Natural Attenuation Monitor

March 2004

This publication is published by the US DOE Monitored Natural Attenuation and Enhanced Passive Remediation for Chlorinated Solvents Technology Alternative Project to provide to all interested parties the latest information on this project.

Prepared for the United States Department of Energy under Contract No. DE-AC09-96-SR18500

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Welcome to our Readers

The *Natural Attenuation Monitor* is provided for multiple audiences to communicate what we are doing and accomplishing. Each reader will likely approach the subject from a different perspective, seeking different information. The Alternative Project, funded by the Office of Environmental Management's Office of Cleanup Technologies, is a 3-year, $6M project on accelerating cleanup of groundwater plumes by using natural and passive remediation of chlorinated solvent contamination. Results of this project are expected to accelerate cleanup by a minimum of 10 years for DOE sites having groundwater plumes contaminated with chlorinated solvents.

The technical team for this U.S. Department of Energy (DOE) project consists of several national experts on MNA and includes participants who helped develop the 1999 U. S. Environmental Protection Agency (EPA) Policy Directive (OSWER Directive 9700.4-17P). The primary assignment to this interdisciplinary team was to generate a summary of the state-of-the-art, particularly for chlorinated solvent applications and to identify high-priority opportunities for advancement. The resulting project is a collaborative effort between state and federal regulators, end users, stakeholders, technology developers, and DOE. Technical lead for the project is Brian B. Looney, PhD, Savannah River Technology Center.

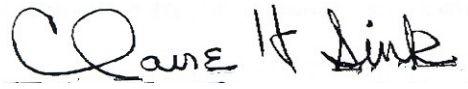
Potential technology users of MNA should find the project useful for their decisions on site remediation planning. The rapid increase in selection of MNA as the sole remedy clearly indicates user interest in and use of the approach.

Regulators should use the project and its *Natural Attenuation Monitor* for information on possible technological advances in MNA. We consulted numerous regulators during project development to identify current issues or concerns from their perspective. We anticipate results of the project to be the basis for addressing the most prominent regulatory issues as an update to the current protocols for implementing MNA. To this end, we have a partnership with the Interstate Technology Regulatory Council (ITRC) to integrate the new results into technical regulatory guidance. The ITRC Natural Attenuation Passive Bioremediation Team co-leaders are from state regulatory agencies in South Carolina and Florida.

Science and technology developers can anticipate getting innovative ideas in the areas deemed "high-priority" for matching with their technological capabilities. We are in the process of funding a suite of near-term applied research and field study projects in those areas. Projects should be in place by May 15, 2004, with a 22-month performance period.

Stakeholders and general readers should find the project useful as a primer on MNA and the more aggressive enhanced passive remediation. The historical review done in 2003 and the supporting document that fully reports the results of that review should be of particular interest as they provide important insight into hands-on experience.

As the project management team, we intend to use the results of this project as a guide for expediting the use of MNA for chlorinated solvents at Savannah River Site and elsewhere at DOE sites. Hanford intends to use the regulatory guidance and technical results of this project to accelerate cleanup by 10 years of its large CCl_4 plume. For Savannah River Site, we see cleanup of groundwater plumes contaminated with chlorinated solvents accelerated by a minimum of 20 years. Results of the project are expected to be used initially in Records of Decision at Savannah River and Hanford sites.



Claire H. Sink, Project Manager
U.S. Department of Energy

Monitored Natural Attenuation A New Direction

Much success has occurred when Monitored Natural Attenuation has been applied to petroleum hydrocarbon contaminated sites. The success at organic solvent contaminated sites, in particular chlorinated solvents, has been more variable. This variability of success between the two types of contaminants is in part due to the natural attenuating processes for petroleum hydrocarbons being more robust and simpler than those for chlorinated solvents. The DOE EM program is responsible for cleanup of 5,700 known contaminated groundwater separate occurrences at sites across the U.S, many of which contain chlorinated solvents. The chlorinated solvents used at DOE facilities tend to be persistent in the subsurface. This leads to groundwater plumes that over time tend to become very large. Estimates for time to remediate range in the 100's of years for these large plumes. These plumes are a concern to DOE, regulators and the public. In response to this challenge, DOE has initiated a project to develop complimentary technical guidance to the EPA OSWER Directive 9200.4-17, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, and EPA *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water,* EPA/600/R-98/128.

