committee. None of the protocols addressed how and when to involve the public. Contingency plans were inadequate. The protocols contained insufficient guidance on when engineered methods could be used to benefit natural attenuation, and when they might interfere with it. Specific guidance on long-term monitoring was found to be lacking. Training or experience needed to implement the protocols and overarching design policies were often overlooked in favor of detailed questionnaires. Despite these apparent inadequacies, all of the existing policy and guidance documents aligned with, and supported, the paradigm documented by the NAS committee.

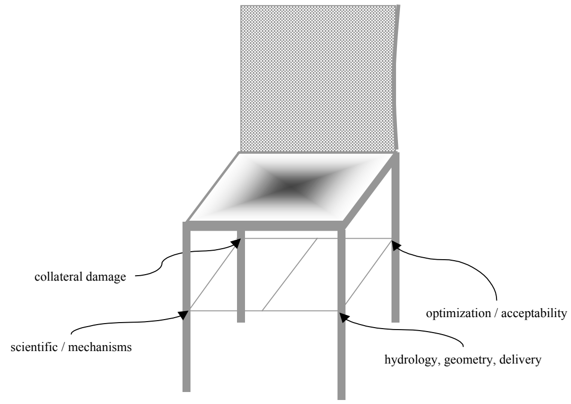
Role of the DOE Monitored Natural Attenuation and Natural Remediation Technology AccelerationProject

The DOE Monitored Natural Attenuation and Natural Remediation Alternative Project supports the central tenants of the existing protocols as articulated above. In particular, the project supports the importance of multiple lines of evidence, the importance of an adequate conceptual model, and the importance of documenting and monitoring mechanisms. The alternative nature of the proposed paradigm is specifically intended to target the inadequacies noted by the NAS panel. This project is predicated on the principle that a "higher standard of care" is, in fact, justified for natural attenuation and natural remediation. To realistically implement this "higher standard of care", however, a completely different technical approach is needed. Attempts to implement natural remediation with standard monitoring systems, attempts to use standard constitutive and comprehensive predictive models, and the like have not proven to be viable. By viewing the overall objectives more systematically, in an ecosystem fashion, a more robust and creative process and protocol is proposed. Such a balanced protocol emphasizes the site-specific nature of the problem as noted by NAS. It also focuses the documentation and subsequent monitoring of processes to the specific zones where the attenuation/remediation is occurring. The alternative protocol development relies on systematic, integrating, and indicator methods to document performance rather than high frequency point measurements in large numbers of wells. Finally, an alternative approach encourages large-scale (but low cost) system modifications that result in sustainable attenuation and remediation. Some of the existing guidance discourages such activities because of a strict adherence to an artificial dichotomy between engineered and natural alternatives.

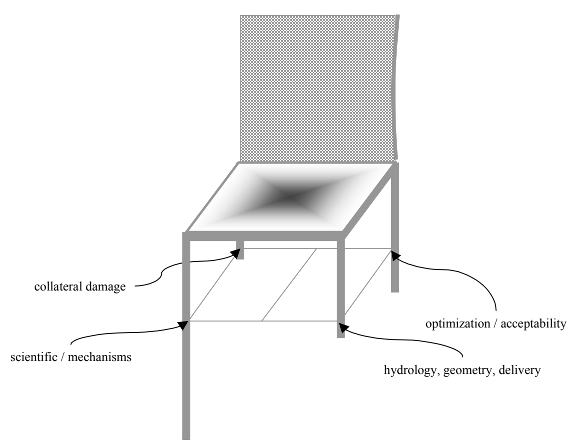
If we extend an analogy from the NAS book and the existing protocols, natural attenuation and natural remediation can be depicted as a chair with four legs – these are:

- scientific understanding of mechanisms
- hydrology, contaminant geometry, delivery
- potential collateral damage
- optimization, acceptability, monitoring and documentation

A protocol leading to maximum usability would balance the various categories and provide connection and support between them as shown below.



