In Situ Remediation Technologies and Site Reuse

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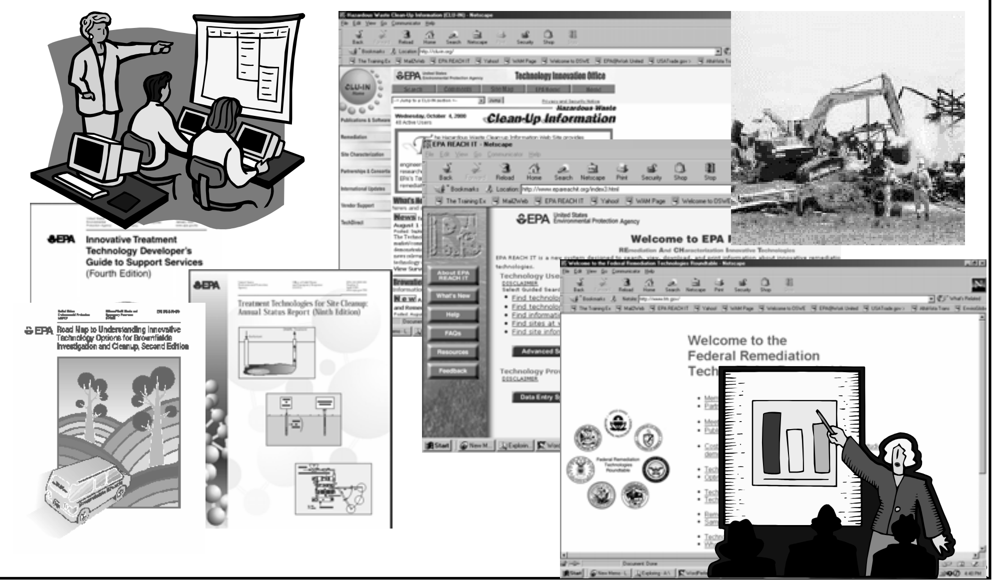
Technology Innovation Program Technology Transfer Efforts



Why Innovate?

- Key drivers in contaminated site restoration:
  - » Cost
  - » Uncertainty
- Still a relatively young industry experiencing change in several areas, mainly:
  - » Technology innovation
  - » Advances in project management
  - » Shifting market drivers
- This presentation touches on each of these areas
  - » Snap shot of the drivers for innovation
  - » The Triad: Synthesizing practitioner experience in smart project management to reduce cost and uncertainty
  - » Technology innovation: Demand and supply side information
  - » Brownfield Technology & Redevelopment Support Center

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Innovative Site Management Approaches & The Land Reuse Equation

Purchase Costs + Redevelopment Costs

vs.

Clean Value

- Transaction costs
- Site prep
- Construction
- Development
- Taxes/admin.
- Marketing
- Etc., etc., etc.

- Revenues
- Resale/asset value
- Social/political

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Innovative Site Management Approaches & The Land Reuse Equation

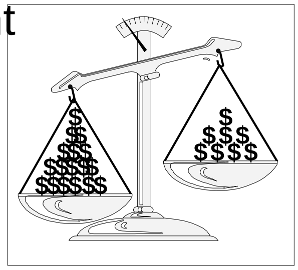
Purchase + Redevelopment

- •Transaction costs
- •Site prep
- •Construction
- •Development
- •Taxes/admin.
- •Marketing
- •Etc., etc., etc.

+

- **•Assessment**
- **•Cleanup**
- **•Liability issues**

vs.



Clean Value

- •Revenues
- •Resale/asset value
- •Social/political

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Real-Time Analytical and Sampling Technologies

- Field analytical, rapid sampling, mobile labs, quick turnaround off-site all allow real-time or near real time analysis
- Rapid turnaround results support dynamic decision making
- Lower costs of field methods support increased density (address sampling uncertainty)
- Field results guide confirmation (address analytical uncertainty)
- Decision support software can help organize and process data, plan field activities

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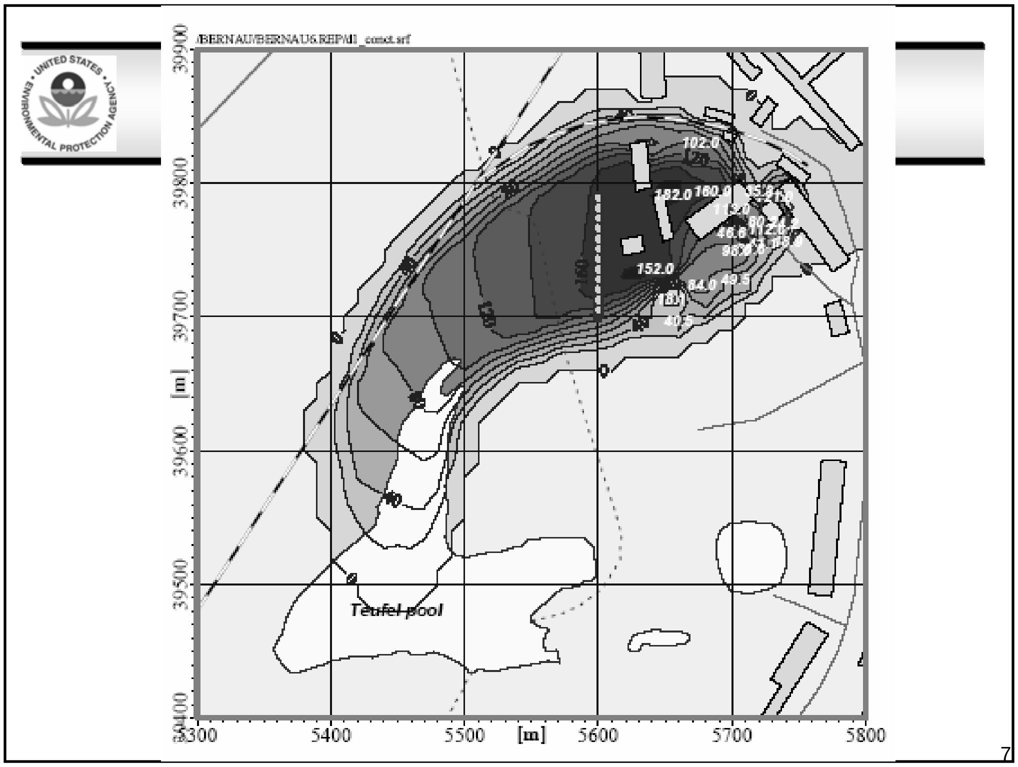
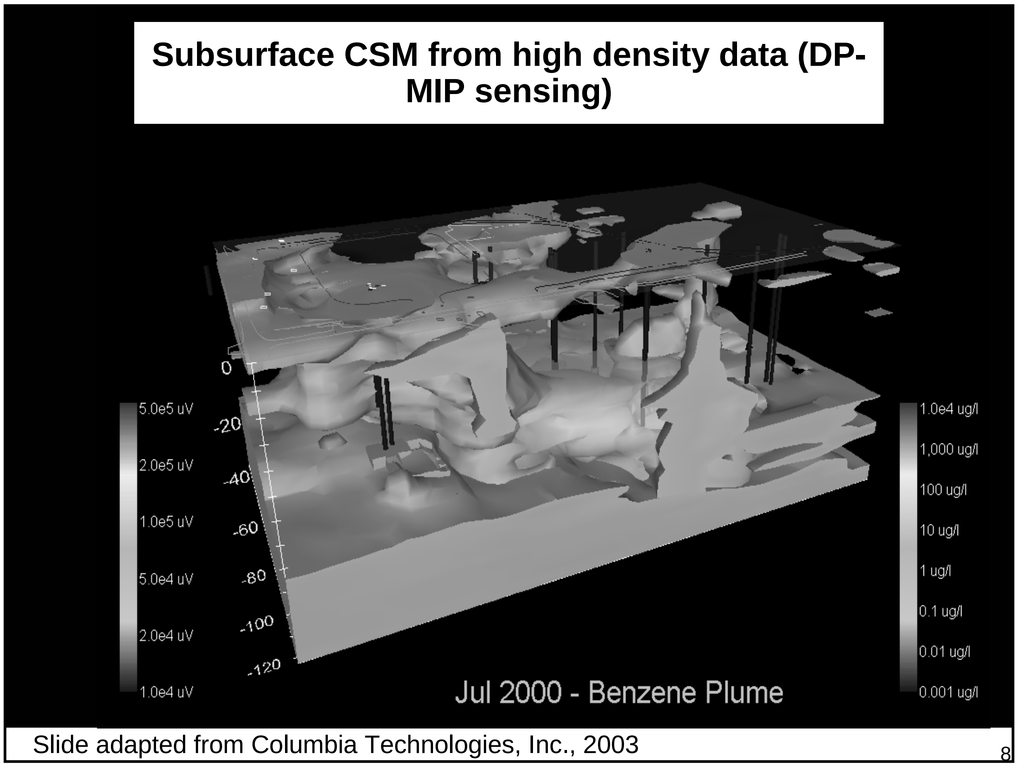


