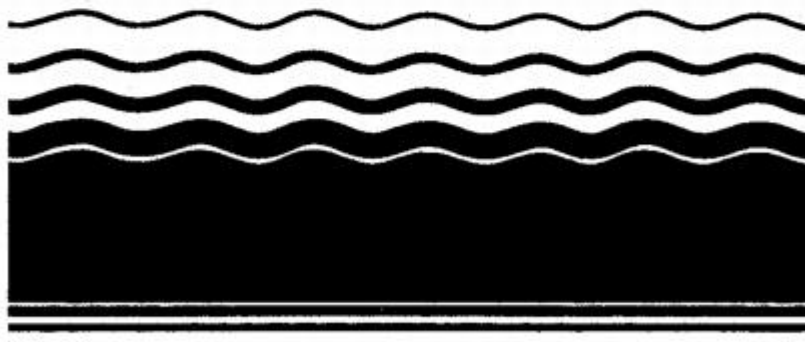


Superfund Innovative Technology Evaluation Program

Technology Profiles Eleventh Edition

Volume 1 Demonstration Program

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION



Technology Profiles
Eleventh Edition

Volume 1
Demonstration Program

**National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268**

NOTICE

The development of this document was funded by the U.S. Environmental Protection Agency (EPA) under Contract No. 68-C-00-185, Task Order 13, to Computer Sciences Corporation. The document was subjected to the Agency's administrative and peer review and was approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use at any particular hazardous waste site.

FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threatens human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions, and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by the EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

Hugh W. McKinnon, Director
National Risk Management Research Laboratory

ABSTRACT

The Superfund Innovative Technology Evaluation (SITE) Program, now in its sixteenth year is an integral part of EPA's research into alternative cleanup methods for hazardous waste sites around the nation. The SITE Program was created to encourage the development and routine use of innovative treatment and monitoring and measurement technologies. Under the program, EPA enters into cooperative agreements with technology developers. These developers research and refine their innovative technologies at bench- or pilot-scale and then, with EPA's support, demonstrate them at hazardous waste sites. As a result, the SITE Program provides environmental decision-makers with data on new, viable treatment technologies that may have performance or cost advantages compared to traditional treatment technologies.

This document is intended as a reference guide for those interested in technologies participating in the SITE Demonstration, Emerging Technology, and Measurement and Monitoring Programs. The two-page profiles are organized into two sections for each program, completed and ongoing projects, and are presented in alphabetical order by developer name. Reference tables for SITE Program participants precede the sections and contain EPA and developer contacts. Inquiries about a SITE technology evaluation or the SITE Program should be directed to the specific EPA project manager; inquiries on the technology process should be directed to the specific technology developer.

Each technology profile contains (1) a technology developer and process name, (2) a technology description, including a schematic diagram or photograph of the process, (3) a discussion of waste applicability, (4) a project status report, and (5) EPA project manager and technology developer contacts. The profiles also include summaries of demonstration results, if available. The technology description and waste applicability sections are written by the developer. EPA prepares the status and demonstration results sections.

A Trade Name Index and Applicability Index are also included in the back of this document. The Applicability Index is organized by 11 media categories, 19 waste categories, and 14 technology categories.

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ACKNOWLEDGMENTS

The project manager responsible for the preparation of this document is Teri Richardson of EPA's National Risk Management Research Laboratory in Cincinnati, Ohio. This document was prepared under the direction of Robert Olexsey, Director of the Land Remediation and Pollution Control Division. Key program area contributors for EPA include Annette Gatchett, and Randy Parker. Special acknowledgment is given to the individual EPA SITE project managers and technology developers who provided guidance and technical support.

Computer Sciences Corporation prepared this document under the direction and coordination of Teri Richardson and Annette Gatchett.

SITE PROGRAM DESCRIPTION

The U.S. Environmental Protection Agency's (EPA) Superfund Innovative Technology Evaluation (SITE) Program, now in its sixteenth year, encourages the development and implementation of (1) innovative treatment technologies for hazardous waste site remediation, and (2) characterization and monitoring technologies for evaluating the nature and extent of hazardous waste site contamination.

The SITE Program was established by EPA's Office of Solid Waste and Emergency Response (OSWER) and the Office of Research and Development (ORD) in response to the 1986 Superfund Amendments and Reauthorization Act (SARA), which recognized a need for an "Alternative or Innovative Treatment Technology Research and Demonstration Program." The SITE Program is administered by ORD's National Risk Management Research Laboratory (NRMRL), headquartered in Cincinnati, Ohio.

The SITE Program includes the following key elements:

- **Demonstration Program** - Conducts and evaluates demonstrations of promising innovative technologies to provide reliable performance, cost, and applicability information for site cleanup decision-making
- **Emerging Technology Program** - Support of the Emerging Technology Program ended in 1998 after completion of all committed projects in the Program
- **Monitoring and Measurement Technologies** - Evaluates technologies that detect, monitor, and measure hazardous and toxic substances to provide better, faster, and more cost-effective methods for producing real-time data during site characterization and remediation
- **Information Transfer Activities** - Disseminates technical information, including engineering, performance, and cost data, on innovative technologies to remove impediments for using innovative technologies.

This Technology Profiles document describes completed and ongoing projects in the Demonstration, Emerging Technology, and Characterization and Monitoring Programs. Figure 1 shows the relationship among the programs and depicts the process of technology development from initial concept to commercial use.

In the Demonstration Program, the technology is field-tested on hazardous waste materials. Engineering and cost data are gathered on the innovative technology so that potential users can assess the technology's applicability to a particular site. Data collected during the field demonstration are used to assess the performance of the technology, the potential need for pre- and post-processing of the waste, applicable types of wastes and waste matrices, potential operating problems, and approximate capital and operating costs.

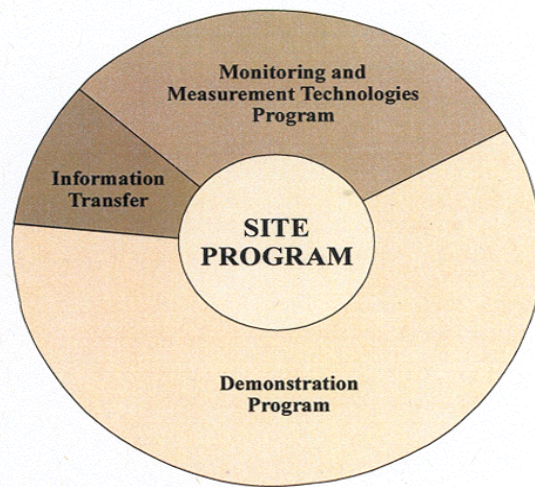


Figure 1 *Development of Innovative Technologies*

At the conclusion of a SITE demonstration, EPA prepares an Innovative Technology Evaluation Report (ITER), Technology Capsule, and Demonstration Bulletin. Often, a videotape of the demonstration is also prepared. These reports evaluate all available information on the technology and analyze its overall applicability to other site characteristics, waste types, and waste matrices. Testing procedures, performance and cost data, and quality assurance and quality control standards are also presented. These demonstration documents are distributed by EPA to provide reliable technical data for environmental decision-making and to promote the technology's commercial use.

The Demonstration Program currently has 147 program participants conducting 141 demonstrations. Of these projects 128 demonstrations are complete and 13 are ongoing. The projects are divided into the following categories: thermal treatment (34), biological degradation (28), physical/chemical treatment (50), solidification/stabilization (13), phytoremediation (5), soil washing (4), materials handling (3), and other (4). Several technologies represent more than one treatment category.

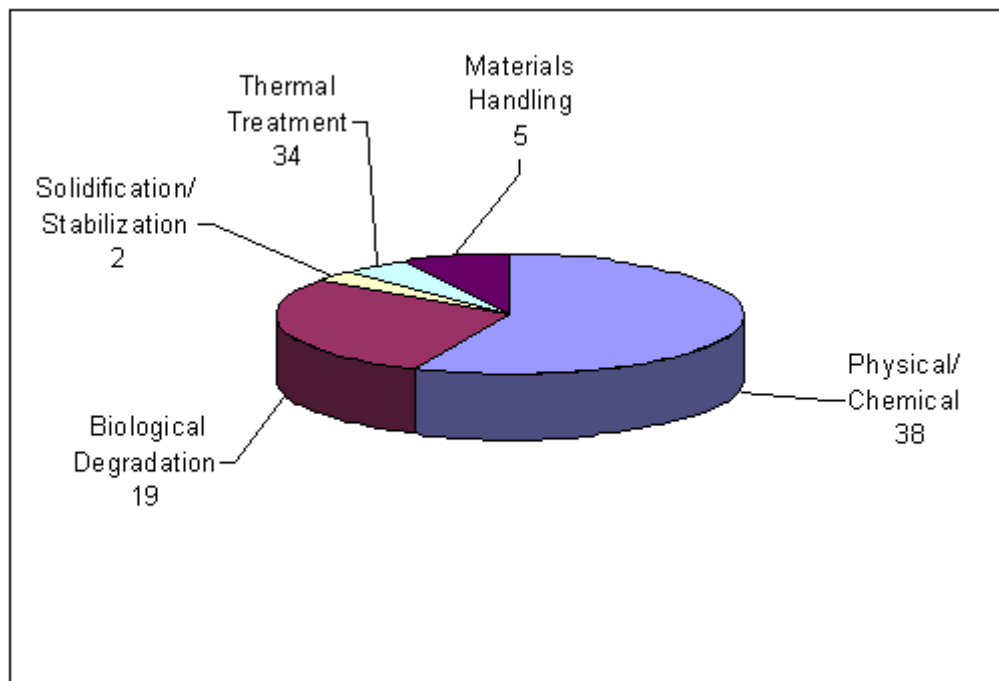


Figure 2: *Innovative Technologies in the Emerging Technology Program*

Figure 2 shows the breakdown of technologies in the Demonstration Program. Profiles for technologies demonstrated under the Demonstration Program are located in Volume I.

EPA has provided technical and financial support to 77 projects in the Emerging Technology Program. Seventy-three are completed and four have exited the program. Eighteen Emerging Technology Program projects participated in the Demonstration Program. The seventh-three active technologies are divided into the following categories: thermal destruction (9), physical/chemical treatment (38), biological degradation (19), solidification/stabilization (2), and materials handling (5). Figure 3 displays the breakdown of technologies in the Emerging Technology Program. Profiles for technologies demonstrated under the Emerging Technology Program are located in Volume II.

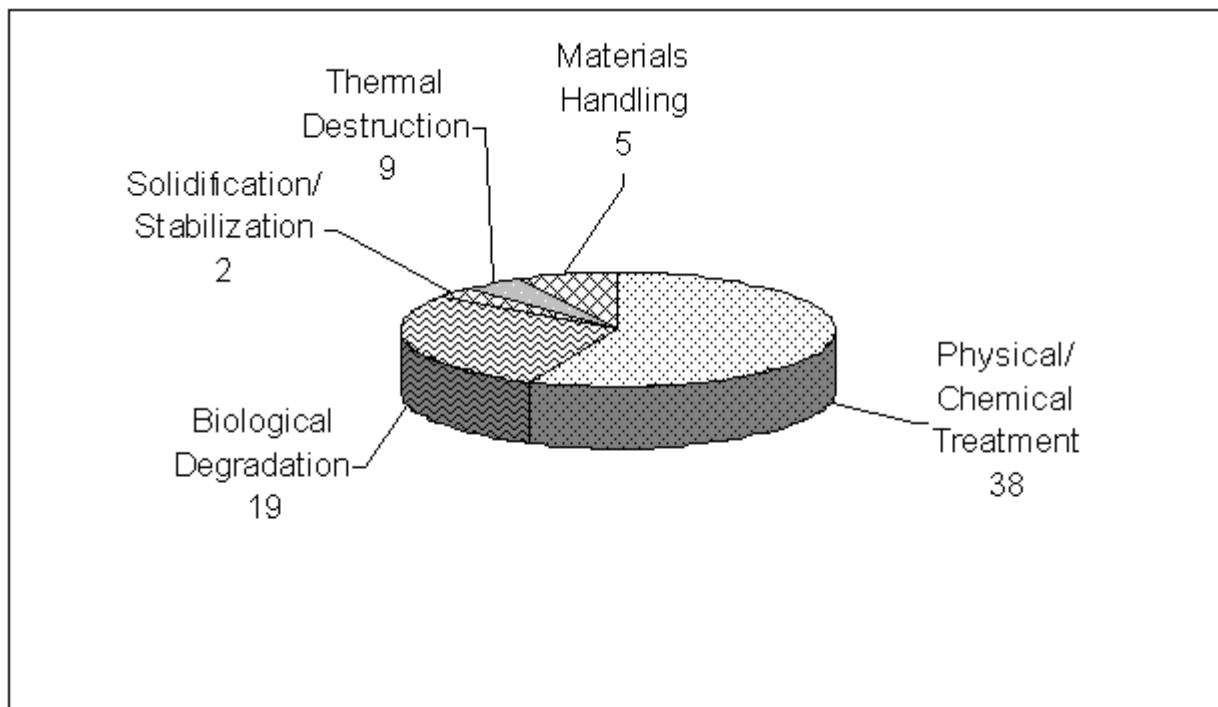


Figure 3: Innovative Technologies in the Demonstration Program

The Monitoring and Measurement Technologies (MMT) Program's goal is to assess innovative and alternative monitoring, measurement, and site characterization technologies. To date, 38 technology demonstrations have occurred under the MMT Program. These demonstrations have included four cone penetrometers, 6 field portable X-ray fluorescence units, 6 portable gas chromatographs, 4 spectrophotometers, 12 field test kits, and 6 soil samplers. Profiles for technologies demonstrated under the MMT Program are located in Volume III.

In the Technology Transfer Program, technical information on innovative technologies in the Demonstration Program, Emerging Technology Program, and MMT Program is disseminated to increase the awareness and promote the use of innovative technologies for assessment and remediation at Superfund sites. The goal of technology transfer activities is to promote communication among individuals requiring current technical information for conducting site investigations and cleanups.

The Technology Transfer Program reaches the environmental community through many media, including:

- Program-specific regional, state, and industry brochures
- On-site Visitors' Days during SITE demonstrations
- Demonstration videotapes
- Project-specific fact sheets to comply with site community relations plans
- ITERs, Demonstration Bulletins, Technology Capsules, and Project Summaries

-
- The SITE Exhibit, displayed nationwide and internationally at conferences
 - Networking through forums, associations, regions, and states
 - Technical assistance to regions, states, and remediation cleanup contractors

SITE information including an electronic version of this document, is available through the following on-line information clearinghouses:

SITE Program Home Page: <http://www.epa.gov/ORD/SITE>

Cleanup Information Bulletin Board System (CLU-IN)

Help Desk: 301-589-8368; Internet Access: <http://www.clu-in.org>

Technical reports may be obtained by calling the National Service Center for Environmental Publications in Cincinnati, Ohio. To find out about newly published documents or to be placed on the SITE mailing list, call or write to:

USEPA/NSCEP
P. O. Box 42419
Cincinnati, OH 45242-2419
1-800-490-9198

SITE PROGRAM CONTACTS

The SITE Program is administered by EPA's Office of Research and Development (ORD), specifically the National Risk Management Research Laboratory (NRMRL). For further information on the SITE Program or its component programs contact:

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TABLE 1
Completed SITE Demonstration Program Projects as of September 2002

Developer/ Technology	Demonstration Location/ Demonstration Date	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
					Inorganic	Organic
Active Environmental, Inc. Mount Holly, NJ TechXtract® Decontamination Process	Pearl Harbor, Hawaii March 1997	Scott Fay 609-702-1500	Dennis Timberlake 513-569-7547	Porous Solid Materials	Heavy Metals, Radionuclides	PCBs, Hydrocarbons
Advanced Remediation Mixing, Inc. (formerly Chemfix Technologies Inc.) Kenner, LA Solidification and Stabilization	Portable Equipment Salvage Company site in Clackamas, OR March 1989	Sam Pizzitola 504-461-0466	Edwin Barth 513-569-7869	Soil, Sludge, Solids	Heavy metals, Low- level Nuclear Waste	Not Applicable
AMEC Earth and Environmental (formerly Geosafe Corporation) Richland, WA GeoMelt Vitrification	Parsons Chemical site in Grand Ledge, MI March - April 1994	James Hansen Matthew Haass 609-942-1292	Teri Richardson 513-569-7949	Soil, Sludge, Sediments	Nonspecific Inorganics	Nonspecific Organics
American Combustion, Inc. Norcross, GA PYRETRON® Thermal Destruction	EPA's Incineration Research facility in Jefferson, AR using soil from Stringfellow Acid Pit Superfund Site in Glen Avon, CA November 1987 - January 1988	Gregory Gitman 770-564-4180	Laurel Staley 513-569-7863	Liquids, Solids, Sludges	Not Applicable	Nonspecific Organics
Arctic Foundations, Inc. Anchorage, AK Cryogenic Barrier	U.S. Department of Energy's Oak Ridge National Laboratory in Oak Ridge, Tennessee in 1998.	Ed Yarmak 907-562-2741 ext. 103	Steven Rock 513-569-7149	Soil	Nonspecific Inorganics	Nonspecific Organics
Argonne National Laboratory Argonne, IL Development of Phytoremediation	Argonne National Laboratory- East Summer of 1999	Christina Negri 630-252-9662	Steven Rock 513-569-7149	Soil, Groundwater	Tritium	VOCs
ARS Technologies, Inc. (formerly Accutech Remedial Systems, Inc.) * Highland Park, NJ * Pneumatic Fracturing Extraction SM and Catalytic Oxidation	New Jersey Environmental Cleanup Responsibility Act site in Hillsborough, NJ July - August 1992	John Liskowitz 908-739-6444	Paul dePercin 513-569-7797	Soil, Rock, Groundwater	Not Applicable	Halogenated and Nonhalogenated VOCs and SVOCs
ASC/EMR WPAFB Wright Patterson AFB, OH Phytoremediation of TCE in Groundwater	Air Force Plant 4 at Naval Air Station Ft. Worth Spring 1996	Greg Harvey 937-255-7716 ext. 302	Steven Rock 513-569-7149	Groundwater, Soil	Not Applicable	TCE, Petroleum, Munitions, Halogenated Hydrocarbons
AWD Technologies, Inc. (formerly Dow Environmental, Inc.) Walnut Creek, CA Integrated AquaDetox Steam Vacuum Stripping and Soil Vapor Extraction/Reinjection	San Fernando Valley Groundwater Basin Superfund site in Burbank, CA September 1990	Ken Solcher 713-914-6607	Gordon Evans 513-569-7684	Groundwater, Soil	Not Applicable	VOCs, Chlorinated Hydrocarbons

* Solicitation Number
 ** From Emerging Technology Program

TABLE 1 (Continued)
Completed SITE Demonstration Program Projects as of September 2002

Developer/ Technology	Demonstration Location/ Demonstration Date	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
					Inorganic	Organic
Bergmann, A Division of Linatex, Inc. Gallatin, TN Soil and Sediment Washing	Toronto, Ontario, Canada and Saginaw Bay Confined Disposal Facility in Saginaw, MI April 1992 and May 1992	John Best 615-230-2100	Annette Gatchett 513-569-7697	Soil, Sediment	Heavy Metals, Radionuclides	PCBs, Nonspecific Organics
Berkeley Environmental Restoration Center Berkeley, CA In Situ Steam Enhanced Extraction Process	Lawrence Livermore National Laboratory in Altamont Hills, CA December 1993	Kent Udell 510-642-2928 Steve Collins 510-643-1900	Paul dePercin 513-569-7797	Soil, Groundwater	Not Applicable	VOCs and SVOCs, Hydrocarbons, Solvents
Billings and Associates, Inc. Albuquerque, NM Subsurface Volatilization and Ventilation System (SVVS®)	Site in Buchanan, MI March 1993 - May 1994	Brad Billings 505-345-1116	Paul dePercin 513-569-7797	Soil, Sludge, Groundwater	Not Applicable	BTEX, Hydrocarbons
BioGenesis Enterprises, Inc. Springfield, VA BioGenesis SM Soil and Sediment Washing Process	Refinery site in Minnesota November 1992	Charles Wilde 703-913-9700	Annette Gatchett 513-569-7697	Soil, Sediment, Sludge	Nonspecific Inorganics	Volatile and Nonvolatile Hydrocarbons, PCBs, Nonspecific Organics
Bio-Rem, Inc. Butler, IN Augmented In Situ Subsurface Bioremediation Process	Williams AFB in Phoenix, AZ May 1992 - June 1993	David Mann 219-868-5823 800-428-4626	Teri Richardson 513-569-7949	Soil, Water	Not Applicable	Halogenated and Nonhalogenated Hydrocarbons
Biotherm, LCC (formerly Dehydro-Tech Corp) Somerville, NJ Biotherm Process TM	EPA's Research Facility in Edison, NJ using wastes from the PAB Oil site in Abbeville, LA August 1991	Not Available	Laurel Staley 513-569-7863	Soil, Sludge, Sediment	Not Applicable	PCBs, Dioxins, PAHs, Hydrocarbon- Soluble Organics
BioTrol® Eden Prairie, MN Biological Aqueous Treatment System	MacGillis and Gibbs Superfund site in New Brighton, MN July - September 1989	Durell Dobbins 612-942-8032	Mary Stinson 732-321-6683	Liquid Waste, Groundwater	Not Applicable	Chlorinated and Nonchlorinated Hydrocarbons, Pesticides
BioTrol® Eden Prairie, MN Soil Washing System	MacGillis and Gibbs Superfund site in New Brighton, MN September - October 1989	Dennis Chilcote 612-942-8032	Mary Stinson 732-321-6683	Soil	Nonspecific Metals	High Molecular Weight Organics, PAHs, PCP, PCBs, Pesticides
Brice Environmental Services Corporation Fairbanks, AK Soil Washing Process	Alaskan Battery Enterprises Superfund site in Fairbanks, AK September 1992	Craig Jones 907-456-1955	John Martin 513-569-7758	Soil	Radioactive and Heavy Metals	Hydrocarbons
BWX Technologies, Inc. (Affiliate of Babcock & Wilcox Co.) Lynchburg, VA Cyclone Furnace	Developer's facility in Alliance, OH November 1991	Evans Reynolds 804-522-6000	Laurel Staley 513-569-7863	Solids, Soil, Sludge	Nonspecific, Low- Level Radionuclides, Heavy Metals	Nonspecific Organics

* Solicitation Number
** From Emerging Technology Program

TABLE 1 (Continued)
Completed SITE Demonstration Program Projects as of September 2002

Developer/ Technology	Demonstration Location/ Demonstration Date	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
					Inorganic	Organic
Calgon Carbon Advanced Oxidation Technologies (formerly Vulcan Peroxidation Systems, Inc.) Pittsburgh, PA perox-pure™ Chemical Oxidation Technology	Lawrence Livermore National Laboratory in Altamont Hills, CA September 1992	Bertrand Dussert 412-787-6681	Norma Lewis 513-569-7665	Groundwater, Wastewater	Not Applicable	Fuel Hydrocarbons, Chlorinated Solvents, PCBs, Phenolics, Pesticides
CF Systems Corporation Boise, ID Liquified Gas Solvent Extraction (LG-SX) Technology	New Bedford Harbor Superfund site in New Bedford, MA September 1988	V.M. Poxleitner 208-386-5361	Laurel Staley 513-569-7863	Soil, Sludge, Sediment, Wastewater	Not Applicable	VOCs, SVOCs, PAHs, PCBs, Dioxins, PCP
COGNIS, Inc.** Boss, MO TERRAMET® Soil Remediation System	Twin Cities Army Ammunition Plant in New Brighton, MN August 1994	William E. Fristad 248-588-4719 Lou Magdits 573-626-3476	Michael Royer 908-321-6633	Soil, Sludge, Sediment	Lead, Heavy Metals	Not Applicable
Colorado Department of Public Health and Environment (Developed by Colorado School of Mines) Denver, CO Constructed Wetlands-Based Treatment	Constructed Wetlands-Based Treatment Began in Summer 1993 Completed November 1993	James Lewis 303-692-3390	Edward Bates 513-569-7774	Acid Mine Drainage	Metals	Not Applicable
Commodore Advanced Sciences, Inc. Albuquerque, NM Solvated Electron Technology Set™ Remediation System	Construction Battalion Supply Center in Port Hueneme, CA September 1996	O.M. Jones 505-872-3508	Paul dePercin 513-569-7797	Soils, Sludges, Sediments, Oils, Hand Tools, Personal Protective Clothing	Not Applicable	PCBs, Pesticides, Halogenated Compounds
Current Environmental Solutions Richland, WA Six-Phase Heating™ of TCE	Cape Canaveral, Florida July 997 Completed 2001	Bill Heath 509-727-4276	Tom Holdsworth 513-569-7675	Groundwater, Soil	Not Applicable	Halogenated Organics
Duke Engineering and Services, Inc. Austin, TX Surfactant Enhanced Aquifer Remediation of Nonaqueous Phase Liquids	Mullican Fields, Pearl Harbor, HI	Dick Jackson John Londergan 512-425-2000	Randy Parker 513-569-7271	Groundwater	Not Applicable	Nonspecific Organics
E.I. DuPont de Nemours and Company, and Oberlin Filter Co. Wilmington, DE Membrane Microfiltration	Palmerton Zinc Superfund site in Palmerton, PA April - May 1990	Ernest Mayer 302-774-2277	John Martin 513-569-7758	Groundwater, Leachate, Wastewater, Electroplating Rinsewaters	Heavy Metals, Cyanide, Uranium	Organic Particulates, Volatile Organics, Oily Wastes

* Solicitation Number
 ** From Emerging Technology Program

TABLE 1 (Continued)
Completed SITE Demonstration Program Projects as of September 2002

Developer/ Technology	Demonstration Location/ Demonstration Date	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
					Inorganic	Organic
Dynaphore, Inc. Richmond, VA FORAGER® Sponge	National Lead Industry site in Pedricktown, NJ April 1994	Norman Rainer 804-288-7109	Carolyn Esposito 732-906-6895	Industrial Discharge, Municipal Sewage, Process Streams, Acid Mine Drainage	Metals	Not Applicable
E&C Williams, Inc. Summerville, SC Calcium Sulfide and Calcium Polysulfide Technologies	Site Mine Facility Butte, Montana November 2000	Robert McManus 843-821-4200	Edward Bates 513-569-7774	Sludge, Groundwater, Sediment, Soils	Mercury	Not Applicable
Earth Tech/Westinghouse Savannah River Co. Roanoke, VA Enhanced In Situ Bioremediation of Chlorinated Compounds in Groundwater	March 1998	Dr. Brian B. Looney 803-725-3692 Rosann Kryczkowski 540-362-7356	Vince Gallardo 513-569-7176	Groundwater	Not Applicable	VOCs
EarthSoft Cantonment, FL EquiS Software	Cantonment, FL Completed in Summer 2002	Mitch Beard 800-649-8855	Richard Eilers 513-569-7809	Not Applicable	Not Applicable	Not Applicable
EcoMat, Inc. Hayward, CA Biological Deitrification Process	Former public water supply well in Bendena, Kansas May - December 1999	Peter J. Hall 510-783-5885	Randy Parker 513-569-7271	Groundwater, Wastewater	Perchlorate	MTBE
ECOVA Corporation Boulder, CO Bioslurry Reactor	EPA's Test and Evaluation Facility in Cincinnati, OH May - September 1991	Not Applicable	Annette Gatchett 513-569-7697	Soil, Sludge, Sediment	Not Applicable	Creosote and Petroleum Wastes
Edenspace, Inc. (formerly Phytotech) Dolles, VA Phytoremediation Technology	Former battery manufacturing facility Tenton, NJ 1997-1998	Michael Blaylock 703-961-8700	Steven Rock 513-569-7149	Soil, Sediment, Groundwater	Not Applicable	Nonspecific Organics
ELI Eco Logic Rockwood, Ontario, Canada Thermal Gas Phase Reduction Process and Thermal Desorption Unit	Middleground Landfill in Bay City, MI October - November 1992	Jim Nash 519-856-9591	Gordon Evans 513-569-7684	Soil, Sludge, Liquids	Not Applicable	PCBs, PAHs, Chlorinated Dioxins and Dibenzofurans, Chlorinated Solvents and Chlorophenols
EmTech Environmental Services (formerly HAZCON, Inc.) Gulfport, MS Dechlorination and Immobilization	Former oil processing plant in Douglasville, PA/October 1987	Ray Funderburk 228-868-9915	Paul dePercin 513-569-7797	Soil, Sludge, Sediment	Heavy Metals	Nonspecific Chlorinated Organics

TABLE 1 (Continued)
Completed SITE Demonstration Program Projects as of September 2002

Developer/ Technology	Demonstration Location/ Demonstration Date	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
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EnviroMetal Technologies Inc. Guelph, Ontario, Canada In Situ and Ex Situ Metal-Enhanced Abiotic Degradation of Dissolved Halogenated Organic Compounds in Groundwater (Two Demonstrations)	Industrial facility in New Jersey and industrial facility in New York November 1994 - February 1995 and May - December 1995	John Vogan Stephanie O'Hannesin 519-824-0432	Annette Gatchett 513-569-7697	Groundwater	Not Applicable	Halogenated Organic Compounds
EnviroMetal Technologies, Inc. Guelph, Ontario, Canada In Situ Reactive Barrier	Rocky Flats Environmental Technology Site in Golden Colorado, 1996	John Vogan 519-824-0432	Thomas Holdsworth 513-569-7675	Groundwater Wastewater	Metals	VOCs
EPOC Water, Inc. Fresno, CA Precipitation, Microfiltration, and Sludge Dewatering	Iron Mountain Superfund site in Redding, CA May - June 1992	Rodney Squires 559-291-8144	Annette Gatchett 513-569-7697	Sludge, Wastewater, Leachable Soil	Heavy Metals	Nonspecific Organics
Filter Flow Technology, Inc. League City, TX Colloid Polishing Filter Method®	DOE's Rocky Flats Plant in Denver, CO September 1993	Tod Johnson 281-332-3438	Annette Gatchett 513-569-7697	Groundwater, Industrial Wastewater	Heavy Metals, Nontritium Radionuclides	Not Applicable
Gas Technology Institute (formerly Institute of Gas Technology) Cement-Lock Technology	Bench-Scale	Anil Goyal 847-768-0605	Edward Barth 513-569-7669	Soil, Sediment	Heavy Metals	Nonspecific Organics
General Atomics (formerly Ogden Environmental) San Diego, CA Circulating Bed Combustor	Developer's facility in San Diego, CA using waste from the McColl Superfund site in Fullerton, CA/March 1989	Dan Jensen 858-445-4158	Douglas Grosse 513-569-7844	Soil, Sludge, Slurry, Liquids	Metals, Cyanides, Nonspecific Inorganics	Halogenated and Nonhalogenated Organic Compounds, PCBs
General Environmental Inc. (formerly Hydrologics, Inc./Cure International, Inc.) Denver, CO CURE®-Electrocoagulation Wastewater Treatment System	DOE's Rocky Flats Plant in Denver, CO August - September 1995	Carl Dalrymple 303-889-5949 Dan Eide 561-575-3500	Steven Rock 513-569-7149	Water	Metals and Radionuclides	Not Applicable
Geokinetics International, Inc. Berkeley, CA Electroheat-Enhanced Nonaquious- Phase Liquids Removal	Pearl Harbor, Oahu, HI 1997	Dr. Stephan R. Clarke 510-704-2941	Thomas Holdsworth 513-569-7645	Clay, Silty Clay, Shale Beds, Gravel Deposits, etc.	Not Applicable	Fuel Oil, Diesel, Kerosene, PAHs, Coal Tar, Hydraulic Fluid, TCE
Geokinetics International, Inc. Berkeley, CA Electrokinetics for Lead Recovery	During the Summer of 2002	Dr. Stephan R. Clarke 510-701-2941	Thomas Holdsworth 513-569-7675	Soil, Sediment	Lead	Not Applicable
GeoTech Development Corporation Newark, NJ Cold Top Ex-Situ Verification of Chromium-Contaminated Soils	Geotech's Pilot Plant in Niagara Falls, NY February-March 1997	Thomas Tate 610-337-8515 William Librizzi 973-596-5846	Marta K. Richards 513-569-7692	Solids, Ash, Slag	Hexavalent Chromium, Heavy metals	Not Applicable

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TABLE 1 (Continued)
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GIS\Solutions, Inc. Concord, CA GIS\Key™ Environmental Data Management System	San Francisco, CA and Washington, DC August 1993 (CA) and December 1993 (DC)	Lawrence Eytel 925-944-3720 ext. 211	Richard Eilers 513-569-7809	Not Applicable	Not Applicable	Not Applicable
GRACE Bioremediation Technologies Mississauga, Ontario, Canada DARAMEND™ Bioremediation Technology	Domtar Wood Preserving facility in Trenton, Ontario, Canada Fall 1993 - September 1994	Alan Seech David Raymond 905-273-5374	Teri Richardson 513-569-7949	Soil, Sediment, Sludge	Lead, Manganese, Zinc	PAHs, PCP, Total Petroleum Hydrocarbons
Gruppo Italimprese (developed by Shirco Infrared Systems, Inc.) (formerly Ecova Europa) Rome, Italy Infrared Thermal Destruction	Peak Oil Superfund site in Brandon, FL and Rose Township-Demod Road Superfund site in Oakland County, MI. August 1987 (FL) and November 1987 (MI)	John Goffi or Grupo Italimprese 606-883-1900	Laurel Staley 513-569-7863	Soil, Sediment	Not Applicable	Nonspecific Organics
High Voltage Environmental Applications, Inc. (formerly Electron Beam Research Facility, Florida International University, and University of Miami) Wilmington, NC High-Energy Electron Irradiation	DOE's Savannah River site in Aiken, SC September - November 1994	William Cooper 910-962-3450	Franklin Alvarez 513-569-7631	Liquid, Sludge	Not Applicable	Most Organics
Horsehead Resource Development Co., Inc. Palmerton, PA Flame Reactor	Developer's facility in Monaca, PA using waste from National Smelting and Refining Company Superfund site in Atlanta, GA March 1991	Regis Zagrocki 724-773-9031	Marta K. Richards 513-569-7692	Soil, Sludge, Industrial Solid Residues	Heavy Metals	Not Applicable
Hrubetz Environmental Services, Inc. Dallas, TX HRUBOUT® Hot Air Injection Process	Kelly Air Force Base in San Antonio, TX January - February 1993	Not Available	Gordon Evans 513-569-7684	Soil	Not Applicable	Halogenated or Nonhalogenated VOCs and SVOCs
Hughes Environmental Systems, Inc. Steam Enhanced Recovery Process	Fuel spill site in Huntington Beach, CA August 1991 - September 1993	Not Available	Paul dePercin 513-569-7797	Soil, Groundwater	Not Applicable	VOCs, SVOCs, Hydrocarbons, Solvents
IIT Research Institute Chicago, IL Radio Frequency Heating	Kelly Air Force Base in San Antonio, TX August 1993	Harsh Dev 312-567-4257	Laurel Staley 513-569-7863	Soil	Not Applicable	Petroleum Hydrocarbons, VOCs, SVOCs, Pesticides
International Waste Technologies and Geo-Con, Inc. Monroeville, PA In Situ Solidification and Stabilization Process	General Electric Service Shop site in Hialeath, FL April 1988	Stephen McCann 412-856-7700	Mary Stinson 732-321-6683	Soil, Sediment, Sludge	Nonspecific Inorganics	PCBs, PCP, Other Nonspecific Organics

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TABLE 1 (Continued)
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IT Corporation Tampa, FL KMnO ₄ (Potassium Permanganate) Oxidation of TCE	LC34, Cape Canaveral, FL	Ernest Mott-Smith 813-612-3677	Tom Holdsworth 513-56-7675	Soil, Groundwater	Not Applicable	Halogenated VOCs
IT Corporation (formerly OHM Remediation Services Corp.) Findlay, OH X*TRAX™ Thermal Desorption	Re-Solve, Inc., Superfund site in North Dartmouth, MA May 1992	Robert Biolchini 419-423-3526	Paul dePercin 513-569-7797	Soil, Sludge, Solids	Mercury, Heavy Metals	VOCs, SVOCs, PCBs, Hydrocarbons
KAI Technologies, LLC. Portsmouth, NH Radio Frequency Heating	Kelly Air Force Base in San Antonio, TX January - July 1994	Raymond Kasevich Michael Marley 413-528-6634	Laurel Staley 513-569-7863	Soil	Not Applicable	Petroleum Hydrocarbons, VOCs, SVOCs, Pesticides
KSE, Inc. Amherst, MA Adsorption-Integrated-Reaction Process	Dover Air Force Base, Dover, Delaware	J.R. Kittrell 413-549-5506	Vince Gallardo 513-569-7176	Air Streams	Not Applicable	VOCs
MacTec-SBP Technologies Company (formerly EG&G Environmental, Inc) Golden, CO No VOCs™ In-Well Stripping Technology	Naval Air Station North Island in San Diego, California June 1998	Mark McGalthery 303-278-3100	Michelle Simon 513-569-7469	Groundwater	Soluble metals	BTEX, TCE, DCE, PAHs, Alcohols, Ketones
Magnum Water Technology El Segundo, CA CAV-OX® Process	Edwards Air Force Base, CA March 1993	Dale Cox 310-322-4143 Jack Simser 310-640-7000	Richard Eilers 513-569-7809	Groundwater, Wastewater	Cyanide	Halogenated Solvents, Phenol, PCP, PCBs, BTEX
Matrix Photocatalytic Inc.** London, Ontario, Canada Photocatalytic Aqueous Phase Organic Destruction	DOE's Oak Ridge Reservation in Oak Ridge, TN August - September 1995	Bob Henderson 519-660-8669	Richard Eilers 513-569-7809	Wastewater, Groundwater, Process Water	Nonspecific Inorganics	Most Organics
Maxymillian Technologies, Inc. (formerly Clean Berkshires, Inc.) Boston, MA Thermal Desorption System	Niagara Mohawk Power Corporation Harbor Point site in Utica, NY November - December 1993	Neal Maxymillian 617-557-6077	Annette Gatchett 513-569-7697	Soil	Cyanide	VOCs, SVOCs, PAHs, Coal Tars

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Micro-BAC® International, Inc. Round Rock, TX Bioaugmentation Process	Lower Colorado River Authority Goldthwaite, TX August 2000	Todd Kenney 512-310-9000	Ronald Herrmann 513-569-7741	Soil, Groundwater, Wastewater	Not Applicable	TPH, PAH, PCB
Minergy Corporation Neenah, WI Glass Furnace Technology for Dredged Sediments	Minergy's pilot glass furnace, located in Winneconne, Wisconsin August 2001	Terrence W. Carroll 920-727-1411	Marta K. Richards 513-569-7271	Sediments	Nonspecific Inorganics	Not Applicable
Morrison Knudsen Corporation/ Spetstamponazheologia Enterprises Boise, ID Clay-Based Grouting Technology	Mike Horse Mine Site in Montana 1994-1996	Rick Raymondi 208-386-5000	Annette Gatchett 513-569-7697	Groundwater, Liquid	Heavy Metals	Nonspecific Organics
New York State Department of Environmental Conservation/ ENSR Consulting and Engineering, and Larsen Engineers Albany, NY Ex Situ Biovault	Sweden 3-Chapman site in Sweden, NY July - December 1994	Jim Harrington 518-457-0337 Dr. David Ramsden 713-520-9900 Dr. N. Sathiyakumar 716-272-7310	Annette Gatchett 513-569-7697	Soil	Not Applicable	Chlorinated and Nonchlorinated VOCs and SVOCs
New York State Department of Environmental Conservation/ SBP Technologies, Inc. Albany NY Groundwater Circulation Biological Treatment Process	Sweden 3-Chapman site in Sweden, NY July 1994 - Fall 1995	Jim Harrington 518-457-0337 Richard Desrosiers 914-694-2280	Michelle Simon 513-569-7469	Soil, Groundwater	Not Applicable	Chlorinated and Nonchlorinated VOCs
New York State Department of Environmental Conservation/ Science Applications International Corp. Albany, NY In Situ Bioventing Treatment System	Sweden 3-Chapman site in Sweden, NY July - December 1994	Jim Harrington 518-457-0337 Richard Cronce 717-901-8100	Annette Gatchett 513-569-7697	Soil	Not Applicable	Chlorinated and Nonchlorinated VOCs, SVOCs
North American Technologies Group, Inc. Bellaire, TX Oleophilic Amine-Coated Ceramic Chip	Petroleum Products Corporation site in Fort Lauderdale, FL June 1994	Tim Torrillion 713-662-2699	Laurel Staley 513-569-7863	Groundwater, Marine Wastes	Not Applicable	Gasoline, Crude Oil, Diesel Fuel, BTEX, PAHs, PCBs, PCP, Trichloroethene
NOVATERRA Associates (formerly Toxic Treatment, Inc.) Los Angeles, CA In Situ Soil Treatment (Steam and Air Stripping)	Annex Terminal in San Pedro, CA September 1989	Phil La Mori 310-328-9433	Paul dePercin 513-569-7797	Soil, Sludge, Liquids	Nonspecific Inorganics, Heavy Metals	VOCs, SVOCs, Hydrocarbons

TABLE 1 (Continued)
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Pharmacia Corporation (formerly Monsanto/DuPont) St. Louis, MO Lasagna™ In Situ Soil Remediation	DOE's Paducah Gaseous Diffusion Plant, Kentucky May 1995	Dr. Sa Ho 314-694-5179	Wendy Davis-Hoover 513-569-7206 Dr. Michael Roulier 513-569-7796	Groundwater, Soils	Nonspecific Inorganics	Nonspecific Organics
Phytokinetics, Inc. North Logan, UT Phytoremediation Process	Former Chevron Terminal #129-0350 Site, Ogden, UT 1996-1999	Ari Ferro 435-750-0985	Steven Rock 513-569-7149	Soil, Sediment, Groundwater	Not Applicable	Nonspecific Organics
Pintail Systems, Inc. Denver, CO Spend Ore Bioremediation Process	EchoBay/McCoy Cover Mine Site near Battle Mountain, NV June 11, 1997 - August 26, 1997	Leslie Thompson 303-367-8443	Patrick Clark 513-569-7561	Spent Ore, Waste Rock, Mine Tailings, Mining Process Water	Cyanide	Not Applicable
Praxis Environmental Technologies, Inc. Burlingame, CA In Situ Thermally Enhanced Extraction (TEE) Process	Operable Unit 2 at Hill Air Force Base, Ogden, UT June and July 1997	Dr. Lloyd Steward 650-548-9288 Major Paul B. Devan 850-283-6288	Paul dePercin 513-569-7797	Soil, Groundwater	Not Applicable	VOCs and SVOCs, Hydrocarbons, Solvents
Regenesis San Clemente, CA Time Release Electron Acceptors and Donors for Accelerated Natural Attenuation	Fisherville Mill, Grafton, MA July 2000 Rocky Mountain Arsenal, Denver, CO May 2001	Dr. Stephen Koenigsberg 949-366-8000	Paul dePercin 513-569-7797	Soil, Groundwater	Not Applicable	Halogenated VOCs
Region 8 and State of Colorado Pittsburgh, PA Multiple Innovative Passive Mine Drainage Technologies	Summitville Mine Superfund Site in the San Juan Mountains in southwestern Colorado	George Watzlaf 412-386-6754 Mike Jenkins 304-329-1056	Edward Bates 513-569-7675	Waste Water, Heavy Metals, Leachate	Metals	Not Applicable
Remediation Technologies, Inc. (formerly Mo Tech, Inc.) Seattle, WA Liquid and Solids Biological Treatment	Niagara Mohawk Power Corporation Facility Harbor Point, Utica, NY June-August 1995	Merv Cooper 206-624-9349	Annette Gatchett 513-569-7697	Soil, Sediment, Sludge	Not Applicable	Biodegradable Organics, Creosote, PCP, PAHs
Resources Conservation Company Bellevue, WA B.E.S.T. Solvent Extraction Technology	Grand Calumet River site in Gary, IN July 1992	William Heins 425-828-2400 ext. 1330	Mark Meckes 513-569-7348	Soil, Sludge, Sediment	Not Applicable	Hydrocarbons, PCBs, PAHs, Pesticides, Herbicides
Retech, M4 Environmental Management Inc. Ukiah, CA Plasma Arc Vitrification	DOE's Component Development and Integration Facility in Butte, MT/July 1991	Ronald Womack Leroy Leland 707-467-1721	Laurel Staley 513-569-7863	Soil, Sludge, Liquids, Solids	Heavy Metals	Nonspecific Organics
Rochem Separation Systems, Inc. Torrance, CA Reverse Osmosis: Disc Tube™ Module Technology	Central Landfill Superfund site in Johnston, RI August 1994	David LaMonica 310-370-3160	Douglas Grosse 513-569-7844	Nonspecific Liquids, Leachates	Nonspecific Inorganics	Organic Solvents

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Rocky Mountain Remediation Services, L.L.C. Golden, CO ENVIROBOND™ Solution	Crooksville/Roseville Pottery Site in Ohio	Bob McPherson 303-966-5414	Ed Barth 513-569-7669	Soil, Waste Streams, Other Media	Lead, Heavy Metals	Not Applicable
Sandia National Laboratories Albuquerque, NM In Situ Electrokinetic Extraction System	SNL RCRA regulated landfill May 1996	Eric Lindgren 505-844-3820 Earl D. Mattson 505-856-3311	Randy Parker 513-569-7271	Soil	Anionic Heavy Metals, Hexavalent Chromium	Not Applicable
SBP Technologies, Inc. Baton Rouge, LA Membrane Filtration and Bioremediation	American Creosote Works in Pensacola, FL October 1991	SBP Technologies, Inc. Baton Rouge, LA 504-755-7711	John Martin 513-569-7758	Groundwater, Surface Water, Storm Water, Landfill Leachates, Industrial Process Wastewater	Not Applicable	Organic Compounds, PAHs, Petroleum Hydrocarbons, TCE, PCP
Sevenson Environmental Services, Inc. (formerly Mae Corp, Inc.) Merrillville, IN MAECTITE® Chemical Treatment Process	Over 40 states, Canada, Italy, and Mexico 1993-1997	Charles McPheeters 219-756-4686	Annette Gatchett 513-569-7697	Soil, Sludge, Sediment, Solids	Lead, Other Heavy Metals	Not Applicable
Smith Environmental Technologies Corporation (formerly Canonic Environmental Services Corporation) Englewood, CO Low Temperature Thermal Aeration (LTTA®)	Pesticide site in Phoenix, AZ September 1992	Joseph Hutton 219-926-8651	Paul dePercin 513-569-7797	Soil, Sludge, Sediment	Not Applicable	VOCs, SVOCs, OCs, OPPs, TPH
SoilTech ATP Systems, Inc. Englewood, CO Anaerobic Thermal Processor	Wide Beach Development Superfund site in Brant, NY and Waukegan Harbor Superfund site in Waukegan, IL May 1991 (NY); June 1992 (IL)	Joseph Hutton 219-926-8651	Paul dePercin 513-569-7697	Soil, Sludge, Sediment	Mercury	Petroleum and Halogenated Hydrocarbons, PAHs, VOCs, SVOCs
Soliditech, Inc. Houston, TX Solidification and Stabilization	Imperial Oil Company/Champion Chemical Company Superfund site in Morganville, NJ December 1988	Bill Stallworth 713-497-8558	Annette Gatchett 513-569-7697	Soil, Sludge	Metals, Nonspecific Inorganics	Nonspecific Organics Oil and Grease
SOLUCORP Industries West Nyack, NY Molecular Bonding System®	Midvale Slag Superfund Site in Midvale, Utah 1997	Robert Kuhn 914-623-2333	Thomas Holdsworth 513-569-7675	Soil, Sludge	Heavy Metals	Not Applicable
Sonotech, Inc. Atlanta, GA Frequency-Tunable Pulse Combustion System	EPA's Incineration Research Facility in Jefferson, AR September - October 1994	Ben Zinn 404-894-3033	Marta K. Richards 513-569-7692	Soil, Sludge, Sediment, Gas	Nonspecific Inorganics	Nonspecific Organics

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Star Organics, L.L.C Dallas, TX Soil Rescue Remediation Fluid	Crooksville/Roseville Pottery Site in Ohio September 1998	Phil G. Clarke 214-522-0742	Ed Barth 513-569-7669	Soil	Lead, Other Heavy Metals	Not Applicable
STC Remediation, Inc. (formerly Silicate Technology Corporation) Scottsdale, AZ Organic Stabilization and Chemical Fixation/Solidification	Selma Pressure Treating Superfund site in Selma, CA November 1990	Scott Larsen Stephen Pegler 480-948-7100	Edward Bates 513-569-7774	Soil, Sludge, Wastewater	Heavy Metals, Cyanides, Fluorides, Arsenates, Chromates, Selenium	Nonspecific Organics, PAHs
SteamTech Environmental Services Bakersfield, CA Steam Enhanced Remediation (SER) at Loring AFB	Loring Air Force Base Summer 2002	Hank Sowers 661-322-6478	Eva Davis 580-436-8548	Soil, Groundwater	Not Applicable	Chlorinated VOCs
SteamTech Environmental Services Bakersfield, CA Steam Enhanced Remediation (SER) at Ridgefield, WA	Ridgefield, WA Spring 2002	Hank Sowers 661-322-6478	Marta Richards 513-569-7692	Soil, Groundwater	Not Applicable	Chlorinated VOCs
Terra-Kleen Response Group, Inc. San Diego, CA Solvent Extraction Treatment System	Naval Air Station North Island in San Diego, CA May - June 1994	Alan Cash 858-558-8762	Mark Meckes 513-569-7348 Terrence Lyons 513-569-7589	Soil, Sludge, Sediment	Not Applicable	PCBs, PCP, PAH, Creosote, Chlorinated Pesticides, PCDD, PCDF
Terra Vac Windsor, NJ In Situ and Ex Situ Vacuum Extraction	Groveland Wells Superfund site in Groveland, MA December 1987 - April 1988	Joseph A. Pezzullo 609-371-0070	Mary Stinson 732-321-6683	Soil, Groundwater	Not Applicable	VOCs, SVOCs
TerraTherm, Inc. Fitchburg, MA In Situ Thermal Destruction	Department of Defense Sites 1995	Dr. Ralph S. Baker 978-343-0300	Marta K. Richards 513-569-7692	Soil	Not Applicable	VOCs, PAH, PCBs
Texaco Inc. S. El Monte, CA Texaco Gasification Process	Developer's Montebello Research Laboratory using a mixture of soil from the Purity Oil Sales Superfund site in Fresno, CA January 1994	Tom Levninger 562-699-0948	Marta K. Richards 513-569-7692	Soil, Sludge, Sediment	Nonspecific Inorganics	Nonspecific Organics
Toronto Harbor Commission Toronto, Ontario Canada Soil Recycling	Toronto Port Industrial District in Toronto, Ontario, Canada April - May 1992	Ken Lundy 416-462-1261 ext. 11	Teri Richardson 513-569-7949	Soil	Nonspecific Inorganics	Nonspecific Organics
U.S. EPA/National Risk Management Research Laboratory Cincinnati, OH Alternative Cover Assessment Program	Various Landfills	Not Applicable	Steven Rock 513-569-7149	Landfills	Not Applicable	Not Applicable

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U.S. EPA/National Risk Management Research Laboratory Cincinnati, OH Base-Catalyzed Decomposition Process	Koppers Company Superfund site in Morrisville, NC August - September 1993	George Huffman 513-569-7431 Yei-Shong Shieh 213-832-0700	Terrence Lyons 513-569-7589	Soil, Sediment, Sludge	Not Applicable	PCBs, PCP, Halogenated Compounds, Polychlorinated Dioxins and Furans
U.S. EPA/National Risk Management Research Laboratory Cincinnati, OH Bioventing	Reilly Tar Site St. Louis Park, MN November 1992	Paul McCauley 513-569-7444	Paul McCauley 513-569-7444	Soil	Not Applicable	Nonspecific Organics
U.S. EPA/National Risk Management Research Laboratory Cincinnati, OH Mobile Volume Reduction Unit	Escambia Treating Company site in Pensacola, FL November 1992	Richard Griffiths 513-569-7832	Teri Richardson 513-569-7949	Soil	Metals	Creosote, PCP, PAHs, VOCs, SVOCs, Pesticides
U.S. EPA/National Risk Management Research Laboratory and INTECH 180 Corporation Cincinnati, OH Fungal Treatment Technology	Brookhaven Wood Preserving site in Brookhaven, MS June - November 1992	John Glaser 513-569-7568 Richard Lamar 801-753-2111	Teri Richardson 513-569-7949	Soil	Not Applicable	PCP, PAHs, Chlorinated Organics
U.S. EPA/National Risk Management Research Laboratory and IT Corporation Cincinnati, OH Debris Washing System	Superfund sites in Detroit, MI; Hopkinsville, KY; and Walker County, GA September 1988 (MI), December 1989 (KY), and August 1990 (GA)	Majid Dosani 513-782-4700	John Martin 513-569-7758	Debris	Nonspecific Inorganics	Nonspecific Organics, PCBs, Pesticides
U.S. EPA/National Risk Management Research Laboratory, University of Cincinnati, and FRX, Inc. Cincinnati, OH Hydraulic Fracturing	Xerox Corporation site in Oak Brook, IL and an underground storage tank spill site in Dayton, OH. July 1991 - September 1992 (IL) and August 1991 - September 1992 (OH)	William Slack 513-469-6040	MMichael Roulier 513-569-7796	Soil, Groundwater	Nonspecific Inorganics	Nonspecific Organics
U.S. EPA Region 9 San Francisco, CA Excavation Techniques and Foam Suppression Methods	McColl Superfund site in Fullerton, CA June - July 1990	John Blevins 415-744-2400	Annette Gatchett 513-569-7697	Soil, Sludge, Sediment, Air	Metals	VOCs, SVOCs
U.S. Filter (formerly Ultrox International Inc.) Sunnyvale, CA Ultraviolet Radiation and Oxidation	Lorentz Barrel and Drum Company site in San Jose, CA March 1989	Dr. Richard Woodling 408-752-1690	Norma Lewis 513-569-7665	Groundwater, Leachate, Wastewater	Not Applicable	Halogenated Solvents, VOCs, Pesticides, PCBs, BTEX, PCP

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Developer/ Technology	Demonstration Location/ Demonstration Date	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
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University of Idaho Research Foundation (formerly licensed by J.R. Simplot Company) Moscow, ID The SABRE™ Process	Bowers Field in Ellensburg, WA and Weldon Spring Ordnance Works site in Weldon Spring, MO July 1993 (WA) and September 1993 - February 1994 (MO)	Ron Satterfield 208-885-4550	Wendy Davis-Hoover 513-569-7206	Soil	Not Applicable	Nitroaromatics
University of Nebraska-Lincoln Lincoln, NE Center Pivot Spray Irrigation System	North Landfill Subsite in Hastings, NE July 1996	Ray Spalding 402-472-7558	Teri Richardson 513-569-7949	Groundwater	Not Applicable	VOCs
WASTECH, Inc. Solidification and Stabilization	Robins Air Force Base in Warner Robins, GA August 1991	Not Available	Terrence Lyons 513-569-7589	Soil, Sludge, Liquids	Nonspecific and Radioactive Inorganics	Nonspecific Organics
Weiss Associates Emeryville, CA ElectroChemical Remediation Technologies (ECRTs)	February 2001	Joe Iovenitti 510-450-6141	Randy Parker 513-569-7797	Soil, Sediment, Groundwater	Heavy Metals	Phenols
Roy F. Weston, Inc. West Chester, PA Low Temperature Thermal Treatment System	Anderson Development Company Superfund site in Adrian, MI November - December 1991	Mike Cosmos 610-701-7423	Paul dePercin 513-569-7797	Soil, Sludge	Not Applicable	VOCs, SVOCs, Petroleum Hydrocarbons, PAHs, PCBs
Roy F. Weston, Inc./IEG Technologies West Chester, PA UVB - Vacuum Vaporizing Well	March Air Force Base, CA May 1993 - May 1994	Mike Cosmos 610-701-7423 Mike Corbin 610-701-3723	Michelle Simon 513-569-7469	Groundwater, Liquid, Soil	Heavy Metals	VOCs, SVOCs
Wheelabrator Clean Air Systems, Inc. (formerly Chemical Waste Management, Inc.) Schaumburg, IL PO*WW*ER™ Technology	Chemical Waste Management's facility in Lake Charles, LA September 1992	Myron Reicher 847-706-6900	Randy Parker 513-569-7271	Wastewater, Leachate, Groundwater, Low-Level Radioactive Mixed Waste	Metals, Volatile Inorganic Compounds, Radionuclides	VOCs and Nonvolatile Organic Compounds
Wilder Construction Company Everett, WA MatCon™ Modified Asphalt Cap	Dover Air Force Base Site April 1999	Karl Yost 425-551-3100	David Carson 513-569-7527	Leachate, Landfills	Not Applicable	Not Applicable
X-19 Biological Products Santa Clara, CA Microbial Degradation of PCBs	Lower Colorado River Authority in Goldthwaite, TX August 2000	Paul Gill 408-970-9485	Ronald Herrmann 513-569-7741	Soil	Not Applicable	VOCs, PAHs, PCBs

* Solicitation Number
 ** From Emerging Technology Program

TABLE 1 (Continued)
Completed SITE Demonstration Program Projects as of September 2002

Developer/ Technology	Demonstration Location/ Demonstration Date	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
					Inorganic	Organic
Xerox Corporation Webster, NY 2-PHASE™ EXTRACTION Process	McClellan Air Force Base in Sacramento, CA August 1994 - February 1995	Ron Hess 716-422-3694 Phil Mook 916-643-5443	Paul dePercin 513-569-7797	Groundwater, Soil, Liquid	Nonspecific Soluble Inorganics	VOCs
ZENON Environmental Inc. Burlington, Ontario, Canada Cross-Flow Pervaporation System	Naval Air Station North Island in San Diego, CA February 1995	Chris Lipski 905-639-6320	Lee Vane 513-569-7799	Groundwater, Leachate, Liquid	Not Applicable	Solvents, Degreasers, Gasoline, Other VOCs
ZENON Environmental Inc. Burlington, Ontario, Canada ZenoGem™ Process	Nascolite Superfund site in Millville, NJ September - November 1994	Chris Lipski 905-639-6320	Daniel Sullivan 908-321-6677	Groundwater, Leachate, Wastewater	Not Applicable	Nonspecific Organics

ACTIVE ENVIRONMENTAL TECHNOLOGIES, INC. (formerly EET, Inc.) (TechXtract® Decontamination Process)

TECHNOLOGY DESCRIPTION:

The TechXtract® process employs proprietary chemical formulations in successive steps to remove polychlorinated biphenyls (PCB), toxic hydrocarbons, heavy metals, and radionuclides from the subsurface of porous materials such as concrete, brick, steel, and wood. Each formulation consists of chemicals from up to 14 separate chemical groups, and formulation can be specifically tailored to individual site.

The process is performed in multiple cycles. Each cycle consists of three stages: surface preparation, extraction, and rinsing. Each stage employs a specific chemical mix.

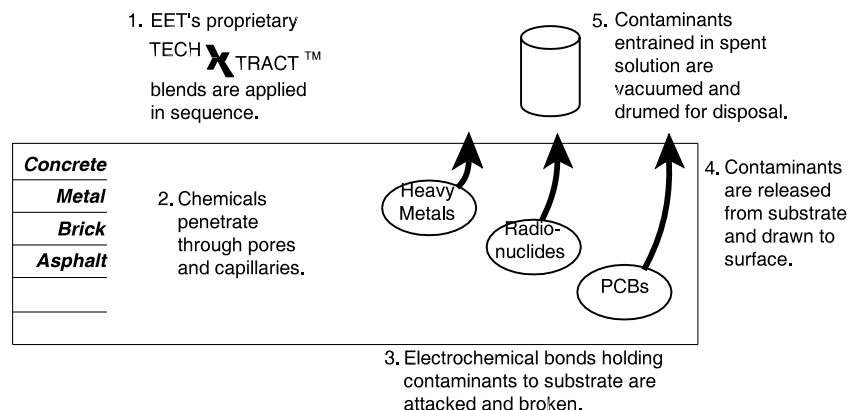
The surface preparation step uses a solution that contains buffered organic and inorganic acids, sequestering agents, wetting agents, and special hydrotrope chemicals. The extraction formula includes macro- and microemulsifiers in addition to electrolyte, flotation, wetting, and sequestering agents. The rinsing formula is pH-balanced and contains wetting and complexing agents. Emulsifiers in all the formulations help eliminate fugitive releases of volatile organic compounds or other vapors.

The chemical formulation in each stage is sprayed on the contaminated surface as a fine mist and worked into the surface with a stiff bristle brush or floor scrubber. The chemicals are allowed to penetrate into the subsurface and are then rinsed or vacuumed from the surface with a wet/dry, barrel-vacuum. No major capital equipment is required.

Contaminant levels can be reduced from 60 to 90 percent per cycle. The total number of cycles is determined from initial contaminant concentrations and final remedial action objectives.

WASTE APPLICABILITY:

The TechXtract® process is designed to treat porous solid materials contaminated with PCBs; toxic hydrocarbons; heavy metals, including lead and arsenic; and radionuclides. Because the contaminants are extracted from the surface, the materials can be left in place, reused, or recycled. After treatment, the contaminants are concentrated in a small volume of liquid waste. The liquid can be disposed as is, incinerated, or solidified for landfill. It will carry the waste characteristics of the contaminant.



Process Flow Diagram of the TECHXTRACT® Process

In commercial applications, the process has reduced PCB concentrations from 1,000,000 micrograms per 100 square centimeters ($\mu\text{g}/100\text{ cm}^2$) to concentrations less than $0.2\text{ }\mu\text{g}/100\text{ cm}^2$. The TechXtract[®] process has been used on concrete floors, walls, and ceilings, tools and machine parts, internal piping, valves, and lead shielding. The TechXtract[®] process has removed lead, arsenic, technetium, uranium, cesium, tritium, and thorium, chrome (+3,+6), gallium, copper, mercury, plutonium, and strontium.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. EAT Demonstrated the TechXtract[®] technology from February 26, 1997 to March 6, 1997. During the demonstration, AET completed 20 TechXtract[®] 100 cycles and 12 300/200 cycles. Post-treatment samples were collected on March 6, 1997. In April 1997 a demonstration project was completed at the Pearl Harbor Naval Complex.

The technology has been used in over 200 successful decontamination projects for the U.S. Department of Energy; U.S. Department of Defense; the electric, heavy manufacturing, steel, and aluminum industries; and other applications. Further research is underway to apply the technology to soil, gravel, and other loose material. AET also plans to study methods for removing or concentrating metals in the extracted liquids.

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ADVANCED REMEDIATION MIXING, INC. (formerly Chemfix Technologies, Inc.) (Solidification and Stabilization)

TECHNOLOGY DESCRIPTION:

In this solidification and stabilization process, pozzolanic materials react with polyvalent metal ions and other waste components to produce a chemically and physically stable solid material. Optional binders and reagents may include soluble silicates, carbonates, phosphates, and borates. The end product may be similar to a clay-like soil, depending on the characteristics of the raw waste and the properties desired in the end product.

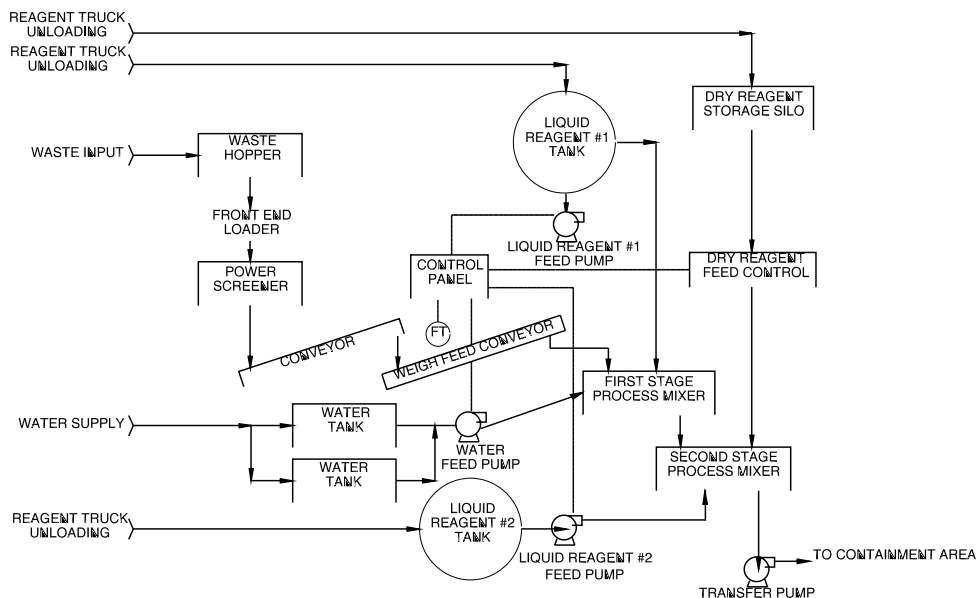
The figure below illustrates the Chemfix Technologies, Inc. (Chemfix), process. Typically, the waste is first blended in a reaction vessel with pozzolanic materials that contain calcium hydroxide. This blend is then dispersed throughout an aqueous phase. The reagents react with one another and with toxic metal ions, forming both anionic and cationic metal complexes. Pozzolans that accelerate and other reagents that precipitate metals can be added before or after the dry binder is initially mixed with the waste.

When a water soluble silicate reacts with the waste and the pozzolanic binder system, colloidal silicate gel strengths are increased within the binder-waste matrix, helping to bind polyvalent metal cations. A large percentage of the heavy metals become part of the calcium silicate and aluminate colloidal structures formed by the pozzolans and calcium hydroxide. Some of the metals, such as lead, adsorb to the surface of the pozzolanic structures. The entire pozzolanic matrix, when physically cured, decreases toxic metal mobility by reducing the incursion of leaching liquids into and out of the stabilized matrices.

WASTE APPLICABILITY:

STATUS:

The solidification and stabilization process was accepted into the SITE Demonstration Program in 1988. The process was demonstrated in March 1989 at the Portable Equipment Salvage Company site in Clackamas, Oregon. The Technology Evaluation



Process Flow Diagram

Report (EPA/540/5-89/011a) and the Applications Analysis Report (EPA/540/A5-89/011) are available from EPA.

In addition, several full-scale remediation projects have been completed since 1977, including a 1991 high solids CHEMSET® reagent protocol designed by Chemfix to treat 30,000 cubic yards of hexavalent chromium-contaminated, high solids waste. The average chromium level after treatment was less than 0.15 milligram per liter and met toxicity characteristic leaching procedure (TCLP) criteria. The final product permeability was less than 1×10^{-6} centimeters per second (cm/sec).

DEMONSTRATION RESULTS:

The demonstration yielded the following results:

- The technology effectively reduced copper and lead concentrations in the wastes. The concentrations in the TCLP extracts from the treated wastes were 94 to 99 percent less than those from the untreated wastes. Total lead concentrations in the untreated waste approached 14 percent.
- The volume of excavated waste material increased between 20 and 50 percent after treatment.
- During the durability tests, the treated wastes showed little or no weight loss after 12 cycles of wetting and drying or freezing and thawing.
- The unconfined compressive strength of the wastes varied between 27 and 307 pounds per square inch after 28 days. Hydraulic conductivity of the treated material ranged between 1×10^{-6} cm/sec and 6.4×10^{-7} cm/sec.
- Air monitoring data suggest there was no significant volatilization of polychlorinated biphenyls during the treatment process.
- Treatment costs were approximately \$73 per ton, including mobilization, labor, reagents, and demobilization, but not disposal.

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AMEC EARTH AND ENVIRONMENTAL **(formerly GeoSafe Corporation)** **(GeoMelt Vitrification, previously In Situ Vitrification)**

TECHNOLOGY DESCRIPTION:

AMEC Earth and Environmental's GeoMelt vitrification process uses electricity to melt soil or other earthen materials at temperatures of 1,600 to 2,000°C, destroying organic pollutants by pyrolysis. Inorganic pollutants are immobilized within the vitrified glass and monolith. Water vapor and organic pyrolysis products are captured in a hood, which draws the off-gases into a treatment system that removes particulates, acid gases and other pollutants.

The process can be applied to materials in situ, or where staged below grade or ex situ. By the addition of feeding and melt withdrawal features, the process can be operated semi-continuously. To begin the vitrification process, an array of large electrode pairs is inserted into contaminated zones containing enough soil for melting to occur (see photograph below). A graphite starter path is used to melt the adjacent soil, which then becomes the primary current-carrying medium for further processing. As power is applied, the melting continues downward and outward at an average rate of 4 to 6 tons per hour, or 1 to 2 inches per hour. The electrode array is lowered progressively, as the melt grows to the desired treatment depth. After cooling, a vitrified monolith with a glass and microcrystalline structure remains. This monolith possesses high strength and excellent weathering and leaching properties.

The melting process is performed under a hood through which air flow is controlled to maintain a negative pressure. Excess oxygen is supplied for combustion of any organic pyrolysis products. Off-gases are treated by quenching, pH-controlled scrubbing, dewatering (mist elimination), heating (for dew point control), particulate filtration, and either activated carbon adsorption or thermal oxidation as a final off-gas polishing step. Individual melt settings may encompass a total melt mass of up to 1,400 tons, a maximum width of 40 feet, and depths as great as 22 feet. Special settings to reach deeper contamination are also possible. Void volume and volatile material removal results in a 30 to 50 percent volume reduction for typical soils. The mobile GeoMelt system is mounted on three semi-trailers. Electric power may be provided by local utility or on-site diesel generator. Typical power consumption ranges from 600 to 800 kilowatt-hours per ton of soil. The electrical supply system has an isolated ground circuit to provide safety.

WASTE APPLICABILITY:

The GeoMelt vitrification process can destroy or remove organics and immobilize most inorganics in contaminated soils, sediments, sludges, or other earthen materials. The process has been tested on a broad range of volatile and semivolatile organic compounds, other organics including dioxins and



In Situ Vitrification Process Equipment

polychlorinated biphenyls (PCB), and on most priority pollutant metals and heavy metal radio-nuclides. The process can also treat large amounts of debris and waste materials present in soil. In addition to soils applications, the process has been used to treat mixed-transuranic (TRU) buried waste and underground tanks containing waste. Underground tank treatment employs a new method of vertically planar melting which enable sideways melting rather than top-down melting. Tanks to 4,500 gallons have been treated to date.

STATUS:

The SITE demonstration of the process occurred during March and April 1994 at the former Parsons Chemical (Parsons) site in Grand Ledge, Michigan. The soil at Parsons was contaminated with pesticides, metals, and low levels of dioxins. The Innovative Technology Evaluation Report (EPA/540/R-94/520) and the Demonstration Bulletin (EPA/540/MR-94/520) are available from EPA.

In October 1995, Geosafe was issued a National Toxic Substances Control Act permit for the treatment of soils contaminated with up to 17,860 parts per million PCBs.

In December 1995, Geosafe completed the remediation of the Wasatch Chemical Superfund Site in Salt Lake City, Utah. This site contained about 6,000 tons of dioxin, pentachlorophenol, herbicide, pesticide, and other organic contaminants in soil containing up to 30 percent debris by weight. In 1996, Geosafe completed remediation of the Apparatus Service Shop Site in Spokane, Washington. A total of 6,500 tons of PCB-contaminated soil was treated at the site.

GeoMelt vitrification is currently being employed for the in situ treatment of mixed-TRU buried waste at the Maralinga Test Range in South Australia. Twenty-one pits containing Plutonium, Uranium, Lead, Barium, and Beryllium are being treated there. That project was to be completed in 1999.

DEMONSTRATION RESULTS:

During the SITE demonstration, about 330 cubic yards of a saturated clayey soil was vitrified in 10 days. This is the equivalent to a production rate of 53 tons per day. The technology met cleanup levels specified by EPA Region 5 for chlordane, 4,4-dichlorodiphenyltrichloroethane, dieldrin, and mercury. Pesticide concentrations were nondetectable in the vitrified soil. Results also indicated that leachable mercury was below the regulatory guidelines (40 CFR Part 261.64), and no target pesticides were detected in the leachate. No target pesticides were detected in the stack gas samples, and metal emissions were below regulatory requirements. Continuous emission monitoring showed that total hydrocarbon and carbon monoxide emissions were within EPA Region 5 limits.

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AMERICAN COMBUSTION, INC. (PYRETRON® Thermal Destruction)

TECHNOLOGY DESCRIPTION:

The PYRETRON® thermal destruction technology controls the heat input during incineration by controlling excess oxygen available to oxidize hazardous waste (see figure below). The PYRETRON® combustor relies on a new technique for mixing auxiliary oxygen, air, and fuel to (1) provide the flame envelope with enhanced stability, luminosity, and flame core temperature, and (2) increase the rate of heat released.

The technology is computer-controlled to automatically adjust the temperatures of the primary and secondary combustion chambers and the amount of excess oxygen. The system adjusts the amount of excess oxygen in response to sudden changes in contaminant volatilization rates in the waste.

The technology fits any conventional incineration unit and can burn liquids, solids, and sludges. Solids and sludges can also be coincinerated when the burner is used with a rotary kiln or similar equipment.

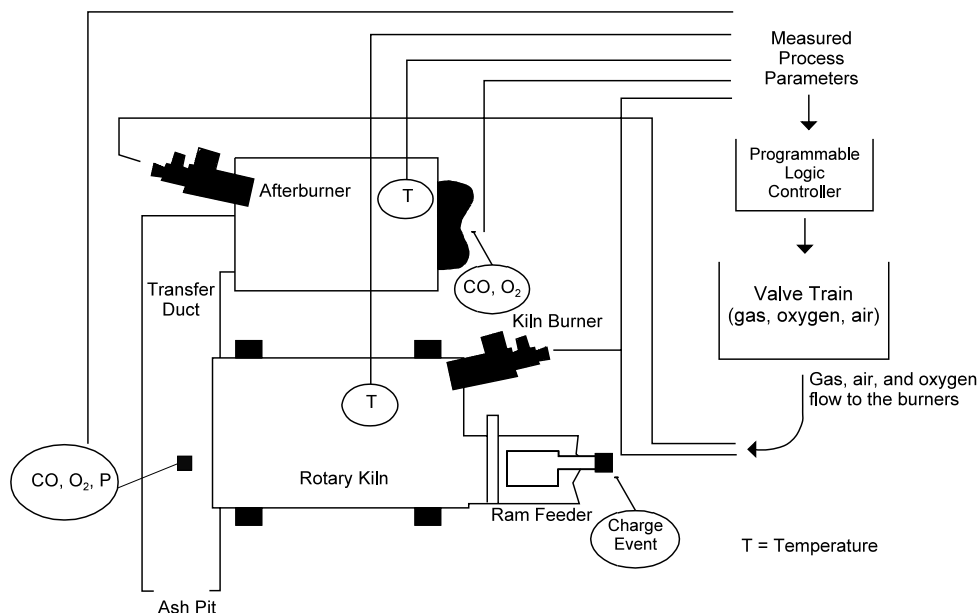
WASTE APPLICABILITY:

The PYRETRON® technology treats high- and low-British thermal unit solid wastes contaminated with rapidly volatilized hazardous organics. In general, the technology treats any waste that can be incinerated. It is not suitable for processing Resource Conservation and Recovery Act heavy metal wastes or inorganic wastes.

STATUS:

The PYRETRON® technology was demonstrated at EPA's Incineration Research Facility in Jefferson, Arkansas, using a mixture of 40 percent contaminated soil from the Stringfellow Acid Pit Superfund site in Glen Avon, California and 60 percent decanter tank tar sludge (K087) from coking operations. The demonstration began in November 1987 and was completed at the end of January 1988.

Both the Innovative Technology Evaluation Report (EPA/540/5-89/008) and Applications Analysis Report (EPA/540/A5-89/008) are available from EPA.



PYRETRON® Thermal Destruction System

DEMONSTRATION RESULTS:

The polynuclear aromatic hydrocarbons naphthalene, acenaphthylene, fluorene, phenanthrene, anthracene, and fluoranthene were selected as the principal organic hazardous constituents (POHC) for the demonstration. The PYRETRON® technology achieved greater than 99.99 percent destruction and removal efficiencies for all six POHCs in all test runs. Other results are listed below:

- The PYRETRON® technology with oxygen enhancement doubled the waste throughput possible with conventional incineration.
- All particulate emission levels from the scrubber system discharge were significantly below the hazardous waste incinerator performance standard of 180 milligrams per dry standard cubic meter at 7 percent oxygen. This standard was in place until May 1993.
- Solid residues were contaminant-free.
- There were no significant differences in transient emissions of carbon monoxide between air-only incineration and PYRETRON® oxygen-enhanced operation with doubled throughput rate.
- Cost savings increase when operating and fuel costs are high and oxygen costs are relatively low.
- The system can double the capacity of a conventional rotary kiln incinerator. This increase is more significant for wastes with low heating values.

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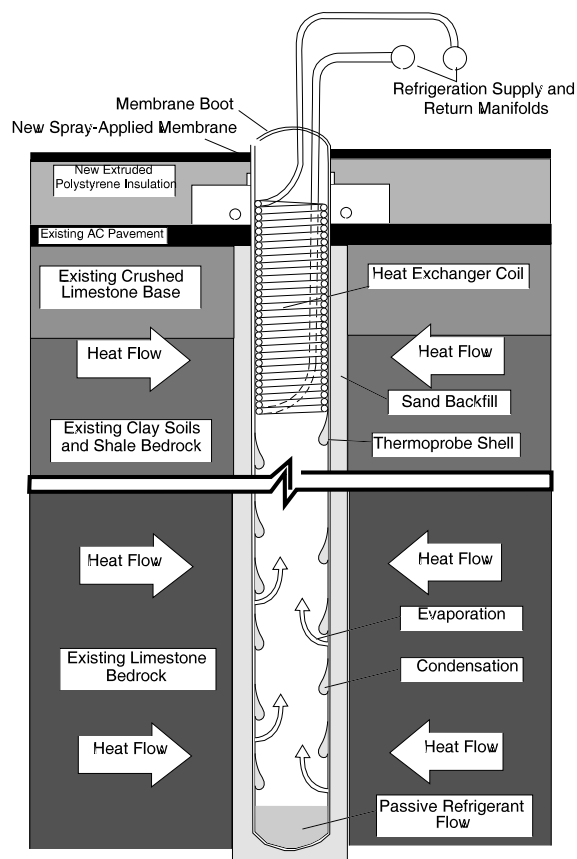
ARCTIC FOUNDATIONS, INC. (Cryogenic Barrier)

TECHNOLOGY DESCRIPTION:

Long-term containment and immobilization of hazardous wastes using ground freezing technology is a relatively new field, even though ground freezing has been used as a temporary construction aid for several years. Ground freezing is ideally suited to control waterborne pollutants, since changing water from a liquid to a solid has an obvious immobilizing effect. The challenge for conventional ground freezing technologies is to be technically and economically viable in the long-term. Arctic Foundations, Inc. (AFI), has developed a ground freezing technology that can be used as a temporary or permanent, long-term solution for containing and immobilizing hazardous wastes. Buried hazardous waste may be totally confined by surrounding it with

a frozen barrier. A frozen barrier is created by reducing the ground temperature around the waste to the appropriate freezing temperature and subsequently freezing the intervening waste. Artificial injection of water is usually unnecessary since moisture is present in sufficient quantities in most soils. The ground freezing process is naturally suited to controlling hazardous waste because in-ground moisture is transformed from serving as a potential waste mobilizing agent to serving as a protective agent.

A typical containment system consists of multiple thermoprobes, an active (powered) condenser, an interconnecting piping system, a two-phase working fluid, and a control system. The thermoprobes (AFI's heat removal devices) and piping are inserted into the soil at strategic locations around and sometimes underneath the waste source depending on the



Cryogenic Barrier Insulation Plan

presence or absence of a confining layer. Two-phase working fluid circulates through the piping and reduces the temperature of the surrounding soil, creating a frozen barrier around the waste source. The thermoprobes may be installed in any position and spacing to create a frozen barrier wall of almost any required shape and size. The selection of working fluids depends on the specific waste application, site conditions, and desired soil temperatures, and may consist of freon, butane, propane, carbon dioxide, or ammonia.

WASTE APPLICABILITY:

The cryogenic barrier can provide subsurface containment for a variety of sites and wastes, including the following: underground storage tanks; nuclear waste sites; plume control; burial trenches, pits, and ponds; in situ waste treatment areas; chemically contaminated sites; and spent fuel storage ponds. The barrier is adaptable to any geometry; drilling technology presents the only constraint.