Much of the S&T effort to date has been directed at identifying and understanding mechanisms, with the bulk of the remaining effort focused on monitoring and documentation. Unfortunately the monitoring investment to date has primarily directed toward “real time” sensors in monitoring wells and other direct replacements for current techniques with an emphasis on showing “equivalency” to current approved methods rather than providing the information necessary for natural remediation. Further, as identified by NAS, past efforts have not adequately addressed legitimate regulatory and stakeholder concerns, nor have they encouraged optimization by aligning engineered actions with natural processes. Little effort or investment has been made in the area of hydrology, geometry and delivery. Similarly, evaluation of collateral damage (for natural and engineered remediation systems) has been underemphasized and, thus, environmental managers have been deprived of a tool to assist in making rational and protective decisions. Thus, the current state of monitored natural attenuation and natural remediation development is unbalanced – a chair with uneven legs.



The primary goal in the DOE Monitored Natural Attenuation and Natural Remediation Alternative Project is to build on the existing MNA and NR efforts and extend the existing efforts using state of the art science and technology to generate a balanced and useful protocol – a chair with four even legs that will support practical use.

A key concept in this emerging DOE approach to addressing contaminated sites is careful and specific matching of technologies to target problems. Aggressive technologies are matched to source areas that pose a high risk grading toward passive technologies that are matched to large and dispersed contaminants or to the later stages of cleanup. The geometry of technologies is matched to the geometric structure of the contamination. The historical development of this matching process and some of the resulting potential opportunities for future science and technology development have been described in recent documents (see for example: *Applied Environmental Technology Development at the Savannah River Site: A Retrospective on the Last Half of the 20th Century, WSRC-MS-2000-00172* and *Technical Targets – A Tool to Support Strategic Planning in the Subsurface Contaminants Focus Area, WSRC-RP-2002-00077*).

MNA and remediation concepts that rely on natural processes are essential to properly address plume fringes and later stages of cleanup. Many of the more aggressive techniques require expensive and comprehensive subsurface access and subsequent use of large amounts of targeted energy or chemical reagents. Such techniques and their adverse collateral damage should be avoided where there is insufficient contaminant and low risk.

Technologies for plume fringes and for the final stages of cleanup address low concentrations of contamination in large volumes of water. Thus, the best technologies for this zone are those that are priced in terms of time ($ per year and the like). To be successful, these technologies must rely on natural, sustainable and measurable processes. This class of technology has gained recent regulatory support under the terminology MNA ("monitored natural attenuation"). For the dilute fringe, technology selection should be directed towards understanding the contaminant destruction and stabilization capabilities of native species and natural populations. A second step is identifying engineering interventions, if needed, to maximize the performance and to ensure that the attenuation process will operate for extended periods. A critical requirement for these technologies is development of logical and cost-effective monitoring strategies.