Common representation/depiction of a contaminant plume (TCE in this instance)

We are used to taking widely spaced samples and modeling groundwater plumes like this.



What the MIP technology is capable of in the hands of a sophisticated user.

Traditional Sampling Can Be Misleading

same well field…2 different sample collection techniques

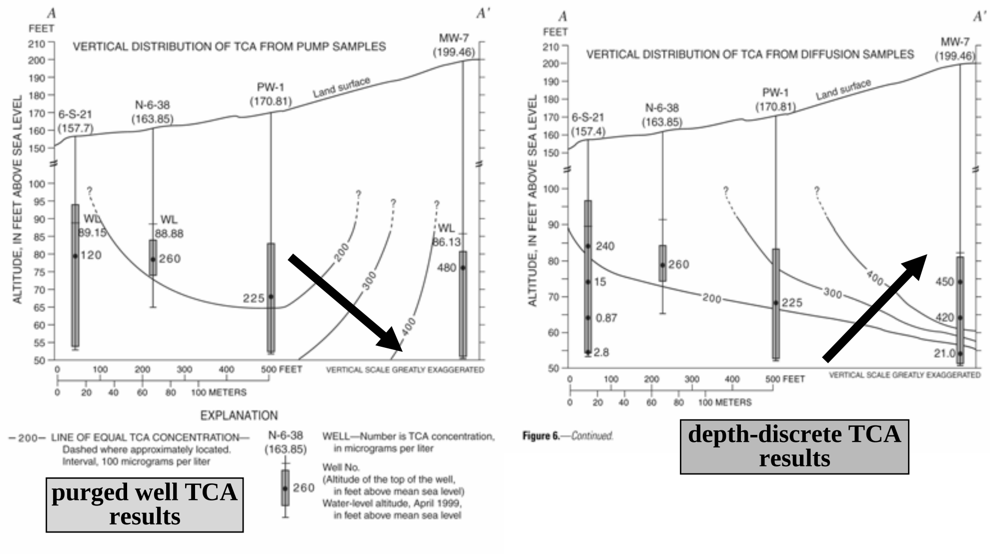


Figure 6. Vertical distribution of TCA concentrations in ground-water samples collected with the diffusion samplers and submersible pump.

Figure 6.—Continued.

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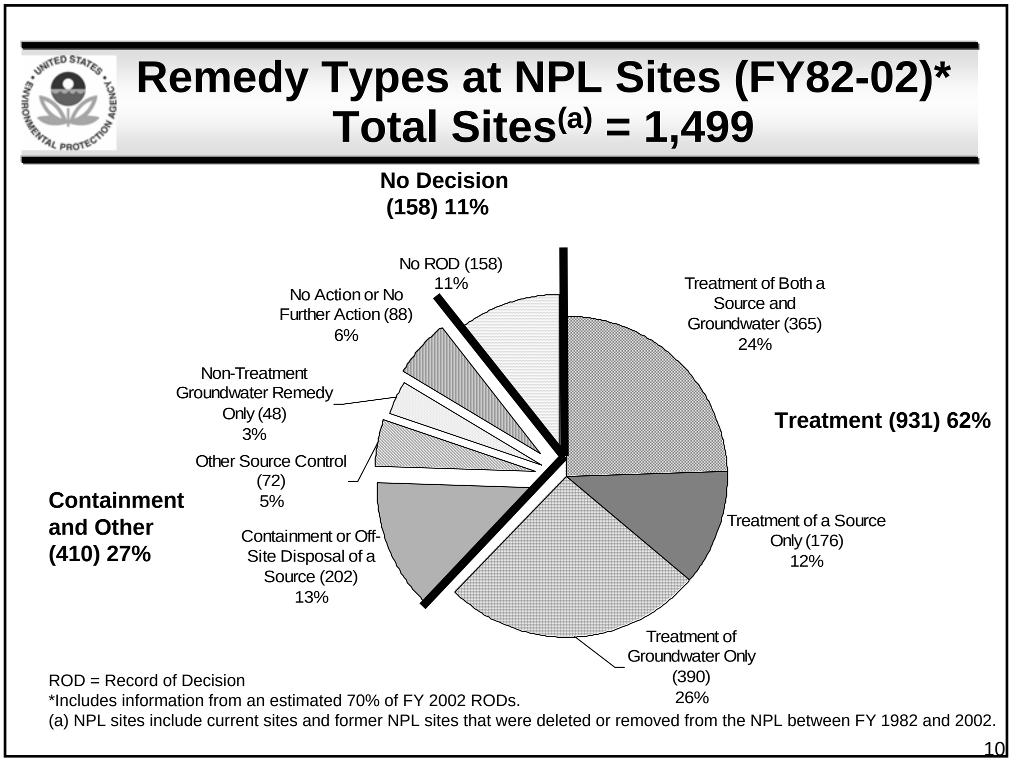
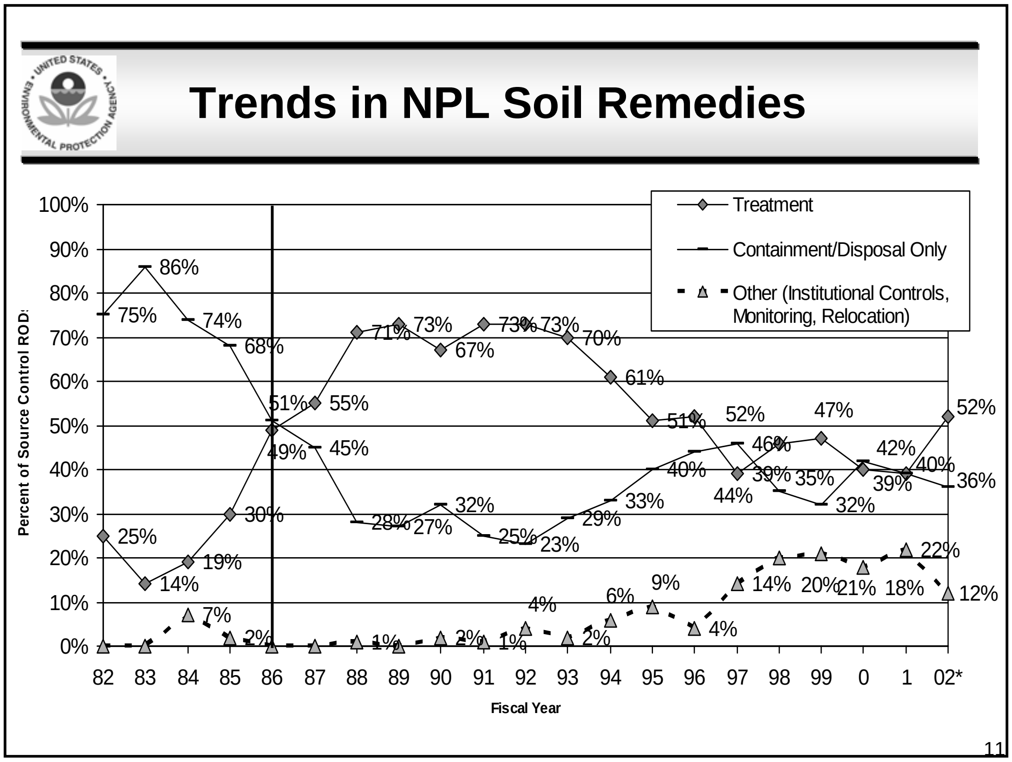
Huffman, R.L. (2002) Comparison of Passive Diffusion Bag Samplers and Submersible Pump Sampling Methods for Monitoring Volatile Organic Compounds in Ground Water at Area 6, Naval Air Station Whidbey Island, Washington. U.S. Geological Survey Water-Resources Investigations Report 02-4203. Available on-line at http://water.usgs.gov/pubs/wri/wri024203/