The goal of the DOE Monitored Natural Attenuation/Enhanced Passive Remediation (MNA/EPR) project is to "provide 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". A Technical Working Group (TWG) of nationally recognized scientists is guiding the project's scientific and technical direction. The TWG identified several key concepts and technical areas to be explored and developed to more thoroughly understand the processes that contribute to natural attenuation of chlorinated solvents. The TWG will work with researchers across the United States to develop a better under-

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Introducing the Technical Working Group

Leading the MNA/EPR project is a group of technical professionals with a broad national representation of the sciences associated with characterization, implementation and monitoring of monitored natural attenuation and enhanced passive remediation of chlorinated solvents. Members of this team come from industry and federal agencies. Several team members contributed to existing EPA protocol development and to parallel DOD efforts. This group of scientists, geologists, biologists and engineers provides the technical direction for this project. They are creative, respected members of their professions. We would like to introduce them at this time.

Brian Looney, an Advisory Scientist with the Savannah River Technology Center (SRTC), coordinates the Technical Working Group. Brian received a B. S. (Envr. Science) degree from Texas Christian University and a Ph.D. (Envr. Engr.) degree from the University of Minnesota. For the past 20 years, Brian has developed environmental characterization and remediation technologies for organic contaminants, metals and radionuclides. Brian strongly believes in the concept of matching characterization and cleanup technologies to each site and his work has focused on developing specific technically based approaches for that matching process.

Francis H. Chapelle received B.A. (Music) and B.S. (Geology) degrees from the University of Maryland, and M.S. and Ph.D. degrees from the George Washington University. He has been a hydrologist for the U.S. Geological Survey (USGS) since 1979. Frank's research interests center on how microbial processes affect the chemical quality of ground water in both contaminated and pristine environments. He has authored more than 100 scientific papers and a textbook (Ground Water Microbiology and Geochemistry) on these subjects. In addition, Frank has written a book for the general reader "The Hidden Sea" describing the history of

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standing of mechanisms, to develop tools for measuring these mechanisms directly, and to develop methods and strategies for the long-term monitoring of these processes. The product of the project will be a technical guidance document that will be based on the work of the TWG and the researchers.

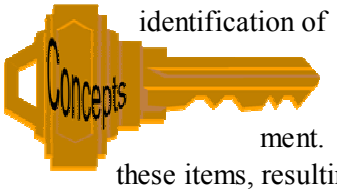
Other products for the project are the Implementation Plan, the *Natural and Passive Remediation of Chlorinated Solvents: Critical Evaluation of Science and Technology Targets* report, and the documentation of the results of the research studies by the researchers. The Implementation Plan and the *Natural and Passive Remediation of Chlorinated Solvents: Critical Evaluation of Science and Technology Targets* report are complete and available (see **Published MNA/EPR Project Documents**). The documentation of the results of the research studies is due at the end of 2005.

A key component of this project is to develop a relationship with regulators, stakeholders and end users. The purpose of this relationship is to have an ongoing dialogue on issues facing this group of people and how the key concepts and directions of this project address those issues. The project team believes that addressing these issues through science will lead to a technical guidance document that will be consistent with end user needs and regulatory policy.

Natural and Passive Remediation of Chlorinated Solvents: Critical Evaluation of Science and Technology Targets

The Technical Working Group (TWG) was formed in April 2003 to strategically guide the MNA/EPR Project. Initial results of their efforts are a list of specific-integrated research and development targets that will focus and guide this project and several key concepts the TWG will develop. The *Natural and Passive Remediation of Chlorinated Solvents: Critical Evaluation of Science and Technology Targets* document is the record of the evaluation and deliberations of the TWG in setting the key concepts and selecting the technical targets for this project.