STATUS:

The AFI cryogenic barrier system was accepted into the SITE Demonstration Program in 1996. The demonstration was conducted over a 5-month period at the U.S. Department of Energy's Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee in 1998. The demonstration was conducted to evaluate the barrier's ability to contain radionuclides from the ORNL Waste Area Grouping 9 Homogeneous Reactor Experiment pond. The evaluation of the technology under the SITE Program was completed in July 1998. The barrier continued in operation after the demonstration to maintain containment of the contaminants.

DEMONSTRATION RESULTS:

Phloxine B dye injected in the center of the impoundment showed no movement over an initial two-week time period. A Phloxine B "hit" was then detected outside the barrier, but upgradient of the injection point. This was inconsistent with other data. After further investigation, it was determined that this anomaly was due to transport through an abandoned, subsurface inlet pipeline to the pond. A temporary, artificial reverse-gradient condition was created by "chasing" the Phloxine B dye with deionized water, pushing the dye through the pipe, which was at least partially void of soil/water during initial freezing. This was a site anomaly considered unrelated to performance of Frozen Soil Barrier technology, although it serves as a "lesson learned" for further deployments.

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ARGONNE NATIONAL LABORATORY

(Development Of Phytoremediation)

TECHNOLOGY DESCRIPTION:

The 317/319 areas at Argonne National Laboratory-East (ANL-E) are contaminated by volatile organic compounds (VOCs) in soil and groundwater and low levels of tritium in the groundwater from past waste disposal practices. As part of a nationwide effort to find more cost-effective and environmentally friendly remediation technologies, the U.S. Department of Energy (DOE), through the Accelerated Site Technology Development (ASTD) program, funded the deployment of a phytoremediation system in the 317/319 area. The 317 and 319 areas are located on the extreme southern end of the ANL-E site, immediately adjacent to the DuPage County Waterfall Glen Forest Preserve. The main objective of this deployment, which was selected in place of the baseline approach of an asphalt cap and extraction wells, are to hydraulically contain groundwater migration and to remove the VOCs and tritium within and downgradient of the source area.

Phytoremediation is a technique using plants to take in contaminants along with water and nutrients from the soil. It is defined as the engineered use of natural processes by which woody and herbaceous plants extract pore water, and entrained chemical substances from subsurface soils degrade, sequester, and transpire them (along with water vapor) into the atmosphere. The process has several advantages over the traditional and often invasive cleanup techniques in which the soil is sometimes dug up and incinerated in a kiln to break down the compounds. Not only is phytoremediation all natural, but the plants can address a range of contaminants at one time. It is also low cost and low maintenance, because the trees do the bulk of the work.

Additional advantages of the phyto-remediation system are (1) the ability of trees to actively promote and assist in the degradation of the contaminants at the source area, which the baseline asphalt cap would not do, and (2) the optimal fit of vegetation with the planned future land use of the contaminated site and adjacent areas, as the phytoremediation plantation will contribute to increased soil fertility to host subsequent prairie species.

WASTE APPLICABILITY:

This technology is designed to treat soils and groundwater contaminated by volatile organic compounds (VOCs) and tritium.

STATUS:

Approximately 800 trees were planted in the summer of 1999. These trees are expected to provide full, year-round hydraulic control by the year 2003 and be self-sustaining for the expected life of the engineering plantation.

The use of the trees to remediate and contain contaminated groundwater has been successfully demonstrated in treating contaminated groundwater. Applied Natural Sciences, Inc. (ANS) demonstrated the use of phreatophytic trees (i.e., plants such as poplars and willows that do not rely on precipitation but seek water deep in the soils) with its TreeMediation™ and TreeWell™ systems, that use a unique and patented process to enhance the aggressive rooting ability of selected trees to clean up soil and groundwater up to 50 ft deep.

DEMONSTRATION RESULTS:

A rapid method was optimized to measure chlorinated solvents and their degradation products in plant tissues. Trichloroacetic acid (TCAA), a known intermediate of the compound of TCE and PCE, was analyzed throughout the vegetative season in addition to the parent compounds as an indicator of their degradation. Both parent compounds and TCAA were found in the plant samples (an indication that the trees are taking up contaminants), with a prevalence of TCAA in the leaf tissue and the parent compounds in the branches. TCAA showed a trend toward accumulation in the leaf tissue as the vegetative season progressed. The levels of TCAA in the leaf samples were quite constant within a single tree but varied significantly as a function of the location of the tree within the contaminated area.

Samples of the air immediately surrounding the leafed branch were compared to air at the contaminated area and from other, uncontaminated areas within Argonne. While the air at the French Drain contained higher concentrations of VOCs than other clean areas on site, the presence of the leafed branches did not induce a measurable increase in the VOC concentration in the air, suggesting that most of the VOCs detected in the air come from direct venting off the soil. Tritium levels in the leaves and transpire of hybrid poplars planted in the hydraulic control area showed levels comparable to background, indicating that the trees have not yet reached the contaminated aquifer.

Preliminary evaluations put the cost savings over the lifetime of deployment at 50 percent of the baseline approach. A significant cost savings over the avoidance of secondary waste (pumped groundwater) and related treatment.

Because the phytoremediation system will reach its optimal growth stage and steady performance state in 2003, future plans are to evaluate the performance of the remediation system. Some of the questions raised by this objective cannot be answered by conventional, compliance-related monitoring, so a more hypothesis-driven approach will be adopted to find mechanistic evidence of the effects of the plants on the removal of the contaminants.

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ARS TECHNOLOGIES, INC.
(formerly Accutech Remedial Systems, Inc.)
(Pneumatic Fracturing ExtractionSM and Catalytic Oxidation)

TECHNOLOGY DESCRIPTION:

Accutech Remedial Systems, Inc. (Accutech), and the Hazardous Substance Management Research Center at the New Jersey Institute of Technology in Newark, New Jersey have jointly developed an integrated treatment system that combines Pneumatic Fracturing ExtractionSM (PFESM) with catalytic oxidation. According to Accutech, the system provides a cost-effective, accelerated approach for remediating less permeable formations contaminated with halogenated and nonhalogenated volatile organic compounds (VOC) and semivolatile organic compounds (SVOC).

The Accutech system forces compressed gas into a geologic formation at pressures that exceed the natural in situ stresses, creating a fracture network. These fractures allow subsurface air to circulate faster and more efficiently throughout the formation, which can greatly improve contaminant mass removal rates.

PFESM also increases the effective area that can be influenced by each extraction well, while intersecting new pockets of contamination that were previously trapped in the formation. Thus, VOCs and SVOCs can be removed faster and from a larger section of the formation.

PFESM can be combined with a catalytic oxidation unit equipped with special catalysts to destroy halogenated organics (see photograph below). The heat from the catalytic oxidation unit can be recycled to the formation, significantly raising the vapor pressure of the contaminants. Thus, VOCs and SVOCs volatilize faster, making cleanup more efficient. PFESM can also be combined with hot gas injection (HGI), an in situ thermal process, to further enhance VOC and SVOC removal rates. HGI returns to the ground the energy generated during catalytic oxidation of the VOCs.



WASTE APPLICABILITY:

The Accutech system can remove halogenated and nonhalogenated VOCs and SVOCs from both the vadose and saturated zones. The integrated treatment system is cost-effective for treating soil and rock when less permeable geologic formations limit the effectiveness of conventional in situ technologies.

According to Accutech, the PFESM-HGI integrated treatment system is cost-effective for treating less permeable soil and rock formations where conventional in situ technologies have limited effectiveness. Activated carbon is used when contaminant concentrations decrease to levels where catalytic oxidation is no longer cost-effective.

STATUS:

The Accutech technology was accepted into the SITE Demonstration Program in December 1990. The demonstration was conducted in summer 1992 at a New Jersey Department of Environmental Protection and Energy Environmental Cleanup Responsibility Act site in Hillsborough, New Jersey. During the demonstration, trichloroethene and other VOCs were removed from a siltstone formation. Results of this demonstration were published in the following documents available from EPA:

- Technology Evaluation Report
(EPA/540/R-93/509)
- Technology Demonstration Summary
(EPA/540/SR-93/509)
- Demonstration Bulletin
(EPA/540/MR-93/509)
- Applications Analysis Report
(EPA/540/AR-93/509)

DEMONSTRATION RESULTS:

The demonstration results indicate that PFESM increased the effective vacuum radius of influence nearly threefold. PFESM also increased the rate of mass removal up to 25 times over the rates measured using conventional extraction technology.

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AWD TECHNOLOGIES, INC (AquaDetox®/SVE System)

TECHNOLOGY DESCRIPTION:

This technology integrates two processes: (1) AquaDetox®, a moderate vacuum steam stripping tower (tower pressure no less than 50 mm Hg) that treats contaminated groundwater and (2) a soil vapor extraction (SVE) system that removes contaminated soil-gas for subsequent treatment with granular activated carbon (GAC). The two technologies are integrated into a closed-loop system, providing simultaneous remediation of contaminated groundwater and soil-gas with no air emissions. The integrated AquaDetox® is a high-efficiency, countercurrent stripping technology developed by the Dow Chemical Company. Stripping is commonly defined as a process that removes dissolved volatile compounds from water. A carrier gas, such as air or steam, is purged through the contaminated water, with the volatile components being transferred from the water into the gas phase. SVE is commonly used for the in-situ removal of VOCs from soil. A vacuum is applied to vadose zone extraction wells to induce airflow within the soil toward the wells. The air acts as a stripping medium that volatilizes the VOCs in the soil. Soil-gas from the extraction wells is typically treated in GAC beds before release to the atmosphere. Alternatively, the treated soilgas is reinjected into the soil to control the direction of airflow in the soil. The

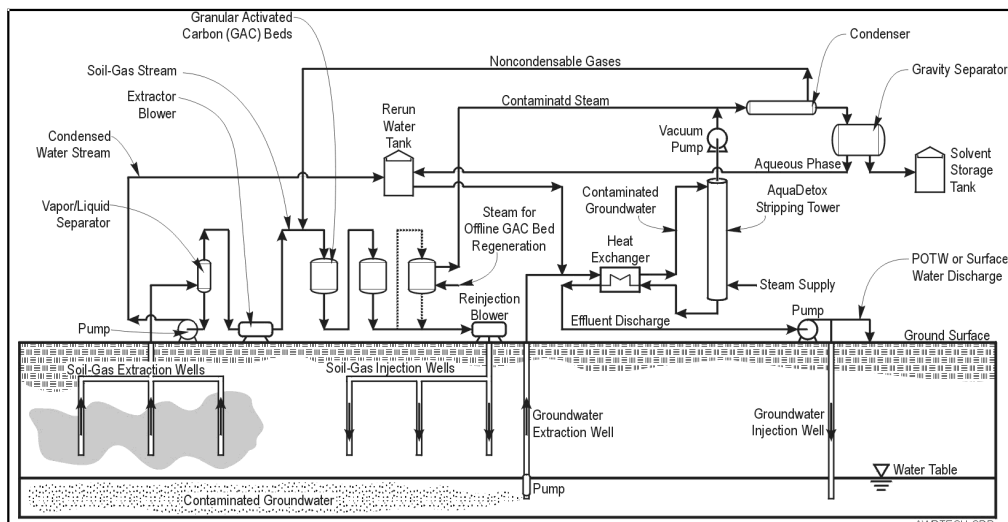
AquaDetox® and SVE systems are connected in a closed loop. Noncondensable vapors from the AquaDetox® system are combined with vapors from the SVE compressor and treated using the GAC beds.

WASTE APPLICABILITY:

AWD technology simultaneously treats groundwater and soil-gas contaminated with volatile organic compounds (VOCs), such as trichloroethylene (TCE) and tetra-chloroethylene (PCE). According to the developer, the AquaDetox® technology can be used to remove a wide variety of volatile compounds and many compounds that are normally considered "nonstrippable" (i.e., those with boiling points in excess of 200°C).

STATUS:

The SITE demonstration was conducted at the Lockheed site in Burbank, California. The treatment system at this site is a full-size unit capable of treating 1,200 gallons per minute (gpm) of groundwater and 300 standard cubic feet per minute (scDm) of soil-gas. The system began operation in September 1988. The demonstration was completed in September 1990.



Integrated AquaDetox®/SVE Schematic

DEMONSTRATION RESULTS:

During the demonstration, the system treated groundwater and soil-gas contaminated with VOCs. The primary contaminants present at the Lockheed site were trichloroethylene (TCE) and tetrachloroethylene (PCE) in soil and groundwater. The effectiveness of the technology was evaluated by analyzing the soil-gas and groundwater samples. The analytical results indicate that the technology effectively reduced the concentration of VOCs in the treated groundwater and soil-gas. Groundwater removal efficiencies of 99.92 percent or better were observed for TCE and PCE. In addition, the effluent groundwater concentrations of TCE and PCE were below the regulatory discharge limit of 5 µg/L. Soil-gas removal efficiencies ranged from 98.0 to 99.9 percent for total VOCs.

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BERGMANN, A DIVISION OF LINATEX, INC.

(Soil and Sediment Washing)

TECHNOLOGY DESCRIPTION:

The soil and sediment washing technology developed by Bergmann, A Division of Linatex, Inc.'s, (Bergman), separates contaminated particles by density and grain size (see photograph below). The technology operates on the hypothesis that most contamination is concentrated in the fine particle fraction (less than 45 microns [μm]) and that contamination of larger particles is generally not extensive.

After contaminated soil is screened to remove coarse rock and debris, water and chemical additives such as surfactants, acids, bases, and chelators are added to the medium to produce a slurry feed. The slurry feed flows to an attrition scrubbing machine. A rotary trommel screen, dense media separators, cyclone separators, and other equipment create mechanical and fluid shear stress, removing contaminated silts and clays from granular soil particles. Different separation

processes create the following four output streams: (1) coarse clean fraction; (2) enriched fine fraction; (3) separated contaminated humic materials; and (4) process wash water. The coarse clean fraction particles, which measure greater than 45 μm (greater than 325 mesh) each, can be used as backfill or recycled for concrete, masonry, or asphalt sand application. The enriched fine fraction particles, measuring less than 45 μm each are prepared for subsequent treatment, immobilization, destruction, or regulated disposal. Separated contaminated humic materials (leaves, twigs, roots, grasses, wood chips) are dewatered and require subsequent treatment or disposal. Upflow classification and separation, also known as elutriation, separates light contaminated materials such as leaves, twigs, roots, or wood chips. The process wash water is treated by flocculation and sedimentation, oil-water separation, or dissolved air flotation to remove solubilized heavy metal and emulsified organic fractions. The treated process wash water is then returned to the plant for reuse.



Bergmann Soil and Sediment Washing

WASTE APPLICABILITY:

This technology is suitable for treating soils and sediment contaminated with organics, including polychlorinated biphenyls (PCB), creosote, fuel residues, and heavy petroleum; and heavy metals, including cadmium, chromium, lead, arsenic, copper, cyanides, mercury, nickel, radionuclides, and zinc.

STATUS:

This technology was accepted into the SITE Demonstration Program in Winter 1991. It was demonstrated in Toronto, Ontario, Canada in April 1992 as part of the Toronto Harbour Commission (THC) soil recycling process. For further information on the THC process, including demonstration results, refer to the THC profile in the Demonstration Program section (completed projects). The technology was also demonstrated in May 1992 at the Saginaw Bay Confined Disposal Facility in Saginaw, Michigan. The Applications Analysis Report (EPA/540/AR-92/075) and the Demonstration Bulletin (EPA/540/MR-92/075) are available from EPA. Since 1981, Bergmann has provided 31 commercial systems, treating up to 350 tons per hour, at contaminated waste sites.

DEMONSTRATION RESULTS:

Demonstration results indicate that the soil and sediment washing system can effectively isolate and concentrate PCB contamination into the organic fractions and the fines. Levels of metals contamination were also beneficially altered from the feed stream to the output streams. The effectiveness of the soil and sediment washing system on the inorganic compounds met or exceeded its performance for PCB contamination. During a 5-day test in May 1992, the Bergmann soil and sediment washing system experienced no downtime as it operated for 8 hours per day to treat dredged sediments from the Saginaw River.

The demonstration provided the following results:

- Approximately 71 percent of the particles smaller than 45- μ m in the input sediment was apportioned to the enriched fine stream.
- Less than 20 percent of the particles smaller than 45- μ m in the input sediment was apportioned to the coarse clean fraction.
- The distribution of the concentrations of PCBs in the input and output streams were as follows:
 - Input sediment = 1.6 milligrams per kilogram (mg/kg)
 - Output coarse clean fraction = 0.20 mg/kg
 - Output humic materials = 11 mg/kg
 - Output enriched fines = 4.4 mg/kg
- The heavy metals were concentrated in the same manner as the PCBs.
- The coarse clean sand consisted of approximately 82 percent of the input sediment.

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BERKELEY ENVIRONMENTAL RESTORATION CENTER (In Situ Steam Enhanced Extraction Process)

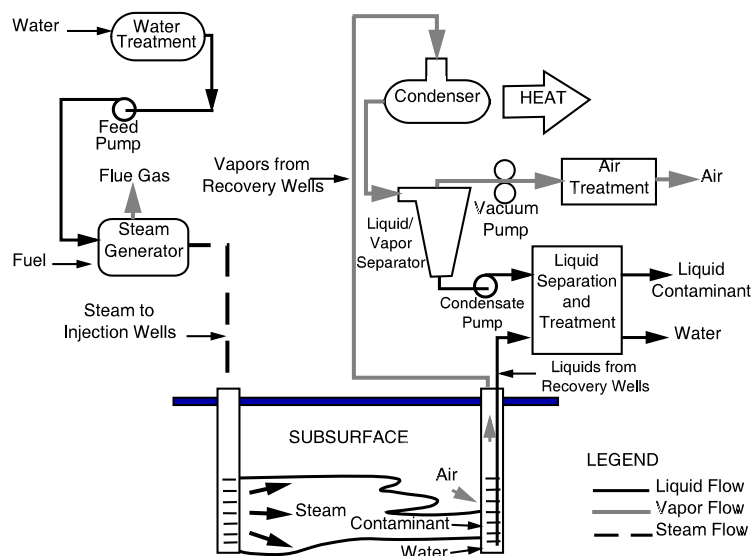
TECHNOLOGY DESCRIPTION:

The in situ steam enhanced extraction (ISEE) process removes volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) from contaminated water and soils above and below the water table (see figure below). Pressurized steam is introduced through injection wells to force steam through the soil to thermally enhance the vapor and liquid extraction processes.

The extraction wells have two purposes: (1) to pump groundwater for ex situ treatment; and (2) to transport steam and vaporized contaminants under vacuum to the surface. Recovered contaminants are condensed and recycled, processed with the contaminated groundwater, or treated in the gas phase. The ISEE process uses readily available components such as injection, extraction, and monitoring wells; manifold piping; vapor and liquid separators; vacuum pumps; and gas emission control equipment.

WASTE APPLICABILITY:

The ISEE process extracts VOCs and SVOCs from contaminated soils and groundwater. The primary compounds suitable for treatment include hydrocarbons such as gasoline, diesel, and jet fuel; solvents such as trichloroethene, 1,1,1-trichloroethane, and dichlorobenzene; or a mixture of these compounds. The process may be applied to contaminants above or below the water table. After treatment is complete, subsurface conditions are amenable to biodegradation of residual contaminants, if necessary. The process can be applied to contaminated soil very near the surface with a cap. Compounds denser than water may be treated only in low concentrations, unless a barrier exists or can be created to prevent downward percolation of a separate phase.



In Situ Steam Enhanced Extraction Process

STATUS:

In August 1988, a successful pilot-scale demonstration of the ISEE process was completed at a site contaminated with a mixture of solvents. Contaminants amounting to 764 pounds were removed from the 10-foot-diameter, 12-foot-deep test region. After 5 days of steam injection, soil contaminant concentrations dropped by a factor of 10.

In December 1993, a full-scale demonstration was completed at a gasoline spill site at Lawrence Livermore National Laboratory (LLNL) in Altamont Hills, California. Gasoline was dispersed both above and below the water table due to a 25-foot rise in the water table since the spill occurred. The lateral distribution of liquid-phase gasoline was within a region 150 feet in diameter and up to 125 feet deep. Appendix A of the Hughes Environmental Systems Innovative Technology Evaluation Report (EPA/540/R-94/510) contains detailed results from the LLNL SITE demonstration. This report is available from EPA.

A pilot-scale test of the ISEE process was conducted in 1994 at Naval Air Station (NAS) Lemoore in California. During 3 months of operation, over 98,000 gallons of JP-5 jet fuel was recovered from medium permeability, partially saturated sand to a depth of 20 feet. Preliminary soil sampling showed reductions of JP-5 jet fuel concentrations from several thousand parts per million (ppm) above the water table to values less than 25 ppm.

During Fall 1998, Berkeley was scheduled to use the ISEE process to remediate a groundwater contaminant plume at Alameda Naval Air Station in California. The contaminant plume contained halogenated organic compounds, including trichloroethene, 1,1,1-trichloroethane, and perchloroethylene.

For more information about similar technologies, see the following profiles in the Demonstration Program section: Hughes Environmental Systems, Inc., (completed projects) and Praxis Environmental Technologies, Inc. (ongoing projects).

DEMONSTRATION RESULTS:

During the SITE demonstration at LLNL, over 7,600 gallons of gasoline were recovered from above and below the water table in 26 weeks of operation. Recovery rates were about 50 times greater than those achieved by vacuum extraction and groundwater pumping alone. The rates were highest during cyclic steam injection, after subsurface soils reached steam temperatures. The majority of the recovered gasoline came from the condenser as a separate phase liquid or in the effluent air stream.

Without further pumping, 1,2-dichloroethene, benzene, ethylbenzene, toluene, and xylene concentrations in sampled groundwater were decreased to below maximum contaminant levels after 6 months. Post-process soil sampling indicated that a thriving hydrocarbon-degrading microbial population existed in soils experiencing prolonged steam contact.

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BILLINGS AND ASSOCIATES, INC. (Subsurface Volatilization and Ventilation System [SVVS®])

TECHNOLOGY DESCRIPTION:

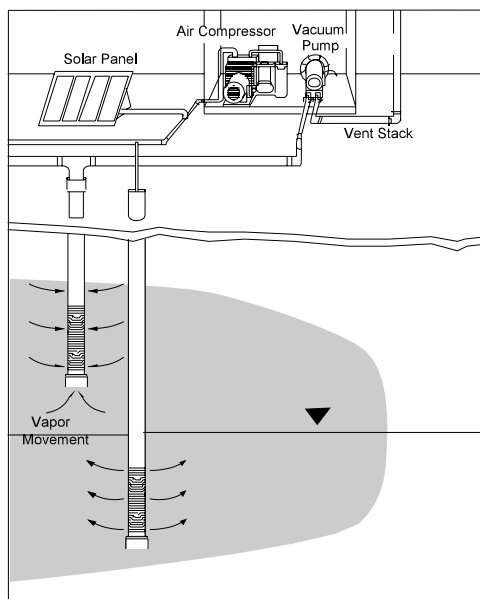
The Subsurface Volatilization and Ventilation System (SVVS®), developed by Billings and Associates, Inc. (BAI), and operated by several other firms under a licensing agreement, uses a network of injection and extraction wells (collectively called a reactor nest) to treat subsurface organic contamination through soil vacuum extraction combined with in situ biodegradation. Each system is designed to meet site-specific conditions. The SVVS® technology has three U.S. patents.

The SVVS® is shown in the figure below. A series of injection and extraction wells is installed at a site. One or more vacuum pumps create negative pressure to extract contaminant vapors, while an air compressor simultaneously creates positive pressure, sparging the subsurface treatment area. Control is maintained at a vapor control unit that houses pumps, control valves, gauges, and other process control hardware. At most sites with subsurface organic contamination, extraction wells are placed above the water table and injection wells are placed below the groundwater.

This placement allows the groundwater to be used as a diffusion device.

The number and spacing of the wells depends on the modeling results of a design parameter matrix, as well as the physical, chemical, and biological characteristics of the site. The exact depth of the injection wells and screened intervals are additional design considerations.

To enhance vaporization, solar panels are occasionally used to heat the injected air. Additional valves for limiting or increasing air flow and pressure are placed on individual reactor nest lines (radials) or, at some sites, on individual well points. Depending on groundwater depths and fluctuations, horizontal vacuum screens, "stubbed" screens, or multiple-depth completions can be applied. Positive and negative air flow can be shifted to different locations at the site to emphasize remediation on the most contaminated areas. Negative pressure is maintained at a suitable level to prevent escape of vapors.



Subsurface Volatilization and Ventilation System (SVVS®)

Because it provides oxygen to the subsurface, the SVVS® can enhance in situ bioremediation at a site, thereby decreasing remediation time. These processes are normally monitored by measuring dissolved oxygen levels in the aquifer, recording carbon dioxide levels in transmission lines and at the emission point, and periodically sampling microbial populations. When required by air quality permits, volatile organic compound emissions can be treated by a patent-pending biological filter that uses indigenous microbes from the site.

WASTE APPLICABILITY:

The SVVS® is applicable to soils, sludges, and groundwater contaminated with gasoline, diesel fuels, and other hydrocarbons, including halogenated compounds. The technology is effective on benzene, toluene, ethylbenzene, and xylene contamination. It can also contain contaminant plumes through its unique vacuum and air injection techniques.

STATUS:

This technology was accepted into the SITE Demonstration Program in winter 1991. A site in Buchanan, Michigan was selected for the demonstration, and initial drilling and construction began in July 1992. The demonstration began in March 1993 and was completed in May 1994. The Demonstration Bulletin (EPA/540/MR-94/529), Technology Capsule (EPA/540/R-94/529a), and Innovative Technology Evaluation Report (EPA/540/R-94/529) are available from EPA. The SVVS® has also been implemented at 95 underground storage tank sites in New Mexico, North Carolina, South Carolina, Florida, and Oklahoma.

BAI is researching ways to increase the microbiological effectiveness of the technology and is testing a mobile unit. The mobile unit will allow rapid field pilot tests to support the design process. This unit will also permit actual remediation of small sites and of small, recalcitrant areas on large sites.

DEMONSTRATION RESULTS:

Results from the SVVS® demonstration are as follows:

- Data indicated that the overall reductions for several target analytes, as determined from individual boreholes, ranged from 71 percent to over 99 percent, over a 1-year period.
- The early phase of the remediation was characterized by higher concentrations of volatile organics in the extracted vapor stream.
- The shutdown tests indicate that the technology stimulated biodegradative processes at the site.

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BIOGENESIS ENTERPRISES, INC. (BioGenesisSM Soil and Sediment Washing Process)

TECHNOLOGY DESCRIPTION:

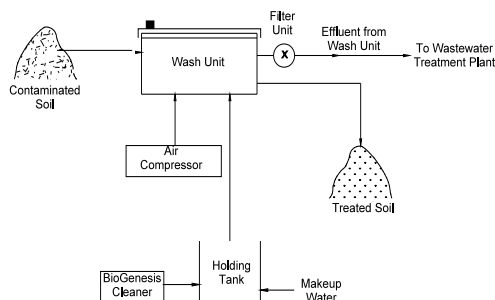
The BioGenesisSM soil and sediment washing process uses specialized, patent-pending equipment, complex surfactants, and water to clean soil, sediment, and sludge contaminated with organic and inorganic constituents. Two types of mobile equipment wash different sizes of particles. A truck-mounted batch unit processes 20 yards per hour, and washes soil particles 10 mesh and larger. A full-scale, mobile, continuous flow unit cleans sand, silt, clay, and sludge particles smaller than 10 mesh at a rate of 20 to 40 yards per hour. Auxiliary equipment includes tanks, dewatering and water treatment equipment, and a bioreactor. Extraction efficiencies per wash cycle range from 85 to 99 percent. High contaminant levels require multiple washes.

The principal components of the process consist of pretreatment equipment for particle sizing, a truck-mounted soil washer for larger particles, a sediment washing unit(s) for fine particles, and water treatment and reconditioning equipment. The BioGenesisSM soil washing system for larger particles consists of a trailer-mounted gondola plumbed for air mixing, water and chemical addition, oil skimming, and liquid drainage (see figure below). Water, BioGenesisSM cleaning chemicals, and soil are loaded into the gondola. Aeration nozzles feed compressed air to

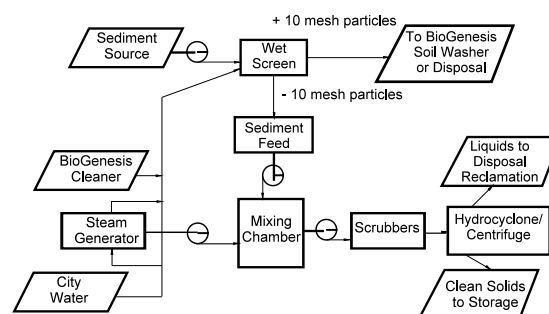
create a fluidized bed. The resulting slurry is agitated to release organic and inorganic contaminants from the soil particles. After mixing, a short settling period allows the soil particles to sink and the removed oil to rise to the water surface, where it is skimmed for reclamation or disposal. Following drainage of the wash water, the treated soil is evacuated by raising the gondola's dump mechanism. Processed soil contains a moisture level of 10 to 20 percent depending on the soil matrix.

A prototype BioGenesisSM sediment washing machine was tested in Environment Canada's Contaminated Sediment Treatment Technology Program. The sediment washing machine is a continuous flow unit. Capacities of up to 80 to 100 cubic yards per hour are possible using full-scale, parallel processing equipment.

In the sediment washing machine, sediment is pretreated to form a slurry. The slurry passes to a shaker screen separator that sizes particles into two streams. Material greater than 1 millimeter (mm) in diameter is diverted to the large particle soil washer. Material 1 mm and smaller continues to the sediment washer's feed hopper. From there, the slurry is injected to the sediment cleaning chamber to loosen the bonds between the pollutant and the particle.



Soil Washing Process



Sediment Washing Process

After the cleaning chamber, the slurry flows to the scrubber to further weaken the bonds between contaminants and particles. After the scrubber, the slurry passes through a buffer tank, where large particles separate by gravity. The slurry then flows through hydrocyclone banks to separate solids down to 3 to 5 microns in size. The free liquid routes to a centrifuge for final solid-liquid separation. All solids go to the treated soil pile; all liquid is routed to wastewater treatment to remove organic and inorganic contaminants. Decontaminated wastewater is recycled back through the process. Equipment configuration varies depending on the soil matrix.

The BioGenesisSM cleaning chemical is a light alkaline mixture of ionic and nonionic surfactants and bioremediating agents that act similarly to a biosurfactant. The proprietary cleaner contains no hazardous ingredients.

WASTE APPLICABILITY:

This technology extracts many inorganics, volatile and nonvolatile hydrocarbons, chlorinated hydrocarbons, pesticides, polychlorinated biphenyls (PCB), polynuclear aromatic hydrocarbons, and most organics from nearly every soil and sediment type, including clay.

STATUS:

The BioGenesisSM soil washing technology was accepted into the SITE Demonstration Program in June 1990. The process was demonstrated in November 1992 on weathered crude oil at a refinery site in Minnesota. Results from the demonstration have been published in the Innovative Technology Evaluation Report (EPA/540/R-93/510) and the SITE Technology Capsule (EPA/540/SR-93/510). The reports are available from EPA. BioGenesis Enterprises, Inc., is planning a future demonstration of the BioGenesisSM sediment washing process using PCB-contaminated sediment.

DEMONSTRATION RESULTS:

Results of the SITE demonstration are presented below:

- Soil washing and biodegradation with BioGenesisSM removed about 85 percent of the total recoverable petroleum hydrocarbon (TRPH)-related contaminants in the soil.
- Treatment system performance was reproducible at constant operating conditions.
- At the end of 90 days, TRPH concentrations decreased an additional 50 percent compared to washing alone.
- The prototype equipment operated within design parameters. New production equipment is expected to streamline overall operating efficiency.

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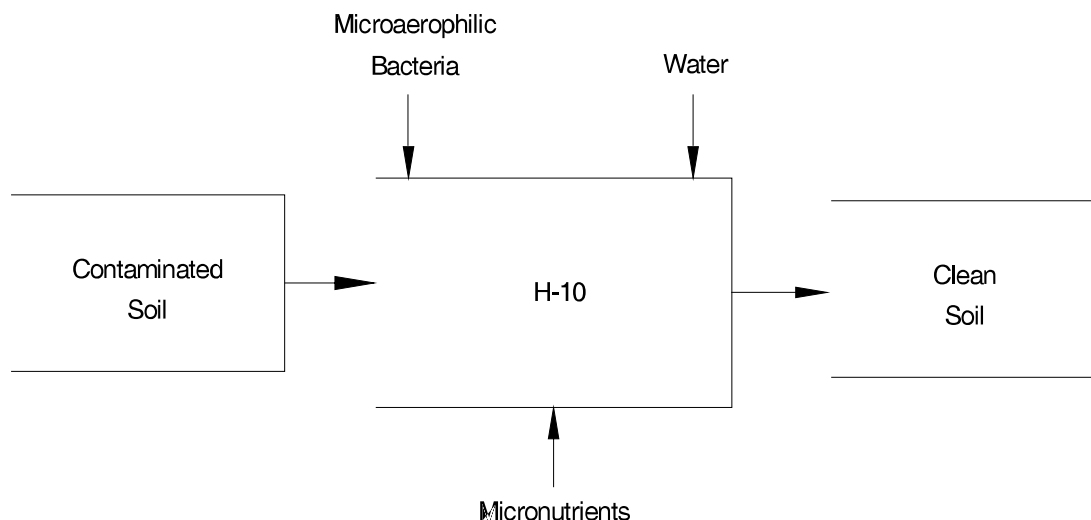
BIO-REM, INC. (Augmented In Situ Subsurface Bioremediation Process)

TECHNOLOGY DESCRIPTION:

The Bio-Rem, Inc., Augmented In Situ Subsurface Bioremediation Process uses a proprietary blend (H-10) of microaerophilic bacteria and micronutrients for subsurface bioremediation of hydrocarbon contamination in soil and water (see figure below). The insertion methodology is adaptable to site-specific situations. The bacteria are hardy and can treat contaminants in a wide temperature range. The process does not require additional oxygen or oxygen-producing compounds, such as hydrogen peroxide. Degradation products include carbon dioxide and water.

The bioremediation process consists of four steps: (1) defining and characterizing the contamination plume; (2) selecting a site-specific application methodology; (3) initiating and propagating the bacterial culture; and (4) monitoring and reporting cleanup.

This technology treats soil and water contaminated with hydrocarbons, including halogenated hydrocarbons. Use of the augmented bioremediation process is site-specific, and therefore engineered for each individual site. The success of the process is dependent on a complete and accurate site characterization study. This data is necessary to determine the treatment magnitude and duration.



Augmented In Situ Subsurface Bioremediation Process

STATUS:

This technology was accepted into the SITE Demonstration Program in winter 1991. The technology was successfully demonstrated at Williams Air Force Base in Phoenix, Arizona from May 1992 through June 1993. The Demonstration Bulletin (EPA/540/ MR-93/527) is available from EPA. Bio-Rem, Inc., has remediated sites throughout the U.S., and in Canada and Central Europe.

DEMONSTRATION RESULTS:

Results from the Demonstration indicate that the BIO-REM process was unsuccessful in reducing target contaminants in the soil to the project clean-up levels.

Baseline sampling indicated that a majority of the soil samples were significantly higher than the cleanup levels of 130 ppb for benzene and 100 ppm for TRPH. Furthermore, soil samples analyzed one and three months after inoculation did not show significant reductions in benzene or TRPH contamination (Table 1). The lack of progress in the remediation prompted concerns regarding the effectiveness of the technology. It was jointly decided between the SITE Program and BIO-REM to collect sixteen samples (four boreholes) at six months to determine the progress of the remediation at the predicted end of the project. Results from the six month sampling event also indicated a lack of significant reduction in contaminant concentrations.

Based on these results, BIO-REM submitted a request to the Air Force to re-inoculate the site based on their assessment that sub-surface lithological conditions inhibited the remedial process. In March of 1993 BIO-REM re-inoculated the site by injecting approximately 35,000 gallons of H-10 slurry into 104 boreholes deepened to a depth of 23 feet below land surface. The inoculation to deeper depths was implemented to overcome the sub-surface lithological conditions identified by BIO-REM. In June of 1993 a confirmatory sampling event initiated by the Air Force. In conjunction with the SITE Program, indicated that significant contamination existed at the site, and that the re-inoculation was unsuccessful in reducing the target contaminants to the project specific clean-up levels. Based on these results, these site activities were concluded.

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BIOTHERM, LLC **(formerly Dehydro-Tech Corporation)** **(Biotherm Process™)**

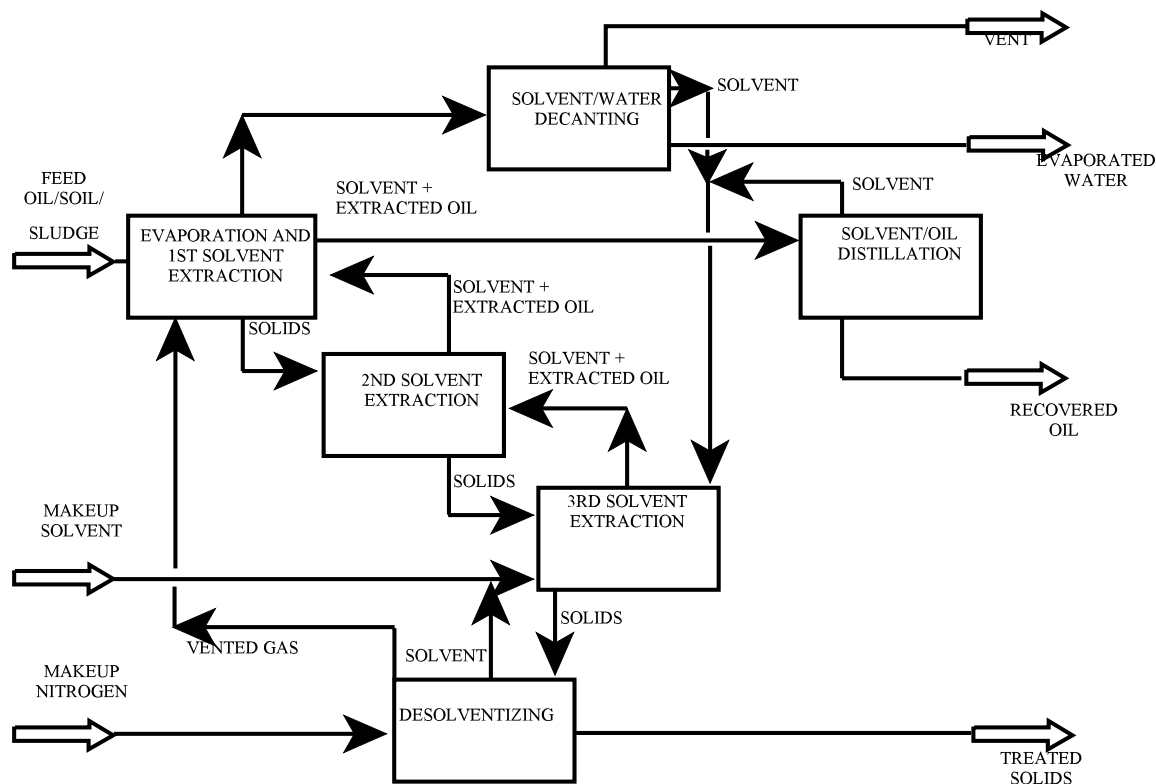
TECHNOLOGY DESCRIPTION:

The Biotherm Process™ combines dehydration and solvent extraction technologies to separate wet, oily wastes into their constituent solid, water, and oil phases (see figure below).

Waste is first mixed with a low-cost hydrocarbon solvent. The resultant slurry mixture is fed to an evaporator system that vaporizes water and initiates solvent extraction of the indigenous oil extraction unit, where solids contact recycled solvent until the target amount of indigenous oil is removed. Depending on the water content of the feed, single-effect or energy-saving multi-effect evaporators may

be used. Next, the slurry of dried solids is treated in a multistage solvent. Finally, solids are centrifuged away from the solvent, followed by "desolventizing," an operation that evaporates residual solvent. The final solids product typically contains less than 2 percent water and less than 1 percent solvent. The spent solvent, which contains the extracted indigenous oil, is distilled to separate the solvent for reuse, and the oil for recovery or disposal.

The Biotherm Process™ yields (1) a clean, dry solid; (2) a water product virtually free of solids, indigenous oil, and solvent; and (3) the extracted indigenous oil, which contains the hazardous hydrocarbon-soluble feed components. The Biotherm Process™



Biotherm Process™ Schematic Diagram

combination of dehydration and solvent extraction has the following advantages: (1) any emulsions initially present are broken and potential emulsion formation is prevented; (2) solvent extraction is more efficient because water is not present; and (3) the dry solids product is stabilized more readily if required (for example, if metals contamination is a concern).

WASTE APPLICABILITY:

The Biotherm Process™ can treat sludges, soils, sediments, and other water-bearing wastes containing hydrocarbon-soluble hazardous compounds, including polychlorinated biphenyls, polynuclear aromatic hydrocarbons, and dioxins. The process has been commercially applied to municipal wastewater sludge, paper mill sludge, rendering waste, pharmaceutical plant sludge, and other wastes.

STATUS:

The Biotherm Process™ was accepted into the SITE Demonstration Program in 1990. The pilot-scale SITE demonstration of this technology was completed in August 1991 at EPA's research facility in Edison, New Jersey. Spent petroleum drilling fluids from the PAB oil site in Abbeville, Louisiana, were used as process feed. The Applications Analysis Report (EPA/540/AR-92/002), Technology Demonstration Summary (EPA/540/SR-92/002), and Technology Evaluation Report (EPA/540/R-92/002) are available from EPA.

DEMONSTRATION RESULTS:

The SITE demonstration of the Biotherm Process™ yielded the following results:

- The process successfully separated the petroleum-contaminated sludge into its solid, indigenous oil, and water phases. No detectable levels of indigenous total petroleum hydrocarbons were present in the final solid product.
- The final solid product was a dry powder similar to bentonite. A food-grade solvent comprised the bulk of the residual hydrocarbons in the solid.
- Values for all metals and organics were well below the Resource Conservation and Recovery Act toxicity characteristic leaching procedure limits for characteristic hazardous wastes.
- The resulting water product required treatment due to the presence of small amounts of light organics and solvent. Normally, it may be disposed of at a local publicly owned treatment works.
- A full-scale Biotherm Process™ can treat drilling fluid wastes at technology-specific costs of \$100 to \$220 per ton of wet feed, exclusive of disposal costs for the residuals. Site-specific costs, which include the cost of residual disposal, depend on site characteristics and treatment objectives.

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BIOTROL® (Biological Aqueous Treatment System)

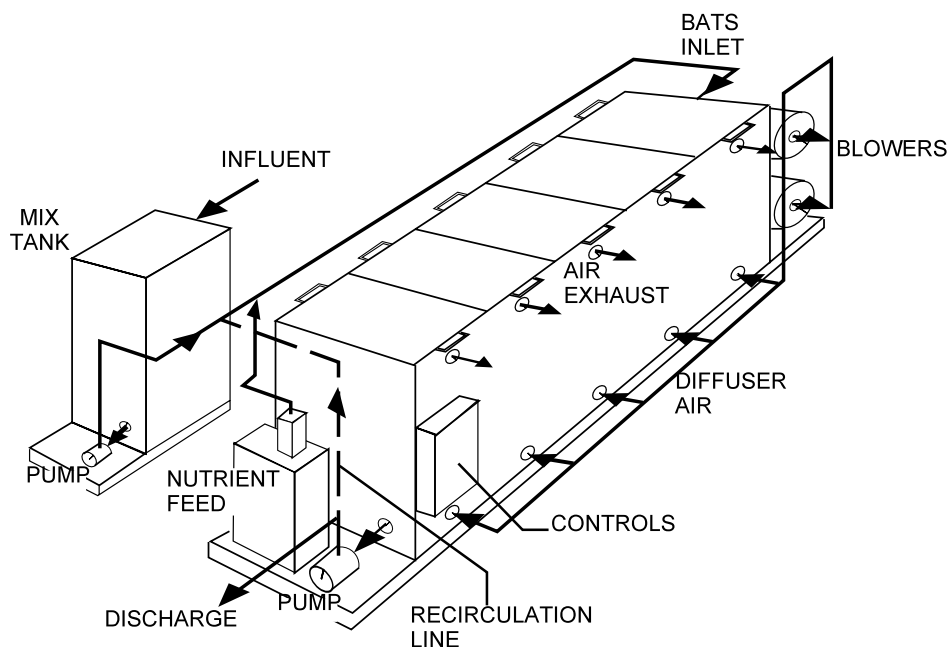
TECHNOLOGY DESCRIPTION:

The BioTrol biological aqueous treatment system (BATS) is a patented biological system that treats contaminated groundwater and process water. The system uses naturally occurring microbes; in some instances, however, a specific microorganism may be added. This technique, known as microbial amendment, is important if a highly toxic or recalcitrant target compound is present. The amended microbial system removes both the target contaminant and the background organic carbon.

The figure below is a schematic of the BATS. Contaminated water enters a mix tank, where the pH is adjusted and inorganic nutrients are added. If necessary, the water is heated to an optimum temperature with a heater and a heat exchanger, to minimize energy costs. The water then flows to the bioreactor, where the contaminants are biodegraded.

The microorganisms that degrade the contaminants are immobilized in a multiple-cell, submerged, fixed-film bioreactor. Each cell is filled with a highly porous packing material to which the microbes adhere. For aerobic conditions, air is supplied by fine bubble membrane diffusers mounted at the bottom of each cell. The system may also run under anaerobic conditions.

As water flows through the bioreactor, the contaminants are degraded to biological end-products, predominantly carbon dioxide and water. The resulting effluent may be discharged to a publicly owned treatment works or reused on site. In some cases, discharge with a National Pollutant Discharge Elimination System permit may be possible.



BioTrol Biological Aqueous Treatment System (BATS)

WASTE APPLICABILITY:

The BATS may be applied to a wide variety of wastewaters, including groundwater, lagoons, and process water. Contaminants amenable to treatment include pentachlorophenol (PCP), creosote components, gasoline and fuel oil components, chlorinated hydrocarbons, phenolics, and solvents. Other potential target waste streams include coal tar residues and organic pesticides. The BATS may also be effective for treating certain inorganic compounds such as nitrates; however, this application has not yet been demonstrated. The system does not treat metals.

STATUS:

The BATS was accepted into the SITE Demonstration Program in 1989. The system was demonstrated under the SITE Program from July to September 1989 at the MacGillis and Gibbs Superfund site in New Brighton, Minnesota. The system operated continuously for 6 weeks at three different flow rates. The Applications Analysis Report (EPA/540/ A5-91/001), the Technology Evaluation Report (EPA/540/5-91/001), and the Demonstration Bulletin (EPA/540/M5-91/ 001) are available from EPA.

During 1986 and 1987, BioTrol performed a successful 9-month pilot-scale field test of the BATS at a wood preserving facility. Since that time, the firm has installed more than 20 full-scale systems and has performed several pilot-scale demonstrations. These systems have successfully treated waters contaminated with gasoline, mineral spirit solvents, phenol, and creosote.

DEMONSTRATION RESULTS:

For the SITE demonstration, the BATS yielded the following results:

- Reduced PCP concentrations from about 45 parts per million (ppm) to 1 ppm or less in a single pass
- Produced minimal sludge and no PCP air emissions
- Mineralized chlorinated phenolics
- Eliminated groundwater biotoxicity
- Appeared to be unaffected by low concentrations of oil and grease (about 50 ppm) and heavy metals in groundwater
- Required minimal operator attention

The treatment cost per 1,000 gallons was \$3.45 for a 5-gallon-per-minute (gpm) pilot-scale system and \$2.43 for a 30-gpm system.

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BIOTROL® (Soil Washing System)

TECHNOLOGY DESCRIPTION:

The BioTrol Soil Washing System is a patented, water-based volume reduction process used to treat excavated soil. The system may be applied to contaminants concentrated in the fine-sized soil fraction (silt, clay, and soil organic matter) or in the coarse soil fraction (sand and gravel).

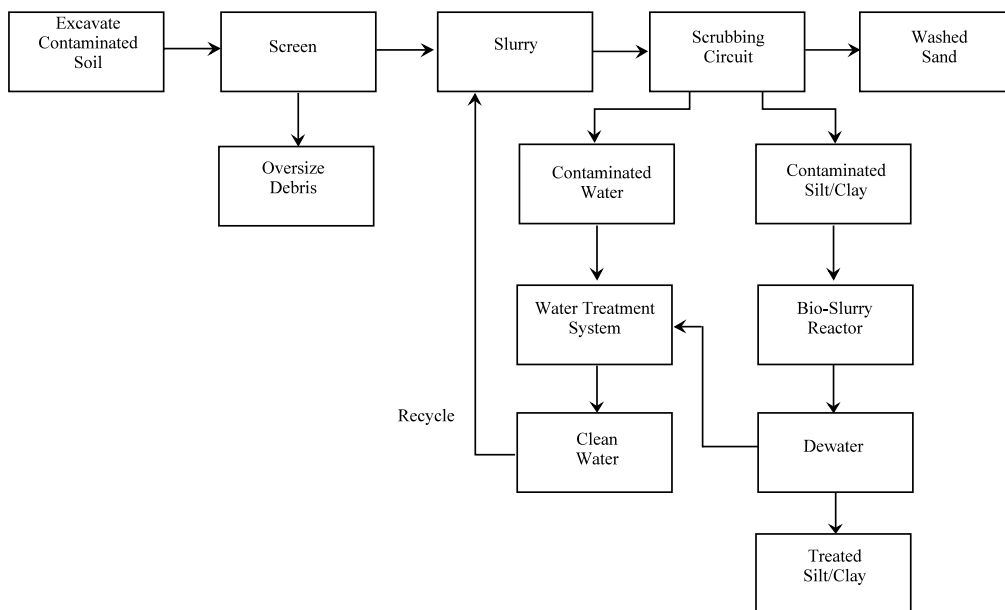
In the first part of the process, debris is removed from the soil. The soil is then mixed with water and subjected to various unit operations common to the mineral processing industry (see figure below). The equipment used in these operations can include mixing trommels, pug mills, vibrating screens, froth flotation cells, attrition scrubbing machines, hydrocyclones, screw classifiers, and various dewatering apparatus.

The core of the process is a multistage, countercurrent, intensive scrubbing circuit with interstage classification. The scrubbing action disintegrates soil aggregates, freeing contaminated

fine particles from the coarser material. In addition, surficial contamination is removed from the coarse fraction by the abrasive scouring action of the particles themselves. Contaminants may also be solubilized, as dictated by solubility characteristics or partition coefficients.

Contaminated residual products can be treated by other methods. Process water is normally recycled after biological or physical treatment. Contaminated fines may be disposed of off site, incinerated, stabilized, or biologically treated.

This system was initially developed to clean soils contaminated with wood preserving wastes, such as polynuclear aromatic hydrocarbons (PAHs) and pentachlorophenol (PCP). The system may also apply to soils contaminated with petroleum hydrocarbons, pesticides, polychlorinated biphenyls, various industrial chemicals, and metals.



BioTrol Soil Washing System Process Diagram

STATUS:

The BioTrol Soil Washing System was accepted into the SITE Demonstration Program in 1989. The system was demonstrated under the SITE Program between September and October 1989 at the MacGillis and Gibbs Superfund site in New Brighton, Minnesota. A pilot-scale unit with a treatment capacity of 500 pounds per hour operated 24 hours per day during the demonstration. Feed for the first phase of the demonstration (2 days) consisted of soil contaminated with 130 parts per million (ppm) PCP and 247 ppm total PAHs; feed for the second phase (7 days) consisted of soil containing 680 ppm PCP and 404 ppm total PAHs.

Contaminated process water was treated biologically in a fixed-film reactor and recycled. A portion of the contaminated soil fines was treated biologically in a three-stage, pilot-scale EIMCO Biolift™ reactor system supplied by the EIMCO Process Equipment Company. The Applications Analysis Report (EPA/540/A5-91/003) and the Technology Evaluation Report Volume I (EPA/540/5-91/003a) and Volume II (EPA/540/5-91/003b and EPA/540/5-91/003c) are available from EPA.

DEMONSTRATION RESULTS:

Key findings from the BioTrol demonstration are summarized below:

- Feed soil (dry weight basis) was successfully separated into 83 percent washed soil, 10 percent woody residues, and 7 percent fines. The washed soil retained about 10 percent of the feed soil contamination; 90 percent of this contamination was contained within the woody residues, fines, and process wastes.

- The multistage scrubbing circuit removed up to 89 percent PCP and 88 percent total PAHs, based on the difference between concentration levels in the contaminated (wet) feed soil and the washed soil.
- The scrubbing circuit degraded up to 94 percent PCP in the process water during soil washing. PAH removal could not be determined because of low influent concentrations.
- The cost of a commercial-scale soil washing system, assuming use of all three technologies (soil washing, water treatment, and fines treatment), was estimated to be \$168 per ton. Incineration of woody material accounts for 76 percent of the cost.

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BRICE ENVIRONMENTAL SERVICES CORPORATION

(Soil Washing Process)

TECHNOLOGY DESCRIPTION:

Brice Environmental Services Corporation (Brice) developed a soil washing process that removes particulate metal contamination from soil. The process has been successfully coupled with acid leaching processes developed by Brice and others for the removal of ionic metal salts and metal coatings from soil. The Brice soil washing process is modular and uses components specifically suited to site soil conditions and cleanup standards. Component requirements and anticipated cleanup levels attainable with the process are determined during treatability testing at Brice's Fairbanks, Alaska facility laboratory. The process is designed to recirculate wash water and leachate solutions.

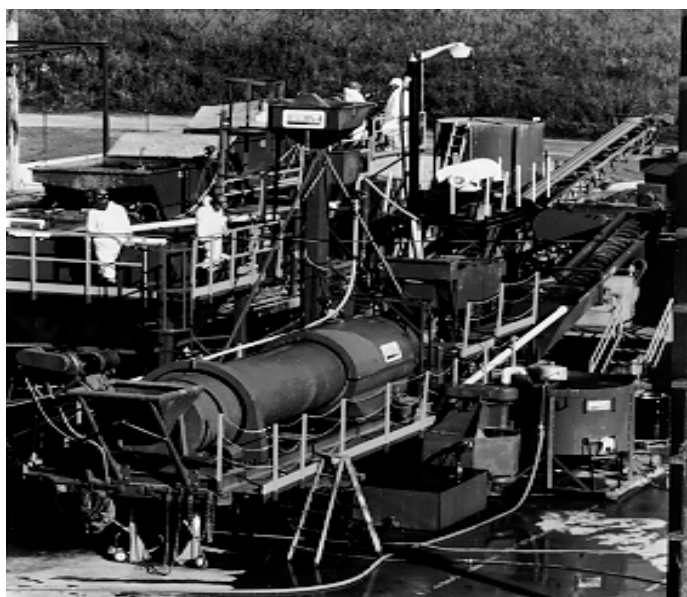
Particulate metal contaminants removed from soil, and metals recovered from the leaching system (if used), are recycled at a smelting facility. Instead of stabilizing the metals in place or placing the materials in a landfill, the Brice technology removes metal contaminants from the soil, thereby eliminating the health hazard associated with heavy metal contamination.

WASTE APPLICABILITY:

The Brice soil washing process treats soils contaminated with heavy metals. Typical materials suited for treatment with the technology include soils at small arm ranges, ammunition manufacturing and testing facilities, foundry sites, and sites used for lead-acid battery recycling.

STATUS:

The Brice soil washing process was accepted into the SITE Demonstration Program in winter 1991. Under the program, the technology was demonstrated in late summer 1992 on lead-contaminated soil at the Alaskan Battery Enterprises (ABE) Superfund site in Fairbanks, Alaska. The Demonstration Bulletin (EPA/540/MR-93/503) and the Applications Analysis Report (EPA/540/ A5-93/503) are available from EPA.



Brice soil Washing Plant

A Brice soil washing plant was operated in New Brighton, Minnesota for 9 months at Twin Cities Army Ammunition Plant (TCAAP - see photograph) to process 20,000 tons of contaminated soil. The wash plant was used in conjunction with a leaching plant (operated by a separate developer) that removed ionic lead following particulate metal removal.

During Fall 1996, Brice performed a soil washing/soil leaching technology demonstration at a small arms range at Fort Polk, Louisiana. The process implemented physical separation of bullet and bullet fragments from soil particles, and included a leaching step for removing residual ionic lead. A total of 835 tons of soil were processed during this demonstration, and all demonstration goals were met with no soil requiring reprocessing.

In August 1998, Brice completed a full-scale soil washing operation at the Marine Corps Air Ground Combat Center in Twentynine Palms, California. This operation involved processing about 12,000 tons of soil at a small arms firing range.

Several successful demonstrations of the pilot-scale unit have been conducted. The results from the SITE demonstration have been published in a Technology Evaluation Report (EPA/540/5-91/006a), entitled "Design and Development of a Pilot-Scale Debris Decontamination System" and in a Technology Demonstration Summary (EPA/540/S5-91/006).

EPA developed a full-scale unit with ancillary equipment mounted on three 48-foot flatbed semi-trailers. EPA was expected to formalize a nonexclusive licensing agreement for the equipment in late 1998 to increase the technology's use in treating contaminated debris.

DEMONSTRATION RESULTS:

The demonstration at the ABE site consisted of three test runs of five hours each, with 48 tons of soil processed. Feed soils averaged 4,500 milligrams per kilogram (mg/kg) and the separated soil fines fraction averaged 13,00 mg/kg. On-line reliability was 92 percent, and all processed gravel passed TCLP testing. Battery casing removal efficiencies during the three runs were 94 percent, 100 percent and 90 percent.

The results for the demonstration at the TCAAP site indicated that the Brice technology reduced the lead load to the leaching process from 39 percent to 53 percent. Soil was continuously processed at a rate of 12 to 15 tons per hour.

Results of the Fort Polk demonstration indicate that the technology reduced lead from firing range soils by 97 percent. All soil processed was below the demonstration goals of 500 mg/kg total lead and 5 milligrams per liter (mg/L) TCLP lead. Average results for all processed soil were 156 mg/kg total lead and 2.1 mg/L TCLP lead. Processing rates ranged from 6 to 12 tons per our hour.

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BWX TECHNOLOGIES, INC.
(an affiliate of BABCOCK & WILCOX CO.)
(Cyclone Furnace)

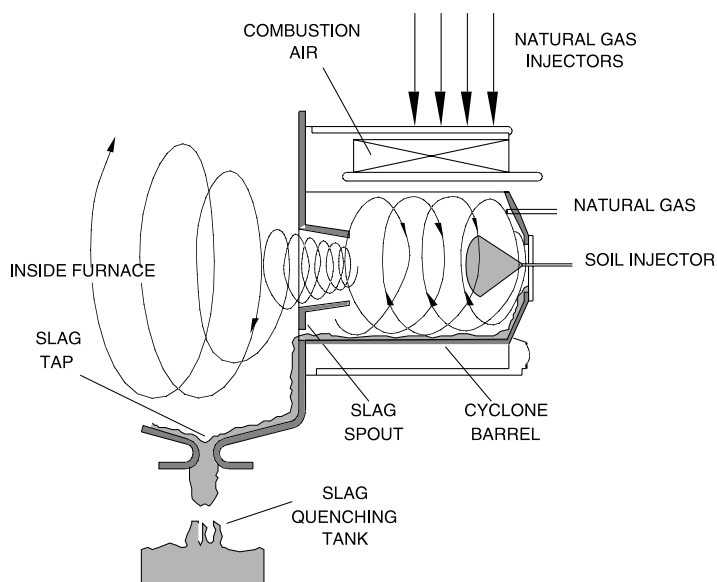
TECHNOLOGY DESCRIPTION:

The BWX Technologies, Inc cyclone furnace is designed to combust coal with high inorganic content (high-ash). Through cofiring, the cyclone furnace can also accommodate highly contaminated wastes containing heavy metals and organics in soil or sludge. High heat-release rates of 45,000 British Thermal Units (Btu) per cubic foot of coal and high turbulence in cyclones ensures the high temperatures required for melting the high-ash fuels and combusting the organics. The inert ash exits the cyclone furnace as a vitrified slag.

The pilot-scale cyclone furnace, shown in the figure below, is a water cooled, scaled-down version of a commercial coal-fired cyclone with a restricted exit (throat). The furnace geometry is a horizontal cylinder (barrel).

Natural gas and preheated combustion air are heated to 820°F and enter tangentially into the cyclone burner. For dry soil processing, the soil matrix and natural gas enter tangentially along the cyclone furnace barrel. For wet soil processing, an atomizer uses compressed air to spray the soil slurry directly into the furnace. The soil or sludge and inorganics are captured and melted, and organics are destroyed in the gas phase or in the molten slag layer. This slag layer is formed and retained on the furnace barrel wall by centrifugal action.

The soil melts, exits the cyclone furnace from the tap at the cyclone throat, and drops into a water-filled slag tank where it solidifies. A small quantity of soil also exits as fly ash with the flue gas from the furnace and is collected in a baghouse. In principle, this fly ash can be recycled to the furnace to increase metal capture and to minimize the volume of the potentially hazardous waste stream.



Cyclone Furnace

The energy requirements for vitrification are 15,000 Btu per pound of soil treated. The cyclone furnace can be operated with gas, oil, or coal as the supplemental fuel. If the waste is high in organic content, it may also supply a significant portion of the required fuel heat input.

Particulates are captured by a baghouse. To maximize the capture of particulate metals, a heat exchanger is used to cool the stack gases to approximately 200°F before they enter the baghouse.

WASTE APPLICABILITY:

The cyclone furnace can treat highly contaminated hazardous wastes, sludges, and soils that contain heavy metals and organic constituents. The wastes may be solid, a soil slurry (wet soil), or liquids. To be treated in the cyclone furnace, the ash or solid matrix must melt (with or without additives) and flow at cyclone furnace temperatures (2,400 to 3,000°F). Because the furnace captures heavy metals in the slag and renders them nonleachable, it is particularly suited to soils that contain lower-volatility radionuclides such as strontium and transuranics.

STATUS:

Based on results from the Emerging Technology Program, the cyclone furnace technology was accepted into the SITE Demonstration Program in August 1991. A demonstration occurred in November 1991 at the developer's facility in Alliance, Ohio. The process was demonstrated using an EPA-supplied, wet synthetic soil matrix (SSM) spiked with heavy metals (lead, cadmium, and chromium), organics (anthracene and dimethylphthalate), and simulated radionuclides (bismuth, strontium, and zirconium). Results from the demonstrations have been published in the Applications Analysis Report (EPA/520/AR-92/017) and Technology Evaluation Report, Volumes 1 and 2 (EPA/504/R-92/017A and EPA/540/R-92/017B); these documents are available from EPA.

DEMONSTRATION RESULTS:

Vitrified slag leachabilities for the heavy metals met EPA toxicity characteristic leaching procedure (TCLP) limits. TCLP leachabilities were 0.29 milligram per liter (mg/L) for lead, 0.12 mg/L for cadmium, and 0.30 mg/L for chromium. Almost 95 % of the noncombustible SSM was incorporated into the slag. Greater than 75% of the chromium, 88% of the strontium, and 97 % of the zirconium were captured in the slag. Dry weight volume was reduced 28%. Destruction and removal efficiencies for anthracene and dimethylphthalate were greater than 99.997% and 99.998%, respectively. Stack particulates were 0.001 grain per dry standard cubic foot (gr/dscf) at 7% oxygen, which was below the Resource Conservation Recovery Act limit of 0.08 gr/dscf effective until May 1993. Carbon monoxide and total hydrocarbons in the flue gas were 6.0 parts per million (ppm) and 8.3 ppm, respectively.

An independent cost analysis was performed as part of the SITE demonstration. The cost to remediate 20,000 tons of contaminated soil using a 3.3-ton-per-hour unit was estimated at \$465 per ton if the unit is on line 80 percent of the time, and \$529 per ton if the unit is on line 60 percent of the time.

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CALGON CARBON ADVANCED OXIDATION TECHNOLOGIES (formerly Vulcan Peroxidation Systems, Inc.) (perox-pure™ Chemical Oxidation Technology)

TECHNOLOGY DESCRIPTION:

The **perox-pure™** treatment system is designed to destroy dissolved organic contaminants in groundwater or wastewater with an advanced chemical oxidation process that uses ultraviolet (UV) radiation and hydrogen peroxide.

In the process, proprietary high-powered, medium-pressure lamps emit high-energy UV radiation through a quartz sleeve into the contaminated water. Hydrogen peroxide is added to the contaminated water and is activated by the UV light to form oxidizing species called hydroxyl radicals:



The hydroxyl radical then reacts with the dissolved contaminants, initiating a rapid cascade of oxidation reactions that ultimately fully oxidize (mineralize) the contaminants. The success of the process is based on the fact that the rate constants for the reaction of $\cdot\text{OH}$

radicals with most organic pollutants are very high. The hydroxyl radical typically reacts a million to a billion times faster than chemical oxidants such as ozone and hydrogen peroxide. In addition, many organic contaminants (e.g., PCE) undergo a change in their chemical structure by the direct absorption of UV light in the UV-C spectral range emitted by Calgon Carbon Corporation's proprietary medium-pressure UV lamps.

WASTE APPLICABILITY:

The **perox-pure™** technology treats groundwater and wastewater contaminated with chlorinated solvents, pesticides, polychlorinated biphenyls, phenolics, ethers, fuel hydrocarbons, and other organic compounds. It is effective on concentrations ranging from low parts per billion to several hundred parts per million (ppm). In certain instances, when used in conjunction with photocatalysts, it can be competitive for contaminated waters at concentrations of several thousand parts per million (ppm). In some cases, the



perox-pure™ Model SSB-30

combination of the **perox-pure™** technology with activated carbon, air stripping, or biological treatment will provide a more economical approach than would be obtained by using only one technology.

STATUS:

The **perox-pure™** technology was accepted into the SITE Demonstration Program in April 1991. A Model SSB-30 (see photograph on previous page) was demonstrated in September 1992 at the Lawrence Livermore National Laboratory Superfund site in Altamont Hills, California. The purpose of this demonstration was to measure how well the **perox-pure™** technology removed volatile organic compounds from contaminated groundwater at the site. The Demonstration Bulletin (EPA/540/MR-93/501), Technology Demonstration Summary (EPA/540/SR-93/501), Applications Analysis Report (EPA/540/AR-93/501), and Technology Evaluation Report (EPA/540/R-93/501) are available from EPA.

This technology has been successfully applied to over 250 sites throughout the United States, Canada, the Far East, and Europe. The treatment units at these sites have treated contaminated groundwater, industrial wastewater, contaminated drinking water, landfill leachates, and industrial reuse streams (process waters). Equipment treatment rates range from several gallons to several thousand gallons per minute.

DEMONSTRATION RESULTS:

Operating parameters for the treatment system were varied during the demonstration. Three reproducibility tests were performed at the optimum operating conditions, which were selected from the initial test runs.

In most cases, the **perox-pure™** technology reduced trichloroethene, tetrachloroethene, chloroform, trichloroethane, and dichloroethane to below analytical detection limits. For each organic contaminant, the **perox-pure™** technology complied with California action levels and federal drinking water maximum contaminant levels at the 95 percent confidence level. The quartz sleeve wipers effectively cleaned the sleeves and eliminated the interference caused by tube scaling.

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CF SYSTEMS CORPORATION

(Liquified Gas Solvent Extraction [LG-SX] Technology)

TECHNOLOGY DESCRIPTION:

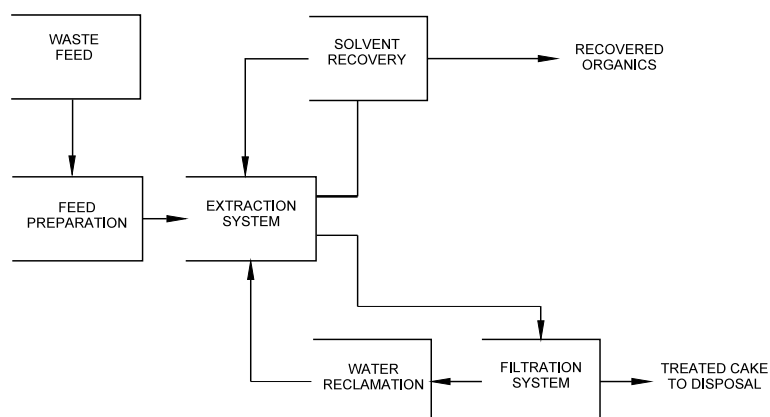
The CF Systems Corporation (CF Systems) liquified gas solvent extraction (LG-SX) technology uses liquified gas solvents to extract organics from soils, sludges, sediments, and wastewaters. Gases, when liquified under pressure, have unique physical properties that enhance their use as solvents. The low viscosities, densities, and surface tensions of these gases result in significantly higher rates of extraction compared to conventional liquid solvents. These enhanced physical properties also accelerate treated water's gravity settling rate following extraction. Due to their high volatility, gases are also easily recovered from the suspended solids matrix, minimizing solvent losses.

Liquified propane solvent is typically used to treat soils, sludges, and sediments, while liquified carbon dioxide is typically used to treat wastewater. The extraction system uses a batch extractor-decanter design for solids and sludges and a continuous trayed tower design for waste-waters and low-solids wastes.

Contaminated solids, slurries, or wastewaters are fed into the extraction system along with solvent (see figure below). After the solvent and organics are separated from the treated feed, the solvent and organic mixture passes to the solvent recovery system. Once in the solvent recovery system, the solvent is vaporized and recycled as fresh solvent. The organics are drawn off and either reused or disposed of. Treated feed is discharged from the extraction system as a slurry. The slurry is filtered and dewatered. The reclaimed water is recycled to the extraction system and the filter cake is sent for disposal or reused.

WASTE APPLICABILITY:

The LG-SX technology can be applied to soils and sludges containing volatile and semivolatile organic compounds and other higher boiling point complex organics, such as polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins, and pentachlorophenol (PCP). This process can also treat refinery wastes and wastewater contaminated with organics.



Liquified Gas Solvent Extraction (LG-SX) Technology

STATUS:

This technology was accepted into the SITE Demonstration Program in 1988. Under the SITE Program, a pilot-scale mobile demonstration unit was tested in September 1988 on PCB-laden sediments from the New Bedford Harbor Superfund site in Massachusetts. PCB concentrations in the harbor sediment ranged from 300 parts per million (ppm) to 2,500 ppm. The Technology Evaluation Report (EPA/540/5-90/002) and the Applications Analysis Report (EPA/540/A5-90/002) are available from EPA.

A pilot-scale treatability study was completed on PCB-contaminated soil from a Michigan Superfund site. Analytical data showed that the treatment reduced PCB levels to below 5 parts per million (ppm), representing a 98 percent removal efficiency for this waste. A Project Summary (EPA/540/SR-95/505), which details results from this work, is available from EPA.

CF Systems completed the first commercial on-site treatment operation at Star Enterprise in Port Arthur, Texas. The propane-based solvent extraction unit processed listed refinery K- and F-wastes, producing Resource Conservation and Recovery Act treated solids that met EPA land-ban requirements. The unit operated continuously from March 1991 to March 1992 and was on-line more than 90 percent of the time. Following heavy metals fixation, the treated solids were disposed of in a Class I landfill.

Effective mid-1998, Morrison Knudsen Corporation, owner of CF Environmental Corporation, has terminated research and development of the LG-SX program, and no longer actively markets the technology.

DEMONSTRATION RESULTS:

This technology was demonstrated concurrently with dredging studies managed by the U.S. Army Corps of Engineers. Contaminated sediments were treated by the LG-SX technology, using a liquified propane and butane mixture as the extraction solvent. The demonstration at the New Bedford site yielded the following results:

- Extraction efficiencies were 90 to 98 percent for sediments containing PCBs between 360 and 2,575 ppm. PCB concentrations were as low as 8 ppm in the treated sediment.
- Volatile and semivolatile organics in aqueous and semisolid wastes were extracted with 99.9 percent efficiency.
- Operating problems included solids retention in the system hardware and foaming in receiving tanks. The problems were corrected in the full-scale operations at Star Enterprise.
- Projected costs for PCB cleanup were estimated at \$150 to \$450 per ton, including material handling and pre- and posttreatment costs. These costs are highly dependent on the utilization factor and job size, which may result in lower costs for large cleanups.

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COGNIS, INC. (TERRAMET® Soil Remediation System)

TECHNOLOGY DESCRIPTION:

The COGNIS, Inc. (COGNIS), TERRAMET® soil remediation system leaches and recovers lead and other metals from contaminated soil, dust, sludge, or sediment. The system uses a patented aqueous leachant that is optimized through treatability tests for the soil and the target contaminant. The TERRAMET® system can treat most types of lead contamination, including metallic lead and lead salts and oxides. The lead compounds are often tightly bound by fine soil constituents such as clay, manganese and iron oxides, and humus.

The figure below illustrates the process. A pretreatment, physical separation stage may involve dry screening to remove gross oversized material. The soil can be separated into oversized (gravel), sand, and fine (silt, clay, and humus) fractions. Soil, including the oversized fraction, is first washed. Most lead contamination is typically associated with fines fraction, and this fraction is subjected to countercurrent leaching to dissolve the adsorbed lead and other heavy metal species. The sand fraction may also contain significant lead, especially if the contamination is due to particulate lead, such as that found in battery recycling, ammunition burning, and scrap yard activities. In this case, the sand fraction is pretreated to remove dense metallic or magnetic

materials before subjecting the sand fraction to countercurrent leaching. Sand and fines can be treated in separate parallel streams.

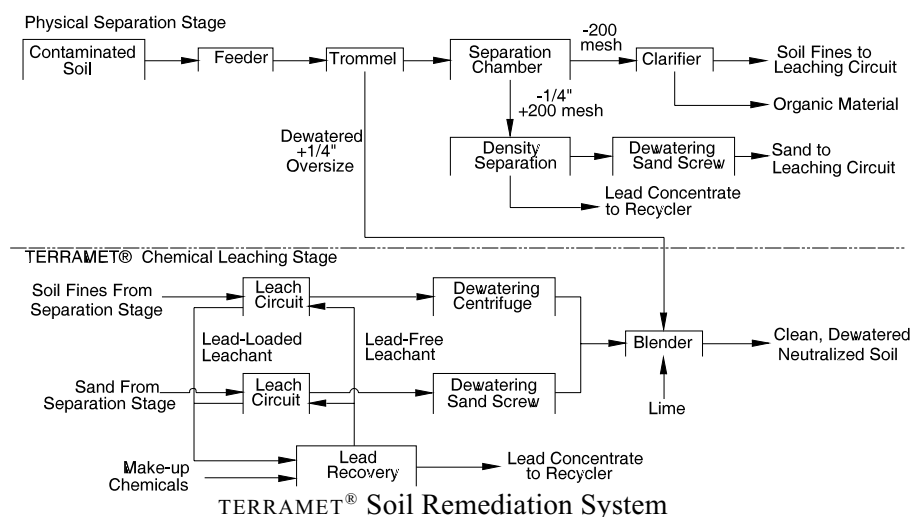
After dissolution of the lead and other heavy metal contaminants, the metal ions are recovered from the aqueous leachate by a metal recovery process such as reduction, liquid ion exchange, resin ion exchange, or precipitation. The metal recovery technique depends on the metals to be recovered and the leachant employed. In most cases, a patented reduction process is used so that the metals are recovered in a compact form suitable for recycling. After the metals are recovered, the leachant can be reused within the TERRAMET® system for continued leaching.

Important characteristics of the TERRAMET® leaching/recovery combination are as follows:

- (1) the leachant is tailored to the substrate and the contaminant;
- (2) the leachant is fully recycled within the treatment plant;
- (3) treated soil can be returned on site;
- (4) all soil fractions can be treated;
- (5) end products include treated soil and recycled metal;
- (6) no waste is generated during processing.

WASTE APPLICABILITY:

The COGNIS TERRAMET® soil remediation system can treat soil, sediment, and sludge contaminated by lead and other heavy metals or metal mixtures. Appropriate



sites include contaminated ammunition testing areas, firing ranges, battery recycling centers, scrap yards, metal plating shops, and chemical manufacturers. Certain lead compounds, such as lead sulfide, are not amenable to treatment because of their exceedingly low solubilities. The system can be modified to leach and recover other metals, such as cadmium, zinc, copper, and mercury, from soils.

STATUS:

This technology was accepted into the SITE Emerging Technology Program in August 1992. Based on results from the Emerging Technology Program, the technology was accepted into the SITE Demonstration Program in 1994. The demonstration took place at the Twin Cities Army Ammunition Plant (TCAAP) Site F during August 1994. The TERRAMET® system was evaluated during a full-scale remediation conducted by COGNIS at TCAAP. The full-scale system was linked with a soil washing process developed by Brice Environmental Services Corporation (BESCOP). The system treated soil at a rate of 12 to 15 tons per hour. A Demonstration Bulletin (EPA/540/MR-93/03) and Applications Analysis Report (EPA/540/AR-93-93/503) are available from the EPA.

The TERRAMET® system is now available through Doe Run, Inc. (see contact information below). For further information about the development of the system, contact the Dr. William Fristad (see contact information below).

DEMONSTRATION RESULTS:

Lead levels in the feed soil ranged from 380 to 1,800 milligrams per kilogram (mg/kg). Lead levels in untreated and treated fines ranged from 210 to 780 mg/kg and from 50 to 190 mg/kg, respectively. Average removal efficiencies for lead were about 75

percent. The TERRAMET® and BESCOP processes operated smoothly at a feed rate of 12 to 15 tons per hour. Size separation using the BESCOP process proved to be effective and reduced the lead load to the TERRAMET® leaching process by 39 to 63 percent. Leaching solution was recycled, and lead concentrates were delivered to a lead smelting facility. The cost of treating contaminated soil at the TCAAP site using the COGNIS and BESCOP processes is about \$200 per ton of treated soil, based on treatment of 10,000 tons of soil. This cost includes the cost of removing ordnance from the soil.

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COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

(Developed by Colorado School of Mines)
(Constructed Wetlands-Based Treatment)

TECHNOLOGY DESCRIPTION:

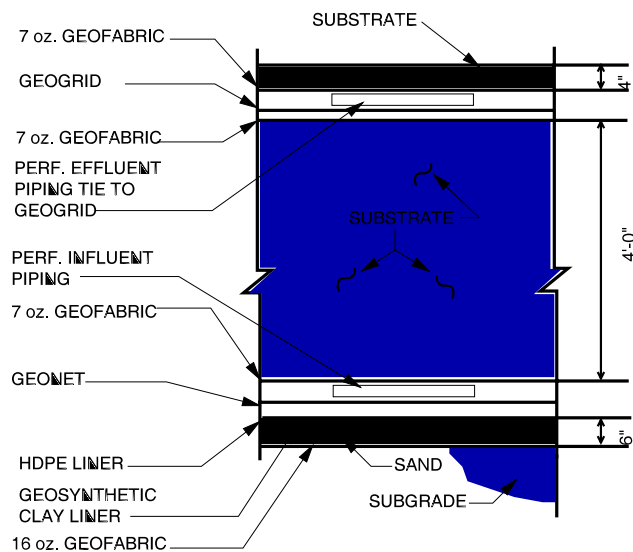
The constructed wetlands-based treatment technology uses natural geochemical and microbiological processes inherent in an artificial wetland ecosystem to accumulate and remove metals from influent waters. The treatment system incorporates principal ecosystem components found in wetlands, such as organic materials (substrate), microbial fauna, and algae.

Influent waters with high metal concentrations flow through the aerobic and anaerobic zones of the wetland ecosystem. Metals are removed by ion exchange, adsorption, absorption, and precipitation through geochemical and microbial oxidation and reduction. Ion Exchange occurs as metals in the water contact humic or other organic substances in the soil medium. Oxidation and reduction reactions that occur in the aerobic and anaerobic zones, respectively, precipitate metals as hydroxides and sulfides. Precipitated and absorbed metals settle in quiescent ponds or are filtered out as the water percolates through the soil or substrate.

The constructed wetlands-based treatment process is suitable for acid mine drainage from metal or coal mining activities. These wastes typically contain high concentrations of metals and low pH. Wetlands treatment has been applied with some success to wastewater in the eastern United States. The process may have to be adjusted to account for differences in geology, terrain, trace metal composition, and climate in the metal mining regions of the western United States.

STATUS:

Based on the results of test conducted during the SITE Emerging Technology Program (ETP), the constructed wetlands-based treatment process was selected for the SITE Demonstration Program in 1991. Results from the ETP test indicated an average removal rate of 50 percent for metals. For further information on the ETP evaluation, refer to the Emerging Technology Summary (EPA/540/R-93/523), or the Emerging Technology Bulletin (EPA/540/F-92/001), which are available from EPA.