CSM based on traditional sampling is very different from CSM based on more detailed, spatially accurate sampling that preserves the integrity of vertical stratification.

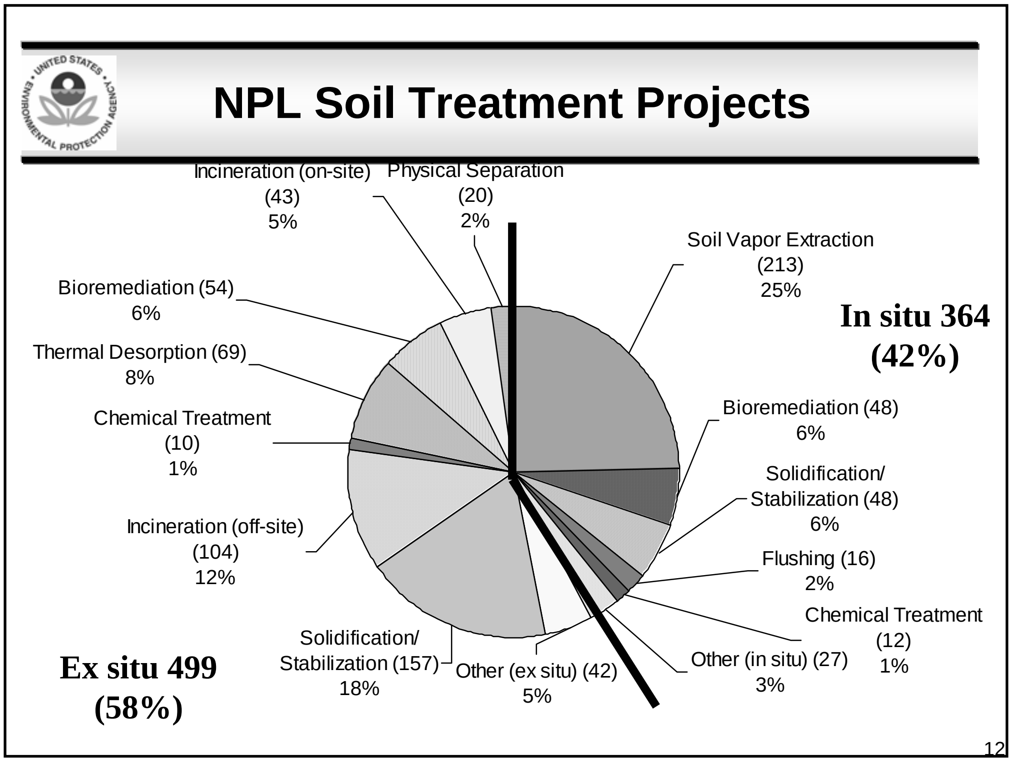


- Some 62% of sites have treatment as part of the remedy
- At 24% of sites both soil and groundwater are being treated
- 13% have selected containment but not treatment. Some of the "off'site disposal" may include treatment, but it is not counted as such due to lack of supporting data. Additionally, removal actions may have taken place at these sites, but are not counted either due to limitations in the available information.
- Only 8% have selected only non-treatment and non-containment remedies, such as institutional controls or alternative water supply

This slide shows information on a site basis, and presents a snapshot of the current state of Superfund remedial actions. The remedies shown for treatment are actual remedy types implemented or currently planned. Treatment remedies that have been changed to another remedy type are not shown.



- The percent of source control RODs selecting treatment climbed to 52% in 2002
- Treatment and containment RODs have held steady at about 40% each between 1997 and 2001
- 2002 saw a drop in RODs selecting “other” remedies, mainly IC’s, as the **<u>sole</u>** remedy
- 31% of the newly selected treatment remedies are innovative technologies (Bioremediation, chemical treatment, phytoremediation, etc.)
- Cumulatively, 50% of source control RODs have selected treatment



Most Common	Most Innovative
Soil vapor extraction (213 projects, 25%)	Chemical treatment (12 projects, 1%)
Solidification/ stabilization (157 projects, 18%)	Phytoremediation (6 projects, <1%)
Incineration (104 projects, 12%)	Thermally enhanced recovery (8 projects, 1%)
Bioremediation (102 projects, 12%)	Multi-phase extraction (8 projects, 1%)
Thermal desorption (69 projects, 8%)	Flushing (16 projects, 2%)

•Two of the most commonly selected remedies, SVE and thermal desorption, were once considered “innovative” technologies.