The TWG's first activity was to identify several lines of inquiry, general research and development areas, that show promise in facilitating the use of MNA/EPR. Two general categories were identified for the lines of inquiry. They are **Scientific Basis** and **Characterization and Monitoring**. Each of these categories underwent a detailed and critical evaluation by the TWG. The purpose was to look at the baseline processes and present-day technologies and document where advancements may facilitate implementation of MNA/EPR. This detailed and critical evaluation resulted in identification of approximately 45 items that show promise for development. The TWG prioritized these items, resulting in 16 high priority technical targets for this project. In addition, 4 high priority policy targets were identified that will be provided to the Natural Attenuation and Passive Bioremediation (NABIR) team (see **ITRC and DOE collaborate on the MNA/EPR Project**) and 6 basic science, long-term, research targets that have been provided to the DOE NABIR Program.

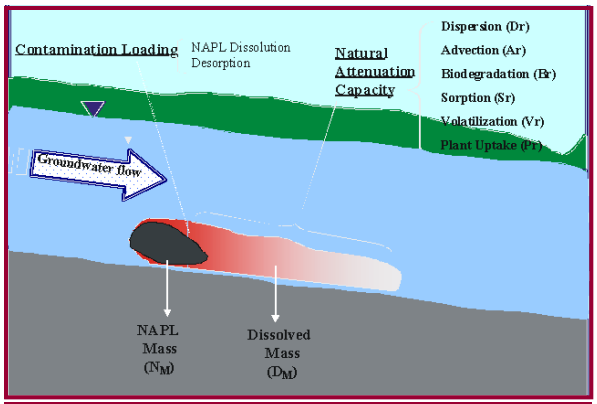


A key concept identified during this evaluation process is using a mass balance of loading versus attenuation capacity as a key decision-making step in determining if MNA will be effective in reducing the contaminants or when MNA is not effective determining if EPR will be effective in reducing the contaminants. This is a conceptually simple process. However, it can be a technically challenging concept to put into practice. One challenge is gathering the needed data to complete the mass balance. Developing tools that will allow direct measurement of the mass balance parameters is an important item identified by the team. Tools needed for long-term monitoring of sites undergoing natural attenuation are on the other end of the spectrum. In order to keep long-term monitoring costs in a range that site owners will find acceptable, indicator tools were identified as worthy of developing. These tools are non-direct monitoring tools that indicate changes are occurring in the system that may result in the attenuation capacity decreasing to such a level that loading is now greater than attenuation capacity.

Balancing Contaminant Loading with Contaminant Attenuation

"Will operation of the selected technology lead to meeting the remediation goals?" For the folks faced with remediating a waste site that is the million dollar question. When selecting Monitored Natural Attenuation as the remedy or part of the remedy for a waste site, it becomes the ten million dollar question. Many people see natural attenuation as a "do nothing" approach to remediation. In fact, it is anything but. The difference between natural attenuation and the more common treatments is the involvement of humans. Mother nature is in control and working hard in natural attenuation processes. As humans, what we do is monitor those processes at work. There are many processes that contribute to natural attenuation of chlorinated solvents. Figuring out which processes are working, to what extent and is it enough to remove the contaminants faster than they enter the system is the big challenge.

Frank Chapelle, a member of the Technical Working Group, has been working on a mass balance approach that will be a tool for evaluating when natural attenuation is a good choice for a remedial option for a waste unit. This approach balances the contaminant loading or input to the system with the contaminant attenuation, called the natural attenuation capacity. This capacity is the sum of all the physical, biological, and chemical processes serving to disperse, biodegrade, chemically transform, immobilize, or sequester contaminants in a ground-water system. These processes consist of physical processes such as dispersion, advection, and volatilization, chemical processes such as sorption and abiotic transformations, and biologic processes such as biodegradation and uptake by plants.