Specific Technical Targets for the MNA/EPR Alternative Project

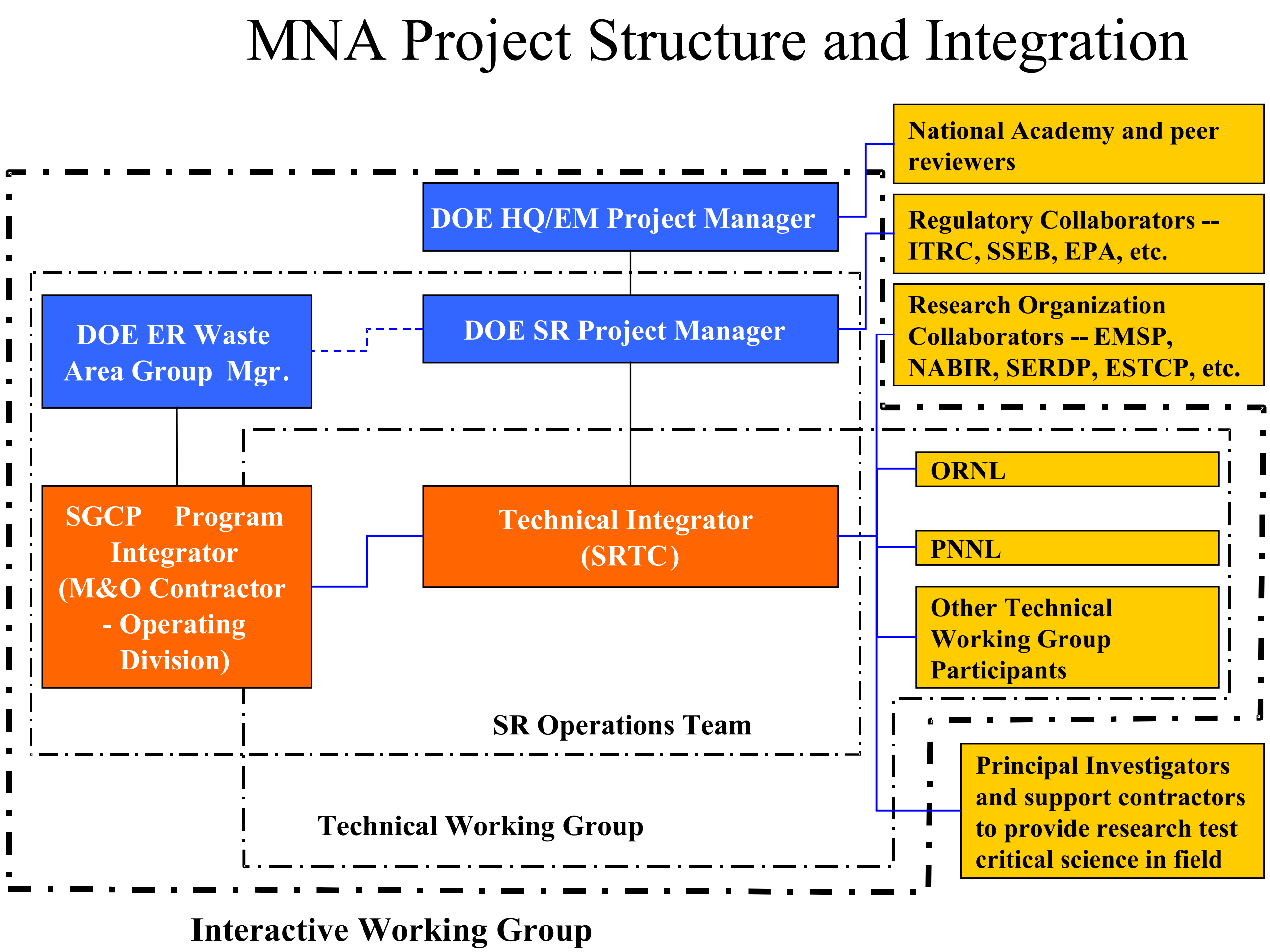
To provide a significant contribution for a reasonable investment, this project must aggressively target the identified issues and gaps – the things that are stopping appropriate use of MNA/EPR – rather than simply generating an interesting collection of research studies. To meet these objectives, this program will be built around a specific set of challenging sites – the Chemical Metals and Pesticides (CMP) Pits and the related reactor seepage basins and disposal pits – where the science can be focused and protocols developed and implemented.

Identifying technical and regulatory issues and data gaps is a crucial step in developing an applied science project to substantially advance progress toward environmental restoration built on natural and sustainable processes – actions such as MNA/EPR. The major gap MNA/EPR has been implementing a successful transition between the active stages of cleanup, in which the source is eliminated, to safe and sustainable environmental stewardship based on natural processes. This gap results primarily from a poor understanding of the scientific basis for MNA and a lack of creativity in implementing and configuring long term solutions.

A core value at the Savannah River Site is that MNA and other natural remediation concepts encompass any configuration of technologies that provide effective, sustained and documentable performance. This approach allows a more robust implementation than the classical "no action" MNA. This Natural Remdiation (NR) paradigm will be a key element in successfully transitioning from active remediation to cost-effective passive remediation. This expanded paradigm emphasizes natural destruction mechanisms (such as microbiological degradation) and detailed understanding of interfaces and the dynamic processes that occur near these interfaces. Example interfaces include groundwater discharge zones near streams (the "hyporheic zone"), groundwater plant interfaces (the "rhizosphere"), vadose zone groundwater interfaces (the "capillary fringe") and others. To support implementation and use of MNA/EPR, an entirely new approach to long-term monitoring will be required.