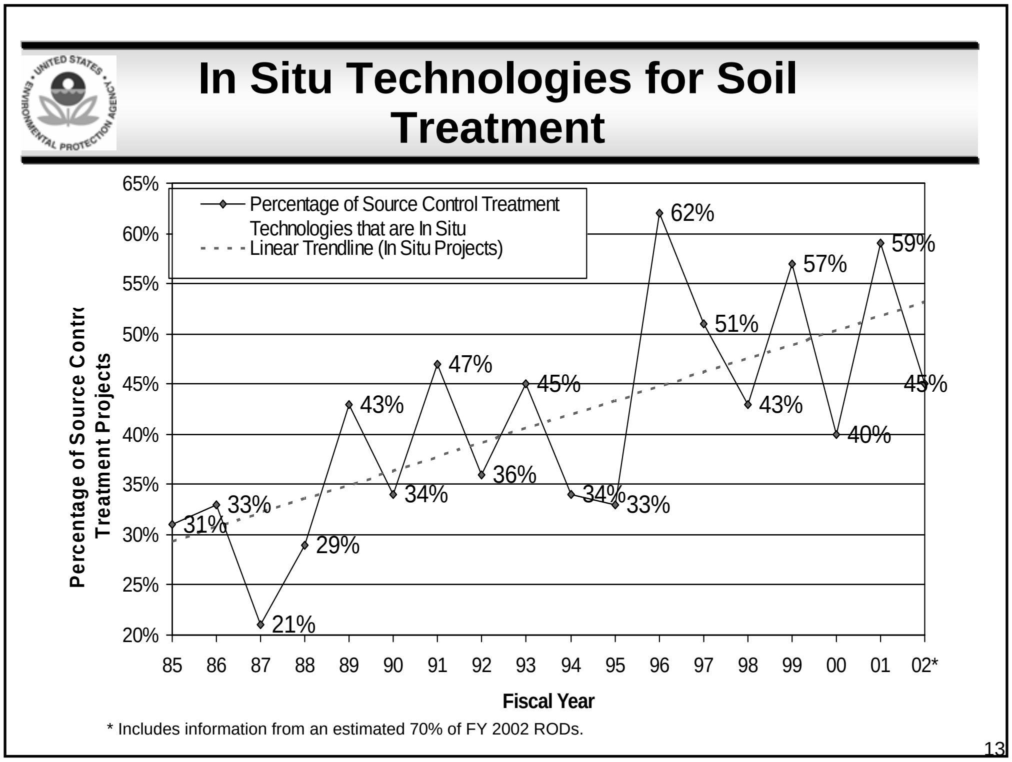
•SVE is used most frequently for volatile organics, S/S is used most frequently for metals

•Incineration, bioremediation, and thermal desorption are used to treat organics

•Chemical treatment, thermally enhanced recovery, and flushing are being used more frequently to treat chlorinated volatile organic compounds and DNAPLs. There is currently some disagreement in the literature about whether chemical treatment is effective for DNAPLs or only for soil and dissolved-phase contaminants

•Phytoremediation is being used more frequently as a low-cost alternative to more aggressive technologies

•Multi-phase extraction is used most often to treat sites with LNAPLs (BTEX, petroleum hydrocarbons)



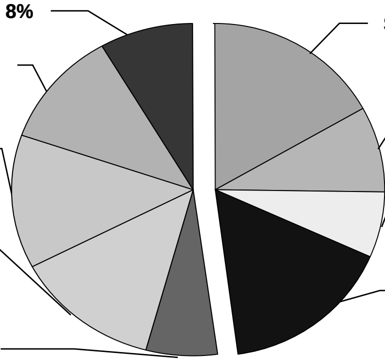
•124 soil treatment projects have been selected since the last report (17 older projects were deleted)

•Figure 2.6 represents source control remedies, NOT groundwater remedies (covered in following slides)

•In situ remedies often address complex contamination problems such as contamination under buildings, deep underground, or over large extensions, in addition frequent cost advantages

Source Control Treatment Projects Selected in FY 2000, 2001, and 2002*

Total Projects = 107



* Includes information from an estimated 70% of FY 2002 RODs.

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Groundwater Remedies

We've broken the P&T "monopoly"

- » In situ remedies are more mature, diverse and specific
  - – In 1991, 5% in situ GW remedies; in 2002, 24%
- » Time, experience, and technology are allowing us to optimize the pumping, treating, and monitoring components of long term P&T systems.
- » As with source control, we are using a "rich" mix of remedies, with a more robust tool box to address each scenario

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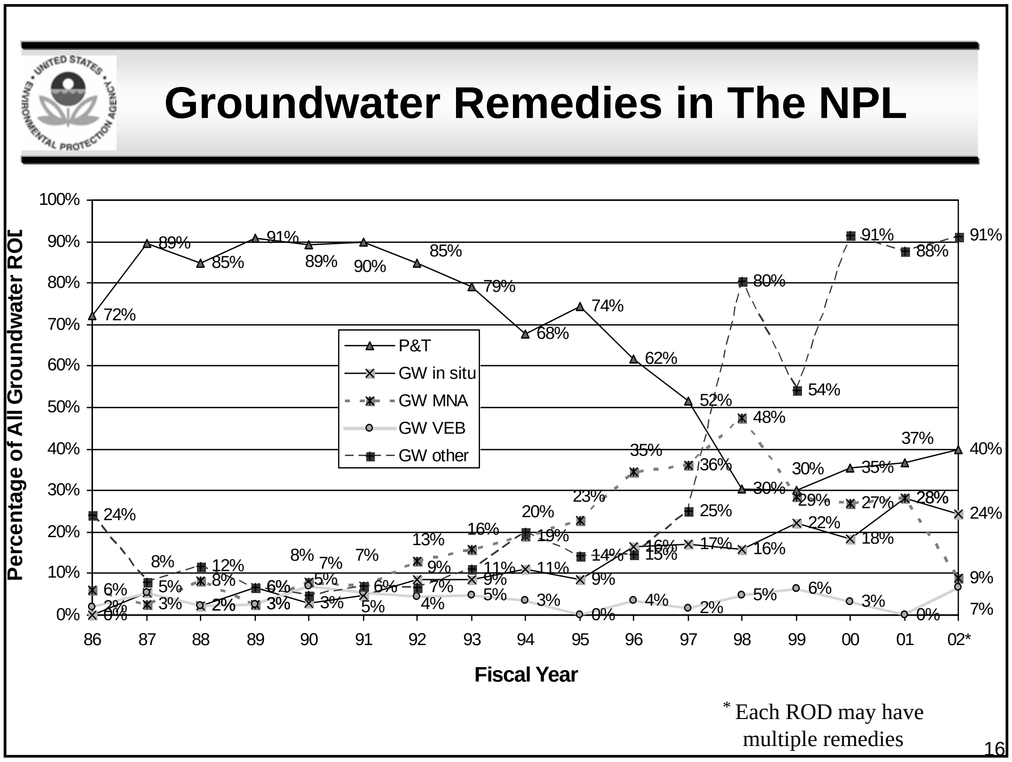
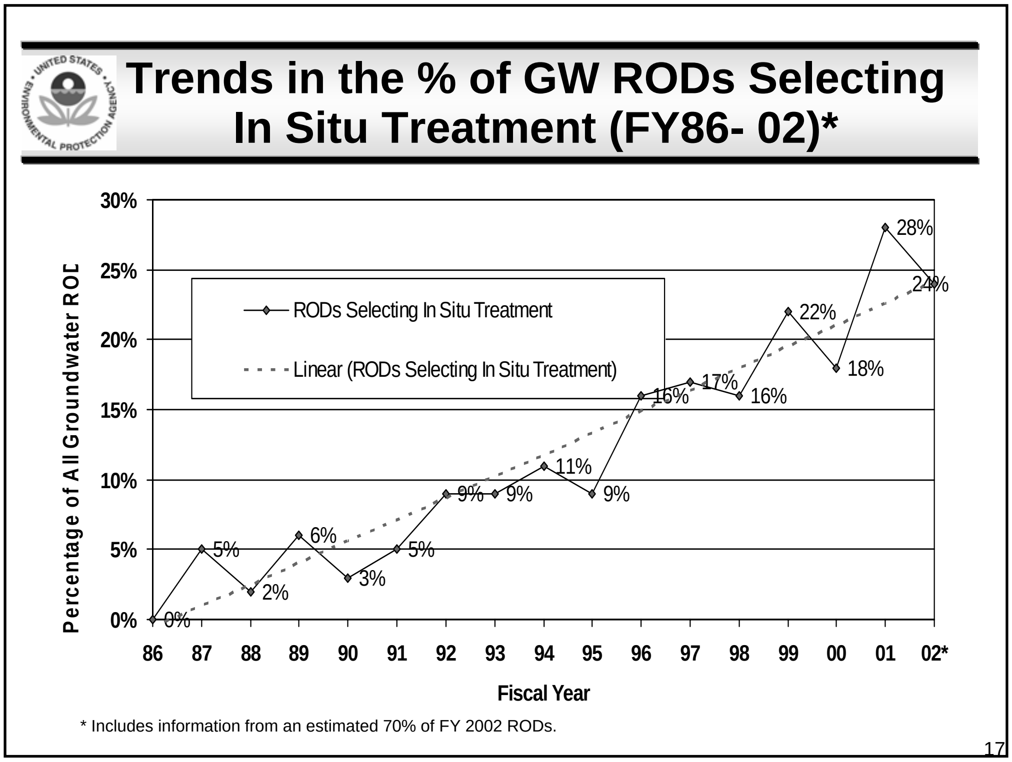