Mass balance between contaminant loading and natural attenuation capacity in ground-water systems.

The figure to the left is an illustration of this concept and identifies the type of processes that contribute to loading and natural attenuation capacity. "Conceptualizing MNA as a balance between contaminant loading/attenuation is useful because it is relatively easy to understand" says Dr. Chapelle, a hydrologist with the USGS, whose research interests center on how microbial processes affect the chemical quality of groundwater and who conducts training courses on monitored natural attenuation for the Department of Defense.

Using the figure, one can visualize that when the loading is less than the natural attenuation capacity, the plume will shrink . When the loading is greater than the natural attenuation capacity, the plume will grow. In this case, monitored natural attenuation alone may not result in achieving remediation goals. One of the positives of this mass balance approach is that is can be applied to entire plumes and to metals and radionuclides, as well as chlorinated solvents. By applying the concept to an entire plume, decisions can be made on how to integrate a treatment system that will result in remediation of the contaminated plume in a reasonable time period. This is consistent with recommendations from the EPA that stress natural attenuation is most appropriate when used in conjunction with engineered reduction of contaminant sources or as a follow up measure.

The challenge will be in measuring the rates of the attenuating processes and the loading processes so that mass balance can be calculated. The Technical Working Group and associated researchers will be developing processes and tools for measuring the processes and calculating the mass balance.

Interested Parties are Introduced to Key Concepts and Technical Targets of the Project

The MNA/EPR project is driven by two central beliefs. First, the project will be driven by science. Second, but equally as important as the first, is that input and support on the directions of the project by interested parties is requisite for this project to be successful. These interested parties include stakeholders, such as citizen's advisory boards; state and federal regulators; and end users, such as environmental consultants and those charged with characterizing and remediating waste sites.

Upon completing the draft of the report *Natural and Passive Remediation of Chlorinated Solvents: Critical Evaluation of Science and Technology Targets* the project team held meetings with interested parties at the Oak Ridge, Hanford and Savannah River Sites. These meeting were held in the period beginning August 11, 2003 and ending September 23, 2003. Participants included citizen's advisory boards from each of the three DOE facilities, state and EPA regulators, and site technical personnel involved in characterizing and remediating the waste units. The three DOE sites each hosted these meetings to facilitate attendance by as many people as possible. The purpose of the meetings was twofold. The purpose of the first part of each meeting was to present the scientific and technical directions to be pursued during the project, the key concepts to be developed and the technical targets that would guide the research efforts. The purpose of the second part of each meeting was to gather feedback on the information presented in the first half of the meeting. This was accomplished through the use of a set of questions that were the starting point for discussing the key concepts, the scientific and technical directions of the project and the technical targets identified.

Overall the meeting participants felt positively toward the project. Reactions to the main ideas of developing the mass balance concept and a 4-phase process to address characterization and monitoring were positive. Most agreed that the idea of balancing contaminant input to and contaminant reduction (attenuation) from a system is conceptually simple and that the difficulty lies in measuring the parameters to complete the equation. People were intrigued by the idea of enhanced passive remediation as a class of technologies that bridges the gap between active treatments and passive ("no human contact") processes. As the TWG is still developing the definition of enhanced passive remediation, there was confusion and discussion of what technologies or processes would fit in this category.

The results of these meetings are documented in the report titled *Summary Document of Workshops for Hanford, Oak Ridge and Savannah River Site as part of the Monitored Natural Attenuation and Enhanced Passive Remediation for Chlorinated Solvents - DOE Alternative Project for Technology Acceleration*. Information on obtaining this document is available in the article titled *Published MNA/EPR Project Document.*

Citizens Advisory Groups Show Interest in MNA/EPR Project

The meetings the MNA/EPR Project Team held with stakeholders, regulators and end users in August and September of 2003 sparked interest with the Citizens Advisory Groups at Hanford, Oak Ridge and Savannah River Sites. Follow-on meetings occurred or are planned at each of these sites.