Schematic Cross Section of Pilot-Scale Upflow Cell

DEMONSTRATION RESULTS:

Studies under the Demonstration Program evaluated process effectiveness, toxicity reduction, and biogeochemical processes at the Burleigh Tunnel, near Silver Plume, Colorado. Treatment of mine discharge from the Burleigh Tunnel is part of the remedy for the Clear Creek/Central City Superfund site. Construction of a pilots-scale treatment system began in summer 1993 and was completed in November 1993. The pilot-scale treatment system covered about 4,200 square feet and consisted of an upflow cell (see figure on previous page) and a downflow cell. Each cell treats about 7 gallons per minute of flow. Preliminary results indicated high removal efficiency (between 80 to 90 percent) for zinc, the primary contaminant in the discharge during summer operation. Zinc removal during the first winter of operation ranged from 60 to 80 percent.

Removal efficiency of dissolved zinc for the upflow cell between March and September remained above 90 percent; however, the removal efficiency between September and December 1994 declined to 84 percent due to the reduction in microbial activity in the winter months. The removal efficiency in the downflow cell dropped to 68 percent in the winter months and was between 70 to 80 percent during the summer months. The 1995 removal efficiency of dissolved zinc for the upflow cell declined from 84 percent to below 50 percent due to substrate hydrologic problems originating from attempts to insulate this unit during the summer months. A dramatic upset event in the spring of 1995 sent about four times the design flow through the upflow cell, along with a heavy zinc load.

The heavy zinc load was toxic to the upflow cell and it never recovered to previous performance levels. Since the upset event, removal efficiency remained at or near 50 percent.

The 1995 removal efficiency of the downflow cell declined from 80 percent during the summer months to 63 percent during winter, again a result of reduced microbial activity. The 1996 removal efficiency of dissolved zinc calculated for the downflow cell increased from a January low of 63 percent to over 95 percent from May through August. The increase in the downflow removal efficiency is related to reduced flow rates through the downflow substrate, translating to increased residence time.

The SITE demonstration was completed in mid-1998, and the cells were decommissioned in August 1998. An Innovative Technology Evaluation Report for the demonstration was to be available in 1999. Information on the technology can be obtained through below-listed sources.

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COMMODORE ADVANCED SCIENCES, INC. (Solvated Electron Technology, SET™ Remediation System)

TECHNOLOGY DESCRIPTION:

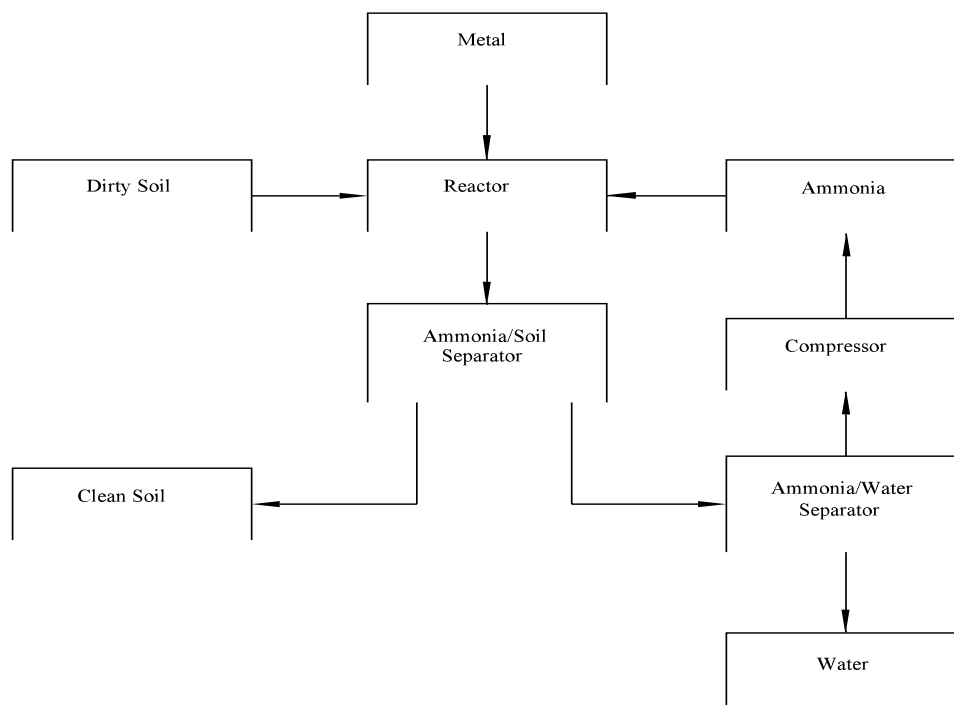
Commodore Applied Technologies, Inc.'s (Commodore), solvated electron technology (SET™) remediation system chemically reduces toxic contaminants such as polychlorinated biphenyls (PCB), pesticides, and other halogenated compounds into benign substances. The solvating system uses a solution of ammonia and an "active" metal to create a powerful reducing agent that can clean up contaminated soils, sediments, and liquids.

A solvated electron solution is a liquid homogeneous mixture that produces a large supply of free electrons. It can be created by combining liquid ammonia with a metal such as sodium, calcium, lithium, or potassium. When a solvated electron solution is mixed with a contaminated material, the free electrons in the solution chemically convert the contaminant to relatively harmless substances and salts.

The SET™ process consists of components to move and recover the ammonia (such as piping, pumps, and tanks), along with reactor vessels which hold the contaminated medium and the solvating solution. The system can be transported to different field sites, but the process is performed ex situ, meaning that the contaminated medium must be introduced into the reactor vessels.

The treatment process begins by placing the contaminated medium into the reactor vessels, where the medium is then mixed with ammonia.

One of the reactive metals (usually sodium) is then added to the contaminated medium-ammonia mixture, and a chemical reaction ensues. After the chemical reaction is complete (about 1 minute), the ammonia is removed to a discharge tank for reuse. The treated medium is then removed from the reactor vessels, tested for contamination, and returned to the site.



Schematic Diagram of the Solvated Electron Remediation System

WASTE APPLICABILITY:

Commodore claims that its solvating electron remediation system can effectively decontaminate soils, sludges, sediments, oils, hand tools, and personal protective clothing. The technology chemically transforms PCBs, pesticides, and other halogenated compounds into relatively benign salts. Commodore also believes that the technology is effective in treating chemical warfare agents and radionuclides.

STATUS:

Commodore was accepted into the SITE Demonstration Program in 1995 and is also participating in the Rapid Commercialization Initiative (RCI). RCI was created by the Department of Commerce, Department of Defense, Department of Energy, and EPA to assist in the integration of innovative technologies into the marketplace.

DEMONSTRATION RESULTS:

Commodore demonstrated the solvating system at the Construction Battalion Supply Center in Port Hueneme, California in September 1996. The demonstration was designed to evaluate the system's performance capability, costs, and design parameters. Results from the demonstration will be presented in an Innovative Technology Evaluation Report, which is available from EPA.

In October 1997, Commodore was awarded a contract to remediate mixed waste material at the U.S. Department of Energy site at Weldon Spring, Missouri using the SET™ technology.

A nationwide permit for the destruction of PCBs and metals in soils was issued for the SET™ process by the EPA in March, 1997.

This permit was amended in May 1998 to include the destruction of PCBs in oil.

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CURRENT ENVIRONMENTAL SOLUTIONS (Six-Phase Heating™ of TCE)

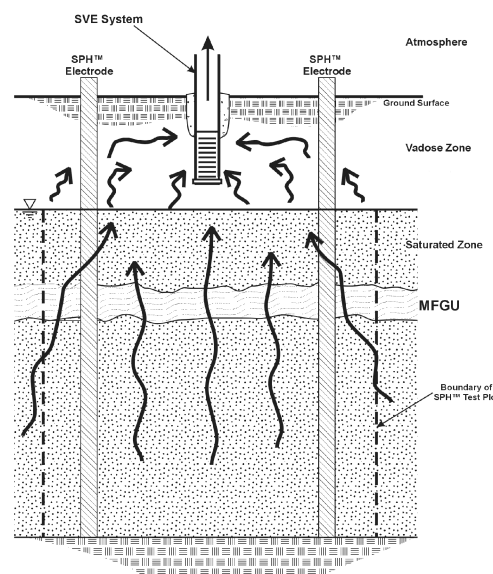
TECHNOLOGY DESCRIPTION:

Six-Phase Heating™ (SPH) is a thermally enhanced soil vapor extraction (SVE) technique that targets both contaminated soil and groundwater. The technology splits conventional three-phase electricity into six phases and delivers the electricity to the subsurface through metal electrodes. Once in the subsurface, the electrical energy resistively heats the soil and groundwater to generate steam. Direct volatilization and in situ steam stripping mobilize the contaminants present in the soil and groundwater. The volatilized contaminants are recovered by SVE, and treated before venting to the atmosphere. Contaminants are also destroyed in situ by means of hydrolysis, hydrous pyrolysis oxidation, and thermally accelerated biodegradation.

The ability of SPH to produce steam in situ in low permeability formations represents a significant advantage over other thermal technologies that are limited by hydraulic transport and conductive transfer to deliver heat to the subsurface. Instead, SPH creates steam within the soil pore structure itself, driving the contaminants towards the surface for collection and treatment.

This is important at heterogeneous sites like Cape Canaveral, where contaminants are trapped in the low-permeability clay and silt stringers in fine grain units. As these stringers are heated, internal steam formation drives contaminants into overlying permeable sands, overcoming diffusion-limited mass transfer and enabling rapid cleanup. When the required voltage was applied to the subsurface soils and groundwater, operating conditions were monitored and maintained within acceptable design limits. After startup, the system was monitored and controlled remotely. Routine visits were performed to collect data and perform system maintenance as required. Four to five weeks were required to heat the test plot to the boiling point of water. An additional seven to eight weeks were required to accomplish cleanup goals.

This technology is designed to treat DNAPL (dense nonaqueous phase liquid) contaminated soils and groundwater. At Cape Canaveral, trichloroethylene (TCE), cis-DCE, trans-DCE, and vinyl chloride in soil and groundwater were treated with SPH.



Conceptual Illustration of Resistive Heating Technology

STATUS:

Scientists and engineers at the Pacific Northwest National Laboratory (PNNL) developed and demonstrated the SPH technology in the early 1990s. In July 1997, Battelle Memorial Institute and Terra Vac Corporation formed a joint venture called Current Environmental Solutions, LLC (CES) to commercialize the SPH technology. SPH has been demonstrated on six occasions at government sites owned by the Department of Defense (DoD) and Department of Energy (DOE) during the past four years. SPH is now being commercially applied on a full-scale basis at a site impacted by chlorinated DNAPL underneath a building.

The Interagency DNAPL Consortium (IDC), recently formed by the DoD DOE and the Environmental Protection Agency (EPA), is tasked with identifying successful technologies for DNAPL remediation, in soils and groundwater, at corresponding government sites. In July of 1998, the IDC selected four in situ technologies for demonstration at an Air Force site in Cape Canaveral, Florida, that was impacted with chlorinated DNAPL. One of the selected technologies included SPH. The demonstration was completed in 2001 and the Application Analysis Report is available from the EPA.

DEMONSTRATION RESULTS:

The SPH technology, provided commercially by Current Environmental Solutions, was demonstrated at Launch Complex 34 at Cape Canaveral, Florida, as part of a multiple technology demonstration for the in situ remediation of DNAPL. The contaminant of concern was TCE, primarily residing as a separate phase along the surface of a clay aquitard at a depth of 45 ft. The demonstration was successful in that 97% of the DNAPL mass was removed, based on analysis of soil cores taken before and after the demonstration. However, the effect of SPH on dissolved-phase fractions of the contaminant could not be quantified because of large influxes of contaminated groundwater caused by tropical storms, and the nearby injection of nearly 2.7 pore volumes of an oxidant solution directly upgradient of the test area. Attempts to perform a total mass balance on the contaminants were similarly confounded.

Based on the production of elevated levels of chloride ion and other degradation by-products throughout the demonstration, decontamination took place as follows:

- 44 % was removed via the primary route, an in situ degradation pathway
- 19% was removed in the vapor phase by steam stripping
- Approximately 2% was mobilized to the surrounding aquifer during a single flooding event, caused by a tropical storm that occurred early in the demonstration

- The remaining 33% could not be accounted for, but is likely to have been degraded in situ
- Sampling wells and soil borings beyond the perimeter of the treatment area revealed a net decrease in contaminant levels, indicating that treatment extended beyond the boundaries of the test cell.
- The total cost of the SPH deployment was \$569K, including all costs for electricity, reporting, secondary waste treatment, equipment mobilization, and significant system modifications and repairs prompted by severe weather. Based on a treatment volume of 6,250 yd³ (4,780 m³), this corresponds to a total unit cost of \$91/yd³ (\$70/m³). Of this, the net cost for SPH implementation (design, installation, operations, demobilization) was \$65/yd³ (\$50/m³), and the cost of electricity was \$12/yd³ (\$9/m³).

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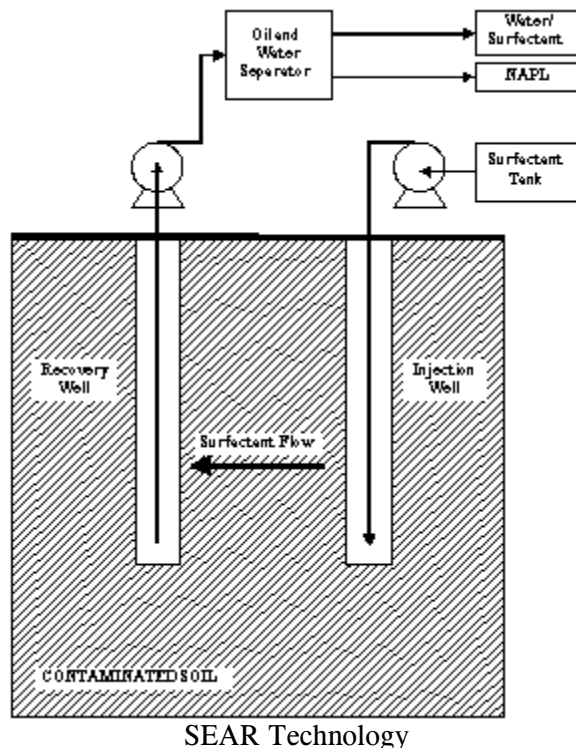
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DUKE ENGINEERING AND SERVICES, INC. (Surfactant Enhanced Aquifer Remediation of Nonaqueous Phase Liquids)

TECHNOLOGY DESCRIPTION:

Surfactant enhanced aquifer remediation (SEAR) technology greatly enhances the removal of residual nonaqueous phase liquids (NAPL) from the subsurface by increasing the solubility of the NAPL and lowering the interfacial tension between the NAPL and aqueous surfactant solution. Increasing the solubility of the NAPL with surfactants substantially enhances the removal of the NAPL mass through pumping. Lowering the interfacial tension between the NAPL and the aqueous surfactant solution reduces the capillary forces that trap the NAPL in the pore spaces of the aquifer. Under certain conditions, the interfacial tension can be lowered sufficiently to drain NAPL from the pore spaces thereby forming an oil bank in the subsurface, which is then recovered at extraction wells.

Before SEAR technology can be implemented, site specific characteristics must be determined. Normal aquifer properties such as stratigraphy, grain size distribution, mineralogy, hydraulic conductivity, vertical and horizontal gradients, depth to ground water, etc., are determined. In addition, a fundamental understanding of the NAPL composition, distribution, and quantity in the subsurface is required. Knowledge of the quantity of NAPL present prior to using SEAR prevents either under- or over-designing the surfactant flood. Laboratory experiments using soil core, contaminant, groundwater, and source water from the site are conducted to determine the optimum surfactant solution mix. A geosystem model is then developed which incorporates all the data gathered. Simulations are run to determine optimum injection and extraction well placement, percent recoveries of the compounds injected, contaminant concentration levels in the effluent, percent removal of the contaminant mass, and all other pertinent results of the surfactant flood.



Once the surfactant flood has been fully designed, the surfactant solution is injected into the contaminated zone in the subsurface through one or more wells. The surfactant is drawn through the subsurface by pumping at surrounding extraction wells. As the surfactant moves through the subsurface it solubilizes or, if the design calls for it, mobilizes the NAPL for recovery at the extraction wells. The recovered groundwater and NAPL are then typically sent to a phase separator. The recovered NAPL is either disposed of or recycled, and the groundwater and surfactant is treated. For large scale projects, recovery and reuse of the surfactant from the effluent stream is economical.

WASTE APPLICABILITY:

SEAR technology is applicable for the rapid removal of residual phase NAPL in the subsurface. Although it does not directly remediate the dissolved phase plume, removal of the source zone contamination can greatly reduce long term liability and risk. SEAR technology can be effective for the removal of a broad range of organic contaminants. This technology may not be suitable for sites with low hydraulic permeabilities (10^{-5} cm/sec or less).

DEMONSTRATION RESULTS:

A demonstration of SEAR to remove a high viscosity hydrocarbon (Navy Special Fuel Oil [NSFO]) was completed at Mullican Field, Pearl Harbor, HI. The hydrocarbon was successfully mobilized using a custom-designed surfactant and heating. The surfactant solution to 60°C.

SEAR technology has been successfully demonstrated with three separate surfactant floods at a U.S. Air Force base containing chlorinated solvent contamination in an alluvial aquifer.

STATUS:

SEAR technology was accepted into the Superfund Innovative Technology Evaluation (SITE) Demonstration program in 1997.

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DYNAPHORE, INC. (FORAGER® Sponge)

TECHNOLOGY DESCRIPTION:

The FORAGER® Sponge (Sponge) is an open-celled cellulose sponge containing a polymer with selective affinity for dissolved heavy metals in both cationic and anionic states. The polymer contains iminodiacetic acid groups which enter into chelation bonding with transition-group heavy metal cations. The polymer's affinity for particular cations is influenced by solution parameters such as pH, temperature, and total ionic content. In general, the following affinity sequence for several representative ions prevails:

$Cd^{++} > Cu^{++} > Hg^{++} > Pb^{++} > Au^{+++} > Zn^{++} > Fe^{+++} > Ni^{++} > Co^{++} > Al^{+++} > Ca^{++} > Mg^{++} > Na^{+}$

During absorption, a cation is displaced from the polymer. The displaced cation may be H^{+} or a cation below the absorbed cation in the affinity sequence.

The polymer also contains tertiary amine salt groups which exhibit selective bonding for anion species such as the following:

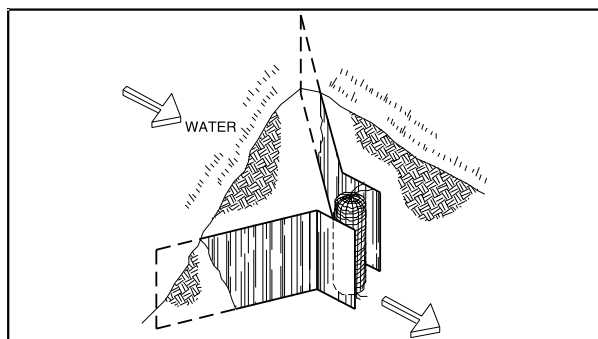
$CrO_4^{-2}, AsO_4^{-3}, Au(CN)_2^{-}, SeO_4^{-2}, HgCl_3^{-}, Ag(S_2O_3)^{-3}, SiO_3^{-2}, UO_4^{-2}$

The absorption of certain anion species can be enhanced by preabsorption of a cation that ordinarily reacts with a sought anion to produce a highly insoluble compound. For example, a Sponge presaturated with Fe^{+3} strongly absorbs arsenate anion because ferric arsenate is highly insoluble.

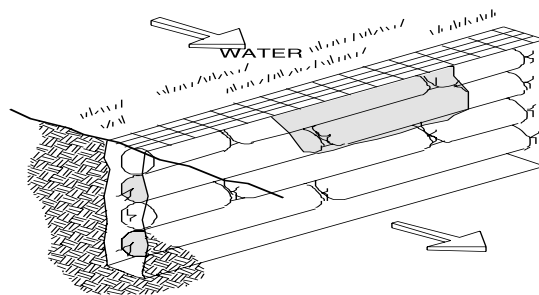
The removal efficiency for transition-group heavy metals is about 90 percent at a flow rate of 0.1 bed volume per minute. The Sponge's highly porous nature speeds diffusional effects, promoting high rates of ion absorption. The Sponge can be used in columns, fishnet-type enclosures, or rotating drums. When used in a column, flow rates of three bed volumes per minute can be obtained at hydrostatic pressures only 2 feet above the bed and without additional pressurization. Therefore, Sponge-packed columns are suitable for unattended field use.

Absorbed ions can be eluted from the Sponge using techniques typically employed to regenerate ion-exchange resins and activated carbon. Following elution, the Sponge can be used in the next absorption cycle. The number of useful cycles depends on the nature of the absorbed ions and the elution technique used. Alternatively, the metal-saturated Sponge can be incinerated. In some instances, the Sponge may be dried and reduced in volume to facilitate disposal.

A trailer-mounted pump-and-treat apparatus can handle up to 10 gallons per minute with low pumping pressures of 4 to 10 pounds per square inch. The apparatus employs four or six Plexiglas columns, connected in series, with valving to expedite regeneration and staging. Each column accommodates a fishnet container of Sponge in the form of half-inch cubes. Groundwater can be remediated in situ using elongated fishnet bags that confine the Sponge. The bags are placed vertically in wells, as shown in the figure to the left, or placed horizontally in trenches, as shown in the figure on the



Fishnet Bags Placed Vertically in a Well



Fishnet Bags Placed
Horizontally in a Trench

next page. Alternatively, the groundwater can be treated aboveground in a packed column configuration.

The Sponge can scavenge metals in concentration levels of parts per million and parts per billion from industrial discharges, municipal sewage, process streams, and acid mine drainage. The Sponge is particularly useful when treating water with low contaminant levels, especially in polishing or end-of-pipe treatments. Because of the low capital investment required, the Sponge is well-suited for use in short-term remediation projects and for sporadic flow conditions.

This technology was accepted into the SITE Demonstration Program in June 1991. The Sponge was demonstrated in April 1994 at the National Lead Industry site in Pedricktown, New Jersey. The Demonstration Bulletin (EPA/540/MR-94/522), Technology Capsule (EPA/540/R-94/522a), and Innovative Technology Evaluation Report(EPA/540/R-94/522) are available from EPA.

Analyte	Average Influent Concentration (µg/L)	Percent Removal
Cadmium	537	90
Copper	917	97
Lead	578	97
Chromium ^{III}	426	32

According to the developer, the Sponge has also effectively removed trace heavy metals from acid mine drainage at three locations in Colorado. In bench-scale tests, the Sponge reduced mercury, lead, nickel, cadmium, and chromium in groundwater from various Superfund sites to below detectable levels. The Sponge was also demonstrated in a field-scale installation at a photoprocessing operation. The process reduced chromate and silver by 75 percent at a cost of \$1,100 per month. In bench-scale tests, the Sponge has removed lead, mercury, and copper from pourable sludges such as simulated municipal sewage, and from soils slurried with water.

DEMONSTRATION RESULTS:

Treatment performance from the SITE demonstration was as follows:

In 1996, the Sponge, configured in a column, was employed in a pump-and-treat remediation of 360,000 gallons of water that had accumulated as a result of a fuel handling operation. The water, containing 0.2 parts per million (ppm) arsenic, was treated at 12 gallons per minute (0.1 bed volume per minute) to produce an effluent having a nondetect level of arsenic.

According to the developer, a newly developed modification of the Sponge (designated Grade 0) has proven effective in removing methyl-*tert*-butyl ether (MTBE) from groundwater and in removing dense non-aqueous phase liquids (DNAPL) from stormwater. The sponge is currently being used in passive, end-of-pipe installations to remove nickel from electroplating effluents.

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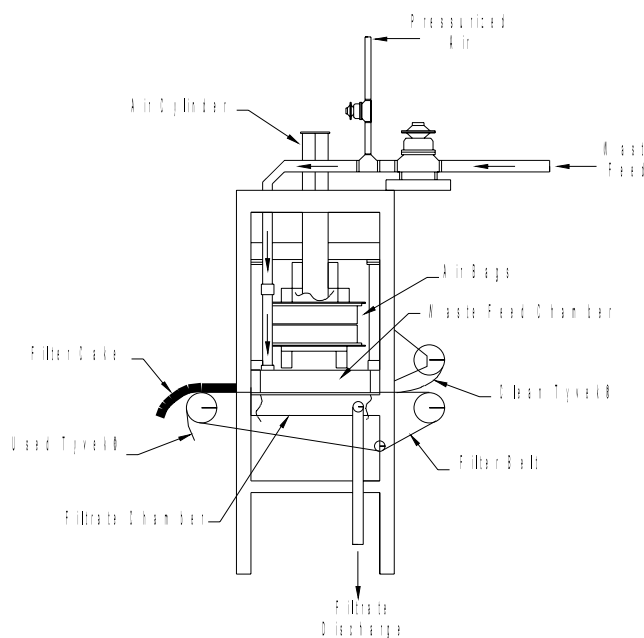
E.I. DUPONT DE NEMOURS AND COMPANY, and OBERLIN FILTER COMPANY (Membrane Microfiltration)

TECHNOLOGY DESCRIPTION:

This membrane microfiltration system is designed to remove solid particles from liquid wastes, forming filter cakes typically ranging from 40 to 60 percent solids. The system can be manufactured as an enclosed unit, requires little or no attention during operation, is mobile, and can be trailer-mounted.

The membrane microfiltration system uses an automatic pressure filter (developed by Oberlin Filter Company), combined with a special Tyvek® filter material (Tyvek® T-980) made of spun-bonded olefin (invented by E.I. DuPont de Nemours and Company) (see figure below). The filter material is a thin, durable plastic fabric with tiny openings about 1 ten-millionth of a meter in diameter. These openings allow water or other liquids and solid particles smaller than the openings to flow through. Solids in the liquid stream that are too large to pass through the openings accumulate on the filter and can be easily collected for disposal.

The automatic pressure filter has two chambers: an upper chamber for feeding waste through the filter, and a lower chamber for collecting the filtered liquid (filtrate). At the start of a filter cycle, the upper chamber is lowered to form a liquid-tight seal against the filter. The waste feed is then pumped into the upper chamber and through the filter. Filtered solids accumulate on the Tyvek® surface, forming a filter cake, while filtrate collects in the lower chamber. Following filtration, air is fed into the upper chamber at a pressure of about 45 pounds per square inch. Air removes any liquid remaining in the upper chamber and further dries the filter cake. When the filter cake is dry, the upper chamber is lifted, and the filter cake is automatically discharged. Clean filter material is then drawn from a roll into the system for the next cycle. Both the filter cake and the filtrate can be collected and treated further before disposal, if necessary.



Membrane Microfiltration System

WASTE APPLICABILITY:

This membrane microfiltration system may be applied to (1) hazardous waste suspensions, particularly liquid heavy metal- and cyanide bearing wastes (such as electroplating rinsewaters), (2) groundwater contaminated with heavy metals, (3) constituents in landfill leachate, and (4) process wastewaters containing uranium. The technology is best suited for treating wastes with solids concentrations of less than 5,000 parts per million; otherwise, the cake capacity and handling become limiting factors. The system can treat any type of solids, including inorganics, organics, and oily wastes, with a wide variety of particle sizes. Moreover, because the system is enclosed, it can treat liquid wastes that contain volatile organics.

STATUS:

The membrane microfiltration system, accepted into the SITE Demonstration Program in 1988, was demonstrated at the Palmerton Zinc Superfund site in Palmerton, Pennsylvania. The demonstration was conducted over a 4-week period in April and May 1990. Groundwater from the shallow aquifer at the site was contaminated with dissolved heavy metals, including cadmium, lead, and zinc. This contaminated groundwater served as the feed waste for the demonstration. The system treated waste at a rate of about 1 to 2 gallons per minute.

The Applications Analysis Report (EPA/540/A5-90/007), the Technology Evaluation Report (EPA/540/5-90/007), and a videotape of the demonstration are available from EPA.

Since 1991, about 12 commercial installations of the technology have been operational.

DEMONSTRATION RESULTS:

During the demonstration at the Palmerton Zinc Superfund site, the membrane microfiltration system achieved the following results:

- Removal efficiencies for zinc and total suspended solids ranged from 99.75 to 99.99 percent (averaging 99.95 percent).
- Solids in the filter cake ranged from 30.5 to 47.1 percent.
- Dry filter cake in all test runs passed the Resource Conservation and Recovery Act paint filter liquids test.
- Filtrate met the applicable National Pollutant Discharge Elimination System standards for cadmium, lead, zinc, and total suspended solids.
- A composite filter cake sample passed the extraction procedure toxicity and toxicity characteristic leaching procedure tests for metals.

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E&C Williams, Inc.
(Calcium Sulfide and Calcium Polysulfide Technologies)

**TECHNOLOGY DESCRIPTION:**

Enthral[®] (CaS) is an inorganic, nonhazardous sulfide compound developed by E&C Williams, Inc., for the treatment of metals and cyanide compounds in various media. Enthral[®] is manufactured as powder, liquid, and granulated solid to provide the widest range of applications and uses.

The primary active ingredient in Enthral[®] is calcium sulfide which reacts with metals to form a metal sulfide. This form of a metal is insoluble under the test conditions imposed by the Toxicity Characteristic Leaching Procedure (TCLP; which simulates the acidic conditions found in most landfills), the Multiple Extraction Procedure (MEP; which simulates approximately 1,000 years of acidic leaching), and the Synthetic Products Leaching Procedure (SPLP; more aggressive than the TCLP). Enthral[®] has an inherently high reaction efficiency, requiring much less product than others.

The powder and liquid forms present enormous potential for soil remediation products for both in situ and ex situ. Enthral[®] is effective over entire range of regulated metals. Its reaction time is nearly instantaneous, allowing for immediate sampling and testing. Stabilized waste is truly stable – it is not subject to leaching at a later date under acidic conditions.

Calcium polysulfide (CaS_x), while derived from different raw materials, shares many characteristics with calcium sulfide. It is effective over the entire range of regulated metals and reacts with metals to form metal sulfides as quickly as contact is achieved. Both are single-phase additives requiring no other compound to completely stabilize metals.

WASTE APPLICABILITY:

Both technologies are suitable for stabilizing metals in a wide variety of media and physical states. Upon exposure to acidic conditions, some hydrogen sulfide gas may be generated. Both sulfide technologies can be formulated to a high alkalinity range to offset the effects of gassing.

STATUS:

The calcium sulfide technology was accepted into the SITE Demonstration Program in November 2000. Enthral[®] was used as the active ingredient on a SITE demonstration at treating mine tailings containing mercury. The setup consisted of treating columns of material from a site mining facility in Butte, Montana. Enthral[®] was used to treat the assigned column(s) and the columns were then subjected to a twelve-week leaching procedure. The results of this study are in the process of final evaluation and will be published in 2002.

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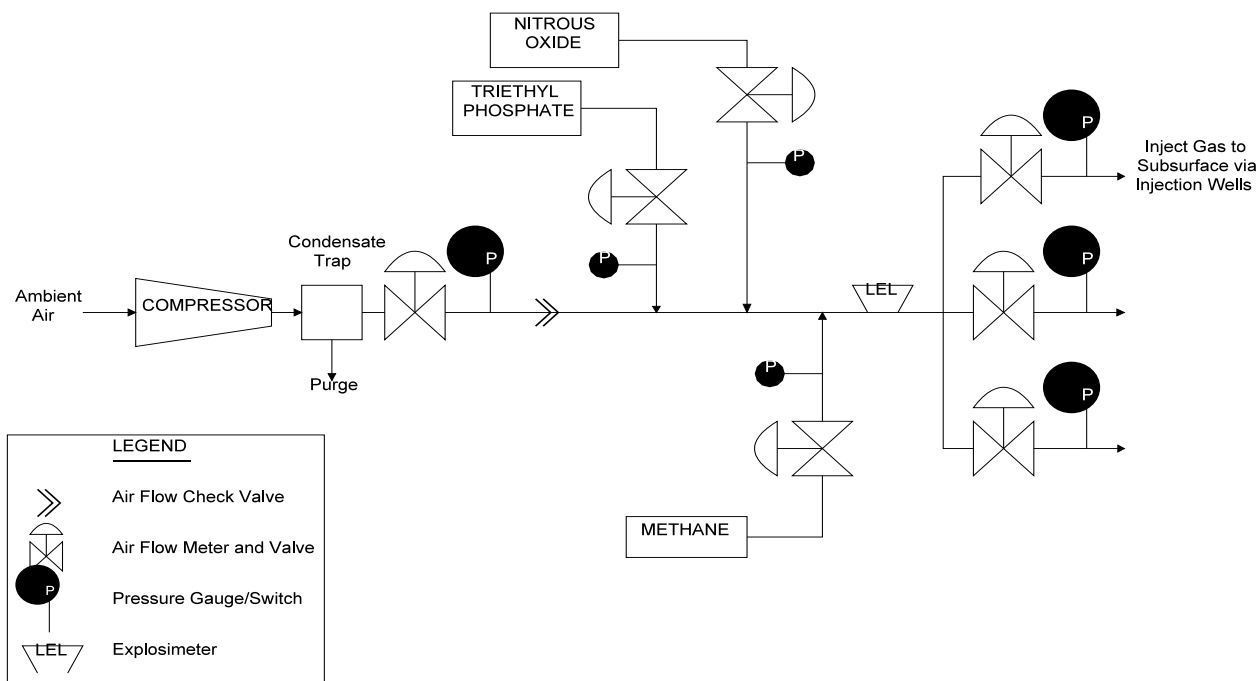
EARTH TECH/WESTINGHOUSE SAVANNAH RIVER COMPANY (Enhanced In Situ Bioremediation of Chlorinated Compounds in Groundwater)

TECHNOLOGY DESCRIPTION:

ITT Night Vision is conducting in situ enhanced aerobic bioremediation of contaminated groundwater in fractured bedrock utilizing technologies developed at the U.S. Department of Energy Savannah River Site and licensed to Earth Tech, Inc. This project currently involves remediation of groundwater in the vicinity of one contaminant source area as a pilot-scale operation, with the possibility of applying the technology elsewhere on site. Contaminants of concern in on-site groundwater include chlorinated solvents and their daughter products, plus acetone and isopropanol. To accelerate the intrinsic (natural) biodegradation observed at the site, the selected remedy involves the subsurface injection of air, gaseous-phase nutrients (triethyl phosphate and nitrous oxide), and methane. The amendments are being added to stimulate existing microbial populations (particularly methanotrophs) so that they can more aggressively break down the contaminants of concern. Amendment delivery to the

is accomplished through an injection well, and the injection zone of influence is confirmed using surrounding groundwater monitoring wells and soil vapor monitoring points.

The patented PHOSter™ process for injection of triethyl phosphate in a gaseous phase was licensed for use at this site as an integral element of the enhanced bioremediation operation. This technology maximizes the subsurface zone of influence of nutrient injection as compared to technologies injecting nutrients in liquid or slurry form. Monitoring of contaminant (and breakdown product) concentrations in groundwater and soil vapor, measurement of microbiological population density and diversity, and monitoring of nutrient concentrations and groundwater geochemical parameters provides feedback on system effectiveness. This in turn allows adjustments to be made in the sequencing and rate of delivery of air, nutrients, and methane in response to changing subsurface conditions.



WASTE APPLICABILITY:

This enhanced bioremediation technology breaks down volatile organic compounds in groundwater. Compounds which are amenable to intrinsic (natural) biodegradation can be degraded more rapidly when the subsurface microbial populations are stimulated through the injection of air, gaseous-phase nutrients, and methane. By providing an aerobic environment for contaminant degradation, harmless breakdown products are produced and toxic daughter products of anaerobic degradation of chlorinated solvents (such as vinyl chloride) can be broken down completely. This in-situ technology is especially applicable in situation where subsurface infrastructure (for example, networks of utilities) limit or preclude excavation or extraction technologies.

STATUS:

The enhanced bioremediation system, currently being used in the ongoing RCRA corrective action interim measure at the ITT Night Vision facility, was accepted into the SITE program in 1997, with system start up occurring in March of 1998. The technology had previously been approved by EPA Region 3 as an Interim Measure part of the facility's ongoing RCRA Corrective Action program.

SITE program participants collected groundwater quality and microbiological data prior to system start up (baseline monitoring), between the air and nutrient injection campaigns (interim monitoring), and after 16 months of operation (final monitoring).

DEMONSTRATION RESULTS:

Baseline monitoring established a statistical reference point for contaminants of concern in groundwater. Interim monitoring suggests that the initial injection campaigns have successfully stimulated the growth of native microbial populations based upon the results of phospholipid fatty acid assays and methanotroph most probable number plate counts. Corresponding decreases in concentrations of contaminants of concern have also been discernible.

Final monitoring indicated that the average percent reduction, based on 28 baseline and 28 final samples were as follows:

- Chloroethane - 36%
- 1,1-Dichloroethane - 80%
- *cis*-1,2-Dichloroethene - 97%
- Vinyl chloride - 96%

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EARTHSOFT (EQuIS Software)

TECHNOLOGY DESCRIPTION:

The EQuIS software is designed as an advanced environmental data management and analysis platform for monitoring and remediation projects. The EQuIS applications provide a data warehouse where environmental data can be entered and reviewed, and then exported to a variety of industry standard tools.

The EQuIS system contains the following components:

EQuIS Chemistry:

Electronic Lab Data Checker

EQuIS CrossTab Report Writer

EQuIS Data Verification Module

CARStat

EQuIS Geology:

LogPlot, RockWorks, GMS, EVS

EQuIS ArcView GIS Interface

EVS, GMS, & ESRI's 3D Analyst

A brief description of each software module is presented in the following paragraphs.

EQuIS Chemistry manages sampling information and analytical data generated in the field or by commercial laboratories. EQuIS Chemistry offers an interface and relational database to organize chemical field and lab data, as well as interfaces to numerous statistical analyses, reporting and visualization packages. Chemistry QA/QC data is also managed to support advanced remediation projects. Referential and relational integrity is enforced resulting in high quality data. Electronic Lab Data Checker (ELDC) allows users to check electronic deliverables for format accuracy using default or user-defined formats. The ELDC can trap out many errors of consistency and completeness. EQuIS CrossTab Report Writer allows users to create complex cross tab reports using data from existing EQuIS Chemistry project databases. EQuIS Data Verification Module (DVM) provides data and review and validation in accordance with EPA programs, as well as analytical program

requirements from other agencies. The DVM produces extensive validation reports and provides a suggested qualifying flag that can be written back to the database. CARStat eliminates unnecessary site assessments and remediation due to misapplication of statistical methods or simple comparison of measurements to regulatory standards. Site-wide false positive and negative rates are directly computed via Monte Carlo simulations.

EQuIS Geology manages geological and geotechnical information. EQuIS Geology facilitates rapid modeling, calibration and analysis using any of several standard commercial borehole logging, groundwater modeling and solid contouring and reporting techniques. EQuIS Arc View GIS Interface encapsulates EQuIS and allows users to query and view EQuIS Chemistry and Geology data inside of ArcView GIS. Many basic and even advanced operations such as creating borehole logs, CrossTab reports, and solid models can be done in only a few keystrokes.

STATUS:

The objective of the SITE Demonstration Program is to develop reliable engineering performance and cost data innovative alternative technologies so that potential users can evaluate the applicability of each technology for a specific site. This demonstration is being performed on environmental data management software and is carried out with data from hazardous waste sites in New Jersey.

In a software evaluation, select data set(s) will be utilized to evaluate capabilities of the software. The procedures used to evaluate the software performance and to document project activities will be critical to this analysis.

In consultation with the EQuIS vendor, seven primary modules will be tested in this evaluation. These are: EQuIS Chemistry, ELDC, EQuIS CrossTab Report Writer, DVM, CARStat, EQuIS Geology, and the EQuIS ArcView GIS Interface. The EPA will publish the technology evaluation results in Summer 2002.

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EcoMat, Inc.

(Biological Denitrification Process)

TECHNOLOGY DESCRIPTION:

EcoMat has developed and patented a continuously circulating reactor that contains fixed film biocarriers that are retained within the system, thereby minimizing solids carryover. Fixed film treatment allows rapid and compact treatment of nitrate with minimal by-products. Methanol is added as a source of carbon for the metabolic processes that remove free oxygen, to encourage the bacteria to consume nitrate instead, and as a source of carbon for cell growth.

The EcoLink membrane media consists of a polyurethane-based sponge that is cut into 1-cm cubes. The media last for a long time – up to several years. The size of the interstitial spaces within the sponge is designed to permit passage of gas, as well as passage of water into these spaces. The surface area involved is sufficiently great to provide for high bacteria concentrations and high interaction efficiency.

The mechanism for anoxic biodegradation of nitrate consists of initial removal of dissolved oxygen followed by the total removal of oxygen from the nitrate. In the first step, available oxygen must be consumed to a dissolved oxygen concentration of <1 mg/L so that the bacteria are forced to substitute the nitrate as the electron acceptor. The nitrate is first reduced to nitrite and then further reduced to nitrogen gas.

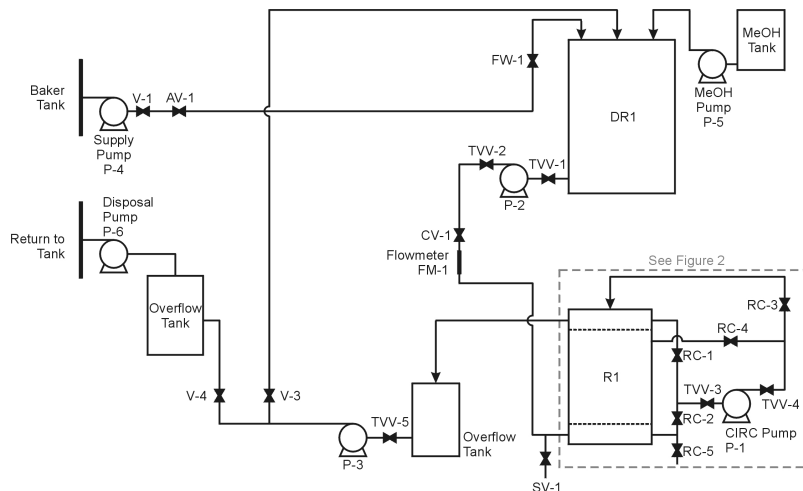
The effluent from the denitrification system will contain small amounts of bacteria and suspended solids, which must be removed by a posttreatment system. EcoMat can incorporate an oxidation component (ozonation and/or ultraviolet disinfection) into its posttreatment system to accomplish some degree of chlorinated hydrocarbon destruction as well as oxidation of any residual nitrite to nitrate, oxidation of any residual methanol, and destruction of bacterial matter. A filtration component can also be incorporated into the posttreatment system to remove suspended solids.

Design of the treatment process/system for a particular site requires the characterization of the water source that will be fed to the system in terms of contaminants present, variability in waste characteristics.

WASTE APPLICABILITY:

This technology is suitable for any water-based contaminant remediation which permits the proliferation of the lives of the various hardy bacteria which consume the oxygen and methanol.

The technology has been applied to nitrate within seawater (in commercial aquariums). It has also been applied to industrial waste. Another potential application is for remediation of sites subject to eutrophication. The system has been demonstrated to remediate perchlorate, after the dissolved oxygen and nitrate have been removed. A relatively minor modification of the reactor permits remediation of both MTBE and ethylene glycol.



EcoMat Perchlorate Removal System

STATUS:

The technology evaluation under the SITE program was conducted between May and December of 1999, and the results have been analyzed (see Technology Evaluation Report, May 2001 draft).

DEMONSTRATION RESULTS:

The demonstration site was the location of a former public water supply well in Bendena, Kansas. The well water is contaminated with high levels of nitrate, with concentrations ranging from 20 to 130 ppm of nitrate (N). The results of the testing program showed that EcoMat successfully removed the nitrate, although the posttreatment systems applied were not always successful in reducing the nitrite sufficiently or in filtering the exiting bacteria and suspended solids. This relatively straightforward work remains to be done before the system is approved for drinking water application.

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ECOVA CORPORATION

(Bioslurry Reactor)

TECHNOLOGY DESCRIPTION:

The ECOVA Corporation (ECOVA) slurry-phase bioremediation (bioslurry) technology aerobically biodegrades creosote-contaminated materials. The technology uses batch and continuous flow bioreactors to process polynuclear aromatic hydrocarbon (PAH)-contaminated soils, sediments, and sludges. The bioreactors are supplemented with oxygen, nutrients, and a specific inoculum of enriched indigenous microorganisms to enhance the degradation process.

Because site-specific environments influence biological treatment, all chemical, physical, and microbial factors are designed into the treatment process. The ultimate goal is to convert organic wastes into relatively harmless by-products of microbial metabolism, such as carbon dioxide, water, and inorganic salts. Biological reaction rates are accelerated in a slurry system because of the increased contact efficiency between contaminants and microorganisms. The photograph below shows the bioslurry reactor.



Bioslurry Reactor

WASTE APPLICABILITY:

The bioslurry reactor is designed to treat highly contaminated creosote wastes. It can also treat other concentrated contaminants that can be aerobically biodegraded, such as petroleum wastes. The bioslurry reactor system must be engineered to maintain parameters such as pH, temperature, and dissolved oxygen within ranges conducive to the desired microbial activity.

STATUS:

This technology was accepted into the SITE Demonstration Program in spring 1991. From May through September 1991, EPA conducted a SITE demonstration using six bioslurry reactors at EPA's Test and Evaluation Facility in Cincinnati, Ohio.

ECOVA conducted bench- and pilot-scale studies to evaluate bioremediation of PAHs in creosote-contaminated soil from the Burlington Northern Superfund site in Brainerd, Minnesota. Bench-scale studies were conducted before pilot-scale evaluations to determine optimal treatment protocols. EIMCO Biolift™ slurry reactors were used for the pilot-scale processing. Data from the optimized pilot-scale program were used to establish treatment standards for K001 wastes as part of EPA's Best Demonstrated Available Technology program.

This technology is no longer available through ECOVA. However, the technology is being implemented by Walsh Environmental Scientists & Engineers. For further information on the technology, contact the EPA Project Manager.

DEMONSTRATION RESULTS:

Results from the SITE demonstration indicated that slurry-phase biological treatment significantly improved biodegradation rates of carcinogenic 4- to 6-ring PAHs. The pilot-scale bioslurry reactor reduced 82 ± 15 percent of the total soil-bound PAHs in the first week. After 14 days, total PAHs had been biodegraded by 96 ± 2 percent. An overall reduction of 97 ± 2 percent was observed over a 12-week treatment period, indicating that almost all biodegradation occurred within the first 2 weeks of treatment. Carcinogenic PAHs were biodegraded by 90 ± 3.2 percent to 501 ± 103 milligrams per kilogram (mg/kg) from levels of $5,081 \pm 1,530$ mg/kg.

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EDENSPACE, INC.
(formerly Phytotech)
(Phytoremediation Technology)

TECHNOLOGY DESCRIPTION:

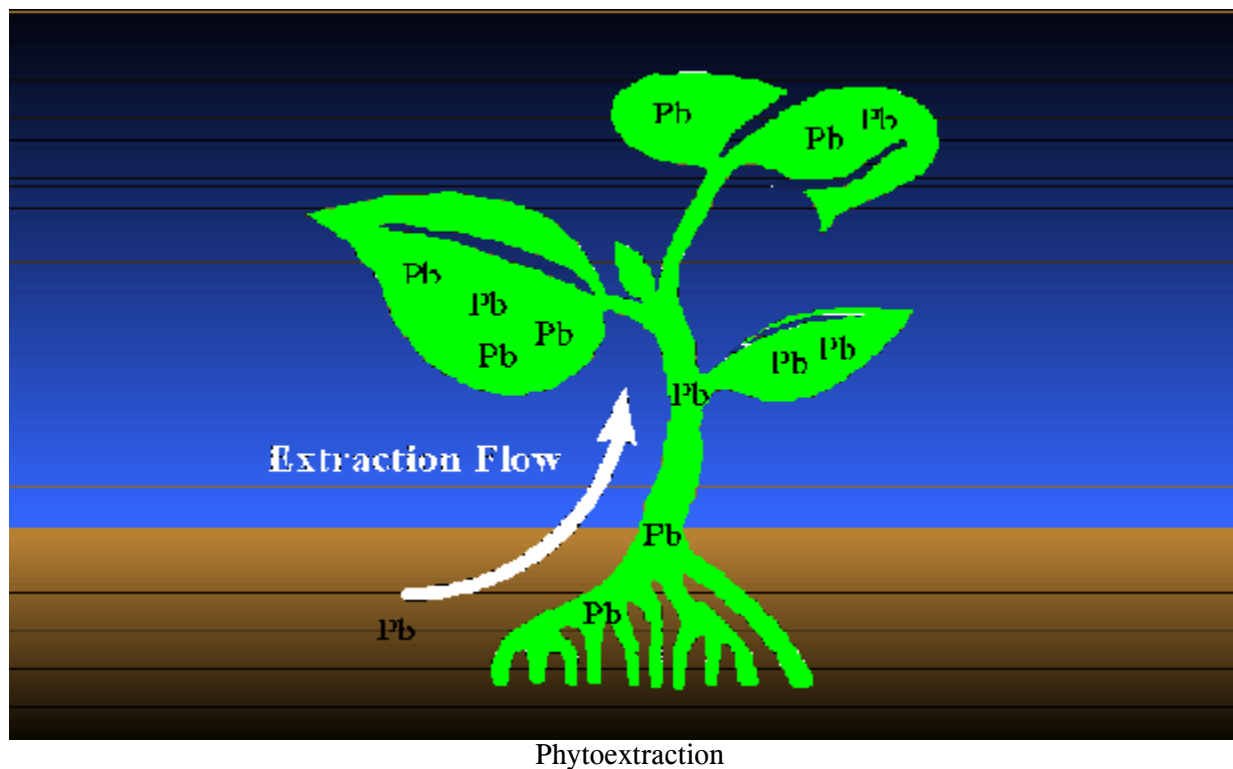
Phytotech is an environmental biotechnology company that uses specially selected and engineered plants to treat soil and water contaminated with toxic metals such as lead and cadmium, as well as radionuclides. The treatment of soils or sediments with this technology is referred to as phytoextraction (see figure below).

Phytoextraction offers an efficient, cost-effective, and environmentally friendly way to clean up heavy metal contamination. Plants are grown in situ on contaminated soil and harvested after toxic metals accumulate in the plant tissues. The degree of accumulation varies with several factors, but can be as high as 2 percent of the plants' aboveground dry weight, leaving clean soil in place with metal concentrations that equal or are less than regulatory cleanup levels. After accumulation in the plant tissues, the contaminant metal must be disposed of,

but the amount of disposable biomass is a small fraction of the amount of soil treated. For example, excavating and landfilling a 10-acre site contaminated with 400 parts per million (ppm) lead to a depth of 1 foot requires handling roughly 20,000 tons of lead-contaminated soil. Phytoextraction of a 10-acre site to remove 400 ppm of lead from the top 1 foot would require disposal of around 500 tons of biomass - about 1/40 of the soil cleaned. In the example cited, six to eight crops would typically be needed, with three or four crops per growing season.

Compared to traditional remedial technologies, phytoextraction offers the following benefits:

- Lower cost
- Applicability to a broad range of metals
- Potential for recycling the metal-rich biomass
- Minimal environmental disturbance
- Minimization of secondary air- and water-borne wastes



WASTE APPLICABILITY:

Phytotech's phytoextraction technology can be used to clean soil or sediments contaminated with lead, cadmium, chromium, cesium/strontium and uranium. Phytoremediation of other metals such as arsenic, zinc, copper, and thorium is in the research stage.

STATUS:

Phytotech was accepted into the SITE Demonstration Program in 1997. Under the SITE Program, Phytotech is demonstrating its phytoremediation technology at a former battery manufacturing facility in Trenton, New Jersey, where soil is contaminated with lead. The site has been prepared and characterized, two crops of Indian Mustard were grown and harvested over the Spring and Summer of 1997, and one crop of sunflowers was grown and harvested in 1998.

Phytotech has also conducted several successful field trials of its phytoextraction technology at other contaminated sites in the U.S. and abroad.

DEMONSTRATION RESULTS:

Results show that treatment increased the portion of the treatment area with lead concentrations below 400 mg/Kg from 31% to 57%. The average lead concentrations accumulated in the above-ground plant tissue samples from the two *Brassica* crops were 830 mg/Kg and 2,300 mg/Kg. Differences in lead uptake between the two *Brassica* crops are attributed to amendment optimization. Lead in the above-ground plant tissues of the sunflowers was measured at an average concentration of 400 mg/Kg. All three of these average values exceeded the minimum project objective of 200 mg/Kg (dry weight). This demonstration confirmed earlier findings that the use of Indian Mustard plants to extract metals is most applicable to intermediate levels of lead contamination (less than 1,500 mg/Kg), soil pH levels of 4.3-8.3, and moderate climates.

Phytotech has conducted several field demonstrations of its rhizofiltration technology for the removal of (1) cesium/strontium at Chernobyl, and (2) uranium from contaminated groundwater at a DOE site in Ashtabula, Ohio. At Chernobyl, sunflowers were shown to extract 95 percent of the radionuclides from a small pond within 10 days. At the Ashtabula site, Phytotech ran a 9-month pilot demonstration during which incoming water containing as much as 450 parts per billion (ppb) uranium was treated to 5 ppb or less of uranium.

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ELI ECO LOGIC, INC.

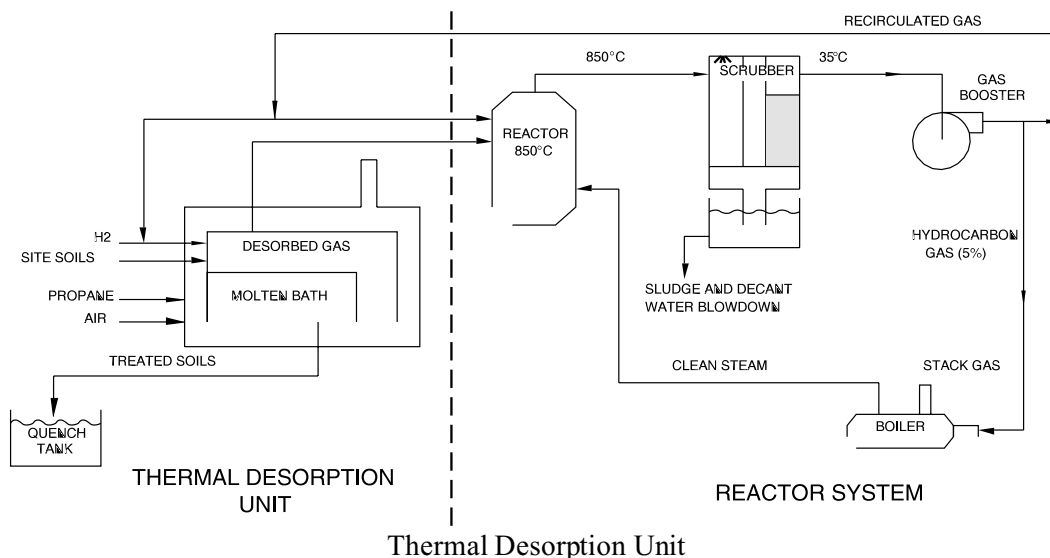
(Thermal Gas Phase Reduction Process and Thermal Desorption Unit)

TECHNOLOGY DESCRIPTION:

The ELI Eco Logic International Inc. (Eco Logic), thermal desorption unit (TDU) is specially designed for use with Eco Logic's gas-phase chemical reduction process. The TDU, shown in the figure below, consists of an externally heated bath of molten tin metal (heated with propane) in a hydrogen gas atmosphere. Tin is used for several reasons: tin and hydrogen are nonreactive; tin's density allows soils to float on the molten bath; molten tin is a good fluid for heat transfer; tin is nontoxic in soil; and tin is used as a bath medium in the manufacture of plate glass.

Contaminated soil is conveyed into the TDU feed hopper, where an auger feeds the soil into the TDU. A screw feeder provides a gas seal between the outside air and the hydrogen atmosphere inside the TDU. The auger's variable speed drive provides feed rate control. Soil inside the TDU floats on top of the molten tin and is heated to 600 °C, vaporizing the water and organic material. Decontaminated soil is removed from the tin bath into a water-filled quench

tank. The water in the quench tank provides a gas seal between the TDU's hydrogen atmosphere and the outside air. A scraper mechanism removes decontaminated soil from the quench tank into drums. After desorption from the soil, the organic contaminants are carried from the TDU to Eco Logic's proprietary gas-phase reduction reactor. In the reactor, the organic contaminants undergo gas-phase chemical reduction reactions with hydrogen at elevated temperatures and ambient pressure. This reaction converts organic and chlorinated organic contaminants into a hydrocarbon-rich gas product. After passing through a scrubber, the gas product's primary components are hydrogen, nitrogen, methane, carbon monoxide, water vapor, and other lighter hydrocarbons. Most of this gas product recirculates into the process, while excess gas can be compressed for later analysis and reuse as supplemental fuel. For further information on the Eco Logic gas-phase chemical reduction process, see the profile in the Demonstration Program section (completed projects).



WASTE APPLICABILITY:

The Eco Logic TDU, when used with the gas-phase chemical reduction reactor, is designed to desorb soils and sludges contaminated with hazardous organic contaminants such as polychlorinated biphenyls (PCB), polynuclear aromatic hydrocarbons, chlorinated dioxins and dibenzofurans, chlorinated solvents, chlorobenzenes, and chlorophenols. The combined technologies are suited for wastes with high water content since water is a good source of hydrogen.

STATUS:

In October and November 1992, the Eco Logic process, including the TDU, was demonstrated at the Middleground Landfill in Bay City, Michigan, under a Toxic Substances Control Act research and development permit. The Demonstration Bulletin (EPA/540/MR-94/504) and the Applications Analysis Report (EPA/540/AR-94/504) are available from EPA.

Further research and development since the demonstration has focused on optimizing the process for commercial operations and improving the design of the soil and sediment processing unit. According to Eco Logic, the TDU design currently in commercial operation has achieved excellent results, with contaminants in soils and sediments desorbed from high parts per million (ppm) levels to low parts per billion levels.

Two commercial-scale SE25 treatment units are currently in operation: one in Perth, Western Australia, and the other at a General Motors of Canada Ltd (GMCL) facility in Ontario. Both are currently treating a variety of waste matrices including DDT residues and PCBs in soils, oils, electrical equipment, concrete, and other solids. Following the GMCL project, the unit will be relocated to Toronto, Ontario where General Electric (GE) and Eco Logic have a contract to destroy PCB-impacted materials stored aboveground at GE's Lansdowne and Davenport facilities.

Eco Logic also has teamed with Westinghouse Electric to treat chemical warfare agents using the process. Eco Logic has been awarded a contract through the Department of Energy's Morgantown Energy Technology Center for treatment of hazardous wastes, radioactive mixed low-level wastes, and energetics-explosives.

DEMONSTRATION RESULTS:

During the demonstration in Bay City, Michigan, the Eco Logic TDU achieved the following:

- Desorption efficiencies for PCBs from the soil of 93.5 percent in run one and 98.8 percent in run two
- Desorption efficiency for hexachlorobenzene (a tracer compound) from the soil of 72.13 percent in run one and 99.99 percent in run two
- PCB destruction and removal efficiencies of 99.99 percent for the combined TDU and reduction reactor

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EMTECH ENVIRONMENTAL SERVICES

(formerly HAZCON, INC.)
(Dechlorination and Immobilization)

TECHNOLOGY DESCRIPTION:

This technology mixes hazardous wastes with cement (or fly ash), water, and one of 18 patented reagents, commonly known as Chloranan, to immobilize heavy metals. The developers also claim that certain chlorinated organics are dechlorinated by the treatment reagents.

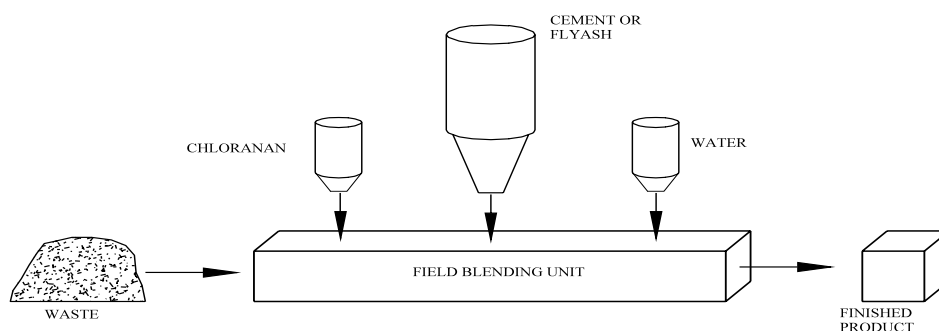
Soils, sludges, and sediments can be treated in situ or excavated and treated ex situ. Sediments can be treated under water. In the finished product, immobilized metals have a very low solubility. Ex situ treatment occurs in batches, with volumetric throughput rated at 120 tons per hour. The treatment process begins by adding Chloranan and water to the blending unit (see figure below). Waste is then added and mixed for 2 minutes. Cement or fly ash is added and mixed for a similar time. After 12 hours, the treated material hardens into a concrete-like mass that exhibits unconfined compressive strengths (UCS) ranging from 1,000 to 3,000 pounds per square inch (psi), with permeabilities of 10^{-9} centimeters per second (cm/sec). The hardened concrete-like mass can withstand several hundred freeze and thaw cycles.

WASTE APPLICABILITY:

The technology is applicable to solid wastes containing heavy metals and organics. The developer claims that, since the 1987 SITE demonstration, the technology has been refined to dechlorinate certain chlorinated organics and to immobilize other wastes, including those with high levels of metals. Wastes with organic and inorganic contaminants can be treated together. The process can treat contaminated material with high concentrations (up to 25 percent) of oil.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1987. The process was demonstrated in October 1987 at a former oil processing plant in Douglassville, Pennsylvania.



Dechlorination and Immobilization Treatment Process

The site soil contained high levels of oil and grease (250,000 parts per million [ppm]) and heavy metals (22,000 ppm lead), and low levels of volatile organic compounds (VOC) (100 ppm) and polychlorinated biphenyls (PCB) (75 ppm). The Applications Analysis Report (EPA/540/A5-89/001) and Technology Evaluation Report (EPA/540/5-89/001a) are available from EPA. A report on long-term monitoring may be also obtained from EPA. The technology has also been used to remediate a California Superfund site with zinc contamination as high as 220,000 ppm.

Since the demonstration in 1987, 17 additional reagent formulations have been developed. These reagents supposedly dechlorinate many chlorinated organics, including PCBs, ethylene dichloride, trichloroethene, and pentachlorophenol.

DEMONSTRATION RESULTS:

For the SITE demonstration, samples were taken after treatment at intervals of 7 days, 28 days, 9 months, and 22 months. Analytical results from these samples were generally favorable. The physical test results indicated a UCS between 220 and 1,570 psi. Low permeabilities (10^{-9} cm/sec) were recorded, and the porosity of the treated wastes was moderate. Durability test results showed no change in physical strength after the wet and dry and freeze and thaw cycles. The waste volume increased by about 120 percent. However, technology refinements now restrict volumetric increases to 15 to 25 percent. Using a smaller volume of additives reduces physical strength, but toxicity reduction is not affected.

The results of the leaching tests were mixed. Toxicity characteristic leaching procedure (TCLP) results for the stabilized wastes showed that concentrations of metals, VOCs, and semivolatile organic compounds (SVOC) were below 1 ppm. Lead concentrations in leachate decreased by a factor of 200 to below 100 parts per billion. VOC and SVOC concentrations in the TCLP leachate were not affected by treatment. Oil and grease concentrations were greater in the treated waste TCLP leachate (4 ppm) than in the untreated waste TCLP leachate (less than 2 ppm).

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ENVIROMETAL TECHNOLOGIES INC.

(In Situ and Ex Situ Metal-Enhanced Abiotic Degradation of Dissolved Halogenated Organic Compounds in Groundwater)

TECHNOLOGY DESCRIPTION:

This remedial technology, developed by the University of Waterloo and EnviroMetal Technologies Inc., degrades dissolved halogenated organic compounds in groundwater with an in situ permeable wall containing reactive metal (usually iron) (see photograph below). The technology may also be used in an aboveground reactor for ex situ treatment.

The technology employs an abiotic electrochemical process. Contaminated groundwater passes through the specially prepared granular reactive iron, which oxidizes, inducing reductive dehalogenation of contaminants. Halogenated organics are degraded to nonhazardous substances, preventing contaminants from migrating further downstream. Observed degradation rates are several times higher than those reported for natural abiotic degradation processes.

In most in situ applications of this technology, groundwater moves naturally through the permeable subsurface wall or is directed by flanking

impermeable sections such as sheet piles or slurry walls. This passive remediation method is a cost-effective alternative to conventional pump-and-treat methods. Aboveground reactor vessels employing this technology may replace or add to treatment units in conventional pump-and-treat systems.

Process residuals may include dissolved ethane, ethene, methane, hydrogen gas, chloride, and ferrous iron. Because contaminants are degraded to nonhazardous substances and not transferred to another medium, this process eliminates the need for waste treatment or disposal.

WASTE APPLICABILITY:

The process was developed to treat dissolved halogenated organic compounds in groundwater.

The technology has degraded a wide variety of chlorinated alkanes and alkenes, including trichloroethene (TCE), tetrachloroethene (PCE), vinyl chloride, 1,1,1-trichloroethane, and 1,2-dichloroethene



(DCE). The technology also degrades other organic contaminants, including Freon-113, ethylene dibromide, certain nitroaromatics, and N-nitrosodimethylamine.

This technology was accepted into the SITE Demonstration Program in spring 1993. A pilot-scale demonstration of the aboveground reactor (ex situ) technology took place from November 1994 to February 1995 at an industrial facility in New Jersey. Groundwater at the facility contained dissolved TCE and PCE.

A second SITE demonstration was performed in New York from May through December 1995. A pilot-scale in situ permeable wall was installed in a shallow sand and gravel aquifer containing TCE, DCE, vinyl chloride, and 1,1,1-trichloroethane. This project may eventually be expanded to full-scale.

A successful permeable in situ wall was installed at the Canadian Forces Base Borden test site in June 1991. The technology removed about 90 percent of the TCE and PCE from groundwater passing through the reactive iron wall. The wall has performed consistently for 5 years. More than 400 sites have been identified where the technology could be applied. Over 75 successful bench-scale feasibility tests have been completed using groundwater from industrial and government facilities in the United States and Canada.

The first full-scale commercial in situ installation of this technology was completed at an industrial facility in California in December 1994. Since that time, twelve additional full-scale in situ systems and ten pilot-scale systems have been installed in locations including Colorado, Kansas, North Carolina and Belfast, Northern Ireland. Aboveground treatment systems have been proposed at sites in the U.S. and Germany.

DEMONSTRATION RESULTS:

During the New Jersey (ex situ) demonstration, about 60,833 gallons of groundwater was treated during 13 weeks of sampling. Conversion efficiency of PCE during the demonstration period exceeded 99.9 percent. Vinyl chloride and cis-1,2-dichloroethene occasionally exceeded the New Jersey Department of Environmental Protection limits. This exceedance may have been caused by a reduction in the iron's reactive capacity due to precipitate formation. Complete demonstration results are published in the Technology Capsule and Innovative Technology Evaluation Report (ITER), which is available from EPA.

For the New York (in situ) demonstration, preliminary data indicate a significant reduction in all critical contaminants present, and no apparent decrease in removal efficiency over the seven month demonstration period. Results of the in situ demonstration of the process are published in an ITER that is available from EPA.

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ENVIROMETAL TECHNOLOGIES, INC. (In Situ Reactive Barrier)

TECHNOLOGY DESCRIPTION:

The Reactive Barrier technology is an innovative treatment system that uses the oxidation capacity of zero-valent iron to induce reduction of oxidized metals, reductive dechlorination of chlorinated volatile organic compounds (VOCs), and immobilization of some metals such as uranium by a combination of reduction and sorbtion.

Granular zero-valent iron oxidizes within the reactor vessel or reactive wall. As groundwater containing VOCs flows through the reactor and around these granules, electrons released by oxidation of the iron create a highly reducing environment in solution.

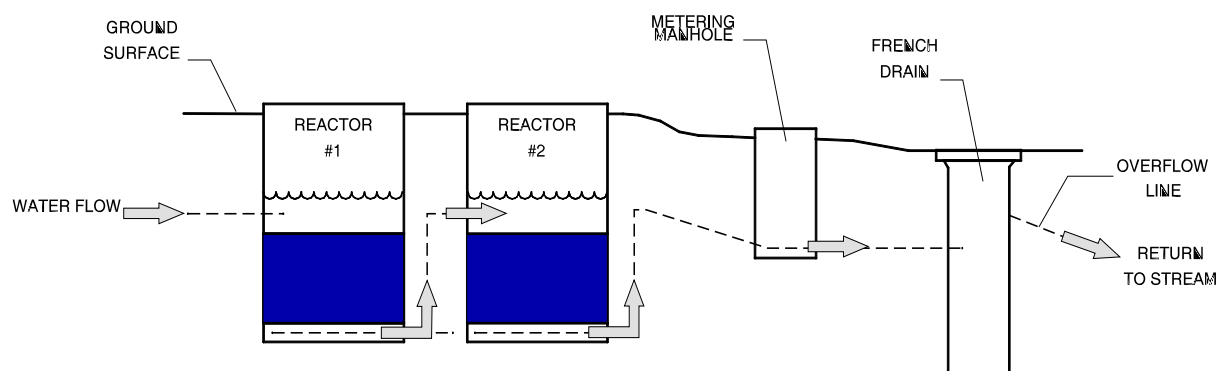
The hydrocarbon-chloride bonds in the chlorinated contaminants become unstable and break down sequentially, forming less chlorinated compounds and releasing nontoxic chloride ions to the groundwater. The completely hydrolyzed hydrocarbon compounds are nontoxic and degrade naturally. The rate of reaction depends primarily on the surface area of the iron or its abundance in the permeable reactive media. The dechlorination reaction is typically accompanied by an increase in groundwater pH and a decrease in oxidation/reduction potential. Inorganic constituents such as calcium, magnesium, and iron combine with carbonate or hydroxide ions in the treated water to

form compounds such as metal carbonates and metal hydroxides that precipitate from solution as groundwater moves through the iron. Due to the precipitation of these metallic compounds from solution, the reaction is also typically accompanied by a decrease in total dissolved solids in the groundwater.

WASTE APPLICABILITY:

The Reactive Barrier technology is applicable to subsurface or above-ground treatment of VOCs and metals in groundwater or wastewater. The technology is adaptable to a variety of sites when used in combination with funnel and gate systems. Depth of the contaminated groundwater is the only constraint on the applicability of the technology.

The technology was accepted into the SITE Demonstration Program in 1996. The demonstration of the technology was completed at the Rocky Flats Environmental Technology Site in Golden, Colorado. The technology's effectiveness was evaluated through sampling and analysis of untreated and treated groundwater that is collected by a french drain system and transferred to two subsurface reactor tanks through gravity flow. Project reports will be available in September 2001.



Schematic of the Reactive Barrier Technology
Installation of Pilot-Scale In Situ Treatment System
at an Industrial Facility in Northeast United States

DEMONSTRATION RESULTS:

Groundwater contamination in this area-known as the mound site plume-originated from a former waste drum storage area used by DOE in the 1950s. Consisting of shallow groundwater with a flowrate of 0.5 to 2.0 gallons per minute, the plume horizontally extends approximately 220 feet. Its primary contaminants are uranium and volatile organic compounds (VOCs), including carbon tetrachloride, tetrachloroethene, trichloroethene, and vinyl chloride.

This barrier system begins with the downgrade-side collection of groundwater in subsurface hydraulic barrier (French drain) lined with high-density polyethylene. The drain is located in the unconfined aquifer at depths ranging from 8 to 15 feet below ground surface. Groundwater is diverted through the drain to piping that transfers it by gravity to the reactive media treatment system containing granular, zero-valent iron.

VOCs are dechlorinated to nonchlorinated hydrocarbons and uranium in the oxidized state (U^{6+}) is converted to uranium in the reduced state (U^{4+}) and precipitated. Following treatment, groundwater exits the barrier system directly through surface water that flows to retention ponds.

Treatment reduced carbon tetrachloride, tetrachloroethene, trichloroethane, and uranium concentrations by >95%. Vinyl chloride concentration was reduced by 70% (2.0 $\mu\text{g/L}$ to 0.6 $\mu\text{g/L}$). The treated effluent was below the Colorado Water Quality Standards for each of the contaminants.

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EPOC WATER, INC.
(Precipitation, Microfiltration, and Sludge Dewatering)

TECHNOLOGY DESCRIPTION:

The precipitation, microfiltration, and sludge dewatering treatment uses a combination of processes to treat a variety of wastes. In the first step of the process, heavy metals are chemically precipitated. Precipitates and all particles larger than 0.2 micron are filtered through a unique tubular textile crossflow microfilter (EXXFLOW). The concentrate stream is then dewatered in a filter press of the same material.

EXXFLOW microfilter modules are fabricated from a proprietary tubular woven polyester. Wastes pumped into the polyester tubes form a dynamic membrane, which produces a high quality filtrate and removes all particle sizes larger than 0.2 micron. The flow velocity continually maintains the membrane, maximizing treatment efficiency.

Metals are removed through precipitation by adjusting the pH in the EXXFLOW feed tank.

Metal hydroxides or oxides form a dynamic membrane with any other suspended solids. The EXXFLOW concentrate stream, which contains up to 5 percent solids, is then dewatered. A semidry cake, up to 0.25 inch thick, is formed inside the tubular filter. When the discharge valve is opened, rollers on the outside of the tubes move to form a venturi within the tubes. The venturi creates an area of high velocity within the tubes, which aggressively cleans the cloth and discharges the cake in chip form onto a wedge wire screen. Discharge water is recycled to the feed tank. Filter cakes are typically 40 to 60 percent solids by weight.



Constituents other than metals can be removed using seeded slurry methods in EXXFLOW. Hardness can be removed by using lime. Oil and grease can be removed by adding adsorbents. Nonvolatile organics and solvents can be removed using adsorbents, activated carbon, or powdered ion-exchange resins. The EXXFLOW demonstration unit (see photograph below) is transportable and is mounted on skids. The unit is designed to process approximately 30 pounds of solids per hour and 10 gallons of wastewater per minute.

WASTE APPLICABILITY:

When flocculation and precipitation techniques are used at close to stoichiometric dosing rates, the EXXFLOW technology removes mixed metals, oil and grease, and suspended solids sized at 0.10 micron.

When the EXXFLOW technology operates with finely divided adsorbent powders, it removes contaminants such as isophthalic acid, acetic acid, methyl ethyl ketone, fluorides, and phosphates from effluents generated by semiconductor manufacture. Treated effluents can then be reclaimed for reuse.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1989. Bench-scale tests were conducted in 1990. The SITE demonstration was conducted during May and June 1992 on highly acidic mine drainage from the Old Number 8 mine seep at the Iron Mountain Superfund site in Redding, California. The Demonstration Bulletin (EPA/540/MR-93/513) and the Applications Analysis Report (EPA/540/AR-93/513) are available from EPA.

This technology was commercialized in 1988. Treatment systems have since been installed at over 45 sites worldwide. System capacities range from 1 gallon per minute to over 2 million gallons per day.

DEMONSTRATION RESULTS:

During the SITE demonstration, developer claims for metal removal efficiencies on acid mine drainage, when neutralizing with sodium hydroxide (NaOH) and calcium hydroxide [Ca(OH)₂], were generally met or exceeded except for aluminum. This was most likely due to excessive alkalinity (high pH) produced by the added NaOH and Ca(OH)₂, which redissolved the aluminum. The claims for all metals, including aluminum, were exceeded when magnesium oxide (MgO) was used as the neutralizing agent. In most cases, no detectable concentrations of heavy metals were present in the permeate samples.

Filter cake produced from the demonstration test contained approximately 12 percent, 31 percent, and 30 percent solids when NaOH, Ca(OH)₂, and MgO, respectively, were used as the treatment chemicals. Toxicity characteristic leaching procedure (TCLP) tests performed on the filter cake showed that leachable levels of TCLP metals were below regulatory limits for each treatment chemical tested.

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FILTER FLOW TECHNOLOGY, INC.

(Colloid Polishing Filter Method®)

TECHNOLOGY DESCRIPTION:

The Colloid Polishing Filter Method® (CPFM®) uses inorganic, oxide-based sorption particles (FF-1000®) and optimized fluidics control to remove ionic, colloidal heavy metals and nontritium radionuclides from water. Beta- and alpha-emitting radionuclides can be treated selectively by modifying the bed formulation. The methodology efficiently removes inorganics from groundwater, pond water, or wastewater based on sorption, chemical and physical properties of the pollutant species, and filtration. The CPFM® is also an efficient heavy metals and radionuclide polishing filter for groundwater and wastewater. Excess solids and total dissolved solids must be removed first, since they overload the beds, resulting in frequent bed backwashing and regeneration cycles and shorter bed lifetimes.

Three different types of CPFM® equipment have been designed and successfully tested: (1) vertical plate design beds with FF-1000® sorption bed particles packaged in polymesh bags or filter packs for field applications; (2) small, filter-housing units for processing less than 1,000 gallons of contaminated

water; and (3) deep-bed, epoxy-coated, stainless steel and carbon steel tanks equipped with special fluidics controls and bed sluicing ports for continuous processing. The photograph below shows a mobile CPFM® unit.

WASTE APPLICABILITY:

The CPFM® has proved to be effective in removing heavy metals and nontritium radionuclides from water to parts per million or parts per billion levels. The ion exchange/sorption method can be used separately to treat water with low total suspended solids; in a treatment train downstream from other technologies (such as soil washing, organics oxidation; or conventional wastewater treatment).

The CPFM®'s major advantages are its high performance; alpha and beta emitter efficiency; and its application to monovalent, divalent, multivalent, and high valence forms existing as colloids, and ionic, chelated, and complexed forms. The same equipment can treat water at different sites, but the preconditioning chemistry and pH must be optimized for each site through bench-scale and field testing.



Mobile CPFM® Unit, Including Mixing Tanks, Pumps, Filter Apparatus, and Other Equipment

STATUS:

This technology was accepted into the SITE Demonstration Program in July 1991. EPA and the U.S. Department of Energy (DOE) cosponsored the technology evaluation. The SITE demonstration occurred in September 1993 at DOE's Rocky Flats Plant (RFP) in Denver, Colorado. The Demonstration Bulletin (EPA/540/MR-94/501), Technology Capsule (EPA/540/R-94/501a), and Innovative Technology Evaluation Report (EPA/540/R-94/501) are available from EPA.

The CPFM[®] has been demonstrated independent of the SITE Program at two locations at DOE's Hanford facility, where it removed Strontium-90, Cesium-137, Plutonium-239, and Americium-241 from water at K-Basin and Strontium-90 from groundwater at Site 100N Area (N-Spring). It also has proven to be effective at several other individual sites. A report detailing the results is available from DOE (DOE/RL-95-110).

DEMONSTRATION RESULTS:

During the SITE demonstration, the CPFM[®] treated about 10,000 gallons of water that contained about 100 micrograms per liter of uranium and 100 picoCuries per liter of gross alpha contamination. The demonstration consisted of three tests. The first test consisted of three 4-hour runs, at a flow rate of about 5 gallons per minute (gpm). For the second test, also run for 4 hours at 5 gpm, the influent water was pretreated with sodium sulfide. The third test was a 15-hour run designed to determine the amount of contamination each filter pack could treat.

The CPFM[®] system removed up to 95 percent uranium and 94 percent gross alpha contamination. However, due to the significant variation in removal efficiencies between runs, average removal efficiencies were significantly less: 80 percent for uranium and 72 percent for gross alpha. Though removal is largely attributable to the colloid filter pack, uranium was significantly removed in runs one and four before colloid filter treatment. Significant gross alpha was also removed before colloid filter treatment in runs one and three. At less than the maximum removal efficiency, effluent from the CPFM[®] system did not meet the Colorado Water Quality Control Commission standards for discharge of waters from RFP.