- •P&T has declined as the sole remedy in RODs from 83% in 1991 to 27% in 2002
- •In recent years, Groundwater RODs have a richer mix of remedies than in early years of the program
- •“Other” remedies, mainly Institutional Controls, were selected in 91% of RODs in 2002, up from 20% averages before 1997
- •In 2002 56% of GW RODs had some form of treatment
- •Cumulatively, 73% of GW RODs have selected groundwater treatment



•In situ treatment has been experiencing a healthy growth, and stood at 24% of all GW RODs in 2002

Most common In situ Groundwater treatment technologies

➢Air sparging

➢Bioremediation

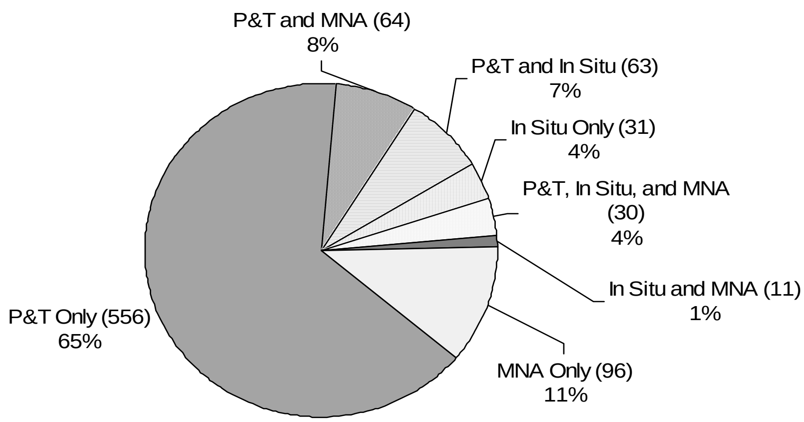
➢Chemical treatment

➢Permeable reactive barriers

➢In-well air stripping

GW Treatment Remedies in Superfund

Sites with P&T, In Situ Treatment, or MNA Selected as Part of a Groundwater Remedy (Total Sites = 851)



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Becoming "Main Stream"; In Situ Groundwater Treatment Remedies Selected in 2000 -- 2002* N= 66

Technology	Number of New Projects
Bioremediation	21
Chemical Treatment	15
Air Sparging	10
Permeable Reactive Barrier	7
Multi-Phase Extraction	4
In-Well Air Stripping	3
Phytoremediation	3
Flushing	2
In Situ Thermal Treatment	1

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In Situ Treatment Technologies
Groundwater

- Established
  - » Air Sparging (fuels, organics)
  - » Bioslurping (fuels, organics)
  - » Enhanced Bioremediation (organics, fuels)
  - » Multiphase Extraction (fuels, organics)

Permeable Reactive Barriers (metals, organics)

- Emerging
  - » Chemical oxidation (fuels, organics)
  - » Electrokinetics (metals)
  - » Phytoremediation (organics)
  - » Recirculating Wells (fuels, organics)
  - » Steam stripping (fuels, organics)

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EPA REACH IT System

- Meant to be a screening tool to identify potentially applicable innovative technologies and vendors
- Open online database released in 1998
- Combined VISITT, VendorFACTs, & ITT systems into a web-based, searchable system (www.epareachit.org)
- Remediation And Characterization Innovative Technologies
- Ongoing updates and periodic streamlining efforts

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Characterization/Monitoring Technologies Listed In EPA REACH IT

- Acoustic Wave Chemical Sensors
- Air Measurement (Weather Measurement Technologies Excluded)
- Air/Gas Sampling Technologies
- Analytical Detectors (Stand Alone Only)
- Analytical Traps
- Borehole
- Chemical Reaction-Based Indicators (Colorimetric)
- Chromatography
- Direct-push
- Downhole Sensors-Vadose Zone
- Electrochemical-based Detectors
- Electromagnetic
- Fiber Optic Chemical Sensors
- Fourier-Transform Infrared (FTIR) Spectroscopy
- Graphite Furnace Atomic Absorption
- Ground Penetrating Radar
- Immunoassays
- Infrared Monitors
- Ion Mobility Spectroscopy
- Laser-induced Fluorescence
- Magnetometry
- Mass Spectroscopy (may include GC/MS)
- Multimedia Sampling
- Non-Specific Screening Tests
- Physical Characterization
- Resistivity/Conductivity
- Seismic Reflection/Refraction
- Software
- Soil Gas Analyzer Systems
- Soil Sampling Technologies
- Solid Phase Extraction
- Spectroscopy
- Thermal Desorption (Characterization)
- Water Monitoring Technology
- Water Sampling Technologies
- X-Ray Fluorescence Analyzers

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Remediation Technologies Listed In EPA REACH IT