Hanford Advisory Board's River and Plateau (R&P) Subcommittee has formed a team to look at the applicability of MNA for Hanford waste sites. Tyler Gilmore, MNA/EPR Project representative, participated in the February 11th meeting of this team. An introduction and overview of MNA was presented at the onset of the meeting. The emphasis of the meeting was for stakeholders and regulators to present their perspectives on MNA and to hold an open discussion between the participating team members and to identify a recommended path forward for the team. As related to the MNA/EPR Project, the R&P Subcommittee's newly formed team wants to remain informed of the Project's progress and will review all Project documents.

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Technical Targets Come to Life

An important part of the MNA/EPR Project is the development of tools and technologies to support the sixteen technical targets that are identified in the *Natural and Passive Remediation of Chlorinated Solvents: Critical Evaluation of Science and Technology Targets* document. The targets that made the final list of sixteen are ones the Technical Working Group (TWG) believed will lead to advancement in the understanding of the natural processes contributing to natural attenuation of chlorinated solvents, new tools for measuring these processes in a direct manner, new tools for evaluating the data and making decisions on appropriateness of MNA, and new tools to assist in designing long-term monitoring programs. The selected technical targets are those that can be advanced in the 3 years of this project. The project team wants to advance the brightest, most innovative ideas that supported the technical targets. In an effort to bring these ideas to the project, scientists, engineers, and technology developers from across the United States were solicited for ideas through a Request for Information that was placed on the Federal Business Opportunities website, the single government point-of-entry for Federal government procurement opportunities over $25,000.

The research ideas submitted to the project team as a result of the request for information were reviewed against the technical targets and a set of evaluation criteria in technical, quality and overall concept categories. Out of 45 research ideas, a short list of 15 were recommended for funding. The 16 technical targets were represented by these 15 research ideas, as some of the research ideas addressed multiple targets. Industry, universities, national laboratories, federal agencies and DOE laboratories are represented by these research ideas and will conduct the research studies they proposed. The research studies represent work in the areas of developing tools and methods to directly measure attenuation mechanisms, developing strategies to support characterization and monitoring, developing tools to support characterization and monitoring, and developing passive or semi-passive enhancements to support Enhanced Passive Remediation.

Field test sites at the Savannah River Site (SRS) have been identified for those researchers requiring field sites to either collect samples or conduct field scale testing. The selected sites present various MNA related challenges to the researchers. The results of the research studies will be provided to the SRS contractor organization responsible for cleaning up the waste units located on the site.

The research studies are slated to begin in the spring of 2004 and will be conducted over a 22 month period.

New Science, New Technologies: Meeting the Technical Targets

An important part of the MNA/EPR Project is investing in new science and new technologies that support the technical targets and key concepts identified by the TWG. A portfolio of fourteen research studies will be funded to support the Technical Targets (see Technical Targets Come to Life) for this project. Two research ideas submitted were complementary and would work best as one research study. Thus, the researchers were asked to work together on a single research study. As applicable, the research studies will be conducted at the field test sites at the SRS. The test beds are waste units where the characteristics of the site make MNA or EPR a potentially viable option. Data obtained during the scientific research studies will be provided to the SRS operating department responsible for the cleanup of those waste units. That data may be incorporated, as appropriate, into the decision making process for the waste unit at which it was collected.

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ITRC and DOE Collaborate on the MNA/EPR Project

The Interstate Technology Regulatory Council (ITRC) has formed a new team, the Natural Attenuation and Passive Bioremediation (NAPB) team, that will collaborate with the DOE MNA/EPR Project team. These two teams will work to develop the "next generation" technical guidance together and to develop and present training courses on this new guidance. Collaboration between the scientific group and regulator groups will assist the Technical Working Group to develop technical areas that will address issues the regulators are faced with in regulating remediation efforts. The MNA/EPR project team believes this will lead to a stronger technical guidance document that will be used/accepted by both regulators and end users.