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GAS TECHNOLOGY INSTITUTE (formerly Institute of Gas Technology) (Cement-Lock™ Technology)

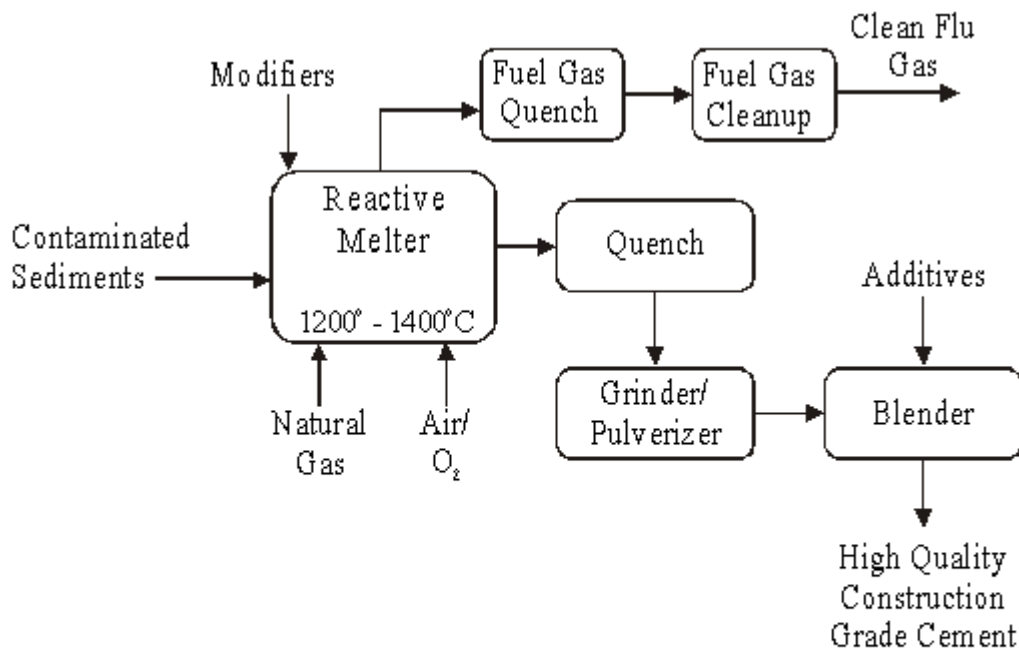
TECHNOLOGY DESCRIPTION:

The Gas Technology Institute (GTI) has developed the Cement-Lock™ Technology, which is a versatile, cost-effective, and environmentally friendly manufacturing technology. This method produces construction-grade cements from a variety of contaminated waste materials such as sediments, concrete and building debris, town gas site soils, Superfund site soils, sludges, chemical wastes, petroleum refinery wastes, and incinerator residues. Organic and inorganic contaminants are present in these wastes across a broad range of concentrations. In the Cement-Lock™ process, contaminated materials and proprietary modifiers are fed to a reactive melter operating under oxidizing conditions where all the organic compounds are completely destroyed and converted to innocuous carbon dioxide and water. Chlorine and sulfur compounds are sequestered and heavy metals are locked within the molten matrix to completely immobilize them.

During processing, the melt (Ecomelt™) is imparted with latent cementitious properties that allow it to be transformed into construction-grade cement. The Cement-Lock Technology is unique because it not only decontaminates the sediment but also converts it into a beneficial commercial commodity, namely, construction-grade cement. The effectiveness of the technology for remediating contaminated sediments has already been verified in bench- and pilot-scale test programs.

WASTE APPLICABILITY:

This technology is suitable for soils and sediments that are contaminated with petroleum hydrocarbons, PCBs, heavy metals and most other organic and inorganic contaminants.



Schematic Diagram of the Cement-Lock™ Process
For Treating Dredged Sediments

STATUS:

This successful project has been transferred from Exploratory Research to the Industrial Program. GRI and Endesco Clean Harbors LLC have entered into a contract to further develop and commercialize this technology.

DEMONSTRATION RESULTS:

Several bench-scale tests were conducted by IGT in which aged siliceous (silica-based aggregate) concrete was mixed with different amounts of inexpensive modifiers and melted at about 2,300°F. The melt was then rapidly quenched to retain the desired amorphous, glassy phase. In one test, the concrete was contaminated with 5,000 ppm of oil and 500 ppm of chromium. The amorphous, glassy material produced was then converted to blended cement per ASTM procedures. The results of the analyses and tests made on the product showed that organic destruction in excess of 99.9% was achieved in the ground melt. An analysis using the EPA TCLP (Toxicity Characteristic Leaching Procedure) procedure indicated the chromium leachability of the blended cement was only 0.097 mg/L in the leachate (the regulatory leachability limit is 5 mg/L). The 3, 7, and 28-day compressive strengths of the blended cement were 2530, 3370, and 5475 psi, respectively. These strengths significantly exceed ASTM C 595 and ASTM C 1157 requirements. Two bench-scale tests using a calcareous (limestone-based) concrete were also conducted. The melts produced were glassy in nature and suitable for producing blended cement.

A large-scale technology demonstration is on hold pending the decision of disposition of dredged sediments from the Detroit River.

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GENERAL ATOMICS **(formerly Ogden Environmental)** **(Circulating Bed Combustor)**

TECHNOLOGY DESCRIPTION:

General Atomics' circulating bed combustor (CBC) uses high velocity air to entrain circulating solids and create a highly turbulent combustion zone that destroys toxic hydrocarbons. The commercial-scale, 3-foot combustion chamber can treat up to 150 tons of contaminated soil daily, depending on the heating value of the feed material.

The CBC operates at lower temperatures than conventional incinerators (1,450 to 1,600°F). The CBC's high turbulence produces a uniform temperature around the combustion chamber and hot cyclone. The CBC also completely mixes the waste material during combustion. Effective mixing and low combustion temperature reduce operating costs and potential emissions of such gases as nitrogen oxide (NO_x) and carbon monoxide (CO). Natural gas, fuel oil, or diesel can be used as auxiliary fuel. No auxiliary fuel is needed for waste streams with a net heating value greater than 2,900 British thermal units per pound.

As shown in the figure below, waste material and limestone are fed into the combustion chamber along with the recirculating bed material. The limestone neutralizes acid gases. A conveyor transports the treated ash out of the system for proper disposal. Hot combustion gases pass through a convective gas cooler and baghouse before they are released to the atmosphere.

The CBC process can treat liquids, slurries, solids, and sludges contaminated with corrosives, cyanides, dioxins and furans, inorganics, metals, organics, oxidizers, pesticides, polychlorinated biphenyls (PCB), phenols, and volatile organic compounds. The CBC is permitted under the Toxic Substances Control Act to burn PCBs in all 10 EPA regions, having demonstrated a 99.99 percent destruction removal efficiency (DRE). Applications of the CBC include a variety of industrial wastes and contaminated site materials. Waste feed for the CBC must be sized to less than 1 inch. Metals in the waste do not inhibit performance and become less leachable after incineration. Treated residual ash can be replaced on site or stabilized for landfill disposal if metals exceed regulatory limits.

STATUS:

The CBC (formerly owned by Ogden Environmental Services) was accepted into the SITE Demonstration Program in 1986. A treatability study on wastes from the McColl Superfund site in California was conducted under the guidance of the SITE Program, EPA Region 9, and the California Department of Health Services in March 1989. A pilot-scale demonstration was conducted at the General Atomics research facility in San Diego, California using a 16-inch-diameter CBC. The demonstration was conducted on soil from the McColl Superfund Site in Fullerton, California.

Several 3-foot-diameter CBCs have been built and successfully operated. At the Swanson River project in Alaska, over 100,000 tons of PCB-contaminated soil was successfully treated to limits of detection that were far below allowable limits. The process took just over 3 years, from mobilization of the transportable unit to demobilization. The unit operated at over 85 percent availability all year, including winter, when temperatures were below -50°F. The soil was delisted and returned to the original site. The unit has subsequently been moved to a Canadian site. Another unit of similar size treated soils contaminated with #6 fuel oil. Over 14,000 tons of soil was successfully treated and delisted.

Upon completion, the site was upgraded to permit operation as a merchant facility treating a wide range of materials from leaking underground fuel tanks at other sites. Two other units of the same size have been constructed in Germany for treatment of munitions wastes consisting of slurried explosives and propellant. These units have been operational since early 1995 and have been permitted under stringent German regulations.

DEMONSTRATION RESULTS:

During the SITE demonstration, the CBC performed as follows:

- Achieved DRE values of 99.99 percent or greater for principal organic hazardous constituents
- Minimized formation of products of incomplete combustion
- Met research facility permit conditions and California South Coast Basin emission standards
- Controlled sulfur oxide emissions by adding limestone and residual materials (fly ash and bed ash); these emissions were nonhazardous. No significant levels of hazardous organic compounds were found in the system, the stack gas, or the bed and fly ash.
- Minimized emissions of sulfur oxide, NO_x, and particulates. Other regulated pollutants were controlled to well below permit levels.

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GENERAL ENVIRONMENTAL, INC.
(formerly Hydrologies, Inc./Cure International, Inc.)
(CURE®-Electrocoagulation Wastewater Treatment System)

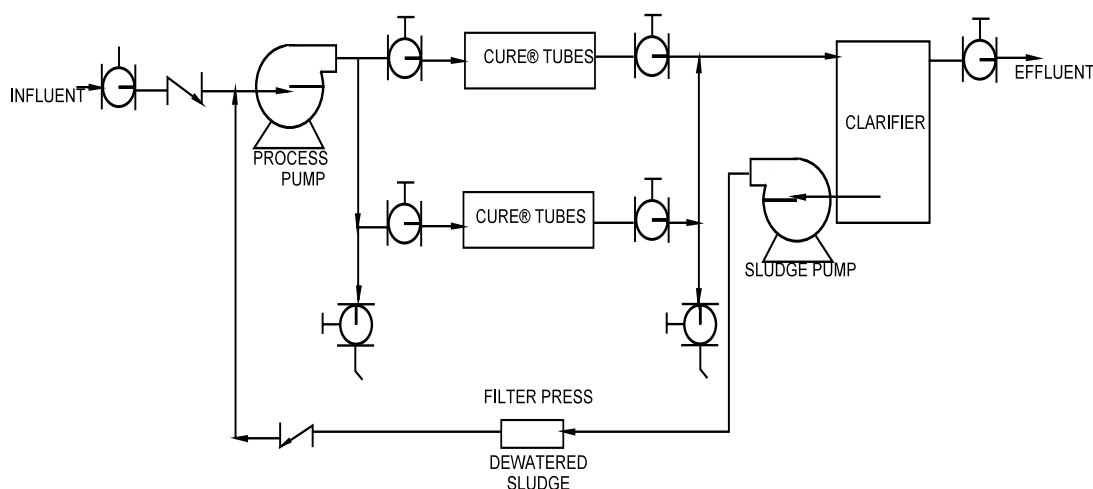
TECHNOLOGY DESCRIPTION:

The CURE® - Electrocoagulation (CURE®) system is designed to remove ionic metal species and other charged particles from water (see figure below). Because many toxic metal ions such as nickel, lead, and chromates are held in solution by electrical charges, they will precipitate out of solution if they are neutralized with oppositely charged ions. The CURE® system is effective at breaking oily emulsions and removing suspended solids. The system improves on previous electrocoagulation methods through a unique geometrical configuration.

The CURE® system's patented geometry maximizes liquid surface contact between the anode and concentric cathode electrocoagulation tubes, thus minimizing the power requirements for efficient operation. The CURE® system allows the contaminated water to flow continuously through the cathode tube, enabling a direct current to pass

uniformly through a water stream. The contaminated water then passes through the annular space between the cathode and anode tubes and is exposed to sequential positive and negative electrical fields. Typical retention time is less than 20 seconds. Water characteristics such as pH, oxidation-reduction potential, and conductivity can be adjusted to achieve maximum removal efficiencies for specific contaminants.

After the treated water exits the electrocoagulation tubes, the destabilized colloids are allowed to flocculate and are then separated with an integrated clarifier system. Polymers can be added to enhance flocculation, but in most cases they are not required. The sludge produced by this process is usually very stable and acid-resistant. Tests have shown that sludges produced by the CURE® system pass the toxicity characteristic leaching procedure (TCLP) and are often disposed of as nonhazardous waste.



CURE®-Electrocoagulation System

WASTE APPLICABILITY:

The CURE® system can treat a broad range of dissolved metals, including aluminum, arsenic, barium, cadmium, chromium, cyanide, iron, lead, nickel, uranium, and zinc. The system can also treat contaminants such as emulsified oils, suspended solids, paints, and dyes. Radionuclides were removed by the system at the Rocky Flats Environmental Technology Site (RFETS).

Because this system treats a wide range of contaminants, it is suited for industries and utilities such as plating, mining, electronics, industrial wastewater, as well as remediation projects.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1993. A bench-scale test of the technology was conducted in April 1995 to determine the ability of the system to remove radionuclides from solar evaporation water at RFETS. The system removed over 90 percent of uranium and plutonium from the test water. The technology was demonstrated during August and September 1995 at RFETS under a joint agreement between the Department of Energy, the State of Colorado, and EPA.

The technology has proven to be very effective in a diverse number of industrial applications including metal refinishing, oil treatment plants, acid mine drainage and cooling towers in the U.S. and internationally. Full or pilot scale units are available from CURE® International, Inc.

DEMONSTRATION RESULTS:

During the SITE demonstration, four 3-hour test runs were conducted at RFETS over a 2-week period. Prior to the demonstration, operating parameters were adjusted during several optimization runs.

The demonstration showed that the system removed 30 to 50 percent of uranium and 60 to 99 percent of plutonium from the solar pond water at RFETS. The radionuclide and metal content of the dewatered sludge indicated that these contaminants were highly concentrated in the sludge. Uranium and plutonium were only slightly leachable by TCLP and no metals were leachable by TCLP. These results suggest that the sludge is very stable and resistant to breakdown.

The Demonstration Bulletin (EPA/540/MR-96/502), Technology Capsule (EPA/540/R-92/502a), and Innovative Technology Evaluation Report (EPA/540/R-96/502) are available from EPA.

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GEOKINETICS INTERNATIONAL, INC.

(Electroheat-Enhanced Nonaqueous-Phase Liquids Removal)

TECHNOLOGY DESCRIPTION:

Geokinetics has developed and fully commercialized a novel in-situ process for the extraction and/or destruction of organic materials (nonaqueous phase liquids [NAPL]) from ground and groundwater. The process combines a novel direct electrical heating process with established soil vapor, dual phase and other extraction approaches. Heat is produced directly in the treatment zone by the passage of an AC current through the soil matrix. In effect, the ground and groundwater become the electrical resistor in a conventional resistive heating circuit.

Multi-phase electrical current is supplied to the soil matrix using proprietary high surface area electrodes inserted directly into the ground. Electrical current, heat-up rate, and other operating parameters are regulated by a proprietary computer-based (impedance matching) control system. This system incorporates automated data logging, fault tolerance, and remote operation to minimize field labor requirements.

The process works by gradually and uniformly heating the treatment zone to 60 to 80°C. This produces the following effects:

- NAPL viscosity is significantly reduced.
- A density inversion of many dense nonaqueous-phase liquid (DNAPL) components will occur causing it to float to the top of the saturated zone.
- The smear zone will greatly reduce or even collapse.

- Nascent biological activity will typically increase dramatically (provided the heat-up rate is managed carefully). This greatly increases natural biodegradation. When the treatment zone has reached its operating temperature, a combination of established extraction techniques are applied as appropriate to remove most or all of the NAPL.
- Treatment times typically include:
 - 1 month for heat-up
 - 4 to 8 months for primary extraction

WASTE APPLICABILITY:

The technology is broadly applicable for enhancing the removal of NAPLs and DNAPLs from a broad range of ground types. Recovered and destroyed contaminants include fuel oil, diesel, kerosene, PAHs, coal tar, hydraulic fluid, TCE, and other chlorinated solvents, ground types treated include clays, silty clays, shale beds, gravel deposits, etc. The technology has been deployed alongside, inside, and underneath existing buildings and structures.

STATUS:

Geokinetics first developed and commercialized the technology in Europe and had more than 40 projects completed or in progress. In the United States, Geokinetics' technology was accepted in the Superfund Innovative Technology Evaluation (SITE) program in 1997. The technology was demonstrated at the Pearl Harbor demonstration site in Oahu, Hawaii.

• **DEMONSTRATION RESULTS:**

The heating process was able to reach the required operating temperature. However, the test well was not installed in an aquifer that communicated with the contaminated zone, so no DNAPL was removed.

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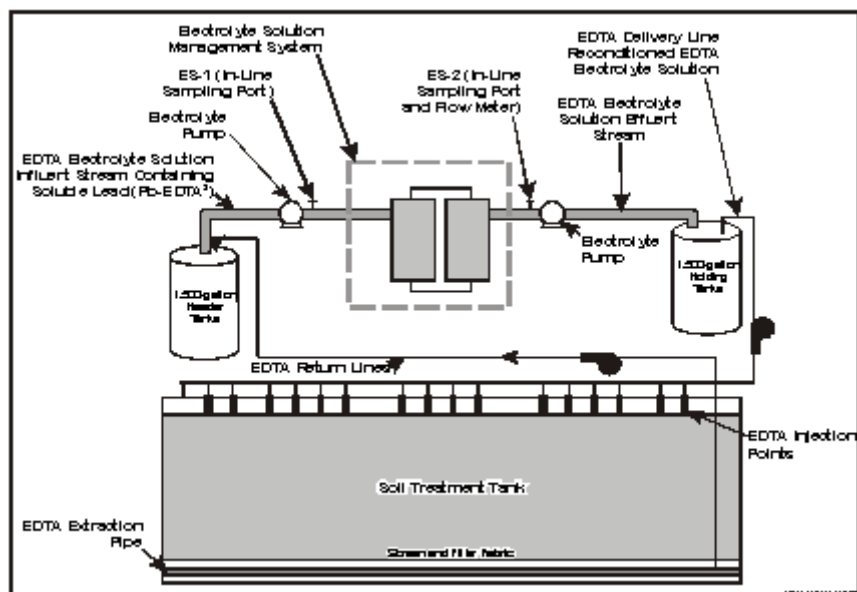
GEOKINETICS INTERNATIONAL INC.

(Electrokinetics for Lead Recovery)

TECHNOLOGY DESCRIPTION:

This technology mobilizes lead in soil by introducing a lead chelating agent, ethylene diamine tetra acetic acid (EDTA), into the soil mass. The chelating agent desorbs lead from the soil and forms an ionic complex with lead in solution. EDTA is a weak organic acid that is nonhazardous and environmentally safe which naturally biodegrades. EDTA was chosen after two treatability studies on site soil demonstrated that it was a successful chelating agent due to its ability to absorb lead from the highly buffered soil at the site.

A 4-cubic-yard batch ex situ treatment process is used to mobilize and remove lead from the site soil. Soil treatment involves flushing with an EDTA electrolyte solution. The electrolyte solution is introduced into the treatment tank containing the volume of soil to be treated through a manifold of microjets distributed across the top of the tank. The solution migrates through the soil column while the EDTA desorbs the lead from the soil, thus forming the $Pb-EDTA^{2-}$ complex. The electrolyte solution (containing the $Pb-EDTA^{2-}$ complex) is then allowed to drain through a port at the bottom of the tank. Once the electrolyte solution has been removed from the tank, it is then delivered to a holding tank prior to being cycled through a proprietary electrochemical processing unit. Here the lead is electroplated out of solution and recovered as metallic lead. Afterward, the electrolyte solution is delivered to a holding tank where it will be regenerated (pH adjusted) before being reintroduced to the soil undergoing treatment. Lead removed from the electrolyte solution is accumulated and delivered off-site for disposal or recycling. The entire system is a batch, closed-loop process. During operation, sensors monitor the concentration of lead in the electrolyte solution extracted from the soil.



FOR FURTHER INFORMATION:

WASTE APPLICABILITY:

This technology is suitable for any soils or sediments containing lead. EDTA has a strong affinity for lead and can effectively sequester lead in solution. However, the electrolyte solution containing the EDTA must be at a pH of 5 to 6 to be effective.

STATUS:

The Electrokinetics for Lead Recovery technology is due to undergo demonstration during the summer of 2002.

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GEOTECH DEVELOPMENT CORPORATION

(Cold Top Ex-Situ Vitrification of Chromium-Contaminated Soils)

TECHNOLOGY DESCRIPTION:

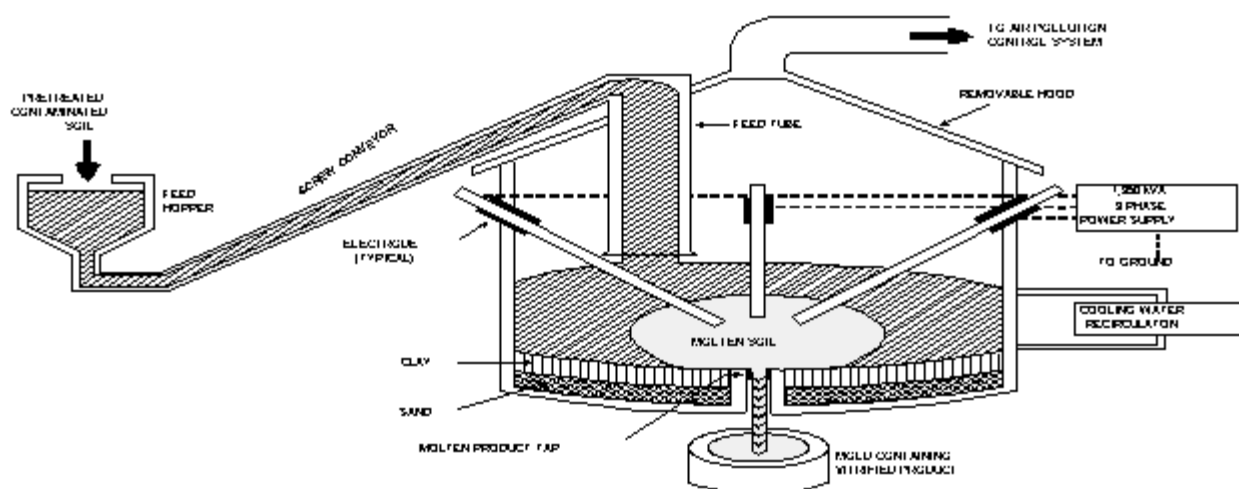
The Geotech Cold Top technology is an ex-situ vitrification process designed to transform metal-contaminated soils into a nonleachable product. The primary component of the technology is a water-cooled, double-walled, steel vessel or furnace with submerged-electrode resistance heating. The furnace and associated equipment are capable of attaining a melting temperature of up to 5,200°F.

The furnace is initially charged with a mixture of sand and alumina/silica clay. Through electrical resistance heating, a molten pool forms; the voltage to the furnace is properly adjusted; and, finally, contaminated soil is fed into the furnace by a screw conveyor. When the desired soil melt temperature is achieved, the furnace plug from below the molten product tap is removed. As the soil melts, the outflow is poured into refractory-lined and insulated molds for slow cooling, and additional soil is added to the furnace to maintain a "cold top." Excess material can be discharged to a water sluice for immediate cooling and collection before off-site disposal. Geotech Development Corporation (Geotech) claims that the Cold Top Vitrification process converts quantities of contaminated soil from a large number of particles into an essentially monolithic, vitrified mass. According to Geotech,

vitrification transforms the physical state of contaminated soil from assorted crystalline matrices to a glassy, amorphous solid state comprised of interlaced polymeric chains. These chains typically consist of alternating oxygen and silicon atoms. It is expected that chromium can readily substitute for silicon in the chains. According to Geotech, such chromium should be immobile to leaching by aqueous solvents and, therefore, biologically unavailable and nontoxic.

WASTE APPLICABILITY:

According to Geotech, the Cold Top Vitrification process has been used to treat soils contaminated with hazardous heavy metals such as lead, cadmium, and chromium; asbestos and asbestos-containing materials; and municipal solid waste combustor ash residue. Geotech claims that radioactive wastes can also be treated by this technology. All waste material must be reduced in size to less than 0.25 inches in diameter. The Cold Top Vitrification process is most efficient when feed materials have been dewatered to less than 5 percent water and organic chemical concentrations have been minimized. Some wastes may require the addition of carbon and sand to ensure that the vitrification process produces a glass-like product. Geotech claims that the vitrified product can have



Cold Top Ex-Situ Vitrification Technology

many uses, including shore erosion blocks, decorative tiles, road-bed fill, and cement or blacktop aggregate.

STATUS:

This technology was accepted into the SITE Demonstration Program in December 1994. In February and March, 1997, this process was demonstrated at Geotech's pilot plant in Niagara Falls, New York. Approximately 10,000 pounds of chromium-contaminated soil from two New Jersey-Superfund sites in the Jersey City area were collected crushed, sieved, dried, mixed with carbon and sand, and shipped to the Geotech plant. The SITE demonstration consisted of one vitrification test run on soil from each site.

DEMONSTRATION RESULTS:

The demonstration results indicate that the Cold Top Vitrification process reduced the concentration of leachable chromium to meet the Resource Conservation and Recovery Act (RCRA) toxicity characteristic leaching procedure (TCLP) total chromium standard. For example, concentrations of 29 and 58 mg/L of TCLP chromium in feed soils were reduced to 1.0 and 0.31 mg/L, respectively, in vitrified products. Field observations and measurements made during the demonstration indicate that several operational issues must be addressed during technology scale-up. First, a consistent and controlled feed system needs to be developed that spreads the waste uniformly over the surface of the molten soil. This feed system must also minimize dust generation. Second, an emission control system needs to be configured to control particulate and gaseous emissions from the furnace and feed system.

The SITE Demonstration Bulletin (EPA/540/HR-97/506) and Technology Capsule (EPA/540/R-97/506a) are available from EPA. Geotech owns a 50-ton-per-day Cold Top Vitrification pilot plant in Niagara Falls, New York. This facility has been

used for over 38 research and customer demonstrations, including the SITE demonstration. Geotech has built or assisted with the construction or upgrading of more than five operating vitrification plants. Geotech has tentative plans to build a commercial Cold Top Vitrification facility within 50 miles of the New Jersey sites. The planned capacity of this facility is 300 tons per day. The facility will be designed to receive, dry, vitrify, and dispose of vitrified product from the chromium sites and municipal solid waste incinerators, as well as other producers of hazardous and nonhazardous waste.

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GIS\SOLUTIONS, INC.

(GIS\Key™ Environmental Data Management System)

TECHNOLOGY DESCRIPTION:

GIS\Key™ v.3.0 is a comprehensive environmental database management system that integrates site data and graphics, enabling the user to create geologic cross-sections, boring logs, potentiometric maps, isopleth maps, structure maps, summary tables, hydrographs, chemical time series graphs, and numerous other maps and line graphs (see table below). The software is networkable, multi-user, 32 bit and year 2000 compliant. It is menu-driven, making it relatively simple to use. All system outputs meet Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reporting requirements and are consistent with current industry practices.

In addition to complete integration between data and graphics, GIS\Key™ v.3.0 integrates different data types, allowing swift production of complex graphics such as geo-chemical cross sections and flux graphics.

GIS\Key™ v.3.0 stores and independently manages metadata (such as maps, graphs, reports, boring logs and sections) from multiple sites. Metadata is geocoded, stored separately from a facility's source data and retrieved by performance of a spatial query. Metadata from a facility may be retrieved, viewed and studied independently or combined with metadata from other facilities for multi-site management.

The GIS\Key™ software can directly export data into the leading three-dimensional visualization systems. These systems produce three-dimensional contaminant plume models and groundwater flow models as well as fence diagrams. GIS\Key™ includes audit or transaction logging capabilities for source data as well as metadata.

The GIS\Key™ v3.0 also employs two new project management and data navigation tools called Scout™ and Smart Query™. Scout™ helps users find and access existing projects, start new projects, browse data and initiate queries that result in reports, maps, and other graphics.

Scout™ also manages data security and multi-user network installations of GIS\Key™ v.3.0. Smart Query™ is a data “drill down” tool which helps users set conditions on project data, displays data meeting those conditions, then creates desired output. GIS\Key™ v3.0 also has new modules for radiological chemistry and RCRA Statistics. Site data related to ecological assessment and air emissions are not managed by this system.

The GIS\Key™ software can be used at any Superfund site to facilitate the collection, reporting, and analysis of site data. The software is designed with numerous checks to assure the quality of the data, including comprehensive quality assurance/quality control protocols. System outputs, listed in the table below, are presentation-

CHEMISTRY	GEOLOGY	HYDROLOGY
<ul style="list-style-type: none"> Isopleth maps of soil or water quality (plan or section view) Graphs <ul style="list-style-type: none"> Time series graphs Chemical versus chemical and inter-well and intra-well Concentration versus position Summary of statistics Trilinear Piper & Stiff diagrams User alerts <ul style="list-style-type: none"> When QA/QC results fall outside data quality objectives When sample results fall outside historical ranges When sample results exceed applicable regulatory standards Sample Tracking; Electronic Lab Interface Presentation-quality data tables 	<ul style="list-style-type: none"> Completely customizable boring logs Geologic cross-section maps Isopach maps Structure maps Presentation-quality data tables <p style="text-align: center;">ALL MODULES:</p> <ul style="list-style-type: none"> GIS\Key Scout™ Interface Independent management of metadata Multi-site management capability Integration between data types Smart Query™ Data Retrieval 3D Modeling, Statistics, GIS Integration 	<ul style="list-style-type: none"> Density-corrected water level, floating product, hydraulic conductivity, and contour maps Water elevation and floating product thickness versus time graphs Flow versus time and chemical flux graphs Presentation-quality data tables <p style="text-align: center;">SYSTEM REQUIREMENTS:</p> <ul style="list-style-type: none"> Hardware: Pentium Class PC 32 MB RAM Operating System: Windows 95/98 or Windows NT

GIS\Key™ Environmental Data Management System Outputs

quality and meet RCRA and CERCLA reporting requirements. GIS\Key™ software provides a three level data validation system which includes 1) sample tracking by custody, sample ID and/or date and time, 2) an electronic laboratory import program that immediately finds, and helps the user fix, quality control (QC) problems with the laboratory data delivery and 3) a series of “User Alert” reports which find data that falls outside of project QC objectives, historical data ranges, or above federal, state, and local or project specific action levels.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1992. The demonstration was held in August 1993 in San Francisco, California, and December 1993 in Washington, DC. The Demonstration Bulletin (EPA/540/MR-94/505), Technology Capsule (EPA/540/SR-94/505), Innovative Technology Evaluation Report (EPA/540/R-94/505), and project videotape are available from EPA.

DEMONSTRATION RESULTS:

The GIS\Key™ software is in use at several Superfund sites including the Crazyhorse site near Salinas, California, and the Moffett Field site near San Jose, California. The U.S. Air Force’s Environmental Data Management and Decision Support working group has successfully tested the effectiveness of the GIS\Key™ technology at Norton Air Force Base in California. The technology is also being used by consultants at over 30 other U.S. Air Force and Department of Energy facilities.

Results from the SITE demonstration indicated that the GIS\Key™ software generated the four types of contour maps necessary to assist in groundwater mapping: hydrogeologic maps, chemical concentration isopleths, geologic structure maps, and geologic structure thickness isopach maps.

Several advanced chemistry reports and construction and borehole summary tables were also automatically prepared using customized GIS\Key™ menu commands. The system automated well and borehole logs based on the information contained in the database. GIS\Key™ provided several editable reference lists, including a list of regulatory thresholds, test methods, and a list of chemical names, aliases, and registry numbers. The GIS\Key™ database menu provided commands for electronic database import and export. Any of the database files used by GIS\Key™ can be used with the general import and export commands available in the database menu.

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GRACE BIOREMEDIATION TECHNOLOGIES (DARAMEND™ Bioremediation Technology)

TECHNOLOGY DESCRIPTION:

The GRACE Bioremediation Technologies organic amendment-enhanced bioremediation technology (DARAMEND™) is designed to degrade many organic contaminants in industrial soils and sediments, including pentachlorophenol (PCP), polynuclear aromatic hydrocarbons (PAHs), and petroleum hydrocarbons. The technology has been applied both in situ and ex situ. In either case, soil may be treated in lifts up to 2 feet deep using available mixing equipment. The technology may also be applied ex situ, as a biopile.

The technology treats batches of soil using DARAMEND™ soil amendments. These amendments are introduced using conventional agricultural equipment (see photograph below), followed by regular tilling and irrigation. DARAMEND™ soil amendments are solid-phase products prepared from natural organic materials to have soil-specific particle size distribution, nutrient content, and nutrient releases kinetics. Soil amendments sharply increase the ability of the soil

matrix to supply water and nutrients to the microorganisms that degrade the hazardous compounds. The amendments can also transiently bind contaminants, reducing the acute toxicity of the soil aqueous phase. This reduction allows microorganisms to survive in soils containing very high concentrations of toxic compounds.

DARAMEND™ treatment involves three fundamental steps. First, the treatment area is prepared. For the ex situ application, a lined treatment cell is constructed. In situ application requires the treatment area to be cleared and ripped to reduce soil compaction. Second, the soil is pretreated; this includes removing debris larger than 4 inches, such as metal or rocks, that may damage the tilling equipment. Sediments under-going treatment must be dewatered. And third, the DARAMEND™ soil amendment is incorporated, usually at 1 percent to 5 percent by weight, followed by regular tilling and irrigating.

Soil is tilled with a rotary tiller to reduce variation in soil properties and contaminant concentrations. Tilling also incorporates the required soil



DARAMEND™ Bioremediation Technology

amendments and helps deliver oxygen to contaminant-degrading microorganisms.

An irrigation system is used to maintain soil moisture in the desired range. If the treatment area is not covered, leachate or surface runoff caused by heavy precipitation is collected and reapplied to the soil as needed.

Equipment needed to implement this technology includes a rotary tiller, irrigation equipment, and excavation and screening equipment. Depending on site-specific factors such as contaminant type and initial concentration, and project schedule and climate, a waterproof cover may be constructed over the treatment area.

WASTE APPLICABILITY:

The DARAMEND™ technology can treat soil, sediment, and other solid wastes such as lagoon sludge. These matrices may be contaminated by a wide range of organic compounds including, but not limited to, PAHs, PCP, petroleum hydrocarbons, and phthalates. Matrices of lead, manganese, and zinc have been effectively treated with the DARAMEND™ technology.

STATUS:

This technology was accepted into the SITE Demonstration Program in spring 1993. The ex situ application of the technology was demonstrated from fall 1993 to summer 1994 at the Domtar Wood Preserving facility in Trenton, Ontario, Canada. The demonstration was one component of a 5,000-ton remediation project underway at the site.

Currently, the DARAMEND™ technology has received regulatory approval, and has been applied at field-scale at five sites in the United States. These sites include the full-scale treatment of PCP impacted soil in Montana, Washington, and Wisconsin, the full-scale treatment of phthalate impacted soil in New Jersey and a pilot-scale demonstration of toxaphene impacted soil in South

Carolina. In addition, the technology has been applied at a number of Canadian sites including a 2,500 tonne biopile in New Brunswick, and two pilot-scale projects targeting pesticides and herbicides in Ontario. The first full-scale application to soil containing organic explosives was scheduled for late 1998.

DEMONSTRATION RESULTS:

In the ex situ demonstration area, the DARAMEND™ technology achieved the following overall reductions: PAHs, 94 percent (1,710 milligram/kilogram [mg/kg] to 98 mg/kg); chlorophenols, 96 percent (352 mg/kg to 13.6 mg/kg); and total petroleum hydrocarbons (TPH), 87 percent. These reductions were achieved in 254 days of treatment, including winter days when no activity occurred because of low soil temperatures. The control area showed a reduction of 41 percent in PAH concentrations; no reduction was seen in the concentration of either chlorinated phenols or TPH during the treatment time. Results from the toxicity analysis (earthworm mortality and seed germination) showed that the toxicity was eliminated or greatly reduced in the treated soil.

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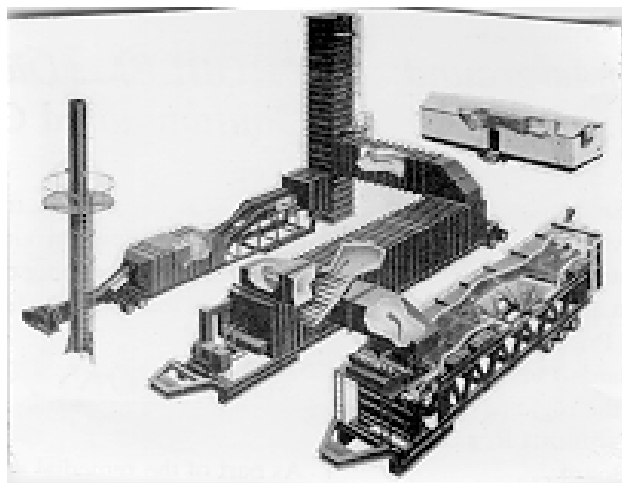
GRUPPO ITALIMPRESSE
(Developed by Shirco Infrared Systems, Inc.)
(formerly Ecova Europa)
(Infrared Thermal Destruction)

TECHNOLOGY DESCRIPTION:

The infrared thermal destruction technology is a mobile thermal processing system that uses electrically powered silicon carbide rods to heat organic wastes to combustion temperatures. Any remaining combustibles are incinerated in an afterburner. One configuration for this mobile system (see figure below) consists of four components: (1) an electric-powered infrared primary chamber; (2) a gas-fired secondary combustion chamber; (3) an emissions control system; and (4) a control center.

Waste is fed into the primary chamber and exposed to infrared radiant heat (up to 1,850°F) provided by silicon carbide rods above the conveyor belt. A blower delivers air to selected locations along the belt to control the oxidation rate of the waste feed.

The ash material in the primary chamber is quenched with scrubber water effluent. The ash is then conveyed to an ash hopper, where it is removed to a holding area and analyzed for organic contaminants such as polychlorinated biphenyls (PCBs).



Mobile Thermal Processing System

Volatile gases from the primary chamber flow into the secondary chamber, which uses higher temperatures, greater residence time, turbulence, and supplemental energy (if required) to destroy these gases. Gases from the secondary chamber are ducted through the emissions control system. In the emissions control system, the particulates are removed in a venturi scrubber. Acid vapor is neutralized in a packed tower scrubber. An induced draft blower draws the cleaned gases from the scrubber into the free-standing exhaust stack. The scrubber liquid effluent flows into a clarifier, where scrubber sludge settles and is removed for disposal. The liquid then flows through an activated carbon filter for reuse or to a publicly owned treatment works for disposal.

This technology is suitable for soils or sediments with organic contaminants. Liquid organic wastes can be treated after mixing with sand or soil. Optimal waste characteristics are as follows:

- Particle size, 5 microns to 2 inches
- Moisture content, up to 50 percent by weight
- Density, 30 to 130 pounds per cubic foot
- Heating value, up to 10,000 British thermal units per pound
- Chlorine content, up to 5 percent by weight
- Sulfur content, up to 5 percent by weight
- Phosphorus, 0 to 300 parts per million (ppm)
- pH, 5 to 9
- Alkali metals, up to 1 percent by weight

STATUS:

EPA conducted two evaluations of the infrared thermal destruction technology. A full-scale unit was evaluated during August 1987 at the Peak Oil Superfund site in Brandon, Florida. The system treated nearly 7,000 cubic yards of waste oil sludge containing PCBs and lead. A pilot-scale demonstration took place at the Rose Township-Demodé Road Superfund site in Michigan during November 1987. Organics, PCBs, and metals in soil were the target waste compounds. Two Applications Analysis Reports (EPA/540/A5-89/010 and EPA/540/ A5-89/007) and two Technology Evaluation Reports (EPA/540/5-88/002a and EPA/540/ 5-89/007a) are available from EPA. In addition, the technology has been used to remediate PCB contamination at the Florida Steel Corporation and the LaSalle Electric Superfund sites.

This technology is no longer available through vendors in the United States. For further information about the technology, contact the EPA Project Manager.

DEMONSTRATION RESULTS:

The results from the two SITE demonstrations are summarized below.

- PCBs were reduced to less than 1 ppm in the ash, with a destruction removal efficiency (DRE) for air emissions greater than 99.99 percent (based on detection limits).
- In the pilot-scale demonstration, the Resource Conservation and Recovery Act standard for particulate emissions (0.08 gram per dry standard cubic foot) was achieved. In the full-scale demonstration, however, this standard was not met in all runs because of scrubber inefficiencies.

- Lead was not immobilized; however, it remained in the ash. Significant amounts were not transferred to the scrubber water or emitted to the atmosphere.
- The pilot-scale unit demonstrated satisfactory performance with high feed rate and reduced power consumption when fuel oil was added to the waste feed and the primary chamber temperature was reduced.
- Economic analysis suggests an overall waste remediation cost of less than \$800 per ton.

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HIGH VOLTAGE ENVIRONMENTAL APPLICATIONS, INC.

(formerly Electron Beam Research Facility, Florida
International University, and University of Miami)
(High-Energy Electron Irradiation)

High-voltage electron irradiation of water produces a large number of reactive chemical species, including the aqueous electron (e_{aq}^-), the hydrogen radical ($H\cdot$), and the hydroxyl radical ($OH\cdot$). These short-lived intermediates break down organic contaminants in aqueous wastes.

In the principal reaction, the aqueous electron transfers to halogen-containing compounds, breaking the halogen-carbon bond and liberating halogen anions such as chloride (Cl^-) or bromide (Br^-). The hydroxyl radical can undergo addition or hydrogen abstraction reactions, producing organic free radicals that decompose in the presence of other hydroxyl radicals and water. In most cases, organics are converted to carbon dioxide, water, and salts. Lower molecular weight aldehydes, haloacetic acids, and carboxylic acids form at low concentrations in some cases.

During the high-voltage electron irradiation process, electricity generates high energy electrons. The electrons are accelerated by the voltage to approximately 95 percent of the speed of light. They are then directed into a thin stream of water or sludge. All reactions are complete in less than 0.1 second. The electron beam and waste flow are adjusted to deliver the necessary dose of electrons. Although this is a form of ionizing radiation, there is no residual radioactivity.

High Voltage Environmental Applications, Inc. (High Voltage), has developed a mobile facility to demonstrate the treatment process (see photograph below).



The Mobile Electron Beam Hazardous Waste Treatment System

WASTE APPLICABILITY:

This treatment process can effectively treat more than 100 common organic compounds. These compounds include the following:

- Trihalomethanes (such as chloroform), which are found in chlorinated drinking water
- Chlorinated solvents, including carbon tetrachloride, trichloroethane, tetrachloroethene (PCE), trichloroethene (TCE), ethylene dibromide, dibromo-chloropropane, hexachlorobutadiene, and hexachloroethane
- Aromatics found in gasoline, including benzene, toluene, ethylbenzene, and xylene (BTEX)
- Chlorobenzene and dichlorobenzenes
- Phenol
- Dieldrin, a persistent pesticide
- Polychlorinated biphenyls
- A variety of other organic compounds

The treatment process is appropriate for removing various hazardous organic compounds from aqueous waste streams and sludges. The high-energy electron irradiation process was accepted into the SITE Emerging Technology Program (ETP) in June 1990. For further information on the pilot-scale facility evaluated under the ETP, refer to the Emerging Technology Bulletins (EPA/540/F-93/502, EPA/540/F-92/009, and EPA/540/F-93/509), which are available from EPA. Based on results from ETP, the process was invited to participate in the Demonstration Program.

The ability of the technology to treat contaminated soils, sediments, or sludges is also being evaluated under the ETP. For further information on this evaluation, refer to the the High Voltage profile in the ETP section (ongoing projects).

The treatment process was demonstrated at the U.S. Department of Energy's Savannah River site in Aiken, South Carolina during two different periods totaling 3 weeks in September and November 1994. A trailer-mounted treatment system was demonstrated on a portion of the Savannah River site known as M-Area.

DEMONSTRATION RESULTS:

During the demonstration, the system treated about 70,000 gallons of M-Area groundwater contaminated with volatile organic compounds (VOC). The principal groundwater contaminants were TCE and PCE, which were present at concentrations of about 27,000 and 11,000 micrograms per liter ($\mu\text{g/L}$), respectively. The groundwater also contained low levels of cis-1,2-dichloroethene (40 $\mu\text{g/L}$). The following compounds were also spiked into the influent stream at approximately 500 $\mu\text{g/L}$: 1,2-dichloroethane, carbon tetrachloride, 1,1,1-trichloroethane, chloroform, and BTEX.

The highest VOC removal efficiencies were observed for TCE (99.5 percent), PCE (99.0 percent), and dichloroethene (greater than 99 percent). Removal efficiencies for chlorinated spiking compounds ranged from 68 to 98 percent, and removal efficiencies for BTEX ranged from 88 to 99.5 percent.

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HORSEHEAD RESOURCE DEVELOPMENT CO., INC. (Flame Reactor)

TECHNOLOGY DESCRIPTION:

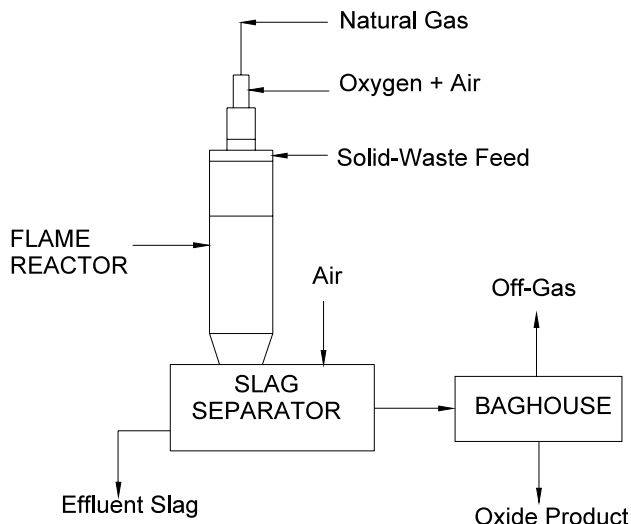
The Horsehead Resource Development Co., Inc. (HRD), flame reactor system is a patented, hydrocarbon-fueled, flash-smelting system that treats residues and wastes contaminated with metals (see figure below). The reactor processes wastes with hot (greater than 2,000°C) reducing gases produced by combusting solid or gaseous hydrocarbon fuels in oxygen-enriched air.

In a compact, low-capital cost, water-cooled reactor, the feed materials react rapidly, allowing a high waste throughput. The end products are glass-like slag; a potentially recyclable, heavy metal-enriched oxide; and in some cases, a metal alloy. The glass-like slag is not toxicity characteristic leaching procedure (TCLP) leachable. The volatile metals are fumed and captured in a baghouse; nonvolatile metals partition to the slag or may be separated as a molten alloy. Organic compounds should be destroyed at the elevated temperature of the flame reactor technology. Volume reduction (of waste to slag plus oxide) depends on the chemical and physical properties of the waste.

In general, the system requires that wastes be dry enough (less than 5 percent total moisture) to be pneumatically fed and fine enough (less than 200 mesh) to react rapidly. HRD claims larger particles (up to 20 mesh) can be processed; however, the efficiency of metals recovery is decreased. The prototype system has a capacity of 1 to 3 tons per hour. According to HRD, individual units can be scaled to a capacity of 7 tons per hour.

WASTE APPLICABILITY:

The flame reactor system can be applied to granular solids, soil, flue dusts, slags, and sludges that contain heavy metals. HRD claims that the flame reactor technology has successfully treated the following wastes: (1) electric arc furnace dust, (2) lead blast furnace slag, (3) soil, (4) iron residues, (5) primary copper flue dust, (6) lead smelter nickel matte, (7) zinc plant leach residues and purification residues, (8) brass mill dusts and fumes, and (9) electroplating sludges.



HRD Flame Reactor Process Flow

The system has treated wastes with the following metal species and concentrations: zinc (up to 40 percent); lead (up to 10 percent); chromium (up to 4 percent); cadmium (up to 3 percent); arsenic (up to 1 percent); copper (up to 8 percent); cobalt; and nickel. According to HRD, the system can also treat soils that are contaminated with a variety of toxic organics.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1990. Currently, the prototype flame reactor system operates as a stationary unit at HRD's facility in Monaca, Pennsylvania. EPA and HRD believe that a mobile system could be designed and constructed for on-site treatment of hazardous waste.

The SITE demonstration was conducted in March 1991 using secondary lead smelter soda slag from the National Smelting and Refining Company (NSR) Superfund site in Atlanta, Georgia. The demonstration was conducted at the Monaca, Pennsylvania facility under a Resource Conservation and Recovery Act research, development, and demonstration permit. This permit allows treatment of wastes containing high concentrations of metals, but only negligible concentrations of organics.

The major objectives of the SITE technology demonstration were to investigate the reuse potential of the recovered metal oxides, evaluate the levels of contaminants in the residual slag and their leaching potential, and determine the efficiency and economics of processing.

A 30,000-standard-tons-per-year commercial flame reactor system processes steel mill baghouse dust (K061) at the North Star Steel Mini Mill near Beaumont, Texas. The plant was activated June 1, 1993, and is reported to be performing as designed.

DEMONSTRATION RESULTS:

Approximately 72 tons of NSR waste material were processed during the demonstration. Partial test results are shown in the table below.

Metal Concentration Ranges in Influent and Effluent			
	Waste Feed (mg/kg)*	Effluent Slag (mg/kg)	Oxide Product (mg/kg)
Arsenic	428-1,040	92.1-1,340	1,010-1,170
Cadmium	356-512	<2.3-13.5	1,080-1,380
Copper	1,460-2,590	2,730-3,890	1,380-1,780
Iron	95,600-130,000	167,000-228,000	29,100-35,600
Lead	48,200-61,700	1,560-11,400	159,000-184,000
Zinc	3,210-6,810	709-1,680	10,000-16,200

* milligrams per kilogram

All effluent slag passed toxicity characteristic leaching procedure criteria. The oxide was recycled to recover lead. The Technology Evaluation Report (EPA/540/5-91/005) and the Applications Analysis Report (EPA/540/A5-91/005) are available from EPA.

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HRUBETZ ENVIRONMENTAL SERVICES, INC. (HRUBOUT® Hot Air Injection Process)

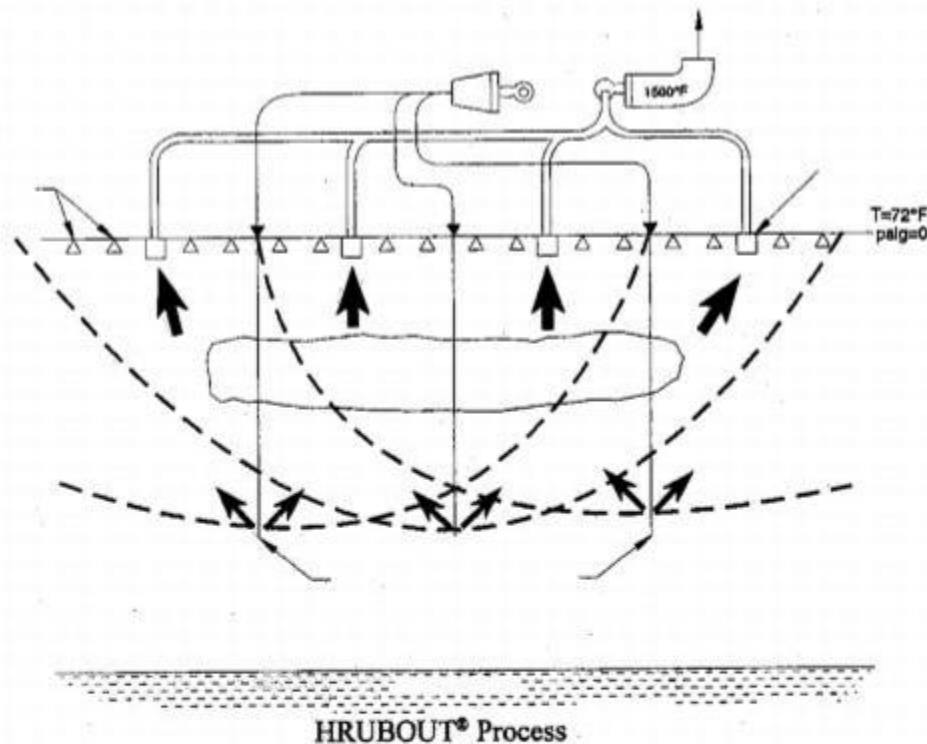
TECHNOLOGY DESCRIPTION:

The HRUBOUT® process is a thermal, in situ and ex situ treatment process designed to remove volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) from contaminated soils. The in situ process is shown in the figure below. Heated air is injected into the soil below the contamination zone, evaporating soil moisture and removing volatile and semivolatile hydrocarbons. As the water evaporates, soil porosity and permeability increase, further facilitating the air flow at higher temperatures. As the soil temperature increases, the less volatile constituents volatilize or are thermally oxidized.

Injection wells are drilled in a predetermined distribution pattern to depths below the contamination zone. The wells are equipped with steel casings, perforated at the bottom, and cemented into the hole above the perforations.

Heated, compressed air is introduced at temperatures of up to 1,200 °F, and the pressure is slowly increased. As the air progresses upward through the soil, the moisture is evaporated, removing the VOCs and SVOCs. A surface collection system captures the exhaust gases under negative pressure. These gases are transferred to a thermal oxidizer, where the hydrocarbons are thermally destroyed in an incinerator at a temperature of 1,500°F.

The air is heated in an adiabatic burner at 2.9 million British thermal units per hour (MMBtu/hr). The incinerator has a rating of 3.1 MMBtu/hr. The air blower can deliver up to 8,500 pounds per hour. The units employ a fully modulating fuel train that is fueled by natural gas or propane. All equipment is mounted on custom-designed mobile units and can operate 24 hours per day.



HRUBETZ ENVIRONMENTAL SERVICES, INC. (HRUBOUT® Hot Air Injection Process)

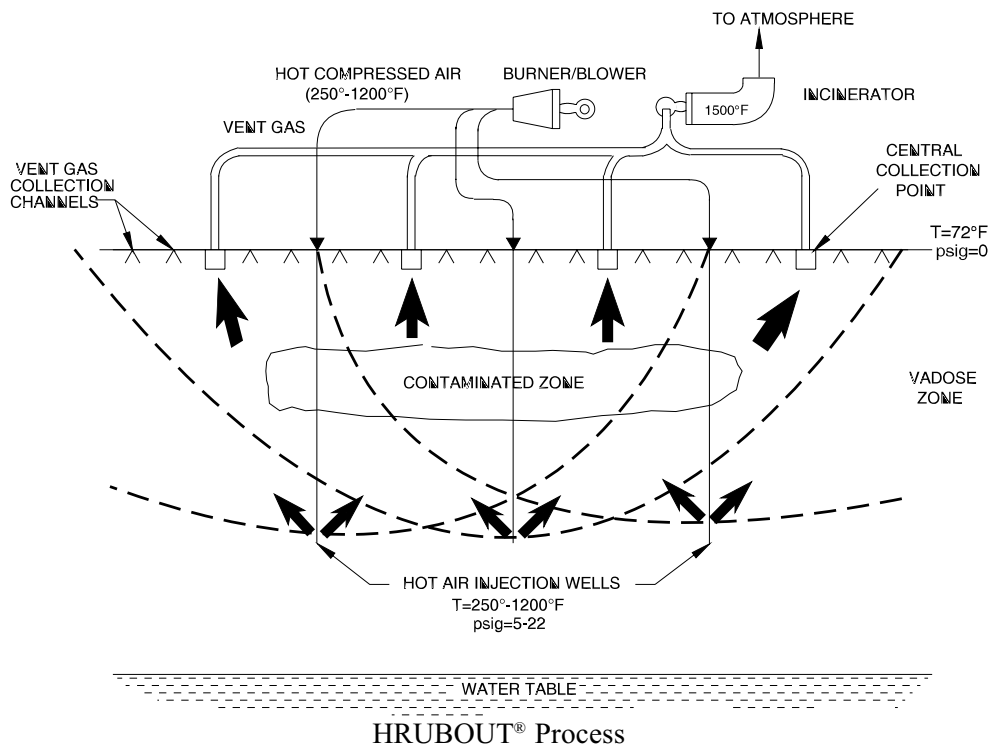
TECHNOLOGY DESCRIPTION:

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WASTE APPLICABILITY:

The HRUBOUT® process can remediate soils contaminated with halogenated or nonhalogenated organic volatiles and semivolatiles, such as gasoline, diesel oil, jet fuel, heating oil, chemical solvents, or other hydrocarbon compounds.

STATUS:

The HRUBOUT® process was accepted into the SITE Demonstration Program in July 1992. The technology was demonstrated at Kelly Air Force Base in San Antonio, Texas from January through February 1993. A 30-foot by 40-foot area of an 80,000-gallon JP-4 jet fuel spill site was chosen as the treatment area. Six heated air injection wells, spaced on a 3-by-2 grid 10 feet apart, were drilled to a depth of approximately 20 feet. The Demonstration Bulletin (EPA/540/MR- 93/524) is available from EPA.

In September 1993, an in situ project was completed at the Canadian Forces military base in Ottawa, Ontario, Canada. Levels up to 1,900 parts per million (ppm) of total petroleum hydrocarbons (TPH) were encountered over a 17-foot by 17-foot area on the base. Five injection wells were drilled to a depth of 30 feet. After 12 days of treatment, borehole samples ranged from nondetect to 215 ppm TPH, meeting closure requirements of 450 ppm TPH.

The containerized version of the HRUBOUT® process was tested in July 1993 at a west Texas site contaminated with Varsol, or naphtha. The soil was excavated for treatment in Hrubetz's insulated container. Analysis of untreated soil revealed TPH at 1,550 ppm. Three loads were treated for about 60 to 65 hours each. Post-treatment samples ranged from nondetect to 7 ppm TPH, meeting the Texas Natural Resource Conservation Commission's background target level of 37 ppm. Large-scale mobile container units, holding up to 40 cubic yards and capable of ex situ treatment of a load in 8 hours, are under development.

The ex situ version of the technology was selected to remediate a site in Toronto, Ontario, Canada, which consisted of about 1,500 cubic yards (yd³) of soil contaminated with gasoline and diesel. Soil contamination was measured at 200 ppm TPH. Following treatment, seven soil samples were collected. Two samples had detectable concentrations of TPH (25 and 37 ppm) and the remaining five samples had nondetectable levels of TPH, achieving the 100 ppm TPH cleanup goal.

About 100 yd³ of toluene-contaminated soil was remediated in Orlando, Florida using the soil pile process with a smaller 5-ton unit. A composite analysis of the excavated soil found toluene at concentrations of up to 1,470 parts per billion; nondetect levels were required for closure. A composite soil sample collected after 96 hours of operation met the closure criteria.

Four patents have been granted, and additional patents are pending. The process was approved by the Texas Natural Resources Conservation Commission in 1991.

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HUGHES ENVIRONMENTAL SYSTEMS, INC.

(Steam Enhanced Recovery Process)

TECHNOLOGY DESCRIPTION:

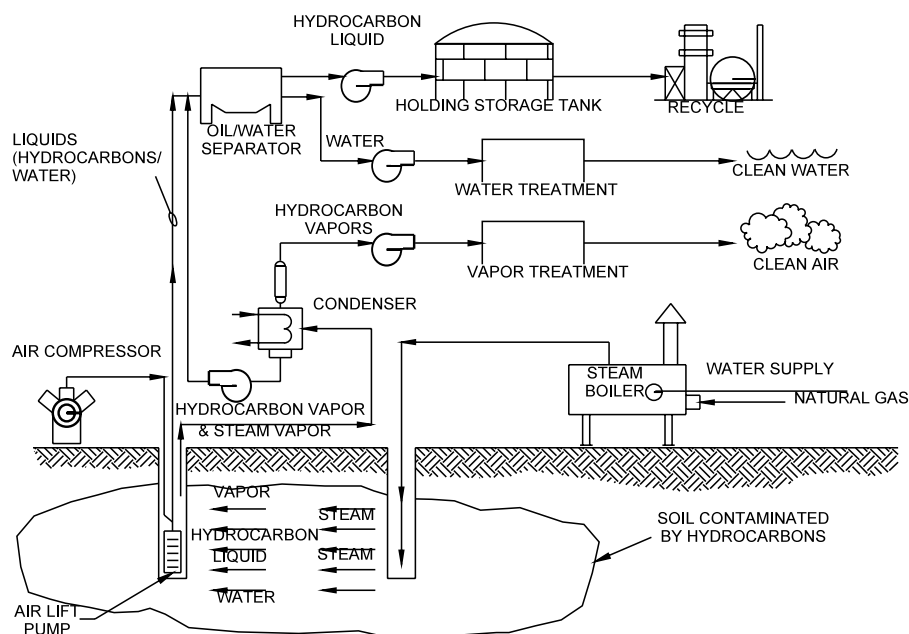
The Steam Enhanced Recovery Process (SERP) removes most volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) from perched groundwater and contaminated soils both above and below the water table (see figure below). The technology is applicable to the in situ remediation of contaminated soils below ground surface and below or around permanent structures. The process accelerates contaminant removal rates and can be effective in all soil types.

Steam is forced through the soil by injection wells to thermally enhance the recovery of VOCs and SVOCs. Extraction wells are used for two purposes: to pump and treat groundwater, and to transport steam and vaporized contaminants to the surface. Recovered nonaqueous liquids are separated by gravity separation. Hydrocarbons are collected for recycling, and water is treated before being discharged to a storm drain or sewer. Vapors can be

condensed and treated by any of several vapor treatment techniques (for example, thermal oxidation and catalytic oxidation). The technology uses readily available components such as extraction and monitoring wells, manifold piping, vapor and liquid separators, vacuum pumps, and gas emission control equipment.

WASTE APPLICABILITY:

The SERP can extract VOCs and SVOCs from contaminated soils and perched groundwater. Compounds suitable for treatment are petroleum hydrocarbons such as gasoline and diesel and jet fuel; solvents such as trichloroethene, trichloroethane, and dichlorobenzene; or a mixture of these compounds. After application of the process, subsurface conditions are excellent for biodegradation of residual contaminants. The process cannot be applied to contaminated soil very near the ground surface unless a cap exists.



Steam Enhanced Recovery Process

STATUS:

This technology was accepted into the SITE Demonstration Program in 1991. The demonstration of the technology began in August 1991 and was completed in September 1993. The demonstration took place in Huntington Beach, California, at a site contaminated by a large diesel fuel spill. The Demonstration Bulletin (EPA/540/MR -94/510), Technology Capsule (EPA/540/R- 94/510a), and Innovative Technology Evaluation Report (EPA/540/R-94/510) are available from EPA.

For more information regarding this technology, see the profiles for Berkeley Environmental Restoration Center (completed projects) or Praxis Environmental Technologies, Inc., in the Demonstration Program section (ongoing profiles).

This technology is no longer available through a vendor. For further information on the technology, contact the EPA Project Manager.

DEMONSTRATION RESULTS:

Evaluation of the posttreatment data suggests the following conclusions:

- The geostatistical weighted average for total petroleum hydrocarbon (TPH) concentrations in the treated soils was 2,290 milligrams per kilogram (mg/kg). The 90 percent confidence interval for this average concentration is 996 mg/kg to 3,570 mg/kg, indicating a high probability that the technology did not meet the cleanup criterion. Seven percent of soil samples had TPH concentrations in excess of 10,000 mg/kg.

- The geostatistical weighted average for total recoverable petroleum hydrocarbon (TRPH) concentrations was 1,680 mg/kg, with a 90 percent confidence interval of 676 mg/kg to 2,680 mg/kg. Levels of benzene, toluene, ethylbenzene, and xylenes (BTEX) were below the detection limit (6 micrograms per kilogram) in treated soil samples; BTEX was detected at low mg/kg levels in a few pretreatment soil samples.
- Analysis of triplicate treated soil samples showed marked variability in soil contaminant concentrations over short distances. Analogous results for TPH and TRPH triplicate samples suggest that the contaminant concentration variability exists within the site soil matrix and is not the result of analytical techniques. This variability is the reason that confidence intervals for the average concentrations are so large.
- The data suggest that lateral or downward migration of contaminants did not occur during treatment.

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IIT RESEARCH INSTITUTE (Radio Frequency Heating)

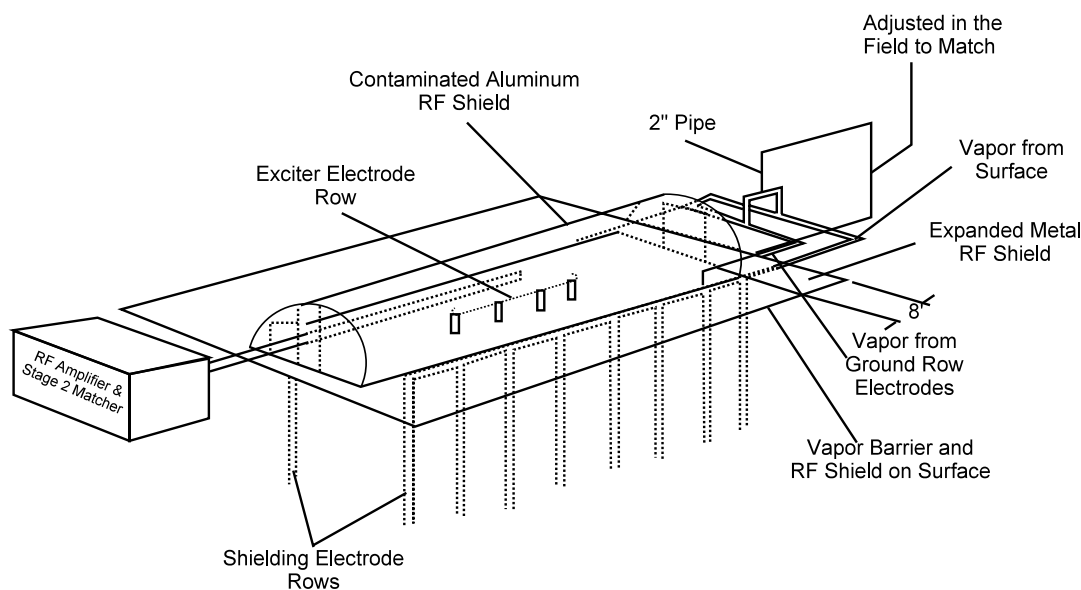
TECHNOLOGY DESCRIPTION:

Radio frequency heating (RFH) is an in situ process that uses electromagnetic energy to heat soil and enhance soil vapor extraction (SVE). Developed by IIT Research Institute, the patented RFH technique heats a discrete volume of soil using rows of vertical electrodes embedded in soil (or other media). Heated soil volumes are bounded by two rows of ground electrodes with energy applied to a third row midway between the ground electrodes. The three rows act as a buried triplate capacitor. When energy is applied to the electrode array, heating begins at the top center and proceeds vertically downward and laterally outward through the soil volume. The technique can heat soils to over 300°C.

RFH enhances SVE in two ways: (1) contaminant vapor pressures are increased by heating, and (2) the soil permeability is increased by drying. Extracted vapor can then be treated by a variety of existing technologies, such as granular activated carbon or incineration.

WASTE APPLICABILITY:

RFH can treat petroleum hydrocarbons, volatile organic compounds, semivolatile organic compounds, and pesticides in soils. The technology is most efficient in subsurface areas with low groundwater recharge. In theory, the technology should be applicable to any polar compound in any nonmetallic media.



In Situ Radio Frequency Heating System

STATUS:

The RFH technique was accepted into the SITE Demonstration Program in summer 1992. The technique was demonstrated in August 1993 at Kelly Air Force Base (AFB), Texas, as part of a joint project with the U.S. Air Force. Brown and Root Environmental was the prime contractor evaluating and implementing RFH for the U.S. Air Force. A field demonstration of the KAI Technologies, Inc. (KAI), RFH technology was completed in June 1994 at the same site for comparison. The Demonstration Bulletin (EPA/540/MR-94/527), Technology Capsule (EPA/540/R-94/527a), and the Innovative Technology Evaluation Report (EPA/540/R-94-527) are available from EPA. For further information on the KAI technology, see the profile in the Demonstration Program section (completed projects).

In 1995, the RFH technique was tested at the former chemical waste landfill at Sandia National Laboratories in Albuquerque, New Mexico. Approximately 800 cubic yards of silty soil was heated. Preliminary results indicate that the contaminant concentration in the extracted vapors increased by a factor of 10 compared to in situ venting.

Two previous field tests were completed using in situ RFH. The first test was completed at a fire training pit, located at the Volk Air National Guard Base in Camp Douglas, Wisconsin. The sandy soil in the pit was contaminated with jet fuel. The second test was completed at Rocky Mountain Arsenal in Colorado, where clayey soil was contaminated by organochlorine pesticides.

DEMONSTRATION RESULTS:

Under the SITE demonstration, statistical analyses for the design treatment zone indicate that total recoverable petroleum hydrocarbons, pyrene, and bis(2-ethylhexyl)phthalate exhibited statistically significant decreases (at the 95 and 97.5 percent confidence levels). Chlorobenzene concentrations appeared to increase during treatment, possibly due to volatilization of chlorobenzene present in the groundwater.

Significant concentrations of 2-hexanone, 4-methyl-2-pentanone, acetone, and methyl ethyl ketone were found in the treated soils, although virtually no ketones were found before treatment. Soil temperatures as high as 1,000°C during the demonstration may have caused partial oxidation of petroleum hydrocarbons. Alternatively, the ketones may have been volatilized from groundwater. At this time, insufficient data are available to determine the source of ketones found in treated soils.

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INTERNATIONAL WASTE TECHNOLOGIES AND GEO-CON, INC.

(In Situ Solidification and Stabilization Process)

TECHNOLOGY DESCRIPTION:

The in situ solidification and stabilization process immobilizes organic and inorganic compounds in wet or dry soils, using reagents (additives) to produce a cement-like mass. The basic components of this technology are (1) Geo-Con, Inc.'s (Geo-Con), deep soil mixing (DSM) system, to deliver and mix the chemicals with the soil in situ; and (2) a batch mixing plant to supply proprietary additives (see figure below).

The proprietary additives generate a complex, crystalline, connective network of inorganic polymers in a two-phase reaction. In the first phase, contaminants are complexed in a fast-acting reaction. In the second phase, macromolecules build over a long period of time in a slow-acting reaction.

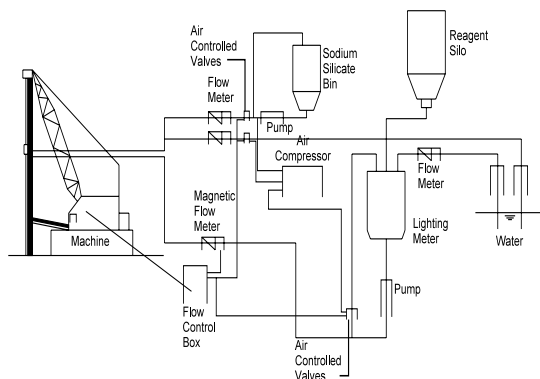
The DSM system involves mechanical mixing and injection. The system consists of one set of cutting blades and two sets of mixing blades attached to a vertical drive auger, which rotates at approximately 15 revolutions per minute. Two conduits in the auger inject the additive slurry and supplemental water. Additives are injected on the downstroke; the slurry is further mixed upon auger withdrawal. The treated soil columns are 36 inches in diameter and are positioned in an overlapping pattern of alternating primary and secondary soil columns.

WASTE APPLICABILITY:

The process treats soils, sediments, and sludge-pond bottoms contaminated with organic compounds and metals. The process has been laboratory-tested on soils containing polychlorinated biphenyls (PCBs), pentachlorophenol, refinery wastes, and chlorinated and nitrated hydrocarbons.

STATUS:

A SITE demonstration was conducted as a joint effort between International Waste Technologies (IWT) and Geo-Con. The demonstration was conducted at the General Electric Service Shop site in Hialeah, Florida in April 1988. IWT provided the treatment reagent, specifically the proprietary additive (HWT-20), and Geo-Con provided both engineering and hardware for the in situ soil treatment. Two 10-by-20-foot areas were treated — one to a depth of 18 feet, and the other to a depth of 14 feet. Ten months after the demonstration, long-term monitoring tests were performed on the treated sectors. A four-auger process was later used to remediate the PCB-contaminated Hialeah site during the winter and spring of 1990. Cooperative efforts between Geo-Con and IWT ended with the remediation of the Hialeah site.



In Situ Solidification and Stabilization Process Flow Diagram

Presently, Geo-Con offers the entire in situ stabilization package, including the treatment chemicals. Geo-Con has used the process to complete over 40 in situ stabilization projects throughout the United States. Significant projects completed to date include the following:

- Construction of a 110,000-square-foot, 60-foot-deep, soil-bentonite DSM wall to contain contaminated groundwater from a former waste pond. All DSM permeabilities were less than 10^{-7} centimeters per second (cm/s).
- Shallow soil mixing and stabilization of 82,000 cubic yards of contaminated soils at a former manufactured gas plant site. The site was declared clean and ultimately converted to a city park.

The DSM system augers have been scaled up to diameters as large as 12 feet. To date, Geo-Con has used this process to treat over 1 million cubic yards of contaminated soils and sludges.

DEMONSTRATION RESULTS:

The SITE demonstration yielded the following results:

- PCB immobilization appeared likely, but could not be confirmed because of low PCB concentrations in the untreated soil. Leachate tests on treated and untreated soil samples showed mostly undetectable PCB levels. Leachate tests performed 1 year later on treated soil samples showed no increase in PCB concentrations, indicating immobilization.
- Data were insufficient to evaluate the system's performance on other organic compounds and metals.
- Each test sample showed high unconfined compressive strength (UCS), low permeability, and low porosity. These physical properties improved in samples retested 1 year later, indicating the potential for long-term durability.

- Bulk density of the soil increased 21 percent after treatment. This treatment increased the treated soil volume by 8.5 percent and caused a small ground rise of 1 inch per foot of treated soil.
- The UCS of treated soil was satisfactory, with values up to 1,500 pounds per square inch.
- The permeability of the treated soil was satisfactory, decreasing to 10^{-6} and 10^{-7} cm/s compared to 10^{-2} cm/s for untreated soil.
- Data were insufficient to confirm immobilization of volatile and semivolatile organics. This may be due to organophilic clays present in the reagent.
- Process costs were \$194 per ton for the 1-auger machine used in the demonstration, and \$111 per ton for a commercial four-auger operation. More recent experience with larger scale equipment reduced process costs to about \$15 per ton plus the cost of reagents. The Technology Evaluation Report (EPA/540/5-89/004a) and the Applications Analysis Report (EPA/540/A5-89/004) are available from EPA.

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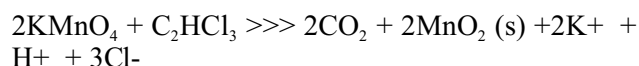
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IT CORPORATION

KMnO₄ (Potassium Permanganate) Oxidation of TCE

TECHNOLOGY DESCRIPTION:

In situ chemical oxidation using potassium permanganate is a potentially fast and low cost solution for the destruction of a broad range of organic compounds, including chlorinated ethylenes and polycyclic aromatic hydrocarbons. This oxidation technology involves injecting a potassium permanganate solution that reacts with volatile organic compounds (VOCs) to form nontoxic by-products such as carbon dioxide, manganese dioxide, and chloride ions. The chemical reaction is as follows:

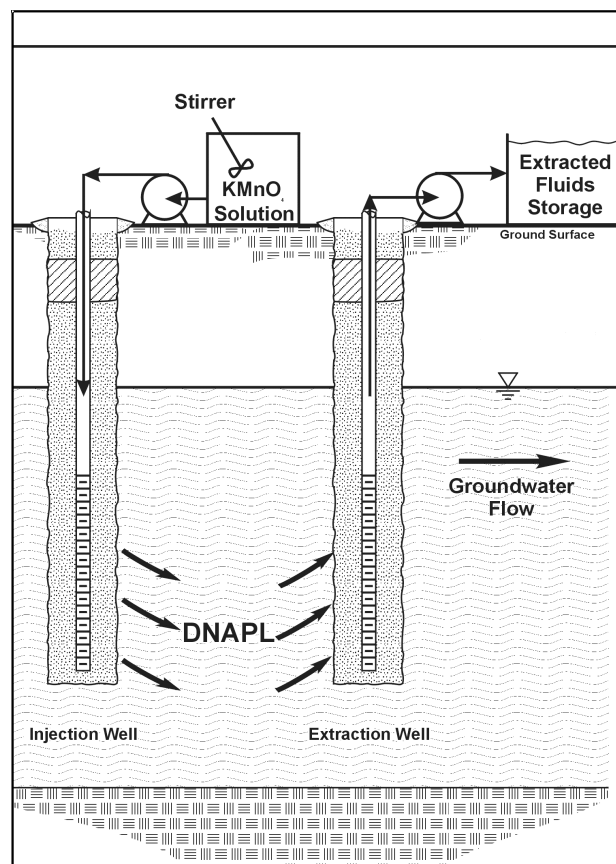


Oxidation using potassium permanganate involves cleavage of carbon-carbon bonds often facilitated by free-radical oxidation mechanisms. The impact of organic matter that will consume the oxidant can be significant and must be considered during the technology selection process at each specific site. In the absence of organic matter, the reaction is second ordered and the rate is governed by the concentration of both TCE and MnO₄⁻ ions.

Several injection points spread throughout the plot will be used to deliver the KMnO₄ to the subsurface. A few centrally located groundwater recovery wells, each screened in different lithologic units, will facilitate flow and extract the injected fluids and groundwater.

WASTE APPLICABILITY:

Potassium permanganate reacts effectively with the double bonds in chlorinated ethylenes such as trichloroethylene, perchloroethylene, dichloroethylene isomers, and vinyl chloride. It is effective for remediation of DNAPL, adsorbed phase and dissolved phase contaminants, and produces innocuous breakdown products, such as carbon dioxide, chloride ions and manganese dioxide.



Conceptual Illustration of In Situ Oxidation Technology

STATUS:

IT Corporation injected potassium permanganate from 20 points across 15 two-foot intervals to a depth of 45 feet in a 50- × 75-foot test cell. These injection intervals encompass three lithologic zones, consisting of a layered mix of sand, shell hash, silts, sandy clays and clay lenses. Permanganate solution, at concentrations of one to three percent, was prepared in an automated feed system and pumped under pressure to each point. This solution is easily handled, mixed and injected, and is nonhazardous.

DEMONSTRATION RESULTS:

The demonstration treatment effectiveness was evaluated by EPA as part of the Superfund Innovative Technology Evaluation (SITE) Program. The total reduction in TCE mass within the oxidation cell was calculated through collection and analysis of soil cores from 12 soil borings with over 192 discrete sample intervals analyzed for TCE. Sampling was performed before treatment and one month after treatment. The results show that the mass of TCE in the oxidation cell was reduced by 82%. DNAPL concentrations (defined as any TCE soil concentration greater than 300 mg/kg) were reduced by as much as 84%. The TCE concentrations were reduced to nondetectable levels at 85 of the 192 sample intervals from initial soil concentrations as high as 10,500 mg/kg. As permanganate was still present throughout the cell during the posttreatment sampling effort, additional TCE reductions may occur. The test results clearly show that the technology was effective in the reduction of TCE (dissolved, absorbed phase and DNAPL).

The posttreatment soil data could be used to target an additional application of permanganate to the remaining TCE areas for full cell reductions to nondetectable levels. A cost model for prediction of the project costs for application of permanganate at other facilities has been prepared and is available for use at other sites.

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IT CORPORATION
(formerly OHM Remediation Services Corp.,
formerly Chemical Waste Management, Inc.)
(X*TRAX™ Thermal Desorption)

TECHNOLOGY DESCRIPTION:

The X*TRAX™ technology is a patented thermal desorption process that removes organic contaminants from soils, sludges, and other solid media (see photograph below). X*TRAX™ is not, however, an incinerator or a pyrolysis system. Chemical oxidation and reactions are discouraged by maintaining an inert environment and low treatment temperatures. Combustion by-products are not formed in X*TRAX™, as neither a flame nor combustion gases are present in the desorption chamber.

The organic contaminants are removed as a condensed liquid, which is characterized by a high heat rating. This liquid may then be destroyed in a permitted incinerator or used as a supplemental fuel. Low operating temperatures of 400 to 1,200°F and low gas flow rates optimize treatment of contaminated media.

An externally fired rotary dryer volatilizes the water and organic contaminants from the contaminated media into an inert carrier gas stream. The inert nitrogen carrier gas transports the organic

contaminants and water vapor out of the dryer. The carrier gas flows through a duct to the gas treatment system, where organic vapors, water vapors, and dust particles are removed and recovered. The gas first passes through a high-energy scrubber, which removes dust particles and 10 to 30 percent of the organic contaminants. The gas then passes through two condensers in series, where it is cooled to less than 40°F.

Most of the carrier gas is reheated and recycled to the dryer. About 5 to 10 percent of the gas is separated from the main stream, passed through a particulate filter and a carbon adsorption system, and then discharged to the atmosphere. This discharge allows addition of make-up nitrogen to the system to keep oxygen concentrations below 4 percent (typically below 1 percent). The discharge

also helps maintain a small negative pressure within the system and prevents potentially contaminated gases from leaking. The volume of gas released from this process vent is approximately 700 times less than from an equivalent capacity incinerator.



WASTE APPLICABILITY:

The X*TRAX™ process has been used to treat solids contaminated with the following wastes: polychlorinated biphenyls (PCB); halogenated and nonhalogenated solvents; semivolatile organic compounds, including polynuclear aromatic hydrocarbons, pesticides, and herbicides; fuel oils; benzene, toluene, ethylbenzene, and xylene; and mercury.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1989. The demonstration was conducted in May 1992 at the Re-Solve, Inc., Superfund site in Massachusetts. After the demonstration, the full-scale X*TRAX™ system, Model 200, remediated 50,000 tons of PCB-contaminated soil at the site. The Demonstration Bulletin (EPA/540/MR-93/502), which details results from the demonstration, is available from EPA.

