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www.epa.gov/TIO
http://clu-in.org/roadmap

Road Map to Understanding Innovative Technology Options for Brownfields Investigation and Cleanup, Third Edition

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ROAD MAP TO UNDERSTANDING INNOVATIVE TECHNOLOGY OPTIONS FOR BROWNFIELDS INVESTIGATION AND CLEANUP, THIRD EDITION

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office
Washington, DC 20460

NOTICE

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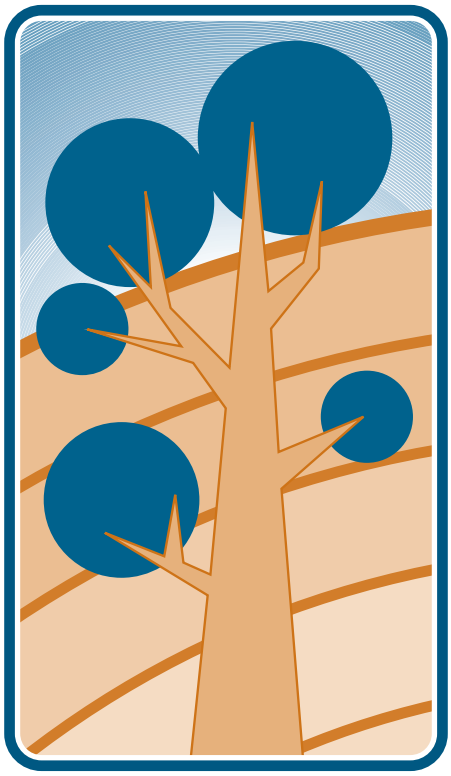
BACKGROUND

The U.S. Environmental Protection Agency (EPA) has defined brownfields sites as "abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination." EPA established its Brownfields Economic Redevelopment Initiative to empower states, communities, and other stakeholders in economic revitalization to work together to accomplish the redevelopment of such sites. Many states and local jurisdictions also help businesses and communities adapt environmental cleanup programs to the special needs of brownfields sites.



Preparing brownfields sites for productive reuse requires the integration of many elements—financial issues, community involvement, liability considerations, environmental assessment and cleanup, regulatory requirements, and more—as well as coordination among many groups of stakeholders. The assessment and cleanup of a site must be carried out in a way that integrates all those factors into the overall redevelopment process. In addition, the cleanup strategy will vary from site to site. At some sites, cleanup will be completed before the property is transferred to new owners. At other sites, cleanup may take place simultaneously with construction and redevelopment activities. Regardless of when and how cleanup is accomplished, the challenge to any brownfields program is to clean up sites in accordance with redevelopment goals. Such goals may include cost-effectiveness, timeliness, and avoidance of adverse effects on structures on the site and on neighboring communities, as well as redevelopment of the land in a way that benefits communities and local economies.

Why Innovative Technologies?

Numerous technology options are available to assist those involved in brownfields cleanup. EPA's Technology Innovation Office (TIO) encourages the use of smarter solutions for characterizing and cleaning up contaminated sites by advocating more effective, less costly technology approaches. The use of innovative technologies to characterize and clean up brownfields sites provides opportunities for stakeholders to reduce the cost of cleanup and accelerate the cleanup schedule. When such factors

as lower cost, an increased level of environmental protection, and improved effectiveness are considered, innovative technologies frequently are more cost-effective and provide better and more efficient cleanup than established treatment technologies. Often, they also are more acceptable to communities.

EPA defines an innovative technology as one that has been used in the field but that does not yet have a long history of full-scale use. In addition, data about the cost and performance of innovative technologies may not be sufficient to encourage decision makers to select those technologies over established technologies. A primary area of interest to EPA is documenting and disseminating information about the cost and performance of innovative technologies. EPA, through its work with the Federal Remediation Technologies Roundtable, has seen significant progress in this area. Innovative technologies are being used in many cleanup programs to assess contamination and to clean up sites.

Comprehensive information about the range of these technologies and their use, as well as technical expertise pertinent to them, is available from EPA's Brownfields Technology Support Center (BTSC), coordinated through TIO and supported by EPA's Office of Research and Development (ORD). Established in 1999 as a pilot program, the BTSC assists brownfields decision makers by presenting strategies for streamlining site assessment and cleanup, identifying information about technology options, evaluating plans and documents, describing complex technologies to communities, and providing demonstration support (see page 11 for more information about the BTSC).

An **Emerging Technology** is an innovative technology that currently is undergoing bench-scale testing, in which a small version of the technology is tested in a laboratory.

An **Innovative Technology** is a technology that has been field-tested and applied to a hazardous waste problem at a site, but lacks a long history of full-scale use. Information about its cost and how well it works may be insufficient to support prediction of its performance under a wide variety of operating conditions.

An **Established Technology** is a technology for which cost and performance information is readily available. Only after a technology has been used at many different sites and the results fully documented is that technology considered to be established.

INTRODUCTION

The *Road Map to Understanding Innovative Technology Options for Brownfields Investigation and Cleanup, Third Edition*, includes new and updated resources to assist in the identification and selection of innovative site characterization and cleanup technologies for brownfields redevelopment. The Road Map and accompanying CD-ROM provide a generally applicable outline of the steps in the cleanup of a site slated for redevelopment, and introduce brownfields stakeholders to the range of innovative technology options and resources available to them. The Road Map provides valuable information to a wide range of stakeholders involved in or affected by the redevelopment of brownfields sites, whether public projects, private developments, or public-private partnerships. The third edition, which incorporates minor revisions in the structure and content of the second edition, has been expanded significantly to include new and updated resources, which are included on the Road Map CD-ROM.

The first edition of the Road Map, published in 1997, provided a broad overview of EPA's brownfields program and an outline of the steps involved in the cleanup of a brownfields site. Targeted primarily at stakeholders who were unfamiliar with the elements of cleaning up a brownfields site, the Road Map built awareness of the advantages offered by innovative technologies. As the brownfields program matured, a second edition of the Road Map was published in 1999 to provide updated information and resources about the program, including additional details about the technologies available for addressing contamination at brownfields sites. This edition, accompanied by a CD-ROM, provided easier access to the wide range of information and resources included in the Road Map.

The new third edition has been developed for use by a broader audience, ranging from those who may have a limited understanding of the brownfields program and technical background to those who are more experienced. Updated with approximately 70 new resources and one-page descriptions of technologies, processes, and initiatives that affect the use and consideration of innovative technologies, the newest edition of the Road Map will help:

- New and less experienced stakeholders learn about EPA's brownfields program in general.
- Decision makers who are familiar with the brownfields programs but are also interested in obtaining more detailed information about technologies. The Road Map provides these users

with current and up-to-date information about the applicability of innovative technologies and ready access to the latest resources that can assist them in making their technology decisions.

- Stakeholders that hire or oversee site cleanup professionals (such as environmental consultants, cleanup contractors, technology vendors, or staff of analytical laboratories). The Road Map provides these stakeholders with a detailed understanding of the different phases of cleanup of a brownfields site and provides information about the role these professionals play in the process and how to encourage consideration of the use of innovative technologies.
- Regulators by increasing their understanding of the brownfields program and the advantages innovative technologies and approaches may provide throughout the cleanup process. The Road Map also serves as a resource for regulators to provide site owners, service providers, and other stakeholders with useful information about the brownfields program.
- Community members by providing information about the general cleanup process and guidelines and mechanisms that ensure that they are involved in the decision-making process.
- Other stakeholders, such as financial institutions and insurance agencies, by providing information for use in assessing and minimizing risk associated with brownfields redevelopment.

It is important to understand that the site characterization and cleanup process may not occur in the sequence outlined in the following chapters. At many sites, several activities may be undertaken concurrently and some steps may reoccur throughout the process. For example, many technologies that are used for characterizing sites during the preliminary phases of a brownfields project may be appropriate for use in later stages of a site cleanup. Understanding the logical progression of the process is crucial to ensuring that the proper groundwork is laid for future phases, and in determining whether activities can be combined or implemented concurrently.

The Road Map is not an official guidance document. Instead, it draws upon EPA's experiences with Superfund sites, corrective action sites under the Resource Conservation and Recovery Act (RCRA), and Underground Storage Tank (UST) sites. Specific conditions—such as the kinds and amount of contamination, the proposed reuses of the property, the financial resources available, and the level of support from neighboring communities—vary from site to site.

New in the Third Edition

- Addition of **72** new resources identified with a "new resource" icon
- Update of **19** resources
- One-page spotlights on specific topics that identify and describe key technologies, processes, and initiatives that affect the use and consideration of innovative technologies at brownfields sites
- Significant expansion of Appendix B, *List of Acronyms and Glossary of Key Terms*
- An index of resources, listed in alphabetical order by title

How to Submit Comments

EPA invites comments from the members of the brownfields community to help ensure that any future versions of the Road Map meet their needs. Please submit comments to:

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Washington, DC 20460
E-mail: *pachon.carlos@epa.gov*
Phone: (703) 603-9904

How to Obtain Additional Copies

Portable document format (pdf) and HTML versions of the Road Map are available for viewing or downloading from the Hazardous Waste Cleanup Information (CLU-IN) web site at *http://clu-in.org/roadmap*. A printed or hard copy version can also be ordered directly from CLU-IN.

If you do not have access to the Internet, a printed or hard copy version of this document can be obtained from:

National Service Center for
Environmental Publications
U.S. EPA
P.O. Box 42419
Cincinnati, OH 45242
Telephone: (800) 490-9198
FAX: (513) 489-8695

When ordering, refer to document number EPA 542-B-01-001.

How to Use the Road Map

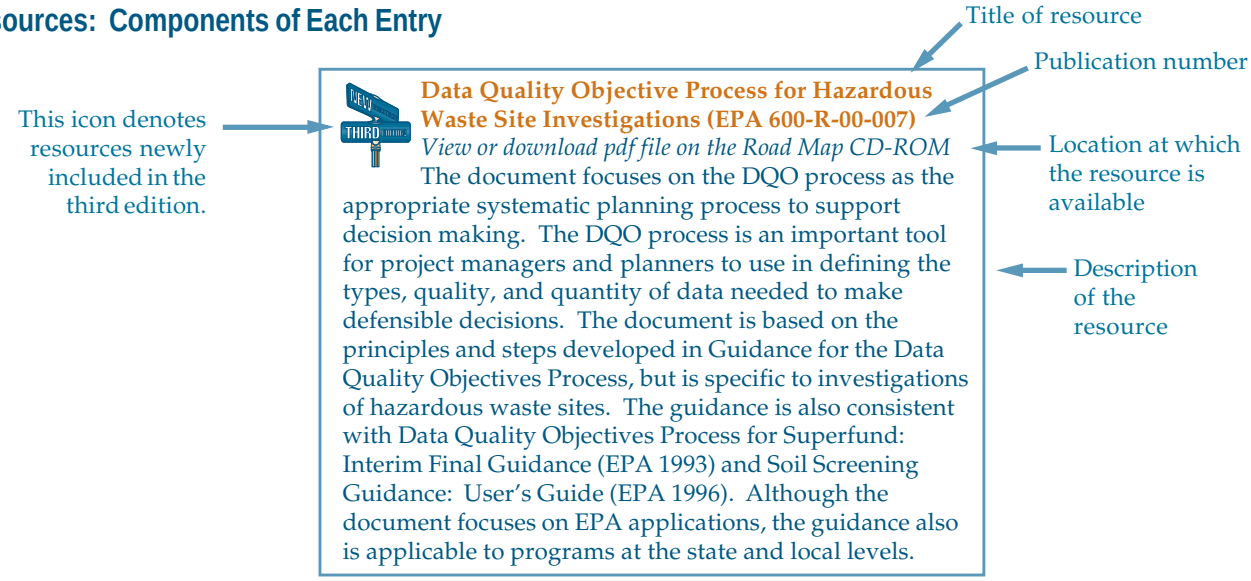
The first section, Before You Begin, discusses important factors that set the stage for the characterization and cleanup of brownfields sites and lists applicable resources. Regulatory guidelines for the process are introduced, and innovative technologies are discussed within the overall framework of the selection of site characterization and cleanup technologies.

The remaining four sections of the Road Map summarize the general phases of the characterization and cleanup of potentially contaminated sites: site assessment, site investigation, assessment of cleanup options, and design and implementation of the remedy.

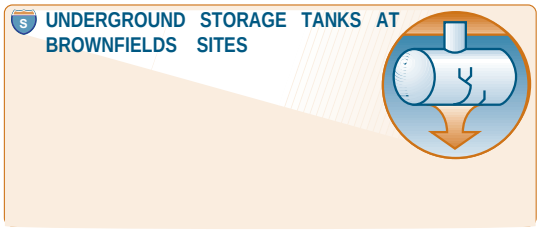
Each section describes the objective to be accomplished, outlines the key questions to be answered, summarizes the activities undertaken during that phase, discusses key questions related to technology selection, lists information resources available to assist in selecting technologies, and indicates specific actions to be taken at the completion of the phase. The resources are grouped by type of resource — technology resources, site-specific resources, or technology-specific resources — and are listed in alphabetical order under each category. Technology resources provide general information about technologies and their application, site-specific resources provide information about the application of innovative technologies to specific contaminants and site types, and technology-specific resources present detailed information about specific technologies and the application of those processes to specific contaminants and media.

• Before You Begin • Site Assessment • Site Investigation • Cleanup Options • Cleanup Design and Implementation

Resources: Components of Each Entry



The Road Map is intended to identify and answer questions related to the selection of technologies, rather than those questions related to other brownfields issues. Please remember that the key questions and activities to be conducted are intended to guide the reader in identifying issues that should be addressed. To serve as guideposts in the cleanup process, the questions take the point of view of the various groups involved in that process. They ask what stakeholders as a group working together—the "we" of each question—must do as assessment and cleanup progresses.



Spotlights

New to this edition are one-page descriptions that "spotlight" key issues related to the characterization and cleanup of brownfields sites, including key technologies, processes, and initiatives that affect the use and consideration of innovative technologies at brownfields sites. The spotlights are included in the section of the Road Map that is most relevant to each application. Each spotlight also includes information about additional resources, as appropriate. The topics of the spotlights are:

- "Other Redevelopment Initiatives"
- "Mothballed Properties"
- "Keys to Technology Selection and Acceptance"
- "The Triad Approach"
- "Data Quality and Representativeness"
- "State Drycleaner Remediation Programs"
- "Remediating Manufactured Gas Plant Sites"
- "Underground Storage Tanks at Brownfields Sites"
- "Phytoremediation Technology"
- "Cleanup of Dense Nonaqueous Phase Liquids"
- "Understanding the Role of Institutional Controls at Brownfields Sites"

Appendices

Several appendices also are included to help stakeholders understand technical issues and terms related to cleanup. *Appendix A, Guide to Contaminants and Technologies*, identifies activities that may have caused contamination at sites being considered for redevelopment and the range of technologies that may be appropriate for use at brownfields sites. *Appendix B, List of Acronyms and Glossary of Key Terms*, defines specialized terms and acronyms used in discussing and describing brownfields cleanup efforts. *Appendix C, List of Brownfields and Technical Support Contacts*, provides information about state and EPA regional and technical points of contact. *Appendix D, How to Order Documents*, provides information about ordering the documents listed in the Road Map.

Index of Resources

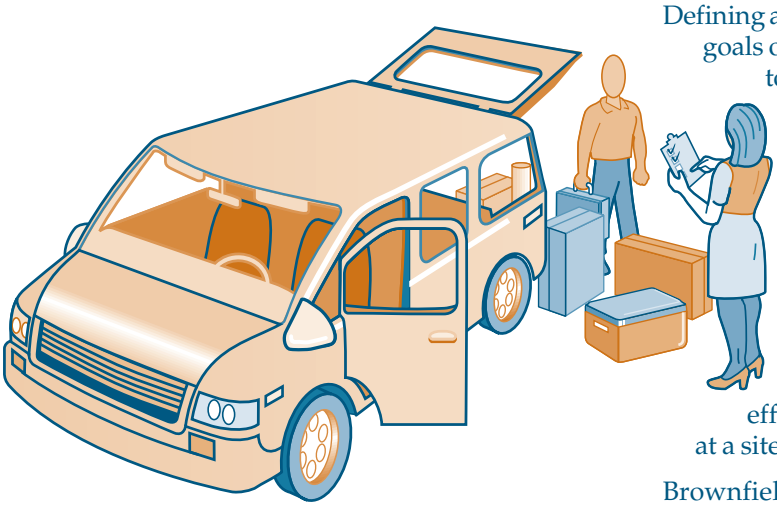
The *Index of Resources* provides a complete list of the resources in the Road Map, sorted alphabetically by title.

Road Map CD-ROM

The Road Map CD-ROM is included with this document. The CD-ROM is organized by the same sections as the Road Map — "Before You Begin," "Site Assessment," "Site Investigation," "Cleanup Options," and "Cleanup Design and Implementation." Each of the resources identified in the Road Map can be viewed or downloaded directly from the CD-ROM or accessed or ordered on line using links provided on the CD-ROM. In addition, of the approximately 160 resources identified in the Road Map, approximately 60 percent can be viewed or downloaded directly from the CD-ROM. Another 40 percent of the resources are Internet sites that can be linked to directly from the CD-ROM. The resources can be searched alphabetically by title and by section.

EPA TIO has provided these resources in an easy-to-use CD-ROM format to facilitate access to the documents, as well as to reduce paper and costs associated with printing and distribution of hard-copy publications.

BEFORE YOU BEGIN



What is the Planned End Use? A Word About Redevelopment

It is important to consider potential redevelopment plans from the outset of any brownfields project. The redevelopment plan (or lack thereof) will govern most brownfields projects, from the identification of site investigation and cleanup standards and the ability to obtain financing to the ultimate affordability or profitability of the project.

Defining and understanding the overall long-term goals of the brownfields project and the decisions to be made throughout the project in support of those goals is a crucial element in identifying appropriate technologies for site investigation and cleanup. Technology tools, when carefully selected, will assist those responsible for the brownfields project in collecting the data necessary to support such decisions and accomplish the established goals. During the many phases of a brownfields project, it is important to keep in mind that technology options are an effective means of achieving the desired result at a site, rather than an end in themselves.

Brownfields projects may be initiated for a number of reasons. A landowner may want to sell a property to a developer who wants to purchase and develop it. A municipality may want to clean up a parcel or area that has become an eyesore, create space for business development, or create a park in a disadvantaged area. A local comprehensive plan may call for infill development of a certain type in a brownfields area. The brownfields process will be tailored to the specific end use, if that use is known. For example, if the redevelopment plan calls for the construction of a light industrial facility, it may be appropriate to apply industrial investigation and cleanup standards that are less stringent than those applicable to property that is to be redeveloped for residential use. The standards required will affect every aspect of the project, from its overall cost (which is generally greater as the standards become more conservative) to the applicability of innovative characterization and cleanup technologies. Keep in mind, however, that new information about contamination or cleanup may require that reuse plans be altered; develop flexible plans so that revised cleanup needs can be incorporated into them.

If the end use is not known at the beginning of the project, the individuals involved should make every attempt at least to identify the general type of desired development, whether industrial, commercial, or residential or a mixed-use development of some sort.

Absent that information, the most conservative assumptions will be made at every stage of the brownfields project, a circumstance that could increase significantly the time and expense of the project and may even make it infeasible.

Understanding Regulations and Regulatory Guidelines and Standard Industry Practices

The redevelopment of brownfields sites may be subject to a variety of federal, state, and local laws, regulations, policies, and guidelines with respect to the characterization and cleanup of the site. Such sites also may be governed by the standard practices of other government, nongovernment, and private institutions.

The applicable laws, regulations, policies, and guidelines will vary by site, depending on the regulatory authority that manages the cleanup. Therefore, it is important to research this information at the outset and to work closely with the regulatory authority throughout the cleanup process. For example, state or local regulatory authorities may manage the cleanup of brownfields sites. These agencies should be consulted to determine what, if any, site-specific requirements or permits are applicable.

Many of the standard practices are designed to help the brownfields redevelopment project obtain financing from public programs and private banks and institutions. Guidance and standards are issued by government and nongovernment organizations, such as the American Society for Testing and Materials (ASTM), the Federal Deposit Insurance Corporation (FDIC), and state and local economic development authorities, and even private lenders.

EPA also can be a valuable resource for brownfields stakeholders by providing regulatory and policy support to facilitate the selection of technologies (see Appendix C, *List of Brownfields and Technical Support Contacts* for information about EPA regional and technical points of contact).

Although compliance with regulations and official policy directives under other federal regulatory and cleanup programs, such as Superfund, may not be required, some of the information gathered and lessons learned under such programs may be useful in the investigation and cleanup of brownfields sites. For example, in the past, a number of sampling events and field mobilizations have been required at many RCRA and Superfund sites to gather sufficient information to characterize the site adequately. Additional sampling has been found necessary for a number of reasons — for example, to ensure that sampling was performed for all potential contaminants, to adequately analyze all pathways of exposure, to obtain representative samples of wastes and environmental media, and to obtain analytical results of the appropriate accuracy to enable regulatory authorities to make decisions about the cleanup with confidence. Multiple sampling events have increased costs and extended the decision-making period for selecting options for site cleanups.

When possible, sampling plans should be flexible and dynamic and should allow for adjustments in the field in light of actual field conditions observed and the analytical results. Such a dynamic approach usually requires a well-rounded technical team that comprises a broad range of technical expertise and the use of field analytical technologies, including an on-site mobile laboratory, to provide quick turnaround analyses.

Seeking and Procuring External Professional Support

Most decision makers at brownfields sites will require technical and legal assistance to fully understand the complexities of investigating and cleaning up a contaminated site. Depending upon the complexity of a particular site, decision makers may request the assistance of environmental consultants, cleanup contractors, technology vendors, or staff of analytical laboratories in performing the many activities required to investigate and clean up sites. The inclusion of these professionals and other experts as members of the brownfields team is recommended.

Some states may require the participation of certified or licensed professionals to help guide the site investigation and cleanup process. To obtain the services of such professionals (individuals or a firm), a request for proposals (RFP) is often used as the procurement mechanism. The RFP addresses approach, qualifications, and cost estimate for the services requested and includes specifications that encourage prospective bidders to think "outside the box" and consider nontraditional approaches. Selection criteria outlined in the RFP should include credentials and demonstrated experience of the individuals or firm in developing valid options for using streamlined strategies and innovative technologies at brownfields sites and successfully implementing the selected option.

To ensure that those individuals or firms responding to an RFP propose approaches that are valid for the site, the RFP also should include, or make readily available, all studies and reports that provide site-specific information that can be used as the basis for making technology decisions. Individuals preparing RFPs may wish to be proactive and provide suggestions for the use of specific strategies and technologies that

appear to be valid for the particular site. When reviewing proposals and interviewing firms, the evaluation team must be prepared to ask pointed, detailed questions about the selection and use of technologies to be assured that the individual or firm chosen to perform the work is qualified to complete the project successfully. Described in this Road Map are many excellent resources that will assist brownfields decision makers in preparing specifications to be included in RFPs, selecting the criteria for evaluating proposals, and developing questions for interviews of those responding to the RFP. For example, see EPA's *Brownfields Technology Primer: Requesting and Evaluating Proposals That Encourage Innovative Technologies for Investigation and Cleanup* on page 29 for more information.

Community Involvement

It is important that brownfields decision makers encourage acceptance of redevelopment plans and cleanup alternatives by involving members of the community early in the decision-making process through community meetings, newsletters, or other outreach activities. For an individual site, the community should be informed about how the use of a proposed technology might affect redevelopment plans or the adjacent neighborhood. For example, the planting of trees for the use of phytoremediation may create aesthetic or visual improvements; on the other hand, the use of phytoremediation may bring about issues related to site security or long-term maintenance that could affect access to the site.

EPA can assist members of the brownfields community by directing its members to appropriate resources and providing opportunities to network and participate in the sharing of information. A number of Internet sites, databases, newsletters, and reports provide opportunities for brownfields stakeholders to network with other stakeholders to identify information about cleanup and technology options. As noted in the preceding section, EPA's Brownfields Technology Support Center is a valuable new resource for brownfields decision makers (see page 11 for more information).

Comparing Innovative Technologies to Other Characterization and Cleanup Options

In addition to innovative site characterization and cleanup technologies, the use of established treatment and containment technologies also should be considered. Examples of containment include containing contaminated soil on site using a cap and limiting migration of contaminants using a vertical engineering barrier such as a slurry wall. In either case, containment does not involve actively treating the waste to recover or degrade contaminants. Examples of established technologies include solidification/stabilization, soil vapor extraction, thermal desorption, incineration, and pump-and-treat. (For a complete list and description of the technologies, see Appendix F, Identification of Remedy and Record of Decision Types for Superfund Remedial Actions, of the *Treatment Technologies for Site Cleanup: Annual Status Report (Tenth Edition)*. The document is available on the Road Map CD-ROM or online at *http://clu-in.org/asr/*.)

When deciding between innovative and established technologies or between treatment and containment technologies, or other options, brownfields stakeholders should consider the specific needs of the individual site and stakeholders. It also is important that brownfields decision makers consider both the current effects of the selected technology approach and its future effects on potential development of the site.

Selecting and Accepting Technologies

The successful cleanup of a brownfields site depends on the selection and acceptance of a specific technology or technology approach. Identified in the box below are the key elements to ensure that a proposed technology will be accepted by all stakeholders, whether site owners, potential buyers, financial service providers, investors, regulators, or affected citizens. Spotlight 3, *Keys to Technology Selection and Acceptance*, on page 38, describes in detail these key elements.

A Quick Look

- Focus on the decisions that support site goals
- Build consensus
- Understand the technology
- Allow flexibility

Information Centers, Training, and Other Resources

Described on the next four pages are some of the resources available to brownfields projects from government and nongovernment institutions, including the various EPA hotlines for statutory and regulatory programs that may affect brownfields projects. The resources provide more general information than the technology resources identified in the chapters that follow. Training courses and programs provided by EPA, as well as other organizations, also are identified. Information about state and local resources can be obtained from the contact for each state listed in Appendix C, *List of Brownfields and Technical Support Contacts*.

INFORMATION CENTERS, TRAINING, AND OTHER RESOURCES

Analysis of State Superfund Programs: 50-State Study, 1998 Update

The document, prepared by the Environmental Law Institute (ELI) in association with EPA, provides an analytical overview of state Superfund programs, and includes information about statutes, program staffing and organization, sites, cleanup activities, cleanup policies and standards, requirements for public participation, funding and expenditures, and enforcement tools. The report also discusses the voluntary remediation and brownfields programs established by the states and presents detailed program information arranged in tables that facilitate comparisons among the states. A copy of the report can be downloaded from ELI's web site at *www.eli.org*; select "Publications", then 1998 Reports. An update of the report is forthcoming in Fall 2001.

Breaking Barriers to the Use of Innovative Technologies: State Regulatory Role in Unexploded Ordnance Detection and Characterization Technology Selection

The report, published in 2000 by the Interstate Technology Regulatory Cooperation (ITRC), contains an analysis of case studies from states having experience in remediating unexploded ordnance (UXO)-contaminated sites. The report supports early and meaningful state regulatory involvement in the selection of innovative UXO characterization and remediation technologies. The report also offers recommendations to ensure the appropriate participation of states in the selection of technologies for characterizing and remediating UXO-contaminated sites. The document can be viewed or downloaded from the Road Map CD-ROM.

Brownfields Technology Support Center

EPA established the Brownfields Technology Support Center (BTSC) to ensure that brownfields decision makers are aware of the full range of technologies available for conducting site assessments and cleanup, and can make informed decisions for their sites. The center helps government decision makers evaluate strategies to streamline the site assessment and cleanup process, identify and review information about complex technology options, evaluate contractor capabilities and recommendations, explain complex technologies to communities, and plan technology demonstrations. The center is coordinated through EPA's TIO and works through EPA's ORD laboratories. Localities can submit requests for assistance:

- Directly through their EPA Regional Brownfields Coordinator
- Online at *http://brownfieldstsc.org*
- By calling 1 (877) 838-7220 (toll free)

For more information about the program, contact Dan Powell of EPA's TIO at (703) 603-7196 or *powell.dan@epa.gov*.

Brownfields: A Comprehensive Guide to Redeveloping Contaminated Property

This book, published by the American Bar Association (ABA), is aimed at an audience of real estate and environmental attorneys, property owners and developers, environmental regulators and consultants, and state and local government leaders. The book provides an overview with background information about the issues and explanations of the federal and state laws governing brownfields. Legal, business, financial, and political issues associated with redeveloping contaminated property also are addressed. The book presents the scientific concepts used to clean up contaminated property, describing risk assessment and remediation strategies. Comprehensive information about state voluntary cleanup programs, with more than 400 pages of information on existing programs, also is provided. The book, published in 1997, can be purchased through ABA's web site at *www.abanet.org* or at bookstores across the country. The ISBN number for the book is 1-57073-439-9.

CLU-IN Studio

CLU-IN Studio, coordinated by EPA's TIO, the ITRC, and other partners, provides free and unlimited access to technical internet seminars, live conference webcasts, and videotapes. Frequently updated, the three types of media provide information about and resources relevant to innovative site characterization and cleanup technologies. The two-hour internet seminars are live web-based slide presentations, each of which has a companion audio portion available by telephone line or RealAudio simulcast. The conference webcasts are live events that combine web-based presentation materials with a companion live audio stream. The videotapes, of which the viewing time ranges from 6 to 28 minutes, also may be viewed or ordered on line. Descriptions and registration information about upcoming events, as well as links to archived seminars and webcasts, are provided at the site at *http://clu-in.org/studio/*.

INFORMATION CENTERS, TRAINING, AND OTHER RESOURCES

EPA Brownfields Economic Redevelopment Initiative Internet Site

This Internet site, coordinated by EPA's Office of Solid Waste and Emergency Response (OSWER) Outreach and Special Projects Staff (OSPS), provides extensive information about EPA's Brownfields Economic Redevelopment Initiative and resources related to the initiative. Descriptions of EPA's brownfields pilots and points of contact in each of the EPA regional offices are provided, as well as publications, regulations, and other documents. Brownfields stakeholders involved in the selection and use of technologies for environmental cleanup may have particular interest in learning more about EPA's Brownfields Cleanup Revolving Loan Fund (BCRLF) Pilots, a program that includes, among other elements, funding of assessment demonstration pilot programs for the assessment of brownfields properties and testing of cleanup and redevelopment models. Specific details about the program, including criteria for eligibility and a list of BCRLF pilots that have been awarded, are available on the web site. The USTFields Initiative, a new program sponsored by EPA's Office of Underground Storage Tanks (OUST) to address cleanup of abandoned underground storage tanks (USTs) is described, as well as the 10 communities recently awarded USTFields funding for the assessment and cleanup of sites. For additional information, visit the web site at *www.epa.gov/brownfields*.

Guidance for Preparing Standard Operating Procedures (SOPs) (EPA 240-B-01-004)

The document provides guidance on the preparation and use of an SOP within a quality system. An SOP is a set of written instructions that document a routine or repetitive activity an organization carries out. The development and use of SOPs are an integral part of a successful quality system because SOPs provide to individuals the information needed to perform a job properly and facilitate consistency in the quality and integrity of a product or end result. SOPs describe both technical and administrative operational elements of an organization that would be managed under a work plan, a quality assurance project plan, or an organization's quality management plan. A copy of the document can be viewed or downloaded from the Road Map CD-ROM.

Handbook of Tools for Managing Federal Superfund Liability Risks at Brownfields and Other Sites (EPA 330-B-98-001)

Developed by EPA's Office of Enforcement and Compliance Assistance (OECA), the handbook is a compilation of tools that can be used to evaluate the benefits of remediating and redeveloping a brownfields property against any environmental risks associated with that property and to address barriers arising from potential liability under Superfund. The document presents background information about CERCLA and summarizes various statutory provisions and agency regulations, policies, and guidance documents that can be used as tools to manage CERCLA liability risks associated with brownfields and other sites. Designed for use by parties involved in the assessment, cleanup, and reuse of brownfields, the handbook provides a basic description of the purpose, applicability, and provisions of each tool. The pdf version of the document can be viewed or downloaded from the Road Map CD-ROM.

Hazardous Substance Research Centers

The Hazardous Substance Research Centers (HSRC) is a national organization, funded in part by EPA, the U.S. Department of Energy (DOE), and the U.S. Department of Defense (DoD), that carries out a program of basic and applied research, technology transfer, and training. HSRC provides free technical assistance to communities with environmental contamination issues through two outreach efforts, the Technical Outreach for Communities (TOSC) Program and the Technical Assistance to Brownfields (TAB) Communities Program. TOSC uses the researchers and professionals at more than 30 universities to help community groups understand the technical issues at hazardous waste sites. Through the TOSC program, toll-free information hotlines are available and workshops and other educational programs are offered. TAB helps communities to clean up and redevelop properties that have been damaged or undervalued by environmental contamination. Through five regional training centers, HSRC's TAB provides training for communities on the following subjects: leadership, risk assessment, brownfields processes, site assessment, and cleanup alternatives. More information is available on HSRC and their brownfields initiatives on their web site at *www.hsrc.org*. Detailed information about the TOSC and TAB programs is available at *www.hsrc.org/hsrc/html/tosc*.

INFORMATION CENTERS, TRAINING, AND OTHER RESOURCES

Hazardous, Toxic and Radioactive Waste Center of Expertise

Coordinated through the U.S. Army Corps of Engineers, the Hazardous, Toxic and Radioactive Waste Center of Expertise (HTRW-CX) provides technical assistance and information about the use of innovative technologies for cleanup of contaminated properties. Detailed information about a variety of available innovative technology resources, points of contact at the HTRW-CX, and upcoming training courses and workshops is provided on the Center's web site. More than 50 case studies of successful applications of innovative technologies also are described. Visit the HTRW-CX web site at *www.environmental.usace.army.mil/info/technical/it/it.html/* for more information.

Interstate Technology and Regulatory Cooperation

The ITRC, created through the Western Governors Association, promotes the use of innovative hazardous waste and remediation technologies. Made up of more than 30 states, several federal partners, stakeholders, and state associations, the ITRC: (1) provides a forum through which states can exchange technical information; (2) creates a network of state contacts for the promotion of innovative technologies; (3) identifies interstate barriers to the deployment of technologies; (4) benchmarks state perspectives about innovative technologies; and (5) develops consensus among state regulators, in collaboration with industry and public stakeholders, on technical regulatory aspects of the use of innovative technologies. Brownfields decision makers who wish to obtain applicable guidance documents for the use of innovative technologies will find several guidance documents developed by the ITRC on ITRC's web site. For additional resources and points of contact, visit the ITRC's web site at *www.ITRCweb.org/*.

RCRA Online

RCRA Online is an online database that provides users access to thousands of letters, memoranda, and questions and answers issued by EPA's Office of Solid Waste (OSW). The documents indexed in the database represent past EPA Headquarters interpretations of the RCRA regulations governing the management of solid, hazardous, and medical waste. Users can retrieve documents through topical, full text, and advanced search functions, as well as view the actual text of documents identified in a search. Detailed instructions on how to use the database are provided, as well as tips for conducting searches. RCRA Online is available online at *www.epa.gov/rcraonline/*. A pdf version of the RCRA Online brochure is provided on the Road Map CD-ROM.

RCRA, Superfund, and Emergency Planning and Community Right-to-Know Act (EPCRA) Hotline

The hotline handles information about EPA's RCRA regulations and programs implemented under RCRA, including the UST program, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), EPCRA, the Superfund Amendments and Reauthorization Act (SARA) Title III, and the Oil Pollution Act (OPA). The hotline also provides referrals for obtaining related documents concerning the RCRA, UST, Superfund/CERCLA, and Pollution Prevention/Waste Minimization programs. The hotline operates daily Monday through Friday, 9:00 a.m. to 6:00 p.m. Eastern Standard Time (EST). The hotline can be reached by telephone at 800-424-9346 for all nongovernment locations outside the Washington, DC metropolitan local calling area, or 703-412-9810 for all locations in the Washington, DC metropolitan local calling area.

Superfund Docket and Information Center

The Superfund Docket and Information Center provides access to Superfund regulatory documents, Superfund Federal Register Notices, Records of Decision (ROD), and public comments sent to EPA. The center operates daily, Monday through Friday, 9:00 a.m. to 4:00 p.m. EST. The center can be reached by telephone at 703-603-9232 or by facsimile at 703-603-9240.

Tax Credits and Deductions for Expensing Environmental Remediation Costs (Section 198)

Section 198 of the Internal Revenue Code (26 U.S.C. §198 (A)(1)(B)(VI)) describes the expensing of costs related to the environmental remediation of qualified contaminated sites. As the code specifies, taxpayers are permitted to treat any qualified environmental remediation expense as an expense that is not chargeable to capital account; such an expenditure can be treated as a deduction for the taxable year in which it is paid or incurred. In general, a qualified remediation expenditure is an expenditure paid or incurred in connection with the abatement or control of hazardous substances at a qualified contaminated site. The specific terms and qualifications are described in Section 198 of the Internal Revenue Code, which can be viewed or downloaded from the Road Map CD-ROM.

INFORMATION CENTERS, TRAINING, AND OTHER RESOURCES

TechDirect

TechDirect, hosted by EPA's TIO, is a free electronic mail service that highlights new publications and events of interest to site assessment and remediation professionals. The message directs subscribers to sources from which they can obtain more information. Interested persons may subscribe on line at *http://clu-in.org/techdrct*.

Toxic Substances Control Act (TSCA) Assistance Information Service

The information service provides information about regulations under TSCA to the chemical industry, labor and trade organizations, environmental groups, and the general public. Technical as well as general information is available. The information service operates daily, Monday through Friday, 8:30 a.m. to 5:00 p.m. EST. The information service can be reached by telephone at 202-554-1404, by facsimile at 202-554-5603, or by e-mail at *tsca-hotline@epa.gov*.

Training Information

Training courses and programs that can be useful to brownfields stakeholders, particularly those involved in technology selection, are identified below:

- EPA's Training-Exchange (TRAINEX), an Internet site that provides a range of training information for representatives of federal, state, local, and tribal agencies, is intended primarily for individuals involved in hazardous waste management and remediation. The site provides information about more than 65 classes, as well as schedules for their delivery. Visit the TRAINEX web site at *www.trainex.org* for additional information.
- EPA's Field-Based Technologies Training Program is particularly appropriate for individuals involved in selecting technologies for site investigation and cleanup. The Field-Based Technologies Training Program consists of two advanced-level training courses - the Field-Based Site Characterization Technologies Course, which introduces a wide array of characterization technologies and the Strategies for Field-Based Analytical and Sampling Technologies Course, which provides an overview of the planning and process issues associated with the use of field-based strategies. The course is designed for environmental professionals and regulators who are involved in the use or implementation of site characterization or data interpretation related to those technologies. For information about the course and schedule for its delivery, visit the TRAINEX web site at *www.trainex.org*; select "CERCLA Education Center (CEC)."
- Information about upcoming courses, provided by a variety of federal and non-federal organizations, is provided on TIO's CLU-IN web site at *http://clu-in.org*; select "Courses and Conferences" under "What's Hot? What's New?
- American Society for Testing and Materials (ASTM) also offers many technical and professional training opportunities which may be of interest to brownfields decision makers. For more information, visit their web site at *www.astm.org/TRAIN*.

GO

DRIVERS

- Community and public interest groups
- Regulatory community (federal, state, local, and tribal)
- Site developers/property owners
- Financial community
- Site cleanup professionals

Site Condition Is Unknown

Site Condition Is Known

Site Assessment
See page 17

?

Is there evidence of possible contamination?

YES

NO

Site Investigation
See page 27

Was contamination found?

NO

YES

Is redevelopment still a practical option?

NO

End Brownfields Project

Does contamination pose a significant threat to local residents?

YES

Contact appropriate government regulatory agencies

NO

Can redevelopment still occur given the cleanup options?

NO

YES

- Bioremediation?
- SVE?
- Thermal Treatment?

Cleanup Options
See page 41

YES

Can risks be managed adequately or addressed to the satisfaction of relevant stakeholders and in light of identified/proposed reuse?

NO

Can redevelopment occur without the need for cleanup?

NO

YES

Was contamination removed, contained, or controlled?