Appendix B
Roles and Responsibilities

To meet the Monitored Natural Attenuation and Natural Remediation Acceleration Project goals and objectives, the overall effort will be performed as collaboration between DOE science and operations organizations at the target site, DOE management, DOE National Laboratories, industry, universities, regulatory and interagency collaborators, and others. A key element of the work is the participation by principal investigators and researchers to provide critical field studies and background information. The project structure and key roles and responsibilities for each of the organizations are pictured and summarized below.



The summary descriptions of each organization's roles and responsibilities are provided below.

<u>DOE HQ/EM Project Manager</u> – Overall responsibility for directing project – setting objectives, monitoring progress, and defining implementation approach to meet DOE needs.

<u>DOE SR Program Manager</u> – Overall responsibility for activities performed at SRS

DOE ER Waste Area Group (WAG) Manager – Overall management responsibility for assuring that the subject waste site(s) is(are) remediated and closed in a responsible and environmentally sound manner. The SGCP Program Integrator reports to the DOE ER WAG Manager. For this project, the DOE ER WAG Manager for Reactor Projects will serve this role because the CMP Pits and nearby reactor area clean up actions are all within that waste area group.

Technology Integrator – Serves as the point of contact for day to day project activities. This role includes: (1) coordinating and providing nearby technical support for scientific aspects of work (especially as they relate to site specific SRS conditions and needs), (2) assisting DOE in coordinating extramural participation, (3) providing a disciplined and clear interface for MNA program activities with the ER Project team, (4) bringing in resources from local universities and university consortia (these organizations such as SREL, SCUREF and ERDA provide expedited access to scientists with unique expertise in local environmental conditions), and (5) managing and serving as subcontract technical representative for extramural contracts. For this project, SRTC will serve this role because they are the technical division for the site M&O Contractor. The Technology Integrator will also coordinate liaison efforts to the Office of Science (SC-75, OBER, etc), to Long Term Stewardship Initiatives, and to other DOE groups as needed.

ORNL, PNNL, and other Technical Working Group Participants -- Technical resources will be identified at DOE National Laboratories (ORNL and PNNL) and funded through the Technology Integrator via an MPO or other appropriate mechanism. This funding will be used to tap into the strong national expertise within DOE and to tap into centers of excellence in critical areas (such as using an "ecosystem monitoring" paradigm as has been advocated in the Long-Term Monitoring Program). Other, non DOE, nationally recognized experts and individuals who provide continuity with past MNA/EPR efforts will also be included in the Technical Working Group and contracted through the technology integrator.

ORNL and PNNL personnel will have additional responsibilities beyond the Technical Working Group. They will be the liaisons for this project with their respective sites DOE and end user personnel, as well as their state and EPA regulators, and their stakeholder organizations.

SGCP Program Integrator – The Soil and Groundwater Closure Project (SGCP), formerly Environmental Restoration Department, is the site owner, end user, and has the ultimate authority for any work that is performed at the field site. In this role, they will serve as coordinator for regulatory issues (through the CERCLA Core Team and the existing SRS/regulator MNR Technical Working Group), training requirements, approval of field-work plans, and the like. The SGCP Program Integrator will coordinate incorporation of the results of the MNA/EPR research into the baseline for ultimate use in accelerating closure. The SGCP Program Integrator will serve as the primary resource for coordinating the diverse research efforts being performed throughout SRS and in the region. As such, they will serve as a clearinghouse for such information to the project and will report on the relevant projects and on the SRS MNA Interactive Working Group efforts / findings (the SRS MNA Interactive Working Group comprises technical representatives from SRS, local universities, SC and EPA regulators). For this project, the SR SGCP Business Unit will serve this role because they are the operating division for the subject activities for the site M&O Contractor.