The full-scale system, Model 200, is presently operating at the Sangamo-Weston Superfund site in South Carolina. More than 45,000 tons of PCB-contaminated soil, clay, and sludge have been thermally treated at this site. Feed material with PCB concentrations of more than 8,800 milligrams per kilogram (mg/kg) has been successfully treated to produce (discharge) PCB levels of less than 2 mg/kg. PCB removal efficiency was demonstrated to be greater than 99.97 percent.

Laboratory-, pilot-, and full-scale X*TRAX™ systems are available. Two laboratory-scale, continuous pilot systems are available for treatability studies. More than 108 tests have been completed since January 1988.

DEMONSTRATION RESULTS:

During the SITE demonstration, X*TRAX™ removed PCBs from feed soil and met the site-specific treatment standard of 25 mg/kg for treated soils. PCB concentrations in all treated soil samples were less than 1.0 mg/kg and were reduced from an average of 247 mg/kg in feed soil to an average of 0.13 mg/kg in treated soil. The average PCB removal efficiency was 99.95 percent.

Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans were not formed within the X*TRAX™ system. Organic air emissions from the X*TRAX™ process vent were negligible (less than 1 gram per day). PCBs were not detected in vent gases.

X*TRAX™ removed other organic contaminants from feed soil. Concentrations of tetrachloroethene, total recoverable petroleum hydrocarbons, and oil and grease were reduced to below detectable levels in treated soil. Metals concentrations and soil physical properties were not altered by the X*TRAX™ system.

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KAI TECHNOLOGIES, LLC. (Radio Frequency Heating)

TECHNOLOGY DESCRIPTION:

Radio frequency heating (RFH) is an in situ process that uses electromagnetic energy to heat soil and enhance bioventing and soil vapor extraction (SVE). The patented RFH technique, developed by KAI Technologies, Inc. (KAI), uses an antenna-like applicator inserted in a single borehole to heat a volume of soil. Large volumes of soil can be treated by RFH employing a control system and an array of applicators. When energy is applied by the applicator to the soil, heating begins near the borehole and proceeds radially outward. This technique can achieve soil temperatures from just above ambient to over 250°C.

RFH enhances SVE in two ways: (1) contaminant vapor pressures are increased by heating; and (2) soil permeability is increased by drying. Extracted vapor can then be treated by a variety of existing technologies.

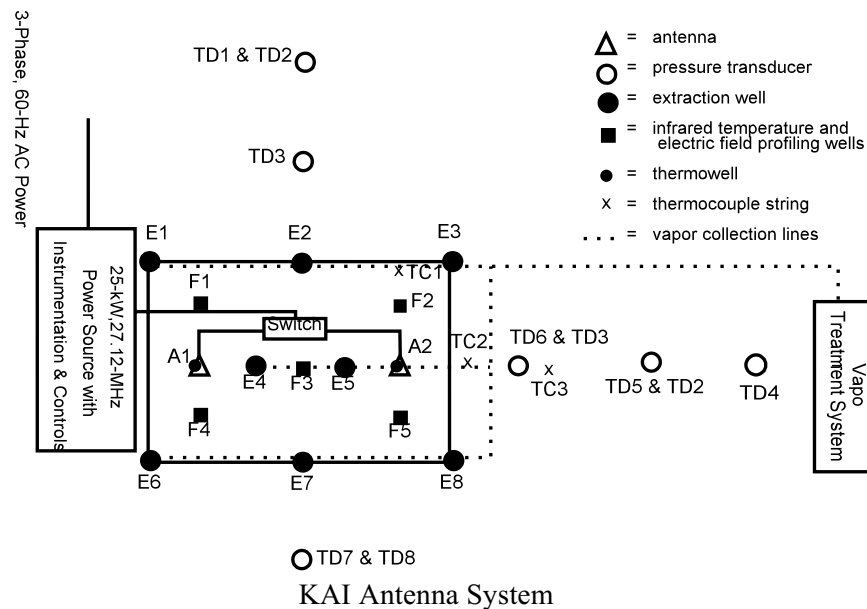
WASTE APPLICABILITY:

The RFH technique has been tested using pilot-scale vertical and horizontal antenna orientations to remove petroleum hydrocarbons and volatile and

semivolatile organics from soils. The technology is most efficient in subsurface areas with low groundwater recharge. In theory, the technology should be applicable to any polar compound in any nonmetallic medium. The flexible design permits easy access for in situ treatment of organics and pesticides under buildings or fuel storage tanks.

STATUS:

The KAI RFH technique was accepted into the SITE Demonstration Program in summer 1992. The technique was demonstrated between January and July 1994 at Kelly Air Force Base, Texas as part of a joint project with the U.S. Air Force Armstrong Laboratory. Brown and Root Environmental was the prime contractor evaluating and implementing RFH for the U.S. Air Force. A field demonstration of the IIT Research Institute RFH technology was completed in summer 1993 at the same site for comparison. The Demonstration Bulletin (EPA/540/MR- 94/528), Technology Capsule (EPA/540/R- 94/528a), and Innovative Technology Evaluation Report (EPA/540/R-94/528) are available from EPA. For further information on the IIT Research Institute technology, see the profile in



the Demonstration Program section (completed projects). KAI is now leasing commercial units to engineering companies around the U.S.

DEMONSTRATION RESULTS:

For this demonstration, the original treatment zone was 10 feet wide, 15 feet long, and 20 feet deep. This treatment zone was based on RFH operation at 13.56 megahertz (MHz); however, RFH was applied at 27.12 MHz to the top 10 feet of the original treatment zone to reduce the time on site by half. Demonstration results were as follows:

- Uniform heating within the revised heating zone: significant regions had soil temperatures in excess of 100 °C with soil temperatures within a 3-foot radius of the antenna exceeding 120 °C.
- Significant amounts of liquid were heated to around 240 °C as strongly suggested by a measurement of 233.9 °C on the outside wall of the heating well liner.
- Soil permeability increased by a factor of 20 within the revised treatment zone.
- In the original treatment zone, the mean removal for total recoverable petroleum hydrocarbons (TRPH) was 30 percent at the 90 percent confidence level. Concentrations in the pretreatment samples varied from less than 169 to 105,000 parts per million (ppm); posttreatment concentrations varied from less than 33 to 69,200 ppm.
- In the revised treatment zone, the mean removal for TRPH was 49 percent at the 95 percent confidence level. Concentrations in the pretreatment samples varied from less than 169 ppm to 6,910 ppm; posttreatment concentrations varied from less than 33 ppm to 4,510 ppm.

- Benzo(o)fluoranthene, benzo(a)pyrene, and bis(2-ethylhexyl)phthalate exhibited statistically significant removals within the original treatment zone. Benzo(o)-fluoranthene, benzo(a)pyrene, chrysene, pyrene, and fluoranthene exhibited statistically significant removals within the revised treatment zone.
- Contaminants may have migrated into and out of the revised treatment zone due to the design and operation of the SVE system. The design of the heated vapor recovery system is an essential component of the efficiency of the overall system.
- Cleanup costs are estimated to range from less than \$80 per ton for large scale to between \$100 to \$250 per ton for small-scale (hot spot) treatments.

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KSE, INC.

(Adsorption-Integrated-Reaction Process)

TECHNOLOGY DESCRIPTION:

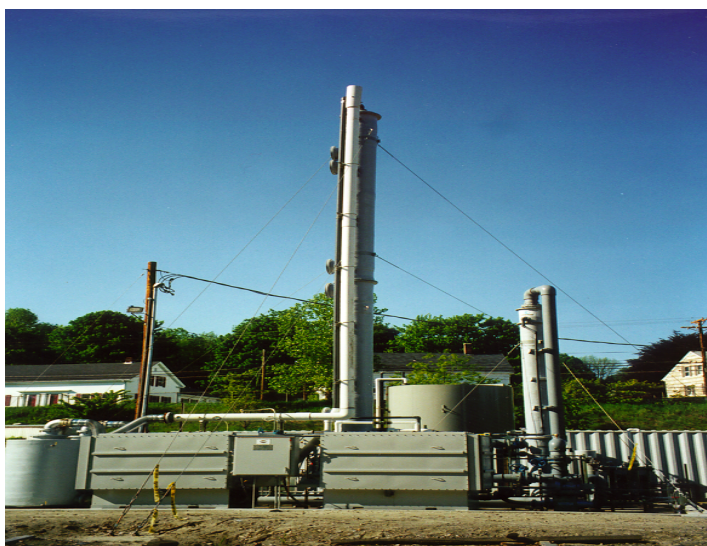
The Adsorption-Integrated-Reaction (AIR 2000) process combines two unit operations, adsorption and chemical reaction, to treat air streams containing dilute concentrations of volatile organic compounds (VOCs) (see photograph below).

The contaminated air stream containing dilute concentrations of VOCs flows into a photocatalytic reactor, where chlorinated and nonchlorinated VOCs are destroyed. The VOCs are trapped on the surface of a proprietary catalytic adsorbent. This catalytic adsorbent is continuously illuminated with ultraviolet light, destroying the trapped, concentrated VOCs through enhanced photocatalytic oxidation. This system design simultaneously destroys VOCs and continuously regenerates the catalytic adsorbent. Only oxygen in the air is needed as a reactant.

The treated effluent air contains carbon dioxide and water, which are carried out in the air stream exiting the reactor. For chlorinated VOCs, the chlorine atoms are converted to hydrogen chloride with some chlorine gas. If needed, these gases can be removed from the air stream with conventional scrubbers and adsorbents. The AIR 2000 process offers

advantages over other photocatalytic technologies because of the high activity, stability, and selectivity of the photocatalyst. The photocatalyst, which is not primarily titanium dioxide, contains a number of different semiconductors, which allows for rapid and economical treatment of VOCs in air. Previous results indicate that the photocatalyst is highly resistant to deactivation, even after thousands of hours of operation in the field.

The particulate-based photocatalyst allows for more freedom in reactor design and more economical scale-up than reactors with a catalyst film coated on a support medium. Packed beds, radial flow reactors, and monolithic reactors are all feasible reactor designs. Because the catalytic adsorbent is continuously regenerated, it does not require disposal or removal for regeneration, as traditional carbon adsorption typically does. The AIR 2000 process produces no residual wastes or by-products needing further treatment or disposal as hazardous waste. The treatment system is self-contained and mobile, requires a small amount of space, and requires less energy than thermal incineration or catalytic oxidation. In addition, it has lower total system costs than these traditional technologies, and can be constructed of fiberglass reinforced plastic (FRP) due to the low operating temperatures.



AIR2000

WASTE APPLICABILITY:

The AIR 2000 process is designed to treat a wide range of VOCs in air, ranging in concentration from less than 1 to as many as thousands of parts per million. The process can destroy the following VOCs: chlorinated hydrocarbons, aromatic and aliphatic hydrocarbons, alcohols, ethers, ketones, and aldehydes.

The AIR 2000 process can be integrated with existing technologies, such as thermal desorption, air stripping, or soil vapor extraction, to treat additional media, including soils, sludges, and groundwater.

STATUS:

The AIR 2000 process was accepted into the SITE Emerging Technology Program in 1995. Studies under the Emerging Technology Program are focusing on (1) developing photocatalysts for a broad range of chlorinated and nonchlorinated VOCs, and (2) designing advanced and cost-effective photocatalytic reactors for remediation and industrial service.

The AIR 2000 Process was initially evaluated at full-scale operation for treatment of soil vapor extraction off-gas at Loring Air Force Base (AFB). Destruction efficiency of tetrachloroethene exceeded 99.8 percent. The performance results were presented at the 1996 World Environmental Congress.

The AIR-I process, an earlier version of the technology, was demonstrated as part of a groundwater remediation demonstration project at Dover AFB in Dover, Delaware, treating effluent air from a groundwater stripper. Test results showed more than 99 percent removal of dichloroethane (DCA) from air initially containing about 1 ppm DCA and saturated with water vapor.

The AIR 2000 Process was accepted into the SITE Demonstration program in 1998. A demonstration was completed at a Superfund site in Rhode Island. A project bulletin was to be completed in 2001 and other project reports are still in preparation.

DEMONSTRATION RESULTS:

A 700 SCFM commercial unit is now operating at a Superfund Site in Rhode Island, destroying TCE, DCE and vinyl chloride in the combined off-gas from a SVE system and a groundwater stripper. Results collected during August to October 1999 show that the system is operating at 99.6% destruction efficiency. The AIR 2000 unit is operating unattended, with the number of UV lamps being illuminated changing automatically in response to changing flow conditions for maximum performance at minimum cost.

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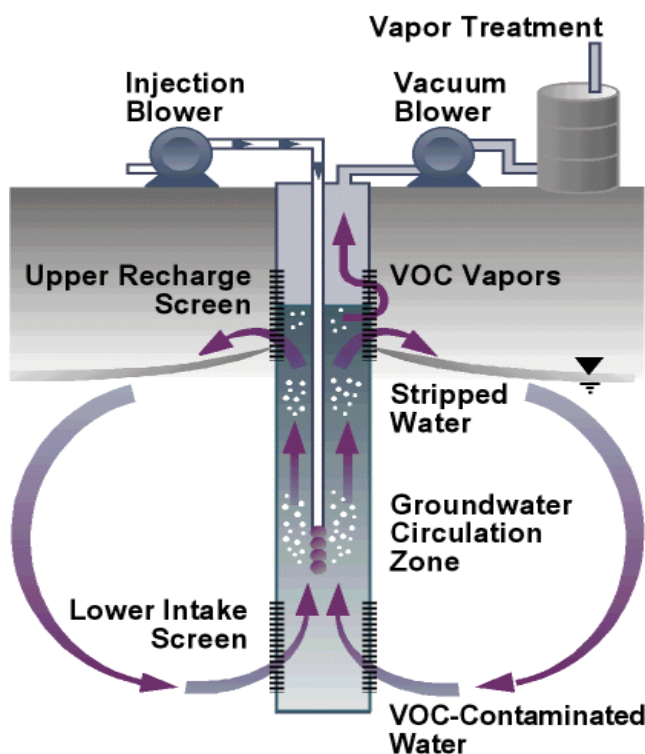
MACTEC-SBP TECHNOLOGIES COMPANY, L.L.C. (formerly EG&G Environmental, Inc.) (NoVOCs™ In-Well Stripping Technology)

TECHNOLOGY DESCRIPTION:

MACTEC-SBP provides the patented NoVOCs™ in-well stripping technology for the in situ removal of volatile organic compounds (VOC) from groundwater (see figure below). NoVOCs™ combines air-lift pumping with in-well vapor stripping to remove VOCs from groundwater without the need to remove, treat, and discharge a wastewater stream. The process also can be adapted to remove both VOCs and soluble metals from groundwater. NoVOCs™ consists of a well screened both beneath the water table and in the vadose zone. An air line within the well runs from an aboveground blower and extends below the water table. Pressurized air injected below the water table aerates the water within the well, creating a density gradient between the aerated water and the more

dense water in the surrounding aquifer. As a result, groundwater flows through the lower well screen and forces the aerated water upward within the well, and is in turn accelerated. The result is arising column of aerated water within the well, essentially acting as an air-lift pump.

As the aerated groundwater column rises within the well, VOC mass transfer occurs from the dissolved phase to the vapor phase. Above the water table, a packer is installed at the upper screen to prevent the passage of rising water or bubbles. The rising water column hits the packer, the bubbles burst, and the entrained VOC vapor is stripped off laterally through the screen by an upper vacuum casing. The VOC-rich vapor is brought to the surface for treatment while the laterally deflected water circulates back into the aquifer. Reinfiltrating water



Schematic Diagram of the NoVOCs™ Technology

creates a toroidal circulation pattern around the well, enabling the groundwater to undergo multiple treatment cycles before flowing downgradient. The VOC-rich vapor is treated using commercially available techniques chosen according to the vapor stream characteristics.

NoVOCs™ also can be used to remove readily reduced metals from groundwater and stabilize them in the vadose zone. Solubilized metals in their oxidized states enter the lower screen by the same route as dissolved VOCs in the groundwater. The nonvolatile metals remain in solution as the VOCs are stripped at the upper screen and the water circulates out of the well. The groundwater and soluble metals then pass through an infiltration and treatment gallery surrounding the upper well screen. This treatment gallery is impregnated with a reducing agent that reduces the soluble metals to an insoluble valence state. The insoluble metals accumulate in the infiltration gallery high above the water table and can be either capped or excavated at the conclusion of remedial action.

WASTE APPLICABILITY:

The process treats groundwater contaminated with volatile petroleum hydrocarbons including benzene, ethylbenzene, and toluene, as well as chlorinated solvents such as tetrachloroethene and trichloroethene. Highly soluble organics like alcohols and ketones are not easily air-stripped from water but are readily biodegraded in the oxygen-rich environment produced by NoVOCs™.

STATUS:

The NoVOCs™ technology was accepted into the SITE Demonstration Program in 1995. The demonstration at Installation Restoration Program Site 9 of Naval Air Station North Island in San Diego, California, was completed in June 1998.

DEMONSTRATION RESULTS:

VOC results for groundwater samples collected from the influent and effluent of the NoVOCs™ system indicated that 1,1-dichloroethene (1,1-DCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), and trichloroethene (TCE) concentrations were reduced by greater than 98, 95, and 93% respectively. The mean concentrations of 1,1-DCE, *cis*-1,2-DCE, and TCE in the untreated water were approximately 3,530, 45,000 and 1,650 micrograms per liter (µg/L), respectively, and the mean concentrations of 1,1-DCE, *cis*-1,2-DCE, and TCE in the treated water discharged from the NoVOCs™ system were 27, 1,400, and 32 µg/L, respectively. The average total VOC mass removed by the NoVOCs™ system ranged from 0.01 to 0.14 pound per hour and averaged 0.10 pound per hour. Accounting for the intermittent operation of the NoVOCs™ system, the mass of total VOCs removed during the entire operation period from 4/20-6/19/98 was estimated to be approximately 92.5 pounds.

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MAGNUM WATER TECHNOLOGY (CAV-OX® Process)

TECHNOLOGY DESCRIPTION:

The CAV-OX® process uses a combination of hydrodynamic cavitation and ultraviolet (UV) radiation to oxidize contaminants in water. The process (see figure below) is designed to remove organic contaminants from wastewater and groundwater without releasing volatile organic compounds into the atmosphere.

The process generates free radicals to degrade organic contaminants. The cavitation process alone has been demonstrated to achieve trichloroethene (TCE) reductions of up to 65 percent. UV excitation and, where necessary, addition of hydrogen peroxide and metal catalysts, provide synergism to achieve overall reductions of over 99 percent. Neither the cavitation chamber nor the UV lamp or hydrogen peroxide reaction generates toxic by-products or air emissions.

Magnum Water Technology (Magnum) estimates the cost of using the CAV-OX® process to be about half the cost of other advanced UV oxidation systems and substantially less than carbon adsorption. Because the process equipment has one moving part, maintenance costs are minimal. According to Magnum, the CAV-OX® process does not exhibit the quartz tube scaling common with other UV equipment.

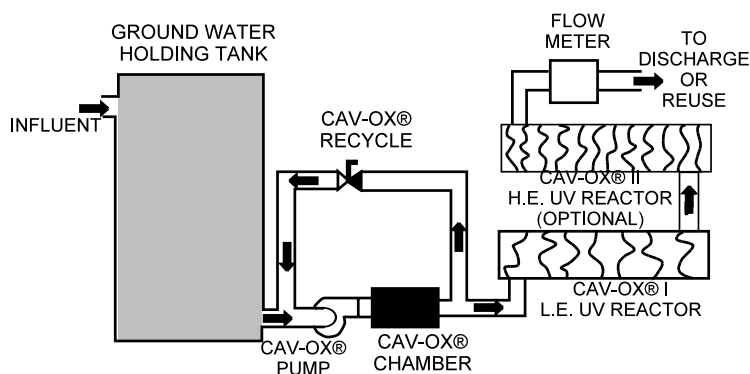
WASTE APPLICABILITY:

The process is designed to treat groundwater or wastewater contaminated with organic compounds. Contaminants such as halogenated solvents; phenol; pentachlorophenol (PCP); pesticides; polychlorinated biphenyls; explosives; benzene, toluene, ethylbenzene, and xylenes; methyl tertiary butyl ether; other organic compounds; and cyanide are suitable for this treatment process. Bacteria and virus strains are also eliminated.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1992 and was demonstrated for 4 weeks in March 1993 at Edwards Air Force Base (AFB) Site 16 in California. The Applications Analysis Report (EPA/540/AR-93/520), Technology Evaluation Report (EPA/540/R-93/520), and a videotape are available from EPA.

Magnum reports that improvements in UV lamp and reactor technologies have improved the efficiency of the CAV-OX® process three- to five-fold, compared with the pilot-scale unit tested at Edwards AFB under the SITE Program. CAV-OX® recently (1996) has proven very effective in potentiating ozone concentrations in water reclamation applications.



The CAV-OX® Process

Ozone gas (O₃) is relatively insoluble in water. However, hydrodynamic cavitation used in the CAV-OX[®] process continuously develops micro bubbles which enhances the dispersion of ozone in water. Three O₃ techniques are available to Magnum: corona discharge with air feed, electrochemical 'water splitting' method, and electrochemical anodic oxidation.

The CAV-OX[®] process has been tested at several public and private sites, including the San Bernadino and Orange County Water Department in California. At a Superfund site, the process treated leachate containing 15 different contaminants. PCP, one of the major contaminants, was reduced by 96 percent in one test series. The process has also been used to remediate former gasoline station sites and successfully reduced contaminants in process streams at chemical and pharmaceutical plants.

The CAV-OX[®] unit was part of an ongoing evaluation at the U.S. Army Aberdeen Proving Ground (Aberdeen). Special features of the unit tested include remote monitoring and control systems for pH, flow rates, H₂O₂ flow rate, storage level and pump rate, UV lamp, main power, pump function, and remote system shutdown control. The 15-gallon-per-minute CAV-OX[®] I Low Energy unit was operated by Army contractors for 9 months. Upon completion of testing at Aberdeen, further CAV-OX[®] II High Energy Tests were conducted at El Segundo. The CAV-OX[®] process achieved contaminant concentrations of greater than 95

percent. During 1997 tests of CAV-OX[®] equipment and/or Pilot Tests were made in Taiwan, Thailand, and Australia. Also, a continuing series of tests for major U.S. corporations are on-going. The CAV-OX[®] process achieved removal efficiencies of greater than 99.9 percent for TCE, benzene, toluene, ethylbenzene, and xylenes. SITE demonstration results for the CAV-OX[®] process are shown in the table below. Results are presented for both the CAV-OX[®] I (cavitation chamber by itself) and CAV-OX[®] II (cavitation chamber combined with UV) demonstrations.

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H ₂ O ₂ ¹ Concen- trations (mg/L) ²	Flow (gpm) ³	CAV-OX® I				Flow (gpm)	TCE 5-kW ⁴	TCE 10-kW	CAV-OX® II								
		TCE	Removal Efficiencies (%)						Benzene 5-kW	Benzene 10-kW	5-kW	Removal Efficiencies (%)		Toluene 5-kW	Toluene 10-kW	Xylene 5-kW	Xylene 10-kW
			Benzene	Toluene	Xylene							Benzene	Toluene				
33.1	0.5	99.9	>99.9	99.4	92.9	1.5	99.6	99.2	99.4	98.8	>99.9	98.6	>99.9	>99.9			
23.4	0.6	99.9	>99.9	>99.9	>99.9	2.0	99.7	99.7	99.5	99.6	>99.9	>99.9	>99.9	>99.9			
4.9	1.5	71.4	88.6	87.4	65.6	4.0	87.7	98.1	89.7	98.7	88.8	97.1	78.7	87.2			
48.3	0.6	99.7	>99.9	>99.9	>99.9	1.4	99.8	99.7	99.8	99.8	>99.9	>99.9	98.7	>99.9			
6.0	0.7	87.8	96.9	94.5	92.1	1.9	98.4	99.3	98.8	99.3	96.9	98.6	93.6	97.0			
4.9	1.5	61.7	81.6	83.8	80.2	3.9	85.1	97.1	89.5	97.8	91.8	97.9	90.4	96.0			
5.9	0.5	96.4	99.4	99.8	98.9	1.4	99.6	99.4	99.6	99.6	99.8	99.8	99.5	99.5			
5.9	0.7	87.1	96.5	97.6	98.1	1.9	97.8	99.2	99.4	99.5	99.5	99.7	99.2	99.7			
6.1	1.5	60.6	86.1	87.3	>99.9	4.0	86.3	98.9	93.5	99.5	94.5	99.6	95.4	>99.9			
0	-	-	-	-	-	1.6	94.1	99.2	49.1	68.1	20.7	54.7	43.3	46.7			
0	-	-	-	-	-	1.8	80.6	97.6	38.5	60.5	48.6	75.2	56.9	83.8			

¹ hydrogen peroxide ² milligrams per liter ³ gallons per minute ⁴ kilowatts

CAV-OX[®] Process Demonstration Results

MATRIX PHOTOCATALYTIC INC.

(Photocatalytic Aqueous Phase Organic Destruction)

TECHNOLOGY DESCRIPTION:

The Matrix Photocatalytic Inc. (Matrix) photocatalytic oxidation system, shown in the photograph below, removes dissolved organic contaminants from water and destroys them in a continuous flow process at ambient temperatures. When excited by light, the titanium dioxide (TiO_2) semiconductor catalyst generates hydroxyl radicals that oxidatively break the carbon bonds of hazardous organic compounds.

The Matrix system converts organics such as polychlorinated biphenyls (PCB); phenols; benzene, toluene, ethylbenzene, and xylene (BTEX); and others to carbon dioxide, halides, and water. Efficient destruction typically occurs between 30 seconds and 2 minutes actual exposure time. Total organic carbon removal takes longer, depending on the other organic molecules and their molecular weights. The Matrix system was initially designed to destroy organic pollutants or to remove total organic carbon from drinking water, groundwater, and plant process water. The Matrix system also destroys organic pollutants such as PCBs, polychlorinated dibenzodioxins, polychlorinated

dibenzofurans, chlorinated alkenes, chlorinated phenols, chlorinated benzenes, alcohols, ketones, aldehydes, and amines. Inorganic pollutants such as cyanide, sulphite, and nitrite ions can be oxidized to cyanate ion, sulphate ion, and nitrate ion, respectively.

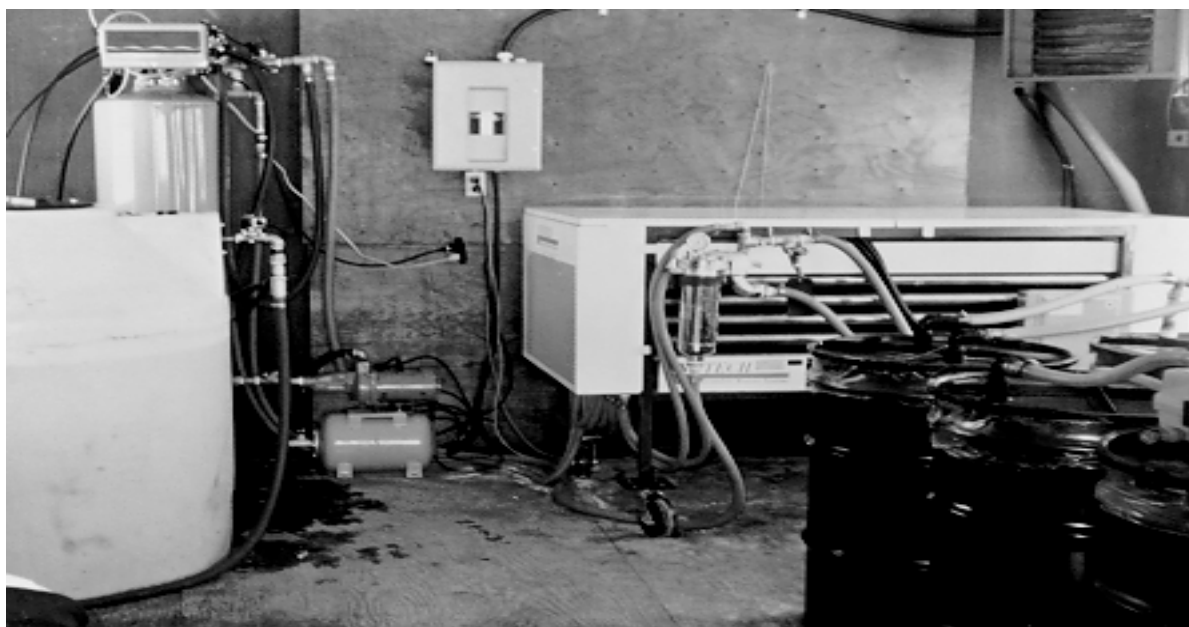
WASTE APPLICABILITY:

The Matrix system can treat a wide range of concentrations of organic pollutants in industrial wastewater and can be applied to the ultrapure water industry and the drinking water industry. The Matrix system can also remediate groundwater.

STATUS:

The system was accepted into the SITE Emerging Technology Program (ETP) in May 1991. Results from the ETP evaluation were published in a journal article (EPA/540/F-94/503) available from EPA. Based on results from the ETP, Matrix was invited to participate in the Demonstration Program.

During August and September 1995, the Matrix system was demonstrated at the K-25 site at the



10-Gallon-Per-Minute TiO_2 Photocatalytic System Treating BTEX in Water

Department of Energy's Oak Ridge Reservation in Oak Ridge, Tennessee. Reports detailing the results from the demonstration are available from EPA.

DEMONSTRATION RESULTS:

Results from the demonstration are detailed below:

- In general, high percent removals (up to 99.9 percent) were observed for both aromatic volatile organic compounds (VOCs) and unsaturated VOCs. However, the percent removals for saturated VOCs were low (between 21 and 40 percent).
- The percent removals for all VOCs increased with increasing number of path lengths and oxidant doses. At equivalent contact times, changing the flow rate did not appear to impact the treatment system performance for all aromatic VOCs and most unsaturated VOCs (except 1,1-dichloroethene [DCE]). Changing the flow rate appeared to impact the system performance for saturated VOCs.
- The effluent met the Safe Drinking Water Act maximum contaminant levels (MCL) for benzene; cis-1,2-DCE; and 1,1-DCE at a significant level of 0.05. However, the effluent did not meet the MCLs for tetrachloroethene (PCE); trichloroethene (TCE); 1,1-dichloroethane (DCA); and 1,1,1-trichloroethane (TCA) at a significant level of 0.05. The influent concentrations for toluene and total xylenes were below the MCLs.
- In tests performed to evaluate the effluent's acute toxicity to water fleas and fathead minnows, more than 50 percent of the organisms died. Treatment by the Matrix system did not reduce the groundwater toxicity for the test organisms at a significant level of 0.05.

- In general, the percent removals were reproducible for aromatic and unsaturated VOCs when the Matrix system was operated under identical conditions. However, the percent removals were not reproducible for saturated VOCs. The Matrix system's performance was generally reproducible in (1) meeting the target effluent levels for benzene; cis-1,2-DCE; and 1,1-DCE; and (2) not meeting the target effluent levels for PCE; TCE; 1,1-DCA; and 1,1,1-TCA.
- Purgable organic compounds and total organic halides results indicated that some VOCs were mineralized in the Matrix system. However, formulation of aldehydes, haloacetic acids, and several tentatively identified compounds indicated that not all VOCs were completely mineralized.

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MAXYMILLIAN TECHNOLOGIES, INC. (formerly Clean Berkshires, Inc.) (Thermal Desorption System)

TECHNOLOGY DESCRIPTION:

The Maxymillian Technologies, Inc., mobile Thermal Desorption System (TDS) uses rotary kiln technology to remove contaminants from soils. The TDS can remediate soils contaminated with volatile organic compounds (VOC), semivolatile organic compounds (SVOC), and polynuclear aromatic hydrocarbons (PAH). The TDS is fully transportable, requires a footprint of 100-by-140 feet, and can be set up on site in 4 to 6 weeks. The system combines high throughput with the ability to remediate mixed consistency soil, including sands, silts, clays, and tars.

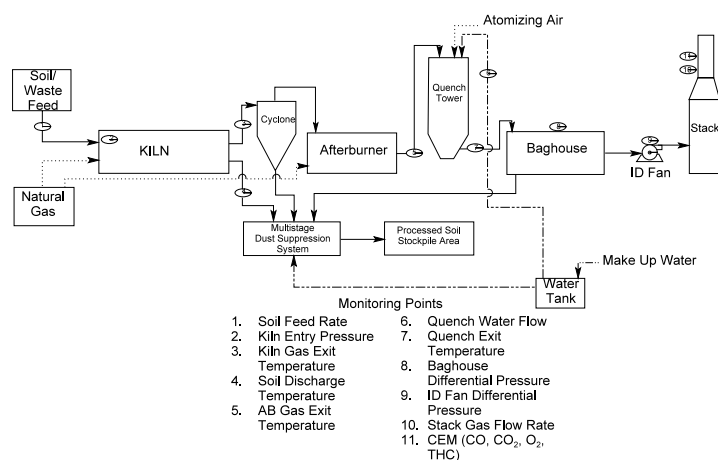
The TDS consists of the following components (see figure below):

- Waste feed system
- Rotary kiln drum desorber
- Cyclone
- Afterburner
- Quench tower
- Baghouse
- Fan and exhaust stack
- Multistage dust suppression system
- Process control room

Soil is first shredded, crushed, and screened to achieve a uniform particle size of less than 0.75 inch. Feed soils are also mixed to achieve uniform moisture content and heating value.

The thermal treatment process involves two steps: contaminant volatilization followed by gas treatment. During the volatilization step, contaminated materials are exposed to temperatures ranging from 600 to 1,000°F in a co-current flow rotary kiln drum desorber where contaminants volatilize to the gas phase. Clean soils are then discharged through a multistage dust suppression system for remoisturization and are stockpiled for testing.

The gas and particulate stream passes from the kiln to the cyclone, where coarse particles are removed. The stream then enters the afterburner, which destroys airborne contaminants at temperatures ranging from 1,600 to 2,000°F. The gas stream is cooled by quenching before passing through a high-efficiency baghouse, where fine particles are removed. The clean gas is then released to the atmosphere through a 60-foot stack. Processed soil, after discharge from the dust suppression system, is stockpiled and allowed to cool prior to sampling.



Mobile Thermal Desorption System

WASTE APPLICABILITY:

The TDS is designed to remove a wide variety of contaminants from soil, including VOCs, SVOCs, PAHs, coal tars, and cyanide.

STATUS:

The TDS was accepted into the SITE Demonstration Program in 1993. The demonstration was conducted in November and December 1993 at the Niagara Mohawk Power Corporation Harbor Point site, a former gas plant in Utica, New York. During the demonstration, the TDS processed three replicate runs of four separate waste streams. Stack emissions and processed soil were measured to determine achievement of cleanup levels. The Demonstration Bulletin (EPA/540/MR-94/507) and Technology Capsule (EPA/540/R-94/507a) are available from EPA.

Following the SITE demonstration, the TDS was chosen to remediate approximately 17,000 tons of VOC-contaminated soil at the Fulton Terminals Superfund site in Fulton, New York. This project was completed in 1995. The system has since been moved to a location in North Adams, Massachusetts.

DEMONSTRATION RESULTS:

Results from the SITE Demonstration are summarized below:

- The TDS achieved destruction removal efficiencies (DRE) of 99.99 percent or better in all 12 runs using total xylenes as a volatile principal organic hazardous constituent (POHC).

- DREs of 99.99 percent or better were achieved in 11 of 12 runs using naphthalene as a semivolatile POHC.
- Average concentrations for critical pollutants in treated soils were 0.066 milligram per kilogram (mg/kg) benzene, toluene, ethylbenzene, and xylene (BTEX); 12.4 mg/kg PAHs; and 5.4 mg/kg total cyanide.
- Comparison of the dry weight basis concentration of pollutants in the feed and treated soil showed the following average removal efficiencies: 99.9 percent for BTEX; 98.6 percent for PAHs; and 97.4 percent for total cyanide.
- The TDS showed good operating stability during the demonstration with only a minor amount of downtime.

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MICRO-BAC® INTERNATIONAL, INC.

(Bioaugmentation Process)

TECHNOLOGY DESCRIPTION:

The M-1000PCB™ is a biological product specifically designed and formulated for the degradation of chlorinated compounds and complex aromatic compounds found in contaminated and/or hazardous wastes. The M-1000PCB™ product consists of live, specially selected, naturally occurring microorganisms, along with a supply of balanced nutrients in a ready-to-use liquid medium. The microorganisms work either anaerobically or aerobically and the system requires no expensive machinery.

The product is nonpathogenic and free of slime-forming and sulfate-reducing bacteria. The live cultures contained in the product do not need to be activated or require an acclimation period prior to use. In a proprietary selection process, MBI isolates and sustains specific strains of bacteria that work together to degrade specific organic compounds. Reportedly, these microorganisms have the ability to thrive in a variety of site conditions characterized by diverse soils and water chemistries, and are capable of using hazardous waste substances as a carbon source.

For soil applications, the product is typically applied

via a spray, as shown in the photograph below. M-1000™ product and nutrient application rates for soil are based on specific site characteristics. Information such as soil type, nutrient availability, soil moisture content, and contaminant type and concentration are considered before applying the technology at a site. The general application rate for the M-1000™ products in soil is one quart of bacteria per one cubic yard of soil. This treatment provides a bacterial concentration of approximately 1,250 ppm. The bacteria is typically applied first, followed by the nutrient formulation.

At a number of sites, the addition of nutrients is used to augment the activity of the product in conditions where macronutrients such as carbon, nitrogen, or phosphate are limited. MBI produces its own nutrient mixtures that are specifically formulated for use with MBI bacteria. The nutrient mixtures are shipped as a dry powder and packaged in single packets or in four packet containers. A single packet of nutrients is typically mixed on-site with 55 gallons of water. This mixture is used to amend approximately 10,000 gallons or 50 cubic yards of the bacteria mix.

Depending upon the duration of treatment, it is often necessary for multiple applications of microbe and



nutrient mixtures. The treated soil is then routinely mixed with a roto-tiller. The frequency of this mixing may vary over the duration of a project, but will generally not be more frequent than once a week.

WASTE APPLICABILITY:

The MBI bioremediation products are specifically targeted for the contaminant groups most frequently encountered; including products for total petroleum hydrocarbons (TPH), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), other aromatic and chlorinated hydrocarbons, gasolines, crude oils, and jet fuels. The M-1000™ products have been applied in a number of different ways. The product has been used successfully in a variety of in situ and ex situ applications, but has also been applied as part of a bioreactor process, in land farms, in biopiles, and in pump-and-treat scenarios. According to the MBI, it apparently works well as an augmentation to other methods or as a stand-alone solution.

STATUS:

The MBI bioaugmentation technology was accepted into the SITE Demonstration Program in 1999. A demonstration is currently in progress at the Lower Colorado River Authority (LCRA) Goldthwaite, Texas, substation. At this site PCB-contaminated soil is being treated with M-1000PCB™ product in an approximate 16- × 8- × 2-ft treatment cell. The overall goal of the project is to reduce PCB concentrations in the soil to a levels of 50 mg/kg or less, on a dry weight basis of the original soil, thus enabling the LCRA to dispose of their soils in a less costly in-state landfill (as opposed to a TSCA landfill).

The SITE Program is conducting soil sampling to evaluate the effectiveness of the MBI technology for treating the PCBs in the soil. The LCRA is performing periodic rototilling of the soil within the treatment cell (see photograph below). As of August 2001, a total of four sampling events have been completed. These included a baseline sampling event conducted in August 2000 to establish pretreatment PCB levels, and three Intermediate sampling events for tracking treatment progress. These intermediate events were conducted in October and December of 2000, and in June of 2001. A final sampling event is scheduled for October 2001.

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MINERGY CORP.

(Glass Furnace Technology for Dredged Sediments)

TECHNOLOGY DESCRIPTION:

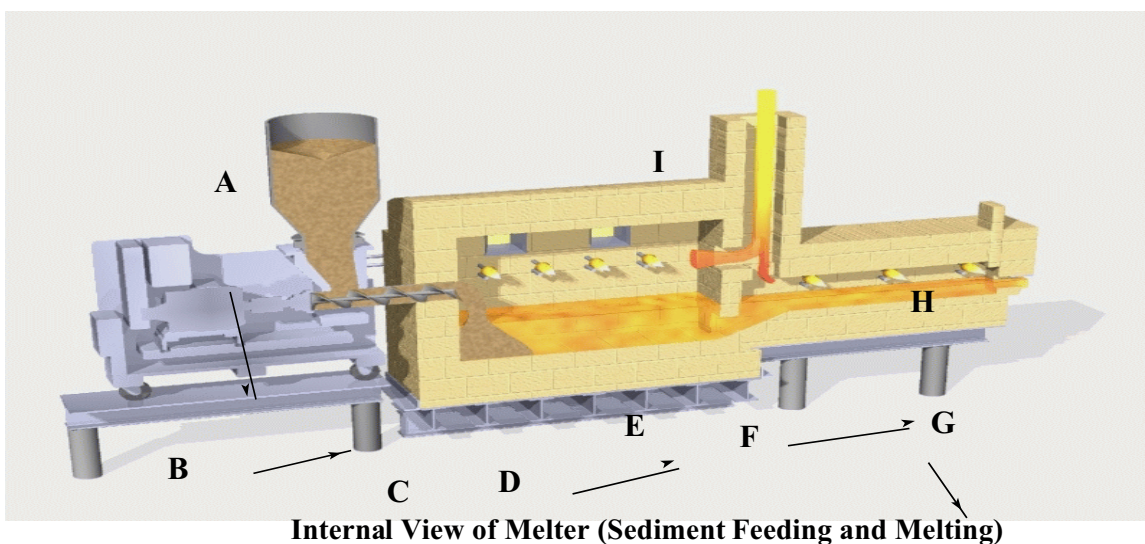
The Glass Furnace Technology is an adaptation of systems that have been used for decades in glass manufacturing. Because a glass furnace has temperatures high enough to melt minerals into glass, there is a corollary benefit of destruction of organic contaminants such as PCBs, and permanent stabilization of trace metals in the resultant glass product matrix.

A glass furnace is a refractory-lined, rectangular melter. Refractory is brick or concrete, which has been specially treated to resist chemical and physical abrasion, has a high melting point, and provides a high degree of insulating value to the process. Current glass furnaces use oxy-fuel burners, combining natural gas and oxygen for a bright flame above the glass. These burners raise the internal temperature of the melter to 2,900 degrees Fahrenheit. At these high

temperatures, PCB contaminants are destroyed, and the sediment melts and flows out of the processing system as molten glass. The molten glass is water quenched to produce an inert aggregate that is marketed to construction companies.

Process Description

Sediment (A) is fed to the hopper above the screw feeder (B). The feeder conveys the sediment continuously into the main section of the melter (C). The extremely high temperatures in the melter cause the sediment to become molten, liquid glass (D). The molten glass flows under a skimmer block (E), into the forehearth (F), where the material continues to form a stable glass. At the end of the melter, the glass flows out (G) into a water quenching tank. A removable block is included at the end of the forehearth (H) to stop the flow of glass if desired. Exhaust gases (I) flow out from the furnace up the square flue, to the air sampling equipment.



WASTE APPLICABILITY:

The target applicable waste for the technology is sediments or soils that have PCB and metals contamination. The process design of a glass

furnace is focused on melting low energy feedstock materials (that is, those with low Btu values). Silica is one of the primary constituents of sediments, making it a perfectly suited material for processing. Because a glass furnace has temperatures high

enough to melt minerals into glass, it has a high destruction efficiency of organic contaminants such as PCBs, and permanent stabilization of trace metals in the resultant glass product matrix. Exhaust gas volumes from a glass furnace are very low, thus enabling downstream carbon filtering to capture contamination by mercury or other light metals.

STATUS:

In August 2001, the Glass Furnace Technology (GFT) was demonstrated in Minergy's pilot glass furnace, located in Winneconne, Wisconsin. The pilot demonstration was performed using 60 tons of sediment dredged from the Lower Fox River, Wisconsin, from which 30 tons of glass were made. EPA SITE was on-site for the two-week demonstration. The SITE report was not yet complete at the time of this writing. The objectives of the SITE analysis are:

- To determine the treatment efficiency (TE) of PCBs in dredged-and-dewatered river sediment when processed in the Minergy GFT.
- To determine whether the GFT glass aggregate product meets the criteria for beneficial reuse under relevant federal and state regulations.
- Determine the unit cost of operating the GFT on dewatered dredged river sediment.
- Quantify the organic and inorganic contaminant losses resulting from the existing or alternative drying process used for the dredged-and-dewatered river sediment.
- Characterize organic and inorganic constituents in all GFT process input and output streams. Of principal concern is the formation of dioxin and furan during the vitrification step.

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MORRISON KNUDSEN CORPORATION/ SPETSTAMPONAZHGEOLGIA ENTERPRISES (Clay-Based Grouting Technology)

TECHNOLOGY DESCRIPTION:

Morrison Knudsen Corporation (MK) is working under a joint venture agreement with Spetstamponazhgeologia Enterprises (STG) of Ukraine to demonstrate the effectiveness of a clay-based grouting technology. This technology uses clay slurries as a base for grout solutions, which are injected into bedrock fracture systems to inhibit or eliminate groundwater flow in these pathways. The clay slurries may also be used as a base for slurry wall construction.

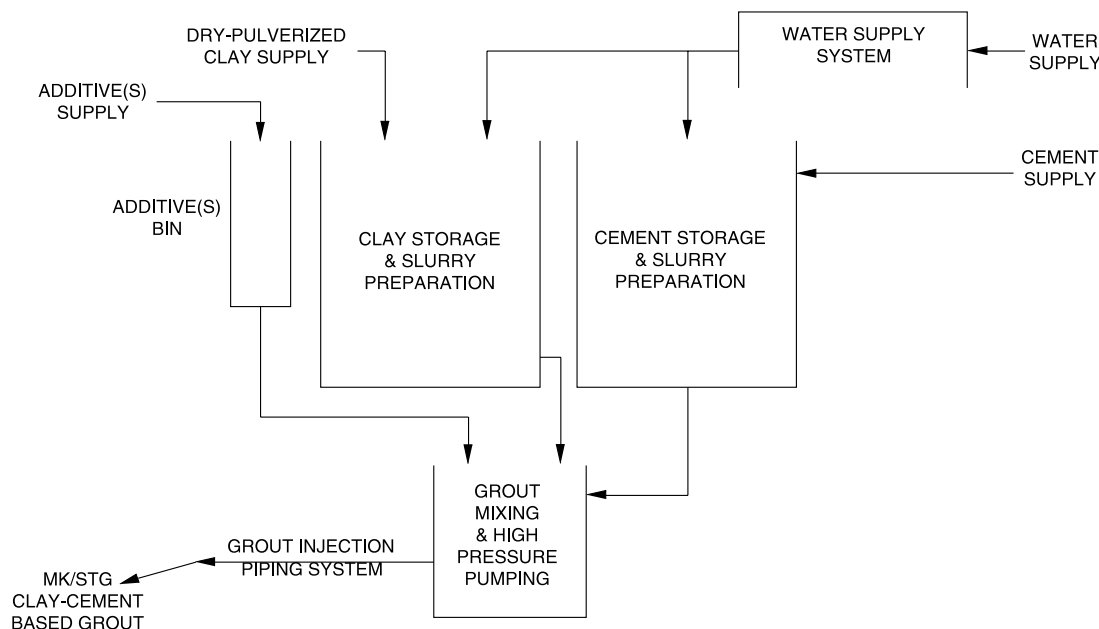
The MK/STG clay-based grouting technology is an integrated method involving three primary phases: obtaining detailed site characteristics; developing a site-specific grout formulation; and grout mixing and injection. The first phase, site characterization, includes obtaining geophysical, geochemical, mineralogical, and hydrogeological information about the target area.

The second phase, a site-specific grout formulation,

is developed in the laboratory. The overall properties of clay-based grout depend on the physical and mechanical properties of the clay, cement, and other additives. Formulated clay-based grouts are viscoplastic systems composed primarily of clay mineral mortar and structure-forming cement. The clay is normally a kaolin/illite obtained from a local source; other additives may be required. The formulation is laboratory-tested to determine suitability for the desired application.

The third phase is grout mixing and placement. The process for preparing and injecting the clay-based grout is shown in the diagram below. Boreholes drilled during the site characterization phase may be used for grout placement. Additional boreholes may be drilled to complete the injection program. A quality assurance program ensures that placement and project objectives are met. After injection, the clay-based grout retains its plasticity and does not crystallize, providing permanent underground protection.

WASTE APPLICABILITY:



Process Flow Diagram of the Clay-Based Grouting Technology

This technology is suitable for providing a flow barrier to groundwater contaminated with both heavy metals and organics. The clay-based grout can be formulated to withstand detrimental conditions such as low pH. The technology can be used at inactive mine sites that produce acid mine drainage. Other potential applications include liquid effluent control from landfills, containment of groundwater contaminated with chemicals or radionuclides, and reduction of brine inflows.

STATUS:

This technology was accepted into the SITE Demonstration Program in winter 1993. It was partially installed in fall 1994 at the abandoned Mike Horse Mine site in Montana; operations were suspended due to winter weather conditions. The third phase, to complete installation of the grout, was canceled due to EPA budget constraints. The demonstration was completed in 1996, but the technology was not fully evaluated due to loss of accessibility to the site.

Over 200 projects using this technology have been completed during the last 20 years in the former Soviet Union and Eastern block countries, as well as in China and Australia. The technology has not been applied in the United States or western hemisphere other than at the Mike Horse Mine site.

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NORTH AMERICAN TECHNOLOGIES GROUP, INC. (Oleophilic Amine-Coated Ceramic Chip)

TECHNOLOGY DESCRIPTION:

This hydrocarbon recovery technology is based on an oleophilic, amine-coated ceramic chip that separates suspended and dissolved hydrocarbons, as well as most mechanical and some chemical emulsions, from aqueous solutions. The oleophilic chip is manufactured by grafting a hydrophobic amine to a mineral support, in this case a ceramic substrate. Each granule is 0.6 to 1 millimeter in diameter, but is very porous and thus has a large surface area. The hydrophobic property of the amine coating makes each granule more effective for microfiltration of hydrocarbons in an unstable emulsion.

The figure below illustrates the process; the separator, filter, and coalescer unit is shown on the next page. The pressure-sensitive filtering bed is regenerated by automatic backflushing. This automatic regeneration eliminates the expense associated with regeneration of carbon and similar filtration media. Recovered hydrocarbons coalesce and can thus be removed by simple gravity separation.

This technology provides cost-effective oil and water separation, removes free and emulsified hydrocarbon contaminants, and significantly reduces hydrocarbon loading to air strippers and

carbon systems. The technology can achieve a concentration of less than 7 parts per million oil and grease in the treated effluent.

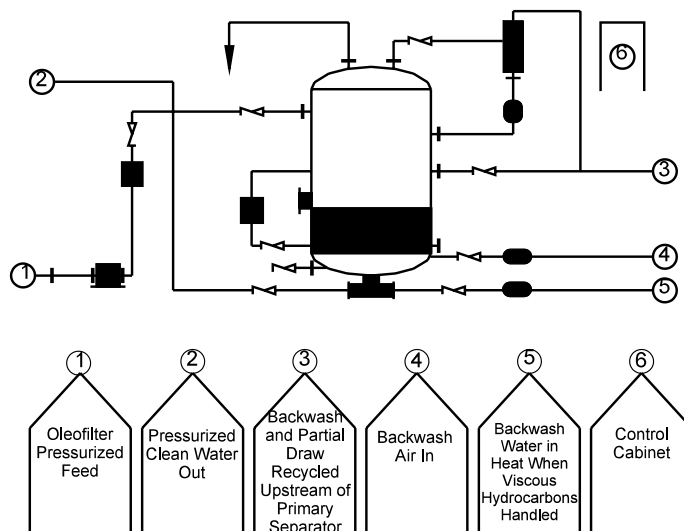
WASTE APPLICABILITY:

The amine-coated granules have proven effective on a wide variety of hydrocarbons, including gasoline; crude oil; diesel fuel; benzene, toluene, ethylbenzene and xylene mixtures; and polynuclear aromatic hydrocarbons. The unit also removes hydrophobic chlorinated hydrocarbons such as pentachlorophenol, polychlorinated biphenyls, and trichloroethene, as well as vegetable and animal oils.

Treatment systems incorporating this technology have been designed for various applications, including (1) contaminated groundwater pump-and-treat systems; (2) in-process oil and water separation; (3) filtration systems; (4) combined oil and water separator-filter-coalescer systems for on-site waste reduction and material recovery; and (5) treatment of marine wastes (bilge and ballast waters).

STATUS:

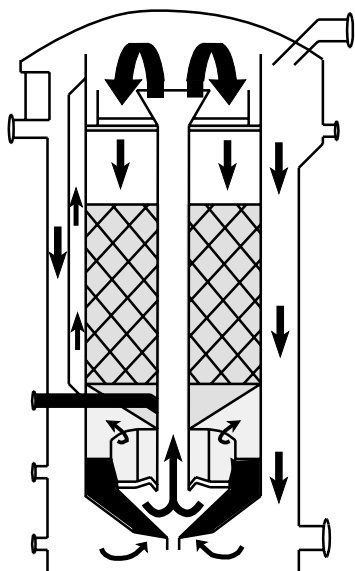
This technology was accepted into the SITE



Schematic Diagram of the Oleofilter Technology

Demonstration Program in December 1992. The SITE demonstration was completed in June 1994 at the Petroleum Products Corporation site in Fort Lauderdale, Florida. The site is a former oil recycling facility where groundwater has been contaminated with a variety of organic and inorganic constituents. The Demonstration Bulletin (EPA/540/MR-94/525) and Innovative Technology Evaluation Report (EPA/540/ R-94/525) are available from EPA.

The technology has been used for several full-scale projects. Several separator-filter-coalescers (see figure below) are in use treating industrial process waters and oily wash waters.



Separator, Filter, and Coalescer

DEMONSTRATION RESULTS:

For the demonstration, five separate evaluation periods (runs) were initiated. Each run used the same feed oil, except run four. The oil for run four was a 3:1 mixture of oil to kerosene. The average total recoverable petroleum hydrocarbon (TRPH) concentrations for the feed streams ranged from 422 to 2,267 milligrams per liter (mg/L). Preliminary data indicate that the system removed at least 90 percent of the TRPH from the emulsified oil and water feed stream.

For the runs where the system operated within normal design parameters, TRPH concentrations in the treated water effluent were reduced to 15 mg/L or less. The oleophilic granules achieved a 95 percent reduction of TRPH concentration for the runs with similar feed oil.

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NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION/ENSR CONSULTING AND ENGINEERING and LARSEN ENGINEERS (Ex Situ Biovault)

TECHNOLOGY DESCRIPTION:

The Ex Situ Biovault, developed by ENSR Consulting and Engineering (ENSR) and Larsen Engineers (Larsen), is a specially designed, aboveground soil pile designed to treat soils contaminated with volatile organic compounds (VOC) and semivolatile organic compounds (SVOC). The biovault is enclosed by a double liner system; the bottom half of the liner contains a leak detection system. The bottom half of the liner is supported by soil berms that serve as side walls.

To construct a biopile, a layer of gravel containing an air distribution system is placed on the bottom liner. The soil to be treated is then placed over the gravel. After placing the soil, a layer of sand containing a second air distribution system is placed on top of the soil. Soaker hoses are also placed on top of the pile. Finally, the top liner is placed on the pile and sealed at all seams. The air distribution systems are designed to control gas flows throughout the pile while the soaker hoses add water and nutrients. A sump is located in the lowest corner of the biovault with a pump that removes the liquids that drain through the soil pile. This liquid is amended with nutrients as needed and recirculated through the soaker hoses. Together, the sump and

soaker hoses form the liquid management system (LMS).

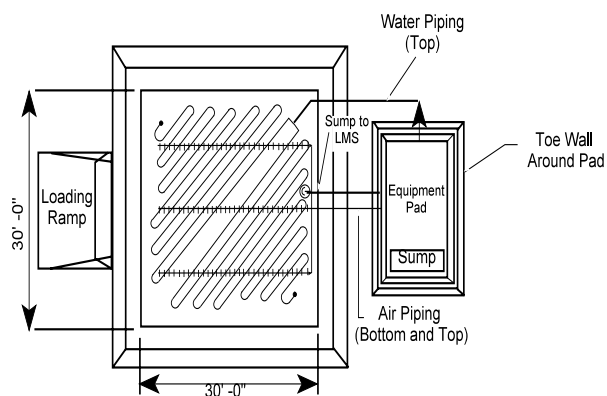
One of the control parameters for biovault operation is the rate of air supply. For the SITE demonstration, two identical vaults were constructed. One vault was operated with a continuous supply of air throughout the course of treatment. In the other biovault, air was supplied intermittently in an effort to cycle the biovault between aerobic and anaerobic conditions.

WASTE APPLICABILITY:

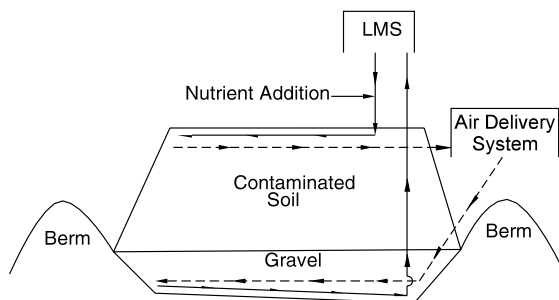
The ex situ biovault is intended to treat soil contaminated with chlorinated and nonchlorinated VOCs, as well as SVOCs. Soil contaminated with VOCs was treated during the demonstration.

STATUS:

ENSR's and Larsen's ex situ biovault was accepted into the SITE Demonstration Program in June 1994. The pilot-scale, multivendor treatability demonstration (MVTd) was jointly sponsored by the New York State Department of Environmental Conservation (NYSDEC), the New York State Center for Hazardous Waste Management, and the



Schematic of the Ex Situ Biovault System



Cross Section of the
Ex Situ Biovault System

SITE Program. The objectives of the MVTD were to (1) generate field data for biological processes, and (2) evaluate the performance of each biological process in meeting NYSDEC clean-up goals.

The demonstration was conducted from July to December 1994 at the Sweden 3-Chapman site in Sweden, New York. The soil at the site was contaminated with elevated levels of acetone, trichloroethene, tetrachloroethene, cis-1,2-dichloroethene, 2-butanone, 4-methyl-2-pentanone, and toluene. The final report is available from the vendor.

In addition to the ENSR and Larsen process, the following systems also were demonstrated:

- SBP Technologies, Inc., Vacuum-Vaporized Well System
- R.E. Wright Environmental, Inc., In Situ Bioventing Treatment System

For information on these technologies, refer to the NYSDEC profiles in the Demonstration Program section (completed projects).

The Demonstration Bulletin (EPA/540/MR-95/524) is available from EPA. The Innovative Technology Evaluation Report, which provides more detailed demonstration results, is being prepared.

DEMONSTRATION RESULTS:

The primary objective of the SITE demonstration was to determine the effectiveness of the biovaults in reducing the concentrations of six target VOCs. The results of the ex situ biovault technology demonstration were as follows:

- Soil concentrations of six target VOCs were significantly reduced over the 5-month demonstration period, but the treatment did not meet NYSDEC criteria.
- Analytical results and field measurements indicated that both biovaults supported biological processes.

- The aerobic and aerobic/anaerobic biovaults performed similarly.

The biovault process is sensitive to ambient temperatures, and cool temperatures during the operating period may have negatively impacted microbial activity. The developers suggest initiating biovault operation in the spring and discontinuing operation when weather conditions become too cold to sustain microbial activity.

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NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION/SCIENCE APPLICATIONS INTERNATIONAL CORP.

(In Situ Bioventing Treatment System)

TECHNOLOGY DESCRIPTION:

The In Situ Bioventing Treatment System, process uses bioventing technology to induce aerobic biological degradation of chlorinated compounds. A series of extraction and injection wells is used to amend the soil environment, creating optimum growth conditions for the indigenous bacteria. Anhydrous ammonia and methane are injected into the subsurface to stimulate the growth of methanotrophic microorganisms. Methanotrophs have the enzymatic capabilities to degrade chlorinated solvents through a cometabolic process.

The treatment system consists of an injection and extraction well field and a soil gas extraction-amendment injection blower unit (see photograph below). The blower unit is operated in the vacuum mode long enough to adequately aerate the subsoil and provide oxygen for the aerobic

bacteria. Injection wells are located between the extraction wells and are manifolded to the pressure port of the blower unit. Anhydrous ammonia is periodically injected into the subsoil to provide a source of nitrogen for the aerobic bacteria. In addition, methane gas is periodically injected to stimulate the growth of methanotrophs. The positive displacement blower unit is equipped with a moisture knockout tank, an automatic water discharge pump, and a control panel that allows remote operation of the system. Air and water discharges are typically treated with granular activated carbon prior to final discharge.

Normal system monitoring consists of periodic soil sampling and analysis and soil gas monitoring. Soil samples are collected and analyzed for volatile organic compounds (VOC), soil fertility parameters, and microbiological parameters such as trichloroethene (TCE) degraders and



In Situ Bioventing Treatment System

methanotrophs. In situ respiration tests are conducted to determine the relative activity of the bacteria in the soil.

WASTE APPLICABILITY:

The technology can treat both chlorinated and nonchlorinated VOCs and semivolatile organic compounds that are biodegradable. The in situ bioventing system process was developed to treat volatile chlorinated aliphatic and aromatic hydrocarbons in the unsaturated soil zone.

STATUS:

The in situ bioventing system process was accepted into the SITE Demonstration Program in June 1994. The in situ bioventing system process was part of a pilot-scale, multivendor treatability demonstration (MVTD) that was jointly sponsored by the New York State Department of Environmental Conservation (NYSDEC), the New York State Center for Hazardous Waste Management, and the SITE Program. The objectives of the MVTD were to (1) generate field data for three biological processes, and (2) evaluate the performance of each biological process in meeting NYSDEC cleanup goals.

The demonstration took place from July to December 1994 at the Sweden 3-Chapman site in Sweden, New York and coincided with the ongoing remediation of the site. Soil at the site contained elevated levels of TCE, acetone, tetrachloroethene, dichloroethene, and toluene. The Demonstration Bulletin (EPA/540/MR-95/525) is available from EPA. The Innovative Technology Evaluation Report, which provides more detailed demonstration results, is being prepared.

In addition to the in situ bioventing process, the following technologies were also demonstrated:

- SBP Technologies, Inc., Vacuum-Vaporized Well system
- ENSR Consulting and Engineering and Larsen Engineers Ex Situ Biovault

For information on these technologies, refer to the NYSDEC profiles in the Demonstration Program section (completed projects).

DEMONSTRATION RESULTS:

The SITE demonstration results indicated that the REWEI process reduced contaminants in the soil. The initial mass of TCE in the soil was reduced by 92 percent with 80 percent removal attributed to biodegradation and 12 percent removed by vapor extraction. Results of the microbiological analyses indicate that the number of total heterotrophic, TCE-degrading, and methane-degrading microorganisms increased during treatment. The inorganic soil nitrogen content increased due to the subsurface injection of anhydrous ammonia.

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NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION/SBP TECHNOLOGIES, INC. (Groundwater Circulation Biological Treatment Process)

TECHNOLOGY DESCRIPTION:

The SBP Technologies, Inc. (SBP), remediation program uses an in situ Unterdruck-Verdampfer-Brunnen (UVB) vertical groundwater circulation well technology, which has been enhanced with an in situ bioreactor to treat soil and groundwater contaminated with chlorinated and non-chlorinated volatile organic compounds (VOC). This process consists of a specially adapted groundwater circulation well, reduced-pressure stripping reactor, an in situ bioreactor, and an aboveground vapor-phase bioreactor.

The UVB technology was developed by IEG mbH in Germany and is distributed in the U.S. by IEG Technologies Corporation. SBP obtained the rights to implement this technology and enhanced it to create a more effective in situ bioremediation technology.

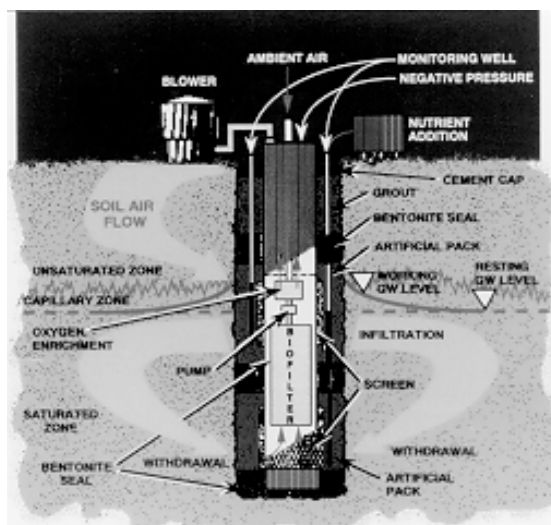
The microbiologically enhanced vertical circulation well technology simultaneously treats the vadose zone, capillary fringe, and saturated zones. During the demonstration, a groundwater convection

(circulation) cell was created radially within the aquifer around the 16-inch UVB well. The UVB well consisted of upper and lower screens separated by a solid riser casing (see the figure below). The lower screen was isolated from the upper screen by a packer, creating two separate screened zones. Contaminated groundwater flowed into the lower screen of the UVB well and was pumped to the upper section. The water rose through the in situ fixed film bioreactor, initially reducing the contaminant load. Groundwater then flowed to the in situ aerator/stripping reactor, where fresh ambient air was mixed with the contaminated groundwater.

The convection cell was developed by allowing the treated groundwater to exit into the upper aquifer. The untreated VOCs exiting the in situ bioreactor system were stripped before the groundwater flowed out of the upper screen into the aquifer as clean water. Oxygenated groundwater from the shallow aquifer circulated to the deep aquifer zone and through the fixed film bioreactor to provide for aerobic degradation. This circulation created a remediation circulation cell in a glacial till geologic formation.

In conjunction with the groundwater remediation, the upper double-cased screen in the well allowed for a one-way soil air flow from the vadose zone to the UVB. This one-way soil venting, created by the reduced-pressure developed in the well by the blower, simultaneously remediated the contaminated unsaturated and capillary fringe zones.

The off-gases from the in situ aerator/stripping reactor passed through an ex situ gas-phase bioreactor for further biotreatment followed by granular activated carbon treatment before they were vented. This bioreactor consisted of spirally wound, microporous, polyvinyl chloride-silica sheets that served as a biosupport for *Pseudomonas cepacia* (strain 17616), a known trichloroethene (TCE) degrader. VOCs in the off-gases, such as toluene, benzene, xylene, TCE, and others, were



Vacuum-Vaporized Well (UVB)
System Standard Circulation

also biologically treated rough a cometabolic process in the gas-phase bioreactor.

WASTE APPLICABILITY:

This technology treats soil and groundwater contaminated with chlorinated and nonchlorinated VOCs.

STATUS:

The UVB system was accepted into the SITE Demonstration Program in June 1994. The pilot-scale, multivendor treatability demonstration (MVTD) was jointly sponsored by the New York State Department of Environmental Conservation (NYSDEC), the New York State Center for Hazardous Waste Management, and the SITE Program. The objectives of the MVTD were to (1) generate field data for three biological processes, and (2) evaluate the performance of each biological process in meeting NYSDEC cleanup goals.

The demonstration took place at the Sweden 3-Chapman site in Sweden, New York. Field work began in July 1994 and was completed in fall 1995. Final reports from the demonstration are available from EPA.

The UVB demonstration coincided with the remediation of the site. Soil at the site contained elevated levels of TCE, acetone, tetrachloroethene, dichloroethene, and toluene. The contaminants of concern (COC) were monitored at 15 groundwater monitoring wells, across the in situ bioreactor, the vadose zone soils, and the ex situ bioreactor, to evaluate the system's performance. A dye tracer test was conducted to determine the extent of the groundwater circulation cell.

In addition to the SBP process, the following technologies were also demonstrated:

- R.E. Wright Environmental, Inc., In Situ Bioventing Treatment System
- ENSR Consulting and Engineering and Larsen Engineers Ex Situ Biovault

For information on these technologies, refer to the NYSDEC profiles in the Demonstration Program section (completed projects).

DEMONSTRATION RESULTS:

During the demonstration, an in situ vertical groundwater circulation cell was established with an effective radius of 40 feet. The UVB system reduced the concentration of COCs in groundwater. The in situ bioreactor provided biotreatment of the COCs in the dissolved phase; removal of COCs from soils was also demonstrated. An ex situ bioreactor was effective in treating off-gas vapors from the UVB system prior to final polishing. Mass balance calculations determined that at least 75 percent of the target COCs in soil and groundwater, within the UVB's radius of influence, were removed during the demonstration.

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NOVATERRA ASSOCIATES

(formerly Toxic Treatment, Inc.)
(In Situ Soil Treatment [Steam and Air Stripping])

TECHNOLOGY DESCRIPTION:

This technology treats contaminated soils and contained groundwater by the simultaneous in situ injection of treatment agents below ground during active mixing by augers or drilling blades (see figure below). The in situ injection of steam and air during mixing strips the volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) from the soil and contained groundwater. The removed organics are captured at the surface and disposed of in an environmentally safe manner.

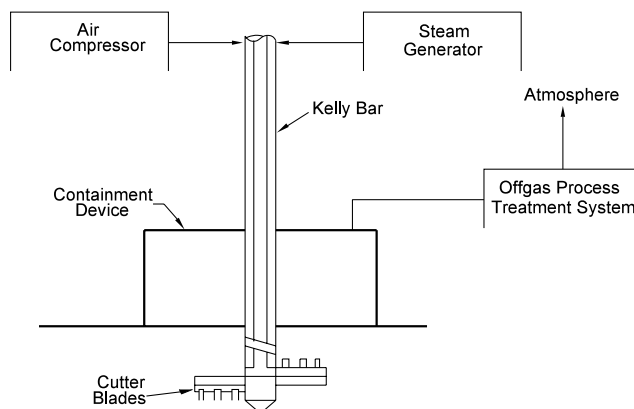
The technology is implemented by a drill unit that can consist of a single or double blade or auger mounted on a large crane or backhoe. The diameter of the drill or auger can vary from 5 to 8 feet, and it is mounted on a kelly that reaches depths of 60 feet.

The steam and air are carried down the center of the kelly(s) and injected into the ground through jets located on the blade or auger arms. The steam is supplied by an oil- or natural gas-fired boiler at 450°F and 500 pounds per square inch gauge (psig). The air heated by the compressor is injected at 250 °F and 200 psig. The steam heats the contaminants in the soil and contained water, increasing the vapor pressure of the VOCs and SVOCs and increasing their removal rates. The direct application of the steam on the soil thermally desorbs the VOCs and SVOCs, increasing their removal percentage. Almost all the VOCs and SVOCs of interest form

azeotropes with steam that boil below 212 °F and contain low concentrations (such as a few percent) of contaminants. These azeotropes significantly increase contaminant removal rates, especially for the higher-boiling-point SVOCs.

The VOC- and SVOC-laden air and steam vapor stream removes the contamination to the surface where it can be captured, if necessary, in a metal container. The container, which makes a tight seal to the ground surface, is connected to a process stream by piping. A suction blower draws the waste stream to the process stream where it is collected or destroyed. The blower creates a slight vacuum in the container and piping as well as a positive displacement inward to the collection or destruction system, thus protecting the outside environment from contamination.

The simplest form of the process system uses a catalytic oxidizer or thermal oxidizer to destroy the contamination before exhausting to the atmosphere. When treating chlorinated VOCs and SVOCs, an acid scrubber can be added if required by the amount of material being processed. Another simple process uses activated carbon to recover the contamination. For the carbon to work efficiently, a cooling system must precede the carbon bed, so the process must also treat contaminated water. If recovery and reuse of the contamination is important or economically desirable, a process system that condenses the gas stream can be used.



In Situ Soil Treatment Process Schematic

The in situ soil treatment technology has also treated contaminated soil by injecting and mixing other agents. Chemical injection processes include the stabilization and solidification of heavy metals, neutralization of acids and bases, and oxidation. The technology has been successfully used to perform bioremediation. The equipment is capable of injecting cement into the soil and making slurry walls. The technology has the unique feature of being able to inject two materials simultaneously or sequentially.

WASTE APPLICABILITY:

This technology can treat solid materials which do not contain obstructions, including soils, sludges, lagoons, and the liquids contained within, such as water and dense and light nonaqueous-phase liquids. The technology is applicable to most VOCs and SVOCs, including pesticides. It is particularly applicable to free product and removal of highly concentrated contamination. It is most effective for removals of 95 to 99 percent of the contamination as a result of the low temperature thermal desorption. After treatment is completed, the soil can meet construction engineering requirements by compacting or injecting small amounts of cement.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1989. A SITE demonstration was performed in September 1989 at the Annex Terminal, San Pedro, California. Twelve soil blocks were treated for VOCs and SVOCs. Liquid samples were collected during the demonstration, and the operating procedures were closely monitored and recorded. In January 1990, six blocks that had been previously treated in the saturated zone were analyzed by EPA methods 8240 and 8270.

The Applications Analysis Report (EPA/540/A5-90/008) was published in June 1991. The technology remediated 30,000 cubic yards at the Annex Terminal after completion of the SITE demonstration and has been used at five other contaminated sites.

DEMONSTRATION RESULTS:

The SITE technology demonstration yielded the following results:

- Removal efficiencies were greater than 85 percent for VOCs present in the soil.
- Removal efficiencies were greater than 55 percent for SVOCs present in the soil.
- Fugitive air emissions from the process were low.
- No downward migration of contaminants resulted from the soil treatment.
- The process treated 3 cubic yards of soil per hour.

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U.S. EPA NRMRL (Alternative Cover Assessment Program)

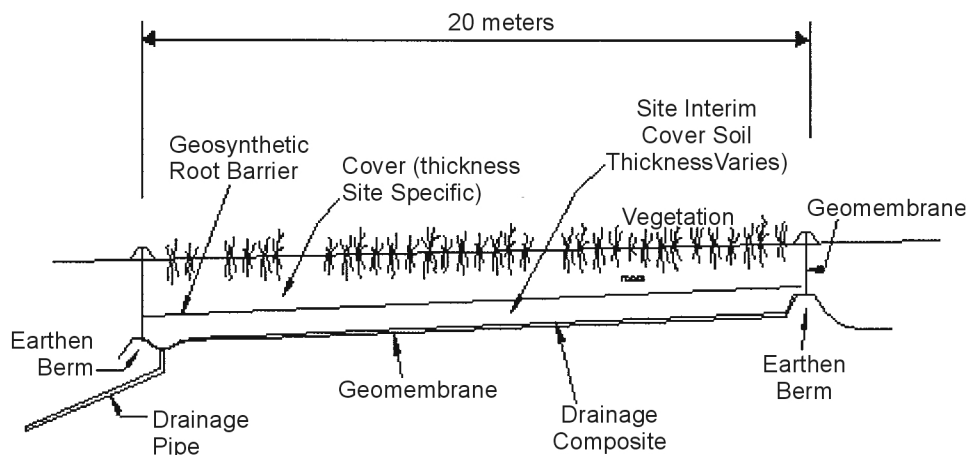
TECHNOLOGY DESCRIPTION:

The goal of the Alternative Cover Assessment Program (ACAP) is the development of field-scale performance data for landfill final cover systems. Both prescriptive (RCRA) and innovative alternative cover designs are currently being tested in the project. The ACAP demonstration has four phases:

- Phase 1 – Initial review of current data collection efforts and numerical modeling capabilities relative to landfill cover design
- Phase 2 – Design, construction, and operation (for 5 years) of a network of alternative cover testing facilities
- Phase 3 – Analysis of field results with improved numerical models to predict long-term performance of alternative cover systems at the selected testing sites
- Phase 4 – Development of a comprehensive guidance document on alternative cover systems

A primary function of a landfill final cover system is to minimize deep percolation to prevent surface and groundwater contamination. Landfill and waste site covers are constructed to meet the requirements of current regulatory guidance, and typically rely on a combination of layers of specified thickness to limit percolation through the cover.

The large costs associated with the construction of the landfill and waste site covers and the desire for constant innovation and performance improvement have resulted in a growing interest for alternative designs. It is ACAP's goal to evaluate the various proposed alternative cover systems. ACAP is currently focusing on evapotranspiration (ET) type covers. ET covers utilize plants to cycle water from the soil profile to the atmosphere during the growing season thus minimizing year-round drainage from the cover system.



WASTE APPLICABILITY:

ACAPs are generally constructed for landfills and waste sites of all scales. In theory, ACAPs can be installed at any location where environmental contaminants must be contained.

STATUS:

Test sections have been installed at landfills in Sacramento County, California; Lake County, Montana; Lewis & Clark County, Montana; Monticello, Utah; Cedar Rapids, Iowa; Omaha, Nebraska; Boardman, Oregon; Altamont, California; Monterey, California; and the Marine Corps Logistics Base in Albany, Georgia. In addition, retrofit monitoring (to study existing alternative covers constructed prior to ACAP) has been established in Cincinnati and Logan, Ohio.

The basic components of the alternative covers for these sites are vegetation and soil. Different communities of trees, shrubs, and grasses are incorporated depending on local soil and climatological conditions. The cover soil is generally local soil, with depth differing in accordance with soil water holding capacity, precipitation patterns, and vegetation selected. Several of the sites include a prescriptive RCRA cover test section. Such side-by-side comparisons will allow direct evaluation of the performance of an alternative to meet or exceed that of the conventional, prescriptive cover.

Each site will contain at least one test section (10 meters x 20 meters) that consists of a large-scale, pan-type *lysimeter* to monitor percolation through tested covers over a period of five years.

During the five years, EPA will monitor and record the climatological conditions (rainfall, snowfall, air temperature, solar radiation, and humidity), and soil parameters (moisture content, moisture potential, and temperature) of each test section. Data will be recorded on a data logger connected to a telemetry unit. The telemetry unit allows remote communication with the data logger and enables data to be downloaded, stored, and analyzed for performance and system status.

Annually during the five years of this project, EPA will release performance reports for each site. EPA predicts that the data collected through ACAP will lead to the development of new computer models for designing and evaluating future landfill covers, new designs, and new methods to regulate such systems.

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U.S. EPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY (Base-Catalyzed Decomposition Process)

TECHNOLOGY DESCRIPTION:

The base-catalyzed decomposition (BCD) process is a chemical dehalogenation technology developed by the National Risk Management Research Laboratory in Cincinnati, Ohio. The process is initiated in a medium-temperature thermal desorber (MTTD) at temperatures ranging from 600 to 950°F. Sodium bicarbonate is added to contaminated soils, sediments, or sludge matrices containing hazardous chlorinated organics including polychlorinated biphenyls (PCB) and polychlorinated dioxins and furans. Chlorinated contaminants that are thermally desorbed from the matrix are condensed and treated by the BCD process. The BCD process chemically detoxifies the condensed chlorinated organic contaminants by removing chlorine from the contaminants and replacing it with hydrogen.

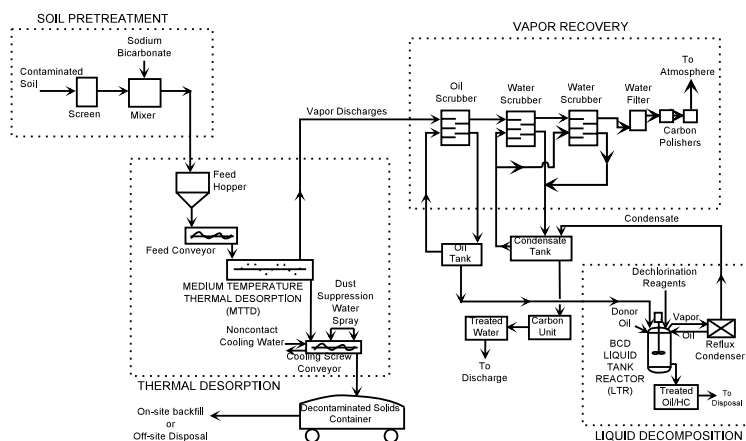
ETG Environmental, Inc. (ETG), and Separation and Recovery Systems, Inc. (SRS), developed the THERM-O-DETOX[®] and SAREX[®] systems and combined them with the BCD process chemistry. The combined process begins by initiating solid-phase dechlorination in the MTTD step (see figure below). In addition to the dechlorination that occurs in the MTTD, organics are thermally desorbed from the matrix, and are condensed and sent to the BCD liquid tank reactor (LTR).

Reagents are then added and heated to 600 to 650°F for 3 to 6 hours to dechlorinate the remaining organics. The treated residuals are recycled or disposed of using standard, commercially available methods. Treated, clean soil can be recycled as on-site backfill.