NO

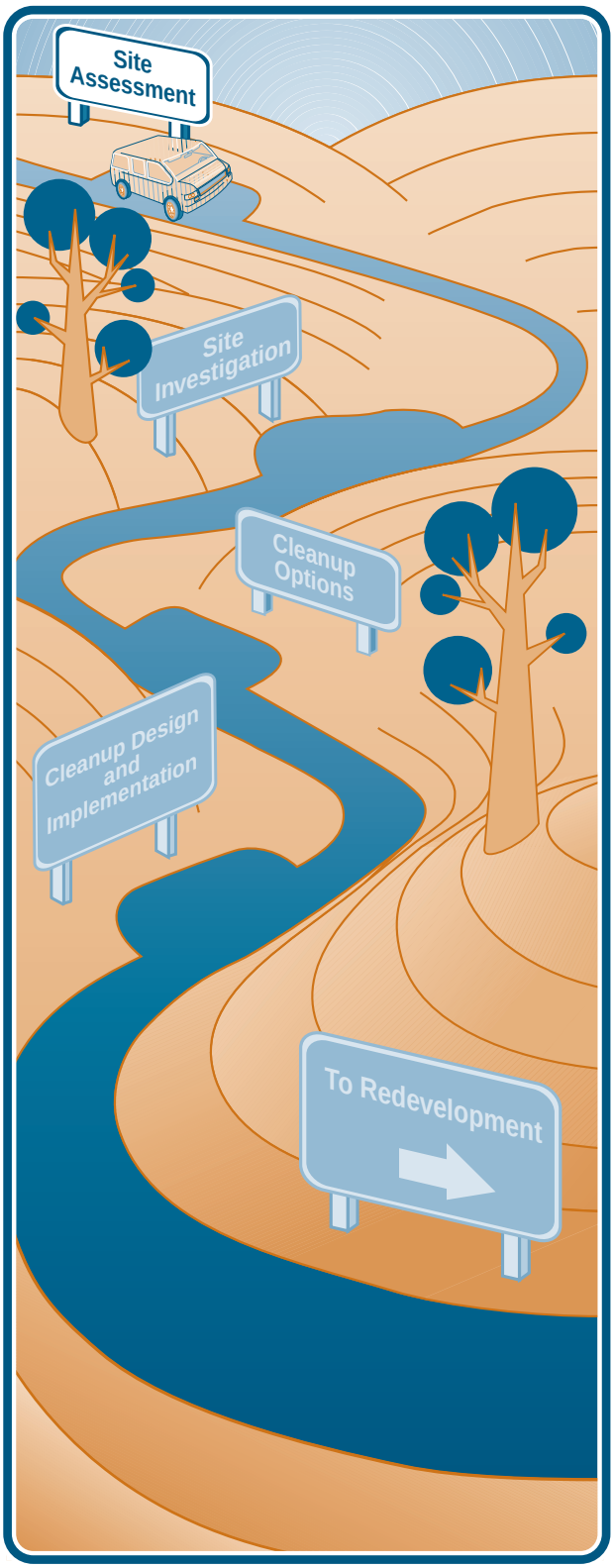
YES

Cleanup Design and Implementation
See page 63

TO REDEVELOPMENT

Blank

SITE ASSESSMENT



Collect and Assess Information About the Brownfields Site

The purpose of this step is to evaluate the potential for contamination at a particular site by collecting and reviewing existing information. The site assessment, typically referred to as an ASTM Phase I environmental site assessment, is an initial investigation usually limited to a search of historical records. The data collected also includes information about past and current environmental conditions and historical uses of the site. The site assessment is the most crucial step in the brownfields process, because any further environmental investigation and cleanup will hinge on whether potential environmental concerns are identified during that phase.

During the site assessment phase, it is important to consider the activities and requirements described in the subsequent chapters and determine how they will be affected by the initial site assessment. Because the information obtained in this phase will determine whether any future work must be done at the site, the site assessment must be thorough and tailored to meet specific data objectives. As discussed in the section Before You Begin, decisions made about the end use of a site and the long-term goals of the brownfields project will determine the types and quantity of data that must be collected, as well as the level of quality the data must attain. The data quality objectives (DQO), in turn, will serve as the basis upon which the best decisions will be made about the most appropriate technologies and techniques to be used in collecting and analyzing the data at a particular site (see Appendix B, *List of Acronyms and Glossary of Key Terms,* for a definition of DQO).

The data collected during this initial step of the cleanup process is extremely important for use in identifying and evaluating the applicability of site assessment and cleanup technologies, as well as in determining whether the property can be cleaned up to the level necessary for its intended reuse. If it is carefully planned, some of the follow-on work, such as limited sampling, may also be accomplished during this phase. The site assessment also can provide a preliminary indication of what types of cleanup technologies might be available. It also is essential to assess and address the needs and concerns of the community (for example, the development of social and economic profiles and the identification of acceptable environmental risk).

Technologies that detect possible contamination in the air may be applicable at this stage as well as some

analytical sampling technologies useful for assessing contamination in soil or groundwater. Examples of sampling and analysis technologies that may be applicable during this phase are presented in Appendix A, *Table A-2, Technologies for Sampling and Analyzing Contaminants Found at Typical Brownfields Sites*. However, the use of technologies may be somewhat limited, since much of the work at this stage involves a search of paper and electronic records.

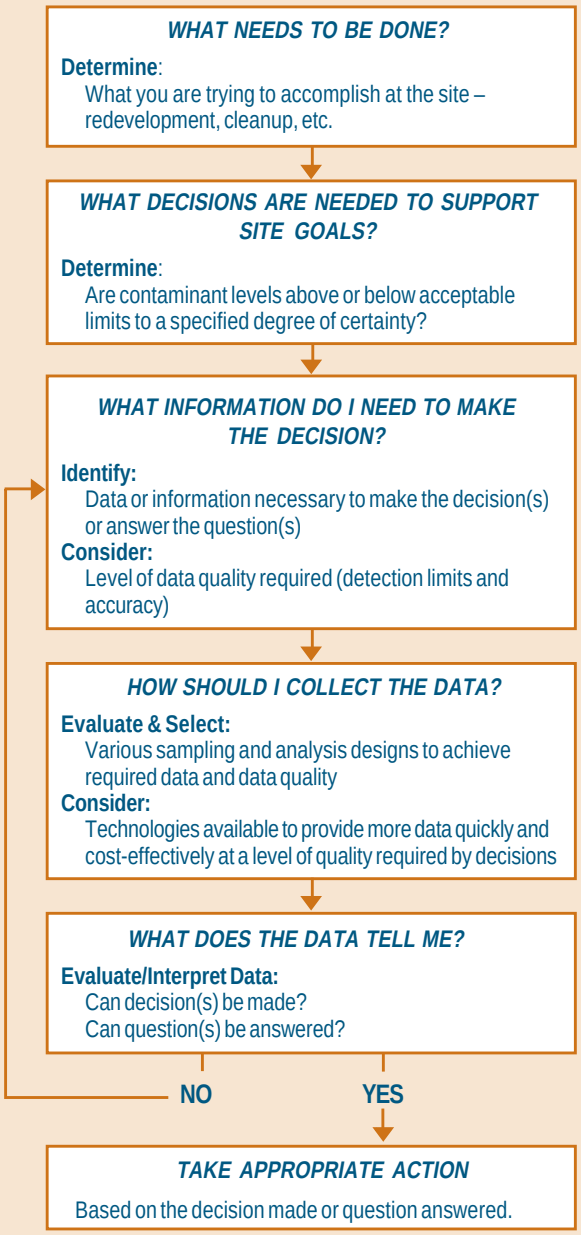
What Do We Need To Know?

Factors that should be considered during this phase include:

1. Has a redevelopment plan been prepared or a proposed end use identified? Is the site located in an area targeted for redevelopment? Is the site located in an industrial area? Will it remain industrial or be rezoned for commercial use? Or is a residential development planned? Will community members who use the property be exposed directly to the soil or sediment?
2. What data are needed to support the long-term goals of the project, address concerns related to it, and ensure its acceptability? What decisions need to be made, and what data should be collected to support those decisions? What level of quality or uncertainty is necessary to meet those goals?
3. What is known about the site? What records exist that indicate potential contamination and past use of the property? Have other environmental actions occurred (such as notices of violation)? Has an environmental audit been conducted? What information is needed to identify the types and extent or the absence of contamination?
4. If the site is located in an area targeted for redevelopment, is the site being considered for cleanup under a federal or state Superfund cleanup initiative?
5. Will the site be entered into a Voluntary Cleanup Program (VCP)? If not, what agency (federal, state, local, or tribal) would be responsible for managing oversight of cleanup? Are there other federal, state, local, or tribal regulatory requirements for site assessment? (See the definition of a VCP in Appendix B, *List of Acronyms and Glossary of Key Terms*)
6. What are the special needs and concerns of the community? How can community involvement be encouraged? How will community views be solicited?
7. What environmental conditions will the community find acceptable? What environmental standards should be considered to ensure that community stakeholders are satisfied with the outcome of the cleanup, in light of the identified and proposed reuse?
8. If the site shows evidence of contamination, who and what will be affected? Who will pay for the cleanup?

The following figure depicts the linkages among the decisions to be made, the data to be collected, and the selection of technologies to expedite the collection of data.

Linking the Decision, Data, and Technologies



How Do We Find The Answers?*

Activities to be conducted during the initial survey of a site include:

- Establish the technical team and take advantage of the team's expertise to determine the adequacy of existing site information and identify potential data gaps
- Ensure that the brownfields decision makers (such as regulators; citizens; property owners; and technical staff, such as chemists and toxicologists) are involved in the decision-making process
- Identify future plans for reuse and redevelopment and goals of the site
- Identify data that must be collected to support the goals of the site
- Determine whether contamination is likely through the conduct of an ASTM Phase I environmental site assessment or its equivalent. A records search is performed and the site is visited, but no sampling of soil or groundwater occurs. The effort includes the following activities:
  - *Identify past owners and the uses they made of the property by conducting a title search and reviewing tax documents, sewer maps, aerial photographs, and fire, policy, and health department documentation related to the property*
  - *Review and analyze city government and other historical records to identify past use or disposal of hazardous or other waste materials at the site*
  - *Review federal and state lists that identify sites that may have environmental contamination; such lists include, but are not limited to: 1) EPA's Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) of potentially contaminated sites, 2) the National Pollutant Discharge Elimination System (NPDES) of permits issued for discharges into surface water, and 3) state records of "emergency removal" actions (for example, the removal of leaking drums or the excavation of explosive waste)*
  - *Interview property owners, occupants, and others associated with the site, such as previous employees, residents, and local planners*
  - *Perform a physical or visual examination of the site, including examination of existing structures for structural integrity and asbestos-containing material*
  - *Test for the presence of various contaminants; for example, lead-based paint, asbestos, and radon in structures*
- Review the applicability of government oversight programs:
  - *Determine whether there is a state VCP and consult with the appropriate federal, state, local, and tribal regulatory agencies to include them in the decision-making process as early as possible*
  - *Determine the approach (such as redevelopment programs, the Superfund program, property transfer laws, or a state brownfields program) that is required or available to facilitate the cleanup of sites (see the section, Before You Begin, for an overview of applicable regulations and regulatory guidelines)*
  - *Identify whether economic incentives, such as benefits from state brownfields programs, or federal brownfields tax credits, can be obtained*
  - *Contact the EPA regional brownfields coordinator to identify and determine the availability of EPA support programs and federal financial incentives (see Appendix C, List of Brownfields and Technical Support Contacts)*
- Determine how to incorporate and encourage community participation:
  - *Identify regulatory requirements for public involvement (see page 13 in the section, Before You Begin, for a description of community services provided by HSRC)*
  - *Assess community interest in the project*
  - *Identify community-based organizations*
  - *Review any community plans for redevelopment*
- Identify factors that may impede redevelopment and reuse
- Begin identifying potential sources for funding site investigation and cleanup activities at the site, if necessary
- Examine unacceptable environmental conditions in terms of initial costs for site improvement and long-term costs for operation and maintenance —

** Please note that the Road Map seeks to answer technology selection questions and is not intended to provide a response to each procedural question identified.*

include potential cleanup options and constraints that may affect redevelopment, such as project schedules, cost, and potential for achieving the desired reuse

- Conduct work at the site and collect data as necessary to define site conditions or to resolve uncertainties related to the site

Where Do We Find Help To Our Technology Questions?

Examples of technology resources that are available to assist in assessing a site are listed below. Although many of the resources are more applicable in later stages, it may be useful to begin thinking now about options and tools for investigation and cleanup. Information about the availability of electronic resources — whether the item is found on the Road Map's accompanying CD-ROM, or on various web sites — also is provided. *Appendix D, How to Order Documents*, provides complete ordering information for documents that are not available on the CD-ROM or on the Internet.

A. Resources for Site Assessment

The documents listed below are resources that provide general information about the availability of technology resources in the form of bibliographies, status reports, and user guidelines.

Assessing Contractor Capabilities for Streamlined Site Investigations (EPA 542-R-00-001)
View or download pdf file on the Road Map CD-ROM
Developed by EPA's BTSC, the resource will assist decision makers on brownfields projects in evaluating the capabilities of contractors who are being considered to perform work in support of site investigations. The resource also identifies potential activities that contractors can perform to enhance the site investigation process through innovative approaches. A comprehensive series of questions that decision makers can use in interviewing contractors and evaluating those contractors' qualifications is presented, followed by information about the relevance of the questions and potential answers to them.

ASTM Standard Guide for Process of Sustainable Brownfields Development (E1984-98)
Order on line at www.astm.org
The guide, developed by ASTM, discusses the redevelopment of a brownfields property for all stakeholders. It identifies impediments to such redevelopment and suggests solutions that can facilitate completion of a successful project. It describes the flexible process of sustainable brownfields redevelopment that actively engages property owners, developers, government agencies, and the community in conducting corrective action, economic evaluation, and other efforts that promote the long-term productive reuse of a brownfields property. The guide, available at $35 per copy, can be downloaded from the ASTM web site, or ordered by telephone at 610-832-9585 or by facsimile at 610-832-9555.

ASTM Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process (E1527-00)
Order on line at www.astm.org
The purpose of the practice, developed by ASTM, is to define commercial and customary practices in the U.S. for conducting Phase I environmental site assessments of commercial real estate with respect to the range of contaminants within the scope of CERCLA, as well as petroleum products. Research and reporting requirements also are identified. The practice, available at $40 per copy, can be downloaded from the ASTM web site or ordered by telephone at 610-832-9585 or by facsimile at 610-832-9555.

Clean-Up Information Home Page on the World Wide Web
View on line at http://clu-in.org
The Internet site provides information about innovative treatment technologies and site characterization technologies to the hazardous waste remediation community. CLU-IN describes programs, organizations, publications, and other tools for EPA and other federal and state personnel, consulting engineers, technology developers and vendors, remediation contractors, researchers, community groups, and individual citizens. Information about issues related to site characterization also is provided: technology verification and evaluation; technology selection tools; guidance and application support; case studies; regulatory development; and publications.

Data Quality Objective Process for Hazardous Waste Site Investigations (EPA 600-R-00-007)
View or download pdf file on the Road Map CD-ROM
The document focuses on the DQO process as the appropriate systematic planning process to support decision making. The DQO process is an important tool for project managers and planners to use in defining the types, quality, and quantity of data needed to make defensible decisions. The document

is based on the principles and steps developed in Guidance for the Data Quality Objectives Process, but is specific to investigations of hazardous waste sites. The guidance is also consistent with Data Quality Objectives Process for Superfund: Interim Final Guidance (EPA 1993) and Soil Screening Guidance: User's Guide (EPA 1996). Although the document focuses on EPA applications, the guidance also is applicable to programs at the state and local levels.

Data Quality Objectives Web Site
Visit on line at www.hanford.gov/dqo/
The DQO web site, sponsored by DOE, is a helpful resource for those responsible for preparing a data collection design. The web site defines the DQO process and explains its role in ensuring that a data collection activity produces results of sufficient quality to support decisions based on those results. The web site provides step-by-step procedures for the DQO process. It also provides a decision process flow chart, describes purposes and goals related to the use of the DQO process, and reviews relevant DOE and contractor directives. It also describes a number of available training courses; lists contacts; and provides glossaries of relevant terms, as well as links to related sites.

Engineering and Design: Requirements for the Preparation of Sampling and Analysis Plans (EM 200-1-3)
View or download pdf file on the Road Map CD-ROM
Developed by the U.S. Army Corp of Engineers, the manual provides guidance for the preparation of project-specific sampling and analysis plans (SAP) for the collection of environmental data. In addition, the manual presents default sampling and analytical protocols that may be used verbatim or modified based in light of the DQOs for a specific project. The goal of the manual is to promote consistency in the generation and execution of sampling and analysis plans and therefore to help investigators generate chemical data of known quality for the purpose to which those data are to be used.

EPA REmediation And CHaracterization Innovative Technologies (REACH IT) Online Searchable Database
View on line at www.epareachit.org
The EPA REmediation And CHaracterization Innovative Technologies (EPA REACH IT) online searchable database provides users comprehensive, up-to-date information about more than 150 characterization technologies and 1,300 remediation technologies. During the preliminary phase of a brownfields project, EPA REACH IT will assist brownfields stakeholders to learn about and become familiar with the range of available technology options that can be employed during the investigation and the cleanup phases that follow, as well as data about various types of sites. Information about analytical screening technologies that may be useful for initial sampling of a site also is provided. EPA REACH IT is accessible only through the Internet.

Expedited Site Characterization (ESC) Method (Ames Laboratory Environmental Technologies Development Program)
View on line at www.etd.ameslab.gov/etd/technologies/projects/esc
Demonstrations of the ESC method conducted by Ames include characterization work performed by commercial contractors at existing contaminated sites. The ESC demonstrations include a public information program of presentations, site tours, exhibits, information packets, and opportunities for discussion.

Improving Sampling, Analysis, and Data Management for Site Investigation and Cleanup (EPA 542-F-01-030A)
View or download pdf file at http://clu-in.org
The document describes the three-pronged "triad approach" that forms the basis of EPA's national strategy for site characterization and site assessment. That streamlined approach to site assessment focuses on the conduct of systematic planning to ensure the effective use of resources; the preparation of a dynamic work plan to support decision making in the field; and the use of on-site analytical tools, rapid sampling platforms, and on-site data interpretation. Following the discussion of the "triad" approach to site investigation, the document briefly reviews a number of recent developments that promise marked benefit to cleanup efforts and sets forth the agency's vision of defensible decisions at an affordable cost that is the goal of the national strategy. The document can be downloaded from CLU-IN under "Publications." See Spotlight 4, *The Triad Approach*, for a more detailed description of the triad approach.

OnSite OnLine Tools for Site Assessment
View on line at www.epa.gov/athens/onsite/
Developed by EPA's ORD and EPA Region 9, the web site offers a set of online tools for site assessment, including calculators for formulas, models, unit conversion factors, and scientific demonstrations for use in assessing the effects of contaminants in groundwater.

Quality Assurance Guidance for Conducting Brownfields Site Assessments (EPA 540-R-98-038)

View or download pdf file on the Road Map CD-ROM

The document informs brownfields site managers about concepts and issues related to quality assurance and provides step-by-step instructions for identifying the type and quality of environmental data needed to present a clear picture of the environmental conditions at a given site.

Sensor Technology Information Exchange (SenTIX)

View on line at www.sentix.org

SenTIX serves as a forum to exchange information about sensor technologies and needs. The purpose of the web site is to serve as a tool to assist those working in the environmental field in cleaning up hazardous waste. The submit and search functions of SenTIX can help match users looking for a sensor technology to meet a specific need. The discussion forum also matches developers, vendors, and users. The site was developed by WPI, a nonprofit organization, under a cooperative agreement with EPA.

B. Site-Specific Resources for Site Assessment

Listed below are survey reports and online tools on the application of innovative technologies to specific contaminants and site types.

EPA Office of Enforcement and Compliance Assurance Industry Sector Notebooks

View or download pdf files on the Road Map CD-ROM

Developed by EPA's Office of Enforcement and Compliance Assurance (OECA), the EPA Sector Notebooks provide extensive profiles of selected major industries; each profile includes information about the processes conducted in the industry, chemical releases and transfers of chemicals, opportunities for pollution prevention, pertinent federal statutes and regulations, and compliance initiatives associated with the sector. Profiles are available on line and in hard copy for the following industry sectors:

- *Aerospace (EPA 310-R-98-001)*
- *Air transportation (EPA 310-R-97-001)*
- *Dry cleaning (EPA 310-R-95-001)*
- *Electronics and computer (EPA 310-R-95-002)*
- *Fossil fuel electronic power generation (EPA 310-R-97-007)*
- *Ground transportation (EPA 310-R-97-002)*
- *Inorganic chemical (EPA 310-R-95-004)*
- *Iron and steel (EPA 310-R-95-005)*
- *Lumber and wood products (EPA 310-R-95-006)*
- *Metal casting (EPA 310-R-97-004)*
- *Metal fabrication (EPA 310-R-95-007)*
- *Metal mining (EPA 310-R-95-008)*
- *Motor vehicle assembly (EPA 310-R-95-009)*
- *Nonferrous metals (EPA 310-R-95-010)*
- *Non-fuel, non-metal mining (EPA 310-R-95-011)*
- *Oil and gas extractions (EPA 310-R-99-006)*
- *Organic chemical (EPA 310-R-95-012)*
- *Petroleum refining (EPA 310-R-95-013)*
- *Pharmaceutical (EPA 310-R-97-005)*
- *Plastic resins and man-made fibers (EPA 310-R-97-006)*
- *Printing (EPA 310-R-95-014)*
- *Pulp and paper (EPA 310-R-95-015)*
- *Rubber and plastic (EPA 310-R-95-016)*
- *Shipbuilding and repair (EPA 310-R-97-008)*
- *Stone, clay, glass, and concrete (EPA 310-R-95-017)*
- *Textiles (EPA 310-R-97-009)*
- *Transportation equipment cleaning (EPA 310-R-95-018)*
- *Water transportation (EPA 310-R-97-003)*
- *Wood furniture and fixtures (EPA 310-R-95-003)*

EPA Region 3 Industry Profile Fact Sheets

View on line at www.epa.gov/reg3hwmd/brownfld/industry.htm

Developed by EPA Region 3, the fact sheets are designed to assist in the initial planning and evaluation of sites that are under consideration for remediation, redevelopment, or reuse. The fact sheets provide general descriptions of site conditions and contaminants commonly found at selected industrial sites. Each fact sheet provides information about the processes conducted in the industry; raw materials characteristic of the industry; environmental media that could be affected; sampling strategies; and suggested parameters for analysis. Fact sheets on the following subjects are available on line:

- *Abandoned chemical facilities*
- *Abandoned laboratories*
- *Abandoned oil facilities*
- *Asbestos pile*
- *Auto body facilities*
- *Battery reclamation facilities*
- *Bethlehem-asbestos/tailing mine*

– *Drum recycling facility*
– *Dye facilities*
– *Electroplating*
– *Glass manufacturing facilities*
– *Gas stations*
– *Infectious wastes*
– *Manufactured gas plants/coal tar sites*
– *Municipal landfill*
– *Ordnance*
– *Paint industry*
– *Pesticide facilities*
– *Petroleum recycling facility*
– *Plastics*
– *Print shops*
– *Quarry sites*
– *Radiation*
– *Rail yard facilities*
– *Salvage yards*
– *Scrap metal*
– *Steel manufacturing - electric arc/coke*
– *Tanning facility*
– *Tire fires*
– *Wood treating facility*

Frequently Asked Questions about Drycleaning (EPA 744-K-98-002)
View or download pdf file on the Road Map CD-ROM
The EPA fact sheet addresses a number of issues related to drycleaning, including EPA's interest in drycleaning, the process of drycleaning, the human health and environmental risks associated with chemical solvents used in the drycleaning process, what drycleaners and the government are doing to reduce those risks, and other methods of cleaning clothes. The document lists additional sources of information about drycleaning and EPA's Design for the Environment Program.

Ordnance and Explosives Mandatory Center of Expertise (MCX) and Design Center
View on line at www.hnd.usace.army.mil/OEW/
The mission of the Ordnance and Explosives MCX and Design Center, which is hosted by the U.S. Army Engineering and Support Center in Huntsville, Alabama, is to safely eliminate or reduce risks posed by ordnance, explosives, and recovered chemical warfare materials at current or formerly used defense sites. The Internet site provides links to information about technical requirements for contracting; fact sheets on ordnance and explosives programs; frequently asked questions related to ordnance response actions; innovative technologies, presentations, and technical papers; and technical guidance and procedures related to ordnance and explosives. Points of contact also are identified.

C. Technology-Specific Resources for Site Assessment

The documents listed below provide detailed information about specific innovative technologies and the application of those processes to specific contaminants and media in the form of engineering analyses, application reports, technology verification and evaluation reports, and technology reviews.

Study of Assessment and Remediation Technologies for Drycleaner Sites
View on line at www.drycleancoalition.org/tech
Prepared by the State Coalition for Remediation of Drycleaners (SCRD) with the support of EPA's TIO, the report presents the results of the coalition's evaluation of assessment and remediation technologies commonly used in cleaning up drycleaner sites. The evaluation was based on the results of responses to questionnaires sent to entities involved in such cleanups in 1999. The report presents those results in detail. An appendix in the report provides descriptions and brief evaluations of assessment technologies frequently used at drycleaner sites.

Underground Storage Tanks and Brownfields Sites (EPA 510-F-00-004)
View or download pdf file on the Road Map CD-ROM
The fact sheet focuses on EPA's "USTFields" Initiative for addressing brownfields properties at which redevelopment is complicated by real or perceived environmental contamination originating from federally regulated USTs. The fact sheet describes the 50 pilot projects implemented or to be implemented under the two phases of the initiative.

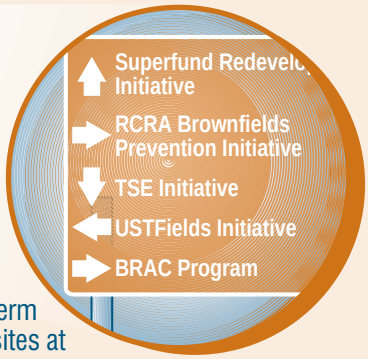
Where Do We Go From Here?

After completing an initial assessment and survey of the environmental conditions at the site, one of the following courses of action may be taken:

Result of Site Assessment	Course of Action
No apparent contamination is found and there is no reason to suspect other media are contaminated. Concerns of stakeholders have been addressed adequately.	*Discuss results with appropriate regulatory officials before proceeding with redevelopment activities.*
Contamination is found that poses a significant risk to human health or the environment.	*Contact the appropriate federal, state, local, or tribal government agencies responsible for hazardous waste. Based on feedback of government agency, determine what cleanup levels are required for redevelopment, and proceed to the SITE INVESTIGATION phase.*
Contamination possibly exists.	*Proceed to the SITE INVESTIGATION phase.*
Contamination definitely exists, BUT no site investigation has been conducted.	*Proceed to the SITE INVESTIGATION phase.*
Contamination definitely exists, AND a site investigation has been performed.	*Proceed to the SITE INVESTIGATION phase if additional investigation is needed; otherwise, proceed to the CLEANUP OPTIONS phase.*

S1 OTHER REDEVELOPMENT INITIATIVES:

Reducing Barriers to Redevelopment of Brownfields Sites



The **Superfund Redevelopment Initiative (SRI)** reflects EPA's commitment to consider reasonably anticipated future land uses when making remedy decisions at Superfund hazardous waste sites. For pilot sites, EPA provides eligible local governments as much as $100,000 to support assessment and public outreach to help determine the future use of a site. The agency also supports a peer matching program that enables local governments and communities that have reused a Superfund site to share their experiences with those just starting the process. Through case studies, fact sheets, an online database of sites, and an Internet site, EPA is providing information about reuse options and the lessons learned through these projects. EPA is evaluating its policies and practices to determine whether changes are needed to further the effort to reuse sites. Further, EPA is forming partnerships with states, local government agencies, citizen groups, and other federal agencies to restore previously contaminated properties as valuable assets for communities. Visit EPA's SRI web site at *www.epa.gov/superfund/programs/recycle* for additional information.

Under **EPA's Resource Conservation and Recovery Act (RCRA) Brownfields Prevention Initiative**, pilot projects are designed to test approaches that better integrate reuse considerations into the corrective action cleanup process. The initiative also addresses concerns that application of RCRA to cleanup activities at brownfields sites may be slowing down the progress of cleanup efforts. Although no grant money is associated with the pilot projects, EPA has engaged contractors to help find ways to expedite cleanup at the pilot sites. EPA has selected four pilot projects that it hopes will illustrate how innovations and reforms under the RCRA corrective action program can reduce barriers to the reuse and redevelopment of RCRA brownfields sites. Additional information about the RCRA Brownfields Prevention Initiative is provided on line at *www.epa.gov/swerosps/bf/rcrabf.htm*.

A Quick Look

- The key components of the Superfund Redevelopment Initiative are: pilots, policies, partnerships, and promotions.
- The purpose of the RCRA Brownfields Initiative is to prevent the creation of future brownfields and ensure the successful cleanup and long-term, sustainable reuse of RCRA facilities.
- Under the TSE Initiative, selected properties will receive concentrated, short-term support to prevent such sites from becoming brownfields sites.
- The USTFields Initiative fosters the cleanup of UST sites.
- Sharing of lessons learned can benefit the BRAC and brownfields programs.

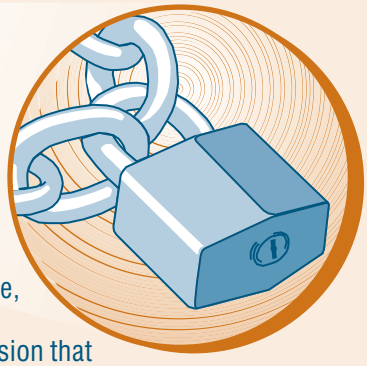
Recently launched by EPA, the **RCRA Brownfields Prevention Targeted Site Efforts (TSE) Initiative** is intended to focus short-term attention and support to sites at which cleanup has been delayed or slowed and to serve as a catalyst to initiate cleanup at such sites to prevent them from becoming brownfields sites. Implemented at the regional level, the TSE program will apply to sites at which there exists significant potential for redevelopment and reuse, and that require a limited amount of EPA support to bring the site to the next level of cleanup, consensus, or appropriate closure. EPA will offer a small amount of funding to support TSE efforts in each region. For more information about the program, contact Sara Rasmussen, EPA Office of Solid Waste, at (703) 308-8399.

EPA's **USTFields Initiative**, a new program undertaken by EPA's Office of Underground Storage Tanks (OUST), is focused on how to improve the cleanup of sites affected by petroleum contamination, thereby fostering the redevelopment of those sites (see Spotlight 8, *Underground Storage Tanks at Brownfields Sites*, for more information about the USTFields Initiative). Additional details about the program also are available on line at *www.epa.gov/swerust1/ustfield/*.

Many aspects of the Department of Defense's (DoD) **Base Realignment and Closure (BRAC) Program** and EPA's brownfields program are similar. Significant issues common to both BRAC and brownfields include eliminating disincentives and providing assurances to developers and financiers, considering future land use in cleanup decisions, and implementing institutional controls. Because federal facilities and brownfields cleanups can have similar effects on communities, EPA and DoD are exploring methods of coordinating BRAC and brownfields activities. Visit the BRAC Internet site at *www.dtic.mil/envirodod/brac/* for online access to policies and initiatives, publications, and points of contact.

S2 MOTHBALLED PROPERTIES:

Unlocking Sites with Innovative Technologies



Many mothballed properties are owned by railroad, petroleum, petrochemical, and utility corporations and are located in the Northeast and Midwest in areas where the economy has shifted away from industrial operations. Formerly used for manufacturing and other industrial uses, mothballed sites are properties which have been left idle or "mothballed" by the site owner. A study conducted by Rutgers University in New Jersey found at least one mothballed brownfields site present in almost 40 percent of the 60 New Jersey cities analyzed; approximately half of these municipalities consider that site to be a serious detriment to urban redevelopment because they often interfere with larger redevelopment plans.

For owners of mothballed sites, innovative technologies offer options for assessment and cleanup that provide more certainty in determining the full extent of contamination and in estimating the costs and time frames to complete these activities, and more viable and cost-effective solutions than traditional technologies. Innovative technologies provide alternatives that can quickly treat and eliminate sources of contamination, and reduce the long-term liability and risk to site owners.

For some sites undergoing cleanup using long-term conventional technologies, such as pump and treat and barriers, consideration should be given to innovative technologies that could greatly expedite the cleanup process and the redevelopment potential of the site. For example, at a former wood treating site in Visalia, California, steam injection was tried instead of the existing pump and treat system. Using this alternative resulted in a 1,000-fold increase in the rate of contaminant recovery. In addition, because steam injection is accelerating the time frame of remediation, there is a projected savings of $25 million in cleanup costs for this site.

As new economic incentives have developed, states, developers, venture capital firms, insurers, and risk assessment firms have entered industrial land markets that could turn mothballed properties into assets. For example, the State of Wisconsin adopted a statutory revision that allows for the recovery of environmental costs from current owners when a city condemns and cleans properties. The city of Milwaukee, a brownfields showcase community, believes the statute significantly increased the city's ability to encourage owners of mothballed properties to move toward redevelopment. For the first time, that state's cost recovery statute gives a city bargaining power in negotiations with owners of mothballed properties.

At the federal level, tax credits and deductions for costs related to environmental remediation can encourage owners of mothballed properties to clean up their properties. As specified in Section 198 of the Internal Revenue Code, taxpayers are permitted to treat as a deduction qualified expenses for environmental remediation at a qualified site. Such an incentive may convince owners of mothballed properties that cleaning up such sites would be more profitable than allowing the sites to remain idle.

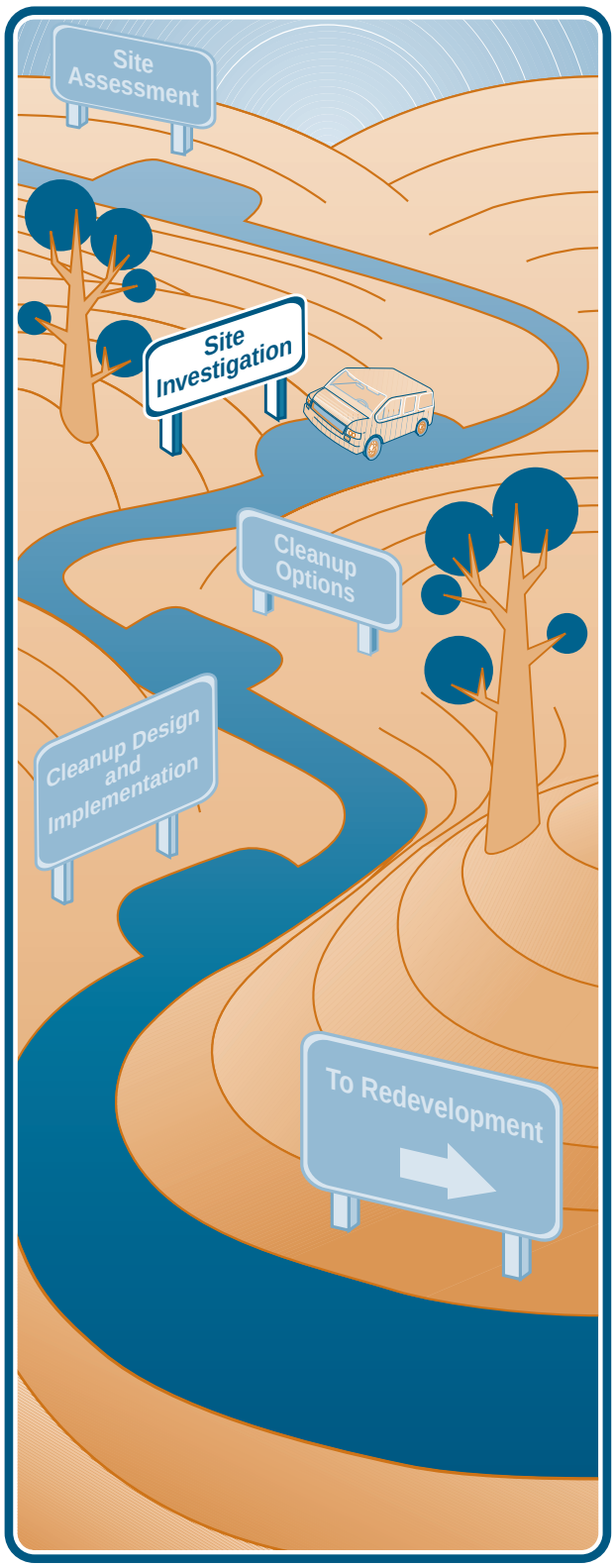
EPA TIO has a project underway to better understand why sites are mothballed and identify where there may be additional opportunities to use innovative technologies and approaches to expedite the cleanup of those sites. Contact Dan Powell of EPA's TIO for more information (see Appendix C, *List of Brownfields and Technical Support Contacts*, for contact information).

A Quick Look

- "Mothballed" sites are large, idle areas formerly used for manufacturing and other industrial uses, and are unavailable for sale or redevelopment.
- Reasons for "mothballing" sites include uncertainty about assessment and cleanup costs and potential liability from contamination that has not been identified, or there is an existing, long-term cleanup program already in place.
- Mothballed sites are problematic because they often interfere with larger development plans.
- Interest is increasing at the local level to identify options to expedite the cleanup of mothballed sites where they are impeding redevelopment plans.

For more information, see the resource numbered 141 in the Index of Resources beginning on page I-1.

SITE INVESTIGATION



Identify the Source, Nature, and Extent of Contamination

This phase focuses on confirming whether any contamination exists at a site, locating any existing contamination, and characterizing the nature and extent of that contamination. It is essential that an appropriately detailed study of the site be performed to identify the cause, nature, and extent of contamination and the possible threats to the environment or to any people living or working nearby. For brownfields sites, the results of such a study can be used in determining goals for cleanup, quantifying risks, determining acceptable and unacceptable risk, and developing effective cleanup plans that do not cause unnecessary delays or costs in the redevelopment and reuse of property. To ensure that sufficient information supporting future activities is obtained, the type of data to be collected during this phase should be determined by the proposed cleanup measures and the proposed end use of the site.

A site investigation, also referred to as an ASTM Phase II environmental site assessment, is based on the results of the site assessment, which is discussed in the preceding section of the Road Map. The site investigation phase may include the analysis of samples of soil and soil gas, groundwater, surface water, and sediment. The migration pathways of contaminants also are examined during this phase, and a baseline risk assessment may be needed to calculate risk to human health and the environment. Examples of sampling and analysis technologies that may be useful during this phase are presented in Appendix A, *Table A-2, Technologies for Sampling and Analyzing Contaminants Found at Typical Brownfield Sites.*

What Do We Need To Know?

Factors that should be considered during the site investigation, if there is evidence of potential or actual contamination include:

1. Will the site be entered into a VCP? If so, will the investigation plan be reviewed through the VCP? If not, are there federal, state, local, and tribal regulatory requirements applicable to the site investigation? What agency will be responsible for managing oversight of this phase? What is to be done if the appropriate agency has not developed standards or guidelines that are suitable for the proposed redevelopment?

2. What technologies are available to facilitate site investigation and to support data collection relevant to the goals of the project? Has the technical team explored the full range of technologies that can produce data of the quality necessary? Can the technologies selected limit the number of mobilizations at the site?
3. Can the need for cleanup be assessed fully and accurately from the information gathered during the site assessment or from a previous site investigation?
4. What issues has the community raised that may affect the site investigation?
5. What are the potential exposure pathways? Who or what could be affected by the contamination or the efforts to clean up the contamination?
6. What happens if significant contamination is found? What happens if contamination poses a "significant threat" to local residents?
7. What happens if the contamination is originating from an adjacent or other off-site source? What happens if background sampling indicates that contamination is originating from a naturally occurring source?
8. Are the infrastructure systems (roads, buildings, sewers, and other facilities) contaminated? Could they be affected by efforts to clean up contamination?

The following table describes field analytical technologies and mobile laboratories.