Appendix C
Summary Versions of Relevant DOE Technical Targets

A full version of the Targets with detailed information is in the original DOE reference WSRC-RP-2002-00077

Improving the Technical Basis for Setting Remediation Goals

Strategic Investment Category: Ensuring Environmental Stewardship

Overview: This target recommends working with end users, regulators and stakeholders to develop a more holistic approach for setting goals. This target identifies several specific technical advances that would improve decisionmaking and recommends rapidly integrating the advances into decision support resources for beneficial use in baseline activities. Vital development themes with particular promise to DOE include: 1) prioritizing the desirability of end states, 2) time phased decisionmaking, 3) technically defensible assessment of collateral damage, and 4) accounting for baseline risk for natural elements and synergistic effect in contaminant mixtures.

Comments: This target addresses vital technical aspects of this important policy topic. One of the most interesting topics to the technical target development team was the identification of collateral damage as an important element to incorporate into decisionmaking (does the cleanup action actually do more harm than good – by using excessive energy, by eliminating habitat, etc.). An area that may be of particular interest to DOE and end users over the next several years is how to deal with remediation of naturally occurring substances such as arsenic or mercury. The target is strong in its description of what is needed to support improved decisionmaking, but points out that the ultimate decisions in this area are policy rather that technical. This has been the reason that these topics are not traditionally viewed as desirable to tackle in a scientific and technical R&D program.

Importance: In almost every case, excessive costs and failures of cleanup systems can be traced back to poor goal setting.

What the target does not say: The target does not advocate continuing a cookbook style use of standard risk assessment approaches. Rather, it suggests specific steps for providing a technical basis to alter the standard approach and incorporate balancing factors in decisionmaking.

Important comments from the team during review: Reviewers felt that this was an important and challenging target.

Links to other technical targets: Depends on key progress in “Advanced Environmental Modeling” and “Methods to Validate and Verify Performance”.

Methods to Verify and Validate Performance

Strategic Investment Category: Ensuring Environmental Stewardship

Overview: This target recognizes the need to develop distinctly different technologies for short term performance monitoring versus long term monitoring. The former relies primarily on improved sensor development, emplacement and data integration, while the later relies primarily on developing wholly new verification paradigms to allow monitoring for decades or centuries. Large scale methods (remote sensing, geophysics), integrating methods (flux or release measurements), and indicator/surrogate methods, among others appear promising for long term monitoring.

Comments: This target addresses an active and important topic area. In its original form, the target was strong in its description of what is needed to support short-term verification and validation of system performance. In its revision the team focused on long term monitoring methods emphasizing their ultimate importance and value, and highlighting in moderate detail what is needed – and what is not needed – for long term monitoring.

Importance: Field experience indicates that overall environmental management costs (and even the regulatory approval to proceed with cleanup activities) are primarily determined by verification and validation issues/approaches/costs.

What the target does not say: The target does not advocate the most popular long term monitoring paradigm of numerous sensors, dataloggers (or wireless transmitters) and “real time” data as the central concept for long term monitoring. Some of these features are retained in the description of short-term performance verification, however. The target does identify and advocate alternative paradigms for long term monitoring that should provide robust and defensible monitoring for less cost and in a way that is useful to EM and to stakeholders. Such monitoring should be considered one of the multiple defenses recommended for environmental response activities by the National Academy of Sciences in their Long Term Stewardship report(s).

Important comments from the team during initial review: Reviewers felt that this was an important target that addressed most of the important issues in an appropriate manner.

Links to other Technical Targets: Depends on making key advances in fate and transport modeling as described in “Advanced Environmental Modeling” and in developing robust and reliable sensors for key contaminants as described in “Techniques and Technologies that support Characterization”.