ETG has continued to develop the THERM-O-DETOX[®] system and now offers continuous systems and batch vacuum systems. The batch vacuum system offers greater operational flexibility for removal and destruction of high hazard, high boiling point contaminants to ensure that treatment standards are met. The vapor recovery system can be set up to use noncontact condensers or chillers and additional final polishing steps to meet the most stringent air emission standards.

WASTE APPLICABILITY:

The BCD process can treat soils, sediments, and sludges contaminated with the following chlorinated compounds: halogenated semivolatile organic compounds (SVOC), including herbicides and pesticides; PCBs; pentachlorophenol (PCP) and other chlorinated phenols; and polychlorinated dioxins and furans.



Base-Catalyzed Decomposition (BCD) Process

STATUS:

The combined BCD process was demonstrated under the SITE Program at the Koppers Company Superfund site in Morrisville, North Carolina, from August through September 1993. The process removed PCP from clay soils to levels below those specified in the Record of Decision. The process also removed dioxins and furans from contaminated soil to 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalent concentrations less than the concentration specified in the Record of Decision.

ETG is also currently operating the batch vacuum system at a New York State Department of Environmental Conservation cleanup site in Binghamton, New York. Approximately 1,500 cubic yards of soil contaminated with herbicides pesticides, dioxins, and furans (F027 waste) are being treated. The Michigan Department of Natural Resources has also approved BCD for a project involving treatment of about 200 cubic yards of F027 soils. At another site, multiple systems will treat soils contaminated with chlorinated volatile organic compounds and high boiling point (800-1150 °F) organic lubricants. The batch vacuum system has also been used to treat sludges at an operating refinery in Puerto Rico and a chemical company in Texas.

For information on the SAREX® system, see the profile for SRS in the Demonstration Program section (ongoing projects).

DEMONSTRATION RESULTS:

The SITE demonstration consisted of four test runs in the MTTD and two test runs in the LTR. Feed soil consisted of a dry, clayey silt and had a residence time of 1 to 2 hours in the MTTD, which was heated to 790 °F to 850 °F. The MTTD off-gases were treated by passing through an oil scrubber, water scrubbers, and carbon filters. The oil from the oil scrubber was transferred to the LTR for BCD treatment. The oil in each LTR test run was batch-processed for 3 to 4 hours at 600 to 630 of.

Key findings from the SITE demonstration are summarized as follows:

- The MTTD achieved removal efficiencies of 99.97 percent or better for PCP and 99.56 percent or better for total dioxins and total furans.
- The treated soils were well below toxicity characteristic leaching procedure limits for SVOCs.
- Treated soil met the cleanup goal of 95 parts per million PCP in all test runs. Treated soil also met a cleanup goal of 7 micrograms per kilogram 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalents in all test runs.
- The LTR batch tests reduced PCP concentrations by 96.89 percent or better, and total dioxin and total furan concentrations by 99.97 percent or better.

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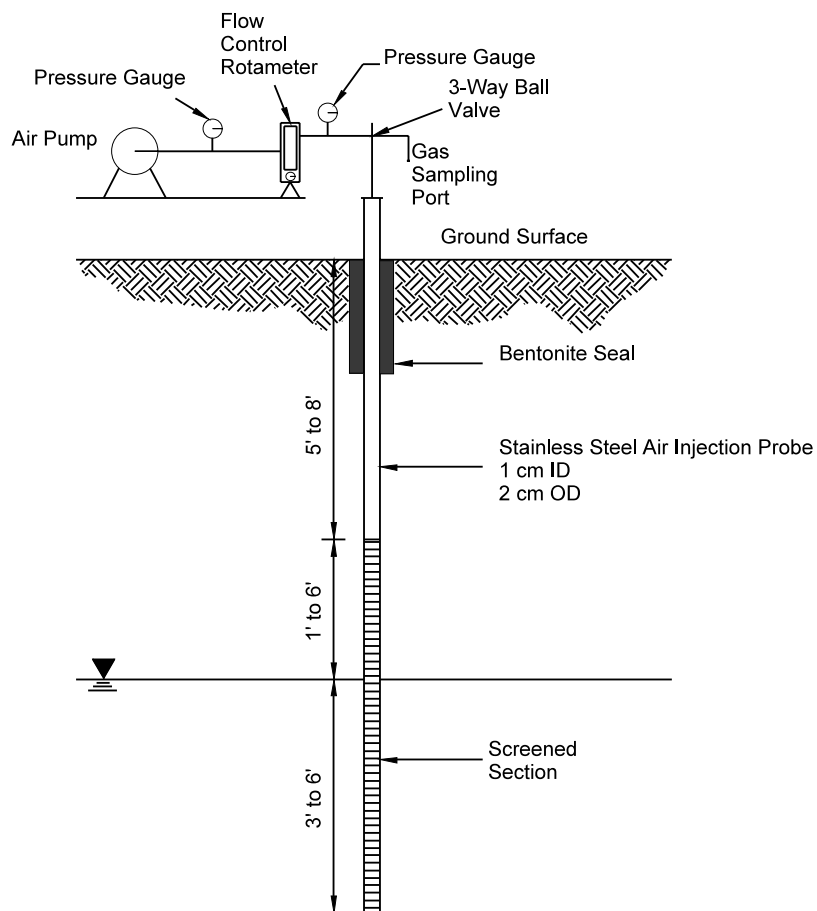
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U.S. EPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY (Bioventing)

TECHNOLOGY DESCRIPTION:

Lack of oxygen in contaminated soil often limits aerobic microbial growth. The bioventing biological system treats contaminated soil in situ by injecting atmospheric air. This air provides a continuous oxygen source, which enhances the growth of microorganisms naturally present in the soil. Additives such as ozone or nutrients may be introduced to stimulate microbial growth.

Bioventing technology uses an air pump attached to one of a series of air injection probes (see figure below). The air pump operates at extremely low pressures, providing inflow of oxygen without significantly volatilizing soil contaminants. The treatment capacity depends on the number of injection probes, the size of the air pump, and site characteristics such as soil porosity.



Bioventing System

WASTE APPLICABILITY:

Bioventing is typically used to treat soil contaminated by industrial processes and can treat any contamination subject to aerobic microbial degradation. Bioventing treats contaminants and combinations of contaminants with varying degrees of success.

STATUS:

This technology was accepted into the SITE Demonstration Program in July 1991. The demonstration began in November 1992 at the Reilly Tar site in St. Louis Park, Minnesota. Soil at this site is contaminated with polynuclear aromatic hydrocarbons.

DEMONSTRATION RESULTS:

Between 1917 and 1972, the 80-acre Reilly Tar site was used for coal tar distillation and wood preserving operations. Wood preserving solutions were estimated to consist of 60-70 percent creosote oil and petroleum oils. Soils at this site consist of approximately 0.6 meters of a topsoil cover underlain by an asphaltic layer, below which coarse sand extends to the water table at approximately 3 meters below ground surface. Sandy soils within the demonstration area were contaminated with PAHs in concentrations as high as 873 mg/Kg.

Respiration tests conducted after two years of system operation suggested that initial oxygen utilization correlated to concentration reductions in the more readily degradable carrier oils (23 percent for naphthalene). Concentrations of the three- and higher-ring PAHs, however, remained unchanged. Final soil data collected in 1997 after five years of treatment showed that bioventing significantly treated the higher-ring PAHs as well. Data analysis indicated concentration reductions of 62 percent, 50 percent, 31 percent, 20 percent, and 24 percent for the 2, 3, 4, 5, and 6-ring PAHs, respectively.

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U.S. EPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY and IT CORPORATION (Debris Washing System)

TECHNOLOGY DESCRIPTION:

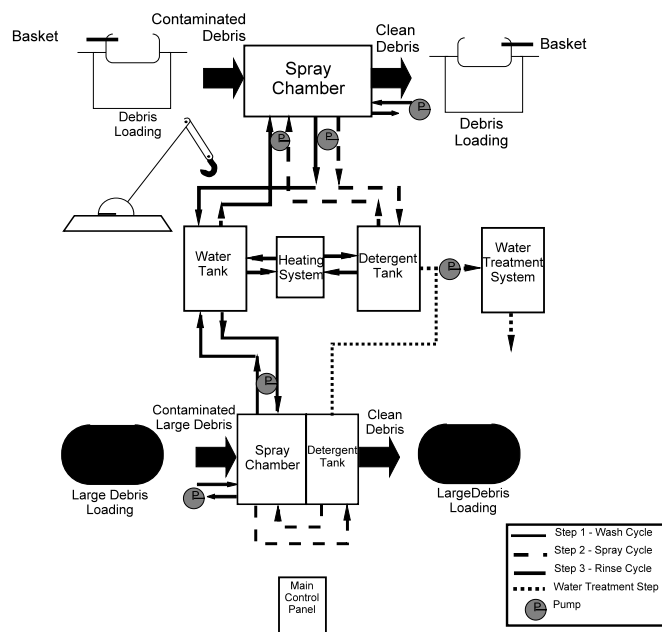
This technology was developed by EPA's National Risk Management Research Laboratory and IT Corporation (IT) for on-site decontamination of metallic and masonry debris at Comprehensive Environmental Response, Compensation, and Liability Act sites. The entire system is mounted on three 48-foot flatbed semi-trailers and can be readily transported from site to site.

The full-scale debris washing system (DWS) is shown in the figure below. The DWS consists of dual 4,000-gallon spray-wash chambers that are connected to a detergent solution holding tank and rinse water holding tank. Debris is placed into one of two 1,200-pound baskets, which in turn is placed into one of the spray-wash chambers using a 5-ton crane integral to the DWS. If debris is large

enough, the crane places it directly into one of the two chambers. Process water is heated to 160°F using a diesel-fired, 2,000,000-British-thermal-unit-per-hour (Btu/hr) water heater. The water is continuously reconditioned using particulate filters, an oil-water separator, and other devices such as charcoal columns or ion-exchange columns. About 8,000 to 10,000 gallons of water is required for the decontamination process. The system is controlled by an operator stationed in a trailer-mounted control room.

WASTE APPLICABILITY:

The DWS can be applied on site to various types of debris (scrap metal, masonry, or other solid debris such as stones) contaminated with hazardous chemicals such as pesticides, dioxins, polychlorinated biphenyls (PCB), or hazardous



Pilot-Scale Debris Washing System

metals.

STATUS:

The first pilot-scale tests were performed in September 1988 at the Carter Industrial Superfund site in Detroit, Michigan. An upgraded pilot-scale DWS was tested at a PCB-contaminated Superfund site in Hopkinsville, Kentucky in December 1989. The DWS was also field tested in August 1990 at the Shaver's Farm Superfund site in Walker County, Georgia. The contaminants of concern were benzonitrile and Dicamba. After being cut into sections, 55-gallon drums were decontaminated in the DWS.

Results from the SITE demonstration have been published in a Technology Evaluation Report (EPA/540/5-91/006a), entitled "Design and Development of a Pilot-Scale Debris Decontamination System" and in a Technology Demonstration Summary (EPA/540/S5-91/006).

In 1993, a manual version of the full-scale DWS was used to treat PCB-contaminated scrap metal at the Summit Scrap Yard in Akron, Ohio. During the 4-month site remediation, 3,000 tons of PCB-contaminated scrap metal (motors, cast iron blocks) was cleaned on site. The target level of 7.7 $\mu\text{g}/100\text{ cm}^2$ was met, in most cases, after a single treatment with the DWS. The cleaned scrap was purchased by a scrap smelter for \$52 per ton. The net costs for the on-site debris decontamination ranged from \$50 to \$75 per ton. The National Risk Management Research Laboratory and IT estimate that the system can decontaminate 50 to 120 tons of typical debris per day.

DEMONSTRATION RESULTS:

At the Carter Industrial Superfund site, PCB reductions averaged 58 percent in batch 1 and 81 percent in batch 2. Design changes based on these tests were made to the DWS before additional field testing.

At the Hopkinsville, Kentucky site, PCB levels on the surfaces of metallic transformer casings were reduced to less than or equal to 10 micrograms PCB per 100 square centimeters ($\mu\text{g}/\text{cm}^2$). All 75 contaminated transformer casings on site were decontaminated to EPA cleanup criteria and sold to a scrap metal dealer.

At the Shaver's Farm Superfund site, benzonitrile and Dicamba levels on the drum surfaces were reduced from the average pretreatment concentrations of 4,556 and 23 $\mu\text{g}/100\text{ cm}^2$ to average concentrations of 10 and 1 $\mu\text{g}/100\text{ cm}^2$, respectively.

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U.S. EPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY and INTECH 180 CORPORATION (Fungal Treatment Technology)

TECHNOLOGY DESCRIPTION:

This biological treatment system uses lignin-degrading fungi to treat excavated soils. These fungi have been shown to biodegrade a wide catalogue of organic contaminants.

The contaminated soil is inoculated with an organic carrier infested with the selected fungal strain. The fungi break down soil contaminants, using enzymes normally produced for wood degradation as well as other enzyme systems.

This technology has the greatest degree of success when optimal growing conditions for the fungi are used. These conditions include moisture control (at 90 percent of field capacity), and temperature and aeration control. Organic nutrients such as peat may be added to soils deficient in organic carbon.

WASTE APPLICABILITY:

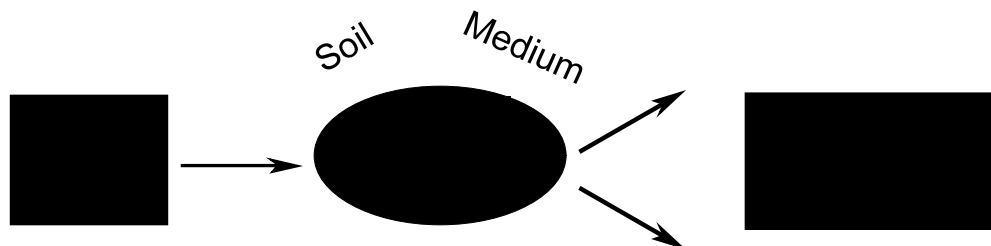
This biological treatment system was initially applied to soil contaminated with organic chemicals found in the wood-preserving industry. These contaminants are composed of chlorinated organics and polynuclear aromatic hydrocarbons (PAH). The treatment system may remediate different contaminants and combinations of contaminants with varying degrees of success. In particular, the SITE Demonstration Program evaluated how well white rot fungi degrade pentachlorophenol (PCP) in combination with creosote PAHs.

STATUS:

This biological treatment system was accepted into the SITE Demonstration Program in April 1991. In September 1991, a treatability study was conducted at the Brookhaven Wood Preserving site in Brookhaven, Mississippi. Site soils were contaminated with 200 to 5,200 milligrams per kilogram (mg/kg) PCP and up to 4,000 mg/kg PAHs.

A full-scale demonstration of this fungal treatment technology was completed in November 1992 to obtain economic data. The Demonstration Bulletin (EPA/540/MR- 93/505) is available from EPA.

The extent of treatment in the full-scale demonstration was disappointing for the time of treatment. The full-scale demonstration was hampered by excessive rainfall which did not permit the treatment beds to be sufficiently tilled. Without this processing, oxygen-depleted conditions developed, leading to loss of fungal biomass and activity. Soil bed applications of this technology may not be suitable in climates of high rainfall. Current costs of fungal treatment operation are estimated at \$150 to \$200 per ton. Lower costs may be achieved with new inoculum formulations which permit reduction in the amount of inoculum mass required for treatment.



In Situ White Rot Fungal Treatment of Contaminated Soil

DEMONSTRATION RESULTS:

The full-scale project involved a 0.25-acre plot of contaminated soil and two smaller control plots. The soil was inoculated with *Phanaerochaete sordida*, a species of lignin-degrading fungus. No other amendments were added to the prepared soil. Field activities included tilling and watering all plots. No nutrients were added. The study was conducted for 20 weeks.

Some key findings from the demonstration were:

- Levels of PCP and the target PAHs found in the underlying sand layer and the leachate from each of the plots were insignificant, indicating low leachability and loss of these contaminants due to periodic irrigation of the soil and heavy rainfall.
- Levels of PCP, the target PAHs, and dioxins in the active air samples collected during the soil tilling events were insignificant, indicating a very low potential for airborne contaminant transport.
- Air emissions data showed that soil tilling activities did not pose significant hazards to field technicians. Contaminated soil, underlying sand, and leachate had no significant contamination.

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**U.S. EPA NATIONAL RISK MANAGEMENT
RESEARCH LABORATORY,
UNIVERSITY OF CINCINNATI, and FRX, INC.
(Hydraulic Fracturing)**

TECHNOLOGY DESCRIPTION:

Hydraulic fracturing is a physical process that creates fractures in soils to enhance fluid or vapor flow in the subsurface. The technology places fractures at discrete depths with hydraulic pressurization at the base of a borehole. These fractures are placed at specific locations and depths to increase the effectiveness of treatment technologies such as soil vapor extraction, in situ bioremediation, and pump-and-treat systems. The technology is designed to enhance remediation in less permeable geologic formations.

The fracturing process begins by injecting water into a sealed borehole until the water pressure exceeds a critical value and a fracture is nucleated (see photograph below). A slurry composed of a coarse-grained sand, or other granular material, and guar gum gel is then injected as the fracture grows away from the well. After pumping, the grains hold the fracture open while an enzyme additive breaks down the viscous fluid. The thinned fluid is pumped from the fracture, forming a permeable

subsurface channel suitable for delivering or recovering a vapor or liquid. These fractures function as pathways for fluid movement, potentially increasing the effective area available for remediation.

The hydraulic fracturing process is used in conjunction with soil vapor extraction technology to enhance recovery of contaminated soil vapors. Hydraulic fractures have recently been used to improve recovery of light nonaqueous phase liquids by increasing recovery of free product and controlling the influence of underlying water. Hydraulically induced fractures are used as channels for fluids and nutrients during in situ bioremediation. The technology has the potential to deliver nutrients and other materials to the subsurface solids useful in bioremediation. Solid nutrients or oxygen-releasing granules can be injected into the fractures.

Real-time techniques for measuring ground surface deformation have been developed to monitor the fracture positions in the subsurface.



Hydraulic Fracturing Process (Well is at center of photograph)

WASTE APPLICABILITY:

Hydraulic fracturing is appropriate for enhancing soil and groundwater remediation. The technology can channel contaminants or wastes for soil vapor extraction, bioremediation, or pump-and-treat systems.

STATUS:

The hydraulic fracturing technology was accepted into the SITE Demonstration Program in July 1991. Demonstrations have been conducted in Oak Brook, Illinois and Dayton, Ohio. The hydraulic fracturing process was integrated with soil vapor extraction at the Illinois site and with in situ bioremediation at the Ohio site. The project was completed in September 1992. The Technology Evaluation and Applications Analysis Reports, which were published under one cover (EPA/540/R-93/505), and the Technology Demonstration Summary (EPA/540/SR-93/505) are available from EPA.

DEMONSTRATION RESULTS:

The first demonstration was conducted at a Xerox Corporation site in Oak Brook, Illinois, where a vapor extraction system has been operating since early 1991. The site is contaminated with ethylbenzene, 1,1-dichloroethane, trichloro-ethene, tetrachloroethene, 1,1,1-trichloroethane, toluene, and xylene. In July 1991, hydraulic fractures were created in two of the four wells, at depths of 6, 10, and 15 feet below ground surface. The vapor flow rate, soil vacuum, and contaminant yields from the fractured and unfractured wells were monitored regularly. Results from this demonstration are as follows:

- Over a 1-year period, the vapor yield from hydraulically fractured wells was one order of magnitude greater than from unfractured wells.
- The hydraulically fractured wells enhanced remediation over an area 30 times greater than the unfractured wells.

- The presence of pore water decreased the vapor yield from wells; therefore, water must be prevented from infiltrating areas where vapor extraction is underway.

The technology was also demonstrated at a site near Dayton, Ohio, which is contaminated with benzene, toluene, ethylbenzene, and xylene (BTEX), and other petroleum hydrocarbons. In August 1991, hydraulic fractures were created in one of two wells at 4, 6, 8, and 10 feet below ground surface. Sampling was conducted before the demonstration and twice during the demonstration at locations 5, 10, and 15 feet north of the fractured and unfractured wells. Results from this demonstration are as follows:

- The flow of water into the fractured well was two orders of magnitude greater than in the unfractured well.
- The bioremediation rate near the fractured well was 75 percent higher for BTEX and 77 percent higher for total petroleum hydrocarbons compared to the rates near the unfractured well.

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U.S. EPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY (Mobile Volume Reduction Unit)

TECHNOLOGY DESCRIPTION:

The volume reduction unit (VRU) is a pilot-scale, mobile soil washing system designed to remove organic contaminants and metals from soil through particle size separation and solubilization. The VRU can process 100 pounds of soil (dry weight) per hour.

The process subsystems consist of soil handling and conveying, soil washing and coarse screening, fine particle separation, flocculation-clarification, water treatment, and utilities. The VRU is controlled and monitored with conventional industrial process instrumentation and hardware.

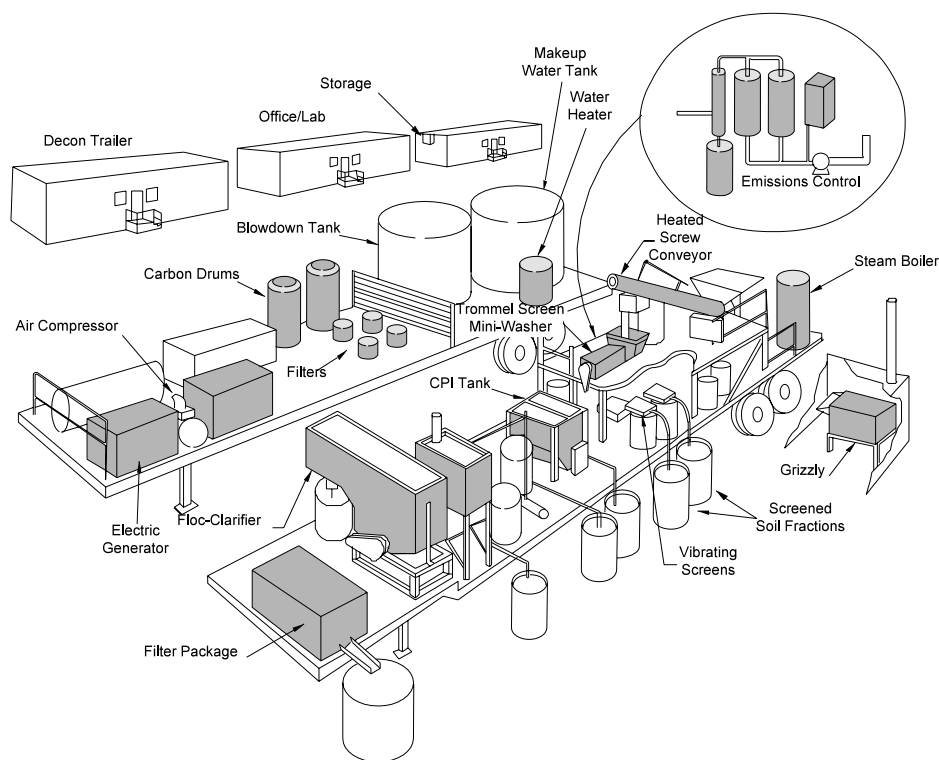
WASTE APPLICABILITY:

The VRU can treat soils that contain organics such as creosote, pentachlorophenol (PCP), pesticides, polynuclear aromatic hydrocarbons (PAH), volatile organic compounds, and semivolatile organic compounds. The VRU also removes metals.

STATUS:

The VRU was accepted into the SITE Demonstration Program in summer 1992.

The demonstration was conducted in November 1992 at the former Escambia Treating Company in Pensacola, Florida. The facility used PCP and creosote PAHs to treat wood products from 1943 to 1982. The Applications Analysis Report (EPA/540/AR-93/508) is available from EPA.



Typical VRU Operational Setup

PHARMACIA CORPORATION (formerly Monsanto/DuPont) (Lasagna™ In Situ Soil Remediation)

TECHNOLOGY DESCRIPTION:

The Lasagna™ process, so named because of its treatment layers, combines electroosmosis with treatment layers which are installed directly into the contaminated soil to form an integrated, in-situ remedial process. The layers may be configured vertically or horizontally (see figures below). The process is designed to treat soil and groundwater contaminants completely in situ, without the use of injection or extraction wells.

The outer layers consist of either positively or negatively charged electrodes which create an electrical potential field. The electrodes create an electric field which moves contaminants in soil pore fluids into or through treatment layers. In the vertical configuration, rods that are steel or granular graphite and iron filings can be used as electrodes. In the horizontal configuration, the electrodes and treatment zones are installed by hydraulic fracturing. Granular graphite is used for the electrodes and the treatment zones are granular iron

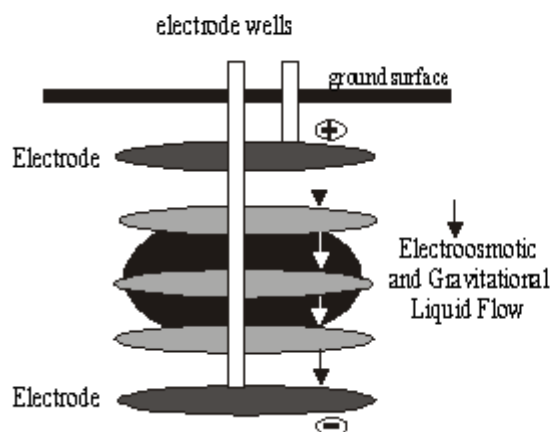
(for zero-valent, metal-enhanced, reductive dechlorination) or granular activated carbon (for biodegradation by methanotropic microorganisms).

The orientation of the electrodes and treatment zones depends on the characteristics of the site and the contaminants. In general, the vertical configuration is probably more applicable to more shallow contamination, within 50 feet of the ground surface. The horizontal configuration, using hydraulic fracturing or related methods, is uniquely capable of treating much deeper contamination.

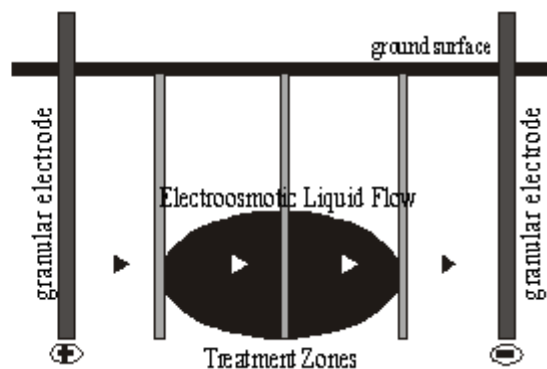
WASTE APPLICABILITY:

The process is designed for use in fine-grained soils (clays and silts) where water movement is slow and it is difficult to move contaminants to extraction wells. The process induces water movement to transport contaminants to the treatment zones so the contaminants must have a high solubility or miscibility in water. Solvents

A. Horizontal Configuration



B. Vertical Configuration



such as trichloroethylene and soluble metal salts can be treated successfully while low-solubility compounds such as polychlorinated biphenyls and polyaromatic hydrocarbons cannot.

STATUS:

The Lasagna™ process (vertical configuration) was accepted into the SITE Demonstration Program in 1995. Two patents covering the technology have been granted to Monsanto, and the term Lasagna™ has also been trademarked by Monsanto. Developing the technology so that it can be used with assurance for site remediation is the overall objective of the sponsoring consortium.

DEMONSTRATION RESULTS:

The vertical configuration demonstration by Pharmacia at the Gaseous Diffusion Plant in Paducah, Kentucky, has been completed. The analysis of trends in TCE contamination of soil before and after Lasagna™ treatment indicated that substantial decreases did occur and the technology can be used to meet action levels.

The horizontal configuration demonstration by the University of Cincinnati and EPA at Rickenbacker ANGB (Columbus, OH) has been completed and both cells decommissioned. The cells were installed in soil containing TCE. The work demonstrated that horizontal Lasagna™ installations are feasible and that the installation results in some treatment of contaminants. The extent of treatment of the TCE-contaminated soil was not clear because of the small size of the cells and transport of TCE into the cells from adjacent contaminated areas.

In cooperation with the U.S. Air Force, EPA installed two horizontal configuration Lasagna™ cells in TCE-contaminated soil at Offutt AFB (Omaha, NE) in November 1998. The cells have been in operation since September 2000. An interim sampling in December 2000 at the four locations with highest concentrations in each cell showed slight decreases in organic chloride in one cell, but these were not statistically different from initial (pretreatment) concentrations. A second interim sampling will be conducted in June 2001 and the final (posttreatment) sampling in September 2001.

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PHYTOKINETICS, INC.

(Phytoremediation Process)

TECHNOLOGY DESCRIPTION:

Phytoremediation is the treatment of contaminated soils, sediments, and groundwater with higher plants. Several biological mechanisms are involved in phytoremediation. The plant's ability to enhance bacterial and fungal degradative processes is important in the treatment of soils. Plant-root exudates, which contain nutrients, metabolites, and enzymes, contribute to the stimulation of microbial activity. In the zone of soil closely associated with the plant root (rhizosphere), expanded populations of metabolically active microbes can biodegrade organic soil contaminants.

The application of phytoremediation involves characterizing the site and determining the proper planting strategy to maximize the interception and degradation of organic contaminants. Site monitoring ensures that the planting strategy is proceeding as planned. The following text discusses (1) using grasses to remediate surface soils



Phytoremediation of Surface Soil

contaminated with organic chemical wastes (Figure 1), and (2) planting dense rows of poplar trees to treat organic contaminants in the saturated groundwater zone (Figure 2).

Soil Remediation - Phytoremediation is best suited for surface soils contaminated with intermediate levels of organic contaminants. Preliminary soil phytotoxicity tests are conducted at a range of contaminant concentrations to select plants which are tolerant. The contaminants should be relatively nonleachable, and must be within the reach of plant roots. Greenhouse-scale treatability studies are often used to select appropriate plant species.

Grasses are frequently used because of their dense fibrous root systems. The selected species are planted, soil nutrients are added, and the plots are intensively cultivated. Plant shoots are cut during the growing season to maintain vegetative, as opposed to reproductive, growth. Based on the types and concentrations of contaminants, several growing seasons may be required to meet the site's



Phytoremediation of the Saturated Zone

remedial goals.

Groundwater Remediation - The use of poplar trees for the treatment of groundwater relies in part on the tree's high rate of water use to create a hydraulic barrier. This technology requires the establishment of deep roots that use water from the saturated zone. Phytokinetics uses deep-rooted, water-loving trees such as poplars to intercept groundwater plumes and reduce contaminant levels. Poplars are often used because they are phreatophytic; that is, they have the ability to use water directly from the saturated zone.

A dense double or triple row of rapidly growing poplars is planted downgradient from the plume, perpendicular to the direction of groundwater flow. Special cultivation practices are used to induce deep root systems. The trees can create a zone of depression in the groundwater during the summer months because of their high rate of water use. Groundwater contaminants may tend to be stopped by the zone of depression, becoming adsorbed to soil particles in the aerobic rhizosphere of the trees. Reduced contaminant levels in the downgradient groundwater plume would result from the degradative processes described above.

WASTE APPLICABILITY:

Phytoremediation is used for soils, sediments, and groundwater containing intermediate levels of organic contaminants.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1995. The demonstration occurred at the former Chevron Terminal #129-0350 site in Ogden, Utah. A total of 40 hybrid poplar trees were planted using a deep rooting technique in 1996 and data were collected through 1999 growing season.

DEMONSTRATION RESULTS:

Water removal rates estimated using a water use multiplier and leaf area index to adjust a reference evapo-transpiration rate was 5 gallons per day per tree in 1998 and 113 gallons per day per tree in 1999. Water removal rates determined using SAP velocity measurements done in September and October of 1998 agreed closely with the estimated values. Although the trees transpired a volume of water equivalent to a 10-ft thickness of the saturated zone, water table elevation data collected in 1999 did not indicate a depression in the water table.

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PINTAIL SYSTEMS, INC.

(Spent Ore Bioremediation Process)

TECHNOLOGY DESCRIPTION:

This technology uses microbial detoxification of cyanide in heap leach processes to reduce cyanide levels in spent ore and process solutions. The biotreatment populations of natural soil bacteria are grown to elevated concentrations, which are applied to spent ore by drip or spray irrigation. Process solutions are treated with bacteria concentrates in continuous or batch applications. This method may also enhance metal remineralization, reducing acid rock drainage and enhancing precious metal recovery to offset treatment costs.

Biotreatment of cyanide in spent ore and ore processing solutions begins by identifying bacteria that will grow in the waste source and that use the cyanide for normal cell building reactions. Native isolates are ideally adapted to the spent ore environment, the available nutrient pool, and potential toxic components of the heap environment. The cyanide-detoxifying bacteria are typically a small fraction of the overall population of cyanide-tolerant species.

For this reason, native bacteria isolates are extracted from the ore and tested for cyanide detoxification potential as individual species. Any natural detoxification potentials demonstrated in flask cyanide decomposition tests are preserved and submitted for bioaugmentation. Bioaugmentation of the cyanide detoxification population eliminates nonworking species of bacteria and enhances the natural detoxification potential by growth in waste infusions and chemically defined media. Pintail

Systems, Inc. (PSI) maintains a bacterial library of some 2,500 strains of microorganisms and a database of their characteristics.

The working population of treatment bacteria is grown in spent ore infusion broths and process solutions to adapt to field operating conditions. The cyanide in the spent ore serves as the primary carbon or nitrogen source for bacteria nutrition. Other required trace nutrients are provided in the chemically defined broths. The bacterial consortium is then tested on spent ore in a 6-inch-by-10-foot column in the field or in the laboratory. The column simulates leach pile conditions, so that detoxification rates, process completion, and effluent quality can be verified. Following column tests, a field test may be conducted to verify column results.

The spent ore is remediated by first setting up a stage culturing system to establish working populations of cyanide-degrading bacteria at the mine site. Bacterial solutions are then applied directly to the heap using the same system originally designed to deliver cyanide solutions to the heap leach pads (see figure on previous page). Cyanide concentrations and leachable metals are then measured in heap leach solutions. This method of cyanide degradation in spent ore leach pads degrades cyanide more quickly than methods which treat only rinse solutions from the pad. In addition to cyanide degradation, biological treatment of heap leach pads has also shown significant biomineralization and reduction of leachable metals in heap leachate solutions.

WASTE APPLICABILITY:

The spent ore bioremediation process can be applied to treat cyanide contamination, spent ore heaps, waste rock dumps, mine tailings, and process water from gold and silver mining operations.

STATUS:

This technology was accepted into the SITE Demonstration Program in May 1994. The field treatability study was conducted, at the Echo Bay/McCoy Cover mine site near Battle Mountain, Nevada, between June 11, 1997 and August 26, 1997.

DEMONSTRATION RESULTS:

Results from the study are summarized below:

- The average % WAD CN reduction attributable to the Biocyanide process was 89.3 during the period from July 23 to August 26. The mean concentration of the feed over this period was 233 ppm, while the treated effluent from the bioreactors was 25 ppm. A control train, used to detect abiotic loss of cyanide, revealed no destruction of cyanide (average control affluent = 242 ppm).
- Metals that were monitored as part of this study were As, Cd, Co, Cu, Fe, Mn, Hg, Ni, Se, Ag, and Zn. Significant reductions were noted for all metals except Fe and Mn. Average reduction in metals concentration after July 23 for all other metals were 92.7% for As 91.6% for Cd, 61.6% for Co, 81.4% for Cu, 95.6% for Hg, 65.0% for Ni, 76.3% for Se, 94.6% for Ag, and 94.6% for Zn. Reductions for As, Cd, Co, and Se are probably greater than calculated due to non-detect levels in some effluent samples. A biomineralization mechanism is proposed for the removal of metals for solution. Biomineralization is a process in which microbes mediate biochemical reactions forming novel mineral assemblages on solid matrices.

- The Aqueous Biocyanide Process was operated for two and one-half months. During the first 42 days (June 11 to July 22) system performance was variable, and occasional downtimes were encountered. This was due to greatly higher cyanide and metals concentration in the feed than was encountered during benchscale and design phases of the project. Once optimized for the more concentrated feed, the system performed well with continuous operation for 35 days (July 23 to August 26). The ability to "re-engineer" the system in the field to accommodate the new waste stream is a positive attribute of the system.

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PRAXIS ENVIRONMENTAL TECHNOLOGIES, INC.

(In Situ Thermally Enhanced Extraction (TEE) Process)

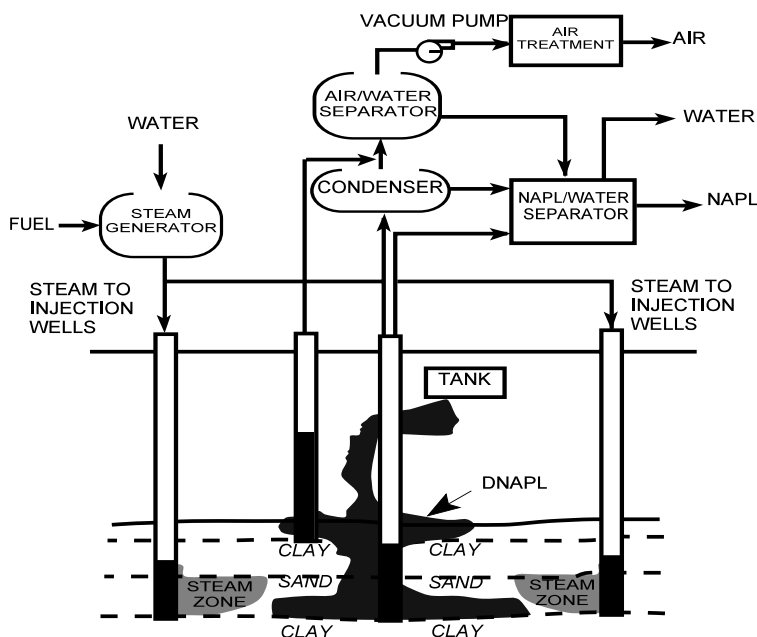
TECHNOLOGY DESCRIPTION:

The PRAXIS TEE in situ thermal extraction process heats soil with steam injection, enhancing pump-and-treat and soil vapor extraction processes used to treat volatile organic compounds (VOC) and semivolatile organic compounds (SVOC). This process is an effective and relatively inexpensive technique to raise a target soil volume to a nearly uniform temperature.

As illustrated in the figure below, steam is introduced to the soil through injection wells screened in contaminated intervals. The vacuum applied to the extraction wells, during and after steam/hot air injection, forms a pneumatic barrier at the treatment boundaries. This barrier limits lateral migration of steam and contaminants while air sweeping the steam zone boundaries carries contaminants to extraction wells.

Groundwater and liquid contaminants are pumped from the extraction wells; steam, air, and vaporized contaminants are extracted under vacuum. After the soil is heated by steam injection, the injection wells can introduce additional agents to facilitate the cleanup.

Recovered vapors pass through a condenser. The resulting condensate is combined with pumped liquids for processing in separation equipment. Separated nonaqueous phase liquids (NAPL) can be recycled or disposed of, and the water is treated prior to discharge. The noncondensable gases are directed to a vapor treatment system consisting of (1) catalytic oxidation equipment, (2) activated carbon filters, or (3) other applicable vapor technologies. The in situ thermal extraction process uses conventional injection, extraction and monitoring wells, off-the-shelf piping, steam generators, condensers, heat exchangers, separation equipment, vacuum pumps, and vapor emission control equipment.



In Situ Thermal Extraction Process

WASTE APPLICABILITY:

The in situ thermal extraction process removes VOCs and SVOCs from contaminated soils and groundwater. The process primarily treats chlorinated solvents such as trichloroethene (TCE), tetrachloroethene (PCE), and dichloro-benzene; hydrocarbons such as gasoline, diesel, and jet fuel; and mixtures of these compounds.

The process can be applied to rapid cleanup of source areas such as dense NAPL pools below the water table surface, light NAPL pools floating on the water table surface, and NAPL contamination remaining after using conventional pumping techniques. Subsurface conditions are amenable to biodegradation of residual contaminants, if necessary, after application of the thermal process. A cap is required for implementation of the process near the soil surface. For dense NAPL compounds in high concentrations, a barrier must be present or created to prevent downward percolation of the NAPLs. The process is applicable in less permeable soils with the use of novel delivery systems such as horizontal wells or fracturing.

STATUS:

This technology was accepted into the SITE Demonstration Program in August 1993. The demonstration occurred at a former waste management area located at Operable Unit 2 at Hill Air Force Base in Ogden, Utah, during June and July 1997. The demonstration site was the location of two former unlined trenches that received unknown quantities of various chlorinated solvent wastes from 1967 to 1975.

DEMONSTRATION RESULTS:

The demonstration focused primarily on assessing and recovering dense NAPL from the trough area and reducing TCE and PCE levels in the lower saturated zone so as to meet or exceed the Record of Decision (ROD) cleanup goals and the Preliminary Remedial Goals (PRG) established for the site's soils.

Soil PRGs for TCE and PCE were 58 milligrams per kilogram (mg/Kg) and 12 mg/Kg respectively. A total of 41 post-characterization soil samples were collected to determine if these goals were met by the technology. Thirty-five of the 41 samples had PCE concentrations below the PRG. Thirty-five of the 41 samples also had TCE concentrations below the PRG. There were 33 samples that had both TCE and PCE concentrations below the specified PRGs. Detailed reports on the demonstration are in preparation and will be available from EPA in 2001. The developer is presently seeking patents on various aspects of the system, while continuing to seek opportunities at other U.S. Department of Defense facilities.

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REGENESIS

(Time Release Electron Acceptors and Donors for Accelerated Natural Attenuation)

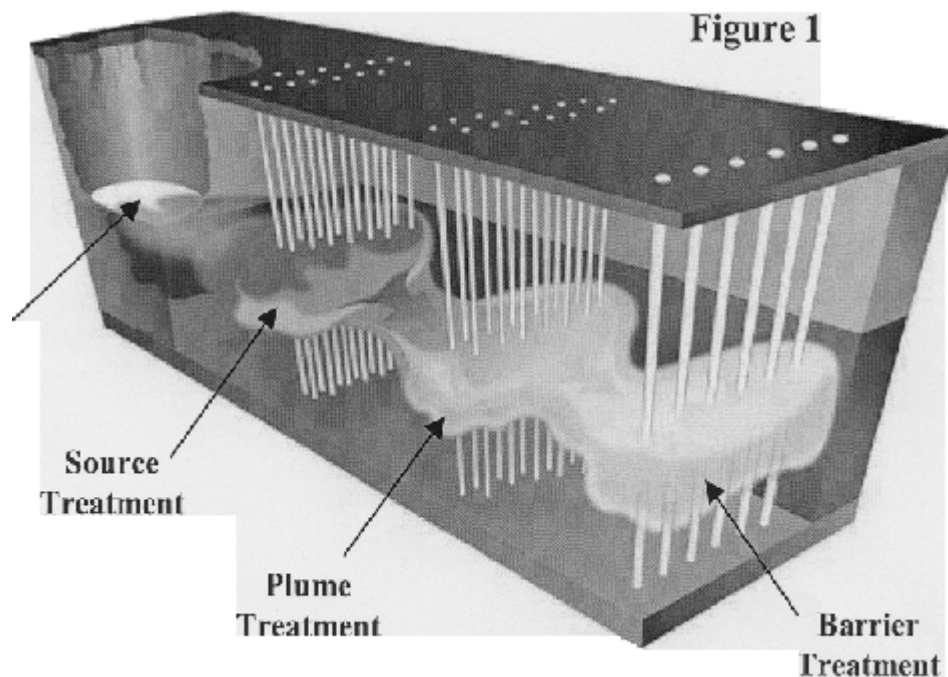
TECHNOLOGY DESCRIPTION:

The Regenes technology is defined as the use of time-released electron acceptors and electron donors for the passive, long-term and cost effective acceleration of the bioremediation component of natural attenuation. The specific products are 1) Oxygen Release Compound (ORC®), which provides the electron acceptor oxygen to enhance the aerobic bioremediation of compounds such as petroleum hydrocarbons and 2) Hydrogen Release Compound (HRC®), which provides the electron donor hydrogen to enhance the anaerobic bioremediation of compounds such as chlorinated solvents. ORC® is a proprietary formulation of magnesium peroxide that only releases oxygen when hydrated and can provide a continuous source of oxygen (electron acceptor) for up to 12 months. HRC® is a polylactate ester and also requires hydration before it releases lactic acid, a fermentable substrate, which generates hydrogen (electron donor) for up to 18 months. Treatment is typically in situ and both products are applied to the

subsurface via direct-push injection or borehole delivery methods. If needed, both products can be applied directly to open excavations via broadcast application techniques. These methods, as illustrated in Figure 1, can be used to emplace barriers to plume migration or be used directly in the plume to treat dissolved and residual contaminant mass.

The bioremediation component of natural attenuation describes a process by which contaminants are reduced in concentration over time by biological action. The process is facilitated by microbes that can be aerobic or anaerobic, requiring either oxygen or hydrogen respectively, to help carry out the degradation of target contaminants. At most sites the subsurface is lacking in these key substrates, which prevents the natural microbial population from facilitating bioremediation. The use of time-released substrates such as ORC® and HRC® typically accelerates natural attenuation 10 to 100 times faster than unassisted natural attenuation.

WASTE APPLICABILITY:



ORC® and HRC® can be applied to chlorinated solvents and hydrocarbon-contaminated groundwater plumes and soils.

STATUS:

Regenesiis was invited to participate in the SITE Demonstration Program in 2000-2001 at two specific sites, Fisherville Mill and the Rocky Mountain Arsenal.

Fisherville Mill -Grafton, Massachusetts

Currently a pilot scale study is being conducted to demonstrate the effectiveness of using HRC® to reduce the concentration of trichloroethylene (TCE) in groundwater at the Fisherville Mill site in Grafton, MA. This site is considered a Brownfield site and has a sandy gravel aquifer impacted with the chlorinated solvent. The Pilot test consists of an array of 15 2-inch-diameter injection wells constructed to deliver the HRC® to the subsurface. The wells were constructed of PVC with a 10-foot screened interval. The HRC® injection well array was installed downgradient of an existing monitoring well. Ten new monitoring wells were constructed downgradient of the HRC injection array to track the progress of the accelerated reductive dechlorination. Hundred pounds of HRC® were injected into each injection well for a total of 1,500 lbs. of HRC®. This activity began in July 2000 and monitoring was scheduled to continue through October 2001. A report was scheduled to be released in December 2001.

Rocky Mountain Arsenal- Denver, Colorado.

Another HRC® field pilot scale study is being carried out at the Rocky Mountain Arsenal. The field demonstration is designed to treat a plume in the northern portion of Basin F that is contaminated by several organic compounds including PCE, TCE, chloroform, methylene chloride, dieldrin and di-isopropylmethyl phosphonate (DIMP). Based on a 60-day bench-scale study completed in March 2000, HRC® was shown to be very effective in dramatically reducing the entire range of contaminants, which prompted the Rocky Mountain Arsenal Water Team to arrange a field pilot test at the site. The recently installed pilot consists of a permeable reactive barrier utilizing 41 HRC® injection points at depths of 42 ft to 54 ft below the ground surface. Thirty-three pounds of HRC® were injected into each injection point for a total of 1,353 lbs of HRC® using direct-push technology and high-pressure injection techniques. This activity began in May 2001 and monitoring is scheduled to continue through October 2001. A report is scheduled to be released for December 2001.

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REGION 8 AND STATE OF COLORADO (Multiple Innovative Passive Mine Drainage Technologies)

TECHNOLOGY DESCRIPTION:

These technologies include a successive alkalinity producing system (SAPS) and a lime addition approach known as the Aquafix system for removing high concentrations of metals (aluminum, copper, iron, manganese, and zinc) from acid mine drainage (AMD). A third treatment technology, an ion exchange system using a mixture of zeolites, was slated for evaluation as well, but construction delays precluded the collection of sufficient data from that system.

The SAPS technology has been developed in public domain over the past 10 years for the remediation of AMD. A SAPS is a pond that contains a combination of limestone and compost overlain by several feet of water (see figure). Mine drainage enters at the top of the pond; flows down through the compost, where the drainage gains alkalinity and the oxidation-reduction potential decreases; then flows into the limestone below. Dissolution of the limestone increases the alkalinity of the water, resulting in the precipitation of metals.

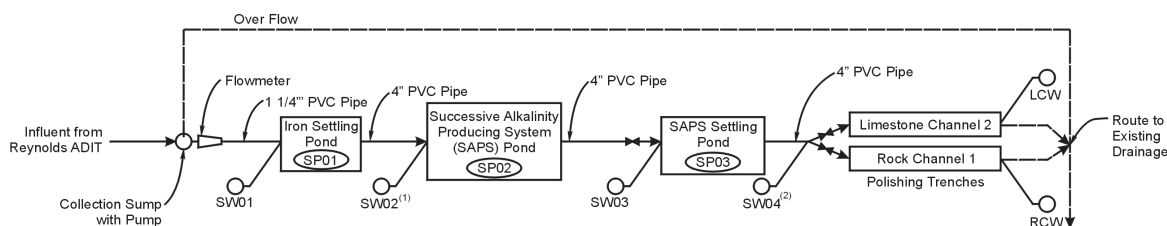
The Aquafix system, a proprietary technology of the Aquafix Corporation, uses lime to increase the pH of the AMD. In this system, a portion of the influent AMD is channeled to turn a water wheel on the Aquafix unit, driving an auger that drops lime from a hopper into the rest of the AMD that is flowing below (see figure). After the lime is added, the AMD is routed through a rock drain to promote mixing and dissolution of the lime and to aerate the AMD. The more alkaline and aerobic conditions cause metals to precipitate from solution.

WASTE APPLICABILITY:

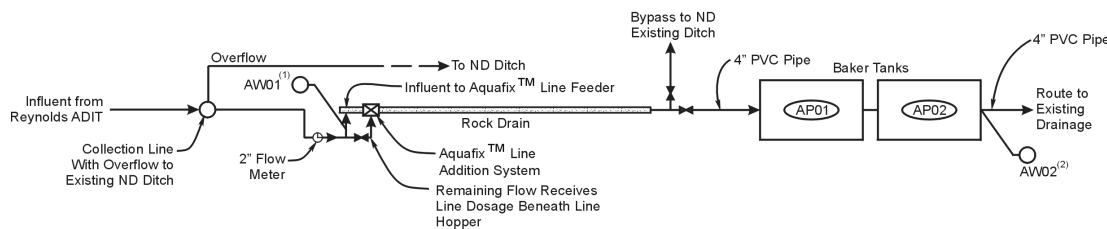
These technologies are suitable for any acidic water containing high concentrations of metals. Treatment at very low concentrations is likely not achievable.

STATUS:

The SAPS technology is in the public domain and has been used in several locations in the midwestern and eastern United States. The Aquafix system is commercially available and has been used at several mine sites in the United States and Canada.



SAPS Treatment System Process Flow Schematic



Aquafix™ Treatment System Process Flow Schematic

Explanation	
	Gate Valve
	Approximate Sampling Location
	Sludge Sampling Location
(1)	Influent Sampling Location for Primary Objective PI
(2)	Effluent Sampling Location for Primary Objective PI

DEMONSTRATION RESULTS:

The demonstration site was the Summitville Mine Superfund Site in the San Juan Mountains in southwestern Colorado. The drainage water at the site is highly acidic and contains high concentrations of metals. The results of the demonstration program indicate that both the SAPS and Aquafix systems removed significant percentages of aluminum, copper, iron, manganese, and zinc from the AMD. Removal efficiencies for the SAPS ranged from 11 percent (manganese) to 97 percent (aluminum) for metals while the removal rate for the Aquafix system was 97 (aluminum and manganese) to 99 percent (copper, iron, and zinc).

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REMEDIATION TECHNOLOGIES, INC. **(formerly MoTech, Inc.)** **(Liquid and Solids Biological Treatment)**

TECHNOLOGY DESCRIPTION:

Liquid and solids biological treatment (LST) is a process that remediates soils and sludges contaminated with biodegradable organics (see figure below). The process is similar to activated sludge treatment of municipal and industrial wastewaters, but it treats suspended solids concentrations greater than 20 percent. First, an aqueous slurry of the waste material is prepared, and environmental conditions such as nutrient concentrations, temperature, and pH are optimized for biodegradation. The slurry is then mixed and aerated for a sufficient time to degrade the target waste constituents.

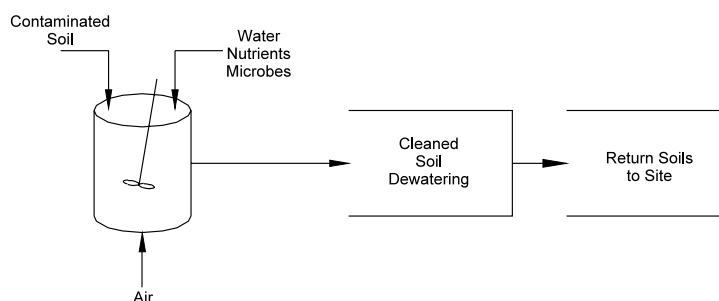
Several physical process configurations are possible, depending on site- and waste-specific conditions. Waste can be treated continuously or in batches in impoundment-based reactors. This configuration is sometimes the only practical option for projects greater than 10,000 cubic yards. Alternatively, tank-based systems may be constructed. Constituent losses due to volatilization must be controlled during LST operations. The potential for emissions is greatest in batch treatment systems and lowest in continuously stirred tank reactor systems, particularly those with long residence times.

Technologies such as carbon adsorption and biofiltration can control emissions.

LST may require pre- and posttreatment operations. However, in situ applications that store treated sludge residues do not require multiple unit operations.

Overall bioremediation in a hybrid system consisting of LST and land treatment systems can provide an alternative to landfilling treated solids. This combination rapidly degrades volatile constituents in a contained system, rendering the waste suitable for landfilling.

Remediation Technologies, Inc. (ReTeC), has constructed a mobile LST pilot system for field demonstrations. The system consists of two reactors, two 2,000-gallon holding tanks, and associated process equipment. The reactors are aerated using coarse bubble diffusers and mixed using axial flow turbine mixers. The reactors can operate separately, or as batch or continuous systems. Oxygen and pH are continuously monitored and recorded. Additional features include antifoaming and temperature control systems.



Liquid and Solids Biological Treatment

WASTE APPLICABILITY:

The technology treats sludges, sediments, and soils containing biodegradable organic materials. To date, the process has mainly treated sludges containing petroleum and wood preservative organics such as creosote and pentachlorophenol (PCP). LST has treated polynuclear aromatic hydrocarbons (PAH), PCP, and a broad range of petroleum hydrocarbons in the laboratory and the field.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1987. The technology was demonstrated under SITE at the Niagara Mohawk Power Corporation facility at Harbor Point in Utica, New York from June through August 1995. The following equipment was used for the demonstration: (1) a 10,000-gallon cylindrical tank (12-foot diameter) with bottom-mounted air diffusers that provided aeration and assisted in suspending solids; (2) a tank cover outfitted with exhaust piping that contained and channeled air discharge; and (3) a spray system that recirculated liquid from within the tank to disperse foam buildup.

ReTeC has applied the technology in the field over a dozen times to treat wood preservative sludges with impoundment-type LST systems. In addition, LST has treated petroleum refinery impoundment sludges in two field-based pilot demonstrations and several laboratory treatability studies.

DEMONSTRATION RESULTS:

Analytical results from the SITE demonstration showed a reduction in oil and grease concentrations from 14,500 to 3,100 milligrams per kilogram (mg/kg), or 79 percent; total PAH concentrations were reduced from 137 to 51 mg/kg, or 63 percent; and total benzene, toluene, ethylbenzene, and xylene concentrations were reduced from 0.083 to 0.030 mg/kg, or 64 percent. PAH leachability in the solids was reduced to nondetect levels after treatment. Toxicity of the solids to earthworms was also decreased by the treatment. Only 24 percent of the earthworms survived when added to untreated contaminated soil, while earthworms placed in treated soil showed no toxic effects.

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RESOURCES CONSERVATION COMPANY (B.E.S.T. Solvent Extraction Technology)

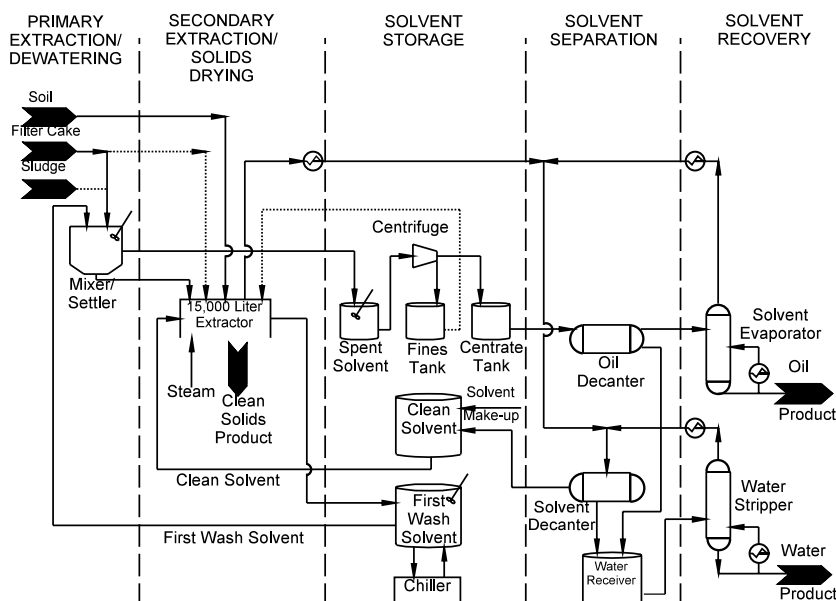
TECHNOLOGY DESCRIPTION:

Solvent extraction treats sludges, sediments, and soils contaminated with a wide range of hazardous contaminants including polychlorinated biphenyls (PCB), polynuclear aromatic hydrocarbons (PAH), pesticides, and herbicides. The waste matrix is separated into three fractions: oil, water, and solids. Organic contaminants, such as PCBs, are concentrated in the oil fraction, while metals are separated into the solids fraction. The volume and toxicity of the original waste is thereby reduced, and the concentrated waste streams can be efficiently treated for disposal.

The B.E.S.T. technology is a mobile solvent extraction system that uses secondary or tertiary amine solvents to separate organics from soils, sediments, and sludges. The B.E.S.T. solvents are hydrophobic above 20°C and hydrophilic below 20 °C. This property allows the process to extract both aqueous and nonaqueous compounds by changing the solvent temperature.

Pretreatment includes screening the waste to remove particles larger than 1 inch in diameter, which are treated separately.

The B.E.S.T. process begins by mixing and agitating the solvent and waste in a mixer/settler. Solids from the mixer/settler are then transferred to the extractor/dryer vessel. (In most cases, waste materials may be added directly to the extractor/dryer and the mixer/settler is not required.) Hydrocarbons and water in the waste simultaneously solubilize with the solvent, creating a homogeneous mixture. As the solvent breaks the oil-water-solid emulsions in the waste, the solids are released and settle by gravity. The solvent mixture is decanted from the solids and centrifuged to remove fine particles.



B.E.S.T. Solvent Extraction Technology

The solvent-oil-water mixture is then heated. As the mixture's temperature increases, the water separates from the organics and solvent. The organics-solvent fraction is decanted and sent to a solvent evaporator, where the solvent is recycled. The organics are discharged for recycling, disposal, or treatment. The water passes to a steam stripping column where residual solvent is recovered for recycling. The water is typically discharged to a local wastewater treatment plant.

The B.E.S.T. technology is modular, allowing for on-site treatment. The process significantly reduces the organic contamination concentration in the solids. B.E.S.T. also concentrates the contaminants into a smaller volume, allowing for efficient final treatment and disposal.

WASTE APPLICABILITY:

The B.E.S.T. technology can remove hydrocarbon contaminants such as PCBs, PAHs, pesticides, and herbicides from sediments, sludges, or soils. System performance can be influenced by the presence of detergents and emulsifiers.

STATUS:

The B.E.S.T. technology was accepted into the SITE Demonstration Program in 1987. The SITE demonstration was completed in July 1992 at the Grand Calumet River site in Gary, Indiana. The following reports are available from EPA:

- Applications Analysis Report (EPA/540/AR-92/079)
- Technology Evaluation Report - Volume I (EPA/540/R-92/079a)
- Technology Evaluation Report - Volume II, Part 1 (EPA/540/R-92/079b)
- Technology Evaluation Report - Volume II, Part 2 (EPA/540/R-92/079c)

- Technology Evaluation Report - Volume II, Part 3 (EPA/540/R-92/079d)
- Technology Demonstration Summary (EPA/540/SR-92/079)

The first full-scale B.E.S.T. unit was used at the General Refining Superfund site in Garden City, Georgia. A 75-ton-per-day B.E.S.T. unit is being installed at Idaho National Engineering Laboratory to extract organic contaminants from mixed wastes.

DEMONSTRATION RESULTS:

The SITE demonstration showed that the B.E.S.T. process removed greater than 99 percent of the PCBs found in river sediments without using mechanical dewatering equipment. Treated solids contained less than 2 milligrams per kilogram PCBs. Comparable removal efficiencies were noted for PAHs.

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RETECH M4 ENVIRONMENTAL MANAGEMENT INC. (Plasma Arc Vitrification)

TECHNOLOGY DESCRIPTION:

Plasma arc vitrification occurs in a plasma arc centrifugal treatment (PACT) system, where heat from a transferred plasma arc torch creates a molten bath that detoxifies the feed material (see figure below). Solids are melted into the molten bath while organics are evaporated and destroyed. Metallic feed material can either form a separate liquid phase underneath the metal oxide slag layer or can be oxidized and become part of the slag layer.

Waste material is fed into a sealed centrifuge, where a plasma torch heats solids to approximately 3,200°F and gas headspace to a minimum of 1,800°F. Organic material is evaporated and destroyed. Off-gases travel through a gas-slag separation chamber to a secondary chamber, where the temperature is maintained at over 2,000°F for at least 2 seconds. The off-gases then flow through an off-gas treatment system.

Inorganic material is reduced to a molten phase that is uniformly heated and mixed by the centrifuge and the plasma arc. Material can be added in-process to control slag quality. When the centrifuge slows, the molten material is discharged as a homogeneous, nonleachable, glassy slag into a mold or drum in the

slag collection chamber. When cooled, the resulting product is a nonleachable, glassy residue which meets toxicity characteristic leaching procedure (TCLP) criteria.

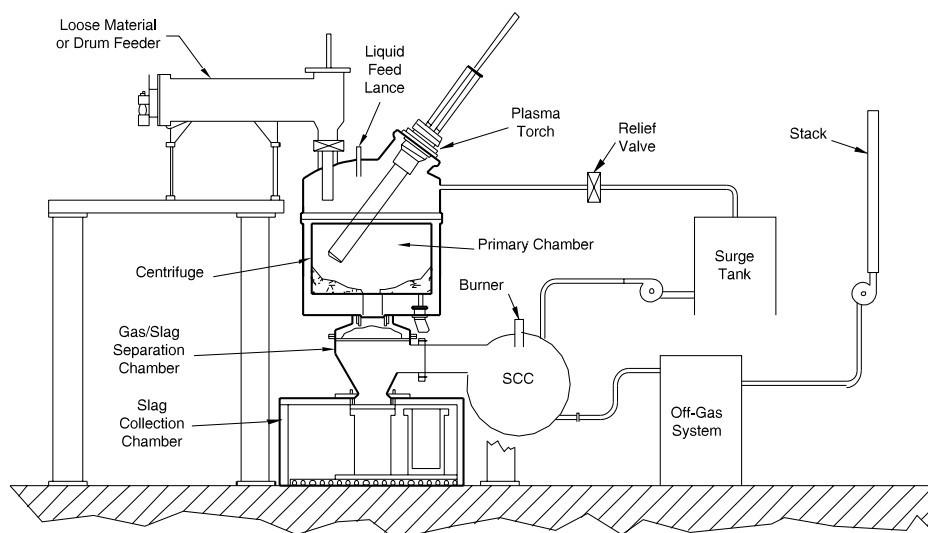
The off-gas treatment system removes particulates, acid gases, and volatilized metals. Off-gas monitoring verifies that all applicable environmental regulations are met. The design of the off-gas treatment system depends on the waste material.

The entire system is hermetically sealed and operated below atmospheric pressure to prevent leakage of process gases. Pressure relief valves connected to a closed surge tank provide relief if gas pressures in the system exceed safe levels. Vented gas is held in the tank, then recycled through the PACT system.

WASTE APPLICABILITY:

The technology can process organic and inorganic solid and liquid wastes. It is most appropriate for mixed, transuranic, and chemical plant wastes; soil containing both heavy metals and organics; incinerator ash; and munitions, sludge, and hospital waste.

Waste may be loose (shredded or flotation process) or contained in 55-gallon drums. It can be in almost



Plasma Arc Centrifugal Treatment (PACT) System

any physical form: liquid, sludge, metal, rock, or sand. Volatile metals in the waste, such as mercury, are recovered by the off-gas treatment system.

STATUS:

The PACT-6 System, formerly PCF-6, was demonstrated under the SITE Program in July 1991 at the Component Development and Integration Facility of the U.S. Department of Energy in Butte, Montana. During the demonstration, about 4,000 pounds of waste was processed. The waste consisted of heavy metal-bearing soil from Silver Bow Creek Superfund site spiked with 28,000 parts per million (ppm) of zinc oxide, 1,000 ppm of hexachlorobenzene, and a 90-to-10 weight ratio of No. 2 diesel oil. All feed and effluent streams were sampled. The Demonstration Bulletin (EPA/540/M5-91/007), Applications Analysis Report (EPA/540/A5-91/007), and Technology Evaluation Report (EPA/540/ 5-91/007b) are available from EPA.

During subsequent testing at the Component Development and Integration Facility, the PACT-6 system achieved the following results:

- Hexachlorobenzene was at or below detection limits in all off-gas samples. The minimum destruction removal efficiency ranged from 99.9968 percent to greater than 99.9999 percent.
- The treated material met TCLP standards for organic and inorganic constituents.
- Particulates in the off-gas exceeded the regulatory standard. The off-gas treatment system is being modified accordingly. Particulate emissions from another PACT-8 system in Switzerland were measured at 1/200th of the U.S. regulatory limit.

- Nitrous oxide (NO_x) levels were very high during the demonstration, but can meet stricter standards. While NO_x concentrations during the demonstration exceeded 5,000 ppm, the NO_x concentrations in the off-gas from the PACT-8 furnace in Switzerland was reduced to 19 ppm. Subsequent PACT-6 applications include military pyrotechnics.

Two PACT-2 systems are in use in Europe, and another one is at Retech for research and development, while five Japanese PACT-8 systems are under construction for European and domestic nuclear and commercial applications. Two PACT-1 bench-scale systems are also in domestic use for nuclear and shipboard testing.

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ROCHEM SEPARATION SYSTEMS, INC. (Reverse Osmosis: Disc Tube™ Module Technology)

TECHNOLOGY DESCRIPTION:

The Rochem Disc Tube™ Module System uses membrane separation to treat aqueous solutions ranging from seawater to leachate contaminated with organic solvents. The system uses osmosis through a semipermeable membrane to separate pure water from contaminated liquids.

Osmotic theory implies that a saline solution may be separated from pure water by a semipermeable membrane. The higher osmotic pressure of the salt solution causes the water (and other compounds having high diffusion rates through the selected membrane) to diffuse through the membrane into the salt water. Water will continue to permeate the salt solution until the osmotic pressure of the salt solution equals the osmotic pressure of the pure water. At this point, the salt concentrations of the two solutions are equal, eliminating any additional driving force for mass transfer across the membrane.

However, if external pressure is exerted on the salt solution, water will flow in the reverse direction from the salt solution into the pure water.

This phenomenon, known as reverse osmosis (RO), can separate pure water from contaminated matrices. RO can treat hazardous wastes by concentrating the hazardous chemical constituents in an aqueous brine, while recovering pure water on

the other side of the membrane.

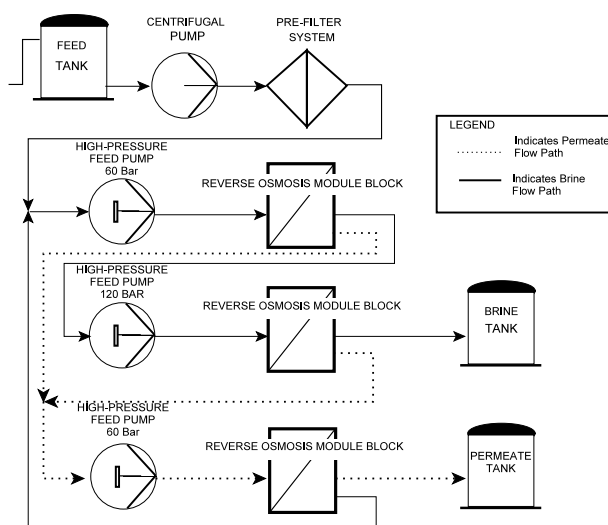
Fluid dynamics and system construction result in an open-channel, fully turbulent feed and water-flow system. This configuration prevents accumulation of suspended solids on the separation membranes, ensuring high efficiency filtration for water and contaminants. Also, the design of the disc tubes allows easy cleaning of the filtration medium, providing a long service life for the membranes.

A general flow path for the Rochem Disc Tube™ Module System as applied at the SITE demonstration is shown on the previous page. Waste feed, process permeate, and rinse water are potential feed materials to the RO modules. The modules are skid-mounted and consist of a tank and a high-pressure feed system. The high-pressure feed system consists of a centrifugal feed pump, a prefilter cartridge housing, and a triplex plunger pump to feed the RO modules. The processing units are self-contained and require electrical and interconnection process piping before operation.

WASTE APPLICABILITY:

Many types of waste material can be treated with this system, including sanitary and hazardous landfill leachate containing both organic and inorganic chemical species.

STATUS:



Three-Stage, Reverse Osmosis Flow Path

This technology was accepted into the SITE Demonstration Program in July 1991. The demonstration was conducted in August 1994 at the Central Landfill Superfund site in Johnston, Rhode Island. The system was used to treat landfill leachate from a hazardous waste landfill. During the demonstration, approximately 4 gallons per minute of contaminated waste was processed over a 3-week period. All feed and residual effluent streams were sampled to evaluate the performance of this technology. The Innovative Technology Evaluation Report (EPA/540/R-96/507), the Technology Capsule (EPA/540/R-96/507a), and the Demonstration Bulletin (EPA/540/MR-96/507) are available from EPA.

DEMONSTRATION RESULTS:

Preliminary results from the demonstration suggest the following:

- Over 99 percent of total dissolved solids, over 96 percent of total organic carbon, and 99 percent of all target metals were removed. In addition, the average percent rejection for volatile organic compounds was greater than the test criteria of 90 percent.
- The average water recovery rate for the Rochem Disc Tube™ Module System during the demonstration was approximately 75 percent. The test criterion was 75 percent treated water recovery rate.
- The Rochem Disc Tube™ Module System operated for 19 days at up to 8 hours per day. Daily operation hours were not as long as planned due to weather and field operational difficulties. However, the system operated long enough to evaluate the technology's performance.

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ROCKY MOUNTAIN REMEDIATION SERVICES, L.L.C. **(ENVIROBOND™ Solution)**

TECHNOLOGY DESCRIPTION:

ENVIROBOND™ is a proprietary solution that binds with metals in contaminated soils and other wastes to form a virtually impenetrable chemical bond. Rocky Mountain Remediation Services, L.L.C., claims that the treatment process effectively prevents metals leaching and can be used with mechanical compaction to reduce the overall volume of contaminated media by 30 to 50 percent. The process generates no secondary wastes and requires minimal handling, transportation, and disposal costs. In addition, unlike some pozzolanic-based reagents, the ENVIROBOND™ liquid is safe to handle and does not generate any emissions.

ENVIROBOND™ consists of a mixture of additives containing oxygen, sulfur, nitrogen, and phosphorous; each additive has an affinity for a specific class of metals. ENVIROBOND™ converts metal contaminants from their leachable form to an insoluble, stable, nonhazardous metallic complex. ENVIROBOND™ is essentially a ligand that acts as a chelating agent. In the chelation reaction, coordinate bonds attach the metal ion to least two ligand nonmetal ions to form a heterocyclic ring. The resulting ring structure is inherently more stable than simpler structures formed in other binding processes. By effectively binding the metals, the process reduces the waste stream's RCRA toxicity characteristic leaching procedure (TCLP) test results to less than the RCRA-regulated levels, subsequently reducing the risks posed to human health and the environment.

The stabilized waste can then be placed in a pit or compacted into the earth using traditional field compaction equipment, or it can be mechanically compacted to produce a solid, compressed form called ENVIROBRIC™. The machine used to form the ENVIROBRIC™ is designed for mass production of sand-clay "rammed earth" bricks. Unlike conventional construction bricks, rammed earth bricks are produced under extremely high compaction forces and are not heated or fired. As a result, the bricks possess very high compressive

strength and a correspondingly low porosity, making them ideal for on-site treatment by solidification/stabilization at industrial sites. The size of the individual bricks can be adjusted depending on specific site requirements, and the bricks have successfully passed various tests designed to measure their long-term durability.

WASTE APPLICABILITY:

The ENVIROBOND™ process does not reduce the overall concentration of metal contaminants; instead it converts them to metal-ligand compounds, rendering them insoluble and stable in the media. The developer claims that the process can be applied to contaminated soils and other media in both industrial and residential use scenarios. At residential sites, contaminated soils and other media in both industrial and residential use scenarios. At residential sites, contaminated soil can be mixed with ENVIROBOND™ and stabilized before being disposed of off site. At industrial sites, ENVIROBOND™ can be mixed with contaminated waste streams or soils and then compacted in the ENVIROBRIC™ process and backfilled on site to reduce the overall volume of contaminated media.

Bench-scale and field tests indicate that ENVIROBOND™ can be added to waste streams containing more than four metal contaminants at concentrations ranging from 200 to more than 5,000 parts per million (ppm). TCLP tests have shown that metals concentrations in leachate from treated media do not exceed RCRA regulatory levels. Metals that can be stabilized with ENVIROBOND™ include arsenic, barium, cadmium, chromium, lead, mercury, nickel, selenium, silver, and zinc. However, the process is less effective in media containing more than 3 percent by weight of metals such as aluminum, magnesium, calcium, and manganese. These metals may reduce the number of chelating sites available by preferentially binding with the ENVIROBOND™ agent.

The ENVIROBOND™ process is capable of achieving high processing rates of 20 to 40 tones per hour and can be used with contaminated media containing as much as 10 percent debris and other matter. For acidic wastes with a pH of 3 or less, buffering compounds can be added to the contaminated media before it is media with ENVIROBOND™. Volatile organic compounds such as benzene, toluene, ethylbenzene, and xylenes do not affect the process.

STATUS:

Under a cooperative agreement with the Ohio EPA, the ENVIROBOND™ process with demonstrated in September 1998 at two separate areas of the Crooksville/Roseville Pottery site in Ohio. Soil at the site, some of it adjacent to residential areas, is contaminated with lead from waste disposal practices associated with pottery production operations. Soil at the demonstration areas contains lead in concentrations ranging from 100 ppm to 80,000 ppm.

DEMONSTRATION RESULTS:

Soil treatment with ENVIROBOND™ reduced the bioavailability of lead by at least 25%, as determined by the Physiological-Based Extracted Test (PBET), and reduced leachable lead concentrations from 247 to 563 mg/L to <0.50 to 2.1 µg/L, as determined by the Toxicity Characteristic Leaching Procedure (TCLP).

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SANDIA NATIONAL LABORATORIES (In Situ Electrokinetic Extraction System)

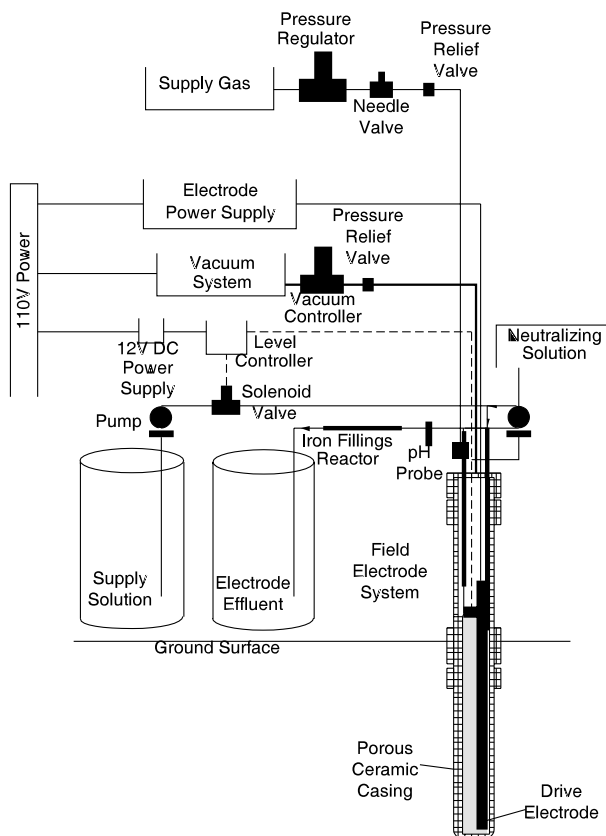
TECHNOLOGY DESCRIPTION:

Electrokinetic remediation has been used successfully to treat saturated soils contaminated with heavy metals. At some sites, however, it may not be desirable to add the quantities of water needed to saturate a contamination plume in the vadose zone. Sandia National Laboratories (SNL) has developed an electrokinetic remediation technology that can be used in unsaturated soils without adding significant amounts of water.

The SNL electrokinetic extraction system, shown in the figure below, consists of three main units: the electrode assembly (electrode casing and internal assemblies), the vacuum system, and the power supply. The electrode casing consists of a porous ceramic end that is 5 to 7 feet long and has an outer diameter of 3.5 inches. During field installation, the

casing is attached to the required length of 3-inch polyvinyl chloride pipe. The electrode internal assembly consists of the drive electrode, a water level control system, and a pump system. The vacuum system consists of a venturi vacuum pump and vacuum regulator that together supply a constant vacuum for the electrode. Up to four 10,000-watt power supplies can operate in either constant voltage or constant current mode.

When the drive electrode is energized, contaminants and other ions are attracted into the electrode casing. The water level control system adds water to, and extracts water from, the electrodes. Water is supplied to the electrode from a supply solution tank at the ground surface. This solution is either drawn into the electrode by the vacuum maintained in the electrode or by a supply pump. At the same time, water is continuously pumped out from the



Schematic Diagram of the In Situ Electrokinetic Extraction System

electrode casing at a constant rate. Part of the contaminated water is sent to an effluent waste tank at the ground surface; the remainder is returned to the electrode to maintain circulation of the fluid surrounding the electrode. A metering pump controlled by in-line pH meters regulates the introduction of neutralization chemicals to each electrode. Process control and monitoring equipment is contained in a 10-foot- by-40-foot instrument trailer.

WASTE APPLICABILITY:

SNL has developed its electrokinetic extraction system to treat anionic heavy metals such as chromate in unsaturated soil. There is no lower limit to the contaminant concentration that can be treated; however, there may be a lower limit on the ratio of contaminant ions to other ions in the soil.

The technology can be expanded to treat saturated soils. Soil that is highly conductive because of a high salinity content is not suitable for this technology. In addition, sites with buried metal debris, such as pipelines, are not appropriate.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. The SITE demonstration began May 1996, at an unlined chromic acid pit within a SNL RCRA regulated landfill. The operation was completed in November 1996 and site closure was completed in April 1997, with a closure report submitted to New Mexico state regulators in September 1997.

DEMONSTRATION RESULTS:

The demonstration verified the technology's capability of removing anionic contaminants from vadose zone soil through passive operation. Approximately 520 grams (g) of hexavalent chromium was removed during the demonstration. Overall hexavalent chromium removal rates varied from 0.074 gram per hour (g/hour) during Test 1 to 0.338 g/hour during Test 5. Overall hexavalent chromium removal efficiencies varied from 0.0359 gram per kilowatt-hour (g/kW-h) during Test 7 to 0.136 g/kW-h during Test 13. More than 50 percent of the postdemonstration soil samples exceeded the toxicity characteristic leach procedure (TCLP) limit of 5 milligrams per liter (mg/L) for total chromium. The soil TCLP leachate concentrations that were above the TCLP limit ranged from 6 to 67 mg/L.

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SBP TECHNOLOGIES, INC.