Highlights of Field Analytical Technologies and Mobile Laboratories
Field Analytical Technologies: Field analytical technologies, often referred to as "field analytics," can be used onsite without the absolute need for a mobile laboratory. Some field analytical technologies are very sophisticated and can yield quantitative results that are comparable to those obtained by analysis in mobile or off-site laboratories. Some field analytical measurements can be made quickly, allowing a high rate of sampling. Under certain conditions, data can be collected in a short period of time. Field analytical technologies are implemented through the use of hand-held instruments, such as the portable gas chromatography and mass spectrometry and the x-ray fluorescence analyzer, as well as the use of bench procedures, such as colorimetric and immunoassay tests.
Mobile Laboratories: A variety of technologies can be used in a mobile laboratory. Such technologies differ from field analytical technologies because they may require more controlled conditions (such as temperature, humidity, and source of electricity) or complex sample preparation that uses solvents or reagents that require special handling or protective equipment that require the handling and storage of chemical standards. Technologies adaptable to mobile laboratories include those used to analyze soil and water samples for inorganic analytes (such as anodic stripping voltammetry) and organic compounds (such as gas chromatography with a variety of detectors). When operated properly and with adequate quality assurance and quality control (QA/QC), the technologies can achieve quantitative results equal to those achieved by off-site analytical laboratories.

How Do We Find The Answers?*

Typical activities that may be conducted during the site investigation phase include:

- Identify the proper mix of technologies (such as field measurement technologies that characterize the physical and chemical aspects of the site and fixed laboratory sampling methods) that can facilitate site investigations and meet the required level of data quality:
  - *Ensure that the laboratory has appropriate detection limits for analytes*
- Determine the environmental conditions at the site (for example, by performing an ASTM Phase II environmental site assessment or equivalent investigation that includes tests to confirm the locations and identities of environmental hazards):
  - *Conduct sampling and analysis to determine the nature, extent, source, and significance of the contamination that may be present at the site*
  - *Conduct sampling and analysis to fully assess the physical, geophysical, and ecological conditions and characteristics of the site*
  - *Interpret the results of the analysis to characterize site conditions*
  - *Determine whether and how (if applicable) the infrastructure systems (including existing structures) are affected by contamination*
- Assess the risk the site may pose to human health and the environment. Consider the following exposure pathways:
  - *For soil and dust, direct contact, ingestion, or inhalation*
  - *For water, ingestion and inhalation*
  - *For air, inhalation or ingestion*
- Consider the use of a site-specific risk assessment to identify cleanup levels when that approach may result in more reasonable cleanup standards or when cleanup standards have not been developed
- Examine unacceptable environmental conditions in terms of initial costs for site improvement and long-term costs for annual operation and maintenance — include potential

** Please note that the Road Map seeks to answer technology selection questions and is not intended to provide a response to each procedural question identified.*

cleanup options and constraints that may affect redevelopment requirements, such as project schedules, costs, and potential for achieving the desired reuse

- Revise assumptions about the site based on data collected at the site
- Begin consideration of sources of funding for site investigation and cleanup activities such as state brownfields programs and federal tax credits:
  - *Contact the EPA regional brownfields coordinator to identify and determine the availability of EPA support programs and federal financial incentives*
- Continue to work with appropriate regulatory agencies to ensure that regulatory requirements are being properly addressed:
  - *Identify and consult with the appropriate federal, state, local, and tribal agencies to include them as early as possible in the decision-making process*
- Educate members of the community about the site investigation process and actively involve them in decision making; consider risk communication techniques to facilitate those activities

Where Do We Find Help To Our Technology Questions?

Listed below are examples of resources that assist in identifying the environmental condition of a site. Information about the availability of electronic resources — whether the item is found on the Road Map's accompanying CD-ROM or on various web sites — also is provided. *Appendix D, How to Order Documents*, provides complete ordering information for documents that are not available on the CD-ROM or on the Internet.

A. Resources for Site Investigation

The documents listed below are resources that provide general information about the availability of technology resources in the form of bibliographies, status reports, and user guidelines.

ASTM Standard Guide for Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases (E1912-98)
Order on line at www.astm.org
Developed by ASTM, the guide describes accelerated site characterization (ASC), a process used to rapidly and accurately characterize confirmed or suspected releases of petroleum. The guide provides a framework that responsible parties, contractors, consultants, and regulators can use to streamline and accelerate site characterization. The guide is available at $35 per copy and can be downloaded from the ASTM web site or ordered by telephone at 610-832-9585 or by facsimile at 610-832-9555.

ASTM Standard Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process (E1903-97)
Order on line at www.astm.org
Developed by ASTM, the guide discusses the framework for employing good commercial and customary practices in the U.S. when conducting Phase II environmental site assessments of commercial property with respect to the potential presence of a range of contaminants within the scope of CERCLA, as well as petroleum products. The practice, available at $35 per copy, can be downloaded from the ASTM web site or ordered by telephone at 610-832-9585 or by facsimile at 610-832-9555.

Brownfields Technology Primer: Requesting and Evaluating Proposals That Encourage Innovative Technologies for Investigation and Cleanup (EPA 542-R-01-005)
View or download pdf file on the Road Map CD-ROM
The BTSC prepared this primer to assist site owners, project managers, and others preparing RFPs to solicit support in conducting activities to investigate and clean up contaminated sites. It is specifically intended to assist those individuals in writing specifications that encourage contractors and technology vendors to propose options for using innovative characterization and remediation technologies at brownfields sites. The primer also provides information, from a technology perspective, to guide review teams in their evaluations of proposals and the selection of qualified contractors.

Cost Estimating Tools and Resources for Addressing the Brownfields Initiatives (EPA 625-R-99-001)
Order on line at www.epa.gov/ncepihom
The guide is one in a series of publications designed to assist communities, states, municipalities, and the private sector to address brownfields sites more effectively. The guide, which is designed to be used with the three guides for specific types of sites - Technical Approaches to Characterizing and Cleaning Up Automotive Repair Sites Under the Brownfields Initiative, Technical Approaches to

Characterizing and Cleaning Up Iron and Steel Mill Sites Under the Brownfields Initiative, and Technical Approaches to Characterizing and Cleaning Up Metal Finishing Sites Under the Brownfields Initiative - provides information about cost estimating tools and resources for addressing cleanup costs at brownfields sites. Many decision makers at brownfields sites may choose to assign the preparation of cost estimates to consultants who are experienced in the cleanup of hazardous waste sites; however, it benefits those decision makers to be able to provide guidance to their consultants and to understand the process sufficiently well to provide an informed review of the estimates prepared. The guide provides general information about the cost estimation process and includes summaries of various types of estimates. The guide also outlines the process of developing "order of magnitude" cost estimates. Information about resources, databases, and models also is provided.

Data Quality Objective Process for Hazardous Waste Site Investigations (EPA 600-R-00-007)

View or download pdf file on the Road Map CD-ROM

The document focuses on the DQO process as the appropriate systematic planning process to support decision making. The DQO process is an important tool for project managers and planners to use in defining the types, quality, and quantity of data needed to make defensible decisions. The document is based on the principles and steps developed in Guidance for the Data Quality Objectives Process, but is specific to investigations of hazardous waste sites. The guidance is also consistent with Data Quality Objectives Process for Superfund: Interim Final Guidance (EPA 1993) and Soil Screening Guidance: User's Guide (EPA 1996). Although the document focuses on EPA applications, the guidance also is applicable to programs at the state and local levels.

Engineering and Design: Requirements for the Preparation of Sampling and Analysis Plans (EM 200-1-3)

View or download pdf file on the Road Map CD-ROM

Developed by the U.S. Army Corp of Engineers, the manual provides guidance for the preparation of project-specific SAPs for the collection of environmental data. In addition, the manual presents default sampling and analytical protocols that may be used verbatim or modified based in light of the DQOs for a specific project. The goal of the manual is to promote consistency in the generation and execution of sampling and analysis plans and therefore to help investigators generate chemical data of known quality for the purpose to which those data are to be used.

EPA Office of Solid Waste SW-846 On-Line: Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods

View on line at www.epa.gov/epaoswer/hazwaste/test/maina.htm

Developed by EPA's Office of Solid Waste (OSW), the web site provides test procedures and guidance that EPA recommends for use in conducting the evaluations and measurements needed to comply with requirements established under RCRA. The manual presents state-of-the-art methods of routine analytical testing, adapted for use under the RCRA program. It presents procedures for field and laboratory quality control, sampling, identification of hazardous constituents in wastes, determination of the hazardous characteristics of wastes (toxicity, ignitability, reactivity, or corrosivity), and determination of the physical properties of wastes. It also provides guidance on selecting appropriate methods.

EPA REACH IT Online Searchable Database

View on line at www.epareachit.org

The EPA REACH IT online searchable database provides users comprehensive, up-to-date information about more than 150 characterization technologies which may be applicable during the site investigation phase. The guided and advanced search capabilities of the system can be used to gather information about innovative technology solutions and service providers. The information is based upon data submitted by vendors and project managers for EPA, DoD, DOE, and state agencies. EPA REACH IT is accessible only through the Internet.

Evaluation of Selected Environmental Decision Support Software (DSS)

View or download pdf file on the Road Map CD-ROM

Developed by DOE's Office of Environmental Management, the report evaluates DSS, computer-based systems that facilitate the use of data, models, and structured decision processes in making decisions related to environmental management. The report evaluates 19 such systems through the application of a rating system that favors software that simulates a wide range of environmental problems. It includes a glossary of terms and a statement of the rationale for the selection of various aspects of the performance of the DSS for evaluation.

Field Analytic Technologies Encyclopedia (FATE)

View on line at http://fate.clu-in.org

The online encyclopedia provides information about technologies that investigators can use in the field to characterize contaminated soil and groundwater; monitor the progress of remedial efforts; and, in some cases, perform confirmation sampling and analysis to support closeout of a site. It highlights new tools for improving cleanup and long-term monitoring of contaminated sites, such as computerization, microfabrication, and biotechnology, that permit the development of analytical equipment that has capabilities that blur the distinction between "screening methods" and "definitive methods." The encyclopedia serves a wide range of users, from engineering students to field technicians and site managers.

Field Sampling and Analysis Technologies Matrix, Version 1.0

View on line at www.frtr.gov/site

The matrix, an online tool, will assist brownfields stakeholders to obtain information about and screen technologies applicable for site investigation. Each site characterization technology is rated in a number of performance categories, such as detection limits, applicable media, selectivity, and turnaround time. Other useful information provided includes technology descriptions; data on commercial status, cost, and certification; and evaluation reports. The matrix is extremely helpful to users who are not familiar with specific characterization technologies, but who know baseline information about a site, such as contaminants and media; for such users, the matrix can identify and screen technologies for potential use at a site.

Guideline for Dynamic Workplans and Field Analytics: The Keys to Cost-Effective Site Characterization and Cleanup

View or download pdf file on the Road Map CD-ROM

Developed by Tufts University in cooperation with EPA, the document provides users with information about the many factors that are to be considered in incorporating field analytical instruments and methods into an adaptive sampling and analysis program for expediting the site investigation process. The guidance is intended to assist federal and state regulators, site owners, consulting engineers, and remediation companies understand how to develop, maintain, and update a dynamic workplan.

Improving the Cost-Effectiveness of Hazardous Waste Site Characterization and Monitoring

View or download pdf file on the Road Map CD-ROM

The report introduces a new standard promoted by EPA's OSWER and TIO that encourages more effective and less costly strategies for characterizing and monitoring hazardous waste sites. The new approach uses an integrated triad of systematic planning, dynamic work plans, and onsite analysis for data collection and technical decision making at hazardous waste sites. Individually, none of the concepts in the triad is new, but it has been demonstrated that the integrated approach completes projects faster, cheaper, and with greater regulatory and client satisfaction than the traditional phased approach. The report includes a list of additional resources regarding innovative technologies and site characterization.

Innovations in Site Characterization Case Study Series

View or download pdf files on the Road Map CD-ROM

The case studies provide cost and performance information about the innovative technologies that support less costly and more representative site characterization. The purpose of the case studies is to analyze and document the effectiveness of new technologies proposed for site cleanup. They present information about the capability of the technologies in analyzing and monitoring cleanup, as well as information about costs associated with the use of the technologies. The following case studies are available:

- *Hanscom Air Force Base, Operable Unit 1 (EPA 542-R-98-006)*
- *Dexsil L2000 PCB/Chloride Analyzer for Drum Surfaces (EPA 542-R-99-003)*
- *Geophysical Investigation at Hazardous Waste Sites (EPA 542-R-00-003)*
- *Site Cleanup of the Wenatchee Tree Fruit Test Plot Site Using a Dynamic Work Plan (2000) (EPA 542-R-00-009)*

Innovative Remediation and Site Characterization Technologies Resources (EPA 542-C-01-001)

Order on line at www.epa.gov/ncepihom

Produced by EPA's TIO, the CD-ROM contains resources that provide information to help federal, state, and private-sector site managers evaluate site assessment and cleanup alternatives. The ability to gain access to resources that provide information about innovative site characterization and

remediation technologies will increase understanding of those technologies and of the cost and performance factors related to them. Such understanding is essential to the consideration of those technologies for use in addressing contamination at hazardous waste sites. Several resources included on the CD-ROM also are available on the Road Map CD-ROM.

Public Technology Inc.'s BrownfieldsTech.org

View on line at www.brownfieldstech.org

The web site, hosted by Public Technology, Inc. (PTI), and sponsored in part by EPA's TIO, provides information about characterization and remediation of brownfields. The site focuses on the demonstration, dissemination, and promotion of innovative characterization and remediation technologies suitable for use at brownfields sites to help local governments increase efficiencies and reduce costs associated with brownfields redevelopment. The site highlights "hot" technologies that currently are proving themselves in the field, provides case studies that introduce the user to cities that are experiencing succession employing innovative site characterization and remediation technologies, profiles of local government leaders who are employing brownfields remediation technologies to good effect, and provides links to other key web sites.

Resources for Strategic Site Investigation and Monitoring (EPA 542-F-01-030B)

View or download pdf file at http://clu-in.org

The document is a concise guide to resources, both existing and planned, that support new, streamlined approaches to site investigation and monitoring. It describes training courses available, including some that are downloadable; lists sources of information about available technologies and guidance documents available through EPA programs; and provides sources of information about technology verification and demonstration efforts. The guide also lists a number of web sites from which related publications and software can be downloaded. The document can be downloaded from CLU-IN under "Publications."

Sensor Technology Information Exchange (SenTIX)

View on line at www.sentix.org

SenTIX serves as a forum to exchange information about sensor technologies and needs. The purpose of the web site is to serve as a tool to assist those working in the environmental field in cleaning up hazardous waste. The submit and search functions of SenTIX can help match users looking for a sensor technology to meet a specific need. The discussion forum also matches developers, vendors, and users. The site was developed by WPI, a nonprofit organization, under a cooperative agreement with EPA.

Site Characterization and Monitoring Technologies: Bibliography of EPA Information Resources (EPA 542-B-98-003)

View on line at http://clu-in.org

The bibliography lists information resources, both publications and electronic databases, that focus on evaluation and use of innovative site characterization and monitoring technologies. The document also provides information on obtaining copies of the documents.

Site Characterization Library, Volume 1, Release 2.0 (EPA 600-C-98-001)

Order on line at www.epa.gov/ncepihom

The CD-ROM, developed by EPA NERL, contains the following documents and software:

- *ASSESS Version 1.1A (PB93-505154) is an interactive QA/QC program designed to assist the user in statistically determining the quality of data from soil samples.*
- *BIOPLUME II is a model for two-dimensional transport of contaminants under the influence of oxygen-limited biodegradation in groundwater.*
- *CalTox is a multimedia total exposure model for hazardous waste.*
- *CHEMFLO enables users to simulate water movement and chemical transport in unsaturated soils.*
- *DEFT is a software package that allows a decision maker to quickly generate cost information about several sampling designs based on DQOs.*
- *FEMWATER/LEWASTE is software which can be used to delineate wellhead protection areas in agricultural regions by using a criterion that considers environmental factors that reduce the concentration of contaminants transported to wells.*
- *Geo-EAS Version 1.2.1 (PB93-504957) is an interactive tool for performing two-dimensional geostatistical analyses of spatially-distributed data.*
- *GEOPACK is a comprehensive geostatistical software package that allows both novices and advanced users to conduct geostatistical analyses of spatially-correlated data.*
- *Geophysics Advisor Expert System Version 2.0 (PB93-505162) is a program that considers several geophysical methods of determining the location of contamination and providing site characterization to make recommendations about the best methods to use at a specific site.*

- *GEOS software facilitates the collection and analysis of geoenvironmental data.*
- *GRITS/STAT is a comprehensive database system for storing, analyzing, and reporting information from groundwater monitoring programs at RCRA, CERCLA, and other regulated facilities and sites.*
- *HELP is a two-dimensional modeling program that simulates water movement into and out of landfills on the basis of a waste management system.*
- *IMES offers a computer-based tool for matching site characteristics with an appropriate exposure assessment model or models.*
- *MOFAT, a two-dimensional, finite element model for simulating coupled multiphase flow and multicomponent transport in planar or radically symmetric vertical sections, can be used to evaluate flow and transport for water, NAPLs, and gas.*
- *MULTIMED is a one-dimensional, steady-state model used to predict the concentrations of contaminants migrating from a waste disposal facility through the subsurface, surface water, and air pathways to receptor sites.*
- *PESTAN assists users in estimating the vertical migration of dissolved organic solutes through the vadose zone to groundwater.*
- *PRZM-2 is a pesticide flow-and-transport model for the root zone and vadose zone.*
- *RETC is a program used in analyzing the hydraulic conductivity properties of unsaturated soil.*
- *Scout Version 2.0 is a user-friendly and menu-driven program that provides a graphical display of data in a multidimensional format that allows visual inspection of data, accentuates obvious outliers, and provides an easy measure for comparing data.*
- *STF (VIP + RITZ) consists of three components that provide information about the behavior of chemicals in soil environments. The models simulate the movement and fate of hazardous chemicals during treatment of oily wastes.*
- *Subsurface Characterization and Monitoring Techniques is an interactive, multimedia version of the two-volume EPA publication titled Subsurface Characterization and Monitoring Techniques. The documents include descriptions of more than 280 site characterization and field monitoring methods of detecting groundwater contamination and other aspects of the subsurface at hazardous waste sites. Geological and hydrogeological characterization topics covered include surface and borehole approaches, geophysical methods, and sampling of solids; drilling; aquifer tests and groundwater sampling; water-state measurement and monitoring; measurement of hydraulic conductivity and flux in the vadose zone; water budget characterization; soil-solute sampling and gas monitoring in the vadose zone; and field chemical analytical methods. The electronic version of the guide includes graphic support with animation and hypertext links that make all text readily accessible.*
- *Total Human Exposure Risk database and Advanced Simulation Environment (THERdbASE), Version 1.2, is an integrated database and analytical and modeling software system for use in exposure assessment calculations and studies. It provides a prototype for smoothly and efficiently linking communication between databases and exposure assessment models.*
- *VLEACH provides users a one-dimensional, finite difference model for making preliminary assessments of the effects on groundwater of leaching of volatile, sorbed contaminants through the vadose zone.*
- *WhAEM is a computer-based tool used in decision-making processes related to the protection of wellheads.*
- *WHPA, a semi-analytical groundwater flow simulation program, can be used for delineating capture zones in a wellhead protection area.*

Superfund Innovative Technology Evaluation (SITE) Program Demonstration Reports

View or download reports at www.epa.gov/ord/SITE/reports.html

An extensive inventory of reports of the evaluation of measurement and monitoring technologies in the SITE program is available to assist decision makers in reviewing technology options and assessing a technology's applicability to a particular site. The reports evaluate all information about a technology; provide an analysis of its overall applicability to site characteristics, waste types, and waste matrices; and present testing procedures, performance and cost data, and QA/QC standards. The Demonstration Bulletins provide summarized descriptions of technologies and announcements of demonstrations. The Innovative Technology Evaluation Reports provide full reports of the demonstration results, including technical data useful to decision makers.

U.S. Department of Energy (DOE) Preferred Alternatives Matrices (PAMs)

View on line at www.em.doe.gov/define

Developed by DOE, the PAMs web site provides access to evaluations of site characterization and remediation technologies preferred by DOE on the basis of the types of contaminants and contaminated media selected. PAMs was developed by DOE's Office of Environmental Restoration (EM-40) to assist decision makers in selecting the most appropriate cleanup alternatives for remediation, waste processing, and decommissioning of sites. It provides a tool for field

personnel to use in focusing remedy selection; expediting implementation of preferred alternatives; eliminating the cost of excessive or redundant treatability studies; and allowing preselection of effective, low-cost remediation alternatives.

U.S. Department of Energy (DOE) Vendor Database for Environmental Applications
View on line at www.cmst.org/vendor
The web site is devoted to measurements of the chemical and physical properties of environmental samples. The Characterization, Monitoring & Sensor Technology – Cross-Cutting Program (CMST-CP) maintains the vendor database as a focal point for environmental measurement technologies. The CMST–CP vendor database matches the user's measurement needs with available products. The site allows the user to enter products and applications, search applications for measurement instruments and sensors, and browse technologies by instrument category.

B. Site-Specific Resources for Site Investigation

Listed below are survey reports on the application of innovative technologies to specific contaminants and site types.

Application of Field-Based Characterization Tools in the Waterfront Voluntary Setting
View or download pdf file on the Road Map CD-ROM
This report investigates the reasons voluntary action to redevelop potentially contaminated property is subject to market constraints and other pressures that differ vastly from those that affect corrective action programs. It sets forth in detail the current level of application of field-based characterization tools at 115 waterfront brownfields sites and sites being addressed under VCP programs.

Characterization of Mine Leachates and the Development of a Ground-Water Monitoring Strategy for Mine Sites (EPA 600-R-99-007)
View or download pdf file on the Road Map CD-ROM
The objective of the research project was to develop a better understanding of the composition of mine waste leachates and to identify cost-effective groundwater monitoring parameters that could be incorporated into a monitoring strategy to reliably detect the migration of contaminants from hard-rock mining operations.

Contaminants and Remedial Options at Pesticide Sites (EPA 600-R-94-202, PB95-183869)
Order on line at www.epa.gov/ncepihom
The document provides information about treatment technologies and the selection of services at pesticide sites to meet acceptable levels of cleanliness as required by applicable regulations. It is targeted primarily for the use of federal, state, or private site removal and remediation managers. The document does not identify or establish cleanup levels.

Contaminants and Remedial Options at Selected Metal-Contaminated Sites (EPA 540-R-95-512, PB95-271961)
Order on line at www.epa.gov/ncepihom
The report provides information on site characterization and the selection of treatment technologies capable of meeting site-specific cleanup levels at sites contaminated with metal. It is targeted to federal, state, and private site removal and remediation managers. The report focuses primarily on metalloid arsenic and metals, including cadmium, chromium, lead, and mercury. The report does not identify or establish cleanup levels.

EPA ORD Brownfields Guides
View on line at www.epa.gov/ncepihom/nepishom
The series of publications are designed to assist communities, states, municipalities, and the private sector to address brownfields sites more effectively. The guides provide decision makers, such as city planners, private sector developers, and others who are involved in redeveloping brownfields, with a better understanding of the technical issues involved in assessing and cleaning up automotive repair sites, iron and steel mill sites, and metal finishing sites. After reading the guides, the user will have a better understanding of activities commonly carried out at such sites and how those activities might cause the release of contaminants into the environment. The guides also provide information about the types of contaminants often found at such sites; a discussion of site assessment, screening and cleanup levels, and cleanup technologies; a conceptual framework for identifying potential contaminants; information about developing a cleanup plan; and a discussion of issues and special factors that should be considered when developing plans and selecting technologies. The following guides are available:

- *Technical Approaches to Characterizing and Cleaning Up Automotive Repair Sites Under the Brownfields Initiative (EPA 625-R-98-008)*

- *Technical Approaches to Characterizing and Cleaning Up Iron and Steel Mill Sites Under the Brownfields Initiative (EPA 625-R-98-007)*
- *Technical Approaches to Characterizing and Cleaning Up Metal Finishing Sites Under the Brownfields Initiative (EPA 625-R-98-006)*

Expedited Site Assessment Tools for Underground Storage Tank Sites: A Guide for Regulators (EPA 510-B-97-001)

View or download pdf file on the Road Map CD-ROM

Produced by EPA's OUST, this guide is designed to help state and federal regulators with responsibility for USTs to evaluate conventional and new site assessment technologies and promote the use of expedited site assessments. The manual covers five major issues related to UST site assessments: the expedited site assessment process; surface geophysical methods for UST site investigations; soil-gas surveys; direct push technologies; and field analytical methods for the analysis of petroleum hydrocarbons. The equipment and methods presented in the manual are evaluated in terms of applicability, advantages, and limitations for use at petroleum UST sites.

Resource for MGP Site Characterization and Remediation: Expedited Site Characterization and Source Remediation at Former Manufactured Gas Plant Sites (EPA 542-R-00-005)

View or download pdf file on the Road Map CD-ROM

The document provides current information about useful approaches and tools being applied at former manufactured gas plant (MGP) sites to the regulators and utilities that are engaged in characterizing and remediating these sites. The document outlines site management strategies and field tools for expediting site characterization at MGP sites; presents a summary of existing technologies for remediating MGP wastes in soils; provides sufficient information about the benefits, limitations, and costs of each technology, tool, or strategy for comparison and evaluation; and provides, through case studies, examples of the ways in which those tools and strategies can be implemented at MGP sites.

Risk-Management Strategy for PCB-Contaminated Sediments

View or order on line at www.nap.edu/books/0309073219/html

The report, prepared by the National Research Council's Committee on the Remediation of PCB-Contaminated Sediments under an EPA grant, reviews the nature of the challenge involved in the management of sediments contaminated with PCBs; provides an overview of current knowledge about the inputs, fates, and effects of PCBs; recommends a risk-based framework for use in assessing remediation technologies and risk-management strategies; and elaborates on the framework as it is applicable specifically to sediments contaminated with PCBs.

C. Technology-Specific Resources for Site Investigation

The documents listed below provide detailed information about specific innovative technologies and the application of those processes to specific contaminants and media in the form of engineering analyses, application reports, technology verification and evaluation reports, and technology reviews.

A User's Guide to Environmental Immunochemical Analysis

View on line at www.epa.gov/nerlesd1/chemistry/immochem/user-guide.htm

Developed by EPA's ORD, the document facilitates transfer of immunochemical methods for the analysis of environmental contaminants to the environmental analytical chemistry laboratory. Field personnel who may have a need to employ a measurement technology at a monitoring site also may find this manual helpful. The document instructs the reader in the use and application of immunochemical methods of analysis for environmental contaminants. It includes a general troubleshooting guide, along with specific instructions for certain analytes. The guide is written in a manner that allows the user to apply the information presented to immunoassays that are not discussed in the manual.

California Environmental Technology Certification Program - California Certified Technologies List

View on line at www.calepa.ca.gov/calcert

The California Environmental Protection Agency's (Cal/EPA) Environmental Technology Certification program Internet site provides the user access to the California Certified Technologies List. The document provides a list of technologies and their respective vendors that have been certified by the state of California. Certification is granted to technologies on the basis of an independent, third-party verification of the technology's performance and ability to meet regulatory specifications and requirements. Developers and manufacturers define quantitative performance claims for their technologies and provide supporting documentation. Cal/EPA reviews that

information and, when necessary, conducts additional testing to verify the claims. Technologies, equipment, and products that are proven to work as claimed receive official state certification.

EPA Dynamic Field Activities Internet Site
View on line at www.epa.gov/superfund/programs/dfa/index.htm
Hosted by EPA's Office of Emergency and Remedial Response (OERR), the Internet site provides resources to assist decision makers to streamline activities conducted at hazardous waste sites using real-time data and real-time decisions. Descriptions of the specific elements of dynamic field activities are provided, as well as related guidance documents and publications, including links to relevant Internet sites. Information about on-site analytical tools suitable for use during dynamic field activities also is provided.

Environmental Technology Verification Reports
View or download pdf files at www.epa.gov/etv
Produced by EPA's ORD, the Environmental Technology Verification (ETV) program reports provide extensive information about the performance of commercial-ready, private sector technologies. The reports, intended for buyers of technologies, developers of technologies, consulting engineers, and state and federal agencies, verify the environmental performance characteristics of those technologies through the conduct of pilots. The reports, as well as other information about the ETV program, are available on the ETV site. ETV reports and verification statements about the following technologies are available:

- *Cone penetrometer-deployed sensor*
- *Environmental decision support software*
- *Explosive detection*
- *Field-portable gas chromatograph/mass spectrometer*
- *Field-portable x-ray fluorescence analyzer*
- *Groundwater sampling*
- *PCB field analysis technologies*
- *Portable gas chromatograph-mass spectrometer*
- *Soil/soil gas sampling*
- *Well-head monitoring for volatile organic compounds (VOC)*
- *Soil sampling technologies*

Federal Facilities Forum Issue: Field Sampling and Selecting On-Site Analytical Methods for Explosives in Soil (EPA 540-R-97-501)
View or download pdf file on the Road Map CD-ROM
This paper was prepared by members of the Federal Facilities Forum, a group of EPA scientists and engineers representing EPA regional offices and committed to the identification and resolution of issues affecting federal facility Superfund and RCRA sites. The purpose of the paper is to provide guidance to remedial project managers (RPM) about field sampling and on-site analytical methods for detecting and quantifying secondary explosive contaminants in soil. The paper is divided into the following sections: (1) background information; (2) overview of sampling and analysis of explosives; (3) data quality objectives; (4) unique sampling and design considerations for dealing with contaminants from explosives; (5) a summary of on-site analytical methods; and, (6) a summary of the EPA reference analytical methods.

Field Validation of a Penetrometer-Based Fiber Optic Petroleum, Oil, and Lubricant (POL) Sensor: Project Summary (EPA 600-SR-97-055)
View on line at www.epa.gov/ncepihom/nepishom
The report provides comprehensive comparisons of in situ measurements from a cone penetrometer-deployed laser induced fluorescence (LIF) petroleum, oil, and lubricant (POL) sensor with traditional field screening methods. The report includes an introduction that describes the system and indicates the technology constraints. In addition to conclusions and recommendations, the report also provides information about methods and materials, such as calibration and sampling procedures, analytical methods, and methods of data reproduction and analysis. Two case studies help illustrate the concepts discussed.

Hydrogeologic Characterization of Fractured Rock Formations: A Guide for Groundwater Remediators; Project Summary (EPA 600-S-96-001)
View or download pdf file on the Road Map CD-ROM
This report describes the conduct and findings of a hydrogeologic characterization study of a saturated fractured, granitic rock aquifer in the foothills of the Sierra Nevada mountains in California. First, the report presents an overview of the problems associated with remediating fractured aquifers, referring to case histories as examples. Brief descriptions of the methods and results of the characterization effort at the experimental field site then are presented. The remaining chapters present particular phases of the characterization effort and a general strategy for hydrogeologic characterization, with each tool and method described in detail. In addition, the report discusses issues related to the effect of incorrect characterization of flow properties on prediction of the behavior of a contaminant.

Tri-Service Site Characterization and Analysis Penetrometer System—SCAPS: Innovative Environmental Technology from Concept to Commercialization

View or download pdf file on the Road Map CD-ROM

The report, published by the U.S. Army Environmental Center, summarizes the development, field demonstration and regulatory acceptance activities associated with the SCAPS technologies that are used to detect, identify, and quantify subsurface contamination in soil and groundwater.

Where Do We Go From Here?

After you have completed your investigation of the environmental conditions at the site, you may take one of the following courses of action:

Results of the Site Investigation		Course of Action
No contamination is found.	➡	*Consult with appropriate regulatory officials before proceeding with redevelopment activities.*
Contamination is found BUT does not pose a significant risk to stakeholders' human health or the environment.	➡	*Consult with appropriate regulatory officials before proceeding with redevelopment activities.*
Cleanup of the contamination found probably will require a small expenditure of funds and time.	➡	*Proceed to the CLEANUP OPTIONS phase.*
Cleanup of the contamination found probably will require a significant expenditure of funds and time. However, contamination does not pose a significant threat to local residents.	➡	*Determine whether redevelopment continues to be practicable as planned, or whether the redevelopment plan can be altered to fit the circumstances; if so, proceed to the CLEANUP OPTIONS phase.*
Contamination is found that poses a significant threat to local residents.	➡	*Contact the appropriate federal, state, local, or tribal government agencies responsible for hazardous waste. If contamination exists at considerable levels, compliance with other programs, such as RCRA and Superfund, may be required.*

S3 KEYS TO TECHNOLOGY SELECTION AND ACCEPTANCE

As described throughout the Road Map, innovative technologies and technology approaches offer many advantages in the cleanup of brownfields sites. Stakeholders in such sites, however, first must accept the technology. Brownfields decision makers should consider the following elements to increase the likelihood that the technology will be accepted, thereby facilitating the cleanup of the site.

1 *Focus on the Decisions that Support Site Goals*

As discussed in Spotlight 4, *The Triad Approach* (see next page), systematic planning is an important element of all cleanup activities. Clear and specific planning to meet explicit decision objectives is essential in managing the process of cleaning up contaminated sites: site assessment, site investigation, site monitoring, and remedy selection. With good planning, brownfields decision makers can establish the cleanup goals for the site, identify the decisions necessary to achieve those goals, and develop and implement a strategy for addressing the decision needs. Technology decisions are made in the context of the requirements for such decisions. All cleanup activities are driven by the project goals. An explicit statement of the decisions to be made and the way in which the planned approach supports the decisions should be included in the work plan.

2 *Build Consensus*

Investing time, before the site work begins, in developing decisions that are acceptable to all decision makers will foster more efficient site activities and make successful cleanup more likely. Conversely, allowing work to begin at a site before a common understanding and acceptance of the decisions have been established increases the likelihood that the cleanup process will be inefficient, resulting in delays and inefficient use of time and money. Further, decision makers must understand that there is uncertainty in all scientific and technical decisions (see below for more information about uncertainty). Clearly defining and accepting uncertainty thresholds before making decisions about the site remedy will build consensus. Decisions also should be made in the context of applicable regulatory requirements, political considerations, budget available for the project, and time constraints.

Managing Uncertainty Managing uncertainty is the unifying theme of the triad approach, and it is a crucial aspect of the effective use of field analytical methods (see Spotlight 4, *The Triad Approach,* on the next page). Although not all field analytical technologies employ screening methodologies (for example, field-portable gas chromatography/mass spectrometry (GC/MS) is a definitive analytical methodology), many such technologies (for example, immunoassays) do. In general, data produced by screening analytical methods will present more analytical uncertainty than data produced by definitive methods. However, that fact in itself does not make definitive methods necessarily "better" than screening methods. Definitive methods are not fool-proof – interferences or other problems can cause a marked increase in their analytical uncertainty. On the other hand, a number of strategies can be used to minimize the analytical uncertainty inherent in screening methods. Such strategies include the selection of appropriate quality assurance and quality control (QA/QC) procedures to ensure that the data are of known and documented quality. Most important, all field analytical technologies offer the unique ability to cost-effectively manage the largest single source of decision error—sampling representativeness—an ability that is not available when requirements to use fixed laboratory methods discourage proactive management of sampling uncertainty.

3 *Understand the Technology*

A thorough knowledge of a technology's capabilities and limitations is necessary to secure its acceptance. All technologies are subject to limitations in performance. Planning for the strengths and weaknesses of a technology maximizes understanding of its benefits and its acceptance. "Technology approvers," typically regulators, community groups, and financial service providers are likely to be more receptive of a new approach if the proposer provides a clear explanation of the rationale for its use and demonstrates confidence in its applicability to specific site conditions and needs. This latter point underscores the importance of carefully selecting an experienced, multidimensional team of professionals who have the expertise necessary to plan, present, and implement the chosen approach.

4 *Allow Flexibility*

Streamlining site activities, whether site assessment, site investigation, removal, treatment, or monitoring, requires a flexible approach. Site-specific conditions, including various physical conditions, contamination issues, stakeholder needs, uses of the site, and supporting decisions, require that all decision makers understand the need for flexibility. Although presumptive remedies, standard methods, applications at other sites, and program guidance can serve as the basis for designing a site-specific cleanup plan and can help decision makers avoid "starting from scratch" at each site, decision makers should be wary of depending too heavily on "boilerplate language" and prescriptive methodologies, as well as standard operating procedures and "accepted" methods. While such tools provide excellent starting points, they lack the flexibility to meet site-specific goals. To ensure an efficient and effective cleanup, the actual technology approach, whether established or innovative, must focus on decisions specific to the site.

S4 THE TRIAD APPROACH:

Streamlining Site Investigations and Cleanup Decisions

The modernization of the collection, analysis, interpretation, and management of data to support decisions about hazardous waste sites rests on a three-pronged "triad" approach. The introduction of new technologies in a dynamic framework allows project managers to meet clearly defined objectives. Such an approach incorporates the elements described below.

Systematic planning is a common-sense approach to assuring that the level of detail in project planning matches the intended use of the data being collected. Once cleanup goals have been defined, systematic planning is undertaken to chart a course for the project that is resource effective, as well as technically sound and defensible to reach these project-critical goals. A team of multidisciplinary, experienced technical staff works to translate the project's goals into realistic technical objectives. The conceptual site model (CSM) is the planning tool that organizes the information that already is known about the site; the CSM helps the team identify the additional information that must be obtained. The systematic planning process ties project goals to individual activities necessary to reach these goals by identifying data gaps in the CSM. The team then uses the CSM to direct the gathering of needed information, allowing the CSM to evolve and mature as work progresses at the site.

A **dynamic work plan** approach relies on real-time data to reach decision points. The logic for decision-making is identified and responsibilities, authority, and lines of communication are established. Dynamic work plan implementation relies on and is driven by critical project decisions needed to reach closure. It uses a decision-tree and real-time uncertainty management practices to reach critical decision points in as few mobilizations as possible. Success of a dynamic approach depends on the presence of experienced staff in the field empowered to make decisions based on the decision logic and their capability to deal with new data and any unexpected issues, as they arise. Field staff maintain close communication with regulators or others overseeing the project during implementation of dynamic work plans.

The use of **on-site analytical tools**, rapid sampling platforms, and on-site interpretation and management of data makes dynamic work plans possible. Such analytical tools are among the key streamlined site investigation tools because they provide the data that are used for on-site decision making. The tools are a broad category of analytical methods and equipment that can be applied at the sample collection site. They include methods that can be used outdoors with hand-held, portable equipment, as well as more rigorous methods that require the controlled environments of a mobile laboratory (transportable). During the planning process, the team identifies the type, rigor, and quantity of data needed to answer the questions raised by the CSM. Those decisions then guide the design sampling modifications and the selection of analytical tools.

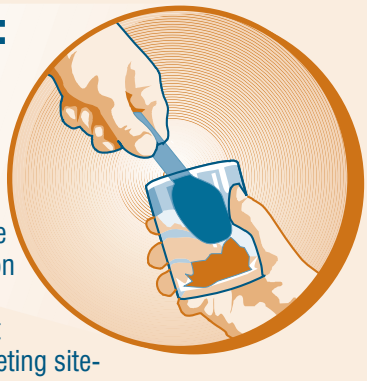
A Quick Look

- Integrates systematic planning, dynamic work plans, and on-site analytical tools to meet project and program goals.
- Takes advantage of real-time results and data assessment to guide additional sampling and to minimize mobilization to reach decision points.
- Focuses site activities on project goals, rather than on analytical methods, thereby saving time and money and fostering better decisions.
- Demonstrated to complete projects faster, cheaper, and with greater regulatory satisfaction than the traditional phased approach to data collection.

For more information, see the resources numbered 42, 53, 69, 77, 78, and 121 in the Index of Resources beginning on page I-1.

S5 DATA QUALITY AND REPRESENTATIVENESS:

Keys to Cost-Effective Site Investigation



The information value of data depends heavily upon the interaction among sampling and analytical designs in relation to the intended use of the data, the site-specific context surrounding that intended use, and the associated quality control. When this concept is understood, on-site analytical tools can play a major role in making environmental decisionmaking more efficient, defensible, and cost-effective. In today's industrial and regulatory climate, practitioners are often required to make immediate decisions that are based on dependable, representative data. The term "representative data" means that there is some stability in the samples and assurance of data density. On-site analytical techniques offer that type of decision-making assurance to the user of the data.