- Acid Extraction
- Adsorption (in situ)
- Air Sparging (in situ) - Groundwater
- Bioremediation (in situ) - Lagoon
- Bioremediation (ex situ) - Biopiles
- Bioremediation (ex situ) - Composting
- Bioremediation (ex situ) - Land Treatment
- Bioremediation (ex situ) - Slurry Phase
- Bioremediation (ex situ) - Solid Phase
- Bioremediation (in situ) - Biosparging
- Bioremediation (in situ) - GW
- Bioventing
- Chemical Immobilization
- Chemical Treatment - Groundwater
- Dechlorination
- Decontamination of Debris
- Delivery/Extraction Systems
- Chemical Treatment - Oxidation/Reduction
- Electrical Separation/Electrokinetics
- Flushing (in situ)
- Fracturing - Hydraulic
- Fracturing - Pneumatic
- In Situ Thermal Treatment
- In Well Air Stripping
- Magnetic Separation
- Materials Handling/Physical Separation
- Mechanical Soil Aeration
- Multi-Phase Extraction
- Off-Gas Treatment
- Permeable Reactive Barrier
- Phytoremediation
- Pump and Treat
- Pyrolysis
- Soil Vapor Extraction
- Soil Washing
- Solidification/Stabilization
- Solvent Extraction
- Thermal Desorption (ex situ)
- Vitrification

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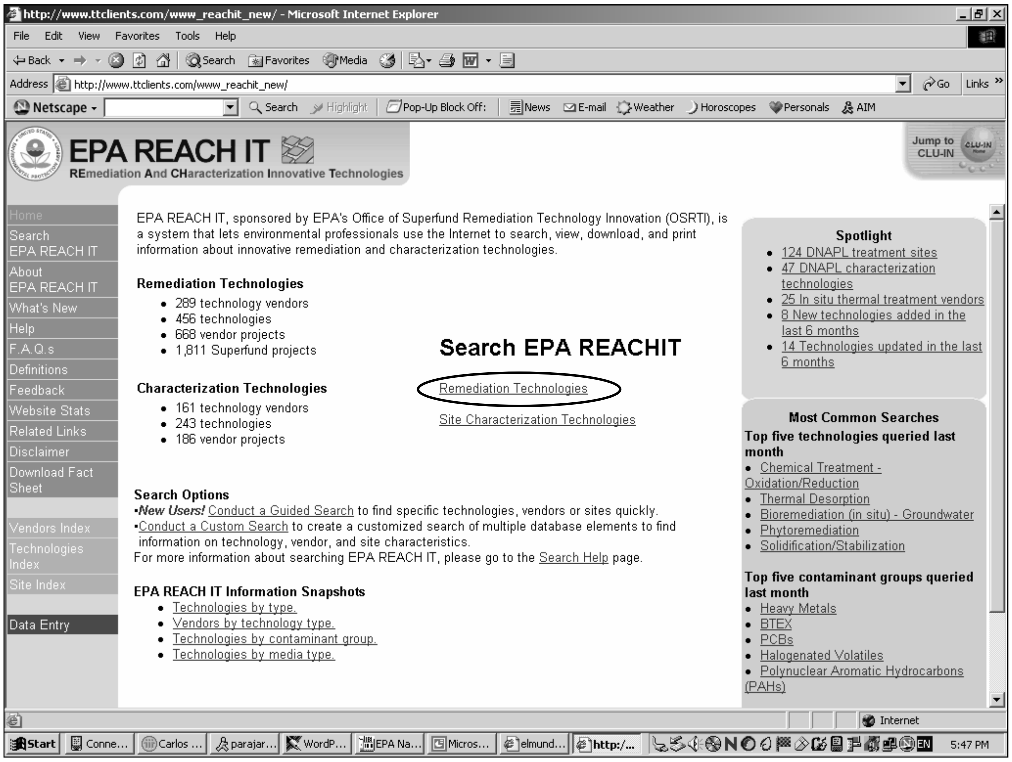
Vendor data

- 287 vendors
- 437 technologies
- 702 vendor projects using remediation technologies