(Membrane Filtration and Bioremediation)

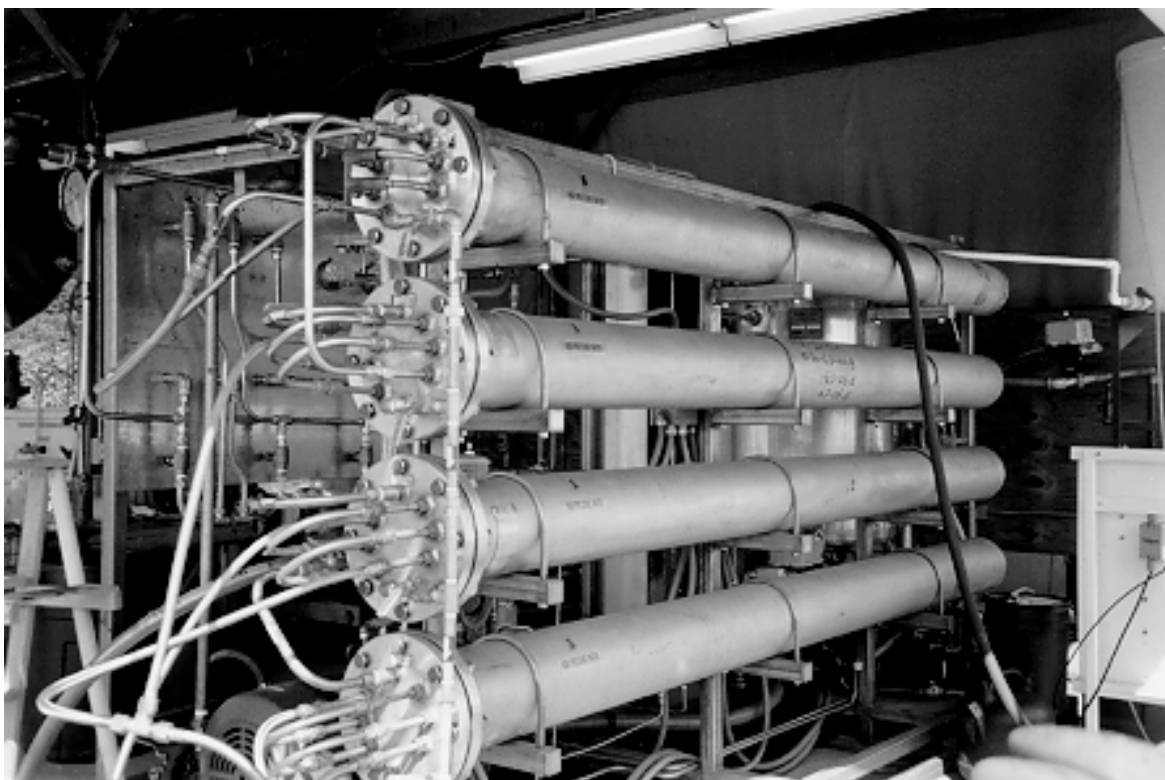
TECHNOLOGY DESCRIPTION:

SBP Technologies, Inc. (SBP), has developed a hazardous waste treatment system consisting of (1) a membrane filtration system that extracts and concentrates contaminants from groundwater, surface water, wash water, or slurries; and (2) a bioremediation system that treats concentrated groundwater, wash water, and soil slurries (see photograph below). These two systems treat a wide range of waste materials separately or as parts of an integrated waste handling system.

The membrane filtration system removes and concentrates contaminants by pumping contaminated liquids through porous stainless steel tubes coated with specifically formulated membranes. Contaminants are collected inside the tube membrane, while "clean" water permeates the

membrane and tubes. Depending on local requirements and regulations, the clean permeate can be discharged to the sanitary sewer for further treatment at a publicly owned treatment works (POTW). The concentrated contaminants are collected in a holding tank and fed to the bioremediation system.

Contaminated water or slurry can also flow directly into the bioremediation system and be polished in the membrane filtration system. The bioremediation system consists of one or more bioreactors that are inoculated with specially selected, usually indigenous microorganisms to produce effluent with low to nondetectable contaminant levels. Integrating the two systems allows removal and destruction of many contaminants.



Membrane Filtration and Bioremediation

WASTE APPLICABILITY:

The membrane filtration system concentrates contaminants and reduces the volume of contaminated materials from a number of waste streams, including contaminated groundwater, surface water, storm water, landfill leachates, and industrial process wastewater.

The bioremediation system can treat a wide range of organic contamination, especially wood-preserving wastes and solvents. A modified version can also treat polynuclear aromatic hydrocarbons (PAH) such as creosote and coal tar; pentachlorophenol; petroleum hydrocarbons; and chlorinated aliphatics, such as trichloroethene.

The two technologies can be used separately or combined, depending on site characteristics and waste treatment needs. For example, for wastewaters or slurries contaminated with inorganics or materials not easily bioremediated, the membrane filtration system can separate the material for treatment by another process. Both the membrane filtration system and the bioremediation system can be used as part of a soil cleaning system to handle residuals and contaminated liquids.

STATUS:

The membrane filtration system, accepted into the SITE Program in 1990, was demonstrated in October 1991 at the American Creosote Works in Pensacola, Florida. The Demonstration Bulletin (EPA/540/MR- 92/014) and Applications Analysis Report (EPA/540/AR-92/014) are available from EPA. A full-scale SITE Program demonstration of the bioremediation system was canceled. However, a smaller-scale field study was conducted at the site; results are available through the developer. SBP is marketing its bioremediation and membrane filtration systems to industrial and governmental clients for on-site treatment of contaminated soil, sludge, and water.

DEMONSTRATION RESULTS:

Results from the SITE demonstration are summarized as follows:

- The system effectively concentrated the PAHs into a smaller volume.
- The process removed 95 percent of the PAHs found in creosote from the feed and produced a permeate stream that was acceptable for discharge to a POTW.
- The membrane removed 25 to 35 percent of smaller phenolic compounds.
- The system removed an average of about 80 percent of the total concentrations of creosote constituents (phenolics and PAHs) in the feedwater and permeate.

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SEVENSON ENVIRONMENTAL SERVICES, INC.
(formerly Mae Corp, Inc.)
(MAECTITE® Chemical Treatment Process)

TECHNOLOGY DESCRIPTION:

The patented MAECTITE® chemical treatment process for lead and other heavy metals uses reagents and processing equipment to render soils, waste, and other materials nonhazardous when tested by the Resource Conservation and Recovery Act toxicity characteristic leaching procedure (TCLP). The MAECTITE® process reduces leachable lead, hexavalent chromium, and other heavy metals to below treatment standards required by land-ban regulations. Lead in treated material, as determined by approved EPA methods (such as the TCLP, extraction procedure toxicity test, and the multiple extraction procedure), complies with limits established by EPA. The photograph below shows a 500-ton-per-day ex situ unit.



500-Ton-Per-Day MAECTITE®
Processing System

Chemical treatment by the MAECTITE® process converts leachable lead into insoluble minerals and mixed mineral forms within the material or waste matrix. MAECTITE® reagents stimulate the nucleation of crystals by chemical bonding to yield mineral compounds in molecular forms. These forms are resistant to leaching and physical degradation from environmental forces. The durability of traditional monolithic solidification-stabilization process end-products is often measured by geotechnical tests such as wet-dry, freeze-thaw, permeability, and unconfined compressive strength. The MAECTITE® process does not use physical binders, is not pozzolanic or siliceous, and does not rely on the formation of metallic hydroxides using hydration mechanisms. Therefore, these tests are not relevant to MAECTITE® product chemical stability, although engineered properties are readily obtained, if required. MAECTITE® is not pH dependent and does not use adsorption, absorption, entrapment, lattice containment, encapsulation, or other physical binding principles. The technology is a true chemical reaction process that alters the structure and properties of the waste, yielding stable compounds.

The MAECTITE® process uses water to assist in dispersing reagents. However, the dehydration characteristic of the process liberates water present in waste prior to treatment (absorbed and hydrated forms) to a free state where it can be removed from the waste matrix by evaporation and capillary drying principles. The ability of treated material to readily lose water, the formation of dense mineral crystals, and the restructuring of the material as a result of MAECTITE® treatment (where interstitial space is minimized), all contribute to reduced waste volume and weight.

Ex situ MAECTITE® processing equipment generally consists of material screening and sizing components, liquid and solid reagent storage delivery subsystems, and a mixing unit such as a pug mill. Equipment is mobile but can be modified

for fixed system operations. In situ MAECTITE® processing equipment is also available; system selection is largely dictated by contaminant plume configuration, soil characteristics, and site space limitations.

WASTE APPLICABILITY:

Materials that have been rendered nonhazardous include soils; sludges; sediments; battery contents, including casings; foundry sands; and firing range soil. Oversized material can be treated with the process as debris, but size reduction often makes processing more efficient. Even sludges with free liquids (as determined by the paint filter test) have been treated to TCLP compliance when excess fluids are present.

The range of lead levels effectively treated has not been fully determined; however, soils with total lead as high as 30 percent by weight and TCLP values over 15,000 milligrams per liter (mg/L) were not problematic. Common lead levels encountered have averaged from 200 milligrams per kilogram to 6,500 with TCLP concentrations averaging 20 to 400 mg/L. Material geochemistry most often dictates final MAECTITE® treatment designs. Furthermore, correlations between total lead and regulated leachable lead levels are inconsistent, with treatment efforts more strongly related to the geochemical characteristics of the waste material.

STATUS:

The chemical treatment technology was initially accepted into the SITE Demonstration Program in March 1992. EPA is seeking a suitable demonstration site.

Sevenson Environmental Services, Inc. (Sevenson), acquired the MAECTITE® technology in 1993 and was issued second, third and fourth patents in 1995, 1996, and 1997 respectively. Combining ex situ and in situ quantities, over 650,000 tons of material has been successfully processed. Treatability studies have been conducted on over 100 different materials in over 40 states, Canada, Italy, and Mexico. The technology has been applied at full-scale demonstration and remedial projects in over 25 states and in all 10 EPA regions.

The MAECTITE® process has been formally accepted into the EPA PQOPS program for the fixation-stabilization of inorganic species. Proprietary technology modifications have shown promise in rendering radionuclides nonleachable using gamma spectral counting methods on TCLP extract.

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SMITH ENVIRONMENTAL TECHNOLOGIES CORPORATION (formerly Canonie Environmental Services Corporation) (Low Temperature Thermal Aeration [LTTA®])

TECHNOLOGY DESCRIPTION:

The Low Temperature Thermal Aeration (LTTA®) technology is a low-temperature desorption process (see figure below). The technology removes organic contaminants from contaminated soils into a contained air stream, which is extensively treated to collect or thermally destroy the contaminants.

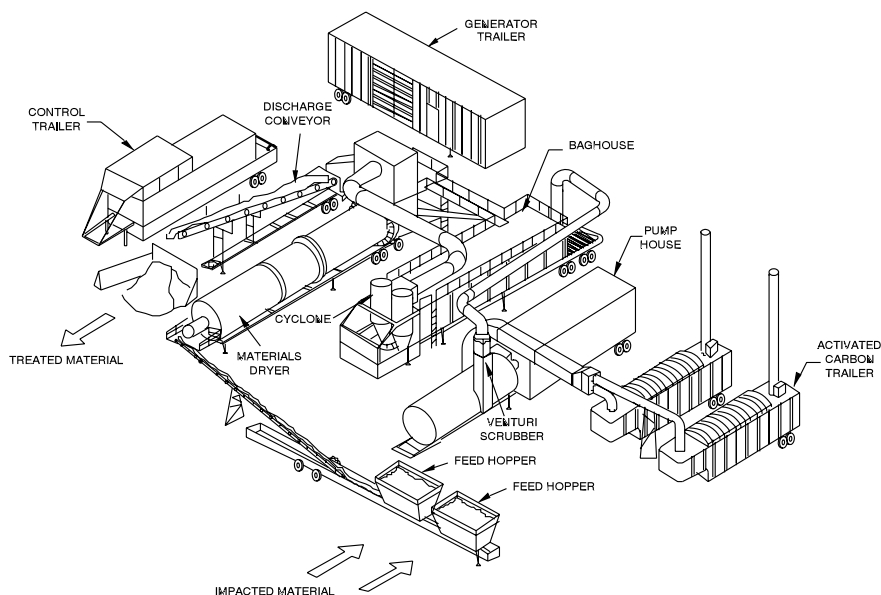
A direct-fired rotary dryer heats an air stream which, by direct contact, desorbs water and organic contaminants from the soil. Soil can be heated to up to 800°F. The processed soil is quenched to reduce temperatures and mitigate dust problems. The processed soil is then discharged into a stockpile. The hot air stream that contains vaporized water and organics is treated by one of two air pollution control systems. One system removes the organic contaminants from the air stream by adsorption on granular activated carbon (GAC) and includes the following units in series: (1) cyclones and baghouse for particulate removal; (2) wet scrubber for acid gas and some organic vapor removal; and (3) GAC adsorption beds for organic removal.

The second air pollution control system can treat soils containing high concentrations of petroleum hydrocarbons. The system includes the following units in series: (1) cyclones for particle removal; (2) thermal oxidizer-afterburner for destruction of organics; (3) quench tower for cooling of air stream; (4) baghouse for additional particle removal; and (5) wet scrubber for acid gas removal.

The LTTA® technology generates no wastewater or waste soils. Cyclone fines and baghouse dust are combined with treated soil and quenched with treated scrubber water. The treated soil, once verified to meet the treatment criteria, is backfilled on site without restrictions. GAC beds used for air pollution control are regenerated or incinerated when spent.

WASTE APPLICABILITY:

LTTA® can remove volatile organic compounds (VOC), semivolatile organic compounds (SVOC), organochlorine pesticides (OCP), organophosphorus pesticides (OPP), and total petroleum hydrocarbons (TPH) from soils, sediments, and some sludges.



Low Temperature Thermal Aeration (LTTA®) Technology

LTТА® has been used at full scale to remove VOCs such as benzene, toluene, tetrachloroethene, trichloroethene, and dichloroethene; SVOCs such as acenaphthene, chrysene, naphthalene, and pyrene; OCPs such as DDT, DDT metabolites, and toxaphene; OPPs such as ethyl parathion, methyl parathion, merphos, and mevinphos; and TPHs.

STATUS:

The LTТА® technology was accepted into the SITE Demonstration Program in summer 1992. LTТА® was demonstrated in September 1992 on soils contaminated with OCPs during a full-scale remediation at a pesticide site in Arizona. The Demonstration Bulletin (EPA/540/MR-93/504) and Applications Analysis Report (EPA/540/AR-93/504) are available from EPA.

The full-scale LTТА® system has remediated contaminated soils at six sites, including three Superfund sites. The system has treated more than 117,000 tons of soil.

DEMONSTRATION RESULTS:

Key findings from the demonstration are summarized below:

- The LTТА® system achieved the specified cleanup criteria for the site, a sliding scale correlating the concentrations of DDT family compounds (DDT, DDE, and DDD) with concentrations of toxaphene. The maximum allowable pesticide concentrations in the treated soil were 3.52 milligrams per kilogram (mg/kg) of DDT family compounds and 1.09 mg/kg of toxaphene.

- Residual levels of all the pesticides in the treated soil were generally below or close to the laboratory detection limit, with the exception of 4,4'-DDE, which was found at residual concentrations of 0.1 to 1.5 mg/kg. Removal efficiencies for pesticides found in the feed soil at quantifiable concentrations are summarized below:

<u>Compound</u>	<u>Efficiency</u>
4,4'-DDD	>99.97%
4,4'-DDE	90.26%
4,4'-DDT	99.97%
Endrin	>99.85%
Toxaphene	>99.83%
Endosulfan 1	>99.98%

- The LTТА® process did not generate dioxins or furans as products of incomplete combustion or thermal transformation.

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SOILTECH ATP SYSTEMS, INC. (Anaerobic Thermal Processor)

TECHNOLOGY DESCRIPTION:

The SoilTech ATP Systems, Inc. (SoilTech), anaerobic thermal processor (ATP) uses a rotary kiln to desorb, collect, and recondense contaminants or recyclable hydrocarbons from a wide variety of feed material (see figure below).

The proprietary kiln contains four separate internal thermal zones: preheat, retort, combustion, and cooling. In the preheat zone, water and volatile organic compounds (VOC) are vaporized. The hot solids and heavy hydrocarbons then pass through a proprietary sand seal to the retort zone. The sand seal allows solids to pass and inhibits gas and contaminant movement from one zone to the other. Concurrently, hot treated soil from the combustion zone enters the retort zone through a second sand seal. This hot treated soil provides the thermal energy necessary to desorb the heavy organic contaminants. The vaporized contaminants are removed under slight vacuum to the gas handling system. After cyclones remove dust from the gases, the gases are cooled, and condensed oil and water are separated into their various fractions.

The coked soil passes through a third sand seal from the retort zone to the combustion zone. Some of the hot treated soil is recycled to the retort zone through the second sand seal as previously described. The remainder of the soil enters the cooling zone. As the hot combusted soil enters the cooling zone, it is

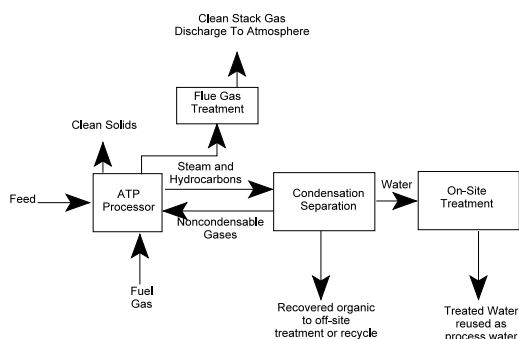
cooled in the annular space between the outside of the preheat zone and the kiln shell. Here, the heat from the combusted soils is transferred indirectly to the soils in the preheat zone. The cooled, treated soil exiting the cooling zone is quenched with water and conveyed to a storage pile.

Flue gases from the combustion zone pass through the cooling zone to an emission control system. The system consists of a cyclone and baghouse to remove particulates, a wet scrubber to remove acid gases, and a carbon adsorption bed to remove trace organic compounds.

WASTE APPLICABILITY:

The system treats soils, sediments, and sludges contaminated with compounds that vaporize at temperatures up to 1,100 °F. Treated solids are free of organics and suited for backfill on site. Applicable contaminants include the following:

- Petroleum hydrocarbons: fuel, oil, lube oil, semivolatile organic compounds (SVOC), VOCs
- Halogenated hydrocarbons: polychlorinated biphenyls (PCB), dioxins, furans, pesticides, herbicides
- Aromatic hydrocarbons: coal tar residues polynuclear aromatic hydrocarbons (PAH)
- Volatile metals: mercury



Anaerobic Thermal Processor (ATP)

STATUS:

This technology was accepted into the SITE Demonstration Program in 1991. The ATP has been demonstrated at two sites. At the first demonstration, in May 1991, a full-scale unit dechlorinated PCB-contaminated soil at the Wide Beach Development Superfund site in Brant, New York. At the second demonstration, completed in June 1992, a full-scale unit remediated soils and sediments at the Waukegan Harbor Superfund site in Waukegan, Illinois. Two additional Superfund sites in Ohio and Kentucky have since been remediated by the ATP. Soils at these sites were contaminated with PCBs, PAHs, and pesticides.

The ATP has been used to treat more than 100,000 tons of waste on four separate sites. The system has operated in compliance with state and federal regulations in New York, Illinois, Ohio, and Kentucky. SoilTech is currently negotiating with a confidential client to remediate 25,000 cubic yards of trichloroethene- (TCE) and PCB-contaminated soil at a site located in Pennsylvania.

ZzSoilTech is continuing its research into more diverse organic remediation applications and bitumen recovery.

DEMONSTRATION RESULTS:

Test results from both SITE demonstrations indicate the following:

- The SoilTech ATP removed over 99 percent of the PCBs in the contaminated soil, resulting in PCB levels below 0.1 part per million (ppm) at the Wide Beach Development site and averaging 2 ppm at the Waukegan Harbor site.
- Dioxin and furan stack gas emissions were below the site-specific standards.

- PCB stack gas emissions were equivalent to 99.99 percent destruction and removal efficiency at the Waukegan Harbor site.
- No volatile or semivolatile organic degradation products were detected in the treated soil. Also, no leachable metals, VOCs, or SVOCs were detected in the treated soil.
- For the Wide Beach Development and Waukegan Harbor remediation projects, soil treatment costs were approximately \$265 and \$155 per ton, respectively. The regulatory support, mobilization, startup, and demobilization costs totaled about \$1,400,000 for each site.

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SOLIDITECH, INC.

(Solidification and Stabilization)

TECHNOLOGY DESCRIPTION:

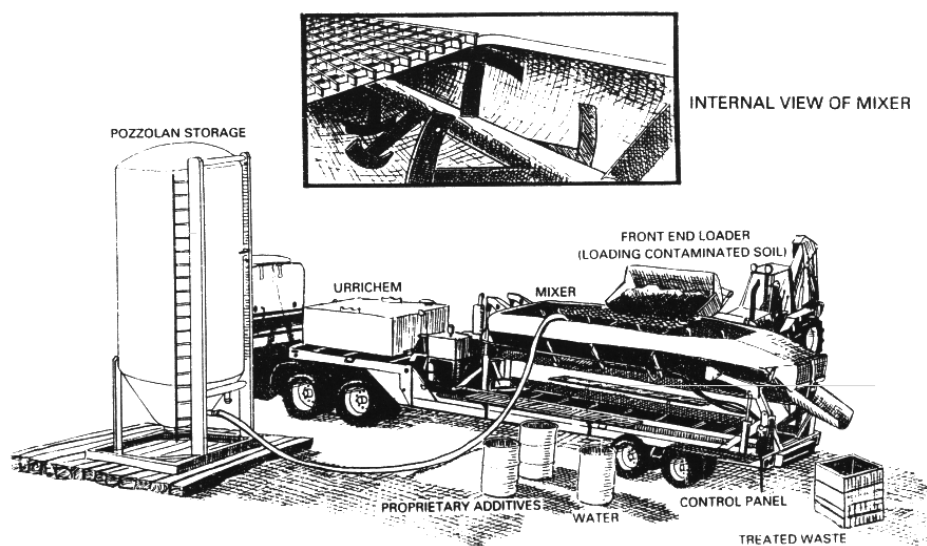
This solidification and stabilization process immobilizes contaminants in soils and sludges by binding them in a concrete-like, leach-resistant matrix. Contaminated waste materials are collected, screened to remove oversized material, and introduced to the batch mixer (see figure below). The waste material is then mixed with water; Urrichem, a proprietary chemical reagent; proprietary additives; and pozzolanic material (fly ash), kiln dust, or cement. After it is thoroughly mixed, the treated waste is discharged from the mixer. Treated waste is a solidified mass with significant unconfined compressive strength (UCS), high stability, and a rigid texture similar to that of concrete.

WASTE APPLICABILITY:

This process treats soils and sludges contaminated with organic compounds, metals, inorganic compounds, and oil and grease. Batch mixers of various capacities can treat different volumes of waste.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1988. The solidification and stabilization process was demonstrated in December 1988 at the Imperial Oil Company/Champion Chemical Company Superfund site in Morganville, New Jersey. This site formerly contained both chemical processing and oil reclamation facilities. Soils, filter cakes, and oily wastes from an old storage tank were treated during the demonstration. These wastes were contaminated with petroleum hydrocarbons, polychlorinated biphenyls (PCB), other organic chemicals, and heavy metals. The Technology Evaluation Report (EPA/540/ 5-89/005a), Applications Analysis Report (EPA/540/A5-89/005), and Demonstration Bulletin (EPA/540/M5- 89/005) are available from EPA. This technology is no longer available through a vendor. Contact the EPA Project Manager for further information.



Soliditech Processing Equipment

DEMONSTRATION RESULTS:

Key findings from the Soliditech demonstration are summarized below:

- Extract and leachate analyses showed that heavy metals in the untreated waste were immobilized.
- The process solidified both solid and liquid wastes with high organic content (up to 17 percent), as well as oil and grease.
- Volatile organic compounds in the original waste were not detected in the treated waste.
- Physical test results of the solidified waste showed (1) UCS ranging from 390 to 860 pounds per square inch (psi); (2) very little weight loss after 12 cycles of wet and dry and freeze and thaw durability tests; (3) low permeability of the treated waste; and (4) increased density after treatment.
- The solidified waste increased in volume by an average of 22 percent. Because of solidification, the bulk density of the waste material increased by about 35 percent.
- Semivolatile organic compounds (phenols) were detected in the treated waste and the toxicity characteristic leaching procedure (TCLP) extracts from the treated waste, but not in the untreated waste or its TCLP extracts. The presence of these compounds is believed to result from chemical reactions in the waste treatment mixture.
- The oil and grease content of the untreated waste ranged from 2.8 to 17.3 percent (28,000 to 173,000 parts per million [ppm]). The oil and grease content of the TCLP extracts from the solidified waste ranged from 2.4 to 12 ppm.
- The pH of the solidified waste ranged from 11.7 to 12.0. The pH of the untreated waste ranged from 3.4 to 7.9.
- PCBs were not detected in any extracts or leachates from the treated waste.
- Visual observation of solidified waste revealed bulk oily material about 1 millimeter in diameter.

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SOLUCORP INDUSTRIES (Molecular Bonding System®)

TECHNOLOGY DESCRIPTION:

The Molecular Bonding System® (MBS) is a process developed for the stabilization of a variety of media, such as soil, sludge, slag, and ash, that is contaminated with heavy metals. The process employs a proprietary mixture of nonhazardous chemicals to convert the heavy metal contaminants from their existing reactive and leachable forms (usually oxides) into insoluble, stable, nonhazardous, metallic-sulfide compounds that will achieve toxicity characteristic leaching procedure (TCLP) levels far below regulatory limits. The MBS process maintains the pH levels in the media within the range where the insolubility of the heavy metal sulfides is assured. The system also provides buffer capacity to ensure that the pH is not significantly altered by the addition of acids or caustics to the media.

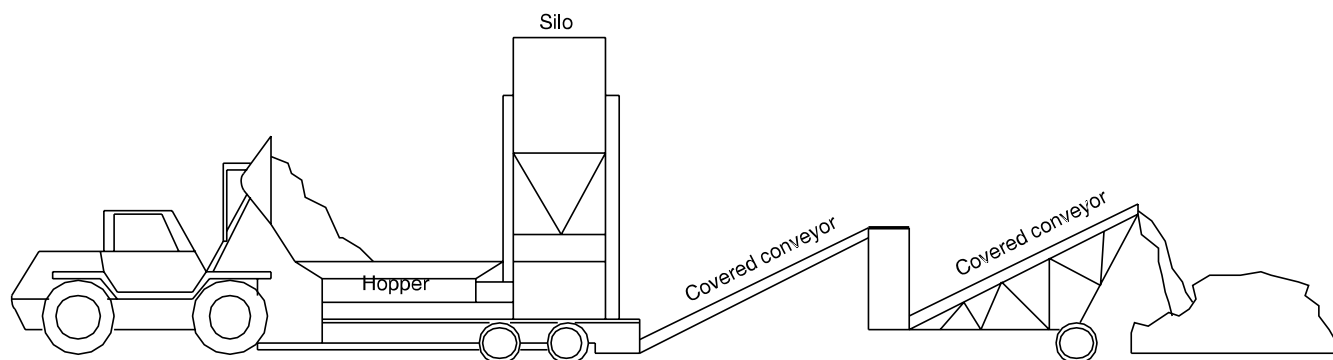
As depicted in the diagram below, the MBS treatment process is completely mobile and easily transportable (to allow for on-site treatment). Waste material is screened and crushed as required to reduce particle sizes to an average 1-inch diameter (particle size reduction increases surface area, which maximizes contact with the reagents). The waste media is then mixed with powdered reagents in a closed-hopper pug mill (the reagent mixture is established through treatability studies for the site-

specific conditions). Water is then added to catalyze the reaction and to ensure homogeneous mixing. There is no curing time and the resulting increase in volume is between 2 to 3 percent. The treated media is then conveyed to a stockpile where it can then be either returned to the original site or disposed in a landfill as cover, fill, or contour material.

MBS can also be applied with traditional in situ mixing techniques such as tillers, eliminating the need for excavating and preparing the soil.

The MBS process can also be used to stabilize waste “in line” during the manufacturing process, preventing the waste from being classified as hazardous. Commercial applications on slag from a secondary smelter are underway.

The MBS process stabilizes heavy metals in soil, sludges, baghouse dust, ash, slag, and sediment. Heavy metals rendered inert by the process include arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. The process can simultaneously stabilize multiple heavy metal contaminants. The presence of organics does not affect treatment by MBS.



Process Flow Diagram of the Molecular Bonding System

STATUS:

The MBS technology was accepted into the SITE Demonstration Program in early 1995. A SITE demonstration was conducted at the Midvale Slag Superfund Site in Midvale, Utah in 1997. Three waste streams contaminated with As, Cd, and Pb were treated, including soil/fill material, slag, and miscellaneous smelter waste without brick. Approximately 500 tons of each waste stream was treated. The treated wastes and soils passed EPA's Multiple Extraction Procedure. The MBS process has undergone extensive bench-scale and pilot-scale testing prior to its successful full-scale commercialization. The same reductions in the TCLP levels of hazardous contaminants achieved in the laboratory were achieved at five manufacturing sites in five different states.

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SONOTECH, INC.

(Frequency-Tunable Pulse Combustion System)

TECHNOLOGY DESCRIPTION:

The Sonotech, Inc., frequency-tunable pulse combustion system (Sonotech system) is designed to significantly improve batch- and continuous-mode combustion or thermal processes (such as incineration) by creating large-amplitude, resonant pulsations inside the combustion chamber. This technology can be applied to new or existing combustion systems. The technology is used in fossil fuel combustion devices, residential natural gas furnaces, and industrial combustion systems. It should prove similarly beneficial to hazardous waste incineration and soil remediation applications.

The Sonotech system (see photograph below) consists of an air inlet, a combustor section, a tailpipe, a control panel, and safety features.

This system is designed to improve an incinerator's performance by (1) increasing mixing rates between the fuel and air, (2) increasing mixing rates between reactive gas pockets and ignition sources, and (3) increasing rates of heat and mass transfer between the gas and the burning waste. These improvements should (1) reduce the amount of excess air required to completely burn the waste, (2) increase destruction and removal efficiencies (DRE) of principal organic hazardous constituents, (3) minimize the formation of products of incomplete combustion, and (4) eliminate or minimize detrimental emissions or "puffs."

The Sonotech system has achieved sound amplitudes as high as 170 decibels and frequencies of 100 to 500 hertz within the combustion chamber. The high frequencies and velocities of these gas oscillations help mix the gases in the chamber and thus reduce or eliminate stratification effects.



Frequency-Tunable Pulse Combustion System Installed at
EPA's Research Facility

The Sonotech system can function alone or as a supplemental retrofit to an existing combustion system. In the latter application, the frequency-tunable pulse combustion system can supply as little as 2 to 10 percent of the total energy requirements. The total fuel supplied to the main burner and the Sonotech system should be less than the amount of fuel supplied to the main burner before retrofitting.

WASTE APPLICABILITY:

This technology can be used with any material that can be treated in a conventional incinerator. Sonotech, Inc., believes that the technology is ready for incineration of hazardous, municipal, and medical wastes.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1992. The 6-week demonstration evaluated whether the technology improved the performance of a larger scale incineration system. To meet this goal, the pilot-scale rotary kiln incinerator at EPA's Incineration Research Facility in Jefferson, Arkansas was retrofit with a Sonotech system. The demonstration took place from September to October 1994. The retrofit incinerator was used to treat coal- and oil-gasification wastes, traditionally incinerated with conventional technology. The Technology Capsule (EPA/540/R-95/502a) is available from EPA.

DEMONSTRATION RESULTS:

The Sonotech system increased the incinerator waste feed rate capacity by 13 to 21 percent compared to conventional combustion. As the demonstration waste had significant heat content, the capacity increase was equivalent to a reduction in the auxiliary fuel needed to

treat a unit mass of waste from 21,100 British thermal unit/pound (Btu/lb) for conventional combustion to 18,000 Btu/lb for the Sonotech system. Visual observations indicated improved mixing in the incinerator cavity with the Sonotech system operating.

Benzene and naphthalene DREs were greater than 99.99%. The average concentration of carbon monoxide exiting the afterburner, corrected to 7 percent oxygen, decreased from 20 parts per million (ppm) with conventional combustion to 14 ppm with the Sonotech system. The average concentration of nitrogen oxides exiting the after burner, corrected to 7 percent oxygen, decreased from 82 ppm with conventional combustion to 77 ppm with the Sonotech system. Average soot emissions exiting the afterburner, corrected to 7 percent oxygen, were reduced from 1.9 milligrams per dry standard cubic meter (mg/dscm) for conventional combustion to less than 1.0 mg/dscm with the Sonotech system. Total air requirements for system combustion, determined from stoichiometric calculations, were lower with the Sonotech system in operation.

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STAR ORGANICS, L.L.C.

(Soil Rescue Remediation Fluid)

TECHNOLOGY DESCRIPTION:

Tart Organics, L.L.C., has developed a liquid remediation solution that binds heavy metal contaminants in soils, sludges, and aqueous solutions. The liquid, called Soil Rescue, consists of organic acids that occur naturally in trace concentrations in soil. The liquid is typically sprayed onto and then tilled into the contaminated media; the application process can be repeated until the metals concentration in the media are reduced to below the applicable cleanup standards. Laboratory and pilot-scale tests have shown that metals concentrations can be reduced to below Research Conservation and Recovery Act (RCRA) regulatory levels.

The Soil Rescue solution does not destroy or remove toxic concentrations of metals. Instead, organic acids in the solution bond with the metals to form more complex metallic compounds in a process known as chelation. Soil Rescue is essentially a ligand that acts as a chelating agent. In the chelation reaction, coordinate bonds attach the metal ion to at least two ligand organic compounds to form a heterocyclic ring. The resulting ring structure is inherently more stable than simpler structures formed in other binding processes.

By effectively binding the metals, the process reduces the waste stream's toxicity characteristic leaching procedure (TCLP) test results to less than the RCRA-regulated levels, subsequently reducing the risks posed to human health and the environment. Once the toxic metals are bound to the ligand, the bond appears to be irreversible. The permanence of the bond has been tested using all recognized EPA test procedures for such determinations, including exposure to boiling acids.

The Soil Rescue process offers the following advantages over some treatment options: (1) it minimized the handling and transports costs associated with treatment and disposal, (2) it requires no air monitoring because it releases no emissions, (3) its liquid application procedure

minimized fugitive dust emissions, (4) it generates no effluent, (5) it requires no stockpiling of contaminated soil, and (6) it minimizes exposure risks for workers because it is sprayed directly onto the contaminated media.

The Soil Rescue solution has been shown to be effective in reducing concentrations of barium, cadmium, chromium, copper, lead, mercury, selenium, and zinc. In situ remediation of heavy metal contaminated soil may be possible in moderately permeable soils. In dense or heavily compacted soils, the remediation procedure may require soil excavation and application of the Soil Rescue solution to moisten the media, followed by mixing in a rotating cylinder. This procedure can be repeated until the metals concentrations in the soil are sufficiently reduced to allow the soil to be replaced as backfill in its original location. At a soil pH of 5.0, a single application can reduce lead concentrations of 1,000 parts per million (ppm) to below the EPA maximum permissible level; with a second application of the remediation fluid, lead concentrations can be reduced to below the RCRA regulatory limit of 5 ppm.

STATUS:

Under a cooperative agreement with the Ohio EPA, the Soil Rescue technology was demonstrated in September 1998 at two separate areas of the Crooksville/Roseville Pottery site in Ohio. Soil at the site, some of it adjacent to residential areas, is contaminated with lead from waste disposal practices associated with pottery production operations. Soil at the demonstration areas contains lead in concentrations ranging from 100 ppm to 80,000 ppm.

DEMONSTRATION RESULTS:

Soil treatment reduced leachable lead concentrations from 364 to 453 mg/L to 2.7 to 3.6 mg/L, as determined by the Toxicity Characteristic Leaching Procedure (TCLP).

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STC REMEDIATION, INC.
(formerly Silicate Technology Corporation)
(Organic Stabilization and Chemical Fixation/Solidification)

TECHNOLOGY DESCRIPTION:

STC Remediation, Inc. (STC Remediation), has developed both chemical organic stabilization and chemical fixation/ solidification technologies that treat inorganic and organic solid hazardous wastes (see photograph below). Leachable organic contaminant concentrations are reduced to well below regulatory limits. The chemical fixation/ solidification technology forms insoluble chemical compounds, reducing leachable inorganic contaminant concentrations in soils and sludges.

STC Remediation's technology has been successfully implemented on numerous full-scale hazardous waste remediation projects, successfully stabilizing more than 750,000 tons of hazardous soils, sediments, and sludges. These sites include Superfund sites and industrial sites across the United States and in Italy.

STC Remediation has evaluated various materials handling and mixing systems for use on full-scale remediation projects. Materials handling processes consist of pretreatment processes for screening and crushing contaminated soils, and placement and conveying systems for handling treated material. Mixing systems consist of various batching plants, pug mills, and high-shear batch mixing systems to properly meter and mix reagents with contaminated soils. STC Remediation provides complete treatability study services during project development and on site technical services and/or contracting services during full scale remediation to ensure effective application of the treatment technologies, documentation, and quality assurance/quality control procedures during the treatment process.



Treatment of Contaminated Soil

WASTE APPLICABILITY:

STC Remediation's technology can treat a wide variety of hazardous soils, sludges, and wastewaters, including the following:

- Soils and sludges contaminated with inorganics, including most metals, cyanides, fluorides, arsenates, chromates, and selenium
- Soils and sludges contaminated with organics, including halogenated aromatics, polynuclear aromatic hydrocarbons, and aliphatic compounds
- Wastewaters contaminated with heavy metals and emulsified and dissolved organic compounds, excluding low-molecular-weight organic contaminants such as alcohols, ketones, and glycols

STATUS:

This technology was accepted into the SITE Demonstration Program in 1988, and the demonstration was completed in November 1990 at the Selma Pressure Treating (SPT) Superfund site in Selma, California. STC Remediation was subsequently selected for the full-scale remediation of the SPT site, which is contaminated with organics, mainly pentachlorophenol (PCP), and inorganics, mainly arsenic, chromium, and copper. The Applications Analysis Report (EPA/540/AR-92/010) is available through the National Technology Information Service (Order No. PB93-172948). The Technology Evaluation Report (EPA/540/R-92/010) and Demonstration Bulletin (EPA/540/MR- 92/010) are available from EPA.

DEMONSTRATION RESULTS:

The SITE demonstration yielded the following results:

- The organic stabilization technology reduced total extractable PCP concentrations up to 97 percent.

- The chemical fixation/stabilization technology stabilized the residual PCP concentrations to very low leachable levels (from 5 to less than 0.3 milligrams per liter).
- STC Remediation's technology immobilized arsenic and copper, while chromium remained well within regulatory limits.
- Long-term monitoring at 18 and 32 months following the demonstration project provided comparable results for PCP, arsenic, and copper, while chromium remained well within regulatory limits.
- The treated wastes had moderately high unconfined compressive strength, averaging 300 pounds per square inch (psi) after 28 days, increasing to more than 700 psi after 18 months.
- Permeability of the treated waste was less than 1.7×10^{-7} centimeters per second). The relative cumulative weight loss after 12 wet/dry and 12 freeze/thaw cycles was negligible (less than 1 percent).
- Treatment costs depend on specific waste characteristics.

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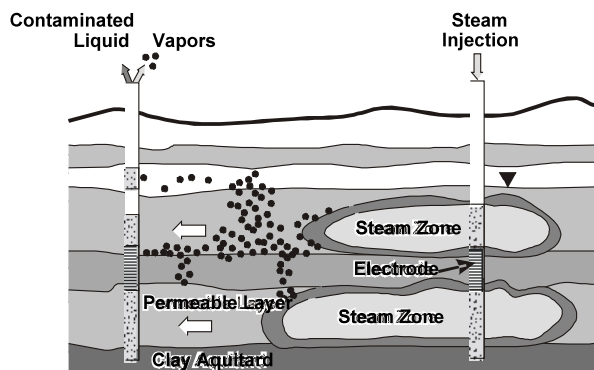
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STEAMTECH ENVIRONMENTAL SERVICES (Steam Enhanced Remediation [SER] at Loring AFB)

TECHNOLOGY DESCRIPTION:

Steam Enhanced Remediation – Dynamic Underground Stripping (SER – DUS) is a combination of technologies previously used separately, adapted to the hydrogeology of typical contaminated sites. Steam is injected at the periphery of the contaminated area to heat permeable subsurface areas, vaporize volatile compounds bound to the soil, and drive contaminants to centrally located vapor and liquid extraction wells. Electrical heating is used for less-permeable clays and fine-grained sediments to vaporize contaminants and drive them into the vapor. Since media at Edwards Air Force Base is fractured bedrock there will be no electrical heating. Progress is monitored by underground imaging, primarily Electrical Resistance Tomography (ERT) and temperature monitoring, which delineates the heated area and tracks the steam fronts daily to ensure total cleanup and precise process control.



SER – DUS is capable of extracting, separating and treating effluent vapors, nonaqueous phase liquids (NAPL), and water on-site for complete contaminant destruction or off-site disposal. The dominant removal mechanisms for volatile contaminants are the increased volatilization and steam stripping when the mixture of water and NAPL reaches the boiling point. Another major removal mechanism of contaminants is the fast

removal of liquid, dissolved and vapor phase contaminants by physical transport to centrally located extraction wells. NAPL is removed from the extraction wells along with hot water. Contaminated vapors are extracted from the wells by aggressive vacuum extraction. In situ destruction of contaminants by thermally accelerated oxidation processes (hydrous pyrolysis, oxidation and biological mineralization) converts harmful chemicals into carbon dioxide and water.

WASTE APPLICABILITY:

Large and small sites contaminated with petroleum products, creosote and solvents can be remediated faster and at lower cost via SER. SER is highly effective for removal of both volatile and semivolatile compounds. SER works both above and below the groundwater table and both LNAPL and DNAPL contaminants can be removed.

STATUS:

Excellent cleanup results have been achieved in the laboratory, simulating cleanup using steam injection and Joule heating for gasoline, oils, creosote, and chlorinated solvent DNAPL. Field demonstrations include successful applications to sites containing chemical mixtures gasoline, jet fuel wood-treating chemicals, and chlorinated solvents such as TCE.

DEMONSTRATION RESULTS:

There has not yet been a demonstration at Loring Air Force Base, so there are no results up to this point. The demonstrations are planned for the summer of 2002.

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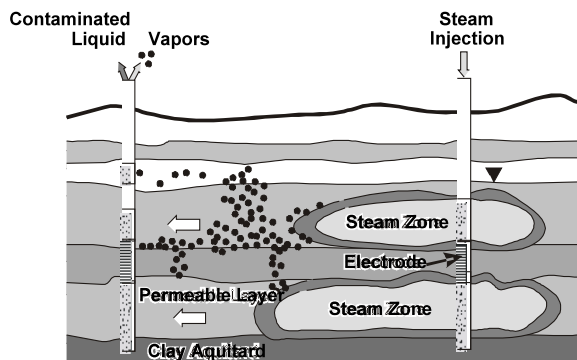
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STEAMTECH ENVIRONMENTAL SERVICES (Steam Enhanced Remediation [SER] at Ridgefield, WA)

TECHNOLOGY DESCRIPTION:

Steam Enhanced Remediation – Dynamic Underground Stripping (SER – DUS) is a combination of technologies previously used separately, adapted to the hydrogeology of typical contaminated sites. Steam is injected at the periphery of the contaminated area to heat permeable subsurface areas, vaporize volatile compounds bound to the soil, and drive contaminants to centrally located vapor and liquid extraction wells. Electrical heating is used for less-permeable clays and fine-grained sediments to vaporize contaminants and drive them into the vapor. Since media at Edwards Air Force Base is fractured bedrock there will be no electrical heating. Progress is monitored by underground imaging, primarily Electrical Resistance Tomography (ERT) and temperature monitoring, which delineates the heated area and tracks the steam fronts daily to ensure total cleanup and precise process control.



SER – DUS is capable of extracting, separating and treating effluent vapors, non-aqueous phase liquids (NAPL), and water on-site for complete contaminant destruction or off-site disposal. The dominant removal mechanisms for volatile contaminants are the increased volatilization and

steam stripping when the mixture of water and NAPL reaches the boiling point. Another major removal mechanism of contaminants is the fast removal of liquid, dissolved- and vapor-phase contaminants by physical transport to centrally located extraction wells. NAPL is removed from the extraction wells along with hot water. Contaminated vapors are extracted from the wells by aggressive vacuum extraction. In situ destruction of contaminants by thermally accelerated oxidation processes (hydrous pyrolysis, oxidation and biological mineralization) converts harmful chemicals into carbon dioxide and water.

WASTE APPLICABILITY:

Large and small sites contaminated with petroleum products, creosote and solvents can be remediated faster and at lower cost via SER. SER is highly effective for removal of both volatile and semivolatile compounds. SER works both above and below the groundwater table and both LNAPL and DNAPL contaminants can be removed.

STATUS:

Excellent cleanup results have been achieved in the laboratory, simulating cleanup using steam injection and Joule heating for gasoline, oils, creosote, and chlorinated solvent DNAPL. Field demonstrations include successful applications to sites containing chemical mixtures gasoline, jet fuel wood-treating chemicals, and chlorinated solvents such as TCE.

DEMONSTRATION RESULTS:

There has not yet been a demonstration in Ridgefield, WA, so there are no results up to this point. The demonstrations are planned for the spring of 2002.

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TERRA-KLEEN RESPONSE GROUP, INC. (Solvent Extraction Treatment System)

TECHNOLOGY DESCRIPTION:

Terra-Kleen Response Group, Inc. (Terra-Kleen), developed the solvent extraction treatment system to remove semivolatile and nonvolatile organic contaminants from soil. This batch process system uses a proprietary solvent blend to separate hazardous constituents from soils, sediments, sludge, and debris.

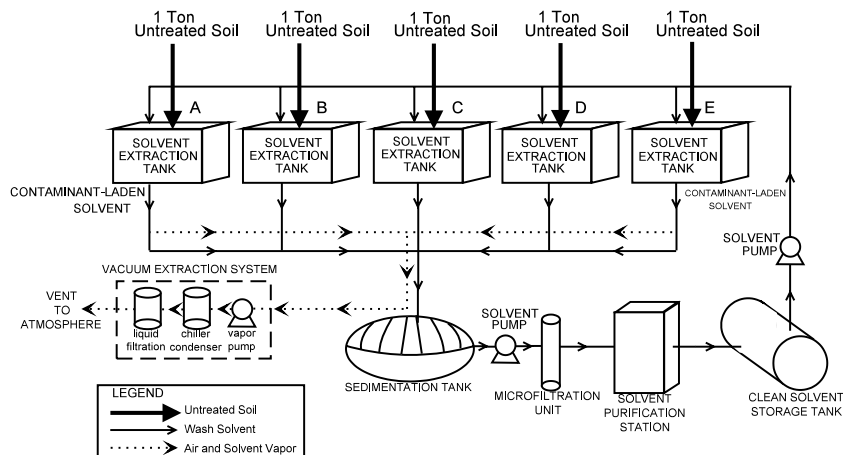
A flow diagram of the Terra-Kleen treatment system is shown below. Treatment begins after excavated soil is loaded into the solvent extraction tanks. Clean solvent from the solvent storage tank is pumped into the extraction tanks. The soil and solvent mixture is held in the extraction tanks long enough to solubilize organic contaminants into the solvent, separating them from the soil. The contaminant-laden solvent is then removed from the extraction tanks and pumped into the sedimentation tank. Suspended solids settle or are flocculated in the sedimentation tank, and are then removed.

Following solvent extraction of the organic contaminants, any residual solvent in the soil is removed using soil vapor extraction and biological treatment. Soil vapor extraction removes the majority of the residual solvent, while biological treatment reduces residual solvent to trace levels. The treated soils are then removed from the extraction tanks.

Contaminant-laden solvents are cleaned for reuse by Terra-Kleen's solvent regeneration process. The solvent regeneration process begins by pumping contaminant-laden solvent from the sedimentation tank through a microfiltration unit and a proprietary solvent purification station. The microfiltration unit first removes any fines remaining in the solvent. The solvent purification station separates organic contaminants from the solvent and concentrates them, reducing the amount of hazardous waste for off-site disposal. The solvent is pumped into the solvent storage tank for use in treating additional soil.

WASTE APPLICABILITY:

The Terra-Kleen solvent extraction treatment system is a waste minimization process designed to remove the following organic contaminants from soils: polychlorinated biphenyls (PCB), chlorinated pesticides, polynuclear aromatic hydrocarbons (PAH), pentachlorophenol, creosote, polychlorinated dibenzo-p-dioxins (PCDD), chlorinated pesticides, and polychlorinated dibenzofurans (PCDF). The system is transportable and can be configured to treat small quantities of soil (1 to 1,000 cubic yards) as well as large volumes generated at remedial sites.



Solvent Extraction Treatment System

STATUS:

The solvent extraction treatment system was demonstrated during May and June 1994 at Naval Air Station North Island (NASNI) Site 4 in San Diego, California. Soils at Site 4 are contaminated with heavy metals, volatile organic compounds (VOC), PCBs (Aroclor 1260), and furans. The Technology Capsule (EPA/540/R-94/521a) and Demonstration Bulletin (EPA/540/MR-94/521) are available from EPA. The Innovative Technology Evaluation Report is available from EPA.

Several full-scale solvent extraction units are in operation at this time. Terra-Kleen has removed PCBs from 10,000 tons of soil at three sites within NASNI, and completed cleanup of a remote Air Force Base PCB site in Alaska. A full-scale system has also removed DDT, DDD, and DDE from clay soil at the Naval Communication Station in Stockton, California.

Terra-Kleen has been selected to participate in the Rapid Commercialization Initiative (RCI). RCI was created by the Department of Commerce, Department of Defense, Department of Energy (DOE), and EPA to assist in the integration of innovative technologies into the marketplace. Under RCI, Terra-Kleen is expanding its capabilities to process PCBs and VOCs in low-level radioactive wastes. The pilot project for this effort was completed in 1997 at DOE's Fernald Plant near Cincinnati, Ohio.

DEMONSTRATION RESULTS:

Findings from the SITE demonstration are summarized as follows:

- PCB Aroclor 1260 concentrations were reduced from an average of 144 milligrams per kilogram (mg/kg) to less than 1.71 mg/kg, an overall removal efficiency of 98.8 percent.

- NASNI untreated soil contained a moisture content of 0.83 percent; a particle size distribution of 80 percent sand, 15 percent gravel, and 5 percent clay; and an overall oil and grease concentration of 780 mg/kg.
- Hexachlorodibenzofuran and pentachlorodibenzofuran concentrations were reduced by 92.7 percent and 84.0 percent, respectively. Oil and grease concentrations were reduced by 65.9 percent.

Additional data were collected at the Naval Communication Station in Stockton, California. The system treated soil contaminated with chlorinated pesticides at concentrations up to 600 mg/kg. Samples taken during system operation indicated that soil contaminated with DDD, DDE, and DDT was reduced below 1 mg/kg, an overall removal efficiency of 98.8 to 99.8 percent.

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TERRATHERM, INC.

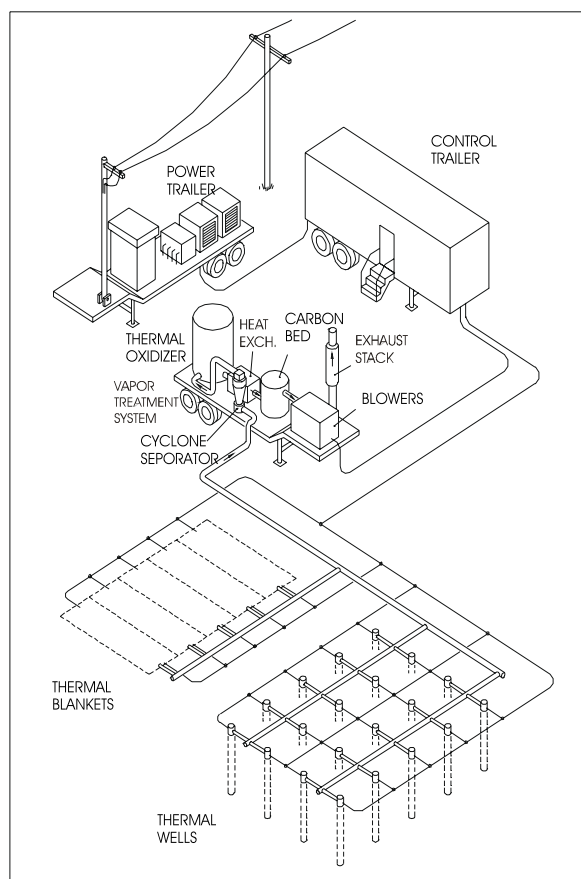
(In Situ Thermal Destruction)

TECHNOLOGY DESCRIPTION:

TerraTherm, Inc.'s patented In Situ Thermal Destruction (ISTD) process utilizes conductive heating and vacuum to remediate soil contaminated with a wide range of organic compounds. Heat and vacuum are applied simultaneously to subsurface soil, either with an array of vertically or horizontally positioned heaters under imposed vacuum. The electrically powered heating elements are operated at temperatures of up to 800°C. In a typical installation for soils contaminated with organochlorine pesticides, polychlorinated biphenyls (PCBs), or polynuclear aromatic hydrocarbons (PAHs), the heater wells are installed at 6 ft to 7.5 ft spacing, with an impermeable liner installed at the soil surface. More volatile compounds can be treated with more widely spaced wells. Heat flows through the soil from the heating elements primarily by thermal conduction, which results in uniform heat distribution because unlike other soil physical properties such as permeability that tend to vary over orders of magnitude, thermal conductivity is nearly invariant over a wide range of soil types (e.g., clay to sand).

As the soil is heated, volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) are vaporized and/or destroyed by a number of mechanisms, including evaporation, boiling of water/steam distillation, boiling of the contaminants, oxidation and pyrolysis. The vaporized water and contaminants are drawn counter-current to the heat flow into the heater-vacuum wells. In practice, most (e.g., 95-99 percent) of the contaminants are destroyed within the soil as they arrive in the superheated soil in proximity of the heated extraction wells. The small fraction of the contaminant mass that has not been destroyed in situ is removed from the

vapor stream at the surface with an air pollution control system.



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The vapor treatment train usually consists of a thermal oxidizer, heat exchanger, dry scrubber, carbon adsorbers, and vacuum blowers. Destruction and removal efficiencies of 99.9 percent have been achieved in the stack effluent with this system for PCBs.

WASTE APPLICABILITY:

Based on the results of completed ISTD remediation projects conducted at seven contaminated sites and numerous treatability studies, the ISTD technology has been proven to be highly effective in removing a wide variety of organic contaminants from soil and buried waste, including pesticides, PCBs, dioxins, chlorinated solvents, PAHs, coal tar, wood-treatment wastes, explosives residues, and heavy and light petroleum hydrocarbons. Achievement of non detect levels throughout the treatment zone is a typical result of approximately two to three months of heating. Soil, waste and sediment can be treated both above and below the water table, although in the case of treatment of SVOCs below the water table, recharge of groundwater into the heated zone must be controlled.

STATUS:

Since 1995, ISTD has been applied at seven field sites, including three demonstrations and four full-scale projects. Of these, four were at CERCLA and/or Department of Defense sites. Currently, TerraTherm, Inc. is engaged in design and implementation of ISTD at four additional project sites. In particular, remediation of the Hex Pit at the Rocky Mountain Arsenal, Commerce City, Colorado, by ISTD is a U.S. EPA Superfund Innovative Technology Evaluation (SITE) demonstration project.

A total of 266 thermal wells, including 210 heater-only and 56 heater-vacuum wells, will be installed during the fall of 2001 in a hexagonal pattern at 6.0-ft spacing and to a depth of 12 feet to treat 2,500 cubic yards of soil. Heating of the Hex Pit is scheduled to begin in January 2002. The treatment zone will be heated over an approximately 75-day period to interwell temperatures of $>325^{\circ}\text{C}$. Subsurface monitoring will track the progress of heating. SITE will carry out isokinetic stack testing as well as pre- and posttreatment

soil sampling both within and just outside the boundaries of the thermal treatment zone to evaluate the degradation efficiency, degree of in-situ destruction, effects on fringe areas, and discharge concentrations.

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TERRA VAC (In Situ and Ex Situ Vacuum Extraction)

TECHNOLOGY DESCRIPTION:

In situ or ex situ vacuum extraction is a process that removes volatile organic compounds (VOC) and many semivolatile organic compounds (SVOC) from the vadose, or unsaturated, soil zone. These compounds can often be removed from the vadose zone before they contaminate groundwater. Soil piles also may be cleaned by ex situ vacuum extraction. The in situ vacuum extraction process has been patented by others and licensed to Terra Vac and others in the United States.

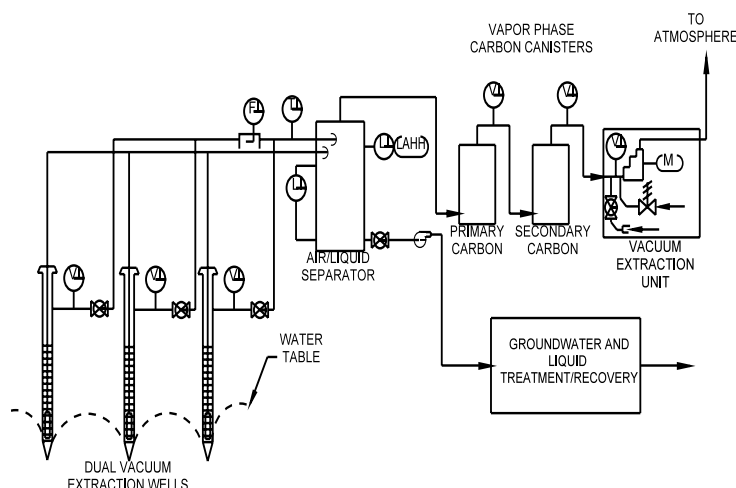
The extraction process uses readily available equipment, including extraction and monitoring wells, manifold piping, air-liquid separators, and vacuum pumps. Vacuum extraction systems may vent directly to the atmosphere or through an emission control device. After the contaminated area is generally characterized, extraction wells are installed and connected by piping to the vacuum extraction and vapor treatment systems.

First, a vacuum pump creates a vacuum in the soil causing in situ volatilization and draws air through the subsurface. Contaminants are removed from the extraction wells and pass to the air-liquid separator.

The vapor-phase contaminants may be treated with an activated carbon adsorption filter, a catalytic oxidizer, or another emission control system before the gases are discharged to the atmosphere. Subsurface vacuum and soil vapor concentrations are monitored with vadose zone monitoring wells.

The technology can be used in most hydrogeological settings and may reduce soil contaminant levels from saturated conditions to nondetectable. The process also works in fractured bedrock and less permeable soils (clays) with sufficient permeability. The process may be used to enhance bioremediation (bioventing). It also may be used in conjunction with dual vacuum extraction, soil heating, pneumatic fracturing, and chemical oxidation to recover a wide range of contaminants. The figure below illustrates one possible configuration of the process.

Typical contaminant recovery rates range from 20 to 2,500 pounds (10 to 1,000 kilograms) per day, depending on the degree of site contamination and the design of the vacuum extraction system.



In Situ Dual Vacuum Extraction Process

WASTE APPLICABILITY:

The vacuum extraction technology may treat soils containing virtually any VOC. It has removed over 40 types of chemicals from soils and groundwater, including solvents and gasoline- and diesel-range hydrocarbons.

STATUS:

The process was accepted into the SITE Demonstration Program in 1987. The process was demonstrated under the SITE Demonstration Program at the Groveland Wells Superfund site in Groveland, Massachusetts, from December 1987 through April 1988. The technology remediated soils contaminated with trichloroethene (TCE). The Technology Evaluation Report (EPA/540/5-89/003a) and Applications Analysis Report (EPA/540/A5-89/003) are available from EPA.

The vacuum extraction process was first demonstrated at a Superfund site in Puerto Rico in 1984. Terra Vac has since applied the technology at more than 20 additional Superfund sites and at more than 700 other waste sites throughout the United States, Europe, and Japan.

DEMONSTRATION RESULTS:

During the Groveland Wells SITE demonstration, four extraction wells pumped contaminants to the process system. During a 56-day period, 1,300 pounds of VOCs, mainly TCE, were extracted from both highly permeable strata and less permeable (10^{-7} centimeters per second) clays. The vacuum extraction process achieved nondetectable VOC levels at some locations and reduced the VOC concentration in soil gas by 95 percent. Average reductions of soil

concentrations during the demonstration program were 92 percent for sandy soils and 90 percent for clays. Field evaluations yielded the following conclusions:

- Permeability of soils is an important consideration when applying this technology.
- Pilot demonstrations are necessary at sites with complex geology or contaminant distributions.
- Treatment costs are typically \$40 per ton of soil but can range from less than \$10 to \$80 per ton of soil, depending on the size of the site and the requirements for gas effluent or wastewater treatment.
- Contaminants should have a Henry's constant of 0.001 or higher.

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TEXACO INC. (Texaco Gasification Process)

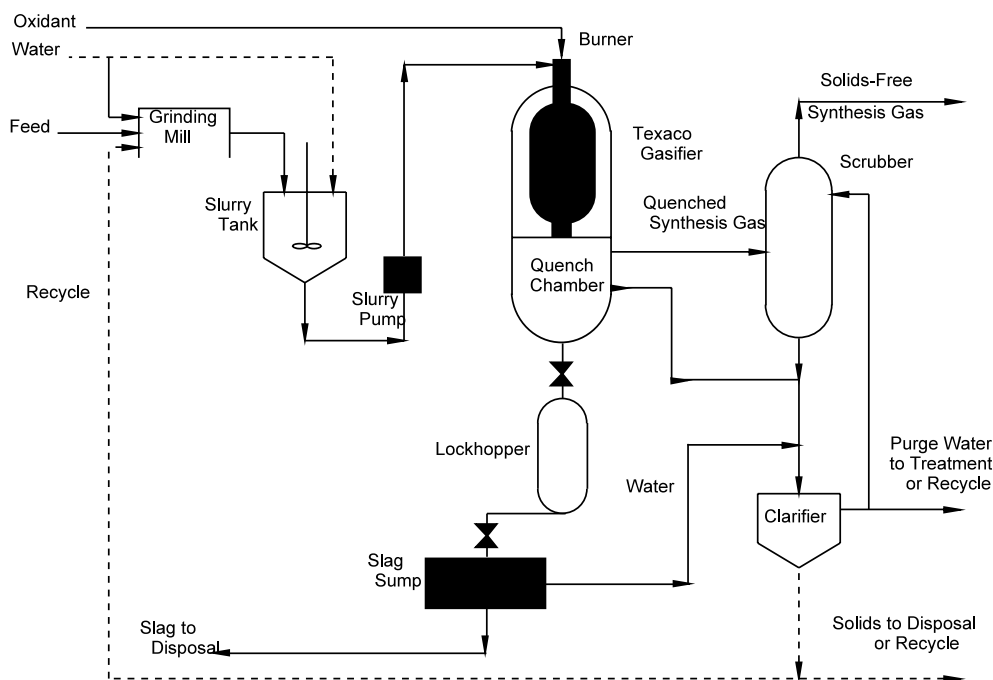
TECHNOLOGY DESCRIPTION:

The Texaco Gasification Process (TGP) is an entrained-bed, noncatalytic, partial oxidation process in which carbonaceous substances react at elevated temperatures and pressures, producing a gas containing mainly carbon monoxide and hydrogen (see figure below). This product, called synthesis gas, can be used to produce other chemicals or can be burned as fuel. Inorganic materials in the feed melt are removed as a glass-like slag.

This technology has operated commercially for over 40 years with feedstocks such as natural gas, heavy oil, coal, and petroleum coke. The TGP processes waste feedstocks at pressures above 20 atmospheres and temperatures between 2,200 and 2,800°F.

Slurried wastes are pumped to a specially designed injector mounted at the top of the refractory lined gasifier. The waste feed, oxygen, and an auxiliary fuel such as coal react and flow downward through the gasifier to a quench chamber that collects the slag. The slag is eventually removed through a lockhopper. A scrubber further cools and cleans the synthesis gas. Fine particulate matter removed by the scrubber may be recycled to the gasifier; a sulfur recovery system may also be added.

After the TGP converts organic materials into synthesis gas, the cooled, water-scrubbed product gas, consisting mainly of hydrogen and carbon monoxide, essentially contains no hydrocarbons heavier than methane. Metals and other ash constituents become part of the glassy slag. The TGP can be configured as a transportable system capable



Texaco Gasification Process

of processing about 100 tons of hazardous waste per day. This system would produce about 6 million standard cubic feet of usable synthesis gas per day with a heating value of approximately 250 British thermal units per standard cubic foot.

WASTE APPLICABILITY:

The TGP can treat the following wastes:

- Contaminated soils, sludges, and sediments that contain both organic and inorganic constituents
- Chemical wastes
- Petroleum residues

Solids in the feed are ground and pumped in a slurry containing 40 to 70 percent solids by weight and 30 to 60 percent liquid, usually water.

Texaco has demonstrated gasification of coal liquefaction residues, petroleum production tank bottoms, municipal sewage sludge, and surrogate contaminated soil. Texaco is operating a gasification facility at its El Dorado, Kansas refinery that will convert up to 170 tons per day of petroleum coke and Resource Conservation and Recovery Act-listed refinery wastes into usable synthesis gas.

STATUS:

The TGP was accepted into the SITE Demonstration Program in July 1991. A demonstration was conducted in January 1994 at Texaco's Montebello Research Laboratory in California using a mixture of clean soil, coal, and contaminated soil from the Purity Oil Sales Superfund site, located in Fresno, California. The mixture was slurried and spiked with lead, barium, and chlorobenzene. Forty tons of slurry was gasified during three demonstration runs. The Demonstration Bulletin (EPA/540/MR-95/514), Technology Capsule (EPA/540/R-94/514a), and Innovative Technology Evaluation Report (EPA/540/R-94/514) are available from EPA.

DEMONSTRATION RESULTS:

Findings from the SITE demonstration are summarized below:

- The average composition of the dry synthesis gas product from the TGP consisted of 37 percent hydrogen, 36 percent carbon monoxide, and 21 percent carbon dioxide. The only remaining organic contaminant greater than 0.1 part per million (ppm) was methane at 55 ppm.
- The destruction and removal efficiency for the volatile organic spike (chlorobenzene) was greater than the 99.99 percent goal.
- Samples of the primary TGP solid product, coarse slag, averaged below the Toxicity Characteristic Leaching Procedure (TCLP) limits for lead (5 milligrams per liter [mg/L]) and barium (100 mg/L). Volatile heavy metals tended to partition to and concentrate in the secondary TGP solid products, fine slag and clarifier solids. These secondary products were above the TCLP limit for lead.

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TORONTO HARBOR COMMISSION (Soil Recycling)

TECHNOLOGY DESCRIPTION:

The Toronto Harbor Commission's (THC) soil recycling process removes inorganic and organic contaminants from soil to produce a reusable fill material (see photograph below). The process consists of three technologies operating in series: a soil washing technology; a technology that removes inorganic contamination by chelation; and a technology that uses chemical and biological treatment to reduce organic contaminants.

The process uses an attrition soil wash plant to remove relatively uncontaminated coarse soil fractions using mineral processing equipment while concentrating the contaminants in a fine slurry which is routed to the appropriate process for further treatment. The wash process includes a trommel washer to remove clean gravel, hydrocyclones to separate the contaminated fines, an attrition scrubber to free fines from sand particles, and a density separator to remove coal and peat from the sand fraction.

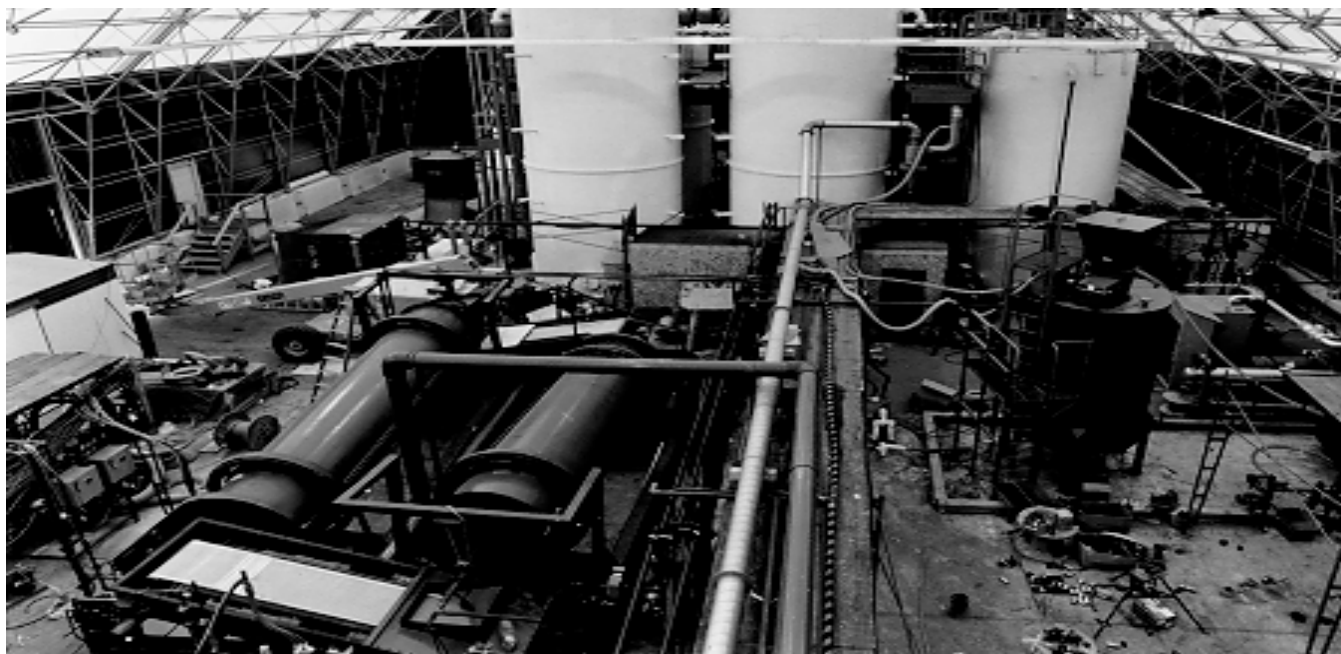
If only inorganic contaminants are present, the

slurry can be treated in the inorganic chelator unit. This process uses an acid leach to free the inorganic contaminant from the fine slurry and then removes the metal using solid chelating agent pellets in a patented countercurrent contactor. The metals are recovered by electrowinning from the chelation agent regenerating liquid.

Organic removal is accomplished by first chemically pretreating the slurry from the wash plant or the metal removal process. Next, biological treatment is applied in upflow slurry reactors using the bacteria which have developed naturally in the soils. The treated soil is dewatered using hydrocyclones and returned to the site from which it was excavated.

WASTE APPLICABILITY:

The technology is designed to reduce organic and inorganic contaminants in soils. The process train approach is most useful when sites have been contaminated as a result of multiple uses over a



Soil Washing Plant (Metal Extraction Screw tubes in Foreground
and Bioslurry Reactors in Background)

period of time. Typical sites where the process train might be used include refinery and petroleum storage facilities, sites with metal processing and metal recycling histories, and manufactured gas and coal or coke processing and storage sites. The process is less suited to soils with undesirable high inorganic constituents which result from the inherent mineralogy of the soils.

STATUS:

The THC soil recycling process was accepted into the SITE Demonstration Program in 1991. The soil recycling process was demonstrated at a site within the Toronto Port Industrial District that had been used for metals finishing and refinery products and petroleum storage. Demonstration sampling took place in April and May 1992.

Results have been published in the Demonstration Bulletin (EPA/520-MR -92/015), the Applications Analysis Report (EPA/540-AR-93/517), the Technology Evaluation Report (EPA/540/R-93/517), and the Technology Demonstration Summary (EPA/540/SR-93/517). These reports are available from EPA.

This technology is no longer available through a vendor. For further information on the technology, contact the EPA Project Manager.

DEMONSTRATION RESULTS:

The demonstration results showed that soil washing produced clean coarse soil fractions and concentrated the contaminants in the fine slurry.

The chemical treatment process and biological slurry reactors, when operated on a batch basis with a nominal 35-day retention time, achieved at least a 90 percent reduction in simple polyaromatic hydrocarbon compounds such as naphthalene, but did not meet the approximately 75 percent reduction in benzo(a)pyrene required to achieve the cleanup criteria.

The biological process discharge did not meet the cleanup criteria for oil and grease, and the process exhibited virtually no removal of this parameter. THC believes that the high outlet oil and grease values are the result of the analytical extraction of the biomass developed during the process.

The hydrocyclone dewatering device did not achieve significant dewatering. Final process slurries were returned to the excavation site in liquid form.

The metals removal process achieved a removal efficiency for toxic heavy metals such as copper, lead, mercury, and nickel of approximately 70 percent.

The metals removal process equipment and chelating agent were fouled by free oil and grease contamination, forcing sampling to end prematurely. Biological treatment or physical separation of oil and grease will be required to avoid such fouling.

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UNIVERSITY OF IDAHO RESEARCH FOUNDATION (formerly licensed to J.R. SIMPLOT COMPANY) (The SABRE™ Process)

TECHNOLOGY DESCRIPTION:

The patented Simplot Anaerobic Biological Remediation (SABRE™) process reduces contamination through on-site bioremediation of soils contaminated with the herbicide dinoseb (2-*sec*-butyl-4,6-dinitrophenol) or nitroaromatic explosives. The biodegradation process begins when contaminated soil is placed in a bioreactor and flooded with buffered water. A source of carbon and a nitroaromatic-degrading consortium of anaerobic bacteria are then added to the bioreactor. Anaerobic conditions are quickly established, allowing the bacteria to degrade the target compounds while preventing polymerization of intermediate breakdown products. A photograph of the technology in operation is shown below.

WASTE APPLICABILITY:

Soil can be treated in above- or in-ground containment ponds. Temperature, pH, and redox potential in the bioreactor are monitored during treatment. A hydromixing system has been engineered to efficiently solubilize the target compound from the soil while maintaining anaerobic conditions. Frequency of mixing depends upon the contaminants present, concentration, soil heterogeneity, and soil type.

This technology is designed to treat soils contaminated with nitroaromatic pesticides and explosives. This contamination most often occurs at rural crop dusting aircraft sites and at ordnance handling and manufacturing facilities.

STATUS:

This technology was accepted into the SITE Emerging Technology Program in January 1990. Based on bench- and pilot-scale results from the Emerging Technology Program, this technology was accepted in the SITE Demonstration Program in winter 1992. Demonstrations for dinoseb and the explosive TNT (2,4,6-trinitrotoluene) were performed at Bowers Field in Ellensburg, Washington and at Weldon Spring Ordnance Works in Weldon Spring, Missouri, respectively. A Technology Capsule describing the dinoseb project (EPA/540/R-94/508a) and an Innovative Technology Evaluation Report describing the TNT project (EPA/540/R-95/529) are available from EPA.



Bioreactors and Soil Mixing System at a TNT-Contaminated Site in Washington

Since then, the process has been evaluated at several other sites. During the winters of 1994 and 1995, two 10-cubic-yard (yd³) batches of soils from Bangor Naval Submarine Base, Washington were treated using the SABRE™ Process. One batch contained TNT, while the other was contaminated with TNT and RDX. Cost savings were realized by using in-ground ponds for bioreactors and efficient mixing. Heaters were also installed to maintain optimum biological activity during the sub-freezing temperatures. Treatment goals were met or surpassed in the 90 days allowed for the project.

A full-scale remediation of 321 yd³ of dinoseb-contaminated soils was completed in October 1995. The site was a former herbicide distributor located near Reedley, CA. The treatment was performed in an above-ground containment already existing on site. Concentrations ranging from 40 to 100 milligrams per kilogram were reduced to nondetect after 28 days of treatment. The soil was mixed three times during treatment using a full-scale, expandable hydromixing system.

A larger evaluation was conducted in fall 1996 at Naval Weapons Station - Yorktown. About 500 yd³ of soil were contained in an in-ground pond measuring 86 ft by 150 ft deep. A full-scale hydromixing system was used to periodically slurry the soil and water mixture.

Process optimization work is ongoing. Collaborative projects with the U.S. Army Corps of Engineers Waterways Experiment Station and the U.S. Army Environmental Center are underway.

DEMONSTRATION RESULTS:

During the Weldon Spring demonstration, TNT was reduced from average concentrations of 1,500 parts per million (ppm) to an average of 8.7 ppm, for an average removal rate of 99.4%. Toxicity testing, which included early seedling growth, root elongation, and earthworm reproduction tests, showed that soil toxicity was significantly reduced. The Weldon Spring demonstration showed the effectiveness of this process even in unfavorable conditions. The treatment time was lengthened by unseasonably cool ambient temperatures. Temperatures in the bioreactor were as low as 4°C; ideal temperatures for the SABRE™ process are 35 to 37 °C.

During the Ellensburg demonstration, dinoseb was reduced from 27.3 ppm to below the detection limit, a greater than 99.8% removal. Other pesticides were also degraded in this process, highlighting the effectiveness of the process even in the presence of co-contaminants. The process was completed in just 23 days, despite 18°C temperatures.

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UNIVERSITY OF NEBRASKA - LINCOLN (Center Pivot Spray Irrigation System)

TECHNOLOGY DESCRIPTION:

Spray irrigation technology with “center pivots” and “linear” systems can be used to remediate groundwater contaminated with volatile organic compounds (VOC). The technology is commonly used to apply irrigation water to vegetable and row crops. While the systems were introduced to irrigate hilly terrain and excessively well-drained soils, the technology has been adapted in both groundwater quality and quantity management areas as a best management practice. This technology severely reduces water application rates and leaching relative to flood irrigation techniques.

The systems consist of an elevated pipeline with nozzles placed at close intervals. Groundwater is pumped through the pipeline and sprayed uniformly over a field as the pipeline pivots or linearly passes over the cropped area. The typical pump rate is between 800 and 2,000 gallons per minute (gpm). These self-propelled systems are highly mechanized and have low labor and operating requirements. The systems do not require level ground, and start-up costs are low.

The sprinkler method applies water over the irrigated area with a fine spray (see the photograph below). Water coverage over the irrigated area is

controlled by the speed with which the “pivot” or “linear” system travels across the field. The heart of the sprinkler irrigation system is the nozzle, which has a small opening through which a high-velocity stream of water is emitted. As the high-velocity water stream leaves the nozzle, it strikes an impact pad and forms a thin film of water. The thin film of water produced by these pads breaks up into small droplets as it leaves the impact pad. Droplet size depends on the stream pressure and design of the impact pad.

The system used in the SITE demonstration program was a center pivot and was located on a seed-corn field in Hastings, Nebraska. The system was equipped with off-the-shelf, fog-producing impact pads for improved volatilization efficiency.

A stratified water droplet collector (SWDC) simultaneously collected spray at four fall heights above ground level, and was specifically contracted for this project by the Dutton-Lainson Company in Hastings, Nebraska. With this device, droplets were collected at heights of 1.5, 4.5, 7.5, and 10.5 feet above the ground surface. Twelve SWDCs were installed parallel to the pivot arm to determine average volatilization efficiencies from the 340 nozzles on the pivot arm.



Center Pivot spray Irrigation System

WASTE APPLICABILITY:

The sprinkler irrigation system is capable of remediating VOC-contaminated groundwater. Removal rates in excess of 95 percent have been demonstrated for groundwater containing ethylene dibromide (EDB), trichloroethene (TCE), 1,1,1-trichloroethane (TCA), and carbon tetrachloride (CT). The method will efficiently volatilize all common volatiles in groundwater that may originate from landfills, degreasers, dry cleaners, electrical industries, gas stations, or refineries. The residuals are transferred to the atmosphere where they are dispersed and most are rapidly degraded in ultraviolet light.

The technique may be limited to individual groundwater VOC concentrations that are less than 1 part per million if residual concentrations of VOCs are mandated to be near or below the maximum contaminant level prior to reaching the ground surface. Otherwise, the technique can be used in any agricultural setting where sufficient groundwater and irrigatable land are available.

The Center Pivot Spray Irrigation system was accepted into the SITE Demonstration Program in late 1995. Under a University of Nebraska project funded by the Cooperative State Research Service of the Department of Agriculture, field tests were completed in the summers of 1994 and 1995 in a seed-corn field in Hastings, Nebraska. The technology was demonstrated under the SITE Program in July 1996 at the North Landfill/FAR-MAR-CO Subsite in Hastings, Nebraska. The 50-acre site is a furrow-irrigated corn field underlain by commingled plumes of groundwater containing EDB, TCE, TCA, CT, 1,1-dichloroethene, and chloroform. The primary goal of the demonstration was to determine the efficiency of the system to remediate VOCs in groundwater to concentrations below the maximum contaminant levels. The results of this demonstration are available in an Innovative Technology Evaluation Report (EPA/540/R-98/502).

Clients involved in large pump-and-treat projects at several military bases are investigating the suitability of the system to their specific site situations. Potential clients include the U.S. Navy, the Army Corps of Engineers, and several state agencies. The technology is currently being used at the Lindsey Manufacturing site in Nebraska and near some grain elevators being remediated by Argonne Laboratory.