Brownfields investigations require innovative approaches that are faster, cheaper, and better than common practices. The faster approach reduces sample turnaround times, facilitates in-field decision-making, and minimizes deployment time of crew and equipment. The more cost-effective approach is used to reduce analytical costs, field-labor costs, and completion times. The better approach results in data quality that is as accurate as that attained by fixed off-site laboratories and refined data analysis based on the results of on-site screening. Brownfields sites are essentially industrial sites at which people will want to take measurements, determine the extent of contamination, and institute a plan. The sampling designs for such sites will be dynamic in nature; therefore, the real-time analytical capability offered by field-portable instruments will be essential in successful sampling. Data representativeness will become increasingly important in site characterization and remediation projects in the near future because it supports the dynamic approach by providing real-time feedback. With liability an important consideration at brownfields sites, managing uncertainties and having representative data that reflect the true site conditions is critical to property transactions. Data representativeness can be used successfully to generate scientifically sound data that are able to support defensible project decisions at substantial cost savings over the cost of current practices.

A Quick Look

- Data quality is the function of the data's information content and its ability to represent the true state of a site.
- Data representativeness is the measure of the degree to which samples can be used to estimate the characteristics of the true state of a hazardous waste site.
- Brownfields are considered an "up-and-coming" application in which data quality and representativness will play an important role.

Increased sampling efficiencies, fostered by the use of innovative technologies, allow more targeted sample collection efforts that minimize the handling of samples that provide little value in meeting site-specific data quality objectives (DQO). Increased field analytical productivity is obtained when the type of analysis performed is targeted so that more samples can be analyzed each day, thereby bringing about more rapid site characterizations and verification of cleanup.

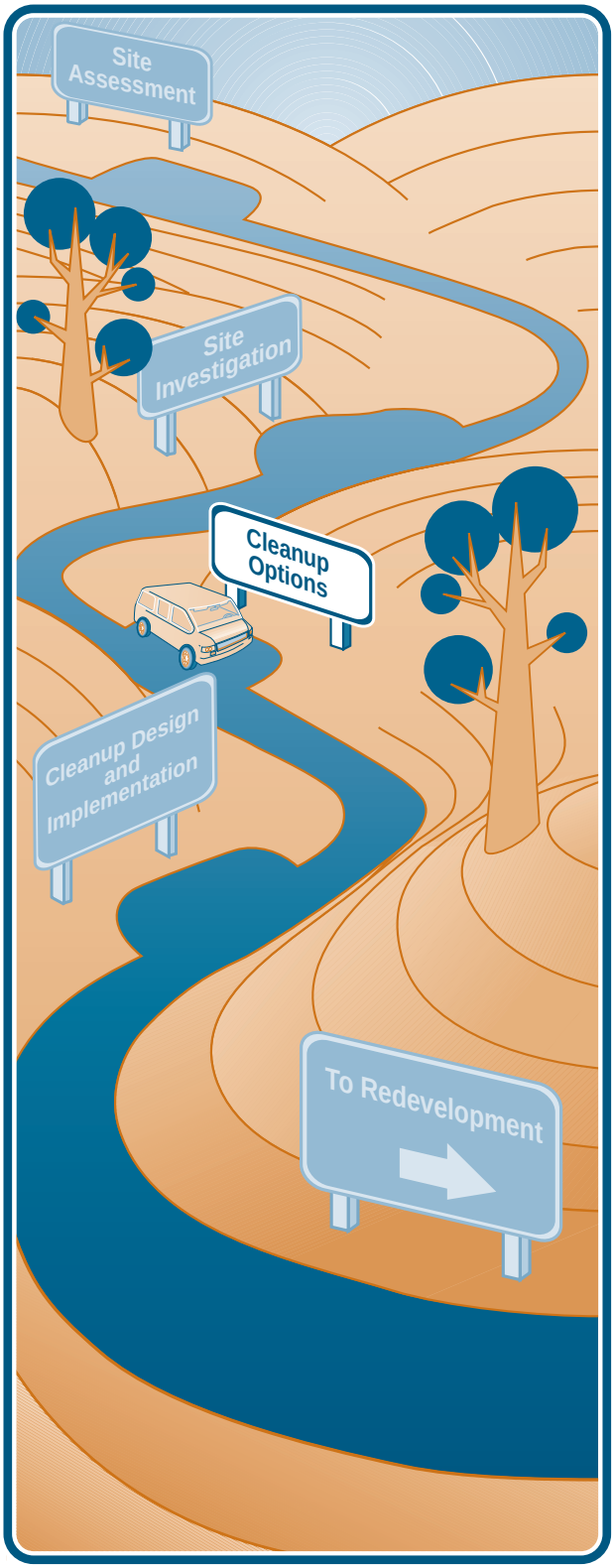
When data needs are articulated clearly, and when a number of modern sampling and analytical options are available, it is possible to optimize data collection so that the information produced is accurate for its intended purpose while still being less costly than previously possible. When applied carefully, on-site analytical methods offer representative and decision-quality data with the added benefits of increased sampling density and real-time availability of results.

Although traditional approaches have tended to focus heavily on the capabilities of definitive analytical methods, the effect of sampling error on the representativeness of monitoring and measurement activities also should be considered. It is important to determine how data obtained from quality assessment samples can be used to identify and control in the measurement process sources of sampling error and uncertainties.

By increasing sampling density, made possible and cost-effective with the use of new sampling and analytical tools, decision makers can reduce uncertainty and increase understanding of the true conditions of a site. This should increase comfort among site owners, buyers, regulators, and surrounding communities, as well as reduce the likelihood of errors and omissions that could negatively affect the site later.

For more information, see the resources numbered 33, 34, and 69 in the Index of Resources beginning on page I-1.

CLEANUP OPTIONS



Evaluate Applicable Cleanup Alternatives for the Site

The review and analysis of cleanup alternatives rely on the data collected during the site assessment and investigation phases, which are discussed in the preceding sections of the Road Map. The purpose of evaluating various technologies is to identify those technologies for their capability to meet specific cleanup and redevelopment objectives. For brownfields sites, it also is important to consider budget requirements and to maintain a work schedule so that the project remains financially viable.

The role of institutional controls, such as easements, covenants, zoning restrictions, and the posting of advisories to increase community awareness of the environmental conditions and cleanup activities at the site, also are important considerations during this phase. See Spotlight 11, *Understanding the Role of Institutional Controls at Brownfields Sites*, for more information about institutional controls.

What Do We Need To Know?

Factors that should be considered during the evaluation of cleanup options include:

1. How do we determine the appropriate and feasible level of cleanup? Are there federal, state, local, and tribal requirements for cleanup? Should risk-based approaches be considered as an option for assessing exposure (see the definition of risk-based corrective action [RBCA] in Appendix B, *List of Acronyms and Glossary of Key Terms*)? Are there prescribed standards for cleanup? Are there provisions for using presumptive remedies?
2. What factors are associated with the implementation of cleanup options? Will the cleanup facilitate or hinder the planned redevelopment? How long will cleanup take? What will cleanup cost? What are the short-term and long-term effects of the cleanup technologies under consideration?
3. Are the cleanup options compatible with regional or local planning and development goals and requirements? Can redevelopment activities (such as construction or renovation of buildings) be conducted concurrently with cleanup?

4. How can the community participate in the review and selection of cleanup options? Are the options acceptable in light of community concerns about protection during cleanup and reuse of the site? What environmental standards should be considered to ensure that community stakeholders are satisfied with the outcome and process of cleanup, given the intended reuse?
5. Is there a need for institutional controls after cleanup? Are proposed institutional controls appropriate in light of community concerns and access to and use of the property? Will institutional controls facilitate or hinder development? What plans, including financial assurances, are being made to ensure that institutional controls remain in place as long as contamination is present?
6. What options are available to monitor the performance of cleanup technologies?

How Do We Find The Answers?*

The process of reviewing and analyzing cleanup options and technology alternatives usually follows these steps:

- Establish goals for cleanup that consider the end use and use either published state or federal guidelines, RBCAs, or site-specific risk assessment results
- Educate members of the community about the site cleanup selection process and actively involve them in decision making
- Review general information about cleanup technologies to become familiar with those that may be applicable to a particular site:
  - *Use the resources in this publication*
  - *See Appendix A, Table A-3, Remedies for Types of Contaminants Found at Typical Brownfields Sites, for examples of technologies that are appropriate for specific types of contaminants*
  - *Conduct searches of existing literature that further describes the technology alternatives*
  - *Analyze detailed technical information about the applicability of technology alternatives*
- Narrow the list of potential technologies that are most appropriate for addressing the contamination identified at the site and that are compatible with the specific conditions of the site and the proposed reuse of the property:
  - *Network with other brownfields stakeholders and environmental professionals to learn about their experiences and to tap their expertise*
  - *Determine whether sufficient data are available to support identification and evaluation of cleanup alternatives*
  - *Evaluate the options against a number of factors, including toxicity levels, exposure pathways, associated risk, future land use, and economic considerations*
  - *Analyze the applicability of a particular technology to the contamination identified at a site*
  - *Determine the effects of various technology alternatives on redevelopment objectives*
- Continue to work with appropriate regulatory agencies to ensure that regulatory requirements are addressed properly:
  - *Consult with the appropriate federal, state, local, and tribal regulatory agencies to include them in the decision-making process as early as possible*
  - *Contact the EPA regional brownfields coordinator to identify and determine the availability of EPA support programs*
- Integrate cleanup alternatives with reuse alternatives to identify potential constraints on reuse and time schedules and to assess cost and risk factors
- To provide a measure of certainty and stability to the project, investigate environmental insurance policies, such as protection against cost overruns, undiscovered contamination, and third-party litigation, and integrate their cost into the project financial package
- Select an acceptable remedy that not only addresses the risk of contamination, but also best meets the objectives for redevelopment and reuse of the property and is compatible with the needs of the community
- Communicate information about the proposed cleanup option to brownfields stakeholders, including the affected community

** Please note that the Road Map seeks to answer technology selection questions and is not intended to provide a response to each procedural question identified.*

Where Do We Find Help To Our Technology Questions?

Examples of resources that will assist in reviewing and analyzing cleanup options are listed on the next page. Information about the availability of electronic resources — whether the item is found on the Road Map's accompanying CD-ROM or on various web sites — also is provided. *Appendix D, How to Order Documents*, provides complete ordering information for documents that are not available on the CD-ROM or on the Internet.

A. Resources for Cleanup Options

The documents listed below are resources that provide general information about the availability of technology resources in the form of bibliographies, status reports, and user guides.

ASTM Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (E1739-95e1)

Order on line at www.astm.org

The purpose of the guide is to define RBCA as a process for assessing and responding to a petroleum release in a manner that ensures the protection of human health and the environment. The guide will assist brownfields decision makers who wish to become familiar with another approach that can be used to assess environmental risk at a site, in conformity with applicable federal, state, local, and tribal regulations. The diversity and flexibility of a RBCA approach is defined and discussed, and the tiered approach of the process is summarized. Although the RBCA process is not limited to a particular site, the guide emphasizes the use of RBCA in response to releases of petroleum. Examples of RBCA applications also are provided. The guide, available at $45 per copy, can be downloaded from the ASTM web site or ordered by telephone at 610-832-9585 or by facsimile at 610-832-9555.

Breaking Barriers to the Use of Innovative Technologies: State Regulatory Role in Unexploded Ordnance Detection and Characterization Technology Selection

View or download the pdf file on the Road Map CD-ROM

The report, published in 2000 by the ITRC workgroup, contains an analysis of case studies from states having experience in remediating unexploded ordnance (UXO)-contaminated sites. The report supports early and meaningful state regulatory involvement in the selection of innovative unexploded ordnance characterization and remediation technologies. The report also offers recommendations to ensure the appropriate participation of states in the selection of technologies for characterizing and remediating UXO-contaminated sites.

Brownfields Technology Primer: Requesting and Evaluating Proposals That Encourage Innovative Technologies for Investigation and Cleanup (EPA 542-R-01-005)

View or download pdf file on the Road Map CD-ROM

The BTSC prepared this primer to assist site owners, project managers, and others preparing RFPs to solicit support in conducting activities to investigate and clean up contaminated sites. It is specifically intended to assist those individuals in writing specifications that encourage contractors and technology vendors to propose options for using innovative characterization and remediation technologies at brownfields sites. The primer also provides information, from a technology perspective, to guide review teams in their evaluations of proposals and the selection of qualified contractors.

Citizen's Guides to Understanding Innovative Treatment Technologies

View or download pdf files on the Road Map CD-ROM

The guides are prepared by EPA to provide site managers with nontechnical outreach materials that they can share with communities in the vicinity of a site. The guides present information on innovative technologies that have been selected or applied at some cleanup sites, provide overviews of the technologies, and present success stories about sites at which innovative technologies have been applied. Spanish versions of the guides are forthcoming. The guides contain information on the following subjects:

- *Bioremediation (EPA 542-F-01-001)*
- *Chemical oxidation (EPA 542-F-01-013)*
- *Fracturing (EPA 542-F-01-015)*
- *In situ flushing (EPA 542-F-01-011)*
- *In situ thermal treatment methods (EPA 542-F-01-012)*
- *Monitored natural attenuation (EPA 542-F-01-004)*
- *Permeable reactive barriers (EPA 542-F-01-005)*
- *Phytoremediation (EPA 542-F-01-002)*
- *SVE and air sparging (EPA 542-F-01-006)*
- *Soil washing (EPA 542-F-01-008)*
- *Thermal desorption (EPA 542-F-01-003)*

Clean-Up Information Home Page on the World Wide Web

View on line at http://clu-in.org

The Internet site provides information about innovative treatment technologies and site characterization technologies to the hazardous waste remediation community. CLU-IN describes programs, publications, and other tools for EPA and other federal and state personnel, consulting engineers, technology developers and vendors, remediation contractors, researchers, community groups, and individual citizens. Information about issues related to site remediation also is provided: technology descriptions and status reports; technology selection tools; programs and organizations; TIO perspectives; and publications.

Cost Estimating Tools and Resources for Addressing the Brownfields Initiatives (EPA 625-R-99-001)

Order on line at www.epa.gov/ncepihom

The guide is one in a series of publications designed to assist communities, states, municipalities, and the private sector to address brownfields sites more effectively. The guide, which is designed to be used with the three guides for specific types of sites - Technical Approaches to Characterizing and Cleaning Up Automotive Repair Sites Under the Brownfields Initiative, Technical Approaches to Characterizing and Cleaning Up Iron and Steel Mill Sites Under the Brownfields Initiative, and Technical Approaches to Characterizing and Cleaning Up Metal Finishing Sites Under the Brownfields Initiative - provides information about cost estimating tools and resources for addressing cleanup costs at brownfields sites. Many decision makers at brownfields sites may choose to assign the preparation of cost estimates to consultants who are experienced in the cleanup of hazardous waste sites; however, it benefits those decision makers to be able to provide guidance to their consultants and to understand the process sufficiently well to provide an informed review of the estimates prepared. The guide provides general information about the cost estimation process and includes summaries of various types of estimates. The guide also outlines the process of developing "order of magnitude" cost estimates. Information about resources, databases, and models also is provided.

Directory of Technology Support Services to Brownfields Localities (EPA 542-B-99-005)

View or download pdf file on the Road Map CD-ROM

The directory provides information about EPA offices, non-government organizations funded by EPA, and other federal agencies that may be able to provide expertise to assist in the selection of technologies for use in characterizing and cleaning up brownfields properties.

EPA REACH IT Online Searchable Database

View on line at www.epareachit.org

EPA REACH IT will assist those involved in brownfields projects to evaluate and select applicable remediation technologies, as well as to gather detailed information about the providers of those technologies. An online searchable database, EPA REACH IT provides comprehensive, up-to-date information about more than 1,300 remediation technologies that can be accessed through the guided and advanced search capabilities of the system. Examples of sites at which a particular type of technology has been implemented also are presented. The information is based upon data submitted by vendors and project managers for EPA, DoD, DOE, and state agencies, as well as information provided by suppliers of innovative technologies. EPA REACH IT is accessible only through the Internet.

Evaluation of Selected Environmental Decision Support Software (DSS)

View or download pdf file on the Road Map CD-ROM

Developed by DOE's Office of Environmental Management, the report evaluates DSS, computer-based systems that facilitate the use of data, models, and structured decision processes in making decisions related to environmental management. The report evaluates 19 such systems through the application of a rating system that favors software that simulates a wide range of environmental problems. It includes a glossary of terms and a statement of the rationale for the selection of various aspects of the performance of the DSS for evaluation.

Evaluation of Subsurface Engineered Barriers at Waste Sites (EPA 542-R-98-005)

View or download pdf file on the Road Map CD-ROM

The report provides a national retrospective analysis of the field performance of barrier systems, as well as information that could be useful in developing guidance on the use and evaluation of such systems. The report contains information about the design, application, and performance of subsurface engineered barriers.

Federal Remediation Technologies Roundtable (FRTR) Case Studies

View on line at www.frtr.gov/cost

The case studies provide the user information about specific remedial technology applications. FRTR case studies are developed by DoD, the U.S. Army Corps of Engineers (USACE), the U.S. Navy, the U.S. Air Force

(USAF), DOE, DOI, and EPA. The case studies focus on full-scale and large field demonstration projects and include information on site background, description of the technology, cost and performance of technology application, and lessons learned. Technologies include innovative and conventional treatment technologies for contaminated soil, groundwater, and solid media. Users can search the case studies by groups of contaminants, media, waste management practices that contribute to contamination, and treatment systems.

Guide to Documenting and Managing Cost and Performance Information for Remediation Projects (EPA 542-B-98-007)

View or download pdf file on the Road Map CD-ROM

The document recommends the types of data that should be collected to document the performance and cost of future cleanups. The guide specifies data elements for 13 conventional and innovative cleanup technologies: soil bioventing, soil flushing, soil vapor extraction, groundwater sparging, in situ groundwater remediation, pump-and-treat technologies, composting, incineration, land treatment, slurry-phase soil bioremediation, soil washing, stabilization, and thermal desorption. The document provides site managers with a standard set of parameters for documenting completed remediation projects. A number of federal agencies have made commitments to using the guidance to collect data for full-scale cleanups, demonstrations, and treatability studies.

Innovative Remediation and Site Characterization Technologies Resources (EPA 542-C-01-001)

Order on line at www.epa.gov/ncepihom

Produced by EPA's TIO, the CD-ROM contains resources that provide information to help federal, state, and private-sector site managers evaluate site assessment and cleanup alternatives. The ability to gain access to resources that provide information about innovative site characterization and remediation technologies will increase understanding of those technologies and of the cost and performance factors related to them. Such understanding is essential to the consideration of those technologies for use in addressing contamination at hazardous waste sites. Several resources included on the CD-ROM also are available on the Road Map CD-ROM.

Innovative Remediation Technologies: Field-Scale Demonstration Projects in North America, 2nd Edition (EPA 542-B-00-004)

View or download pdf files on the Road Map CD-ROM

A revision and expansion of EPA's publication, "Completed North American Innovative Technology Demonstration Projects," is now available in an online, searchable database of ongoing and completed field demonstrations of innovative remediation technologies sponsored by government agencies working in partnership with private technology developers to bring new technologies into the hazardous waste remediation marketplace.

Public Technology Inc.'s BrownfieldsTech.org

View on line at www.brownfieldstech.org

The web site, hosted by PTI, and sponsored in part by EPA's TIO, provides information about characterization and remediation of brownfields. The site focuses on the demonstration, dissemination, and promotion of innovative characterization and remediation technologies suitable for use at brownfields sites to help local governments increase efficiencies and reduce costs associated with brownfields redevelopment. The site highlights "hot" technologies that currently are proving themselves in the field, provides case studies that introduce the user to cities that are experiencing succession employing innovative site characterization and remediation technologies, profiles of local government leaders who are employing brownfields remediation technologies to good effect, and provides links to other key web sites.

Rapid Commercialization Initiative (RCI) Final Report for an Integrated In Situ Remediation Technology (Lasagna™) (DOE/OR/22459-1)

View or download pdf file on the Road Map CD-ROM

This report describes demonstration results for the Lasagna™ process, a process which uses established geotechnical methods to install degradation zones in contaminated soil and electrosmosis to move the contaminants back and forth through these zones until treatment is completed.

Remediation Technologies Screening Matrix and Reference Guide, Version 3.0 (PB98-108590)

View on line at www.frtr.gov/matrix/

The document is intended to assist site remediation project managers to narrow the field of remediation alternatives and identify potentially applicable technologies for more detailed assessment and evaluation before remedy selection. The document

S6 STATE DRYCLEANER REMEDIATION PROGRAMS:
An Innovative Approach to Cleanup

State-mandated programs have had a major impact on turning former drycleaner sites into marketable properties. With support from EPA's TIO, the State Coalition for Remediation of Drycleaners (SCRD) was established in 1998 to provide a forum for the exchange of information and the discussion of implementation issues related to established state drycleaner programs, share information and lessons learned, and encourage the use of innovative technologies in the remediation of drycleaner sites. The coalition is made up of representatives of states that have established drycleaner remediation programs, including Alabama, Florida, Illinois, Kansas, Minnesota, Missouri, North Carolina, Oregon, South Carolina, Tennessee, and Wisconsin.

A subgroup of the coalition has focused its efforts on conducting research about state programs and the use of innovative technologies to assess and remediate sites contaminated with drycleaning solvents. Its 1999 report, "Study of Assessment and Remediation Technologies for Drycleaner Sites" indicates that a variety of technologies are being used at drycleaner sites. For example, site characterization techniques include active and passive sampling of soil-gas, direct push techniques, geophysical techniques, and monitoring wells and borings. Several technologies for detecting dense nonaqueous phase liquids (DNAPL), a great concern at drycleaner sites, including ultraviolet fluorescence and hydrophobic dyes, also have been demonstrated to be effective. As described in the report, the methods most commonly used to reduce solvents present in soil include excavation, soil vapor extraction (SVE), and bioventing, and natural attenuation, air sparging, and multi-phase extraction for groundwater.

Even though many of the state programs are fairly new and most have very limited budgets, they have been effective in performing the necessary tasks in a timely manner. To date, the states' drycleaning programs have performed at least 236 site assessments and 100 remedial actions and closed 16 drycleaning sites. The numbers are increasing rapidly as the drycleaner programs in each state continue to mature.

A Quick Look

- Drycleaners use chlorinated solvents, particularly tetrachloroethene (PCE), in their operations, and have contributed to contamination of soil and groundwater at many brownfields sites.
- Contaminants likely to be found at drycleaner sites include: PCE, trichloroethene (TCE), and cis 1,2-dichloroethene (cis-DCE).
- Innovative technologies are of particular benefit to small drycleaner sites because limited funding for cleanup of such sites is often an issue.

For more information, see the resources numbered 62, 115, 132, and 133 in the Index of Resources beginning on page I-1.

KEY RESOURCE

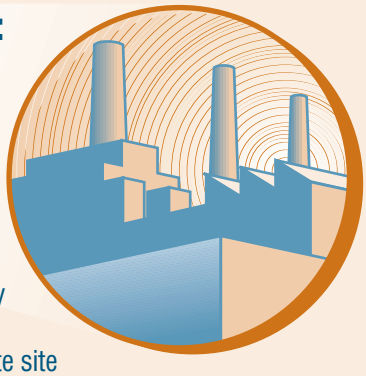
State Coalition for Remediation of Drycleaners (SCRD) Internet Site

View on line at www.drycleancoalition.org

The Internet site, supported by EPA's TIO, provides extensive information about state remediation programs and resources related to the remediation of drycleaner sites. Descriptions of state programs and points of contact in each of the 11 member states are provided. Publications, regulations, and other documents are identified as well. Brownfields stakeholders involved in the assessment and cleanup of drycleaner sites in Florida, Illinois, Kansas, Minnesota, North Carolina, Oregon, South Carolina, Tennessee, Washington, and Wisconsin may be particularly interested in the detailed information provided about programs in those states. Profiles of the remediation of specific sites throughout the U.S. are intended to assist users, particularly state officials, in making more informed decisions related to the remediation of sites in their states, and, when possible, to provide additional resources. Publications developed by the SCRD, as well as state and federal resources pertinent to issues associated with drycleaner sites, can be viewed on line or downloaded at no charge.

S7 REMEDIATING MANUFACTURED GAS PLANT SITES:

Emerging Remediation Technologies



From the early 1800s through the mid-1900s, manufactured gas plant (MGP) sites were operated nationwide to produce gas from coal or oil for lighting, heating, and cooking. The gas manufacturing and purification processes conducted at the plants yielded gas plant residues that included tars, sludges, lampblack, light oils, spent oxide wastes, and other hydrocarbon products. Although many of the by-products were recycled, excess residues remained at MGP sites. The residues contain polycyclic aromatic hydrocarbons (PAH), petroleum hydrocarbons, benzene, cyanide, metals, and phenols. The base contaminant, coal tar, is composed of a complex mixture of PAHs that generally exhibit low volatility, low solubility, and low biodegradability. Consequently, those components are difficult to treat.

There are an estimated 3,000 to 5,000 former MGP sites across the country; some of those sites still are owned by the successors to the utilities that founded them. MGPs typically were built on the outskirts of cities that since have grown. Today, therefore, the under-used sites often are located in inner city areas, many of which are being considered for redevelopment under the brownfields program. The redevelopment of MGP sites for reuse can help the utility industry turn potential liabilities into assets. For example, in the city of Fort Myers, Florida, a former MGP site was redeveloped into a private, nonprofit museum and aquarium called the Imaginarium.

As the business environment has spurred companies to reassess land holdings and better manage environmental concerns, the MGP sites have become a central focus. Many companies are investigating and remediating such sites. The similarities in the configuration of the sites and in the contaminants found at them provide opportunities to apply innovative approaches that benefit from economies of scale. Former MGP sites offer an ideal opportunity to apply tools and technologies that expedite site characterization and source remediation.

A Quick Look

- Although MGPs have closed and most have been demolished, such facilities have left a legacy of environmental contamination.
- Releases of coal tars, oils, and condensates produced in MGP plants contributed to a wide range of contamination with PAHs, phenols, benzene, and cyanide.
- As utilities discover more MGP sites, they are faced with the need to identify cost-effective, environmentally safe, and innovative approaches for the characterization and remediation of those sites.

Thermal desorption has been used successfully to remediate soils that contain MGP wastes (for example, lampblack and coal tar), achieving reductions of more than 98 percent in concentrations of PAHs; total petroleum hydrocarbons (TPH); benzene, toluene, ethylbenzene, and xylene (BTEX) compounds; and cyanide. Performance data have demonstrated that less than 10 parts per billion (ppb) of residual PAHs and cyanides can be achieved through the application of thermal desorption. Other technologies that have proven successful in remediating MGP wastes include co-burning in utility boilers, recycling in road beds, in situ bioremediation, landfarming, and soil washing.

Because former MGP sites are prevalent and represent a large area of unused land with complex remedy needs, new technologies are being encouraged and field-tested to demonstrate their technical feasibility. Opportunities exist to demonstrate and refine new assessment and remediation technologies that can assist in expediting cleanup processes that can place these contaminated sites back into productive use.

For more information, see the resource numbered 120 in the Index of Resources beginning on page I-1.

summarizes the strengths and weaknesses of innovative and conventional technologies for remediation of soils, sediments, sludges, groundwater, surface water, and air emissions and off-gases; it focuses primarily on demonstrated technologies. Treatment, containment, separation of wastes, and enhanced recovery technologies are covered. Additional references and information resources also are included.

Reuse Assessments: A Tool to Implement the Superfund Land Use Directive (OSWER Directive 9355.7-06P)

View or download pdf file on the Road Map CD-ROM

The memorandum, signed June 4, 2001 by EPA's OERR, presents information that supports the development of assumptions related to future land use when making remedy selection decisions for response actions conducted at Superfund sites. The Reuse Assessment guide, which provides information about the collection and evaluation of information for developing assumptions, and the Superfund Land Use Directive, which provides basic information about developing and using future land use assumptions to support Superfund remedial actions, are included as attachments to the directive.

Site Remediation Technology InfoBase: A Guide to Federal Programs, Information Resources, and Publications on Contaminated Site Cleanup Technologies, Second Edition (EPA 542-B-00-005)

View or download pdf file on the Road Map CD-ROM

Prepared by the member agencies of the FRTR, the guide identifies programs, resources, and publications of the federal government related to technologies for the cleanup of contaminated sites.

Superfund Innovative Technology Evaluation (SITE) Program: Technology Profiles, Tenth Edition

View on line at www.epa.gov/ORD/SITE/profiles3.htm

The SITE documents, contained in three separate volumes, provide profiles of more than 150 demonstration, emerging, and monitoring and measurement technologies currently being evaluated. Each technology profile identifies the developer and process name of the technology, describes the technology, discusses its applicability to waste, and provides a project status report and contact information. The profiles also include summaries of demonstration results, if available.

The following volumes are available:

- *Demonstration Program, Volume 1 (EPA 540-R-99-500A)*
- *Emerging Technology Program, Volume 2 (EPA 540-R-99-500B)*
- *Monitoring and Measurement Program, Volume 3 (EPA 540-R-99-500C)*

Synopses of Federal Demonstrations of Innovative Site Remediation Technologies, Third Edition (EPA 542-B-93-009, PB94-144565)

Order on line at www.epa.gov/ncepihom

The document is a compilation of abstracts that describe field demonstrations of innovative technologies that treat hazardous waste at contaminated sites. The abstracts are information resources that hazardous waste site project managers can use to assess the availability and practicability of innovative technologies for treating contaminated groundwater, soils, and sludge. The document describes more than 110 demonstrations, sponsored by federal agencies, in six different technology categories, involving the use of innovative technologies to treat soil and groundwater. A matrix that lists the demonstration categories, the type of contaminant, media that can be treated, and the treatment setting for each innovative technology demonstrated also is provided in the document.

Tank RACER Software Program

View on line at www.epa.gov/swerust1/tnkracr1.htm

Tank Remedial Action Cost Engineering and Requirements (RACER) is a Windows™-based system that provides fast, accurate, and comprehensive cost estimates for cleanups at petroleum and UST sites. The software estimates costs for cleanups on a site-specific basis for all phases of remediation, including site assessment, remedial design, remedial action, operation and maintenance, tank closure, and site work and utilities, as well as the costs of using alternative technologies, such as air sparging, bioremediation, bioventing, groundwater extraction wells, land farming, natural attenuation, SVE, and thermal desorption. The software was developed under an interagency agreement between the USAF and EPA. A newer version, Tank RACER 2001, is now available. Visit the web site identified above for more information.

TechKnow™ Database

View on line at www.techknow.org

Developed by the Global Network of Environment & Technology (GNET), TechKnow is an online, interactive database which allows users to gain access to and provide information about innovative and sustainable technologies. For each technology profiled, a summary, development information, status, and cost is provided. The Internet site also

provides contact information for the technologies. Users may access the TechKnow database at the Internet site identified above. There is no cost to use TechKnow, but users are required to register on GNET.

Treatment Technologies for Site Cleanup: Annual Status Report (ASR) (Tenth Edition) (EPA 542-R-01-004)
View or download pdf file on the Road Map CD-ROM
The ASR documents, as of summer 2000, the status of treatment technology applications at more than 900 soil and groundwater cleanup projects in the Superfund program, selected RCRA corrective action sites, and DOE and DoD sites. The report updates the projects included in the ASR ninth edition and provides information about projects obtained from 96 records of decision (ROD) signed in 1998 and 1999. The report examines both source control technologies (addressing soil, sludge, sediment, and other solid wastes) and innovative groundwater treatment technologies. For the most frequently selected technologies in the Superfund remedial program, the report analyzes selection trends over time, contaminant groups treated, quantity of soil treated (for soil treatment technologies), and the status of project implementation.

U.S. Department of Energy (DOE) Preferred Alternatives Matrices (PAMs)
View on line at www.em.doe.gov/define
Developed by DOE, the PAMs web site provides access to evaluations of site characterization and remediation technologies preferred by DOE on the basis of the types of contaminants and contaminated media selected. PAMs was developed by DOE's Office of Environmental Restoration (EM-40) to assist decision makers in selecting the most appropriate cleanup alternatives for remediation, waste processing, and decommissioning of sites. It provides a tool for field personnel to use in focusing remedy selection; expediting implementation of preferred alternatives; eliminating the cost of excessive or redundant treatability studies; and allowing preselection of effective, low-cost remediation alternatives.

B. Site-Specific Resources for Cleanup Options

Listed below are survey reports on the application of innovative technologies to specific contaminants and site types.

Assessment of Phytoremediation as an In-Situ Technique for Cleaning Oil-Contaminated Sites
View or download pdf file on the Road Map CD-ROM
The document, which is based on a review of the relevant literature, provides examples of the phytoremediation of petroleum hydrocarbons and discusses the key mechanisms of that process, as well as the special considerations involved in phytoremediation of petrochemicals. The document also discusses the benefits, limitations, and costs of phytoremediation, compared with alternative approaches, including natural attenuation, engineering, and bioremediation.

Bioremediation and Phytoremediation of Pesticide-Contaminated Sites, The
View or download pdf file on the Road Map CD-ROM
The technology assessment report discusses the use of bioremediation and phytoremediation for the cleanup of sites contaminated with pesticides. It provides information about the current status of the two technologies to federal and state agencies, consulting engineering firms, private industries, and technology developers.

Catalog of EPA Materials on USTs (EPA 510-B-00-001)
View or download pdf file on the Road Map CD-ROM
The booklet provides an annotated list of UST materials and includes ordering information. Many of the informational leaflets, booklets, videos, and software items listed are designed to provide UST owners and operators with information to help them comply with the federal UST requirements.

EPA ORD Brownfields Guides
View on line at www.epa.gov/ncepihom/nepishom
The series of publications are designed to assist communities, states, municipalities, and the private sector to address brownfields sites more effectively. The guides provide decision makers, such as city planners, private sector developers, and others who are involved in redeveloping brownfields, with a better understanding of the technical issues involved in assessing and cleaning up automotive repair sites, iron and steel mill sites, and metal finishing sites.

After reading the guides, the user will have a better understanding of activities commonly carried out at such sites and how those activities might cause the release of contaminants into the environment. The guides also provide information about the types of contaminants often found at such sites; a discussion of site assessment, screening and cleanup levels, and cleanup technologies; a conceptual framework for identifying potential contaminants; information about developing a cleanup plan; and a discussion of issues and special factors that should be considered when developing plans and selecting technologies. The following guides are available:

- *Technical Approaches to Characterizing and Cleaning Up Automotive Repair Sites Under the Brownfields Initiative (EPA 625-R-98-008)*
- *Technical Approaches to Characterizing and Cleaning Up Iron and Steel Mill Sites Under the Brownfields Initiative (EPA 625-R-98-007)*
- *Technical Approaches to Characterizing and Cleaning Up Metal Finishing Sites Under the Brownfields Initiative (EPA 625-R-98-006)*

Groundwater Cleanup: Overview of Operating Experience at 28 Sites (EPA 542-R-99-006)

View or download pdf file on the Road Map CD-ROM

The report summarizes information about the groundwater remediation systems at 28 sites throughout the U.S. at which completed or ongoing groundwater cleanup programs are in place. It includes details about design, operation, and performance of the systems; capital, operating, and unit costs of the systems; and factors that potentially affect the cost and performance of the systems. The report compares and contrasts data from the case studies to assist those involved in evaluating and selecting remedies for groundwater contamination at hazardous waste sites. Of the 28 projects presented in the case studies, 24 are Superfund remedial actions, one is a Superfund removal action, one is a cleanup conducted by state authorities, and two are corrective actions taken under RCRA. The sites represent a range of site types and hydrogeological conditions.

How To Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers (EPA 510-B-94-003, S/N 055-000-00499-4)

Order on line at www.epa.gov/ncepihom

The guide was developed to assist state regulators in efficiently and confidently evaluating corrective action plans (CAP) that incorporate alternative technologies. The guide, written in nontechnical language, takes the reader through the steps involved in reviewing a CAP. Each chapter presents a comprehensive description of the technology, an explanation of how it works, and a flow chart that illustrates the decision points in the process; information that will help the regulator evaluate whether a given technology will clean up a given site successfully; discussion and instruction to help the regulator evaluate whether a CAP is technically sound; a check list to assist the regulator in determining whether or not the CAP includes all the steps necessary; and a list of references.

IDC Home Page

View on line at www.getf.org/dnaplguest

The web site is sponsored by the Interagency Dense Nonaqueous Phase Liquid (DNAPL) Consortium (IDC). It reports on the IDC's effort to evaluate and compare the cost and performance of three innovative remediation technologies for the treatment of DNAPLS. The three technologies are being applied for the treatment of trichloroethylene (TCE) at Launch Complex 34 at Cape Canaveral Air Force Station, Florida. The three technologies being demonstrated in side-by-side plots at the launch area are chemical oxidation with the use of potassium permanganate, six-phase heating, and dynamic underground stripping.

Innovative Measures for Subsurface Chromium Remediation: Source Zone, Concentrated Plume, and Dilute Plume; Environmental Research Brief (EPA 600-S-97-005)

View or download pdf file on the Road Map CD-ROM

This report describes innovative measures for addressing chromium contamination in each of the three areas described in the title. For the source zone, surfactant-enhanced chromium extraction is evaluated; for the concentrated plume, polyelectrolyte-enhanced ultrafiltration is evaluated; and for the dilute plume, the effectiveness of the permeable barrier wall is evaluated.

MTBE Fact Sheet #2: Remediation of MTBE-Contaminated Soil and Groundwater (EPA 510-F-98-002)

View or download pdf file on the Road Map CD-ROM

Developed by EPA's OUST, the fact sheet describes the physical and chemical characteristics of methyl tert butyl ether (MTBE) and identifies alternative technologies for remediating it.

NATO/CCMS Pilot Study Evaluation of Demonstrated and Emerging Technologies for the Treatment of Contaminated Land and Groundwater (Phase III) 2000 Annual Report (EPA 542-R-01-001)

View or download pdf file on the Road Map CD-ROM

The volume presents updated summaries of information about 29 projects, as well as reports on legislative, regulatory, programmatic, and research issues related to contaminated land in each participating country.

Pay-For-Performance Cleanups: Effectively Managing Underground Storage Tank Cleanups (EPA 510-B-96-002)

View on line at www.epa.gov/ncepihom/nepishom

Pay-for-performance cleanup agreements allow users to pay contractors a fixed price as measurable environmental goals are reached, rather than paying using a more typical time-and-materials contract. This document focuses on the experience of the UST Bureau of the New Mexico Environment Department and is supplemented by the experience and ideas of representatives of other states, contractors, and EPA. The document is intended as a starting point for owners of USTs to use in designing pay-for-performance cleanup programs. The document first identifies the advantages of pay-for-performance cleanup agreements, such as cost and time savings. It then explains how to implement a pay-for-performance cleanup program. Many tips for ensuring the success of pay-for-performance agreement programs are provided. It also presents information about enlisting the support of stakeholders, such as that of state technical and funding staff, government auditors, legislators and legislative staff, and cleanup contractors. In addition to providing instructions for constructing such an agreement, the document provides an example of how to calculate performance payments.

Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites (EPA 540-R-96-023)

Order on line at www.epa.gov/ncepihom

Produced by EPA's OERR, the guidance defines EPA's presumptive response strategy and discusses technologies for the ex situ treatment component of a groundwater remedy. It also explains how EPA intends to exercise its discretion in implementing the National Contingency Plan (NCP).

Rapid Site Assessment Applied to the Florida Department of Environmental Protection's Drycleaning Solvent Cleanup Program

View or download pdf file on the Road Map CD-ROM

The 1997 report describes the use of rapid site assessments to characterize soil and groundwater contamination at drycleaning facilities. Conducted under the Florida Department of Environmental Protection's Drycleaning Solvent Cleanup Program (DSCP), the rapid site assessments are an innovative approach used to address site assessment and cleanup of contaminated drycleaning facilities. The paper describes legislative, administrative, and technical aspects of the program that permit drastic reductions in the time and costs associated with assessing soil and groundwater contamination for this site type.