Organic Source Zone Stabilization and Treatment

Strategic Investment Category: Eliminating Contaminant Sources

Overview: This target advocates continuing the past SCFA progress in moving through the National Academy of Sciences' chart of remediation challenges from less difficult to more difficult. Thus, the target recommends a central strategy of collaboration with other agencies to advance practical application of organic source zone treatment methods. The specific focus for future activities is on enhanced removal and in-situ destruction technologies for conditions that are more difficult than those already addressed by SCFA (fractured systems and low permeability media). Another vital objective highlighted in this target is development and selection of techniques that are compatible with a transition to less aggressive and more passive polishing of the site – for example, technologies that do not foreclose on biological remediation because they cause long term sterilization of the subsurface. A final concept described in the target is the need for characterization tools to designate and delineate the source zone so that expensive and aggressive cleanup methods are not applied in areas where they are not needed.

Comments: A key strength of this target is that it recommends addressing "organic source zone" technology challenges in an orderly and technically based manner. It recognizes and summarizes the successful DOE-interagency historical development efforts that have resulted in several alternative technologies (now commercially available) for cleaning up organics in simple to moderately complex settings (steam/DUS, six phase heating, and surfactants). These successes resulted from collaborative investment by DOE and other federal agencies.

Importance: Successfully remediating organic source zones is an absolute requirement for implementing successful cleanup strategies in the downgradient primary and dilute fringe portions of the plume. Slow "leakage" from the source zone is the reason that plume treatment technologies are perceived to be failing (taking hundreds of years).

What the target does not say: The target discourages the concept that physical containment is viable for organic source zones.

Important comments from the team during initial review: This was positively received.

Links to other Technical Targets: Depends on making key advances in fate and transport modeling as described in "Advanced Environmental Modeling" and in developing efficient "Access and Delivery" methods. This target also relies on developing and implementing improved decisionmaking and performance verification approaches as described in "Methods to Verify and Validate Performance" and "Improving the Technical Basis for Setting Remediation Goals".

Advanced Sustainable Containment Systems

Strategic Investment Category: Isolating Contaminants

Overview: Devise/Develop containment systems based on natural analogs. Develop containment systems that have robustness based on fundamental theoretical processes ("long life") and which integrate with related remediation activities.

Comments: This target was quite well conceived and written and carefully and comprehensively lays out the vital objectives related to science, engineering/implementation, and creative monitoring. The emphasis on natural analogs as a means to document the long term performance of containment systems was interesting, useful and strategic.

Importance: Properly applied and monitored, physical containment and barriers will remain a central activity in DOE environmental management for the foreseeable future. Advancing the science and technology base relatively rapidly is particularly important to closure sites that need to implement and document such systems in the next several years.

What the target does not say: The target does not advocate barriers as a sole solution to environmental problems. Instead, it suggests that they be considered one of the multiple defenses recommended for environmental response activities by the National Academy of Sciences in their Long Term Stewardship report(s).

Important comments from team during initial review: Reviewers felt that this was one of the most complete and well-written targets. It is relatively comprehensive (i.e., it could comprise an entire reasonably anticipated research program budget) and will require some prioritization. A few reviewers commented that this target had significant overlap with aspects of the "Integrated Containment-Treatment (Smart Containment)" and that they might be combined. Others felt that the more pragmatic objectives of cap verification – items that are currently critical to closure sites – might be de-emphasized if the targets were combined.

Links to other Technical Targets: Depends on making key advances in fate and transport modeling as described in "Advanced Environmental Modeling" and in developing and implementing improved decisionmaking and performance verification approaches as described in "Methods to Verify and Validate Performance" and "Improving the Technical Basis for Setting Remediation Goals".

Effective and Sustainable Technological Solutions for Contaminant Plumes

Strategic Investment Category: Controlling Contaminant Plumes

Overview: Several vital scientific and technical objectives remain: 1) optimizing active treatment systems, 2) understanding the relationship between performance and the completeness of source zone treatment, 3) developing technologies that transition more quickly to monitored natural attenuation (e.g., through emplacement of long term reagent materials, through identification of measurable natural processes that destroy, stabilize, or detoxify dilute plume contaminants), and 4) developing design approaches and viable monitoring strategies. The target does not distinguish between organics, metals, and radionuclides, because the possible actions and challenges for the various contaminants tend to come together in the primary plume and more dilute areas. This target is structured to support development of the general class of technologies often referred to as "monitored natural attenuation." The target emphasizes that sustainable technologies must be technically based to be accepted and implemented. The target was strong in the way that it linked mechanisms and monitoring concepts.