EPA-verified data

- 1,811 projects at Superfund sites using remediation technologies (ASR Data)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EPA REACH IT, sponsored by EPA's Office of Superfund Remediation Technology Innovation (OSRTI), is a system that lets environmental professionals use the Internet to search, view, download, and print information about innovative remediation and characterization technologies.
Remediation Technologies
289 technology vendors
456 technologies
668 vendor projects
1,811 Superfund projects
Characterization Technologies
161 technology vendors
243 technologies
186 vendor projects
Search EPA REACHIT
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Site Characterization Technologies
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•Conduct a Custom Search to create a customized search of multiple database elements to find information on technology, vendor, and site characteristics.
For more information about searching EPA REACH IT, please go to the Search Help page.
EPA REACH IT Information Snapshots
Technologies by type.
Vendors by technology type.
Technologies by contaminant group.
Technologies by media type.
Spotlight
124 DNAPL treatment sites
47 DNAPL characterization technologies
25 In situ thermal treatment vendors
8 New technologies added in the last 6 months
14 Technologies updated in the last 6 months
Most Common Searches
Top five technologies queried last month
Chemical Treatment - Oxidation/Reduction
Thermal Desorption
Bioremediation (in situ) - Groundwater
Phytoremediation
Solidification/Stabilization
Top five contaminant groups queried last month
Heavy Metals
BTEX
PCBs
Halogenated Volatiles
Polynuclear Aromatic Hydrocarbons (PAHs)
Internet
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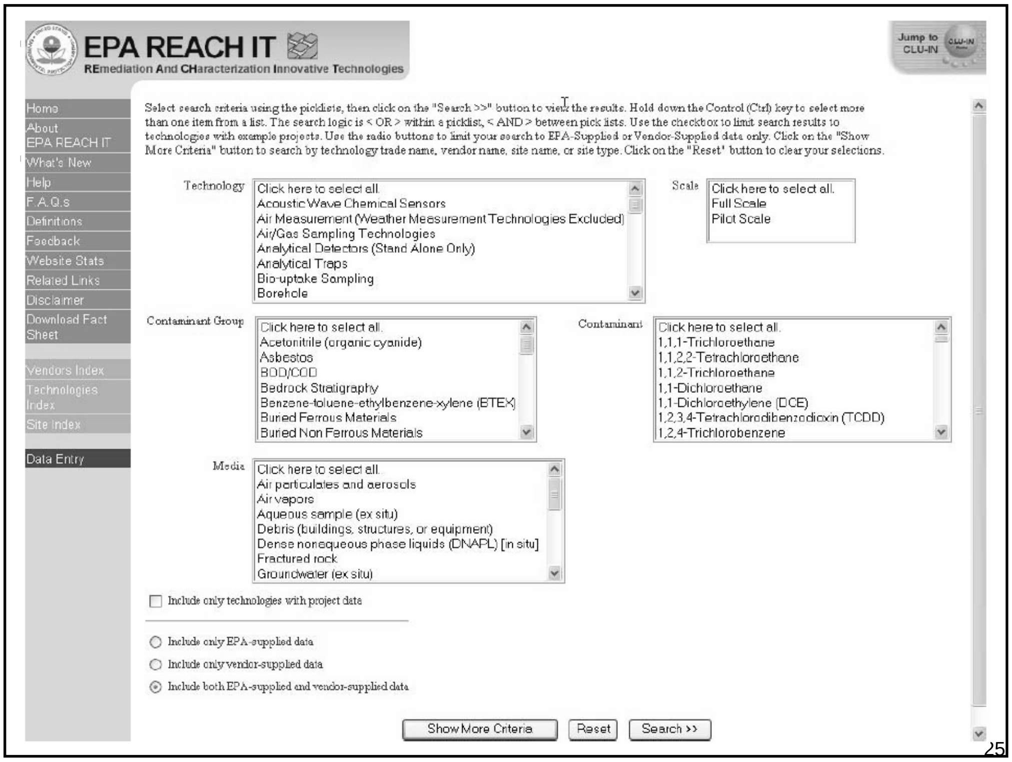
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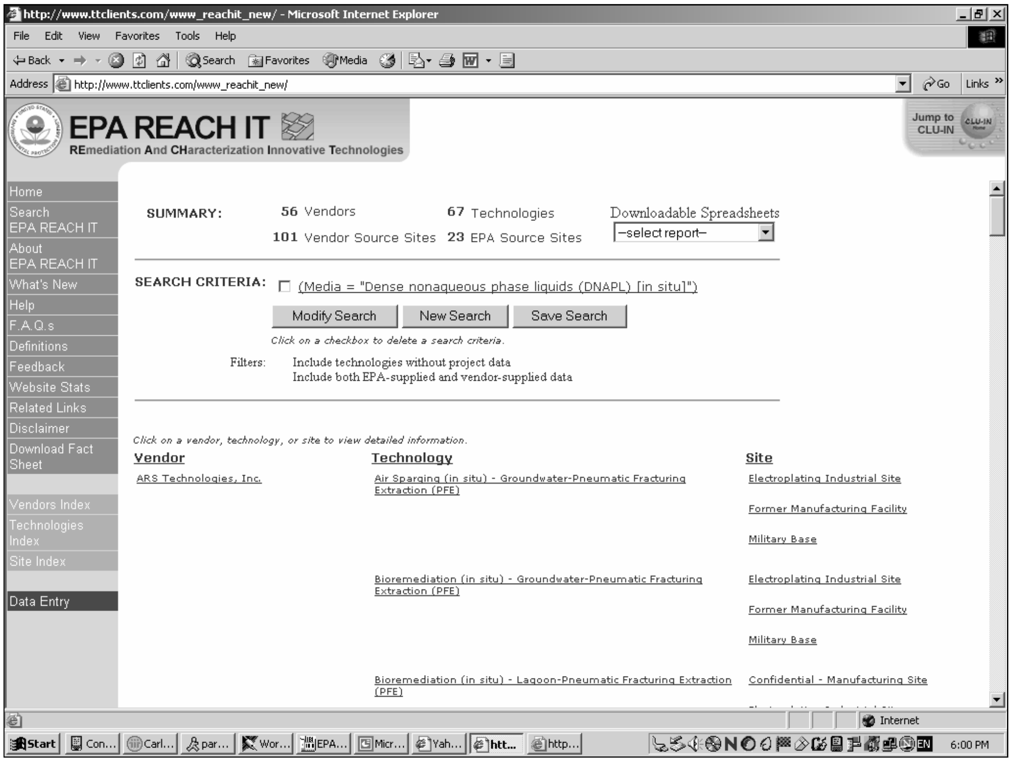
Select search criteria using the picklists, then click on the "Search >>" button to view the results. Hold down the Control (Ctrl) key to select more than one item from a list. The search logic is < OR > within a picklist, < AND > between pick lists. Use the checkbox to limit search results to technologies with example projects. Use the radio buttons to limit your search to EPA-Supplied or Vendor-Supplied data only. Click on the "Show More Criteria" button to search by technology trade name, vendor name, site name, or site type. Click on the "Reset" button to clear your selections.
Technology
Click here to select all.
Acoustic Wave Chemical Sensors
Air Measurement (Weather Measurement Technologies Excluded)
Air/Gas Sampling Technologies
Analytical Detectors (Stand Alone Only)
Analytical Traps
Bio-uptake Sampling
Borehole
Scale
Click here to select all.
Full Scale
Pilot Scale
Contaminant Group
Click here to select all.
Acetonitrile (organic cyanide)
Asbestos
BOD/COD
Bedrock Stratigraphy
Benzene-toluene-ethylbenzene-xylene (BTEX)
Buried Ferrous Materials
Buried Non Ferrous Materials
Contaminant
Click here to select all.
1,1,1-Trichloroethane
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1-Dichloroethane
1,1-Dichloroethylene (DCE)
1,2,3,4-Tetrachlorodibenzodioxin (TCDD)
1,2,4-Trichlorobenzene
Media
Click here to select all.
Air particulates and aerosols
Air vapors
Aqueous sample (ex situ)
Debris (buildings, structures, or equipment)
Dense nonaqueous phase liquids (DNAPL) [in situ]
Fractured rock
Groundwater (ex situ)
Include only technologies with project data
Include only EPA-supplied data
Include only vendor-supplied data
Include both EPA-supplied and vendor-supplied data
Show More Criteria
Reset
Search >>
25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SUMMARY: 56 Vendors 67 Technologies
101 Vendor Source Sites 23 EPA Source Sites
Downloadable Spreadsheets
SEARCH CRITERIA: (Media = "Dense nonaqueous phase liquids (DNAPL) [in situ]")
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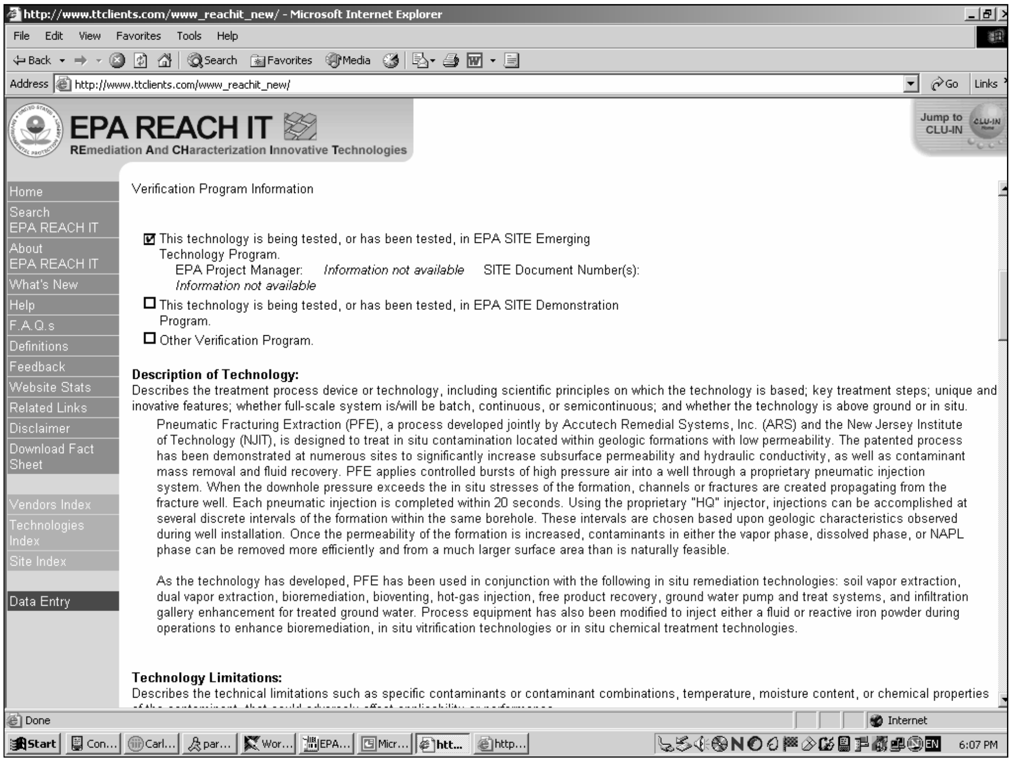
New Search
Save Search
Click on a checkbox to delete a search criteria.
Filters: Include technologies without project data
Include both EPA-supplied and vendor-supplied data
Click on a vendor, technology, or site to view detailed information.
Vendor
Technology
Site
ARS Technologies, Inc.
Air Sparging (in situ) - Groundwater-Pneumatic Fracturing Extraction (PFE)
Electroplating Industrial Site
Former Manufacturing Facility
Military Base
Bioremediation (in situ) - Groundwater-Pneumatic Fracturing Extraction (PFE)
Electroplating Industrial Site
Former Manufacturing Facility
Military Base
Bioremediation (in situ) - Lagoon-Pneumatic Fracturing Extraction (PFE)
Confidential - Manufacturing Site