Recent Developments for In Situ Treatment of Metal-Contaminated Soils (EPA 542-R-97-004)

View or download pdf file on the Road Map CD-ROM

The document provides hazardous waste cleanup professionals with an update on the status of four available and promising technologies for in situ remediation of soil contaminated with heavy metals: electrokinetics; phytoremediation; soil flushing; and solidification and stabilization. The report is intended to assist in screening new technologies early in the remedy evaluation and selection process.

Resource for MGP Site Characterization and Remediation: Expedited Site Characterization and Source Remediation at Former Manufactured Gas Plant Sites (EPA 542-R-00-005)

View or download pdf file on the Road Map CD-ROM

The document provides current information about useful approaches and tools being applied at former MGP sites to the regulators and utilities that are engaged in characterizing and remediating these sites. The document outlines site management strategies and field tools for expediting site characterization at MGP sites; presents a summary of existing technologies for remediating MGP wastes in soils; provides sufficient information about the benefits, limitations, and costs of each technology, tool, or strategy for comparison and evaluation; and provides, through case studies, examples of the ways in which those tools and strategies can be implemented at MGP sites.

State Coalition for Remediation of Drycleaners (SCRD) Internet Site
View on line at www.drycleancoalition.org
The Internet site, supported by EPA's TIO, provides extensive information about state remediation programs and resources related to the remediation of drycleaner sites. Descriptions of state programs and points of contact in each of the 11 member states are provided. Publications, regulations, and other documents are identified as well. Brownfields stakeholders involved in the assessment and cleanup of drycleaner sites in Florida, Illinois, Kansas, Minnesota, North Carolina, Oregon, South Carolina, Tennessee, Washington, and Wisconsin may be particularly interested in the detailed information provided about programs in those states. Profiles of the remediation of specific sites throughout the U.S. are intended to assist users, particularly state officials, in making more informed decisions related to the remediation of sites in their states, and, when possible, to provide additional resources. Publications developed by the SCRD, as well as state and federal resources pertinent to issues associated with drycleaner sites, can be viewed on line or downloaded at no charge.

State Programs to Clean Up Drycleaners
View on line at www.drycleancoalition.org/survey
Prepared by the SCRD with the support of EPA's TIO, the report presents a survey that focuses on three principal areas: general administrative issues, fee and fund solvency issues, and benefits associated with the various programs. The report provides information about the number of sites in the various state programs, the remediation stage of each site, the system for setting priorities among sites, the fee system, the fee structure, average fees, deductibles and insurance coverage, revenues collected, fund balances, benefits of participation, limit of funds, and requirements of facility owners and operators. Detailed tables that present data gathered during the survey are included as an appendix to the report.

Treatment Experiences at RCRA Corrective Actions (EPA 542-F-00-020)
View or download pdf file on the Road Map CD-ROM
The fact sheet summarizes information about the use of treatment technologies at 30 RCRA corrective action sites. It focuses on ongoing or completed cleanups of contaminated soil or groundwater at RCRA sites for which key information, such as the type of technology used and the point of contact, was available. The sites illustrate the types of cleanups conducted at RCRA corrective action sites; they are not intended to be representative of all cleanups conducted under RCRA.

Treatment Technology Performance and Cost Data for Remediation of Wood Preserving Sites (EPA 625-R-97-005)
Order on line at www.epa.gov/ttbnrmrl/625/R-97/005.htm
The document presents information about applicable treatment alternatives for the remediation of soil and groundwater at wood preserving sites. The document provides decision makers with a better understanding of technologies suitable for cleaning up such sites. Background information about the wood preserving industry in general is presented, as well as information about contaminants commonly found at wood preserving sites, such as PCPs, PAHs, dioxins and furans, and inorganic compounds. The document describes a number of technologies that have been used to remediate wood preserving sites; treatability and case studies also are presented. Additional sources of information are provided.

Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites
View or download pdf file on the Road Map CD-ROM
The policy directive, issued April 21, 1999, provides guidance to the staff of EPA, the public, and the regulated community on how EPA intends to exercise its discretion in implementing national policy on the use of monitored natural attenuation for the remediation of contaminated soil and groundwater at sites regulated under the programs of EPA's OSWER.

C. Technology-Specific Resources for Cleanup Options

The documents listed below provide detailed information about specific innovative technologies and the application of those processes to specific contaminants and media in the form of engineering analyses, application reports, technology verification and evaluation reports, and technology reviews.

Anaerobic Biodegradation of BTEX in Aquifer Material; Environmental Research Brief (EPA 600-S-97-003)
View or download pdf file on the Road Map CD-ROM
The study focuses on anaerobic biodegradation of BTEX isomers in aquifer material from two petroleum-contaminated aquifers. Two different techniques were used to evaluate the ability of indigenous microorganisms to anaerobically degrade BTEX and to estimate the rate of degradation.

Analysis of Selected Enhancements for Soil Vapor Extraction (EPA 542-R-97-007)
View or download pdf file on the Road Map CD-ROM
The report provides an engineering analysis of, and status report on, selected enhancements for SVE treatment technologies. The report is intended to assist project managers who are considering an SVE treatment system by providing then with an up-to-date report on the status of enhancement technologies; an evaluation of each technology's applicability to various site conditions; a presentation of cost and performance information; a list of vendors that specialize in the technologies; a discussion of the relative strengths and limitations of the technologies; recommendations of factors to be kept in mind when considering the enhancements; and a compilation of references. The five enhancement technologies discussed in the report are air sparging, dual-phase extraction, directional drilling, pneumatic and hydraulic fracturing, and thermal enhancement.

Assessment and Remediation of Contaminated Sediments (ARCS) Program: Guidance for In Situ Subaqueous Capping of Contaminated Sediments (EPA 905-B-96-004)
View on line at www.epa.gov/glnpo/sediment/iscmain/index.html
Published by EPA's Great Lakes National Program Office, the document provides technical guidance for subaqueous, in situ capping as a remediation technique for contaminated sediments. Descriptions of the processes, identification of the design requirements, and a recommended sequence for design also are provided.

Bioremediation in the Field Search System (BFSS) Version 2.1
View or download database on the Road Map CD-ROM
The searchable database provides information about sites at which bioremediation is being tested or implemented or at which cleanup by bioremediation has been completed. The database covers sites being addressed under CERCLA, RCRA, TSCA, as well as those being addressed under the UST Program. Information is available about location, media, contaminants, technology, cost, and performance.

Bioremediation of Chlorinated Solvent Contaminated Groundwater
View or download pdf file on the Road Map CD-ROM
The report is intended to provide a basic summary of in situ treatment technologies for groundwater contaminated with chlorinated solvents. It includes information gathered from a range of currently available sources, including project documents, reports, periodicals, Internet searches, and personal communication with parties involved in the use of the technologies.

Brownfields Technology Primer: Selecting and Using Phytoremediation for Site Cleanup (EPA 542-R-01-006)
View or download pdf file on the Road Map CD-ROM
The BTSC developed this document to provide an educational tool for site owners, project managers, and regulators to help evaluate the applicability of the phytoremediation process at brownfields sites. The primer explains the types of biological processes involved in phytoremediation; provides examples of the sites and contaminants where phytoremediation has been applied; and discusses technical considerations in selecting and designing phytoremediation systems, activities necessary to operate and maintain phytoremediation systems, and examples of estimated potential cost savings from using phytoremediation versus more conventional treatment processes. The primer also provides a comprehensive list of other resources that are available to assist decision makers in evaluating phytoremediation as an option for cleaning up contaminated sites.

California Environmental Technology Certification Program - California Certified Technologies List
View on line at www.calepa.ca.gov/calcert
The Cal/EPA Environmental Technology Certification program Internet site provides the user access to the California Certified Technologies List. The document provides a list of technologies and their respective vendors that have been certified by the state of California. Certification is granted to technologies on the basis of an independent, third-party verification of the technology's performance and ability to meet regulatory specifications and requirements. Developers and manufacturers define quantitative performance claims for their technologies and provide supporting documentation. Cal/EPA reviews that information and, when necessary, conducts additional testing to verify the claims. Technologies, equipment, and products that are proven to work as claimed receive official state certification.

CLU-IN Technology Focus
View on line at http://clu-in.org
Technology Focus, a section of EPA TIO's CLU-IN site, provides a compilation of the most relevant information sources about a

range of remediation technologies. Grouped by specific technology, the resources provide a description, information about the applications and use of the technology, relevant engineering and regulatory guidance, and links to training sources and additional references. Information about the following technologies are available: air sparging, bioremediation of chlorinated solvents, bioventing/ biosparging, fracturing, groundwater circulating wells, in situ flushing, in situ oxidation, multi-phase extraction, natural attenuation, permeable reactive barriers, phytoremediation, soil vapor extraction, and thermal desorption.

Cost Analyses for Selected Groundwater Cleanup Projects: Pump-and-Treat Systems and Permeable Reactive Barriers (EPA 542-R-00-013)

View or download pdf file on the Road Map CD-ROM

Developed on the basis of case studies prepared by EPA, other members of the Federal Remediation Technologies Roundtable, and the Remediation Technologies Development Forum, the report presents the results of an analysis of groundwater cleanup costs for pump-and-treat systems and permeable reactive barriers (PRB) at 48 sites. Targeted for site managers, technology developers, and users, as well as others involved in groundwater remediation efforts, the report provides detailed information about the costs of groundwater cleanup technologies and factors that affect those costs. Of the 48 sites, 32 were pump-and-treat systems and 16 were PRBs.

Engineered Approaches to In Situ Bioremediation of Chlorinated Solvents: Fundamentals and Field Applications (EPA 542-R-00-008)

View or download pdf file on the Road Map CD-ROM

The report provides an overview of in situ bioremediation for the remediation of chlorinated solvents in contaminated soil and groundwater. It describes mechanisms for the degradation of chlorinated solvents, enhancements of such mechanisms by the addition of various materials and chemicals, design approaches, and factors to consider when selecting and using the technology. The report also presents a list of vendors of the technology and nine case studies of field applications.

Engineering and Design: Adsorption Design Guide (DG 1110-1-2)

View or download pdf file on the Road Map CD-ROM

The guide, published by the U.S. Army Corps of Engineers, provides practical guidance for the design of liquid- and vapor-phase devices for the adsorption of organic chemicals. The adsorptive media addressed include granular activated carbon (GAC) and other alternative adsorption media, such as powdered activated carbon (PAC) and non-carbon adsorbents. It addresses various types of adsorption media, applicability, use of various adsorption process technologies, design of equipment and ancillary components, availability, advantages, disadvantages, regeneration methods, costs, and safety considerations.

EPA Region 5 Monitored Natural Attenuation Report

View or download pdf file on the Road Map CD-ROM

The report describes a natural attenuation field study conducted jointly by EPA Region 5, the Wisconsin Department of Natural Resources, the Illinois Environmental Protection Agency, and Amoco Corporation that has been underway since October 1994.

Field Applications of In Situ Remediation Technologies: Chemical Oxidation (EPA 542-R-98-008)

View or download pdf file on the Road Map CD-ROM

The document describes recent pilot demonstrations and full-scale applications of chemical oxidation processes that treat soil and groundwater in place or increase the solubility and mobility of contaminants to improve their removal by other remediation technologies.

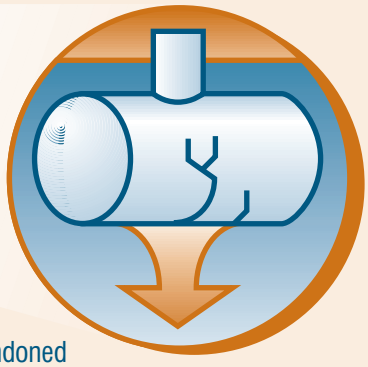
Field Applications of In Situ Remediation Technologies: Ground-Water Circulation Wells (EPA 542-R-98-009)

View or download pdf file on the Road Map CD-ROM

The report is one in a series of reports that document recent pilot demonstrations and full-scale applications that treat soil and groundwater in situ or increase the solubility and mobility of contaminants to improve their removal by other remediation technologies. It is hoped that the information provided will facilitate more frequent consideration of new, less costly, and more effective technologies to address the problems associated with hazardous waste sites and petroleum contamination.

S8 UNDERGROUND STORAGE TANKS AT BROWNFIELDS SITES:

Technology Options for Tank Remediation



Of the estimated 450,000 brownfields sites in the U.S., approximately 100,000 to 200,000 contain abandoned underground storage tanks (UST) or are affected by leaks of petroleum from such tanks. With so many sites requiring remediation, EPA is promoting faster, more effective, and less costly alternatives to established cleanup methods. Although established technologies, such as pump-and-treat systems or the excavation and disposal in a landfill, have proven effective and are frequently used, innovative technologies may be applicable for cleanup of USTs.

EPA's Office of Underground Storage Tanks (OUST) has worked with EPA's Office of Research and Development (ORD) to foster development of innovative site assessment and cleanup technologies, such as field measurement techniques, soil vapor surveying, vacuum-enhanced free product recovery, active and passive bioremediation, and monitored natural attenuation. OUST continues to encourage scientifically sound, rapid, and cost-effective corrective action at UST sites. It also encourages the use of expedited site assessments as a means of streamlining the corrective action process, improving data collection, and reducing the overall cost of remediation.

EPA's OUST is undertaking the USTFields initiative to address petroleum contamination from abandoned tanks generally excluded from EPA's Brownfields Economic Redevelopment Initiative. The initiative also is intended to take advantage of the many advances in brownfields work that can be applied at the numerous USTFields sites. Like the brownfields program, the USTFields program provides grants to states for community pilot projects to plan cleanups, eliminate contamination of groundwater, protect public health, and allow the future economic development of such sites. When grants are awarded, special consideration is given to cities that are experiencing problems related to contamination with MTBE. EPA believes the USTFields Initiative will demonstrate how to make better use of limited resources to clean up sites affected by petroleum contamination, thereby fostering the redevelopment of those sites.

A Quick Look

- USTs are present at many brownfields sites because the owners have closed their businesses and do not have the funds necessary to remove tanks or properly clean up the tanks.
- Contaminants likely to be found at UST sites include petroleum hydrocarbons; gasoline; diesel fuel; methyl tertiary butyl ether (MTBE); benzene, toluene, ethylbenzene, and xylene (BTEX); JP-4 jet fuels; and solvents.
- The USTFields Initiative, a new program of EPA's OUST, focuses attention on abandoned or underused industrial and commercial properties at which redevelopment is complicated by environmental contamination originating from USTs.

For more information, see the resources numbered 8, 11, 23, 52, 93, 101, 140, 155, and 156 in the Index of Resources beginning on page I-1.

KEY RESOURCE

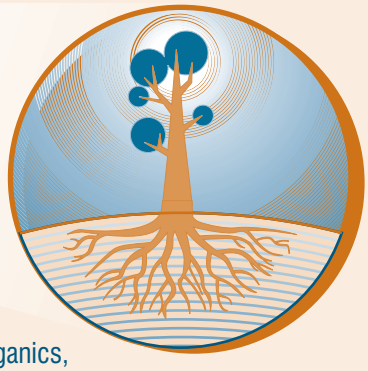
EPA's Office of Underground Storage Tanks Internet Site

View on line at www.epa.gov/oust

Hosted by EPA's OUST, the Internet site provides resources and tools to assist owners and operators of USTs and brownfields stakeholders to better assess their options for the operation, maintenance, and cleanup of USTs. Information and guidance about technologies suitable for cleaning up releases from UST systems are provided, as well as details about current federal UST regulations and UST program priorities, including specific details about the USTFields Initiative. Points of contact in each of the EPA regional offices also are identified. An extensive number of UST publications can be viewed on line or downloaded at no charge. In addition, information about state-sponsored UST programs, including links to state Internet sites, is provided on OUST's site at *www.wpa.gov/swerust1/states/index.htm*.

S9 PHYTOREMEDIATION TECHNOLOGY:

A Growing Field



Phytoremediation includes the use of plants and natural processes to remediate or stabilize hazardous wastes in soil, sediments, surface water, or groundwater. By acting as filters or traps, plants can degrade organic pollutants, extract metal contaminants, or contain and stabilize the movement of contaminants. Phytoremediation first was tested actively at waste sites in the early 1990s, and use of the approach has been increasing. Phytoremediation has been implemented on a full or demonstration scale at more than 200 sites nationwide. As the number of projects grows, new information about the cost and performance of phytoremediation will become available.

Phytoremediation provides many advantages because it has the potential to work at a broad variety of sites and on myriad contaminants involving potentially less costs than other options. Types of sites at which phytoremediation has been applied with some degree of success in cleaning up the sites include: pipelines, industrial and municipal landfills, agricultural fields, wood treatment sites, military installations, fuel storage tank farms, army ammunition plants, sewage treatment plants, and mining sites.

A Quick Look

- An aesthetically pleasing, passive cleanup technology powered by solar energy.
- A technology that is most useful at sites at which shallow, low levels of contamination are present.
- A cost-effective technology that has the potential to clean up a wide variety of brownfields sites.
- Can also be used for other functions related to site cleanup, such as erosion control and runoff control.

Phytoremediation is being tested and evaluated for its effectiveness in treating a wide array of contaminants found at brownfields sites. Current results indicate that plants have the potential to enhance remediation of petroleum hydrocarbons; benzene, ethylbenzene, toluene, and xylene (BTEX); polycyclic aromatic hydrocarbons (PAH); polychlorinated biphenyls (PCB); chlorinated solvents; heavy metals; and pesticide waste. In addition to providing a long-term solution, phytoremediation is an excellent option for providing an interim solution for containing the spread of contaminants and beginning the treatment process. Phytoremediation does not require the excavation of soil, and its application may require only minimal material handling. Further, phytoremediation can have a positive effect on the aesthetic character of a site, may be an attractive alternative for use at large sites at which other methods of remediation are not cost-effective or practical, and can be used in conjunction with other technologies when the redevelopment and land use plans for the site include the use of vegetation.

Decision makers at brownfields sites at which there are relatively low concentrations of contaminants (that is, organics, nutrients, or metals) over a large cleanup area and in shallow soils, streams, and groundwater should consider the use of phytoremediation. Phytoremediation also may be considered for use in conjunction with other technologies when redevelopment and land use plans for a site include the use of vegetation. Among the types of plants used for phytoremediation are: hybrid poplar, willow, and cottonwood trees; rye, Bermuda, sorghum, and fescue grasses; legumes (clover, alfalfa, and cowpeas); aquatic and wetland plants (water hyacinth and bullrush); and hyperaccumulators for metals (such as alpine pennycress for zinc or alyssum for nickel). If levels of contamination are so high that the concentrations of contaminants are toxic to plants (phytotoxic), phytoremediation may not be an effective treatment option.

Because phytoremediation has been used primarily on a demonstration-scale basis at this time, site owners may find it necessary to show its potential applicability and efficacy on a site-specific basis. Doing so may require an up-front commitment of time and resources to demonstrate that the performance of phytoremediation is comparable to the performance of traditionally accepted technology options. However, such an investment ultimately could save site owners significant amounts of money when they clean up their properties for redevelopment.

For more information, see the resources numbered 19, 25, 28, 87, 88, 106, 107, and 108 in the Index of Resources beginning on page I-1.

Field Applications of In Situ Remediation Technologies: Permeable Reactive Barriers (EPA 542-R-99-002)
View or download pdf file on the Road Map CD-ROM
One of a series of reports that summarize pilot demonstrations and full-scale applications of technologies that treat soil and groundwater, the document presents profiles of a number of applications of PRBs. Each profile identifies, to the extent the information is available, the name of the site, its location, its characteristics, the principal contaminants present, the installation date of the PRB, the type of construction, the costs of design and construction, the reactive materials used, and the results achieved. The profiles also discuss lessons learned and lists a point of contact for obtaining further information. A bibliography of articles and documents related to PRBs also is included.

Geophysical Techniques to Locate DNAPLs: Profiles of Federally Funded Projects (EPA 542-R-98-020)
View or download pdf file on the Road Map CD-ROM
The document provides to researchers and practitioners a status report on federal projects that are using noninvasive geophysical techniques to locate DNAPLs in the subsurface.

Groundwater Issue Paper: Steam Injection for Soil and Aquifer Remediation (EPA 540-S-97-505)
View or download pdf file on the Road Map CD-ROM
The document contains detailed information on how steam injection can be used to recover organic contaminants from the subsurface, the contaminant and subsurface conditions for which the process may be appropriate, and general design and equipment considerations.

Ground-Water Remediation Technologies Analysis Center (GWRTAC) Technology Reports
View or download reports on the Road Map CD-ROM
Developed by the Ground-Water Remediation Technologies Analysis Center (GWRTAC), a variety of reports about groundwater technologies and how they work are available to assist decision makers in reviewing technology options and assessing a technology's applicability to a particular site. The Technical Overview Reports are intended to provide a general overview and introduction to selected groundwater technologies. More detailed information and technical analyses is provided in the Technical Evaluation Reports which provide, for specific technologies, comprehensive descriptions of the technology and performance information; information about its applicability and cost; discussion of regulatory and policy requirements and issues; and a summary of lessons learned. The Technology Status Reports are summary documents which provide information about the status of specific groundwater technologies or topics. Examples of some of the topics covered include: air sparging; bioslurping; DNAPL remediation; electrokinetics; hydraulic, pneumatic, and blast-enhanced fracturing; in situ bioremediation; in situ chemical treatment; in situ flushing; permeable reactive barriers; phytoremediation; and surfactants and cosolvents.

Hydraulic Optimization Demonstration for Groundwater Pump-and-Treat Systems
View or download pdf file on the Road Map CD-ROM
The report, contained in two separate volumes, presents a screening analysis that users can use to determine whether they can achieve significant cost savings by altering key aspects of an existing or planned pump-and-treat-system. The first volume, intended for a broad audience, describes the screening analysis, which uses spreadsheets to allow quick and inexpensive cost comparison of alternatives under consideration for use at a site, in terms of net present value (NPV). The second volume, targeted for a more technical audience, provides case study examples of the application of hydraulic optimization at three sites. Site-specific factors, as well as the steps involved to conduct the analysis, are described in detail. The following volumes are available:

- *Volume I: Pre-Optimization Screening (Method and Demonstration (EPA 542-R-99-011A)*
- *Volume II: Application of Hydraulic Optimization (EPA 542-R-99-011B)*

In Situ Electrokinetic Remediation of Metal Contaminated Soils Technology Status Report (SFIM-AEC-ET-CR-99022)
View or download pdf file on the Road Map CD-ROM
The report, published by the U.S. Army Environmental Center for the Environmental Security Technology Certification Program (ESTCP), provides an overview of the current developmental status of electrokinetic remediation for metals-contaminated soils. The report identifies concerns about the in situ application of the technology and issues that require further investigation. It also presents the results of a field demonstration conducted at Naval Air Weapons

Station at Point Mugu to illustrate concerns about the in situ application of the technology at its current stage of development.

In Situ Treatment of Contaminated Sediments
View or download pdf file on the Road Map CD-ROM
The document provides a technology assessment about in situ treatment technologies applicable for cleanup of contaminated sediments. It is intended to provide federal agencies, states, consulting engineering firms, private industries, and technology developers with information on the current status of this technology.

ITRC Phytoremediation Decision Tree
View or download pdf file on the Road Map CD-ROM
The document, produced by the ITRC workgroup, provides a tool that can be used to determine whether phytoremediation can be effective at a given site. It is designed to complement existing phytoremediation documents. It allows the user to use basic information about a specific site, through a flow chart layout, to decide whether phytoremediation is feasible at that site.

Introduction to Phytoremediation (EPA 600-R-99-107)
View or download pdf file on the Road Map CD-ROM
The document provides a tool for regulators, owners, neighbors, and managers to use in evaluating the applicability of phytoremediation to a site. The document defines terms and provides a framework for use in developing an understanding of phytoremediation applications. It is a compilation of information obtained through research and remediation work that has been done to date.

Leak Detection for Landfill Liners: Overview of Tools for Vadose Zone Monitoring (EPA 542-R-98-019)
View or download pdf file on the Road Map CD-ROM
The report provides a basic summary of tools in current use for detection of leaks in landfill liners. It includes information gathered from a range of currently available sources, including project documents, reports, periodicals, Internet searches, and personal communication with parties involved in such efforts.

Monitored Natural Attenuation of Chlorinated Solvents (EPA 600-F-98-022)
View or download pdf file on the Road Map CD-ROM
The fact sheet, written for a nonscientific audience and intended to assist federal, state, and local regulators in educating the public about complex environmental issues, explains what the term "monitored natural attenuation" (MNA) means when it is used to describe a potential strategy for remediating a contaminated site. It also describes the various physical, chemical, and biological processes of natural attenuation that may take place at a site contaminated with chlorinated solvents and explains how decision makers evaluate the role of MNA at a contaminated site.

Monitored Natural Attenuation of Petroleum Hydrocarbons (EPA 600-F-98-021)
View or download pdf file on the Road Map CD-ROM
The fact sheet, written for a nonscientific audience and intended to assist federal, state, and local regulators in educating the public about complex environmental issues, explains what the term "MNA" means when it is used to describe a potential strategy for remediating a contaminated site. It also describes the various physical, chemical, and biological processes of natural attenuation that may take place at a site contaminated with petroleum hydrocarbons and explains how decision makers evaluate the role of MNA at a contaminated site.

MTBE Treatment Case Studies and Web Site
View on line at www.epa.gov/oust/mtbe/mtberem.htm
The searchable web site provides data on completed and ongoing applications of MTBE treatment for drinking water and contaminated media. The case studies describe technologies (both in situ and ex situ aboveground) that have been used to treat MTBE in groundwater, soil, and drinking water. Technologies included are air stripping and sparging, carbon adsorption, bioremediation (in situ and ex situ), in situ chemical oxidation, soil vapor and dual-phase extraction, and pump-and-treat systems. The 18 full case studies are from 2 to10 pages long and vary in level of detail, depending on the data available. The web site also provides summary information about 20 additional treatment applications.

Multi-Phase Extraction: State of the Practice (EPA 542-R-99-004)
View or download pdf file on the Road Map CD-ROM
The report describes the use of multi-phase extraction (MPE) for the remediation of contaminated soil and groundwater, focusing primarily on the application of MPE at sites at which contamination with halogenated VOCs is present. The report describes MPE technology and the various configurations used for it, indicates the

types of site conditions to which MPE is applicable, and discusses the advantages and potential limitations of the use of MPE at such sites. In addition, the report provides information about vendors of MPE and case studies that summarize cost and performance data on applications of the technology at three sites.

Natural Attenuation of Chlorinated Solvents in Groundwater: Principles and Practices

View or download pdf file on the Road Map CD-ROM

The industrial members of the Bioremediation of Chlorinated Solvents Consortium (bioconsortium) of the RTDF prepared the document to disseminate up-to-date scientific information about natural attenuation of chlorinated solvents. The mission of the RTDF bioconsortium is to accelerate the development of cost-effective bioremediation processes for degrading chlorinated solvents and to achieve public and regulatory acceptance of those processes as safe and effective. The document provides a framework to be used in evaluating natural attenuation of chlorinated VOCs.

Natural Attenuation of MTBE in the Subsurface under Methanogenic Conditions (EPA 600-R-00-006)

View or download pdf file on the Road Map CD-ROM

The document presents a case study conducted at the former Fuel Farm Site at the U.S. Coast Guard Support Center at Elizabeth City, North Carolina. The case study is intended to answer several questions: Can MTBE be biodegraded under methanogenic conditions in groundwater that was contaminated by a fuel spill? Will biodegradation produce lower concentrations of MTBE than those required under regulatory standards? Is the rate of degradation in the laboratory adequate to explain the distribution of MTBE in the groundwater at the field site? What is the relationship between the degradation of MTBE and the degradation of the BTEX compounds? What is the rate of natural attenuation at the source area?

Overview of the Phytoremediation of Lead and Mercury

View or download pdf file on the Road Map CD-ROM

The report assesses the current state of phytoremediation as an innovative technology and discusses its usefulness and potential in the remediation of lead- and mercury-contaminated soils found at hazardous waste sites. The advantages and disadvantages, limitations, current status, projected market, and environmental concerns associated with this new and innovative technology are discussed. Case studies involving the phytoremediation of lead and mercury detailing bench and full-scale projects are also provided.

Permeable Reactive Barrier Technologies for Contaminant Remediation (EPA 600-R-98-125)

View or download pdf file on the Road Map CD-ROM

The document provides information about treatable contaminants, design, feasibility studies, and construction options. Summaries of several current installations also are provided.

Permeable Reactive Barriers for Inorganics

View or download pdf file on the Road Map CD-ROM

The report provides a summary of information about permeable reactive barriers for inorganics and a discussion of the current status of such barriers. It contains information gathered from a range of currently available sources, including project documents, reports, periodicals, the Internet, and personal communication with parties involved in projects that use the barriers.

Permeable Reactive Subsurface Barriers for the Interception and Remediation of Chlorinated Hydrocarbon and Chromium (VI) Plumes in Ground Water (EPA 600-F-97-008)

View or download pdf file on the Road Map CD-ROM

Prepared by EPA's ORD, the document discusses the use of barrier walls employing zero-valent iron as the reactive substrate for treating groundwater contaminated with chlorinated hydrocarbons or chromium.

Phytoremediation of Contaminated Soil and Groundwater at Hazardous Waste Sites (EPA 540-S-01-500)

View or download pdf file on the Road Map CD-ROM

The issue paper was developed for the EPA Regional Ground Water Forum. The paper provides a concise discussion of the processes associated with the use of phytoremediation as a cleanup or containment technique for remediation of hazardous waste sites, sediment, groundwater, surface water, and wastewater.

Phytoremediation of TCE in Groundwater Using Populus
View or download pdf file on the Road Map CD-ROM
The document provides a basic understanding of phytoremediation for shallow groundwater and reports on the status of the technology.

Phytoremediation Resource Guide (EPA 542-B-99-003)
View or download pdf file on the Road Map CD-ROM
The document aids decision makers in reviewing the applicability of phytoremediation extraction treatment technologies. The document also provides access information on electronic resources and hotlines; cites relevant federal regulations; and provides abstracts of more than 100 pertinent resources, such as bibliographies, guidance documents, workshop proceedings, overview documents, study and test results, and test designs and protocols. Included is a phytoremediation treatment technology resource matrix that compares the documents by technology type, affected media, and contaminants. The guide also provides detailed information on how to obtain the publications listed.

Phytotechnology Technical and Regulatory Guidance (Phyto-2)
View or download pdf file on the Road Map CD-ROM
The document, published by the ITRC, provides technical and regulatory guidance to help regulators understand, evaluate, and make informed decisions about phytotechnology proposals. The document includes a description of phytotechnologies and discussions of regulatory and policy issues, technical requirements for phytotechnologies, and concerns on the part of stakeholders. It also provides case studies and technical references.

Presumptive Remedy: Supplemental Bulletin, Multi-Phase Extraction Technology for VOCs in Soil and Groundwater (EPA 540-F-97-004)
View or download pdf file on the Road Map CD-ROM
Produced by EPA and the USAF, this fact sheet provides an explanation of the technology and explains how to determine whether multi-phase extraction is applicable to a site contaminated with VOCs in soil and groundwater. The fact sheet also recommends MPE as a potential enhancement for SVE in the presumptive remedy for sites with VOCs in soil.

Pump and Treat Ground-Water Remediation: A Guide for Decision Makers and Practitioners (EPA 625-R-95-005)
View on line at www.epa.gov/ORD/WebPubs/pumptreat
The guide provides an introduction to pump-and-treat groundwater remediation by addressing such questions as, "When is pump-and-treat an appropriate remediation approach?" and "How can the design and operation of a pump-and-treat system be optimized and its performance measured?" The guide is intended to provide decision makers with a foundation for evaluating the appropriateness of conventional or innovative approaches.

Solidification/Stabilization Use at Superfund Sites (EPA 542-R-00-010)
View or download pdf file on the Road Map CD-ROM
The report provides to interested stakeholders, such as project managers, technology service providers, consulting engineers, site owners, and the general public, the most recent information about solidification/stabilization applications at Superfund sites, as well as information about trends in the use of the technology, specific types of applications, and costs.

Study of Assessment and Remediation Technologies for Drycleaner Sites
View on line at www.drycleancoalition.org/tech
Prepared by the SCRD with the support of EPA's TIO, the report presents the results of the coalition's evaluation of assessment and remediation technologies commonly used in cleaning up drycleaner sites. The evaluation was based on the results of responses to questionnaires sent to entities involved in such cleanups in 1999. The report presents those results in detail. An appendix provides descriptions and brief evaluations of assessment technologies frequently used at drycleaner sites.

Subsurface Containment and Monitoring Systems: Barriers and Beyond (Overview Report)
View or download pdf file on the Road Map CD-ROM
The document provides a summary of information about subsurface barriers —vertical and horizontal — with an emphasis on emerging and innovative vertical barrier technologies. It also presents a discussion of the current status of such barriers. The report is not intended to be inclusive; it merely provides an overview of the current work in the field

on subsurface barrier technologies drawn from information gathered from a range of sources, including project documents, reports, periodicals, the Internet, and personal communication with parties involved in projects that use such barriers.

Subsurface Remediation: Improving Long-Term Monitoring and Remedial Systems Performance Conference Proceedings, June 1999 (EPA 540-B-00-002)

View or download pdf file on the Road Map CD-ROM

The document summarizes the presentations made and workshops conducted during a conference on improving long-term monitoring (LTM) and the performance of remedial systems. The conference, sponsored and developed by the FRTR, took place in St. Louis, Missouri from June 8 through 11, 1999. The conference provided up-to-date information about LTM and system optimization through presentations and topical workshops.

Technical and Regulatory Requirements for Enhanced In Situ Bioremediation of Chlorinated Solvents in Groundwater

View or download pdf file on the Road Map CD-ROM

The report describes enhanced in situ bioremediation (EISB) and examines the circumstances under which its application is appropriate. It also discusses related regulatory and policy issues, such as the ban under RCRA on land disposal and technical requirements for implementation of EISB. The report was prepared by the Interstate Technology and Regulatory Cooperation Workgroup.

Underground Injection Control (UIC) Program

View on line at www.epa.gov/safewater/uic.html

The UIC Program works with state and local governments to oversee underground injection of waste to prevent contamination of drinking-water resources. Among the wastes the UIC program regulates are: more than nine billion gallons of hazardous waste every year; more than two billion gallons of brine from oil and gas operations every day; and automotive, industrial, sanitary and other wastes that are injected into shallow aquifers.

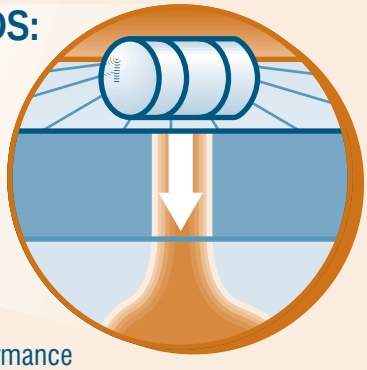
Where Do We Go From Here?

After you have reviewed options for cleanup, you may take any of the following courses of action:

Result of the Review of Cleanup Options		Course of Action
The proposed cleanup option appears feasible.	➡	*Proceed to the CLEANUP DESIGN AND IMPLEMENTATION phase.*
No cleanup option appears feasible in light of the proposed redevelopment and land reuse needs (such as project milestones and cost and intended reuse).	➡	*Determine whether revising the redevelopment plan remains a practicable option; if so, proceed to the CLEANUP DESIGN AND IMPLEMENTATION phase. If contamination exists at considerable levels, compliance with other programs, such as RCRA and Superfund, may be required.*

S10

CLEANUP OF DENSE NONAQUEOUS PHASE LIQUIDS: A Widespread Challenge



It is estimated that billions of dollars will be spent by the private and public sector to clean up sites contaminated with dense nonaqueous phase liquid (DNAPL). Denser than water, DNAPLs tend to sink through the water table and form a product pool on top of such impermeable soil layers as clay. DNAPLs also can sink and migrate laterally through fractures in bedrock. Numerous variables influence fate and transport of DNAPLs in the subsurface, and it can be difficult to predict the path DNAPLs will take.

Because of these properties, DNAPLs act as a continuing source of contamination. DNAPLs may cause serious, long-term contamination of groundwater and pose a significant challenge to cleanup of the site, especially for established technologies such as pump-and-treat. At sites with significant DNAPL contamination, pump-and-treat systems may require several hundreds of years to clean up the groundwater.

Sites likely contaminated with DNAPLs include drycleaning facilities, wood preserving sites, manufactured gas plants (MGP) sites, and solvent sites (industrial operations using large quantities of solvents, as well as solvent disposal/recovery sites).

To accelerate the development and implementation of innovative technologies for remediating DNAPLs in groundwater, a multiagency consortium – the Interagency DNAPL Consortium (IDC) – was formed. The consortium has developed a national action plan that proposes collaborative efforts among federal agencies, private sector entities, and responsible parties in research and development, technology demonstrations, and full-scale technology deployment to reduce the perceived risk associated with innovative technologies. The interagency agreement supports the testing of new and existing technologies in side-by-side demonstrations to compare cost and performance data that will be used to expedite regulatory acceptance and use of innovative remedial technologies at other sites.

A Quick Look

- Most commonly occurring DNAPLs typically are industrial chlorinated solvents – trichloroethene (TCE), tetrachloroethene (PCE), and carbon tetrachloride (CCl_4). Other prevalent DNAPLs include creosote, pentachlorophenol, and polycyclic aromatic hydrocarbon (PAH) coal tars.
- DNAPLs are present at 60 to 70 percent of Superfund National Priorities List (NPL) sites.
- Among the number of innovative technologies that are demonstrating success and providing promising results in reducing contamination with DNAPLs are dynamic underground stripping, six-phase soil heating, chemical oxidation, radio-frequency heating, and surfactant flushing.

The IDC has selected three technologies, dynamic underground stripping, six-phase soil heating, and chemical oxidation with potassium permanganate to demonstrate the effectiveness and cost-efficiency of those technologies in removing DNAPLs. Technical reports to be released in fall 2001 will document the cost and performance of the technologies. The reports will be made available to site owners, regulators, and stakeholders to support decision makers in making informed decisions about the economics and performance capabilities of those technologies for the remediation of DNAPLs.

For more information, see the resources numbered 63, 76, and 81 (specifically the case study titled "Geophysical Investigation at Hazardous Waste Sites") in the Index of Resources beginning on page I-1.

CLEANUP DESIGN AND IMPLEMENTATION

Develop and Carry Out Detailed Cleanup Plans for the Site

This phase focuses on the design and implementation of a cleanup plan to prepare the property for redevelopment and reuse. The design of the cleanup plan and implementation of the technology options selected in the previous phase involves close coordination with all other redevelopment efforts in the immediate vicinity of the site.

What Do We Need To Know?

Factors that should be considered during the design and implementation of cleanup activities include:

1. Are there federal, state, local, and tribal requirements for the design, installation, and monitoring of cleanup activities?
2. How will cleanup be monitored so that work can be stopped when cleanup goals are reached?
3. How best can the community participate in the design and implementation of the cleanup plan?
4. What can be done to protect the community and other property during cleanup?
5. What are the tradeoffs between cost and meeting redevelopment project deadlines? Can redevelopment activities (such as renovation of existing buildings and construction of roads and sewage systems) be performed concurrently with cleanup activities?
6. What are the long-term effects of the selected technology on the liability or on the future use of the site? What are the effects of a catastrophic change to the environment (for example, a hurricane or changes to the subsurface)?
7. Will long-term monitoring be required? If so, how will it be managed?
8. Will institutional controls facilitate or hinder redevelopment? Now? In the future?