Comments: This target was strong in the way that it linked source zone treatment with transitioning to monitored natural/sustainable processes. In general, active treatment methods for the primary plume are relatively mature, while transitioning approaches and paradigms require significant development.

Importance: A unified and linked concept in remediation that addresses the source -primary plume – and distal dilute plume in an organized and comprehensive fashion represents the most promising approach to more rational action at many DOE facilities. Development, documentation, and implementation of sustainable technologies has been identified as one of the most important medium to long term goals in DOE EM. This topic is at the heart of NAS/NRC recommendations on Long Term Stewardship and these "technologies" represent one of the final protections in the recommended multiple defenses.

What the target does not say: The target does not say that pump and treat does not work – rather that a treatment train or systems approach is needed to address the various portions of the plume with their varying characteristics. The target highlights the fact that rational actions in the primary plume and dilute zone are predicated on source zone stabilization and treatment. The target does not say that sustainable technologies (e.g., MNA) are desirable and applicable to every site or that such technologies can always be implemented alone. Rather, the target emphasizes incorporating this class of action into a treatment system.

Important comments from the team during initial review: Reviewers felt that this target was well conceived.

Links to other Technical Targets: Depends on making key advances in "Advanced Environmental Modeling" and in "Methods to Verify and Validate Performance" and "Improving the Technical Basis for Setting Remediation Goals". This target also depends on success in eliminating both the organic and metal/radionuclide source zones that feed contaminant plumes.

Subsurface Access and Delivery

Strategic Investment Category: Enabling DOE's Clean-Up Efforts

Overview: The most important objectives highlighted in this cross cutting target are: 1) access under obstructions, 2) delivery of fluid for treatment or containment, 3) deep access, 4) difficult access, and 5) delivery of devices.

Comments: This target was well conceived and written. The writers addressed access for sampling, delivery of devices, and delivery of fluids for subsurface manipulation and remediation. The target identifies that poor access, rather than poorly understood chemistry or biology, is the primary reason for poor remediation system performance. The target documents the strong historical contribution of DOE (horizontal wells, cone penetromenter systems, and the like). Because of the wide range of end-user needs on this topic, the target provides an initial assessment of priorities and tabulates the relative importance of the various vital objectives that were identified.

Importance: Improved access methods were a widely distributed and critical end-user need throughout the DOE complex. This cross-cutting area has not been emphasized over the past several years and the group felt that a target to focus strategic investment was absolutely necessary. This target is particularly important to closure sites that need to implement and document cleanup in the next several years.

What the target does not say: The target does not suggest that improving access, without appropriate decisionmaking, technology selection and verification methods will entirely solve key environmental challenges at DOE sites.

Important comments from the team during initial review: Reviewers felt that this was a complete and well-written target. Comments were particularly positive on the approach used for providing insight and prioritization of the five vital development objectives.

Links to other Technical Targets: Depends on making key advances in performance verification approaches as described in "Methods to Verify and Validate Performance". This target supports the cleanup targets, particularly those related to source zone treatment and stabilization.

Techniques and Technologies that Support Characterization

Strategic Investment Category: Enabling DOE's Clean-Up Efforts

Overview: Vital themes identified and described for this target include: 1) improvement of non-invasive characterization technologies, 2) measurements at various scales (point and volume integrated) to support multiple objectives, 3) development of field deployable systems, and 4) integration of multiple types of characterization data.

Comments: This was a complex and difficult target to write. The target does a good job in identifying the important issues, but needs more detail and prioritization to help it to be strategic (see review comments). One of the most acclaimed aspects of the target is a discussion of moving toward field screening to enhance representativeness and to reduce costs and, where needed, to perform measurements in-situ in cases where representative measurements can not be made at the surface. Scale issues are well described, with related vital objectives providing solutions from various complementary perspectives (integrating measurements, direct push "continuous" measurements, etc.).