Judie Kean, Florida Department of Environmental Protection, and Kimberly Wilson, South Carolina Department of Health and Environmental Control will lead this new team. Claire Sink, DOE Office of Cleanup Technologies, Brian Looney, SRTC, and Tom Early, Oak Ridge National Laboratory, will represent the DOE MNA/EPR Project team on the NAPB team. The team will meet for the first time on March 24, 2004 during the ITRC Spring Meeting. The team will consist of members representing state regulators, universities, industry and federal agencies.

Information on the NAPB team is found on the ITRC website at www.itrcweb.org. Kimberly Wilson can be reached at wilsonka@ITRCWEB.net. Judie Kean can be reached at judie.kean@dep.state.fl.us.

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Tom Early, MNA/EPR Project representative, spoke to the Oak Ridge Site Specific Advisory Board (SSAB) on October 15, 2003 on MNA. The stakeholders were supportive of the mass balance concept, but identified some of the challenges as related to the Oak Ridge Site. "I think MNA/EPR is a viable remediation selection, but education of the decision parties and the public is crucial. The Natural Attenuation Monitor the project will publish will educate as well as inform about progress of the MNA/EPR project and help the Oak Ridge Reservation in remedy selection." said Norman Mulvenon, executive vice-chair of the OR SSAB, who attended both meetings with project personnel. The SSAB will monitor the progress of the MNA/EPR Project.

On September 9, 2003 Brian Looney presented the MNA/EPR project to the Facilities Dispositions and Site Remediation committee (FD&SRC) of the Savannah River Site Citizens Advisory Board (SRS CAB), followed by a second presentation on September 22 to the full SRS CAB. "The Facilities Disposition and Site Remediation committee of the Savannah River Site Citizens Advisory Board applauds DOE and its weapons complex sites, its contractors, and its regulators for developing and coordinating the use of innovative, cost-effective, and workable solutions, such as MNA/EPR, for environmental clean up. Our committee introduced Recommendation #175, which was passed by the Board on Nov. 18, 2003, offering the Board's support of and suggestions for continued development and study of such forward-thinking processes" said Perry Holcomb, FD&SRC chairman, SRS CAB. Part of the recommendation the SRS CAB requested, and DOE SR has concurred, requires the MNA/EPR Project team to prepare a white paper discussing the effect of aggressive source treatments on the ability for natural attenuation to occur as a follow-on treatment at chlorinated solvent sites and to keep the CABs and others up-to-date on the project. This white paper and the newsletter's first edition will be presented to the SRS CAB on March 22, 2004.

One of four testbeds at the Savannah River Site where researchers can conduct studies to support MNA /EPR Project.

The MNA/EPR Project Team will provide updates to the Advisory Boards and other interested parties as requested. Annual updates will be provided to Savannah River, Oak Ridge and Hanford Advisory Boards.

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various mystic and rational approaches to understanding ground-water systems, and how the idiosyncrasies of aquifers often complicates efforts to assess and clean up environmental contamination.

Thomas Early has a Ph.D. in geochemistry from Washington University, St. Louis, MO and over 30 years experience in addressing groundwater environmental problems. For the past 17 years he has been at Oak Ridge National Laboratory. For much of that time he was associated with DOE's Office of Science and Technology, which was responsible for developing innovative technologies in support of cleanup activities at DOE sites. His area of emphasis is groundwater geochemistry and source zone treatments for chlorinated solvents.

Tyler Gilmore, a Senior Research Scientist with the Pacific Northwest National Laboratory, has been working on groundwater and soil remediation technology development for 17 years. Tyler has extensive laboratory and field experience in the application and development of novel and innovative methods and technologies and holds 4 patents related to environmental characterization and remediation. Tyler has served as an expert for characterization and monitoring techniques for many successful projects at Hanford. He served as a national resource to DOE in providing technical assistance to other sites and in serving on technology panels and peer reviews.