How Do We Find The Answers?*

Typical activities that may be conducted during this phase include:

- Review all applicable federal, state, local, and tribal regulatory guidelines and regulations to determine all specific requirements, including guidelines for state VCPs
- Continue to work with the appropriate regulatory agencies to ensure that regulatory requirements are being properly addressed:
  - *Consult with the appropriate federal, state, local, and tribal regulatory agencies to include them in the decision-making process as early as possible*
  - *Contact the EPA regional brownfields coordinator to identify and determine the availability of EPA support programs*
- Develop conceptual plans for cleanup and subsequent monitoring that incorporate technology options and consider the effect of any cleanup activities on the proposed reuse of the property and the schedule for project design or construction:
  - *Develop or review the schedule for completion of the project*
  - *Obtain a final amount for the funds available for project development*
  - *Coordinate the renovation and construction of infrastructure with cleanup activities*
  - *Coordinate activities with developers, financiers, construction firms, and members of the local community*
- Establish contingency plans to address the discovery of additional contamination during cleanup, including tools such as environmental insurance policies
- Develop procedures for community participation, for example, by working with community advisory boards or local redevelopment authorities
- Implement and monitor the cleanup plan and performance of the technology selected
- Work with the state VCP program, if applicable, and or county or local officials to facilitate the placement and implementation of institutional controls

Where Do We Find Help To Our Technology Questions?

Listed below are examples of technology resources that provide information about applicable regulatory guidelines and regulations and community outreach materials. In addition, technologies identified during the site investigation phase may be appropriate to monitor cleanup performance and close-out. Information about the availability of electronic resources — whether the item is found on the Road Map's accompanying CD-ROM or on various web sites — also is provided. *Appendix D, How to Order Documents*, provides complete ordering information for documents that are not available on the CD-ROM or on the Internet.

A. Resources for Cleanup Design and Implementation

The documents listed below are resources that provide general information about the availability of technology resources in the form of bibliographies and status reports. Online searchable databases also are included.

Best Management Practices (BMPs) for Soil Treatment Technologies: Suggested Operational Guidelines to Prevent Cross-Media Transfer of Contaminants During Cleanup Activities (EPA 530-R-97-007)

View or download pdf file on the Road Map CD-ROM

The document provides guidance for designing and conducting soil remediation activities at RCRA and other hazardous waste sites so that cross-contamination is minimal. The document is expected to assist in reducing exposure of workers to contaminants by identifying the potential for transfer from medium to medium and recommending control mechanisms that could be applied during implementation of treatment technologies for soil. The BMPs are provided for seven technology categories: containment technologies; soil washing; thermal treatment; vapor extraction; bioremediation; incineration; and other physical and chemical treatments. The document also provides case studies and information about field validation activities that EPA undertook at soil remediation sites in 1996 and 1997.

** Please note that the Road Map seeks to answer technology selection questions and is not intended to provide a response to each procedural question identified.*

Characterization of Mine Leachates and the Development of a Ground-Water Monitoring Strategy for Mine Sites (EPA 600-R-99-007)

View or download pdf file on the Road Map CD-ROM

The objective of the research project was to develop a better understanding of the composition of mine waste leachates and to identify cost-effective groundwater monitoring parameters that could be incorporated into a monitoring strategy to reliably detect the migration of contaminants from hard-rock mining operations.

Citizen's Guides to Understanding Innovative Treatment Technologies

View or download pdf files on the Road Map CD-ROM

The guides are prepared by EPA to provide site managers with nontechnical outreach materials that they can share with communities in the vicinity of a site. The guides present information on innovative technologies that have been selected or applied at some cleanup sites, provide overviews of the technologies, and present success stories about sites at which innovative technologies have been applied. Spanish versions of the guides are forthcoming. The guides contain information on the following subjects:

- *Bioremediation (EPA 542-F-01-001)*
- *Chemical oxidation (EPA 542-F-01-013)*
- *Fracturing (EPA 542-F-01-015)*
- *In situ flushing (EPA 542-F-01-011)*
- *In situ thermal treatment methods (EPA 542-F-01-012)*
- *Monitored natural attenuation (EPA 542-F-01-004)*
- *Permeable reactive barriers (EPA 542-F-01-005)*
- *Phytoremediation (EPA 542-F-01-002)*
- *SVE and air sparging (EPA 542-F-01-006)*
- *Soil washing (EPA 542-F-01-008)*
- *Thermal desorption (EPA 542-F-01-003)*

Directory of Technology Support Services to Brownfields Localities (EPA 542-B-99-005)

View or download pdf file on the Road Map CD-ROM

The directory provides information about EPA offices, non-government organizations funded by EPA, and other federal agencies that may be able to provide expertise to assist in the selection of technologies for use in characterizing and cleaning up brownfields properties.

EPA Directive: Initiatives to Promote Innovative Technology in Waste Management Programs (OSWER Directive 9380.0-25, EPA 542-F-96-012)

View or download pdf file on the Road Map CD-ROM

The policy directive, issued April 29, 1996, describes several initiatives to facilitate the testing, demonstration, and use of innovative cleanup and field measurement technologies and stresses EPA's commitment to promoting the development and commercialization of environmental technologies. The initiatives under the directive place a high priority on selecting innovative treatment and characterization technologies, reducing impediments to the development and use of innovative technologies, and sharing the risks of using innovative treatment technologies.

EPA REACH IT Online Searchable Database

View on line at www.epareachit.org

EPA REACH IT is an online searchable database that assists brownfields stakeholders in obtaining comprehensive information about technologies useful for monitoring cleanup of brownfields sites. Specific information about applicable technologies and their service providers can be accessed readily using the guided and advanced search capabilities of the system. EPA REACH IT is accessible only through the Internet.

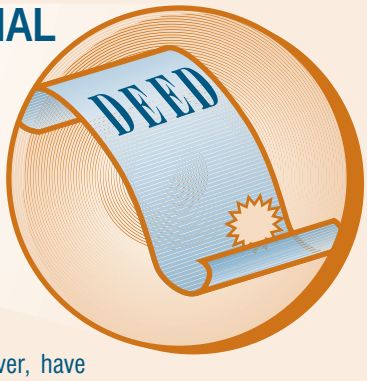
Federal Remediation Technologies Roundtable (FRTR) Case Studies

View on line at www.frtr.gov/cost

The case studies provide the user information about specific remedial technology applications. FRTR case studies are developed by DoD, USACE, the U.S. Navy, the U.S. Air Force (USAF), DOE, DOI, and EPA. The case studies focus on full-scale and large field demonstration projects and include information on site background, description of the technology, cost and performance of technology application, and lessons learned. Technologies include innovative and conventional treatment technologies for contaminated soil, groundwater, and solid media. Users also can search the case studies by groups of contaminants, media, waste management practices that contribute to contamination, and treatment systems.

S11 UNDERSTANDING THE ROLE OF INSTITUTIONAL CONTROLS AT BROWNFIELDS SITES:

Major Concepts and Issues



Institutional controls are administrative and legal restrictions or limitations placed on the use of a site to minimize potential exposure to chemicals of concern or to prevent activities that might interfere with the effectiveness of a response action. Institutional controls are vital elements of response alternatives because they influence and supplement the physical component of the remedy to be implemented. On one hand, the right combination of institutional controls is necessary to ensure the protectiveness of the remedy; on the other hand, the wrong mix of institutional controls can be a real or perceived impediment to reuse of a site.

The term "institutional control" can be applied to a wide spectrum of legal and administrative measures. In general, mechanisms for creating institutional controls can be divided into four categories – proprietary controls, governmental controls, enforcement and permit tools with institutional control components, and informational devices. Proprietary controls are unique because they are based on real property law. Examples of proprietary controls include covenants, which are written contracts that can prohibit specific types of development or use of construction on the land, and easements, which can grant access or restrict the owner to uses that are compatible with the intended use. Governmental controls involve restrictions that generally fall within the traditional police powers of state and local governments to impose and enforce. Examples of government controls include zoning, by which restrictions can be imposed through the local zoning or land use planning authority that limits access and prohibits disturbance of the response action, well drilling prohibitions, and such ordinances as building permit processes and master planning activities.

A Quick Look

- Institutional controls are administrative and legal mechanisms that are intended to reduce exposure to residual contamination and protect the integrity of a remedy at former industrial facilities or waste disposal sites by controlling resources.
- The role of institutional controls is an important consideration during the cleanup of a brownfields site.
- Examples of institutional controls include covenants, recorded deed notices, restrictions, and advisories.

Another common type of institutional controls is enforcement mechanisms or permits. Such institutional controls include Administrative Orders, Consent Decrees, and RCRA permits that require a land owner, usually a potential responsible party (PRP), to limit certain activities at a site. Those institutional controls are used most frequently for CERCLA and RCRA cleanups. The final category of institutional controls is informational tools. Informational tools provide information about residual or capped contamination or notification that such contamination may remain on site or that a remedy has been undertaken. Typical examples of such tools include state registries of contaminated properties, deed notices, and advisories. Informational devices are used most frequently as a secondary measure to help ensure the overall reliability of other institutional controls. Institutional controls also are designed to ensure that the post-remediation use of the property is compatible with the level of cleanup.

Institutional controls, however, have several limitations. For example, deed notices are informational, not enforceable. An easement cannot be established unless there is a party willing to hold the easement. Some state governments cannot hold easements, and other parties may be unwilling to do so. Zoning laws may not be fully effective unless they are monitored and enforced over the long term, and local governments may not have the resources necessary to conduct such oversight. Further, zoning ordinances are not necessarily permanent; they can be repealed, or local governments can grant exceptions to them after public hearings.

Concern has been expressed about the long-term viability of institutional controls as a remediation tool. For example, they may be forgotten; enforcement agencies may not effectively review properties or land users' actions; or land users simply may take their chances. Institutional controls are a mechanism for providing a certain degree of safety in the absence of technology that could clean contaminated sites thoroughly. Decision makers should weigh the full costs of such options, including capital costs, costs of long-term sampling and analysis, and costs of replacing equipment, as well as concerns about potential long-term risks associated with contaminants left in place, against the cost options that would remove the contaminants permanently.

Because land use remains the principal domain of local governments, those governments play a significant role in the management and oversight of institutional controls; however, it is not always clear what that role will be. Many local governments do not yet have the capacity and resources necessary to meet the challenges of long-term stewardship. With an improved understanding of the terms and issues related to institutional controls, local governments and brownfields stakeholders will be in a better position to respond effectively to the long-term challenges of using institutional controls to promote reuse, while ensuring that public health and the environment are protected.

For more information, see the resource numbered 85 in the Index of Resources beginning on page I-1.

Improving the Cost-Effectiveness of Hazardous Waste Site Characterization and Monitoring

View or download pdf file on the Road Map CD-ROM

The report introduces a new standard promoted by EPA's OSWER and TIO that encourages more effective and less costly strategies for characterizing and monitoring hazardous waste sites. The new approach uses an integrated triad of systematic planning, dynamic work plans, and onsite analysis for data collection and technical decision making at hazardous waste sites. Individually, none of the concepts in the triad is new, but it has been demonstrated that the integrated approach completes projects faster, cheaper, and with greater regulatory and client satisfaction than the traditional phased approach. The report includes a list of additional resources regarding innovative technologies and site characterization.

Institutional Controls: A Site Manager's Guide to Identifying, Evaluating, and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups (EPA 540-F-00-005)

View or download the pdf file on the Road Map CD-ROM

The fact sheet provides site managers and decision makers at Superfund and RCRA corrective action sites with an overview of the types of institutional controls (IC) that commonly are used or implemented and outlines the factors that generally should be considered when evaluating and selecting ICs as part of the remedy. The fact sheet also provides guidance to the public and the regulated community in the matter of how EPA intends to evaluate and implement ICs as part of cleanup decisions. Detailed descriptions of the different types of ICs are provided, as well as a glossary, and a checklist for implementing ICs.

Reusing Cleaned Up Superfund Sites: Recreational Use of Land Above Hazardous Waste Containment Areas (EPA 540-K-01-002)

View or download pdf file on the Road Map CD-ROM

The report provides technical information about how sites at which waste containment areas are present have been reused safely for recreational purposes, while ensuring that the integrity and protectiveness of the remedy are maintained. The information is helpful when considering recreational reuse options during EPA's process of selecting and designing a cleanup plan for a Superfund site. The information presented in the report draws on experiences gained through lessons learned from previous recreational redevelopment projects at Superfund and other contaminated sites.

State Policy and Regulatory Barriers to In Situ Ground Water Remediation (EPA 542-R-96-001)

View or download pdf file on the Road Map CD-ROM

The report identifies specific state regulatory and policy barriers to the use of techniques that enhance in situ groundwater treatment technologies through the subsurface injection of surfactants, cosolvents, and nutrients. The report also describes the experiences and policies of each state and provides contact information for obtaining additional assistance.

Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water (EPA 600-R-98-128)

View or download pdf file on the Road Map CD-ROM

The report provides guidance for environmental managers about the steps that must be taken to understand the rate and extent to which natural processes are reducing contaminant concentrations at sites that are contaminated by chlorinated solvents. Data collected with this protocol can be used to evaluate natural attenuation through biological processes as part of a protective overall site remedy. The protocol is the result of a collaborative field and laboratory research effort involving researchers from EPA ORD, the USAF, and the U.S. Geological Survey.

WASTECH® Series of Innovative Site Remediation Technology Engineering Monographs

See Appendix D, How to Order Documents, for a WASTECH order form, or view the order form on the Road Map CD-ROM

The WASTECH® project generates authoritative, consensus-based engineering monographs for remediation of hazardous waste sites and contaminated soils and groundwater. WASTECH® is funded by EPA, DoD, DOE, and the American Academy of Environmental Engineers®. During Phase I of the project, eight monographs were published in 1994 and 1995 covering the basics of these technologies, i.e., identification and description, potential applications, process evaluations, and limitations. During 1997 and early 1998, an additional seven volumes covering the design and applications, including actual case studies, were produced. Copies of the individual monographs (by technology type) or the entire series may be purchased

by contacting the American Academy of Environmental Engineers® by telephone at 410-266-3390 or by facsimile at 410-266-7653. The volumes contain information on the following technologies:

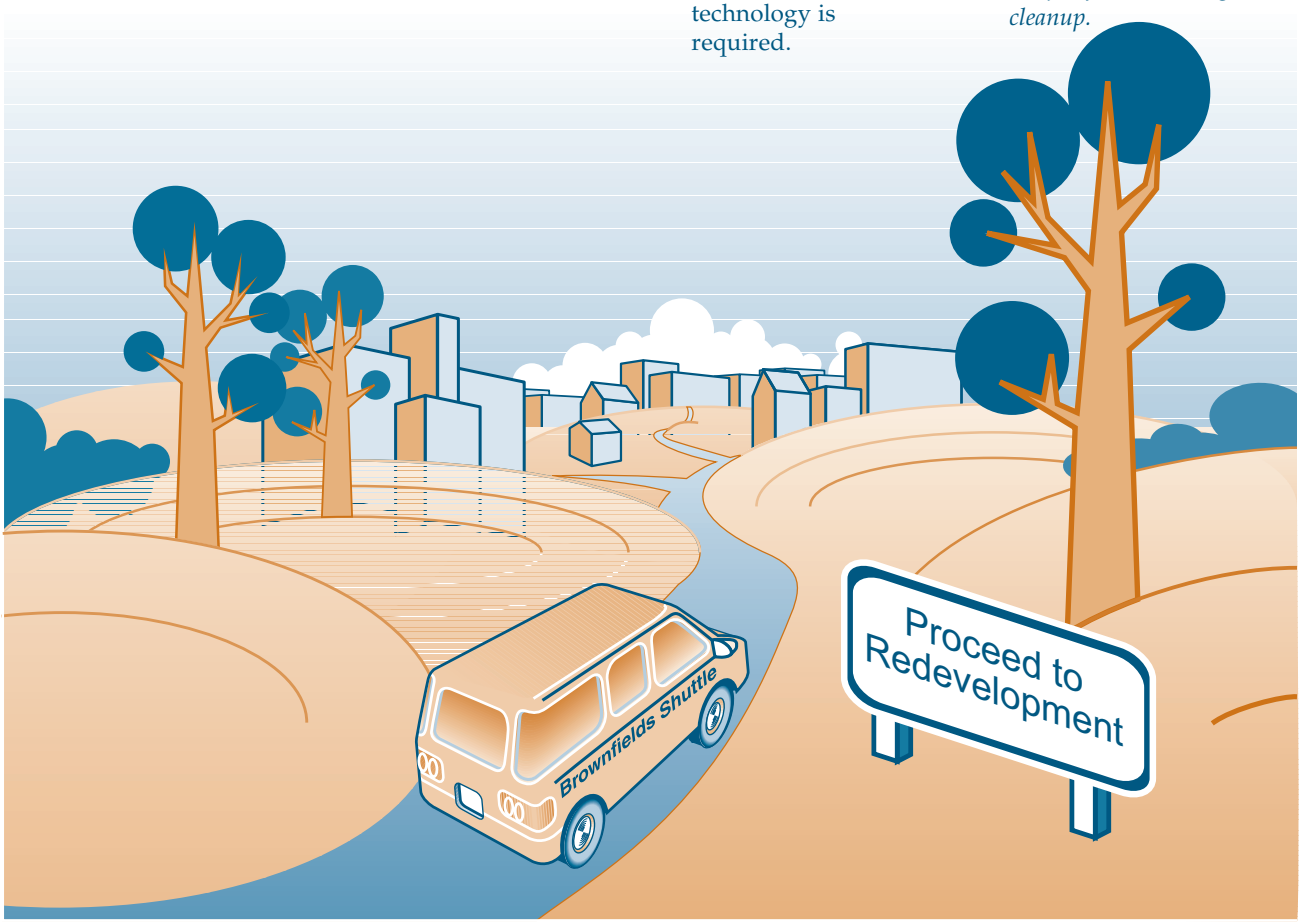
- *Bioremediation*
- *Chemical treatment*
- *Soil washing/soil flushing*
- *Solidification/stabilization*
- *Solvent/chemical extraction*
- *Thermal desorption*
- *Thermal destruction*
- *Vacuum vapor extraction*

Where Do We Go From Here?

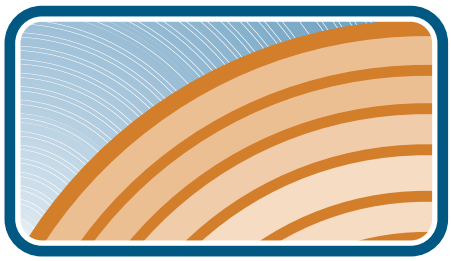
Next Steps

After you have completed cleanup, you may take one of the following courses of action:

Result of Cleanup	Course of Action
Contamination has been removed, contained, or controlled.	*Consult with the appropriate regulatory officials before proceeding with redevelopment activities.*
Additional contamination has been discovered.	*Continue cleanup activities. However, you may have to return to the SITE INVESTIGATION phase to determine the extent and nature of the contamination.*
Long-term monitoring of cleanup and performance of the technology is required.	*Return to the SITE INVESTIGATION phase to collect after-performance samples for monitoring cleanup.*



APPENDICES



APPENDIX A

Appendix A

GUIDE TO CONTAMINANTS AND TECHNOLOGIES

The tables provided in this appendix are intended to assist brownfields stakeholders to better understand the types of contaminants typically found at brownfields sites and the range of technologies that may be appropriate to assess and remediate those contaminants during the phases of a site cleanup. Information for the tables was compiled from several sources, including EPA *Guides to Pollution Prevention* for selected industries, EPA's REACH IT online searchable database, as well as many other EPA sources. A list of specific citations used is provided on page A-3.

The following table identifies activities that may have caused contamination at brownfields sites. The table summarizes contaminants that are related to such activities and identifies sources for the contaminants. However, it is not an exhaustive list of contaminants that can be found at a brownfields site. Identifying contaminants that may be present should be determined on a site-by-site basis. Such a determination should be conducted thoroughly and carefully.

Table A-1. Contaminants Found at Typical Brownfields Sites

Past Activities Typically Conducted at Brownfields Sites	Typical Contaminants
Agriculture	Volatile organic compounds (VOC), arsenic, copper, carbon tetrachloride, ethylene dibromide and methylene chloride, pesticides, insecticides, herbicides, grain fumigants
Automotive refinishing and repair	Metals and metal dust, various organic compounds, solvents, paint and paint sludges, scrap metal, waste oils
Battery recycling and disposal	Lead, cadmium, acids, nickel, copper, zinc, arsenic, chromium
Chloro-alkali manufacturing	Chlorine compounds, mercury
Coal gasification	Polycyclic aromatic hydrocarbons (PAH), sulfur compounds, cyanide, aluminum, iron, lead, nickel, chromium
Cosmetics manufacturing	Heavy metals, dusts, solvents, acids
Dry cleaning activities	VOCs such as chloroform and tetrachloroethane, various solvents, spot removers, fluorocarbon 113, perchloroethylene
Dye facilities	2-naphthylamine, 4-aminobiphenyl, benzidine
Electroplating operations	Various metals such as cadmium, chromium, copper, nickel, and cyanide
Glass manufacturing	Arsenic, lead
Herbicide manufacturing and use	Dioxin, metals, herbicides
Hospitals	Formaldehyde, radionuclides, photographic chemicals, solvents, mercury, ethylene oxide, chemotherapy chemicals
Incinerators	Dioxin, various municipal and industrial waste, ash, ordnance compounds, metals
Landfills—municipal and industrial	Metals, VOCs, polychlorinated biphenyls (PCB), ammonia, methane, household products and cleaners, pesticides, hydrogen sulfide
Leather manufacturing	Toluene, benzene
Machine shops/metal fabrication	Metals, VOCs, dioxin, beryllium, degreasing agents, solvents, waste oils
Manufactured gas plant	Non-halogenated VOCs and non-halogenated semi-volatile organic compounds (SVOC) such as PAHs and carcinogenic PAHs, including naphthalene, phenanthrene, anthracene, chrysene, and benzo(a)pyrene
Marine maintenance industry	Solvents, paints, cyanide, acids, VOC emissions, heavy metal sludges, degreasers
Munitions manufacturing	Lead, explosives, copper, antimony, unexploded ordnance (UXO)
Paint/ink manufacturing	Metals (such as chromium, cadmium, lead, and zinc), VOCs, chloroform, ethyl benzene, solvents, paints, inks

Past Activities Typically Conducted at Brownfields Sites (continued)	Typical Contaminants
Pesticide manufacturing	VOCs, arsenic, copper, pesticides, insecticides, herbicides, fungicides, xylene, chlorinated organic compounds, solvents
Petroleum refining and reuse	Petroleum hydrocarbons; benzene, toluene, ethylbenzene, and xylene (BTEX); fuels; oil and grease
Pharmaceutical manufacturing	Lead, various organic chemicals, organic solvents
Photographic manufacturing and uses	Silver bromide, methylene chloride, solvents, photographic products
Plastics manufacturing	Polymers, phthalates, cadmium, solvents, resins, chemical additives, VOCs
Printing industry	Silver, solvents, acids, waste oils, inks and dyes, photographic chemicals
Railroad yards	Petroleum hydrocarbons, VOCs, BTEX, solvents, fuels, oil and grease, lead, PCBs, PAHs, phthalates, carbazole, dieldrin, dibenzofurans
Research and educational institutions	Inorganic acids, organic solvents, metals and metal dust, photographic waste, waste oil, paint, heavy metals, pesticides
Scrap metal operations	Metals (such as lead and nickel), PCBs, dioxin, transformers
Semiconductor manufacturing	Metals, VOCs, carbon tetrachloride, degreasing agents, solvents
Smelter operations	Metals (such as lead, copper, and arsenic)
Underground storage tanks	Petroleum hydrocarbons, gasoline, diesel fuel, BTEX, MTBE, solvents, metals, POLs
Wood pulp and paper manufacturing	Chlorinated organic compounds, dioxins, furans, chloroform, resin acids
Wood preserving	Creosote, pentachlorophenol (PCP), arsenic, chromium, copper, PCBs, PAHs, beryllium, dioxin, wood preservatives, zinc, petroleum hydrocarbons

Table A-2, Technologies for Sampling and Analyzing Contaminants Found at Typical Brownfields Sites
Examples of technologies that may be used for sampling and analysis are presented below.

Contaminant Types*	Sampling and Analysis Technologies
Fuels and Non-halogenated VOCs (gasoline, diesel, motor oil, BTEX, acetone, TPH, PAH)	Colorimetric Test Kits; Immunoassay Test Kits; Laser-induced Fluorescence/Cone Penetrometer; Gas Chromatography/Mass Spectrometry; Diffusion Samplers; Infrared Monitors
Halogenated VOCs (PCE, TCE, vinyl chloride)	Portable Gas Chromatography/Mass Spectrometry; Colorimetric Test Kits; Immunoassay Test Kits; Infrared Monitors; Diffusion Samplers
Non-halogenated SVOCs (chrysene, naphthalene, phenanthrene, pyrene)	Gas Chromatography/Mass Spectrometry; Laser-Induced Fluorescence/Cone Penetrometer
Halogenated SVOCs (chlordane, PCBs, PCP, dioxins, furans, pesticides)	Gas Chromatography/Mass Spectrometry; Immunoassay Test Kits; Colorimetric Test Kits
Inorganic Compounds (arsenic, cadmium, chromium, mercury, lead)	Immunoassay Test Kits; X-ray Analyzers; Electrochemical Detector Kits; Graphite Furnace Atomic Absorption Spectroscopy
Explosives (TNT, RDX, HMX)	Colorimetric Test Kits; Immunoassay Test Kits; Gas Chromatography/Mass Spectrometry
Oxygenates (MTBE, ethanol, ethyl tertiary butyl ether [ETBE], tertiary amyl methyl ether [TAME])	Portable Gas Chromatography/Mass Spectrometry; Colorimetric Test Kits; Immunoassay Test Kits; Infrared Monitors; Diffusion Samplers

* The contaminants in parentheses are examples of each type of contaminant.

Table A-3, Remedies for Types of Contaminants Found at Typical Brownfields Sites
Identified below are types of technologies that may be appropriate for specific types of contaminants.

Contaminant Type*	Examples of Site Remedies	
	Soils, Sediments, and Sludges	Groundwater, Surface Water, and Leachate
Fuels and Non-halogenated VOCs (gasoline, diesel, motor oil, BTEX, acetone, TPH, PAH)	Biopile; Bioventing; Incineration; Natural Attenuation; Soil Flushing; Soil Vapor Extraction (SVE); Solidification/ Stabilization; Soil Washing; Thermal Desorption	Air Sparging; Bioslurping; Biosparging; Bioreactors; Dual-Phase Extraction; Permeable Reactive Barriers; Phytoremediation; UV Oxidation
Halogenated VOCs (PCE, TCE, vinyl chloride)	Bioventing; Bioremediation; Solvent Extraction	Air Sparging; Dual-Phase Extraction; Permeable Reactive Barriers; Pump and Treat
Non-halogenated SVOCs (chrysene, naphthalene, phenanthrene, pyrene)	Solvent Extraction; Thermal Desorption; Thermally Enhanced SVE	Bioreactors; Bioslurping; Permeable Reactive Barriers; Soil/Steam Flushing
Halogenated SVOCs (chlordane, PCBs, PCP, dioxins, furans, pesticides)	Incineration; Thermal Desorption; Thermally Enhanced SVE	Bioreactors; Bioslurping; Permeable Reactive Barriers
Inorganic Compounds (arsenic, cadmium, chromium, mercury, lead)	Chemical Oxidation/Reduction; Electrokinetic Separation; Soil Flushing Soil Washing; Solidification/Stabilization; Phytoremediation; Solvent Extraction	Permeable Reactive Barriers; Phytoremediation; Pump and Treat using Ion Exchange or Adsorption
Explosives (TNT, RDX, HMX)	Bioremediation; Soil Washing; Solvent Extraction; Thermal Desorption	Bioreactor; Permeable Reactive Barriers; Phytoremediation
Oxygenates (MTBE, ethanol, ETBE, TAME)	SVE; Thermal Desorption; Bioremediation	Pump and Treat using Granular Activated Carbon (GAC), Air Sparging, Bioremediation; Chemical Oxidation; Dual-Phase Extraction

* The contaminants in parentheses are examples of each type of contaminant.

LIST OF CITATIONS USED TO IDENTIFY COMMON CONTAMINANTS AND TECHNOLOGIES

Bioremediation of Hazardous Waste: Research Development, and Field Evaluation (EPA 540-R-95-532)

Brownfields Technology Primer: Requesting and Evaluating Proposals That Encourage Innovative Technologies for Investigation and Cleanup (EPA 540-R-01-005)

Contaminants and Remedial Options at Selected Metal-Contaminated Sites (EPA 540-R-95-512, PB95-271961)

Dry Cleaning and Laundry Plants, Fact Sheet (EPA 530-SW-90-027b)

EPA OECA Industry Sector Notebooks

EPA ORD Brownfields Guides

EPA Region 3 Industry Profile Fact Sheets

EPA REmediation And CHaracterization Innovative Technologies (EPA REACH IT)

Federal Remediation Technologies Roundtable (FRTR) Case Studies

Field Sampling and Analysis Technologies Matrix, Version 1.0

Guidelines for Waste Reduction and Recycling: Metal Finishing, Electroplating, Printed Circuit Board Manufacturing, Hazardous Waste Reduction Program, Oregon Department of Environmental Quality (No document number)

Guides to Pollution Prevention:

- *Research and Educational Institutions (EPA 625-7-90-010)*
- *Selected Hospital Waste Streams (EPA 625-7-90-009)*
- *The Automotive Refinishing Industry (EPA 625-7-91-016)*
- *The Automotive Repair Industry (EPA 625-7-91-013)*
- *The Commercial Printing Industry (EPA 625-7-90-008)*
- *The Fiberglass-Reinforced and Composite Plastics Industry (EPA 625-7-91-014)*
- *The Marine Maintenance and Repair Industry (EPA 625-7-91-015)*
- *The Mechanical Equipment Repair Industry (EPA 625-R-92-008)*
- *The Pesticide Formulating Industry (EPA 625-7-90-004)*
- *The Pharmaceutical Industry (EPA 625-7-91-017)*

Low-Level Mixed Waste: A RCRA Perspective for NRC Licenses (EPA 530-SW-90-057)

Pollution Prevention Technologies for the Bleached Kraft Segment of the U.S. Pulp and Paper Industry (EPA 600-R-93-110)

Resource for MGP Site Characterization and Remediations: Expedited Site Characterization and Source Remediation at Former Manufactured Gas Plant Sites (EPA 542-R-00-005)

Solving the Hazardous Waste Problem: EPA's RCRA Program (EPA 530-SW-86-037)

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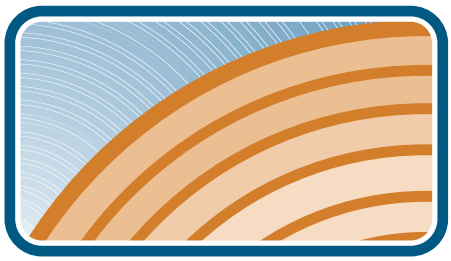


APPENDIX B

Appendix B

LIST OF ACRONYMS and GLOSSARY OF KEY TERMS

ARAR	Applicable or Relevant and Appropriate Requirement
ASTM	American Society for Testing and Materials
BDAT	Best Demonstrated Available Technology
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
BTSC	EPA Brownfields Technology Support Center
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CERI	Center for Environmental Research Information
CLU-IN	EPA Hazardous Waste Clean-up Information Web Site
CMS	Corrective Measure Study
CSM	Conceptual Site Model
CWA	Clean Water Act
DNAPL	Dense Nonaqueous Phase Liquid
DQO	Data Quality Objective
EPA	U.S. Environmental Protection Agency
EPA REACH IT	EPA REmediation And CHaracterization Innovative Technologies Online Searchable Database
EPCRA	Emergency Planning and Community Right-to-Know Act
ESA	Environmental Site Assessment
FATE	EPA Field Analytic Technologies Encyclopedia
FDIC	Federal Deposit Insurance Corporation
GAC	Granular Activated Carbon
HRS	Hazard Ranking System
HSWA	Hazardous and Solid Waste Amendments
IC	Institutional Control
IDC	Interagency DNAPL Consortium
IRIS	Integrated Risk Information System
ITT	Innovative Treatment Technology
LDR	Land Disposal Restrictions
LNAPL	Light Nonaqueous Phase Liquid
LUST	Leaking Underground Storage Tank
MGP	Manufactured Gas Plant
MTBE	Methyl Tertiary Butyl Ether
NAPL	Nonaqueous Phase Liquid
NCP	National Contingency Plan
NERL	National Exposure Research Laboratory
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	National Response Center
O&M	Operation and Maintenance
OERR	Office of Emergency and Remedial Response
ORD	Office of Research and Development
OSWER	Office of Solid Waste and Emergency Response
OUST	Office of Underground Storage Tanks
PAH	Polycyclic Aromatic Hydrocarbon
PA/SI	Preliminary Assessment and Site Inspection
PBMS	Performance-Based Measurement System
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PCP	Pentachlorophenol
PRP	Potentially Responsible Party
QA/QC	Quality Assurance and Quality Control
RBCA	Risk-Based Corrective Action
RBDM	Risk-Based Decision-Making
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design and Remedial Action
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
RQ	Reportable Quantity
SARA	Superfund Amendments and Reauthorization Act
SCRD	State Coalition for Remediation of Drycleaners
SDWA	Safe Drinking Water Act
SITE	Superfund Innovative Technology Evaluation
SOP	Standard Operating Procedure
SRI	Superfund Redevelopment Initiative
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TIO	Technology Innovation Office
TPH	Total Petroleum Hydrocarbon
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
UST	Underground Storage Tank
UXO	Unexploded Ordnance
VCP	Voluntary Cleanup Program
VOC	Volatile Organic Compound

The following is a list of specialized terms used during the cleanup of brownfields sites.

Absorption
Absorption is the passage of one substance into or through another.

Adsorption
Adsorption is the adhesion of molecules of gas, liquid, or dissolved solids to a surface. The term also refers to a method of treating wastes in which activated carbon is used to remove organic compounds from wastewater. *See also Carbon Adsorption.*

Air Sparging
In air sparging, air is injected into the ground below a contaminated area, forming bubbles that rise and carry trapped and dissolved contaminants to the surface. Air sparging is often used in conjunction with soil vapor extraction systems. *See also Soil Vapor Extraction.*

Air Stripping
Air stripping is a treatment technology that removes or "strips" VOCs from contaminated groundwater or surface water. As air is forced through the water, VOCs are volatilized. *See also Volatile Organic Compound.*

American Society for Testing and Materials (ASTM)
The ASTM sets standards for many services, including methods of sampling and testing of hazardous waste and media contaminated with hazardous waste.

Applicable or Relevant and Appropriate Requirement (ARAR)
As defined under CERCLA, ARARs are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limits set forth under federal or state law that specifically address problems or situations present at a CERCLA site. ARARs are major considerations in setting cleanup goals, selecting a remedy, and determining how to implement that remedy at a CERCLA site. ARARs must be attained at all CERCLA sites unless a waiver is attained. ARARs are not national cleanup standards for the Superfund program. *See also Comprehensive Environmental Response, Compensation, and Liability Act and Superfund.*

Aquifer
An aquifer is an underground rock formation composed of such materials as sand, soil, or gravel that can store groundwater and supply it to wells and springs.

ARAR
CERCLA requires that Superfund remedial actions attain standards that are legally applicable or relevant and appropriate to the circumstances at a given Superfund site. ARARs are used in conjunction with risk-based goals to establish cleanup goals at Superfund sites. ARARs are established on a site-by-site basis, and may include those under federal laws and regulations and those under state and local laws and regulations

Aromatics
Aromatics are organic compounds that contain 6-carbon ring structures, such as creosote, toluene, and phenol, that often are found at dry cleaning and electronic assembly sites.

Baseline Risk Assessment
A baseline risk assessment is an assessment conducted before cleanup activities begin at a site to identify and evaluate the threat to human health and the environment. After remediation has been completed, the information obtained during a baseline risk assessment can be used to determine whether the cleanup levels were reached.

BDAT
Under the RCRA Land Disposal Restrictions Program, EPA establishes treatment standards governing specific waste codes that are based on the performance of BDAT. Of the proven, available technologies, EPA designates as BDAT the technology that best minimizes the mobility or toxicity of the hazardous waste constituents of a waste.

Bedrock
Bedrock is the rock that underlies the soil; it can be permeable or non-permeable. *See also Confining Layer and Creosote.*

Best Demonstrated AvailableTechnology (BDAT)
A BDAT is a technology that has demonstrated the ability to reduce a particular contaminant to a lower concentration than other currently available technologies. BDATs can change with time as technologies evolve.

Biodegradability
Biodegradability is the capability of a substance to break down into simpler substances, especially into innocuous products, by the actions of living organisms (that is, microorganisms).

Biopile
Biopile is an aerated static pile composting process in which soil is mixed with amendments on a treatment area that includes leachate collection systems and aeration with blowers or vacuum pumps. It is used to reduce concentrations of petroleum constituents through the use of biodegradation. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation.

Bioremediation
Bioremediation refers to treatment processes that use microorganisms such as bacteria, yeast, or fungi to break down hazardous substances into less toxic or nontoxic substances. Bioremediation can be used to clean up contaminated soil and water. In situ bioremediation treats contaminated soil or groundwater in the location in which it is found. For ex situ bioremediation processes, contaminated soil is excavated or groundwater is pumped to the surface before they can be treated.

Bioreactor
Bioreactors use microorganisms in attached or suspended biological systems to degrade contaminants in water. In suspended biological systems, such as activated sludge, fluidized beds, or sequencing batch reactors, contaminated water is circulated in an aeration basin microbes aerobically degrade organic matter and produce carbon dioxide, water, and biomass. In attached systems, such as rotating biological contactors (RBC) and trickling filters, a microbial population is established on an inert support matrix. the cells form a sludge, which is settled out in a clarifier and is recycled to the aeration basin and disposed of.

Biosensor
A biosensor is a portable device that uses living organisms, such as microbes, or parts and products of living organisms, such as enzymes, tissues, and anitbodies, to produce reactions to specific chemical contaminants.

Bioslurping
Bioslurping is the adaptation of vacuum-enhanced dewatering technologies to remediate hydrocarbon-contaminated sites. Bioslurping combines elements of both bioventing and free-product recovery to simultaneously recover free product and bioremediate soils in the vadose zone. Bioventing stimulates the aerobic bioremediation of hydrocarbon-contaminated soils and vacuum-enhanced free-product recovery extracts light nonaqueous phase liquids (LNAPL) from the capillary fringe and the water table. *See also Vadose Zone*.

Biotechnology
Biotechnology refers to the application of advanced biological techniques in the manufacture of industrial products (for example, antibiotics and insulin) or for environmental management (for example, waste recycling).

Bioventing
Bioventing is an in situ remediation technology that stimulates the natural biodegradation of aerobically degradable compounds in soil by the injection of oxygen into the subsurface. Bioventing has been used to remediate releases of petroleum products, such as gasoline, jet fuels, kerosene, and diesel fuel. *See also Bioremediation and Soil Vapor Extraction.*

Borehole
A borehole is a hole cut into the ground by means of a drilling rig.

Borehole Geophysics
Borehole geophysics are nuclear or electric technologies used to identify the physical characteristics of geologic formations that are intersected by a borehole.

Brownfields
Brownfields sites are abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination.

BTEX
BTEX is the term used for benzene, toluene, ethylbenzene, and xylene-volatile aromatic compounds typically found in petroleum products, such as gasoline and diesel fuel.

Cadmium
Cadmium is a silvery-white metallic element that is used in a variety of manufacturing operations, including the manufacture of batteries, coatings, alloys, and pigments. Cadmium is a heavy metal. *See also Heavy Metal.*

Carbazole
Carbazole is formed as a result of the incomplete combustion of nitrogen-containing organic matter. When heated to decomposition, such matter emits toxic fumes of carbon monoxide, carbon dioxide, and nitrogen oxides. Carbazole is used in making

photographic plates sensitive to ultraviolet light and in the manufacture of reagents, explosives, insecticides, lubricants, and rubber antioxidants.

Carbon Adsorption

Carbon adsorption is a remediation technology that removes contaminants from air or water through physical adsorption into the carbon grain. Carbon is "activated" to improve adsorption through a process that creates porous particles that have large internal surface areas. A number of commercial grades of activated carbon are available to meets the needs of specific applications.

Carbon Tetrachloride

Carbon tetrachloride is a colorless, highly volatile liquid that has a strong ethereal odor similar to that of chloroform. It mixes sparingly with water and, when heated to decomposition, emits highly toxic fumes of phosgene. Carbon tetrachloride is used primarily as a chemical intermediate in the production of the refrigerants Freon 11 and 12. It also has been used as a general solvent in industrial degreasing operations and as an industrial solvent in the manufacture of cables and semiconductors.