Importance: Characterization currently represents the largest early project investment. As a result, significant improvements in characterization methods will rapidly improve the EM program.

What the target does not say: The target does not say in-situ measurements are needed for all constituents.

Important comments from the team during initial review: Reviewers felt that this target was generally well conceived but probably needed more detail and prioritization on strategic investment directions (parts of it read more like a comprehensive list of an unconstrained program).

Links to other Technical Targets: Depends on creatively exploiting observations and data from basic science studies and on making key advances in performance verification approaches as described in "Methods to Verify and Validate Performance". This target supports the cleanup targets, particularly those related to source zone treatment and stabilization.

Biogeochemical Processes that Determine Contaminant Fate

Strategic Investment Category: Enabling DOE's Clean-Up Efforts

Overview: The effective implementation of remediation strategies and natural attenuation for the cleanup of DOE sites depends on understanding critical chemical, physical and biological processes. Particular important research themes include: 1) redox conditions that affect biogeochemical processes, 2) anthropogenic influences on the biogeochemistry of natural systems and extreme environments, and 3) coupling and scaling issues.

Comments: This target was strong because it prioritized the complex topic and clearly identified the key/vital early investment themes embodied in end-user experiences. What makes this topic challenging is that there has been so much work done in the area and there are so many uncertainties in specific details, and that there are so many scientists who advocate investing in their specific area of interest. Thus, this subteam made a relatively courageous decision to highlight a few key areas and open the target up to the potential criticisms that this topic, or that topic, is overlooked. The consensus after the target was written, was that the highlighted items were appropriate and that they represent strategic technical objectives that would advance both the critical science and be useful.

Importance: The particular biogeochemical processes highlighted in this target are the ones responsible for most of the biogeochemical end-user problems (and/or they represent potential creative solutions via subsurface manipulation).

What the target does not say: The target does not provide a comprehensive prioritized list of all of the biogeochemical uncertainties nor a detailed plan to resolve them all over a 10 or 20 year period (as is done in the Vadose Zone Roadmap for example). The more comprehensive look, while highly desirable, was viewed as unrealistic and not aligned with the needs of targets to provide strategic investment information to DOE.

Important comments from the team during initial review: Reviewers felt that this was an important, challenging and well-written target.

Links to other Technical Targets: Requires continued basic research and approaches to link the results to the field scale through the "Advanced Environmental Modeling" target.

Advanced Environmental Modeling

Strategic Investment Category: Enabling DOE's Cleanup Efforts

Overview: The vital needs associated with modeling fundamental environmental processes are: 1) identifying and filling fundamental environmental process knowledge gaps (as described in the Vadose Zone Roadmap, for example), 2) improving uncertainty quantification techniques, and 3) near term transitioning techniques from state-of-art to state-of-practice.

Comments: This was a complex and difficult target to write. The target does a good job in identifying the important issues. In the second meeting more detail and prioritization was added to help it to be strategic (see review comments). Some of the target's original objectives were too general ("Identification and filling of fundamental environmental process knowledge gaps", "Development of more comprehensive uncertainty quantification techniques"). Others represent good near term goals ("Transitioning from state-of-art computing to state-of-practice in modeling").

Importance: The ability to accurately model and/or understand fundamental processes is often identified as critical success. There is a perception that better models will "eliminate" surprises and lead to optimized remediation.

What the target does not say: The target does not completely support or refute ideas about the role of deterministic modeling in addressing this target or improving end-user actions.

Important comments from the team during initial review: Reviewers felt that this target needed more detail and focus on a subset of critical issues, possibly using biogeochemical processes as a model for how to select items to include. This modification was made during the second meeting.

Links to other Technical Targets: Progress toward this target is the most commonly cited link to meet almost all of the other technical targets. This target requires information from the biogeochemistry, heterogeneous system, and other science providing targets.