Dr. Michael Heitkamp has over 26 years of experience in environmental microbiology and biotechnology. His training and experience span microbial ecology, microbial physiology, molecular biology, chemical biodegradation and laboratory, pilot-scale and field testing of novel microbial technologies for biotreatment of water, air and soils. Dr. Heitkamp was a charter Steering Committee member on the EPA Remediation Technology Development Forum (RTDF). He recently completed his ninth year of appointment on the Environmental Committee of the American Society for Microbiology. He commonly serves as a senior technical resource for numerous national proposal review panels, national technical workshops and several technical steering committees for the DOE. In 1999, Michael joined SRTC as Research Manager for the Environmental Biotechnology Section where he leads a multi-disciplinary research team in the discovery, development & deployment of environmental biotechnologies at the Savannah River Site and other locations in the DOE complex.

Dr. David Major, a Principal of GeoSyntec Consultants, Inc., is recognized for his expertise on the *in situ* biodegradation of chlorinated solvents in natural or engineered environments. His knowledge and expertise has led to serving on national committees, including the steering committee of the U.S EPA RTDF Consortium on Bioremediation of Chlorinated Solvents, and the EPA Science Advisory Board (SAB) to review the efficacy of DNAPL treatment technologies. Dr. Major has trained thousands of state and federal regulators on MNA through courses that he prepared in association with the RTDF and Interstate Technology Regulatory Council Workgroup (ITRC).

W. Jody Waugh is Principal Scientist with S.M. Stoller Corporation at the DOE's Environmental Sciences Laboratory in Grand Junction, Colorado. He received a PhD in Rangeland Ecology from the University of Wyoming in 1986. He has more than 20 years of research and applications experience monitoring the performance of existing engineered covers for uranium mill tailings, designing and evaluating alternative evapotranspiration covers, developing phytoremediation technologies for arid-land applications, and projecting the long-term ecology and performance near-surface remedies. He is currently working on long-term stewardship issues of the DOE Office of Legacy Management.

Gary Wein received his PhD. in Botany and Plant Physiology from Rutgers University in 1984. Be-

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tween 1986 and 2001 he served as a Research Manager at the University of Georgia's Savannah River Ecology Laboratory coordinating research on wetlands and other ecological systems. Dr. Wein currently is a member of the Savannah River Site Soil and Groundwater Closure Projects where he coordinates it's Monitored Natural Remediation program and conducts human health and ecological risk assessments.

Todd H. Wiedemeier, president of T.H. Wiedemeier & Associates LLC, has over 14 years of experience in remediation and has conducted natural attenuation and bioremediation feasibility studies at more than 100 sites contaminated with fuel hydrocarbons, MTBE, and chlorinated solvents. He is the author of more than 100 publications on remediation, including the widely used Air Force Center for Environmental Excellence document titled *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Hydrocarbons Dissolved in Groundwater* and the USEPA document titled *Technical Protocol for Evaluating the Natural Attenuation of Chlorinated Solvents Dissolved in Groundwater*. Todd is the senior author of *Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface* published by John Wiley & Sons and is working on a protocol for evaluating the natural attenuation of MTBE. Todd teaches several short courses including *Natural and Enhanced Bioremediation, Low Cost Remediation Strategies*, and *Remediation by Natural Attenuation.*

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The topics for the research studies and the organizations conducting the studies are:

- Generating broadly-applicable dehalogenation rate constants — Cornell Univ.
- Advancement of nucleic acid based tools for monitoring in situ reductive dechlorination – direct measurement tools.— Georgia Tech/Univ. of Toronto
- Research on oxidative and reductive processes — U.S. Geological Survey (USGS)
- Use of electron shuttles to biologically enhance abiotic dechlorination — Industry and EPA
- Structural features of VOCs and contaminant solid interactions—Irreversible Sorption — Pacific Northwest National Laboratory (PNNL)
- Scenario based framework for Enhanced Passive Remediation/MNA decision making — Industry and PNNL
- Microsparger for wellhead measurements — PNNL and Savannah River Technology Center (SRTC)
- Developing an MNA modeling tool based on RT3D — PNNL and Auburn Univ.
- Improving the integration of modeling into MNA: The mass balance utility kit — Industry and Auburn Univ.
- Strategy and system for long term monitoring using artificial intelligence and decision support systems — USGS and Industry
- Innovative oxygen sensor for remote subsurface oxygen measurements — SRTC
- Field testing passive flux meter for multiple solute fluxes — Developing direct measures of contaminant flux — Univ. of Florida
- Push-Pull tests to determine in situ attenuation capacity at a field scale — Industry, Oregon State Univ., Oak Ridge National Laboratory (ORNL)
- EPR using bioaugmentation with aerobic bacteria for cis-DCE degradation — Cornell Univ., U.S. Air Force, Industry.

These projects will be initiated by May 15, 2004 and continue for a 22 month period. Results of the research will be incorporated into the technical guidance document written by the TWG. The researchers will be encouraged to publish the results of their studies in appropriate journals.

Scientist collecting sediment samples in wetlands at the Savannah River Site.

Published MNA/EPR Project Documents

A running list of all documents that are a product of this project will be presented here. Documents will be added to the list once they have been approved for public release. Most documents will be available from the Office of Scientific and Technical Information's website (www.OSTI.gov). Each listing will include the document title, hot link, and short description.

• *Scientific Basis for Monitored Natural Attenuation and Enhanced Passive Remedation for Chlorinated Solvents – DOE Alternative Project for Technology Acceleration Implementation Plan* (www.osti.gov/bridge/product.biblio.jsp?osti_id=810006&queryId=1&start=0), WSRC-RP-2003-00286, Department of Energy, Office of Scientific and Technical Information, Oak Ridge TN, February 20, 2003. This document outlines the purpose, goals and structure of the project. It includes schedules, milestones and deliverables.

• *Historical and Retrospective Survey of Monitored Natural Attenuation: A Line of Inquiry Supporting Monitored Natural Attenuation and Enhanced Passive Remediation of Chlorinated Solvents* (www.osti.gov/bridge/product.biblio.jsp?osti_id=820972&queryId=1&start=0), WSRC-TR-2003-00333, Department of Energy, Office of Scientific and Technical Information, Oak Ridge TN, October 20, 2003. This document summarizes the results of a survey conducted of professionals in the environmental remediation business to evaluate the state of practice for MNA. The results of this survey were used by the Technical Working Group in the writing of the *Natural and Passive Remediation of Chlorinated Solvents: Critical Evaluation of Science and Technology Targets*.

• *Summary Document of Workshops for Hanford, Oak Ridge and Savannah River Site as part of the Monitored Natural Attenuation and Enhanced Passive Remediation for Chlorinated Solvents - DOE Alternative Project for Technology Acceleration* (www.osti.gov/bridge/product.biblio.jsp?osti_id=820971&queryId=1&start=0), WSRC-RP-2003-1044, Department of Energy, Office of Scientific and Technical Information, Oak Ridge TN, October 20, 2003. This document summarizes the feedback the project team received from regulators, stakeholders and end users during meetings held at Hanford, Oak Ridge and Savannah River Sites. The purpose of the meetings was to provide information on the direction and key concepts of this project and to elicit feedback on the direct and key concepts.

• *Natural and Passive Remediation of Chlorinated Solvents: Critical Evaluation of Science and Technology Targets* (this document has been approved for public release, but is not available on the OSTI website at this date), WSRC-TR-2003-00328, Department of Energy, Office of Scientific and Technical Information, Oak Ridge TN, February 2004. This document identifies the key technical concepts this project will develop. There is an evaluation of potential technical/scientific areas that have the potential for development and an identification of 16 technical targets that will be pursued during this project.