Chemical Dehalogenation

Chemical dehalogenation is a chemical process that removes halogens (usually chlorine) from a chemical contaminant, rendering the contaminant less hazardous. The chemical dehalogenation process can be applied to common halogenated contaminants such as PCBs and dioxins, which may be present in soil and oils. Dehalogenation can be effective in removing halogens from hazardous organic compounds, such as dioxins, PCBs, and certain chlorinated pesticides. The treatment time is short, energy requirements are moderate, and operation and maintenance costs are relatively low. This technology can be brought to the site, eliminating the need to transport hazardous wastes. *See also Polychlorinated Biphenyl and Dioxin.*

Chemical Reduction/Oxidation

Chemical treatments typically involve chemical reduction/oxidation (redox) reactions that chemically convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, or inert. Redox reactions involve the transfer of electrons from one compound to another. Specifically, one reactant is oxidized (loses electrons) and one is reduced (gains electrons). The oxidizing agents most commonly used for treatment of hazardous contaminants are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide. In cyanide oxidation, organic cyanides are oxidized to less hazardous compounds through chemical reactions. This method can be applied in situ or ex situ to soils, sludges, sediments, and other solids and also can be applied for the in situ treatment of groundwater.

Chlorinator

A chlorinator is a device that adds chlorine, in gas or liquid form, to water or sewage to kill bacteria.

Clean Air Act (CAA)

The CAA is a federal law passed in 1970 that requires EPA to establish regulations to control the release of contaminants to the air to protect human health and environment.

Cleanup

Cleanup is the term used for actions taken to deal with a release or threat of release of a hazardous substance that could affect humans and or the environment. The term sometimes is used interchangeably with the terms remedial action, removal action, response action, or corrective action.

Clean Water Act (CWA)

CWA is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to U.S. waters. This law gave EPA the authority to set wastewater discharge standards on an industry-by-industry basis and to set water quality standards for all contaminants in surface waters.

Colorimetric

Colorimetric refers to chemical reaction-based indicators that are used to produce reactions to individual, or classes of compounds. The reactions, such as visible color changes or other easily noted indications, are used to detect and quantify contaminants.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA is a federal law passed in 1980 that created a special tax that funds a trust fund, commonly known as Superfund, to be used to investigate and clean up abandoned or uncontrolled hazardous waste sites. CERCLA required for the first time that EPA step beyond its traditional regulatory role and provide response authority to clean up hazardous waste sites. EPA has primary responsibility for managing cleanup and enforcement activities authorized under CERCLA. Under the program, EPA can pay for cleanup when parties responsible for the

contamination cannot be located or are unwilling or unable to perform the work, or take legal action to force parties responsible for contamination to clean up the site or reimburse the federal government for the cost of the cleanup. *See also Superfund.*

Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS)
CERCLIS is a database that serves as the official inventory of Superfund hazardous waste sites. CERCLIS also contains information about all aspects of hazardous waste sites, from initial discovery to deletion from the NPL. The database also maintains information about planned and actual site activities and financial information entered by EPA regional offices. CERCLIS records the targets and accomplishments of the Superfund program and is used to report that information to the EPA Administrator, Congress, and the public. *See also National Priorities List and Superfund.*

Conceptual Site Model (CSM)
A CSM, a key element used in facilitating cleanup decisions during a site investigation, is a planning tool that organizes information that already is known about a site and identifies the additional information necessary to support decisions that will achieve the goals of the project. The project team then uses the CSM to direct field work that focuses on the information needed to remove significant unknowns from the model. The CSM serves several purposes – as a planning instrument; as a modeling and data interpretation tool; and as a means of communication among members of a project team, decision makers, stakeholders, and field personnel.

Cone Penetrometer
The cone penetrometer is a truck-mounted device that rapidly penetrates the ground to collect samples. It has been used for approximately the last 50 years for geotechnical applications, but its use for site characterization is relatively new.

Confining Layer
A "confining layer" is a geological formation characterized by low permeability that inhibits the flow of water. *See also Bedrock and Permeability.*

Contaminant
A contaminant is any physical, chemical, biological, or radiological substance or matter present in any media at concentrations that may pose a threat to human health or the environment.

Corrective Measure Study (CMS)
If the potential need for corrective measures is verified during a RCRA Facility Investigation (RFI), the owner or operator of a facility is then responsible for performing a CMS. A CMS is conducted to identify, evaluate, and recommend specific corrective measures based on a detailed engineering evaluation. Using data collected during the RFI, the CMS demonstrates that proposed measures will be effective in controlling the source of contamination, as well as problems posed by the migration of substances from the original source into the environment. The measures also must be assessed in terms of technical feasibility, ability to meet public health protection requirements and protect the environment, possible adverse environmental effects, and institutional constraints. *See also RCRA Facility Investigation.*

Corrosivity
Corrosive wastes include those that are acidic and capable of corroding metal such as tanks, containers, drums, and barrels.

Creosote
Creosote is an oily liquid obtained by the distillation of wood that is used as a wood preservative and disinfectant and often is found at wood preserving sites. *See also Aromatics and Light Nonaqueous Phase Liquid.*

Cylinder Recovery Vessel
Cylinders or containers often cannot be sampled safely through the valve mechanism because of the condition of the container. The cylinder recovery vessel (CRV) was developed to safely control the hazards posed by such containers. The system provides for sampling and recontainerization of the cylinder's contents in a contained, inert environment. The vessel and system are designed to accommodate the high pressures and wide variety of gases and liquids present in gas cylinders.

Data Quality
The term data quality refers to all features and characteristics of data that bear on its ability to meet the stated or implied needs and expectations of the user.

Data Quality Objective (DQO)
DQOs are qualitative and quantitative statements specified to ensure that data of known and appropriate quality are obtained. The DQO process is a series of planning steps, typically conducted during site assessment and investigation, that is designed to ensure that the type, quantity, and quality of

environmental data used in decision making are appropriate. The DQO process involves a logical, step-by-step procedure for determining which of the complex issues affecting a site are the most relevant to planning a site investigation before any data are collected.

Dechlorination
Dechlorination, the process used primarily to treat and destroy halogenated aromatic contaminants, is the chemical reaction that removes halogens (usually chlorine) from the primary structure of the contaminating organic chemical. Dechlorination can treat contaminated liquids, soils, sludges, and sediments, as well as halogenated organics and PCBs, pesticides, and some herbicides.

Dense Nonaqueous Phase Liquid (DNAPL)
A DNAPL is one of a group of organic substances that are relatively insoluble in water and more dense than water. DNAPLs tend to sink vertically through sand and gravel aquifers to the underlying layer.

Detection Limit
The lowest concentration of a chemical that can be distinguished reliably from a zero concentration.

Dibenzofurans
Dibenzofurans are a group of polynuclear aromatic compounds, some of which are toxic. *See also Polynuclear Aromatic Hydrocarbon.*

Dieldrin
Dieldrin is an insecticide that was used until 1974 to control insects on cotton, corn, and citrus crops, as well as to control locusts, mosquitoes, and termites. It also was used as a wood preservative. Most uses of dieldrin were banned in 1987.

Diffusion Samplers
Diffusion samplers use natural molecular diffusion to cause the molecules of volatile organic compounds (VOC) to pass from groundwater through a semipermeable sampler. Diffusion samplers use a membrane that is filled with water and suspended in the screened interval of a well until chemical equilibrium occurs. The sampler then is retrieved, and the contents are analyzed. Diffusion samplers may offer many advantages over conventional groundwater sampling techniques because they eliminate the need for purging and disposal and can be left in targeted areas for a period of time, thereby allowing collection of a more representative sample. Vapor-based sampler analysis, which can be performed rapidly and inexpensively on field or laboratory gas chromatographs, yields relative concentrations of VOCs. Water-based sampler analysis provides the advantage of quantifying specific concentrations of VOCs through standard laboratory methods. *See also Gas Chromatography and Volatile Organic Compounds.*

Dioxin
A dioxin is any of a family of compounds known chemically as dibenzo-p-dioxins. They are chemicals released during combustion. Concern about them arises from their potential toxicity and the risk posed by contamination in commercial products. Boilers and industrial furnaces are among the sources of dioxins.

Direct Push Sampling
Direct push sampling is a technique in which a sampling tube is hydraulically pushed or driven into the subsurface, collecting material as it advances. This technique can be used when sampling for constituents, including VOCs, SVOCs, PCBs, and PAHs.

Disposal
Disposal is the final placement or destruction of toxic, radioactive or other wastes; surplus or banned pesticides or other chemicals; polluted soils; and drums containing hazardous materials from removal actions or accidental release. Disposal may be accomplished through the use of approved secure landfills, surface impoundments, land farming, deep well injection, or ocean dumping.

Dual-Phase Extraction
Dual-phase extraction, also known as multi-phase extraction, is a technology that uses a vacuum system to remove various combinations of contaminated groundwater, separate-phase petroleum product, and vapors from the subsurface. The system lowers the water table around a well, exposing more of the formation. Contaminants in the newly exposed vadose zone then are accessible to soil vapor extraction. Once above ground, the extracted vapors or liquid-phase organics and groundwater are separated and treated. *See also Soil Vapor Extraction.*

Dynamic Underground Stripping
Dynamic underground stripping is a process that employs vapor extraction during underground steaming and electrical heating. The heat, supplied by steam and electricity, vaporizes contaminants trapped in the soil. Once vaporized, the contaminants are removed by vacuum extraction. The process is monitored and guided by underground imaging.

Dynamic Work Plan
A dynamic work plan is a work plan that allows project teams to make decisions in the field about how site activities will progress. Dynamic work plans provide the strategy for the way in which dynamic field activities will take place. As such, they document a flexible, adaptive sampling and analytical strategy. Dynamic work plans are supported by the rapid turnaround of data collected, analyzed, and interpreted in the field.

Easement
An easement is a right to use the land of another for a specific purpose, such as a right-of-way or a utility.

Electrochemical Detector Kits
Electrochemical test kits use the electrical charges of ions that make up the target analyte(s) to identify and quantify the target analyte(s) in a sample. Typically, the ions are attracted to an anode or a cathode or both, depending on their charge, resulting in the generation of an electrical current that is measured and converted into a sample concentration by the unit's display or electronics. An analyte-specific catalyst can be used to aid in the reaction. The self-contained kits include all the equipment and supplies necessary to produce an analytical result.

Electrokinetic Separation
In electrokinetic separation, electrochemical and electrokinetic processes are used to desorb, and then remove, metals and polar organics. This in situ soil processing technology is primarily a separation and removal technique for extracting contaminants from soils. The principle of electrokinetic remediation relies upon application of a low-intensity direct current through the soil between ceramic electrodes that are separated into a cathode array and an anode array, mobilizing charged species and causing ions and water to move toward the electrodes. The current creates an acid front at the anode and a base front at the cathode. The generation of acidic condition in situ may help to mobilize sorbed metal contaminants to be transported to the collection system at the cathode.

Electromagnetic (EM) Geophysics
EM geophysics refers to technologies used to detect spatial (horizontal and vertical) differences in subsurface electromagnetic characteristics. The data collected provide information about subsurface environments.

Electromagnetic (EM) Induction
EM induction is a geophysical technology used to create a magnetic field beneath the earth's surface, which in turn causes a secondary magnetic field to form around nearby objects that have conductive properties, such as ferrous and nonferrous metals. The secondary magnetic field then is used to detect and measure buried debris.

Emergency Removal
An emergency removal is an action initiated in response to a release of a hazardous substance that requires on-site activity within hours of a determination that action is appropriate.

Emerging Technology
An emerging technology is an innovative technology that currently is undergoing bench-scale testing. During bench-scale testing, a small version of the technology is built and tested in a laboratory. If the technology is successful during bench-scale testing, it is demonstrated on a small scale at field sites. If the technology is successful at the field demonstrations, it often will be used full scale at contaminated waste sites. As the technology is used and evaluated at different sites, it is improved continually. *See also Established Technology and Innovative Technology.*

Enforcement Action
An enforcement action is an action undertaken by EPA under authority granted to it under various federal environmental statutes, such as CERCLA, RCRA, CAA, CWA, TSCA, and others. For example, under CERCLA, EPA may obtain voluntary settlement or compel potentially responsible parties (PRP) to implement removal or remedial actions when releases of hazardous substances have occurred. *See also Comprehensive Environmental Response, Compensation, and Liability Act; Potentially Responsible Party; and Removal Action.*

Engineered Control
An engineered control, such as barriers placed between a contaminated area and the rest of a site, is a method of managing environmental and health risks. Engineered controls can be used to limit exposure pathways.

Environmental Audit
An environmental audit usually refers to a review or investigation that determines whether an operating facility is in compliance with relevant environmental regulations. The audit may include checks for possession of required permits, operation within

permit limits, proper reporting, and record keeping. The typical result is a corrective action or compliance plan for the facility.

Environmental Risk
Environmental risk is the chance that human health or the environment will suffer harm as the result of the presence of environmental hazards.

Environmental Site Assessment (ESA)
An ESA is the process that determines whether contamination is present at a site.

Established Technology
An established technology is a technology for which cost and performance information is readily available. Only after a technology has been used at many different sites and the results fully documented is that technology considered established. The most frequently used established technologies are incineration, solidification and stabilization, and pump-and-treat technologies for groundwater. *See also Emerging Technology and Innovative Technology.*

Exposure Pathway
An exposure pathway is the route of contaminants from the source of contamination to potential contact with a medium (air, soil, surface water, or groundwater) that represents a potential threat to human health or the environment. Determining whether exposure pathways exist is an essential step in conducting a baseline risk assessment. *See also Baseline Risk Assessment.*

Ex Situ
The term ex situ or "moved from its original place," means excavated or removed.

Ex Situ Bioremediation
Ex situ bioremediation uses microorganisms to degrade organic contaminants in excavated soil, sludge, and solids. The microorganisms break down contaminants by using them as a food source. The end products typically are carbon dioxide and water. Ex situ bioremediation includes slurry-phase bioremediation, in which the soils are mixed with water to form a slurry to keep solids suspended and microorganisms in contact with the soil contaminants; and solid-phase bioremediation, in which the soils are placed in a cell or building and tilled with added water and nutrients. Land farming and composting are types of solid-phase bioremediation.

Filtration
Filtration is a treatment process that removes solid matter from water by passing the water through a porous medium, such as sand or a manufactured filter.

Flame Ionization Detector (FID)
A FID is an instrument often used in conjunction with gas chromatography to measure the change of signal as analytes are ionized by a hydrogen-air flame. It also is used to detect phenols, phthalates, PAHs, VOCs, and petroleum hydrocarbons. *See also Portable Gas Chromatography.*

Fluid/Vapor Extraction
In fluid/vapor extraction, a high-vacuum system is applied to remove liquid and gas simultaneously from low-permeability or heterogeneous formations. The vacuum extraction well includes a screened section in the zone of contaminated soils and groundwater and is used to remove contaminants from above and below the water table. The system lowers the water table around the well, exposing more of the formation. Contaminants in the newly exposed vadose zone are then accessible for vapor extraction, which can remove contaminants more efficiently than pump-and-treat systems.

Fourier Transform Infrared Spectroscopy
A fourier transform infrared spectroscope is an analytical air monitoring tool that uses a laser system chemically to identify contaminants.

Fumigant
A fumigant is a pesticide that is vaporized to kill pests. They often are used in buildings and greenhouses.

Furan
Furan is a colorless, volatile liquid compound used in the synthesis of organic compounds, especially nylon.

Gas Chromatography
Gas chromatography is a technology used for investigating and assessing soil, water, and soil gas contamination at a site. It is used for the analysis of VOCs and SVOCs. The technique identifies and quantifies organic compounds on the basis of molecular weight, characteristic fragmentation patterns, and retention time. Recent advances in gas chromatography that are considered innovative are portable, weather-proof units that have self-contained power supplies.

Graphite Furnace Atomic Absorption (GFAA) Spectroscopy
Graphite furnace atomic absorption (GFAA) spectroscopy is a highly sensitive spectroscopic technique that provides excellent detection limits for measuring concentrations of metals in liquid sample media. Water samples may be analyzed directly, while soil samples first must undergo an extraction process to draw the contaminants into solution for analysis. The sample is vaporized in the graphite furnace, and light of a specific wavelength then is passed through the atomic vapor of an element of interest. The attenuation of the intensity of the light as a result of absorption is measured, and the amount of attenuation is converted into an estimate of the contaminant metal's concentration.

Ground-Penetrating Radar (GPR)
GPR is a technology that emits pulses of electromagnetic energy into the ground to measure its reflection and refraction by subsurface layers and other features, such as buried debris.

Groundwater
Groundwater is the water found beneath the earth's surface that fills pores between such materials as sand, soil, or gravel and that often supplies wells and springs. *See also Aquifer.*

Halogenated Organic Compound
A halogenated organic compound is a compound containing molecules of chlorine, bromine iodine, and fluorine. Halogenated organic compounds were used in high-voltage electrical transformers because they conducted heat well while being fire resistant and good electrical insulators. Many herbicides, pesticides, and degreasing agents are made from halogenated organic compounds.

Hazard Ranking System (HRS)
The HRS is the primary screening tool used by EPA to assess the risks posed to human health or the environment by abandoned or uncontrolled hazardous waste sites. Under the HRS, sites are assigned scores on the basis of the toxicity of hazardous substances that are present and the potential that those substances will spread through the air, surface, water, or groundwater, taking into account such factors as the proximity of the substance to nearby populations. Scores are used in determining which sites should be placed on the NPL. *See also National Priorities List.*

Hazardous Substance
As defined under CERCLA, a hazardous substance is any material that poses a threat to public health or the environment. The term also refers to hazardous wastes as defined under RCRA. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive. If a certain quantity of a hazardous substance, as established by EPA, is spilled into the water or otherwise emitted into the environment, the release must be reported. Under the legislation cited above, the term excludes petroleum, crude oil, natural gas, natural gas liquids, or synthetic gas usable for fuel.

Hazardous and Solid Waste Amendments (HSWA)
HSWA are 1984 amendments to RCRA which required phasing out land disposal of hazardous waste and added minimum technology requirements. *See also Resource Conservation and Recovery Act.*

Heavy Metal
The term heavy metal refers to a group of toxic metals including arsenic, chromium, copper, lead, mercury, silver, and zinc. Heavy metals often are present at industrial sites at which operations have included battery recycling and metal plating.

Herbicide
A herbicide is a chemical pesticide designed to control or destroy plants, weeds, or grasses.

High-Frequency Electromagnetic (EM) Sounding
High-frequency EM sounding, the technology used for nonintrusive geophysical exploration, projects high-frequency electromagnetic radiation into subsurface layers to detect the reflection and refraction of the radiation by various layers of soil. Unlike ground-penetrating radar, which uses pulses, the technology uses continuous waves of radiation. *See also Ground-Penetrating Radar.*

Hot Air Injection
With hot air injection, hot air or steam is injected below the contaminated zones to heat contaminated soil. The heating enhances the release of contaminants from the soil matrix so they can be extracted and captured for further treatment and recycling.

Hydrazine
Hydrazine is a highly toxic liquid used in rocket propellant, agricultural chemicals, drugs, spandex fibers, antioxidants, plating metals on glass and plastic, explosives, and in boiler feedwater. The chemical compound causes a severe explosion hazard when exposed to heat.

Hydrocarbon
A hydrocarbon is an organic compound containing only hydrogen and carbon, often occurring in petroleum, natural gas, and coal.

Hydrogen Sulfide (HS)
HS is a gas emitted during decomposition of organic compounds. It also is a byproduct of oil refining and burning.

Hydrogeology
Hydrogeology is the study of groundwater, including its origin, occurrence, movement, and quality.

Hydrology
Hydrology is the science that deals with the properties, movement, and effects of water found on the earth's surface, in the soil and rocks beneath the surface, and in the atmosphere.

Hydrophobic Dye
Hydrophobic dye is added to liquids to assist in the observation of the presence of items that are colorless.

Hyperaccumulator
A hyperaccumulator is a metallophyte that accumulates an exceptionally high level of a metal to a specified concentration or to a specified multiple of the concentration found in nonaccumulators. The term is used in reference to plants used in Phytoremediation. *See also Metallophytes and Phytoremediation.*

Ignitability
Ignitable wastes can create fires under certain conditions. Examples include liquids, such as solvents that readily catch fire, and friction-sensitive substances.

Immunoassay
Immunoassay is an innovative technology used to measure compound-specific reactions (generally colorimetric) to individual compounds or classes of compounds. The reactions are used to detect and quantify contaminants. The technology is available in field-portable test kits.

In Situ Thermal Treatment
In situ thermal treatment is a treatment process that involves heating contaminated soil in place to vaporize organic contaminants in the soil. The surface area to be treated is usually covered with silicone rubber mats to provide insulation and to form a vapor barrier.

Incineration
Incineration is a treatment technology that involves the burning of certain types of solid, liquid, or gaseous materials under controlled conditions to destroy hazardous waste.

Infill Development
Infill development is new construction on previously developed land in cities or developed suburbs. The term often refers to redevelopment of small residential, commercial, or industrial properties. An important aspect of many infill development projects is the enhancement of the built environment with open space and parks.

Information Repository
An information repository is a location in a public building that is convenient for local residents, such as a public school, city hall, or library, that contains information about a Superfund site, including technical reports and reference documents.

Infrared Monitor
An infrared monitor is a device used to monitor the heat signature of an object, as well as to sample air. It may be used to detect buried objects in soil.

Inorganic Compound
An inorganic compound is a compound that generally does not contain carbon atoms (although carbonate and bicarbonate compounds are notable exceptions) and tends to be more soluble in water. Examples of inorganic compounds include various acids, potassium hydroxide, and metals.

Innovative Technology
An innovative technology is a process that has been tested and used as a treatment for hazardous waste or other contaminated materials, but lacks a long history of full-scale use and information about its cost and how well it works sufficient to support prediction of its performance under a variety of operating conditions. An innovative technology is one that is undergoing pilot-scale treatability studies that usually are conducted in the field or the laboratory and require installation of the technology, and provide performance, cost, and design objectives for the technology. Innovative technologies are being used under many federal and state cleanup programs to treat hazardous wastes that have been improperly released. *See also Emerging Technology and Established Technology.*

Ion Exchange
Ion exchange, a common method of softening water, depends on the ability of certain materials to remove and exchange ions from water. These ion exchange materials, generally composed of unsoluble organic polymers, are placed in a filtering device. Water softening exchange materials remove calcium and magnesium ions, replacing them with sodium ions.

Ionization
Ionization is the process which causes an atom to gain or lose electrons, which results in the atom having a negative or positive charge.

Insecticide
An insecticide is a pesticide compound specifically used to kill or control the growth of insects.

In Situ
The term in situ, "in its original place," or "on-site", means unexcavated and unmoved. In situ soil flushing and natural attenuation are examples of in situ treatment methods by which contaminated sites are treated without digging up or removing the contaminants.

In Situ Bioremediation
In situ bioremediation techniques stimulate and create a favorable environment for microorganisms to grow and use contaminants as a food and energy source. Generally, this means providing some combination of oxygen, nutrients, and moisture, and controlling the temperature and pH. Sometimes, microorganisms adapted for degradation of the specific contaminants are applied to enhance the process. Bioventing is a common form of in situ bioremediation. Bioventing uses extraction wells to circulate air with or without pumping air into the ground.

In Situ Oxidation
In situ oxidation is an innovative treatment technology that oxidizes contaminants that are dissolved in groundwater and converts them into insoluble compounds.

In Situ Soil Flushing
In situ soil flushing is an innovative treatment technology that floods contaminated soils beneath the ground surface with a solution that moves the contaminants to an area from which they can be removed. The technology requires the drilling of injection and extraction wells on site and reduces the need for excavation, handling, or transportation of hazardous substances. Contaminants considered for treatment by in situ soil flushing include heavy metals (such as lead, copper, and zinc), halogenated organic compounds, aromatics, and PCBs. *See also Aromatics, Halogenated Organic Compound, Heavy Metal, and Polychlorinated Biphenyl.*

In Situ Vitrification
In situ vitrification is a soil treatment technology that stabilizes metal and other inorganic contaminants in place at temperatures of approximately 3000°F. Soils and sludges are fused to form a stable glass and crystalline structure with very low leaching characteristics.

In Situ Well Aeration
For in situ well aeration, air is injected into a double screened well, allowing the VOCs in the contaminated groundwater to transfer from the dissolved phase to the vapor-phase by air bubbles. As the air bubbles rise to the water surface, the vapors are drawn off and treated by an SVE system.

Institutional Controls
An institutional control is a legal or institutional measure which subjects a property owner to limit activities at or access to a particular property. They are used to ensure protection of human health and the environment, and to expedite property reuse. Zoning and deed restrictions are examples of institutional controls.

Integrated Risk Information System (IRIS)
IRIS is an electronic database that contains EPA's latest descriptive and quantitative regulatory information about chemical constituents. Files on chemicals maintained in IRIS contain information related to both noncarcinogenic and carcinogenic health effects.

Joint and Several Liability
Under CERCLA, joint and several liability is a concept based on the theory that it may not be possible to apportion responsibility for the harm caused by hazardous waste equitably among potentially responsible parties (PRP). Joint liability means that more than one PRP is liable to the plaintiff. Several liability means that the plaintiff may choose to sue only one of the defendants and recover the entire amount. One PRP therefore can be held liable for the entire cost of cleanup, regardless of the share of waste that PRP contributed. Joint and several liability is used only when harm is indivisible. If defendants can apportion harm, there is no several liability. *See also Potentially Responsible Party and Strict Liability.*

Lampblack
Lampblack is a finely divided, bulky, black soot, at one time the most important black pigment used in the manufacture of printing inks. It is one of several gas plant residues found at manufactured gas plant (MGP) sites. *See also Manufactured Gas Plant.*

Land Disposal Restrictions (LDR)
LDR is a RCRA program that restricts the land disposal of RCRA hazardous wastes and requires treatment to established treatment standards or a required technology. LDRs may be an important ARAR for Superfund actions. *See also Applicable or Relevant and Appropriate Requirement and Resource Conservation and Recovery Act.*

Landfarming
Landfarming is the spreading and incorporation of wastes into the soil to initiate biological treatment.

Landfill
A sanitary landfill is a land disposal site for nonhazardous solid wastes at which the waste is spread in layers compacted to the smallest practical volume.

Laser-Induced Fluorescence/Cone Penetrometer
Laser-induced fluorescence/cone penetrometer is a field screening method that couples a fiber optic-based chemical sensor system to a cone penetrometer mounted on a truck. The technology can be used for investigating and assessing soil and water contamination.

Leachate
A leachate is a contaminated liquid that results when water collects contaminants as it trickles through wastes, agricultural pesticides, or fertilizers. Leaching may occur in farming areas and landfills and may be a means of the entry of hazardous substances into soil, surface water, or groundwater.

Lead
Lead is a heavy metal that has been used in the manufacture of gasoline, paints, and other substances. *See also Heavy Metal.*

Light Nonaqueous Phase Liquid (LNAPL)
An LNAPL is one of a group of organic substances that are relatively insoluble in water and are less dense than water. LNAPLs, such as oil, tend to spread across the surface of the water table and form a layer on top of the water table.

Long-Term Monitoring
Long-term monitoring of a site typically is performed to verify that contaminants pose no risk to human health or the environment and that natural processes are reducing contaminant levels and risk as predicted.

Magnetrometry
Magnetrometry is a geophysical technology used to detect disruptions that metal objects cause in the earth's localized magnetic field.

Manufactured Gas Plant
Manufactured gas plants (MGP) were operated nationwide from the early 1880s through the mid-1900s. MGPs produced gas from coal or oil for lighting, heating, and cooking. The gas manufacturing and purification processes conducted at the plants yielded residues that included tars, sludges, lampblack, light oils, spent oxide wastes, and other hydrocarbon products. Although many of the byproducts were recycled, excess residues containing PAHs, petroleum hydrocarbons, benzene, cyanide, metals, and phenols remained at MGP sites.

Mass Spectrometry
Mass spectrometry is a method of chemical analysis in which the substance to be analyzed is heated and placed in a vacuum. The resulting vapor is exposed to a beam of electrons that causes ionization to occur, either of the molecules or their fragments. The ionized atoms are separated according to their mass and can be identified on that basis.

Mechanical Soil Aeration
Mechanical soil aeration agitates contaminated soil using tilling or other means to volatilize contaminants.

Medium
A medium is a specific environment–air, water, or soil–which is the subject of regulatory concern and activities.

Mercury
Mercury is a heavy metal that can accumulate in the environment and is found in thermometers, measuring devices, pharmaceutical and agricultural chemicals, chemical manufacturing, and electrical equipment. *See also Heavy Metal.*

Mercury Vapor Analyzer
A mercury vapor analyzer is an instrument that provides real-time measurements of concentrations of mercury in the air.

Metallophytes
Metallophytes are plants that preferentially colonize in metal-rich soils.

Methane
Methane is a colorless, nonpoisonous, flammable gas created by anaerobic decomposition of organic compounds.

Methanogenic
The term methanogenic refers to anaerobic oxidation of petroleum hydrocarbons, as well as fermentation of hydrocarbons to methane.

Methyl Tertiary Butyl Ether
Methyl tertiary butyl ether (MTBE), a synthetic chemical, is a volatile, flammable, colorless liquid. MTBE has a relatively high vapor pressure and is water soluble to a significant degree. MTBE usually is produced in a refinery by mixing a feedstock of isobutylene with methanol. The isobutylene is derived by steam-cracking during production of olefin and fluid-cracking during production of gasoline. Concern about them arises from its potential contamination of groundwater as a result of releases from underground storage tanks of gasoline that contains oxygenates. *See also Oxygenates.*

Migration Pathway
A migration pathway is a potential path or route of contaminants from the source of contamination to contact with human populations or the environment. Migration pathways include air, surface water, groundwater, and land surface. The existence and identification of all potential migration pathways must be considered during assessment and characterization of a waste site.

Mixed Waste
Mixed waste is low-level radioactive waste contaminated with hazardous waste that is regulated under RCRA. Mixed waste can be disposed only in compliance with the requirements under RCRA that govern disposal of hazardous waste and with the RCRA land disposal restrictions, which require that waste be treated before it is disposed of in appropriate landfills.

Mobile Laboratory
A mobile laboratory refers to a collection of analytical instruments contained in a vehicle that can be deployed to a project site. A mobile laboratory offers many of the advantages of a fixed laboratory, such as protection from the elements, a power supply, and climate control, while still providing the advantages of analyzing samples on site while the project is in progress. A mobile laboratory may even allow the use of laboratory-grade instruments which otherwise could not be taken into the field. Configurations can vary in sophistication from a single instrument mounted in a sampling van, to large truck trailers and recreational vehicles equipped with multiple instruments and laboratory-grade support equipment.

Monitored Natural Attenuation
The term monitored natural attenuation refers to the remedial approach that allows natural processes to reduce concentrations of contaminants to acceptable levels. Monitored natural attenuation involves physical, chemical, and biological processes that act to reduce the mass, toxicity, and mobility of subsurface contamination. Physical, chemical, and biological processes involved in monitored natural attenuation include biodegradation, chemical stabilization, dispersion, sorption, and volatilization.

Monitoring Well
A monitoring well is a well drilled at a specific location on or off a hazardous waste site at which groundwater can be sampled at selected depths and studied to determine the direction of groundwater flow and the types and quantities of contaminants present in the groundwater.

Mothballed Sites
The term mothballed sites refers to large, idle areas that formerly were used for manufacturing and other industrial uses and are not available for sale or redevelopment.

National Contingency Plan (NCP)
The NCP, formally the National Oil and Hazardous Substances Contingency Plan, is the major regulatory framework that guides the Superfund response effort. The NCP is a comprehensive body of regulations that outlines a step-by-step process for implementing Superfund responses and defines the roles and responsibilities of EPA, other federal agencies, states, private parties, and the communities in response to situations in which hazardous substances are released into the environment. *See also Superfund.*

National Pollutant Discharge Elimination System (NPDES)
NPDES is the primary permitting program under the Clean Water Act, which regulates all discharges to surface water. It prohibits discharge of pollutants into waters of the United States unless EPA, a state, or a tribal government issues a special permit to do so.

National Priorities List (NPL)
The NPL is EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial response under Superfund. Inclusion of a site on the list is based primarily on the score the site receives under the HRS. Money from Superfund can be used for cleanup only at sites that are on the NPL. EPA is required to update the NPL at least once a year. *See also Hazard Ranking System and Superfund.*

National Response Center (NRC)
The NRC, staffed by the U.S. Coast Guard, is a communications center that receives reports of discharges or releases of hazardous substances into the environment. The U.S. Coast Guard in turn, relays information about such releases to the appropriate federal agency.

Neutralization
Neutralization is a chemical reaction between an acid and a base. The reaction involves acidic or caustic wastes that are neutralized using caustic or acid additives.

Nitric Oxide
Nitric oxide is a gas formed by combustion under high temperature and high pressure in an internal combustion engine.

Nonaqueous Phase Liquid (NAPL)
NAPLs are organic substances that are relatively insoluble in water and are less dense than water. *See also Dense Nonaqueous Phase Liquid and Light Nonaqueous Phase Liquid.*

Non-Point Source
The term non-point source is used to identify sources of pollution that are diffuse and do not have a point of origin or that are not introduced into a receiving stream from a specific outlet. Common non-point sources are rain water, runoff from agricultural lands, industrial sites, parking lots, and timber operations, as well as escaping gases from pipes and fittings.

Operation and Maintenance (O&M)
O&M refers to the activities conducted at a site, following remedial actions, to ensure that the cleanup methods are working properly. O&M activities are conducted to maintain the effectiveness of the remedy and to ensure that no new threat to human health or the environment arises. Under the Superfund program, the state or PRP assumes responsibility for O&M, which may include such activities as groundwater and air monitoring, inspection and maintenance of the treatment equipment remaining on site, and maintenance of any security measures or institutional controls.

Organic Chemical or Compound
An organic chemical or compound is a substance produced by animals or plants that contains mainly carbon, hydrogen, and oxygen.

Oxygenate
Oxygenates are hydrocarbons added to fuels to increase the oxygen content of those fuels to improve combustion, thereby reducing emissions, such as carbon monoxide and other pollutants. Examples of oxygenates include methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME), ethanol, and other ethers and alcohols. *See also Methyl Tertiary Butyl Ether.*

Ozone
Ozone is a form of oxygen found naturally which provides a protective layer in the stratosphere shielding the earth from the harmful health effects on human health and the environment from ultraviolet radiation. Ozone also is a chemical oxidant and a major component of smog in the troposphere, the earth's atmospheric layer below the stratosphere extending 7 to 10 miles from the earth's surface.

Pentachlorophenol (PCP)
PCP, a chemical compound containing carbon, chlorine, oxygen, and hydrogen, is a contaminant used in feed stock material and chemical manufacturing.

Performance-Based Measurement System (PBMS)
EPA defines PBMS as a set of processes through which the data needs or limitations of a program or project are specified and serve as criteria for selected appropriate methods to meet those needs in a cost-effective manner. EPA uses the term to convey what must be accomplished, but not prescriptively how to do it. The PBMS initiative places regulatory emphasis on obtaining analytical results that provide adequate information to support the regulatory decision, but leaves the choice of analytical procedures up to the user. The PBMS approach gives regulators and members of the regulated community increased flexibility in selecting technologies, while still meeting mandated monitoring requirements. The use of PBMS is intended to reduce barriers to the use of new monitoring technologies.

Permeability
Permeability is a characteristic that represents a qualitative description of the relative ease with which rock, soil, or sediment will transmit a fluid (liquid or gas).

Permeable Reactive Barriers
Permeable reactive barriers, also known as passive treatment walls, are installed across the flow path of a contaminated plume. As groundwater flows through the PRB, contaminants are either degraded or retained in a concentrated form by the reactive material. Examples of reactive media include zero-valent metals, chelators, sorbents, and microbes.

Pesticide
A pesticide is a substance or mixture of substances intended to prevent or mitigate infestation by, or destroy or repel, any pest. Pesticides can accumulate in the food chain and or contaminate the environment if misused.

Phase I Environmental Assessment
A Phase I environmental assessment is an initial environmental investigation that is limited to a historical records search to determine ownership of a site and to identify the kinds of chemical processes that were carried out at the site. A Phase I assessment includes a site visit, but does not include any sampling. If such an assessment identifies no significant concerns, Phase II and III audits are not necessary. Phase I assessments also are commonly referred to as site assessments.

Phase II Environmental Assessment
A Phase II environmental assessment is an investigation that includes tests performed at the site to confirm the location and identity of environmental hazards. The assessment includes preparation of a report that includes recommendations for cleanup alternatives. Phase II assessments also are commonly referred to as site investigations.

Phase III Environmental Audit
A Phase III environmental audit is the third step in the assessment that includes the removal of contaminated materials from a site and their legal disposal.

Phenols
A phenol is one of a group of organic compounds that are byproducts of petroleum refining, tanning, and textile, dye, and resin manufacturing.

Photoionization Detector (PID)
A PID is a nondestructive detector, often used in conjunction with gas chromatography, that measures the change of signal as analytes are ionized by an ultraviolet lamp. The PID also is used to detect VOCs and petroleum hydrocarbons. *See also Portable Gas Chromatography.*

Physical Separation
Physical separation processes use different size sieves and screens to concentrate contaminants into smaller volumes. Most organic and inorganic contaminants tend to bind, either chemically or physically, to the fine fraction of the soil. Fine clay and silt particles are separated from the coarse sand and gravel soil particles to concentrate the contaminants into a smaller volume of soil that could then be further treated or disposed.

Phytoremediation
Phytoremediation is an innovative treatment technology that uses plants and trees to clean up contaminated soil and water. Plants can break down, or degrade, organic pollutants or stabilize metal contaminants by acting as filters or traps. Phytoremediation can be used to clean up metals, pesticides, solvents, explosives, crude oil, polyaromatic carbons, and landfill leachates. Its use generally is limited to sites at which concentrations of contaminants are relatively low and contamination is found in shallow soils, streams, and groundwater.

Phytotechnology
The term phytotechnology refers to technologies that use living plants. *See also Phytoremediation.*

Phytotoxic
The term phytotoxic is used to describe a substance that is harmful to plants.

Plasma High-Temperature Metals Recovery
Plasma high-temperature metals recovery is a thermal treatment process that purges contaminants from solids and soils such as metal fumes and organic vapors. The vapors can be burned as fuel, and the metal fumes can be recovered and recycled. This innovative treatment technology is used to treat contaminated soil and groundwater.

Plume
A plume is a visible or measurable emission or discharge of a contaminant from a given point of origin into any medium. The term also is used to refer to measurable and potentially harmful radiation leaking from a damaged reactor.

Point Source
A point source is a stationary location or fixed facility from which pollutants are discharged or emitted or any single, identifiable discharge point of pollution, such as a pipe, ditch, or smokestack.

Polychlorinated Biphenyl (PCB)
PCBs are a group of toxic, persistent chemicals, produced by chlorination of biphenyl, that once were used in high voltage electrical transformers because they conducted heat well while being fire resistant and good electrical insulators. These contaminants typically are generated from metal degreasing, printed circuit board cleaning, gasoline, and wood preserving processes.

Polycyclic Aromatic Hydrocarbon (PAH)
A PAH is a chemical compound that contains more than one fused benzene ring. They are commonly found in petroleum fuels, coal products, and tar.

Potassium Permanganate
Potassium permanganate is a crystalline compound that is soluble in water, acetone, and methanol, but is decomposed by ethanol. It is used widely as a powerful oxidizing agent, as a disinfectant in a variety of applications, and as an analytical oxidant reagent in redox titrations.

Potentially Responsible Party (PRP)
A PRP is an individual or company (such as owners, operators, transporters, or generators of hazardous waste) that is potentially responsible for, or contributing to, the contamination problems at a Superfund site. Whenever possible, EPA requires PRPs, through administrative and legal actions, to clean up hazardous waste sites they have contaminated. *See also Comprehensive Environmental Response, Compensation, and Liability Act and Superfund.*

Preliminary Assessment and Site Inspection (PA/SI)
A PA/SI is the process of collecting and reviewing available information about a known or suspected hazardous waste site or release. The PA/SI usually includes a visit to the site.