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Verification Program Information

☑ This technology is being tested, or has been tested, in EPA SITE Emerging Technology Program.
EPA Project Manager: *Information not available* SITE Document Number(s): *Information not available*

☐ This technology is being tested, or has been tested, in EPA SITE Demonstration Program.

☐ Other Verification Program.

Description of Technology:
Describes the treatment process device or technology, including scientific principles on which the technology is based; key treatment steps; unique and inovative features; whether full-scale system is/will be batch, continuous, or semicontinuous; and whether the technology is above ground or in situ.

Pneumatic Fracturing Extraction (PFE), a process developed jointly by Accutech Remedial Systems, Inc. (ARS) and the New Jersey Institute of Technology (NJIT), is designed to treat in situ contamination located within geologic formations with low permeability. The patented process has been demonstrated at numerous sites to significantly increase subsurface permeability and hydraulic conductivity, as well as contaminant mass removal and fluid recovery. PFE applies controlled bursts of high pressure air into a well through a proprietary pneumatic injection system. When the downhole pressure exceeds the in situ stresses of the formation, channels or fractures are created propagating from the fracture well. Each pneumatic injection is completed within 20 seconds. Using the proprietary "HQ" injector, injections can be accomplished at several discrete intervals of the formation within the same borehole. These intervals are chosen based upon geologic characteristics observed during well installation. Once the permeability of the formation is increased, contaminants in either the vapor phase, dissolved phase, or NAPL phase can be removed more efficiently and from a much larger surface area than is naturally feasible.

As the technology has developed, PFE has been used in conjunction with the following in situ remediation technologies: soil vapor extraction, dual vapor extraction, bioremediation, bioventing, hot-gas injection, free product recovery, ground water pump and treat systems, and infiltration gallery enhancement for treated ground water. Process equipment has also been modified to inject either a fluid or reactive iron powder during operations to enhance bioremediation, in situ vitrification technologies or in situ chemical treatment technologies.

Technology Limitations:
Describes the technical limitations such as specific contaminants or contaminant combinations, temperature, moisture content, or chemical properties

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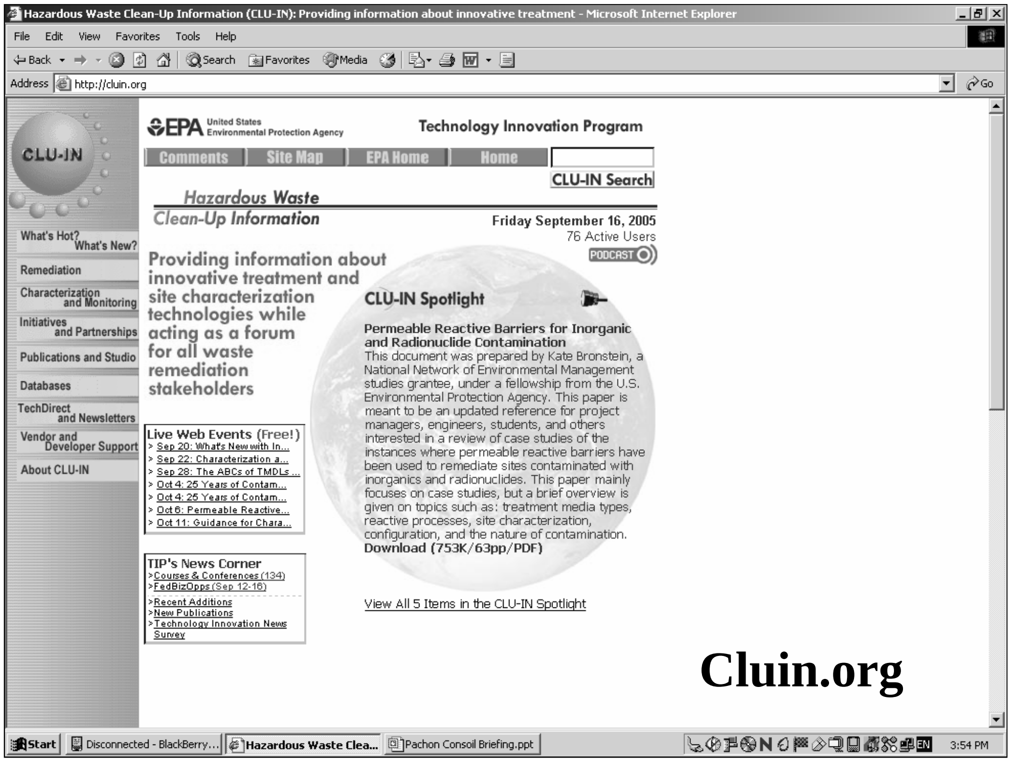
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Friday September 16, 2005
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Providing information about innovative treatment and site characterization technologies while acting as a forum for all waste remediation stakeholders
CLU-IN Spotlight
Permeable Reactive Barriers for Inorganic and Radionuclide Contamination
This document was prepared by Kate Bronstein, a National Network of Environmental Management studies grantee, under a fellowship from the U.S. Environmental Protection Agency. This paper is meant to be an updated reference for project managers, engineers, students, and others interested in a review of case studies of the instances where permeable reactive barriers have been used to remediate sites contaminated with inorganics and radionuclides. This paper mainly focuses on case studies, but a brief overview is given on topics such as: treatment media types, reactive processes, site characterization, configuration, and the nature of contamination.
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Technology Information Service

Highlights

- Broadcasts monthly e-mail messages to a list of over 21,000.
- Highlights events of interest to site remediation and site assessment professionals.
- Describes new products and provides instructions on how to obtain them.

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