Presumptive Remedies
Presumptive remedies are preferred technologies for common categories of CERCLA sites that have been identified through historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation.

Pump and Treat
Pump and treat is a general term used to describe remediation methods that involve the pumping of groundwater to the surface for treatment. It is one of the most common methods of treating polluted aquifers and groundwater.

Quality Assurance (QA)
QA is a system of management activities that ensure that a process, item, or service is of the type and quality needed by the user. QA deals with setting policy and implementing an administrative system of management controls that cover planning, implementation, and review of data collection activities. QA is an important element of a quality system that ensures that all research design and performance, environmental monitoring and sampling, and other technical and reporting activities conducted by EPA are of the highest possible quality.

Quality Control (QC)
QC refers to scientific precautions, such as calibrations and duplications, that are necessary if data of known and adequate quality are to be acquired. QC is technical in nature and is implemented at the project level. Like QA, QC is an important element of a quality system that ensures that all research design and performance, environmental monitoring and sampling, and other technical and reporting activities conducted by EPA are of the highest possible quality.

Radioactive Waste
Radioactive waste is any waste that emits energy as rays, waves, or streams of energetic particles. Sources of such wastes include nuclear reactors, research institutions, and hospitals.

Radionuclide
A radionuclide is a radioactive element characterized according to its atomic mass and atomic number, which can be artificial or naturally occurring. Radionuclides have a long life as soil or water pollutants. Radionuclides cannot be destroyed or degraded; therefore, applicable technologies involve separation, concentration and volume reduction, immobilization, or vitrification. *See also Solidification and Stabilization.*

Radon
Radon is a colorless, naturally occurring, radioactive, inert gaseous element formed by radioactive decay of radium atoms. *See also Radioactive Waste and Radionuclide.*

RCRA Facility Assessment (RFA)
A RFA is performed at a facility to determine the existence of any continuous or non-continuous releases of wastes. During the RFA, EPA or state regulators gather information on solid waste management units and other areas of concern at RCRA facilities, evaluate this information to determine whether there are releases that warrant further investigation and action, and determine the need to proceed to a RCRA Facility Investigation. *See also Resource Conservation and Recovery Act.*

RCRA Facility Investigation (RFI)
The purpose of a RFI is to gather sufficient data at a facility to fully characterize the nature, extent, and rate of migration of contaminant releases identified in the RCRA Facility Assessment. The data generated during the RFI is used to determine the potential need for corrective measures and to aid in the selection and implementation of these measures. *See also Corrective Measure Study and Resource Conservation and Recovery Act.*

Reactivity
Reactive wastes are unstable under normal conditions. They can create explosions and or toxic fumes, gases, and vapors when mixed with water.

Record of Decision (ROD)
A ROD is a legal, technical, and public document that explains which cleanup alternative will be used at a Superfund NPL site. The ROD is based on information and technical analysis generated during the remedial investigation and feasibility study (RI/FS) and consideration of public comments and community concerns. *See also Preliminary Assessment and Site Investigation and Remedial Investigation and Feasibility Study.*

Release
A release is any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, leaching, dumping, or disposing into the environment of a hazardous or toxic chemical or extremely hazardous substance, as defined under RCRA. *See also Resource Conservation and Recovery Act.*

Remedial Design and Remedial Action (RD/RA)
The RD/RA is the step in the Superfund cleanup process that follows the RI/FS and selection of a remedy. An RD is the preparation of engineering plans and specifications to properly and effectively implement the remedy. The RA is the actual construction or implementation of the remedy. *See also Remedial Investigation and Feasibility Study.*

Remedial Investigation and Feasibility Study (RI/FS)
The RI/FS is the step in the Superfund cleanup process that is conducted to gather sufficient information to support the selection of a site remedy that will reduce or eliminate the risks associated with contamination at the site. The RI involves site characterization -- collection of data and information necessary to characterize the nature and extent of contamination at the site. The RI also determines whether the contamination presents a significant risk to human health or the environment. The FS focuses on the development of specific response alternatives for addressing contamination at a site.

Removal Action
A removal action usually is a short-term effort designed to stabilize or clean up a hazardous waste site that poses an immediate threat to human health or the environment. Removal actions include removing tanks or drums of hazardous substances that were found on the surface and installing drainage controls or security measures, such as a fence at the site. Removal actions also may be conducted to respond to accidental releases of hazardous substances. CERCLA places time and money constraints on the duration of removal actions. *See also Comprehensive Environmental Response, Compensation, and Liability Act.*

Reportable Quantity (RQ)
The RQ is the quantity of hazardous substances that, when released into the environment, can cause substantial endangerment to public health or the environment. Under CERCLA, the federal government must be notified when quantities equaling or exceeding RQs specified in regulations are released.

Representative Sampling
The term representative sampling refers to a portion of material or water that is as nearly identical in content and consistency as possible to that in a larger body of material or water being sampled. To prevent segregation and to provide a level of accuracy, the sample is representative of the volume and nature of the material being sampled.

Resin
Resins are solids or semi-solids of plant origin used principally in lacquers, varnishes, inks, adhesives, synthetic plastics, and pharmaceuticals.

Resource Conservation and Recovery Act (RCRA)
RCRA is a federal law enacted in 1976 that established a regulatory system to track hazardous substances from their generation to their disposal.

The law requires the use of safe and secure procedures in treating, transporting, storing, and disposing of hazardous substances. RCRA is designed to prevent the creation of new, uncontrolled hazardous waste sites.

Response Action
A response action is a short-term removal action or a long-term remedial response, authorized under CERCLA that is taken at a site to address releases of hazardous substances.

Reuse Assessment
A reuse assessment involves the collection and evaluation of information to develop assumptions about reasonably anticipated future land use(s) at Superfund sites. It provides a tool for implementing the Superfund land use directive and can involve a review of available records, visual inspections of the site, and discussions with local government officials, property owners, and community members about potential future land uses.

Risk-Based Corrective Action (RBCA)
As defined by EPA, RBCA is a streamlined approach through which exposure and risk assessment practices are integrated with traditional components of the corrective action process to ensure that appropriate and cost-effective remedies are selected and that limited resources are allocated properly. RBCA refers specifically to the standard *Guide for Risk-Based Corrective Action Applied At Petroleum Release Sites,* published by ASTM. The RBCA process can be tailored to applicable state and local laws and regulatory practices. *See also American Society for Testing and Materials.*

Risk-Based Decision-Making (RBDM)
The term RBDM refers to a process through which decisions are made about contaminated sites according to the risk each site poses to human health and the environment. RBDM is a mechanism for identifying necessary and appropriate action at any phase of the corrective action process. Depending on known or anticipated risks to human health and the environment, appropriate action can include site closure, monitoring and data collection, active or passive remediation, containment, or imposition of institutional controls.

Risk Communication
Risk communication, the exchange of information about health or environmental risks among risk assessors, risk managers, the local community, news media and interest groups, is the process of informing members of the local community about environmental risks associated with a site and the steps that are being taken to manage those risks.

Safe Drinking Water Act
The Safe Drinking Water Act (SDWA) of 1974 was established to protect the quality of drinking water in the United States. The act focuses on all waters actually or potentially designed for use as drinking water, whether from aboveground or underground sources. The Act authorized EPA to establish safe standards of purity and requires all owners or operators of public water systems to comply with primary (health-related) standards. State governments that assume that authority from EPA also encourage attainment of secondary (nuisance-related) standards.

Sampling and Analysis Plan
A sampling and analysis plan (SAP) documents the procedural and analytical requirements for a one-time or time-limited project that involves the collection of samples of water, soil, sediment, or other media to characterize areas of potential environmental contamination. A SAP contains all the elements of a quality assurance project plan (QAPP) and a field sampling plan (FSP) that must be provided to meet the requirements for any project funded by the EPA under which environmental measurements are to be taken.

Sanborn Map
A Sanborn map is a record kept for insurance purposes that shows, for a specific property, the locations of such items as USTs, buildings, and areas where chemicals have been used for certain industrial processes. A Phase I environmental audit includes a review of Sanborn maps. *See also Phase I Environmental Audit.*

Saturated Zone
The saturated zone is the area beneath the surface of the land in which all openings are filled with water.

Seismic Reflection and Refraction
Seismic reflection and refraction is a technology used to examine the geophysical features of soil and bedrock, such as debris, buried channels, and other features.

Semi-Volatile Organic Compound (SVOC)
SVOCs, composed primarily of carbon and hydrogen atoms, have boiling points greater than 200°C. Common SVOCs include PCBs and phenol. *See also Phenol and Polychlorinated Biphenyl.*

Significant Threat
The term refers to the level of contamination that a state would consider significant enough to warrant an action. The thresholds vary from state to state.

Six-Phase Soil Heating
Six-phase soil heating is an in situ thermal technology for the remediation of contamination of soil and groundwater. The process splits conventional electricity into six electrical phases for the electrical resistive heating of soil and groundwater. Each electrical phase is delivered to one of six electrodes placed in a hexagonal array. The voltage gradient between phases causes an electrical current to flow through the soil and groundwater. Resistivity causes the temperature to rise. As the soil and groundwater are heated uniformly to the boiling point of water, the water becomes steam, stripping volatile and semivolatile contaminants from the pore spaces. In addition, removal of the soil moisture increases the air permeability of the soils, which can further increase the rate at which contaminants are removed.

Site Characterization and Analysis Penetrometer System
The Site Characterization and Analysis Penetrometer System (SCAPS) was developed by the Division of the Naval Command, Control, and Ocean Surveillance Center (NCCOSC), in collaboration with the U.S. Army and the U. S. Air Force. SCAPS, a cone penetrometer testing system, coupled with laser-induced fluorescence (LIF), measures fluorescence with optical fibers. The measurement is made through a sapphire window on a probe that is pushed into the ground with a truck-mounted cone penetrometer testing platform. *See also Cone Penetrometer and Laser-Induced Fluorescence/Cone Penetrometer.*

Sludge
Sludge is a semisolid residue from air or water treatment processes. Residues from treatment of metal wastes and the mixture of waste and soil at the bottom of a waste lagoon are examples of sludge, which can be a hazardous waste.

Slurry-Phase Bioremediation
Slurry-phase bioremediation, a treatment technology that can be used alone or in conjunction with other biological, chemical, and physical treatments, is a process through which organic contaminants are converted to innocuous compounds. Slurry-phase bioremediation can be effective in treating various SVOCs and nonvolatile organic compounds, as well as fuels, creosote, PCPs, and PCBs.

Soil Boring
Soil boring is a process by which a soil sample is extracted from the ground for chemical, biological, and analytical testing to determine the level of contamination present.

Soil Flushing
In soil flushing, large volumes of water, at times supplemented with treatment compounds, are applied to the soil or injected into the groundwater to raise the water table into the zone of contaminated soil. Contaminants are leached into the groundwater, and the extraction fluids are recovered from the underlying aquifer. When possible, the fluids are recycled.

Soil Gas
Soil gas consists of gaseous elements and compounds that occur in the small spaces between particles of the earth and soil. Such gases can move through or leave the soil or rock, depending on changes in pressure.

Soil Vapor Extraction (SVE)
SVE is a process that physically separates contaminants from soil in a vapor form by exerting a vacuum through the soil formation. SVE removes VOCs and some SVOCs from soil beneath the ground surface.

Soil Washing
Soil washing is an innovative treatment technology that uses liquids (usually water, sometimes combined with chemical additives) and a mechanical process to scrub soils, removes hazardous contaminants, and concentrates the contaminants into a smaller volume. The technology is used to treat a wide range of contaminants, such as metals, gasoline, fuel oils, and pesticides. Soil washing is a relatively low-cost alternative for separating waste and minimizing volume as necessary to facilitate subsequent treatment. It is often used in combination with other treatment technologies. The technology can be brought to the site, thereby eliminating the need to transport hazardous wastes.

Solidification and Stabilization
Solidification and stabilization are the processes of removing wastewater from a waste or changing it chemically to make the waste less permeable and susceptible to transport by water. Solidification and stabilization technologies can immobilize many heavy metals, certain radionuclides, and selected organic compounds, while decreasing the surface area and permeability of many types of sludge, contaminated soils, and solid wastes.

Solubility
Solubility is a measure of the amount of solute that will dissolve in a solution. It is the ability or tendency of one substance to dissolve into another at a given temperature and pressure and is generally expressed in terms of the amount of solute that will dissolve in a given amount of solvent to produce a saturated solution.

Solvent
A solvent is a substance, usually liquid, that is capable of dissolving or dispersing one or more other substances.

Solvent Extraction
Solvent extraction is an innovative treatment technology that uses a solvent to separate or remove hazardous organic contaminants from oily-type wastes, soils, sludges, and sediments. The technology does not destroy contaminants, but concentrates them so they can be recycled or destroyed more easily by another technology. Solvent extraction has been shown to be effective in treating sediments, sludges, and soils that contain primarily organic contaminants, such as PCBs, VOCs, halogenated organic compounds, and petroleum wastes. Such contaminants typically are generated from metal degreasing, printed circuit board cleaning, gasoline, and wood preserving processes. Solvent extraction is a transportable technology that can be brought to the site. *See also Halogenated Organic Compound, Polychlorinated Biphenyl, and Volatile Organic Compound.*

Standard Operating Procedure
A standard operating procedure (SOP) is a step-by-step procedure that promotes uniformity in operations to help clarify and augment such operations. SOPs document the way activities are to be performed to facilitate consistent conformance to technical and quality system requirements and to support data quality. The use of SOPs is an integral part of a successful quality system because SOPs provide individuals with the information needed to perform a job properly and facilitate consistency in the quality and integrity of a product or end result. SOPs also provide guidance in areas in which the exercise of professional judgment is necessary and specify procedures that are unique to each task.

Steam Injection
Steam injection is a remediation technology that uses the addition of steam to the subsurface to heat the soil and groundwater and drive off contaminants. The technology was developed by the petroleum industry to enhance recovery of oils from reservoirs, and has been adapted by the remediation industry for use in the recovery of organic contaminants from the subsurface.

Stratigraphy
Stratigraphy is the study of the formation, composition, and sequence of sediments, whether consolidated or not.

Strict Liability
Strict liability is a concept under CERCLA that empowers the federal government to hold PRPs liable without proving that the PRPs were at fault and without regard to a PRP's motive. PRPs can be found liable even if the problems caused by the release of a hazardous substance were unforeseeable, the PRPs acted in good faith, and state-of-the-art hazardous waste management practices were used at the time the materials were disposed of. *See also Potentially Responsible Party.*

Subsurface
Underground; beneath the surface.

Surfactant Flushing
Surfactant flushing is a technology used to treat contaminated groundwater. Surfactant flushing of NAPLs increases the solubility and mobility of the contaminants in water so that the NAPLs can be biodegraded more easily in an aquifer or recovered for treatment aboveground. *See also Nonaqueous Phase Liquid.*

Surface Water
Surface water is all water naturally open to the atmosphere, such as rivers, lakes, reservoirs, streams, and seas.

Superfund
Superfund is the trust fund that provides for the cleanup of hazardous substances released into the environment, regardless of fault. The Superfund was established under CERCLA and subsequent amendments to CERCLA. The term Superfund also is used to refer to cleanup programs designed and conducted under CERCLA and its subsequent amendments. *See also Comprehensive Environmental Response, Compensation, and Liability Act.*

Superfund Amendment and Reauthorization Act (SARA)
SARA is the 1986 act amending CERCLA that increased the size of the Superfund trust fund and established a preference for the development and use of permanent remedies, and provided new enforcement and settlement tools. *See also Comprehensive Environmental Response, Compensation, and Liability Act.*

Superfund Innovative Technology Evaluation (SITE) Program
The SITE program is an effort established by EPA in 1986 to advance the development, evaluation, and commercialization of innovative treatment technologies for assessing and cleaning up hazardous waste sites. The program provides an opportunity for technology developers to demonstrate their technologies' ability to successfully process and remediate hazardous waste. The SITE program has four components—the Emerging Technology Program, the Demonstration Program, the Measurement and Monitoring Program, and the Technology Transfer Program.

Systematic Planning
Systematic planning is a planning process that is based on the scientific method. It is a common-sense approach designed to ensure that the level of detail in planning is commensurate with the importance and intended use of the data, as well as the available resources. Systematic planning is important to the successful execution of all activities at hazardous waste sites, but it is particularly important to dynamic field activities because those activities rely on rapid decision-making. The data quality objective (DQO) process is one formalized process of systematic planning. All dynamic field activities must be designed through the use of systematic planning, whether using DQO steps or some other system. *See also Data Quality Objective.*

Test Methods for Evaluating Waste, Physical/ Chemical Methods (SW-846)
SW-846 refers to an EPA guidance and reference document, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, which is intended to assist analytical chemists and other users in the RCRA and Superfund programs by suggesting procedures that analysts have found to be successful when applied to typical samples. The SW-846 methods are analytical and sampling methods that have been evaluated and approved for use in complying with RCRA regulations. The methods are not intended to be prescriptive, nor are all technologies or methods that may be used are identified.

Tetrachloroethene
Tetrachloroethene is a nonflammable manufactured chemical widely used for dry cleaning fabrics and in metal-degreasing operations. It also is used as a starting material (building block) for the production of other manufactured chemicals. Other names for tetrachloroethene include PERC, tetrachloroethylene, perchloroethylene, and PCE.

Thermal Desorption
Thermal desorption is an innovative treatment technology that heats soils contaminated with hazardous wastes to temperatures from 200 to 1,000°F so that contaminants that have low boiling points will vaporize and separate from the soil. The vaporized contaminants then are collected for further treatment or destruction, typically by an air emissions treatment system. The technology is most effective at treating VOCs, SVOCs and other organic contaminants, such as PCBs, PAHs, and pesticides. It is effective in separating organics from refining wastes, coal tar wastes, waste from wood treatment, and paint wastes. It also can separate solvents, pesticides, PCBs, dioxins, and fuel oils from contaminated soil. *See also Polyaromatic Hydrocarbon, Polychlorinated Biphenyl, Semivolatile Organic Compound, and Volatile Organic Compound.*

Toluene
Toluene is a colorless liquid chemical with a sweet, strong odor. It is used as a solvent in aviation gasoline and in making other chemicals, perfumes, medicines, dyes, explosives, and detergents.

Total Petroleum Hydrocarbon (TPH)
TPH refers to a measure of concentration or mass of petroleum hydrocarbon constituents present in a given amount of air, soil, or water.

Toxicity
Toxicity is a quantification of the degree of danger posed by a substance to animal or plant life.

Toxicity Characteristic Leaching Procedure (TCLP)
The TCLP is a testing procedure used to identify the toxicity of wastes and is the most commonly used test for degree of mobilization offered by a solidification and stabilization process. Under this procedure, a waste is subjected to a process designed to model the leaching effects that would occur if the waste was disposed of in a RCRA Subtitle D municipal landfill. *See also Solidification and Stabilization.*

Toxic Substance
A toxic substance is a chemical or mixture that may present an unreasonable risk of injury to health or the environment.

Toxic Substances Control Act (TSCA)
TSCA was enacted in 1976 to test, regulate, and screen all chemicals produced or imported into the U.S. TSCA requires that any chemical that reaches the consumer marketplace be tested for possible toxic

effects prior to commercial manufacture. Any existing chemical that poses health and environmental hazards is tracked and reported under TSCA.

Treatment, Storage, and Disposal Facility (TSD)
TSDs are sites at which hazardous substances are treated, stored, or disposed. TSD facilities are regulated by EPA and states under RCRA. *See also Resource Conservation and Recovery Act.*

Trichloroethene (TCE)
TCE is a stable, low-boiling colorless liquid that is used as a solvent, metal degreasing agent, and in other industrial applications. TCE also is known as trichloroethylene.

Ultraviolet (UV) Fluorescence
An UV fluorescence system and analytical technique is based on imaging of UV-excited fluorescence from a contaminant. A camera is gated and synchronized with a pulsed UV light source to refuse interfering ambient light. Under computer control, a liquid crystal tuned filter (LCTF) selects the spectral band of fluorescence. As an alternative, an interference filter can be used to provide a higher light throughout at a particular spectral region. The multispectral features allow optimization of the detection of a particular contaminant on a selected material surface. The system is transportable and the imaging head is small enough to be mounted on a tripod or controlled by robots.

Uncertainty
The term uncertainty refers to the inherent unknown quantities present in all scientific and technical decisions. Uncertainties can arise from incomplete knowledge of the nature and extent of contamination, an inability to predict a technology's performance under site-specific conditions, or new or changing regulatory requirements.

Underground Injection Control
Underground injection control (UIC) is the prevention of contamination by keeping injected fluids within the well and the intended injection zone or, in the case of the injection of fluids directly or indirectly into an underground source of drinking water (USDW), ensuring that injected fluids do not cause a public water system to violate drinking-water standards or otherwise have an adverse effect on public health. The minimum requirements affect the siting of an injection well and the construction, operation, maintenance, monitoring, testing, and closure of the well.

Underground Storage Tank (UST)
A UST is a tank and any underground piping connected to the tank that is used to contain gasoline or other petroleum products or chemical solutions and that is placed in such a manner that at least 10 percent of its combined volume is underground.

Unexploded Ordnance
The term exploded ordnance refers to any munition, weapon delivery system, or ordnance item that contains explosives, propellants, and chemical agents. Unexploded ordnance (UXO) consists of the same items after they: (1) have been armed or otherwise prepared for action; (2) have been launched, placed, fired, or released in such a manner as to constitute a hazard to operations, installations, personnel, or material; and (3) remain unexploded either by design or by malfunction, or for any other reason.

Unsaturated Zone
The unsaturated zone is the area between the land surface and the uppermost aquifer (or saturated zone). The soils in an unsaturated zone may contain air and water.

Vadose Zone
The vadose zone is the area between the surface of the land and the surface of the water table in which the moisture content is less than the saturation point and the pressure is less than atmospheric. The openings (pore spaces) also typically contain air or other gases.

Vapor
Vapor is the gaseous phase of any substance that is liquid or solid at atmospheric temperatures and pressures. Steam is an example of a vapor.

Vitrification
Vitrification is a process that uses electrical power to heat and melt soil contaminated with organic or inorganic contaminants. As the molten material cools, it forms a hard glass and crystalline product that incorporates the contaminants. Vitrification can be performed in situ or ex situ and typically involves temperatures above 2,000EC.

Volatile Organic Compound (VOC)
A VOC is one of a group of carbon-containing compounds that evaporate readily at room temperature. Examples of VOCs include trichloroethane; trichloroethylene; and BTEX. These contaminants typically are generated from metal degreasing, printed circuit board cleaning, gasoline, and wood preserving processes.

Volatilization
Volatilization is the process of transfer of a chemical from the aqueous or liquid phase to the gas phase. Solubility, molecular weight, and vapor pressure of the liquid and the nature of the gas-liquid affect the rate of volatilization.

Voltammetric Stripping
Voltammetric stripping is a field-portable technology that uses electrochemistry to detect and quantify metals in environmental samples. Specific metals can be targeted for detection and quantification by the technology, which generally is applied to water samples.

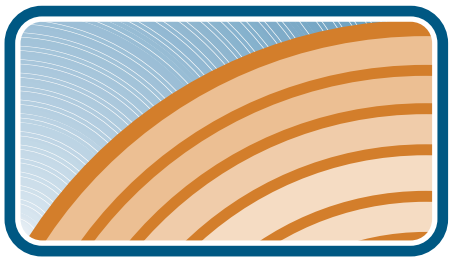
Voluntary Cleanup Program (VCP)
A VCP is a formal means established by many states to facilitate assessment, cleanup, and redevelopment of brownfields sites. VCPs typically address the identification and cleanup of potentially contaminated sites that are not on the Superfund NPL. Under VCPs, owners or developers of a site are encouraged to approach the state voluntarily to work out a process by which the site can be readied for development. Many state VCPs provide technical assistance, liability assurances, and funding support for such efforts. *See also National Priorities List.*

Wastewater
Wastewater is spent or used water from an individual home, a community, a farm, or an industry that contains dissolved or suspended matter.

Water Table
A water table is the boundary between the saturated and unsaturated zones beneath the surface of the earth, the level of groundwater, and generally is the level to which water will rise in a well. *See also Aquifer and Groundwater.*

X-Ray Fluorescence Analyzer
An x-ray fluorescence analyzer is a self-contained, field-portable instrument, consisting of an energy dispersive x-ray source, a detector, and a data processing system that detects and quantifies individual metals or groups of metals.

Zoning
Zoning is the exercise of the civil authority of a municipality to regulate and control the character and use of property.



APPENDIX C

Appendix C

LIST OF BROWNFIELDS AND TECHNICAL SUPPORT CONTACTS

The lists included in this appendix identify contacts at the state and EPA regional levels, as well as EPA technical support staff in the Technology Innovation Office and the Office of Research and Development. The individuals are available to assist cleanup and redevelopment efforts at brownfields sites.

The points of contact listed are current, according to information available at the time of publication.

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ALASKA

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ARIZONA

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ARKANSAS

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HAWAII

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INDIANA

www.ai.org/idem/oer/index.html

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KANSAS

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MAINE

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MASSACHUSETTS

www.state.ma.us/dep/bwsc/bwschome.htm

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Fax: (609) 292-2117

NEW MEXICO

www.nmenv.state.nm.us/

Chris Bynum
Environment Department
Superfund Oversight Section
P.O. Box 26110
Santa Fe, NM 87502
Phone: (505) 827-2754
Fax: (505) 827-2965
E-mail: chris_bynum@nmenv.state.nm.us

NEW YORK

www.dec.state.ny.us/

Christine Costopoulos
Division of Remedial Response
NY Department of Environmental Conservation
50 Wolf Road
Albany, NY 12233-7010
Phone: (518) 457-5861
Fax: (518) 457-9639
E-mail: cjcostop@gw.dec.state.ny.us

NORTH CAROLINA

http://wastenot.ehnr.state.nc.us/

Bruce Nicholson
Special Remediation Branch, Superfund Section
1646 Mail Service Center
Raleigh, NC 27699-1646
Phone: (919) 733-2801 ext. 353
E-mail: bruce.nicholson@ncmail.us

NORTH DAKOTA

www.ehs.health.state.nd.us/ndhd/environ/wm/index.htm

Kurt Erickson
Division of Waste Management
ND Department of Health and Consolidated Labs
P.O. Box 5520
Bismark, ND 58506-5520
Phone: (701) 328-5166
Fax: (701) 328-5200
E-mail: ccmail.cerickso@ranch.state.nd.us

OHIO

www.epa.state.oh.us/derr/

Amy Yersavich
Voluntary Action Program
OH Environmental Protection Agency
122 South Front Street
P.O. Box 1049
Columbus, OH 43216-1049
Phone: (614) 644-2285
Fax: (614) 728-1791
E-mail: amy.yersavich@epa.state.oh.us

OKLAHOMA

www.deq.state.ok.us/waste.html

Rita Kottke
Waste Management Division
OK Department of Environmental Quality
P.O. Box 1677
707 N. Robinson
Oklahoma City, OK 73101-1677
Phone: (405) 702-5127
Fax: (405) 702-5101
E-mail: rita.kottke@deqmail.state.ok.us

Anil Lyon
Department of Environmental Quality
Waste Management Division
1000 Northeast 10th Street
Oklahoma City, OK 73117-1212
Phone: (405) 271-7128
Fax: (405) 271-1342
E-mail: anil.lyon@oklaosf.state.ok.us

OREGON

www.deq.state.or.us/wmc/cleanup/clean.htm

Alan Kiphut
Voluntary Cleanup Section
Waste Management and Cleanup Division
OR Department of Environmental Quality
811 S.W. Sixth Avenue
Portland, OR 97204
Phone: (503) 229-6834
Fax: (503) 229-6977
E-mail: kiphut.alan@deq.state.or.us

PENNSYLVANIA

www.dep.state.pa.us/dep/deputate/airwaste/wm/default.htm

Scott Dunkelberger
Grants Office
Department of Community and Economic Development
494 Forum Building
Harrisburg, PA 17120
Phone: (717) 787-7120
Fax: (717) 787-2890
E-mail: sdunkel@doc.state.pa.us

David Hess
Department of Environmental Protection
Philadelphia, PA
Phone: (717) 783-7509
E-mail: hess.david@al.dep.state.pa.us

STATE BROWNFIELDS CONTACTS (continued)

PENNSYLVANIA (continued)

James Shaw
Department of Environmental Protection
Bureau of Land Recycling & Waste Management
400 Market Street
P.O. Box 8471
Harrisburg, PA 17105
Phone: (717) 787-7120
Fax: (717) 787-1904
E-mail: landrecyclng@al.dep.state.pa.us

RHODE ISLAND

www.state.ri.us/dem

Greg Fine
Office of Waste Management
RI Department of Environmental Management
235 Promenade Street
Providence, RI 02908
Phone: (401) 277-2797
Fax: (401) 277-3812

SOUTH CAROLINA

www.state.sc.us/dhec

Gail Jeter
Bureau of Land and Waste Management
SC Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201
Phone: (803) 896-4069
Fax: (803) 896-4001
E-mail: jetergr@columb34.dhec.state.sc.us

SOUTH DAKOTA

www.state.sd.us/state/executive/denr/denr.html

Mark Lawrenson
Division of Environmental Regulation
SD Department of Water and Natural Resources
523 East Capitol, Foss Building
Pierre, SD 57501
Phone: (605) 773-5868
Fax: (605) 773-6035

TENNESSEE

www.state.tn.us/environment/dsf/home.htm

Andrew Shivas
Division of Superfund
TN Department of Environment and Conservation
401 Church Street
14th Floor, L&C Annex
Nashville, TN 37214
Phone: (615) 532-0912
Fax: (615) 532-0938
E-mail: ashivas@mail.state.tn.us

TEXAS

www.tnrcc.state.tx.us/homepgs/oprr.html

Chuck Epperson
Voluntary Cleanup Section
TX Natural Resource Conservation Commission
P.O. Box 13087 - MC221
Austin, TX 78711-3087
Phone: (512) 239-2498
Fax: (512) 239-1212
E-mail: cepperso@tnrcc.state.tx.us

UTAH

www.eq.state.ut.us/EQERR/errhmpg.htm

Brent Everett
Division of Environmental Response and Remediation
168 North 1950 West
1st Floor
Salt Lake City, UT 84116
Phone: (801) 536-4100
Fax: (801) 536-4242
E-mail: beverett@deq.state.ut.us

VERMONT

www.anr.state.vt.us/

George Desch
Department of Environmental Conservation
VT Agency of Natural Resources
103 S. Main Street
Waterbury, VT 05671-0404
Phone: (802) 241-3491
Fax: (802) 244-3296
E-mail: georged@dec.anr.state.vt.us

VIRGINIA

www.deq.state.va.us/

Erica Dameron
VA Department of Environmental Quality
629 E. Main Street
Richmond, VA 23219
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Fax: (804) 698-4334
E-mail: esdameron@deq.state.va.us

WASHINGTON

www.ecy.wa.gov

Curtis Dahlgren
WA Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
Phone: (360) 407-7187
Fax: (360) 407-7154
E-mail: cdah461@ecy.wa.gov

WASHINGTON, D.C.

Angelo Tompros
Department of Consumer and Regulatory Affairs
Environmental Regulation Administration
2100 Martin Luther King Jr. Ave., SE
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Washington, DC 20020
Phone: (202) 645-6080
Fax: (202) 645-6622

WEST VIRGINIA

www.dep.state.wv.us/

Ken Ellison
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Charleston, WV 25301
Phone: (304) 558-5929
Fax: (304) 558-0256
E-mail: kellison@mail.dep.state.wv.us

WISCONSIN

www.dnr.state.wi.us/org/aw/rr

Darsi Foss
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Madison, WI 53707-7921
Phone: (608) 267-6713
Fax: (608) 267-7646
E-mail: fossd@dnr.state.wi.us

WYOMING

http://deq.state.wy.us/

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E-mail: cander@missc.state.wy.us

EPA Regional Brownfields Coordinators

REGION 1

Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

www.epa.gov/region01/brownfields/

Lynne Jennings
U.S. EPA
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MC HIO
One Congress Street, Suite 1100
Boston, MA 02114-2023
Phone: (617) 918-1210
Fax: (617) 918-1291
E-mail: jennings.lynne@epa.gov

REGION 2

New Jersey, New York, Puerto Rico, Virgin Islands

www.epa.gov/r02earth/superfnd/brownfld/bfmainpg.htm

Larry D'Andrea
U.S. EPA
Region 2
290 Broadway
18th Floor
New York, NY 10007-1866
Phone: (212) 637-4314
Fax: (212) 637-4360
E-mail: dandrea@epa.gov

REGION 3

Delaware, Washington, D.C., Maryland, Pennsylvania, Virginia, West Virginia

www.epa.gov/reg3hwmd/brownfld/hmpage1.htm

Tom Stolle
U.S. EPA
Region 3
MC 3HS 34
1650 Arch Street
Philadelphia, PA 19103
Phone: (215) 814-3129
Fax: (215) 814-3254
E-mail: stolle.tom@epa.gov

REGION 4

Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee

www.epa.gov/region4/index.html

Mickey Hartnett
U.S. EPA
Region 4
61 Forsyth Street
Atlanta, GA 30303
Phone: (404) 562-8661
Fax: (404) 562-8628
E-mail: hartnett.mickey@epa.gov

REGION 5

Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin

www.epa.gov/R5Brownfields/

Joe Dufficy
U.S. EPA
Region 5
MC HFE-5J
77 West Jackson Boulevard
Chicago, IL 60604-3507
Phone: (312) 886-1960
Fax: (312) 886-7910
E-mail: dufficy.joe@epa.gov

REGION 6

Arkansas, Louisiana, New Mexico, Oklahoma, Texas

www.epa.gov/earth1r6/6sf/bfpages/sfbfhome.htm

Stan Hitt
U.S. EPA
Region 6
MC 6SF-P
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733
Phone: (214) 665-6736
Fax: (214) 665-6660
E-mail: hitt.stan@epa.gov

REGION 7

Iowa, Kansas, Missouri, Nebraska

www.epa.gov/region07/brownfields/index.html

Susan Klein
U.S. EPA
Region 7
SUPR
901 North 5th Street
Kansas City, KS 66101
Phone: (913) 551-7786
Fax: (913) 551-7948
E-mail: klein.susan@epa.gov

REGION 8

Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming

www.epa.gov/region08/land_waste/bfhome/bfhome.html

Kathie Atencio
U.S. EPA
Region 8
MC 8EPR-SA
999 18th Street, Suite 300
Denver, CO 80202-2466
Phone: (303) 312-6803
Fax: (303) 312-6071
E-mail: atencio.kathie@epa.gov

REGION 9

Arizona, California, Hawaii, Nevada, American Samoa, Guam

www.epa.gov/region09/waste/brown/index.html

Jim Hanson
U.S. EPA
Region 9
75 Hawthorne Street
San Francisco, CA 94105
Phone: (415) 744-2237
Fax: (415) 744-1796
E-mail: hanson.jim@epa.gov

REGION 10

Alaska, Idaho, Oregon, Washington

www.epa.gov/swerosps/bf/index.html#other

Tim Brincefield
U.S. EPA
Region 10
MC ECL-122
1200 Sixth Avenue
Seattle, WA 98101
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Fax: (206) 553-0124
E-mail: brincefield.timothy@epa.gov

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www.epa.gov/brownfields

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EPA Technical Support Contacts

BROWNFIELDS TECHNOLOGY SUPPORT CENTER

Online: *http://clu-in.org/brownfieldstsc*
Phone: (877) 838-7220 (Toll Free)

EPA Contact: Dan Powell
Technology Innovation Office
U.S. EPA
Phone: (703) 603-7196
E-mail: powell.dan@epa.gov

GENERAL INFORMATION: TECHNOLOGY INNOVATION OFFICE

CLEANUP TECHNOLOGIES

John Kingscott
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Ariel Rios Building
1200 Pennsylvania Avenue, NW (5102G)
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REGULATORY INFORMATION

See page C-6 for information about EPA regional points of contact.

SITE CHARACTERIZATION AND MONITORING

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SPECIFIC TECHNICAL SUPPORT: OFFICE OF RESEARCH AND DEVELOPMENT

CLEANUP TECHNOLOGIES

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Joan Colson
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Office of Research and Development
U.S. EPA
26 Martin Luther King Drive
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GROUNDWATER REMEDIATION TECHNOLOGIES

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E-mail: burden.david@epa.gov

SITE CHARACTERIZATION TECHNOLOGIES

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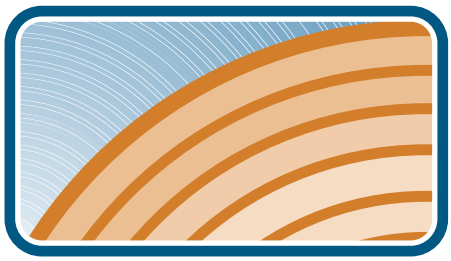
Phone: (702) 798-2432
Fax: (702) 798-2261
E-mail: koglin.eric@epa.gov



APPENDIX D

Appendix D

HOW TO ORDER DOCUMENTS

Each resource described in this document can either be viewed or downloaded directly from the accompanying CD-ROM, or accessed or ordered on line using links provided on the CD-ROM. Many of the documents are provided in portable document format (pdf). Printed or hard copy versions of the publications are available through EPA's National Service Center for Environmental Publications (NSCEP). NSCEP is a central repository for all EPA documents, with more than 7,000 titles in paper and electronic format. The documents are available free of charge, but supplies may be limited. You may order one copy each of as many as five documents within any two-week period. Documents may be ordered on line, by telephone, by facsimile, or by using the order form provided on the following page. Please include the EPA document numbers of all publications ordered.

Some EPA publications also may be available on EPA's National Environmental Publications Internet Site (NEPIS), EPA's online repository of more than 7,000 documents. Visit the NEPIS site at *www.epa.gov/ncepihom/nepishom* to search for, view, and print documents. The collection may include documents that no longer are available in print. In addition, since some EPA offices make selected documents available through their own Web sites, you may wish to visit the Web site, "Publications on the EPA Site" at *www.epa.gov/epahome/publications2.htm* for more information about obtaining documents.

Publications that have numbers beginning with PB, or publications that are out of stock at NSCEP, may be purchased from the National Technical Information Service (NTIS).

Publications of the WASTECH partnerships may be ordered by using the order form provided at the end of this appendix.

The addresses, telephone and facsimile numbers, and web addresses for the services are listed below:

NSCEP *National Service Center for Environmental Publications*
U.S. Environmental Protection Agency
P.O. Box 42419
Cincinnati, OH 45242
Telephone: (800) 490-9198
Telephone: (513) 489-8190 (Government Employees)
Fax: (513) 489-8695
WWW: *www.epa.gov/ncepihom*

NTIS *National Technical Information Service*
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703) 605-6000
Fax: (703) 605-6900
E-mail: orders@ntis.fedworld.gov
WWW: *www.ntis.gov*

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Mail/Fax to: American Academy of Environmental Engineers
130 Holiday Court, Suite 100, Annapolis, MD 21401
Phone: 410-266-3311, Fax: 410-266-7653

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130 Holiday Court, Suite 100, Annapolis, MD 21401
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American Academy of Environmental Engineers
130 Holiday Court, Suite 100
Annapolis, MD 21401

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INDEX OF RESOURCES

Index No.	Title of Resource	Page

To View the Road Map CD-ROM:

To view the resources on the Road Map CD-ROM, you will need to have both a web browser and Adobe® Acrobat® Reader 4.0 installed on your computer. For your convenience, both can be installed from this CD.

Note: In the instructions, the CD-ROM drive is referred to as the "D" drive. If your CD-ROM is installed on a different drive, please substitute the appropriate drive letter.

Getting Started

To view the Road Map CD-ROM, insert the CD into your CD-ROM drive. Click on the "Start" button, select "Run," and type **D:\start.htm**.

Software Installation

To install Netscape, go to Start, Run, and type **D:\software\netscape.exe** and follow the on-screen directions.

To install Adobe® Acrobat® Reader 4.0, go to Start, Run, and type **D:\software\acrobat4.exe** and follow the on-screen directions.

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