DEMONSTRATION RESULTS:

The results of this demonstration, combined with previous results obtained by UNL, provide significant performance data and serves as the foundation for conclusions about the system's effectiveness and applicability to similar remediation projects.

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U.S. FILTER (formerly Ultrox International, Inc.) (Ultraviolet Radiation and Oxidation)

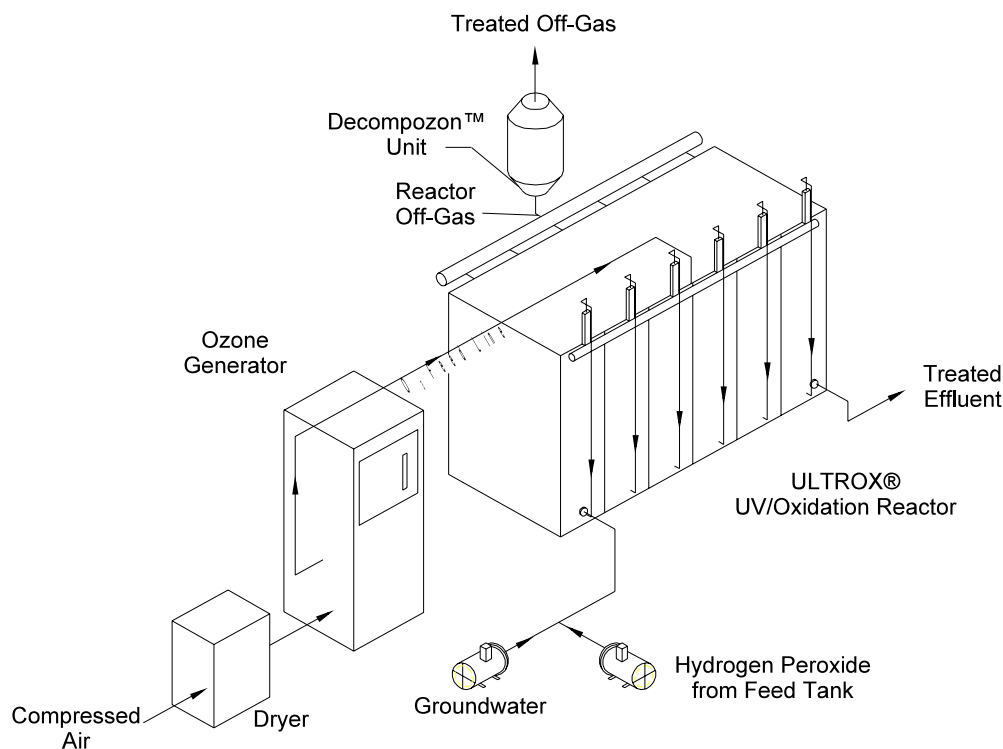
TECHNOLOGY DESCRIPTION:

This ultraviolet (UV) radiation and oxidation technology uses UV radiation, ozone, and hydrogen peroxide to destroy toxic organic compounds, particularly chlorinated hydrocarbons, in water. The technology oxidizes compounds that are toxic or refractory (resistant to biological oxidation) to parts per million (ppm) or parts per billion (ppb) levels.

The UV radiation and oxidation system consists of the UV-oxidation reactor, an air compressor and ozone generator module, and a hydrogen peroxide feed system (see figure below). The system is skid-mounted and portable, and permits on-site treatment

of a wide variety of liquid wastes. Reactor size is determined by the expected wastewater flow rate and the necessary hydraulic retention time needed to treat the contaminated water. The approximate UV intensity, and ozone and hydrogen peroxide doses, are determined from pilot-scale studies.

Reactor influent is simultaneously exposed to UV radiation, ozone, and hydrogen peroxide to oxidize the organic compounds. Off-gas from the reactor passes through a catalytic ozone destruction Decompozon™ unit, which reduces ozone levels before air venting. The Decompozon™ unit also destroys volatile organic compounds (VOC) stripped off in the reactor.



UV Radiation and Oxidation System (Isometric View)

Effluent from the reactor is tested and analyzed before disposal.

WASTE APPLICABILITY:

The UV radiation and oxidation system treats contaminated groundwater, industrial wastewaters, and leachates containing halogenated solvents, phenol, penta-chlorophenol, pesticides, polychlorinated biphenyls, explosives, benzene, toluene, ethylbenzene, xylene, methyl tertiary butyl ether, and other organic compounds. The system also treats low-level total organic carbon and reduces chemical oxygen demand and biological oxygen demand.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1989. A field-scale demonstration of the system was completed in March 1989 at the Lorentz Barrel and Drum Company site in San Jose, California. The testing program was designed to evaluate system performance while varying five operating parameters: (1) influent pH, (2) retention time, (3) ozone dose, (4) hydrogen peroxide dose, and (5) UV radiation intensity. The Demonstration Bulletin (EPA/540/M5-89/012), Technology Demonstration Summary (EPA/540/S5-89/012), Applications Analysis Report (EPA/540/A5-89/012), and Technology Evaluation Report (EPA/540/5-89/012) are available from EPA.

The technology is fully commercial, with over 30 systems installed. Units with flow rates ranging from 5 gallons per minute (gpm) to 1,050 gpm are in use at various industries and site remediations, including aerospace, U.S. Department of Energy, U.S. Department of Defense, petroleum, pharmaceutical, automotive, woodtreating, and municipal facilities. UV radiation and oxidation technology has been included in records of decision for several Superfund sites where groundwater pump-and-treat remediation methods will be used.

DEMONSTRATION RESULTS:

Contaminated groundwater treated by the system during the SITE demonstration met regulatory standards at the appropriate parameter levels. Out of 44 VOCs in the wastewater, trichloroethene, 1,1-dichloroethane, and 1,1,1-trichloroethane were chosen as indicator parameters. All three are relatively refractory to conventional oxidation.

The Decompozon™ unit reduced ozone to less than 0.1 ppm, with efficiencies greater than 99.99 percent. VOCs present in the air within the treatment system were not detected after passing through the Decompozon™ unit. The system produced no harmful air emissions. Total organic carbon removal was low, implying partial oxidation of organics without complete conversion to carbon dioxide and water.

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US EPA REGION 9

(Excavation Techniques and Foam Suppression Methods)

TECHNOLOGY DESCRIPTION:

Excavation techniques and foam suppression methods have been developed through a joint EPA effort involving the National Risk Management Research Laboratory (Cincinnati, Ohio), Air and Energy Engineering Research Laboratory (Research Triangle Park, North Carolina), and EPA Region 9 to evaluate control technologies during excavation operations.

In general, excavating soil contaminated with volatile organic compounds (VOC) results in fugitive air emissions. When using this technology, the area to be excavated is surrounded by a temporary enclosure (see photograph below). Air from the enclosure is vented through an emission control system before being released to the atmosphere. For example, in the case of hydrocarbon and sulfur dioxide emissions, a scrubber and a carbon adsorption unit would be used

to treat emissions. As an additional emission control method, a vapor suppressant foam can be applied to the soil before and after excavation.

WASTE APPLICABILITY:

This technology is suitable for controlling VOC and sulfur dioxide emissions during excavation of contaminated soil.

STATUS:

This technology was demonstrated at the McColl Superfund site in Fullerton, California, in June and July 1990. An enclosure 60 feet wide, 160 feet long, and 26 feet high was erected over an area contaminated with VOCs and sulfur dioxide. A backhoe removed the overburden and excavated underlying waste. Three distinct types of waste were encountered during excavation: oily mud, tar, and hard coal-like char.



Excavation Area Enclosure

The following documents, which contain results from the demonstration, are available from EPA:

- Applications Analysis Report
(EPA/540/AR-92/015)
- Technology Evaluation Report
(EPA/540/R-93/015)
- Demonstration Summary
(EPA/540/SR-92/015)

DEMONSTRATION RESULTS:

During excavation, the 5-minute average air concentrations within the enclosed area were up to 1,000 parts per million (ppm) for sulfur dioxide and up to 492 ppm for total hydrocarbons (THC). The air pollution control system removed up to 99 percent of the sulfur dioxide and up to 70 percent of the THCs.

The concentrations of air contaminants inside the enclosure were higher than expected. These high concentrations were due in part to the inability of the vapor suppressant foams to form an impermeable membrane over the exposed wastes. The foam reacted with the highly acidic waste, causing the foam to degrade. Furthermore, purge water from foaming activities made surfaces slippery for workers and equipment. A total of 101 cubic yards of overburden and 137 cubic yards of contaminated waste was excavated. The tar waste was solidified and stabilized by mixing with fly ash, cement, and water in a pug mill. The char wastes did not require further processing.

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WASTECH, INC. (Solidification and Stabilization)

TECHNOLOGY DESCRIPTION:

This technology solidifies and stabilizes organic and inorganic contaminants in soils, sludge, and liquid wastes. First, a proprietary reagent chemically bonds with contaminants in wastes. The waste and reagent mixture is then mixed with pozzolanic, cementitious materials, which combine to form a stabilized matrix. Reagents are selected based on target waste characteristics. Treated material is a nonleaching, high-strength, stabilized end-product.

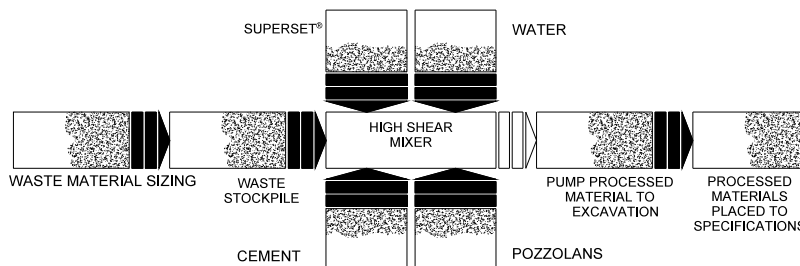
The WASTECH, Inc. (WASTECH), technology uses standard engineering and construction equipment. Because the type and dose of reagents depend on waste characteristics, treatability studies and site investigations must be conducted to determine the proper treatment formula.

Treatment usually begins with waste excavation. Large pieces of debris in the waste must be screened and removed. The waste is then placed into a high shear mixer, along with premeasured quantities of water and SuperSet®, WASTECH's proprietary reagent (see figure below).

Next, pozzolanic, cementitious materials are added to the waste-reagent mixture, stabilizing the waste and completing the treatment process. The WASTECH technology does not generate by-products. The process may also be applied in situ.

WASTE APPLICABILITY:

The WASTECH technology can treat a wide variety of waste streams consisting of soils, sludges, and raw organic streams, including lubricating oil, evaporator bottoms, chelating agents, and ion-exchange resins, with contaminant concentrations ranging from parts per million levels to 40 percent by volume. The technology can also treat wastes generated by the petroleum, chemical, pesticide, and wood-preserving industries, as well as wastes generated by many other chemical manufacturing and industrial processes. The WASTECH technology can also be applied to mixed wastes containing organic, inorganic, and radioactive contaminants.



WASTECH Solidification and Stabilization Process

STATUS:

The technology was accepted into the SITE Demonstration Program in spring 1989. A field demonstration at Robins Air Force Base in Warner Robins, Georgia was completed in August 1991. WASTECH subsequently conducted a bench-scale study in 1992 under glovebox conditions to develop a detailed mass balance of volatile organic compounds.

This technology is no longer available from the vendor. For further information about the process, contact the EPA Project Manager.

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WEISS ASSOCIATES

(ElectroChemical Remediation Technologies [ECRTs])

TECHNOLOGY DESCRIPTION:

ElectroChemical Remediation Technologies (ECRTs) utilize an AC/DC current passed between an electrode pair (one anode and one cathode) in soil, sediment, or groundwater to either mineralize organic contaminants through the ElectroChemicalGeoOxidation (ECGO) process, or complex, mobilize, and remove metal contaminants through the Induced Complexation (IC) process, either in situ or ex situ. Field remediation data suggest that ECRTs-IC cause electrochemical reactions in soil, sediment, and groundwater to generate metallic ion complexes from the target contaminant metals. Electric power is passed through a proprietary direct current (DC)/alternating current (AC) converter that produces a low-voltage and low-amperage DC/AC current. When this modified electrical current is passed through the sediment via the electrodes, the sediment particles become polarized and are purported to develop electrical properties similar to a capacitor. These complexes subsequently migrate to the electrodes down the electrokinetic gradient and are deposited onto the electrodes, which can be removed and recycled. ECRTs-IC operates at electrical power levels below those of conventional electrokinetic methods. A unique feature of ECRTs-IC, in marked contrast to electrokinetics, is that metals migrate to both the anode and cathode. According to the technology developer, when the polarized particles discharge electricity in the ECGO, the energy given off induces chemical reactions (redox reactions), which decompose organic contaminants.

Typically, ECRTs are preferred to be implemented in situ. As such, site activities are only minimally disturbed in contrast to excavation and off-site disposal. ECRTs are powered by the existing site electrical grid or through a power generator.

WASTE APPLICABILITY:

ECRT is capable of remediating mercury, phenolic compounds, metal, and organic contaminants in sediments, soil, and groundwater.

STATUS:

The Washington Department of Ecology (Ecology) is proposing to amend an existing legal agreement (Agreed Order for Interim Action) with Georgia-Pacific (G-P) to provide Ecology access to the Georgia-Pacific Log Pond (Log Pond) to conduct a sediment treatment pilot study. The Log Pond is located in Bellingham Bay adjacent to the G-P facility at 300 W. Laurel Street, Bellingham. Under the amendment, Ecology and other partners will conduct a sediment treatment pilot study on a small area of the Log Pond.

The Log Pond is a subunit of the Whatcom Waterway Site and consists of intertidal and subtidal aquatic lands adjacent to the Whatcom Waterway Federal Navigation Channel in Bellingham.

The Log Pond is part of the Whatcom Waterway contaminated sediment site and was capped with clean sediments from other Puget Sound Corps of Engineers maintenance dredging projects in February 2001. This capping was conducted under an Agreed Order for Interim Action with Ecology. The ECRT apparatus will be installed in 2002.

Installation of the pilot study infrastructure will generally involve placing two pairs of sheet pile electrodes into the sediment (four sheet piles: two positive and two negative electrodes). The sheet piles will be placed in parallel at a distance of 30 to 50 feet. The sheet piles will be placed into the sediment by vibratory hammer equipment in such a manner as to minimize any disturbance of contaminated sediments and the sediment cap.

Operation of the ECRT apparatus, along with monitoring activities outlined above, will continue until the objectives of the pilot study have been met, whichever is earlier.

An in-progress U.S. bench-scale test strongly suggests migration of total mercury to the anode. These results show that ECRTs-IC are rapid and effective.

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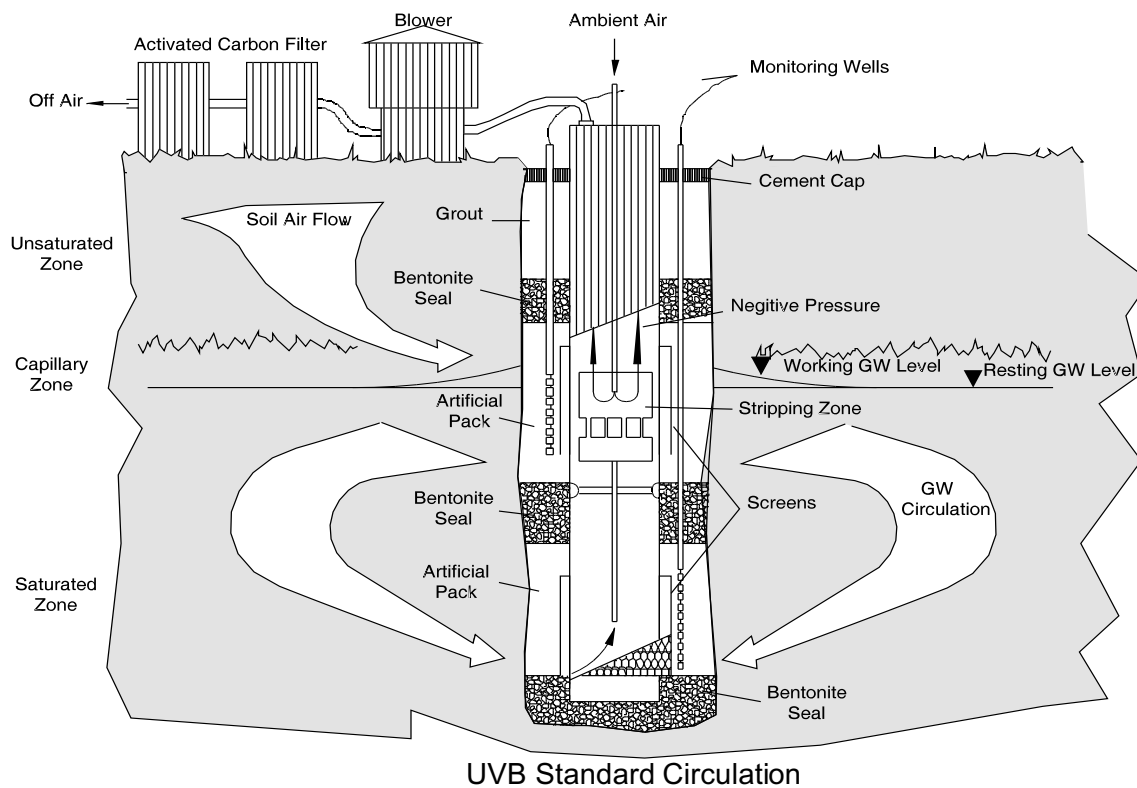
ROY F. WESTON, INC./IEG TECHNOLOGIES (UVB - Vacuum Vaporizing Well)

TECHNOLOGY DESCRIPTION:

The Unterdruck-Verdampfer-Brunnen (UVB) system is an in situ system for remediating contaminated aquifers. The basic system is simple in design and operation, consisting of a well, a groundwater extraction pump, a negative pressure stripping reactor, and an electric blower. While in operation, the water level rises inside the UVB well casing due to reduced atmospheric pressure generated by the blower, increasing the total hydraulic head in the well. Atmospheric air enters the well through a fresh air pipe connected to the stripping reactor. The incoming fresh air forms bubbles as it jets through the pinhole plate of the stripping reactor and mixes with the influent groundwater in the well casing, creating an "air lift" effect as the bubbles rise and expand to the stripping reactor. After treatment, the movement of water out of the well develops a groundwater circulation cell

around a remediation well. The circulating groundwater transports contaminants from the adjacent soils and groundwater to the well, where these contaminants are removed using a combination of physical, chemical and biological treatment processes. The technology is capable of mobilizing and treating contaminants that are water soluble (dissolved phase) or are present as dense non aqueous phase liquids (DNAPL) or light non aqueous phase liquids (LNAPL). The technology also can extract and treat soil gas from the unsaturated zone.

Due to the presence of a natural groundwater flow, the total amount of water circulating around the UVB well at any given time consists of (1) a portion of up gradient groundwater captured by the influent screen section, and (2) recirculated groundwater. This ratio is typically 15 to 85 percent respectively. Groundwater leaving the circulation cell exits



through the downstream release zone in a rate equal to the up gradient groundwater being captured. These flow dynamics and the dimensions of the capture zone, circulation cell, and release zone can be calculated using design aids based on numerical simulations of the groundwater hydraulics and can be validated by monitoring the actual performance results of the system.

The advantage of the UVB technology over external pump-and-treat technologies is its ability to treat contaminants while maintaining a net equilibrium flow in the aquifer, eliminating adverse effects associated with excessive mounding or draw-down of groundwater due to continuous extraction and replacement of equal volumes of water. Additionally, the circulation well serves as a mechanism for flushing contaminants from the soils and aquifer to the well casing for treatment on a continuous basis. As a secondary benefit, because the primary treatment process is physical removal through air stripping, the dissolved oxygen levels in the groundwater passing through the well can theoretically increase up to 10 milligrams per liter within the aquifer, enhancing bioremediation by indigenous micro-organisms.

WASTE APPLICABILITY:

This technology can be used to assist in treating a variety of soil and groundwater pollutants ranging from chlorinated solvents to gasoline constituents, polycyclic aromatic hydrocarbons, heavy metals, and nitrates.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1993, and a demonstration was completed at March Air Force Base, California, in May 1994. The Demonstration Bulletin (EPA/540/MR- 95/500), Technology Capsule (EPA/540/R- 95/500a), and Innovative Technology Evaluation Report (EPA/540/R-95/500) are available from EPA.

DEMONSTRATION RESULTS:

Demonstration results indicate that the UVB system reduced trichloroethene (TCE) in groundwater by an average of 94 percent. The average TCE concentration from the outlet of the UVB system in the treated groundwater was approximately 3 micrograms per liter ($\mu\text{g/L}$), with only one event above 5 $\mu\text{g/L}$. The inlet TCE concentration averaged 40 $\mu\text{g/L}$. Results of a dye tracer study indicated that the radius of the circulation cell was at least 40 feet. Modeling of the study indicated a circulation cell radius of 60 feet. In general, TCE in the shallow and intermediate screened wells showed a concentration reduction both vertically and horizontally during the demonstration. TCE concentrations in these wells appeared to homogenize as indicated by their convergence and stabilization. Variations in TCE concentrations were noted in the deep screened wells.

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ROY F. WESTON, INC.
(Low Temperature Thermal Treatment System)

TECHNOLOGY DESCRIPTION:

The Roy F. Weston, Inc. (Weston), low temperature thermal treatment (LT³®) system thermally desorbs organic compounds from contaminated soil without heating the soil to combustion temperatures. The transportable system (see photograph below) is assembled on three flat-bed trailers and requires an area of about 5,000 square feet, including ancillary and support equipment. The LT³® system consists of three segments: soil treatment, emissions control, and water treatment.

The LT³® thermal processor consists of two jacketed troughs, one above the other. Each trough houses four intermeshed, hollow screw conveyors. A front-end loader feeds soil or sludge onto a conveyor that discharges into a surge hopper above the thermal processor. Hot oil circulating through the troughs and screws heats the soil to 400 to 500°F, removing contaminants. A second stage indirect heater is available to achieve 1,000°F discharge temperatures. Soil is discharged from the thermal processor into a conditioner, where a water spray cools the soil and minimizes dust emissions.

A fan draws desorbed organics from the thermal processor through a fabric filter baghouse. Depending on contaminant characteristics, dust collected on the fabric filter may be retreated, combined with treated material, or drummed separately for off-site disposal. Exhaust gas from the fabric filter is drawn into an air-cooled condenser to remove most of the water vapor and organics. The gas is then passed through a second, refrigerated condenser and treated by carbon adsorption.

Condensate streams are typically treated in a three-phase, oil-water separator to remove light and heavy organic phases from the water phase. The water phase is then treated in a carbon adsorption system to remove residual organic contaminants. Treated condensate is often used for soil conditioning, and only the organic phases are disposed of off site.



Low Temperature Thermal Treatment (LT³®) System

WASTE APPLICABILITY:

This system treats soils and sludges contaminated with volatile and semivolatile organic compounds (VOC and SVOC). Bench-, pilot-, and full-scale LT³® systems have treated soil contaminated with the following wastes: coal tar, drill cuttings (oil-based mud), No. 2 diesel fuel, JP-4 jet fuel, leaded and unleaded gasoline, petroleum hydrocarbons, halogenated and nonhalogenated solvents, VOCs, SVOCs, polynuclear aromatic hydrocarbons, polychlorinated biphenyls, pesticides, herbicides, dioxins, and furans.

STATUS:

The LT³® system was accepted into the SITE Demonstration Program in September 1991. In November and December 1991, the LT³® system was demonstrated under the SITE Program as part of a proof-of-process test for full-scale remediation of the Anderson Development Company (ADC) Superfund site in Adrian, Michigan. The system was tested on lagoon sludge from the ADC site. This sludge was contaminated with VOCs and SVOCs, including 4,4-methylene bis(2-chloroaniline) (MBOCA).

The Demonstration Bulletin (EPA/540/ MR-92/019) and Applications Analysis Report (EPA/540/AR-92/019) are available from EPA.

DEMONSTRATION RESULTS:

During the demonstration, the system throughput was approximately 2.1 tons per hour. Six replicate tests were conducted, each lasting approximately 6 hours. The SITE demonstration yielded the following results:

- The LT³® system removed VOCs to below method detection limits (less than 0.060 milligram per kilogram [mg/kg] for most compounds).
- The LT³® system achieved MBOCA removal efficiencies greater than 88 percent; MBOCA concentrations in the treated sludge ranged from 3.0 to 9.6 mg/kg.

- The LT³® system decreased the concentrations of all SVOCs in the sludge, with the exception of phenol, which increased possibly due to chlorobenzene.
- Dioxins and furans were formed in the system, but the 2,3,7,8-tetra-chlorodibenzo-p-dioxin isomer was not detected in treated sludges.
- Stack emissions of nonmethane total hydrocarbons increased from 6.7 to 11 parts per million by volume during the demonstration; the maximum emission rate was 0.2 pound per day (ppd). The maximum particulates emission rate was 0.02 ppd, and no chlorides were measured in stack gases.

The economic analysis of the LT³® system's performance compared the costs associated with treating soils containing 20, 45, and 75 percent moisture. The treatment costs per ton of material were estimated to be \$37, \$537, and \$725, respectively.

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WHEELABRATOR CLEAN AIR SYSTEMS, INC. (formerly Chemical Waste Management, Inc.) (PO*WW*ER™ Technology)

TECHNOLOGY DESCRIPTION:

The PO*WW*ER™ technology is used to treat and reduce complex industrial and hazardous wastewaters containing mixtures of inorganic salts, metals, volatile and nonvolatile organics, volatile inorganics, and radionuclides. The proprietary technology combines evaporation with catalytic oxidation to concentrate and destroy contaminants, producing a high-quality product condensate.

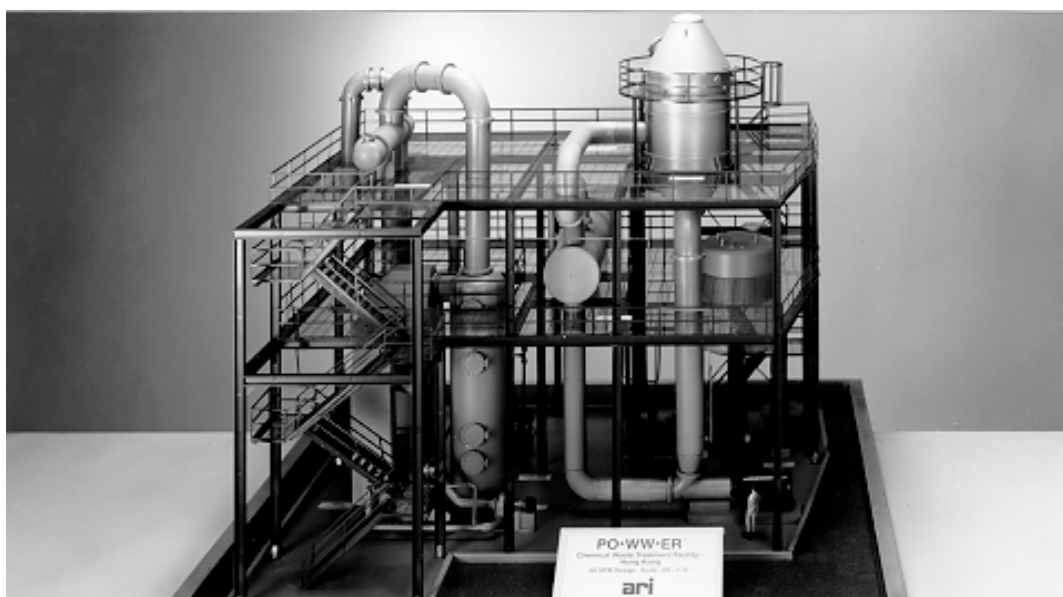
Wastewater is first pumped into an evaporator, where most of the water and contaminants are vaporized and removed, concentrating the contaminants into a small volume for further treatment or disposal. The contaminant vapors then pass over a bed of proprietary robust catalyst, where the pollutants are oxidized and destroyed. Depending on the contaminant vapor composition, effluent vapors from the oxidizer may be treated in a scrubber. The vapors are then condensed to produce water (condensate) that can be used as either boiler

or cooling tower makeup water, if appropriate. Hazardous wastewater can thus be separated into a small contaminant stream (brine) and a large clean water stream without using expensive reagents or increasing the volume of the total stream. The photograph below illustrates a PO*WW*ER™ - based wastewater treatment plant.

WASTE APPLICABILITY:

The PO*WW*ER™ technology can treat wastewaters containing a mixture of the following contaminants:

Organic	Inorganic	Radioactive
<ul style="list-style-type: none"> • Halogenated volatiles • Halogenated semivolatiles • Nonhalogenated volatiles • Nonhalogenated semivolatiles • Organic pesticides/herbicides • Solvents • Benzene, toluene, ethyl- benzene, and xylene • Organic cyanides • Nonvolatile organics 	<ul style="list-style-type: none"> • Heavy metals • Nonmetallic toxic elements • Cyanides • Ammonia • Nitrates • Salts 	<ul style="list-style-type: none"> • Plutonium • Americium • Uranium • Technetium • Thorium • Radium • Barium



PO*WW*ER™-Based Wastewater Treatment Plant

Suitable wastewaters for treatment by the PO*WW*ER™ technology include landfill leachates, contaminated groundwaters, process wastewaters, and low-level radioactive mixed wastes.

STATUS:

The technology was accepted into the SITE Demonstration Program in 1991. The demonstration took place in September 1992 at the Chemical Waste Management, Inc., Lake Charles, Louisiana, facility. Landfill leachate, an F039 hazardous waste, was treated in a pilot-scale unit. The Applications Analysis Report (EPA/540/AR-93/506) and Technology Evaluation Report (EPA/540/R-93/506) are available from EPA.

A commercial system with a capacity of 50 gallons per minute is in operation at Ysing Yi Island, Hong Kong. A pilot-scale unit, with a capacity of 1 to 1.5 gallons per minute, is available and can treat radioactive, hazardous, and mixed waste streams.

DEMONSTRATION RESULTS:

The ability of the PO*WW*ER™ system to concentrate aqueous wastes was evaluated by measuring the volume reduction and concentration ratio achieved. The volume of brine produced during each 9-hour test period was about 5 percent of the feed waste volume processed in the same period. The concentration ratio, defined as the ratio of total solids (TS) concentration in the brine to the TS concentration in the feed waste, was about 32 to 1.

The feed waste contained concentrations of volatile organic compounds (VOC) ranging from 320 to 110,000 micrograms per liter (µg/L); semivolatile organic compounds (SVOC) ranging from 5,300 to 24,000 µg/L; ammonia ranging from 140 to 160 milligrams per liter (mg/L); and cyanide ranging from 24 to 36 mg/L. No VOCs, SVOCs, ammonia, or cyanide were detected in the product condensate.

The PO*WW*ER™ system removed sources of feed waste toxicity. The feed waste was acutely toxic with median lethal concentrations (LC₅₀) consistently below 10 percent. The product condensate was nontoxic with LC₅₀ values consistently greater than 100 percent, but only after the product condensate was cooled and its pH, dissolved oxygen level, and hardness or salinity were increased.

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WILDER CONSTRUCTION COMPANY

(MatCon™ Modified Asphalt Cap)

TECHNOLOGY DESCRIPTION:

MatCon™ is an asphalt mixture produced by using a proprietary binder and a specified aggregate gradation in a conventional hot mix asphalt plant. A MatCon™ cover can be constructed within a few days using conventional asphalt paving equipment. Maintenance of the cover is relatively easy, using conventional asphalt paving repair equipment and materials. According to the manufacturer, MatCon™ asphalt is much less permeable and possesses superior flexural strength compared to conventional asphalt. MatCon™ asphalt has a permeability of 1.0×10^{-8} cm/sec or less, which far exceeds the requirement of less than 1.0×10^{-5} cm/sec established for landfill covers that do not have a geomembrane liner.

WASTE APPLICABILITY:

The MatCon™ technology is applicable as a final cover at many hazardous waste sites. The potential for hazardous waste site reuse is a major advantage of this technology. Uses being planned for the MatCon™ cover include the following: staging area for heavy equipment and vehicles; light industrial manufacturing; and sports facilities, such as tennis courts and tracks.

STATUS:

Wilder Construction Company installed a pilot-scale cover system at the Dover Air Force Base site in April 1999 for purposes of evaluating the MatCon™ technology. The evaluation cover measures approximately 126 by 220 feet and consists of three sections: (1) 12-inch-thick MatCon™ asphalt with a drainage layer (Section I), (2) 4-inch-thick MatCon™ asphalt (Section II), and (3) 4-inch-thick conventional asphalt (Section III). The drainage layer in Section I was constructed as a 4-inch-thick channel of open-graded asphalt between two 4-inch-thick MatCon™ layers. The purpose of this drainage layer was to collect and allow measurement of the water that infiltrated through the top 4 inches of the cover. The purpose of constructing both conventional asphalt and

MatCon™ sections was to allow a direct comparison of the physical properties of each type of asphalt based on laboratory testing of cover samples. To monitor surface runoff, a lined ditch was constructed downgradient from the cover, and berms were constructed to direct the runoff from Section I of the cover into the drainage ditch. Surface runoff was measured continuously with a flowmeter, which recorded both instantaneous and cumulative flow.

The two primary objectives of the SITE Program evaluation of the MatCon™ technology were to: (1) compare the in-field permeability of the MatCon™ cover to the RCRA requirement of less than 1.0×10^{-5} cm/sec, and (2) compare the permeability and flexural properties of MatCon™ asphalt to those of conventional hot mix asphalt. Secondary objectives of the evaluation were to: (1) compare various laboratory-measured physical characteristics (including load capacity/deformation, shear strength, joint permeability, and aging and degradation characteristics) of MatCon™ asphalt with those of conventional asphalt covers; (2) assess the field performance of the MatCon™ cover under extreme weather conditions and vehicle loads; (3) estimate a cumulative hydrologic balance for the MatCon™ cover at the DAFB site; and (4) estimate the costs of MatCon™ cover installation.

DEMONSTRATION RESULTS:

Preliminary laboratory testing results indicate that the permeability of the MatCon™ cover at the DAFB site is less than 1.0×10^{-8} cm/sec, whereas the permeability of the adjacent conventional asphalt cover is between 2.70×10^{-4} cm/sec and 1.0×10^{-5} cm/sec. Flexural tests of samples of the MatCon™ and the conventional asphalt covers indicate that the MatCon™ cover tolerates three times more deflection without cracking compared to the conventional asphalt cover. Field hydrologic data obtained to date at the DAFB site indicates an average field permeability of about 2.3×10^{-8} cm/sec, respectively. Complete data from the field permeability testing are available in the EPA Technology Evaluation Report.

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**ASC/EMR WPAFB
(U.S. Air Force)
(Phytoremediation of TCE in Groundwater)**

TECHNOLOGY DESCRIPTION:

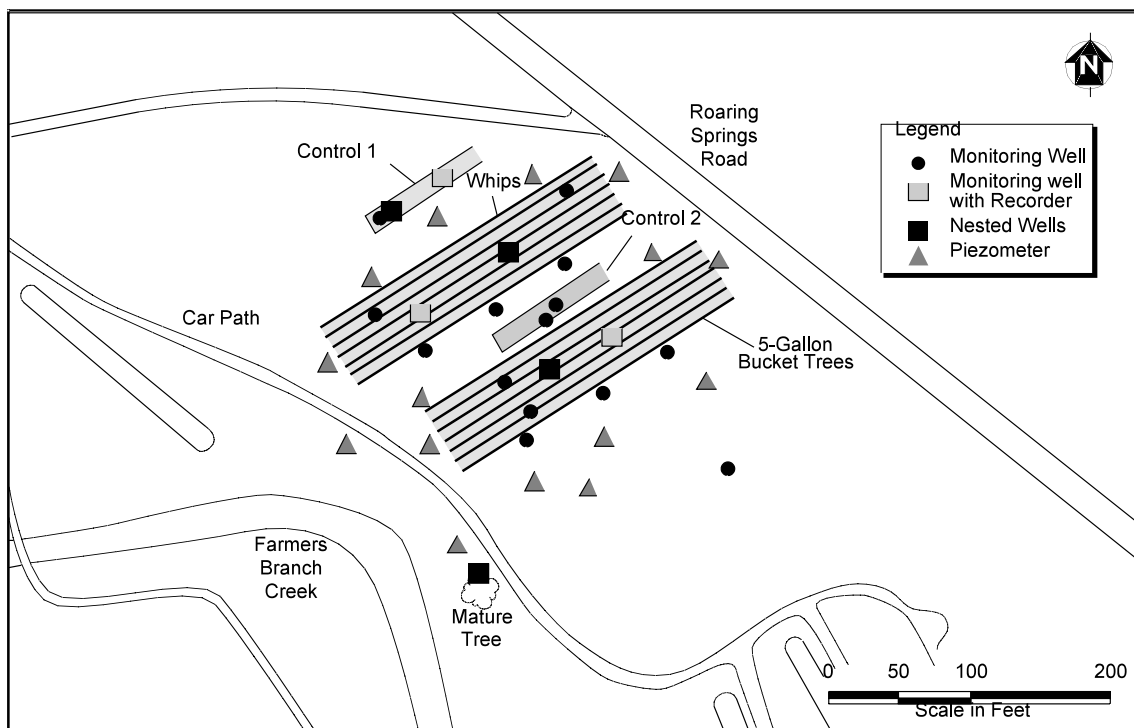
The phytoremediation system is a low-cost, low-maintenance system that is consistent with a long-term contaminant reduction strategy. Trees were planted in trenches as a short rotation woody crop employing standard techniques developed by the U.S. Department of Energy (DOE). The phytoremediation system was designed to intercept and remediate a chlorinated ethene contaminant plume. The system relies on two mechanisms to achieve this goal: (1) hydraulic removal of contaminated groundwater through tree transpiration and (2) biologically mediated in situ reductive dechlorination of the contaminant. The tree root systems introduce organic matter to the aquifer system, which drives the microbial communities in the aquifer from aerobic to anaerobic communities that support the reductive dechlorination.

WASTE APPLICABILITY:

This technology is suitable for any groundwater contaminated with dense non-aqueous phase liquid contaminants such as TCE.

STATUS:

The U.S. Air Force Plant 4 and adjacent Naval Air Station, Fort Worth, Texas, has sustained contamination in an alluvial aquifer through the use of chlorinated solvents in the manufacture and assembly of military aircraft. Dispersion and transport of TCE and its degradation products have occurred, creating a plume of contaminated groundwater. Planting and cultivating of Eastern Cottonwood (*Populus deltoids*) trees above the dissolved TCE plume in a shallow (under 12 feet) aerobic aquifer took place in spring 1996. The trees



Schematic Diagram of the Site Layout at Naval Air Station Ft. Worth

were planted as a short rotation woody crop employing standard techniques developed by the DOE to grow biomass for energy and fiber. Data are being collected to determine the ability of the trees to perform as a natural pump-and-treat system.

DEMONSTRATION RESULTS:

The first three growing seasons resulted in a remediation system that reduced the mass of contaminants moving through the site. The maximum observed reduction in the mass flux of TCE across the downgradient end of the site during the three-year demonstration period was 11 percent. Increases in the hydraulic influence and reductive dechlorination of the dissolved TCE plume are expected in the future, and may significantly reduce the mass of contaminants. Modeling results indicate that hydraulic influence alone may reduce the volume of contaminated groundwater that moves off-site by up to 30 percent. The decrease in mass flux that can be attributed to in situ reductive dechlorination has yet to be quantified.

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X-19 BIOLOGICAL PRODUCTS

(Microbial Degradation of PCBs)

TECHNOLOGY DESCRIPTION:

X-19 Biological Products of Santa Clara, CA (X-19), has developed and marketed a microbiological polymer that was originally developed for use in the agricultural and horticultural industry as a soil conditioner. The product, which has the appearance and consistency of fine-grained organic humus, has been applied to soils to degrade pesticides and herbicides. Fresh X-19 product may contain upwards of a half billion colonies of bacteria per gram.

The X-19 product is applied in a semidry state. It is mixed with the contaminated soil at a 30% mix ratio. During this mixing ("the primary processing stage") a light application of moisture is added to activate the microflora.

The X-19 treatment can be accomplished both in situ and ex situ. Ex situ techniques using some type of aboveground enclosure are faster and easier to control. The product is also able to absorb moisture, preventing the leaching or transporting of contaminants to lower levels. The application of the product is simple, requires few personnel, and a single application is normally sufficient to meet any site-specific remedial goals.

Soil moisture is the primary monitoring requirement for the technology, and should be conducted on a biweekly schedule. Should soil moisture levels drop below 28%, more water should be added to the soil.

Depending upon a number of site-specific factors, soil being treated in an aboveground enclosure might have to be turned once near the middle of the treatment period, but generally there is no need for periodic tilling. The aboveground enclosures used for treating the soil are simply covered with plastic and are generally left undisturbed throughout the treatment period.

According to X-19, the product is nontoxic to plants and animals, and no permits are required to ship or apply the product.

WASTE APPLICABILITY:

The product is successful in bioremediating soils containing a large variety of chlorinated hydrocarbon insecticides including toxaphene, dieldrin, and others. X-19 has applied the product to soils contaminated with petroleum hydrocarbons (motor spirits, diesel fuels, oils) and has claimed that the product facilitated the complete degradation of semivolatile compounds such as polychlorinated biphenyls (PCBs), pentachlorophenol (PCP), and polynuclear aromatic hydrocarbons (PAHs). The vendor has also claimed complete degradation of trichloroethene (TCE), trichloroethane (TCA), and other common volatile organic compounds (VOCs).

STATUS:

A demonstration of X-19's bioaugmentation process was conducted at a Lower Colorado River Authority (LCRA) electrical substation in Goldthwaite, Texas. At this site PCB-contaminated soil was treated with the X-19 product in an approximate 16 ft × 8 ft × 2 ft treatment cell. The overall goal of the study was to reduce PCB concentrations in the soil to a level of 50 mg/kg or less, on a dry weight basis of the original soil. The < 50 mg/kg threshold would enable the LCRA to dispose of the soils in a less costly in-state landfill.

DEMONSTRATION RESULTS:

The SITE Program conducted a multievent soil sampling to evaluate the effectiveness of the X-19 technology for treating the PCBs in the soil. The LCRA conducted periodic monitoring of the amended soil mixture within the treatment cell. A total of five sampling events were conducted. These events included a baseline sampling (August 2000) to establish pretreatment PCBs levels; three intermediate sampling events for tracking treatment progress (conducted in October and December of 2000, and in June of 2001); and a final posttreatment sampling event conducted in October 2001. Preliminary results for the demonstration are not yet available.

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XEROX CORPORATION (2-PHASE™ EXTRACTION Process)

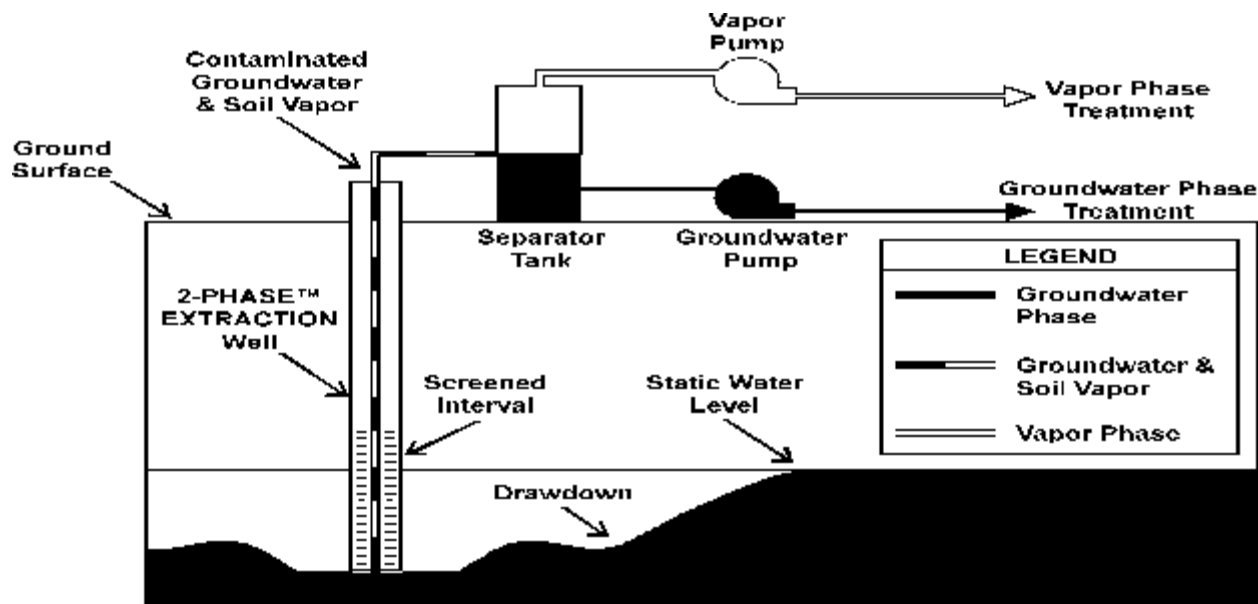
TECHNOLOGY DESCRIPTION:

The 2-PHASE™ EXTRACTION Process was developed as an alternative to conventional pump-and-treat technology, particularly in low conductivity formations such as silts and clays that are impacted by volatile organic compounds (VOC). 2-PHASE™ EXTRACTION uses a high-vacuum source applied to an extraction tube within a water well to increase groundwater removal rates (consequently the dissolved phase of contamination) and to volatilize and extract that portion of contaminant from the sorbed or free product phases. Vacuum lift of water is not a limiting factor in the application of the technology. Since a mixed vapor-liquid column is extracted from the well, the 2-PHASE™ EXTRACTION technology allows a single piece of equipment (a high vacuum source) to remove contaminants in both the liquid and vapor phases.

To extract both groundwater and soil vapor from a single extraction well, the 2-PHASE™ EXTRACTION process uses a vacuum pump to apply a high vacuum (generally 18 to 29 inches of

mercury) through a central extraction tube, which extends down the well. Soil vapor drawn into the well by the vacuum provides for a high velocity vapor stream at the bottom tip of the extraction tube, which entrains the contaminated groundwater and lifts it to ground surface. As groundwater moves through the extraction system, as much as 95 percent of the VOCs in the water phase are transferred to the vapor phase. The vapor and water phases are then separated at the surface in a separator tank. The water phase requires only carbon polishing prior to discharge, provided that the compounds are adsorbable. With some compounds the water carbon treatment can be eliminated. The vapor phase is subjected to carbon treatment, bioremediation, resin regeneration, catalytic oxidation, or other vapor phase treatment (based on contaminant characteristics, mass loadings, and economics) prior to release to atmosphere.

A kick-start system can induce flow and help dewater the well. The flow of atmospheric air can be regulated by adjustment of the gate valve to: (1) optimize the air-to-water flow ratio to minimize



Schematic of the 2-PHASE™ EXTRACTION Process

water “slug” production at startup (the term slug refers to an irregular pulsation of water through the extraction tube which indicates irregular water flow); (2) maximize tube penetration into the saturated zone; and (3) maximize the groundwater flow rate by optimizing the applied vacuum to the well’s annular space.

Recent technology improvements include a well design that allows for contaminant removal from desired vertical zones within the subsurface. By providing a means to manipulate preferential flow, this innovative well design provides the ability to focus contaminant extraction at shallow zones and deep zones within the same well which results in a thorough removal of contaminants from the impacted area. Xerox and Licensee experience with 2-PHASE™ EXTRACTION typically has shown a reduction in remediation time by 1 to 2 orders of magnitude over conventional pump and treat/soil vapor extraction.

WASTE APPLICABILITY:

2-PHASE™ EXTRACTION has been successfully demonstrated for the removal of total petroleum hydrocarbons and chlorinated hydrocarbons from groundwater and soils.

The Xerox 2-PHASE™ EXTRACTION process was accepted into the SITE Demonstration Program in summer 1994. The demonstration began in August 1994 at a contaminated groundwater site at McClellan Air Force Base in Sacramento, California, and was completed in February 1995. Reports of the demonstration are available from EPA.

The Xerox 2-PHASE™ EXTRACTION received eight patents from 1991-1998 and several patents are pending. The technology is available under license and is used extensively in the United States, Canada, South America, Great Britain, and Europe.

DEMONSTRATION RESULTS:

Results from the demonstration are detailed below:

- The total contaminant (trichloroethene, tetrachloroethene, Freon 133™) mass removal during the 6-month demonstration was estimated at 1,600 pounds, of which 99.7 percent was extracted from the vapor phase.
- The system extracted 1.4 million gallons of groundwater and 24.4 million cubic feet of soil vapor.
- The radius of capture in the groundwater extended from 100 to 300 feet from the extraction well. The radius of influence in the vadose zone extended 200 feet from the extraction well.
- The estimated cost of using the process was \$28 per pound compared to an estimated \$1370 per pound for a conventional pump and treat system.

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ZENON ENVIRONMENTAL INC. (Cross-Flow Pervaporation System)

TECHNOLOGY DESCRIPTION:

The ZENON Environmental Inc. (ZENON), cross-flow pervaporation technology is a membrane-based process that removes volatile organic compounds (VOC) from aqueous matrices. The technology uses an organophilic membrane made of nonporous silicone rubber, which is permeable to organic compounds, and highly resistant to degradation.

In a typical field application, contaminated water is pumped from an equalization tank through a prefilter to remove debris and silt particles, and then into a heat exchanger that raises the water temperature to about 165°F (75°C). The heated water then flows into a pervaporation module containing the organophilic membranes. The composition of the membranes causes organics in solution to adsorb to them. A vacuum applied to the system causes the organics to diffuse through the membranes and move out of the pervaporation module. This material is then passed through a condenser generating a highly concentrated liquid called permeate. Treated water exits the pervaporation module and is discharged from the

system. The permeate separates into aqueous and organic phases. Aqueous phase permeate is sent back to the pervaporation module for further treatment, while the organic phase permeate is discharged to a receiving vessel.

Because emissions are vented from the system downstream of the condenser, organics are kept in solution, thus minimizing air releases. The condensed organic materials represent only a small fraction of the initial wastewater volume and may be subsequently disposed of at significant cost savings. This process may also treat industrial waste streams and recover organics for later use.

WASTE APPLICABILITY:

Pervaporation can be applied to aqueous waste streams such as groundwater, lagoons, leachate, and rinse waters that are contaminated with VOCs such as solvents, degreasers, and gasoline. The technology is applicable to the types of aqueous wastes treated by carbon adsorption, air stripping, and steam stripping.



ZENON Cross-Flow Pervaporation System

STATUS:

This technology was accepted into the SITE Emerging Technology Program (ETP) in January 1989. The Emerging Technology Report (EPA/540/F-93/503), which details results from the ETP evaluation, is available from EPA. Based on results from the ETP, ZENON was invited to demonstrate the technology in the SITE Demonstration Program. A pilot-scale pervaporation system, built by ZENON for Environment Canada's Emergencies Engineering Division, was tested over a 2-year period (see photograph on previous page). During the second year, testing was carried out over several months at a petroleum hydrocarbon-contaminated site in Ontario, Canada.

A full-scale SITE demonstration took place in February 1995 at a former waste disposal area at Naval Air Station North Island in San Diego, California. The demonstration was conducted as a cooperative effort among EPA, ZENON, the Naval Environmental Leadership Program, Environment Canada, and the Ontario Ministry of Environment and Energy.

Organics were the primary groundwater contaminant at the site, and trichloroethene (TCE) was selected as the contaminant of concern for the demonstration. The Demonstration Bulletin (EPA/540/MR- 95/511) and Demonstration Capsule (EPA/540/R-95/511a) are available from EPA.

DEMONSTRATION RESULTS:

Analysis of demonstration samples indicate that the ZENON pervaporation system was about 98 percent effective in removing TCE from groundwater. The system achieved this removal efficiency with TCE influent concentrations of up to 250 parts per million at a flow rate of 10 gallons per minute (gpm) or less. Treatment efficiency remained fairly consistent throughout the demonstration; however, the treatment efficiency decreased at various times due to mineral scaling problems.

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ZENON ENVIRONMENTAL INC. (ZenoGem™ Process)

TECHNOLOGY DESCRIPTION:

ZENON Environmental Inc.'s, ZenoGem™ Process integrates biological treatment with membrane-based ultrafiltration (see figure below). This innovative system treats high strength wastes at long sludge retention time but short hydraulic residence time. As a result, the bioreactor's size is significantly reduced. Membrane filtration reduces the turbidity of the treated wastewater to less than 1 nephelometric turbidity unit.

In the ZenoGem™ Process, wastewater contaminated with organic compounds first enters the bioreactor, where contaminants are biologically degraded. Next, the process pump circulates the biomass through the ultrafiltration membrane system, or ultrafilter. The ultrafilter separates treated water from biological solids and soluble materials with higher molecular weights, including emulsified oil. The solids and soluble materials are then recycled to the bioreactor.

The ZenoGem™ Process captures higher molecular weight materials that would otherwise pass through conventional clarifiers and filters. The ZenoGem™ Process pilot-scale system is mounted on a 48-foot trailer and consists of the following six major components:

- Polyethylene equalization/holding tank: reduces the normal flow concentration fluctuations in the system
- Polyethylene bioreactor tank: contains the bacterial culture that degrades organic contaminants
- Process and feed pumps: ensures proper flow and pressure for optimum system performance
- Ultrafiltration module: contains rugged, clog-free, tubular membranes that remove solids from treated water.
- Clean-in-place tank: includes all the necessary valves, instrumentation, and controls to clean the membrane filters
- Control panel and computer: monitors system performance



ZenoGem™ Process

The treatment capacity of the pilot-scale, trailer-mounted system is about 500 to 1,000 gallons of wastewater per day; however, a full-scale system can treat much larger quantities of wastewater. The trailer is also equipped with a laboratory that enables field personnel to conduct tests to evaluate system performance. The system is computer-controlled and equipped with alarms to notify the operator of mechanical and operational problems.

WASTE APPLICABILITY:

The ZenoGem™ Process is designed to remove biodegradable materials, including most organic contaminants, from wastewater to produce a high quality effluent. The process consistently nitrifies organics and can denitrify organics with the addition of an anoxic bioreactor. The process is limited to aqueous media and may be used to treat high strength leachates, contaminated groundwater, and soil washing effluent.

STATUS:

The ZenoGem™ Process was accepted into the SITE Demonstration Program in summer 1992. The ZenoGem™ Process was demonstrated at the Nascolite Superfund site in Millville, New Jersey, from September through November 1994. Groundwater at this 17.5-acre site is contaminated with methyl methacrylate (MMA) and other volatile organic compounds from manufacturing polymethyl methacrylate plastic sheets, commonly known as Plexiglas. The Demonstration Bulletin (EPA/540/MR-95/503), and Technology Capsule (EPA/540/R-95/503a), and Innovative Technology Evaluation Report (EPA/540/R-95/503) are available from EPA.

Since the development of the ZenoGem™ technology in 1987, ZENON has performed pilot tests for government and private clients on several different types of wastewater, including oily wastewater, metal finishing wastes, cleaning solutions containing detergents, alcohol-based cleaning solutions, landfill leachate, aqueous paint-

stripping wastes, and deicing fluids. Information about the two demonstrations conducted in Canada and the United States is available from ZENON.

DEMONSTRATION RESULTS:

During the 3-month demonstration, sampling results showed that the system achieved average removal efficiencies of greater than 99.9 percent for MMA and 97.9 percent for chemical oxygen demand. MMA concentrations measured in the off-gas emission stream indicated insignificant volatilization. The ultrafiltration system effectively dewatered the process sludge, which yielded a smaller waste volume for off-site disposal. Sludge dewatering resulted in an approximate volume reduction of 60 percent and a solids increase from 1.6 to 3.6 percent. The process effluent was clear and odorless, and accepted for discharge by the local publicly owned treatment works. During the demonstration, the system was left unattended at night and on weekends, demonstrating that computer control is practical for extended operating periods.

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TABLE 2
Ongoing SITE Demonstration Program Projects as of September 2002

Developer	Technology	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
					Inorganic	Organic
Earth-Tech Roanoke, VA (HSA)	In-Situ Enhanced Bioremediation of Groundwater	Brian B. Looney 808-725-7673 Rosann Kryczkowski 540-362-7326	Vince Gallardo 513-569-7679	Groundwater	Not Applicable	VOCs
Electro-Petroleum, Inc. Wayne, PA	Electro-Kinetically Aided Remediation (EKAR)	Dr. J. Kenneth Whittle 610-687-9070	Randy A. Parker 513-569-7271	Soil	Various radionuclides, arsenic, cadmium, lead, nickel, mercury	Acetone, BTEX, PAHs, TCE
Geokinetics International, Inc. Palo Alto, CA	Electrokinetic Remediation Process	Steven Schwartzkopf 415-424-3176	Thomas Holdsworth 513-569-7679	Clay, Silty Clay, Shale Beds, Gravel Deposits, etc.	Not Applicable	Feul Oil, Diesel, Kerosene, PAHs, Coal Tar, Hydraulic Fluid, TCE
Harding ESE A MacTec Company (formerly ABB Environmental Services, Inc.) Wakefield, MA.	Two-Zone, Plume Interception, In Situ Treatment Strategy	Willard Murray 781-245-6606	Randy Parker 513-569-7271	Groundwater, Soil	Inorganic Chloride	Chlorinated and Nonchlorinated Organic Compounds
Integrated Water Resources, Inc Santa Barbara, CA.	Dynamic Underground Stripping & Hydrous Pyrolysis Oxidation	Roger Aines 925-423-7184 Robin Newmark 925-423-3644 Norman Brown 805-966-7757	Thomas Holdsworth 513-569-7679	Groundwater, Soil	Not Applicable	Chlorinated solvents, fuels, creosote
Lewis Environmental Services, Inc./ Hickson Corporation Etna, PA	Chromated Copper Arsenate Soil Leaching Process	Tom Lewis III 412-799-0959	Randy Parker 513-569-7571	Leachate, liquid, Soil, Wastewater	Mteals, Nonspecific Inorganics	Nonspecific Organics
Lockheed Martin Missiles and Space Co., and Geokinetics International, Inc. Palo Alto, Ca	Electrokinetic Remediation Process	Steven Schwartzkopf 415-424-3176	Tom Holdsworth 513-569-7679	Soil, Sludges, Sediment	Heavy Metals	Polar Organics
Matrix Photocatalytic Inc., London, Ontario, Canada	Photocatalytic Air Treatment	Bob Henderson 519-660-8669	Paul de Percin 513-569-7797	Air	Not Applicable	VOCs, SVOCs
Process Technologies, Inc. Boise, ID	Photolytic Destruction of Vapor-Phase Halogens	Not Available	Paul dePercin 513-569-7797	Air, Gases	Not Applicable	VOCs, CFCs, HCFCs
Recycling Sciences International, Inc. Chicago, IL	Desorption and Vapor Extraction System	William Meenan 312-663-4269	Richard Eilers 513-569-7809	Soil, Sediment, Sludge	Volatile Inorganics	VOCs, SVOCs, PCBs, PAHs, PCP, Pesticides
RKK, Ltd. Arlington, WA	CRYOCELL®	Ronald Krieg 360-653-4844	Steven Rock 513-569-7149	Soil	Nonspecific Inorganics	Nonspecific Organics
Selentec Environmental Technologies, Inc. Atlanta, GA	Selentec MAG*SEP SM Technology	Steve Weldon 770-640-7059	Randy Parker 513-569-7271	Water, Wastewater	Heavy Metals, Radionuclides	Not Applicable
SIVE Services Dixon, CA	Steam Injection and Vacuum Extraction	Douglas Dieter 707-678-8358	Michelle Simon 513-569-7469	Soil	Not Applicable	VOCs, SVOCs

* Solicitation Number

** An additional demonstration is planned for this technology. Refer to the profile in the Demonstration Program section (completed projects) for more information.

*** From Emerging Technology Program

TABLE 2 (Continued)
Ongoing SITE Demonstration Program Projects as of September 2002

Developer	Technology	Technology Contact	EPA Project Manager	Applicable Media	Applicable Waste	
					Inorganic	Organic
Vortec Corporation*** Collegeville, PA	Vitrification Process	James Hnat 610-489-2255	Teri Richardson 513-569-7949	Soil, Sludge, Sediment	Metals, Other Nonspecific Inorganics	Nonspecific Organics
Western Research Institute Laramie, WY	Contained Recovery of Oily Wastes	Lyle Johnson 307-721-2281	Eugene Harris 513-569-7862	Soil, Groundwater	Not Applicable	Coal Tars, Petroleum By-Products, PCP, Chlorinated Solvents
Wheelabrator Technologies Inc. Hampton, NH	WES-PHix® Stabilization Process	Mark Lyons 603-929-3403	Teri Richardson 513-569-7949	Soil, Sludge	Metals	Not Applicable

* Solicitation Number
 ** An additional demonstration is planned for this technology. Refer to the profile in the Demonstration Program section (completed projects) for more information.
 *** From Emerging Technology Program

EARTH TECH, INC.
(formerly ITT Night Vision)
(In Situ Enhanced Bioremediation of Groundwater)

TECHNOLOGY DESCRIPTION:

ITT Night Vision is conducting in situ enhanced aerobic bioremediation of contaminated groundwater in fractured bedrock utilizing technologies developed at the U.S. Department of Energy Savannah River Site. The site demonstration involved remediation of groundwater in the vicinity of one contaminant source area as a pilot-scale operation, with the possibility of applying the technology elsewhere on site. Contaminants of concern in on-site groundwater included chlorinated solvents and their products, plus acetone and isopropanol. To accelerate the intrinsic (natural) biodegradation observed at the site, the selected remedy involves the subsurface injection of air, gaseous-phase nutrients (triethyl phosphate and nitrous oxide), and methane. The amendments were added to stimulate existing microbial populations (particularly methanotrophs) so that they could more aggressively break down the contaminants of concern. Amendment delivery to the surface was accomplished through an injection well, and the injection zone of influence was confirmed using surrounding groundwater monitoring wells and soil vapor monitoring points.

The patented PHOSter™ process for injection of triethyl phosphate in a gaseous phase was licensed for use at this site as an integral element of the enhanced bioremediation operation. This technology maximizes the subsurface zone of influence of nutrient injection as compared to technologies injecting nutrients in liquid or slurry form. Monitoring of contaminant (and breakdown product) concentrations in groundwater and soil vapor, measurement of microbiological population density and diversity, and monitoring of nutrient concentrations and groundwater geochemical parameters provides feedback on system effectiveness. This in turn allows adjustments to be made in the sequencing and rate of delivery of air, nutrients, and methane in response to changing subsurface conditions.

WASTE APPLICABILITY:

The Enhanced In-Situ Bioremediation process is applicable for creating volatile organic compounds (VOCs) in groundwater that can be naturally biodegraded, including some hard to degrade chlorinated VOCs. The mixture of air and gaseous phase nutrients that is injected into the subsurface provides an aerobic environment for contaminant degradation. Toxic products resulting from anaerobic degradation of chlorinated solvents (e.g., vinyl chloride) may be broken down completely in this aerobic environment. The in-situ process is especially applicable for hydrogeologically complex sites where injected nutrient flow patterns are uncertain (i.e., in fractured bedrock gaseous phase nutrient injection is more likely to affect a larger area than liquid nutrient injection). The process is also applicable in situations where subsurface utilities limit or preclude the use of technologies requiring excavation.

The enhanced bioremediation system, currently being used in the ongoing RCRA corrective action interim measure at the ITT Night Vision facility, was accepted into the SITE program in 1997, (the demonstration was conducted March 1998 to August 1999) with system start up occurring in March of 1998. The technology had previously been approved by EPA Region 3 as an Interim Measure part of the facility's ongoing RCRA Corrective Action program.

Due to the positive performance of the technology during the SITE Demonstration project, the remediation system was expanded to address the entire contamination plume at the site.

Demonstration results are shown in Table 1. Results were based on 28 baseline and 28 final samples for the four critical analytes and are presented in Table 1. VOC concentrations were determined by EPA SW-846 Method 8260. The results indicate that the targeted 75 percent reduction was achieved or exceeded for two of the four critical compounds, from baseline to final events.

Target Compound	Contaminant Concentration (µg/L)		Average Percent Reduction	Statistically Significance Present Reduction
	Baseline	Final		
CA	256	210	36	4
1,1-DCA	960	190	80	71
<i>cis</i> -1,2-DCE	1,100	90	97	55
VC	1,100	45	96	52

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ELECTRO-PETROLEUM, INC.

(Electro-Kinetically Aided Remediation [EKAR])

TECHNOLOGY DESCRIPTION:

Electrokinetics is a general term describing a variety of physical changes, electrochemical reactions and coupled flows, which can occur when electrical current flows through soils containing one or more phases of fluids. Electrokinetically-Aided Remediation (EKAR), which utilizes electric fields to drive fluids and charged particles through a porous medium, is being developed for in-situ soil remediation. In this process, an electrical current or potential difference is applied across electrodes placed into soil in the treatment area. The applied electrical current effectively enlarges the throat diameter of soil pores, compared to Darcy flow, and changes the capillary forces allowing NAPL to pass through. Dissolved organic and non-aqueous phase liquids (NAPLs) will also accompany the increased electroosmotic water flux toward the cathode. Hydrolyzed ionic species and charged colloidal particles will drift toward the electrode of opposite polarity.

A typical electrokinetic field deployment is set up as follows:. A seven-spot pattern consisting of six anode wells surrounding a central cathode extraction well is used to remediate a volume of subsurface material. NAPL concentrations are extracted at the electrode wells for further treatment or disposal. The mobility of the ions and pore fluids decontaminates the soil mass. EKAR can supplement or replace conventional pump and treat technologies.

WASTE APPLICABILITY:

Electrokinetically aided remediation has particular applicability to both organic and inorganic contaminants in low permeability soils. Electrokinetic mechanisms increase fluid flow through fine grained porous media. This mechanism increases the removal of mobile non-aqueous phase liquid, its residual, and its aqueous phases. It is equally effective with both LNAPL and DNAPL. Because of the electrokinetically imposed electric field's ability to drive charged particles through a fluid, the technology can be used to increase particulate contaminant flux through soil and transport microbes to contaminated zones for bioremediation. Electrochemical treatment may be engineered to extract soluble species of cations and anions without the need for water flushing and secondary treatments.

STATUS:

Bench laboratory studies investigating the metals, organics, and radionuclides, have been completed. Organics investigated included acetone, BTEX, and PAHs. Metals removal investigations focused on arsenic, cadmium, chromium, lead, nickel and mercury.

Radionuclides investigated included cesium, cobalt, technetium, strontium, and uranium. Bench scale treatability tests have shown significant removal of TCE from core samples.

The technology is scheduled to be demonstrated at Offut Air Force Base, Nebraska in 2003, and evaluated for its ability to remediate TCE contaminated soils.

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GEOKINETICS INTERNATIONAL, INC. (Electrokinetic Remediation Process)

TECHNOLOGY DESCRIPTION:

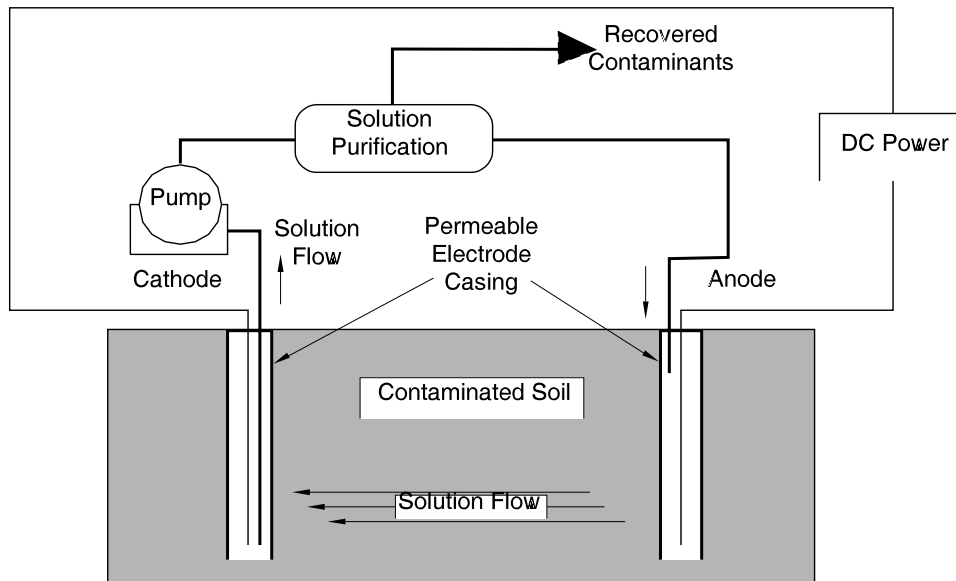
The Electrokinetic Remediation (ER) process removes metals and organic contaminants from soil, mud, sludge, and marine dredgings. ER uses electrochemical and electrokinetic processes to desorb and remove metals and polar organics. The technology may be applied in situ or in the batch mode.

The figure below is a flow diagram of the batch reactor. Waste material is placed into the batch reactor, between Ebonex® ceramic electrodes that are divided into a cathode array and an anode array. A direct current is then applied, causing ions and water to move toward the electrodes. Metal ions, ammonium ions, and positively charged organic compounds move toward the cathode. Anions such as chloride, cyanide, fluoride, nitrate, and negatively charged organic compounds move toward the anode. Two primary mechanisms transport contaminants through the soil: electromigration and electroosmosis. In electromigration, charged particles are transported through the substrate. In contrast, electroosmosis is the movement of a liquid

containing ions relative to a stationary charged surface. Of the two, electromigration is much faster and it is the principle mechanism for the ER process.

The electrodes are positioned inside permeable casings that are inserted into the waste material. After the annulus of each casing is filled with water, the current is turned on. The water passes from the anode casing into the waste and toward the cathode. This procedure (1) supports electrokinetic movement of the contaminants through the soil; (2) helps maintain soil moisture, thereby sustaining the electric field; and (3) enables various chemicals that enhance contaminant removal to be added as required.

As the water accumulates in the annulus of the cathode casing, it is pumped out for processing. Processing involves removal of contaminants by electrochemical means, producing a concentrated contaminant brine that can be either further processed or disposed of as hazardous waste. The water is then returned to the annulus of the anode casing.



Flow Diagram of the Electrokinetic Remediation Process

WASTE APPLICABILITY:

ER is designed to remove heavy metals, anions, and polar organics from soil, mud, sludge, and dredgings. Treatable concentrations range from a few parts per million (ppm) to tens of thousands ppm. The batch technology is most appropriate for sites with contaminated estuarine and river muds and dredgings, sewage processing sludges, and fines remaining after soil washing. The process can be used with virtually any substrate. ER's effectiveness is sharply reduced for wastes with a moisture content of less than 10 percent.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1994. A demonstration of the process will be conducted at the Alameda Naval Air Station in California.

The ER process has been used successfully at several European sites on soils contaminated with metals.

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HARDING ESE, A MACTEC COMPANY
(formerly ABB Environmental Services, Inc.)
(Two-Zone, Plume Interception, In Situ Treatment Strategy)

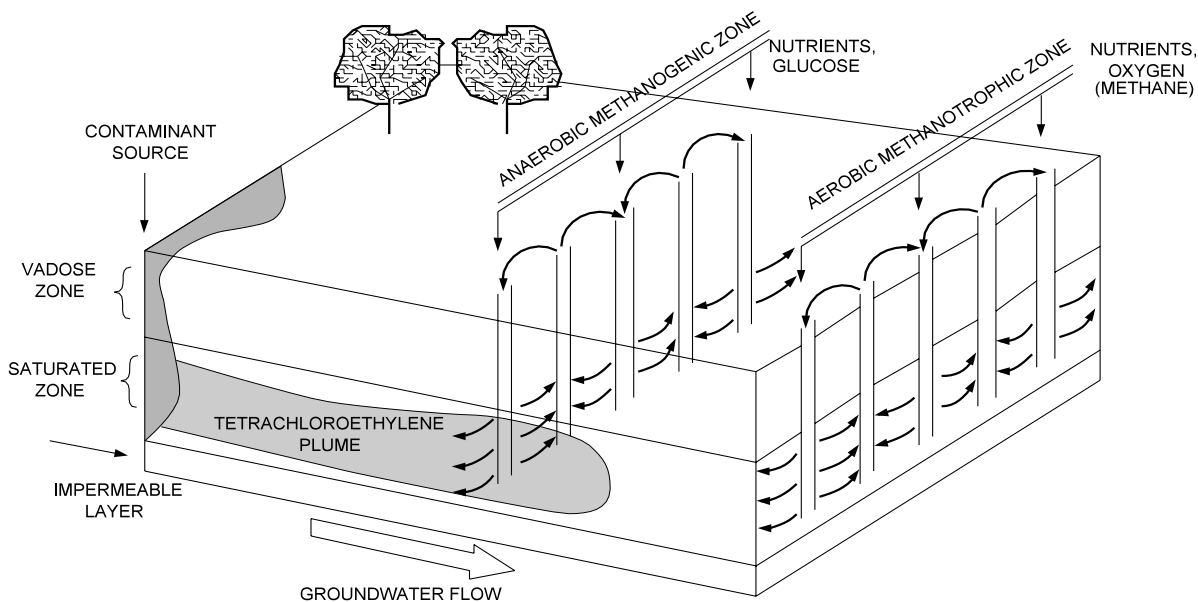
TECHNOLOGY DESCRIPTION:

The two-zone, plume interception, in situ treatment strategy is designed to treat chlorinated and nonchlorinated organic compounds in saturated soils and groundwater using a sequence of anaerobic and aerobic conditions (see figure below). The in situ anaerobic and aerobic system constitutes a treatment train that biodegrades a wide assortment of chlorinated and nonchlorinated compounds.

When applying this technology, anaerobic and aerobic conditions are produced in two distinct, hydraulically controlled, saturated soil zones. Groundwater passes through each zone as it is recirculated through the treatment area. The first zone, the anaerobic zone, is designed to partially dechlorinate highly chlorinated solvents such as tetrachloroethene (PCE), trichloroethene (TCE), and 1,1,1-trichloroethane with natural biological processes. The second zone, the aerobic zone, is designed to biologically oxidize the partially dechlorinated products from the first zone, as well as other compounds that were not susceptible to the anaerobic treatment phase.

Anaerobic conditions are produced or enhanced in the first treatment zone by introducing a primary carbon source, such as lactic acid, and mineral nutrients, such as nitrogen and phosphorus. When proper anaerobic conditions are attained, the target contaminants are reduced. For example, PCE is dechlorinated to TCE, and TCE is dechlorinated to dichloroethene (DCE) and vinyl chloride. Under favorable conditions, this process can completely dechlorinate the organics to ethene and ethane.

Aerobic conditions are produced or enhanced in the second treatment zone by introducing oxygen, mineral nutrients such as nitrogen and phosphorus, and possibly an additional carbon source, such as methane (if an insufficient supply of methane results from the upstream, anaerobic zone). When proper aerobic conditions are attained in this zone, partially dechlorinated products and other target compounds from the first zone are oxidized. For example, less-chlorinated ethenes such as DCE and vinyl chloride are cometabolized during the aerobic microbiological degradation of methane.



Two-Zone, Plume Interception, In Situ Treatment Strategy

The treatment strategy is designed to biologically remediate subsoils by enhancing indigenous microorganism activity. If indigenous bacterial populations do not provide the adequate anaerobic or aerobic results, specially adapted cultures can be introduced to the aquifer. These cultures are introduced using media-filled trenches that can support added microbial growth.

WASTE APPLICABILITY:

The two-zone, plume interception, in situ treatment strategy is designed to treat groundwater and saturated soils containing chlorinated and nonchlorinated organic compounds.

STATUS:

The two-zone, plume interception, in situ treatment strategy was accepted into the SITE Emerging Technology Program in July 1989. Optimal treatment parameters for field testing were investigated in bench-scale soil aquifer simulators. The objectives of bench-scale testing were to (1) determine factors affecting the development of each zone, (2) evaluate indigenous bacterial communities, (3) demonstrate treatment of chlorinated and nonchlorinated solvent mixtures, and (4) develop a model for the field remediation design. The Emerging Technology Bulletin (EPA/540/F-95/510), which details the bench-scale testing results, is available from EPA.

A pilot-scale field demonstration system was installed at an industrial facility in Massachusetts. Pilot-scale testing began in September 1996. Results from this testing indicate the following:

- The reductive dechlorination of PCE and TCE to DCE, VC, and ethene has been accomplished primarily by sulfate-reducing bacteria.

- A time lag of about 4 months was required before significant reductive dechlorination occurred. This corresponded to the time and lactic acid dosing required to reduce the redox to about -100 throughout the treatment cell.
- Sequential anaerobic-aerobic (Two-Zone) biodegradation of PCE and its degradation products appear to be a viable and cost-effective treatment technology for the enhancement of natural reductive dechlorination processes.

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INTEGRATED WATER RESOURCES, INC.

(Dynamic Underground Stripping & Hydrous Pyrolysis Oxidation)

TECHNOLOGY DESCRIPTION:

Dynamic Underground Stripping and Hydrous Pyrolysis Oxidation are components of a toolbox of remediation techniques that mobilize and remove as well as destroy, *in situ*, a variety of organic contaminants including chlorinated solvents (TCE and PCE), fuels and creosote. Steam is injected through stainless steel wells, creating a steam-front that volatilizes the contaminants as it moves towards groundwater and vapor extraction wells where contaminants are brought to the surface for *ex situ* treatment. When the site reaches the target temperature, and for the period afterward while the target zone remains hot, a portion of the contaminants will be destroyed *in situ* by Hydrous Pyrolysis/Oxidation, producing the byproducts carbon dioxide, water and, for chlorinated compounds, a chloride ion.

Toolbox Technologies Defined:

Dynamic Underground Stripping (DUS): Subsurface heating by steam injection and/or electrical heating, to volatilize and mobilize contaminants for removal through vacuum extraction wells.

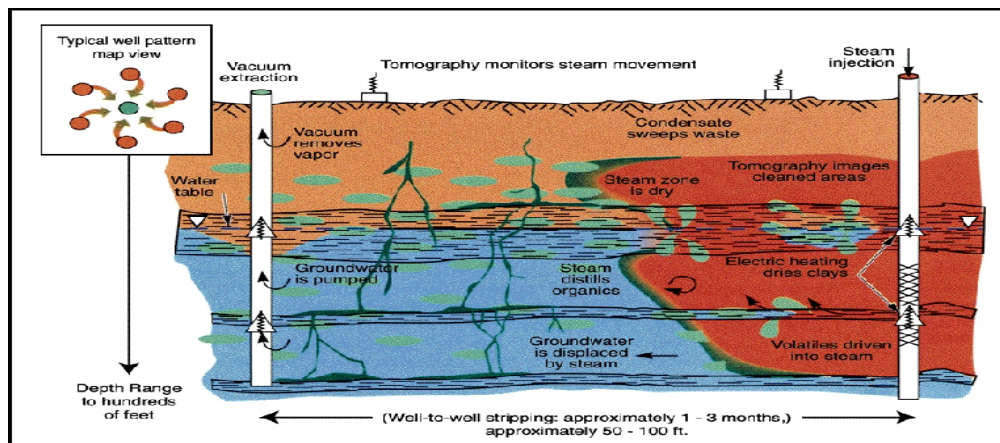
Hydrous Pyrolysis/Oxidation (HPO): *In situ* physical/chemical destruction process for organic contaminants involving oxidation. Contaminants are destroyed in the aquifer during pulsed steam injection. HPO processes will continue after steam injection is ceased.

Electrical Resistance Tomography (ERT): Provides nearly real-time tomographic imaging of thermal distribution within the subsurface during heating, allowing modification and fine-tuning of steam injection and vacuum extraction parameters for process control and performance review.

In contrast to many existing remediation technologies, DUS/HPO toolbox technologies work quickly and efficiently, with site closure in months to years as opposed to decades. In addition to free product removal, the technology can provide treatment of contaminated aquifers to drinking water standards. DUS/HPO technology is also less expensive than many traditional pump and treat processes, in part due to the dramatically reduced treatment time. Data from pilot and full scale projects indicate that full treatment costs range between \$35 and \$50 per cubic yard of contaminated volume.

WASTE APPLICABILITY:

DUS/HPO technology is effective at sites contaminated by chlorinated solvents (including TCE, PCE and CC14), fuels, and creosote. Former Energy Secretary Richardson stated that these technologies are applicable to one quarter of the nation's Superfund Sites.



The technologies are well-suited to application in a variety of geological environments, including heterogeneous aquifers which are typically problematic for pump-and-treat and related techniques. DUS/HPO works above and below the water table and has no practical depth constraint. DUS/HPO toolbox technologies may have special advantages in hydrogeological environments where existing technologies are known to be inapplicable or largely ineffectual.

At the project currently underway at Cape Canaveral Launch Complex 34, in addition to remediation of both sands and fine-grained silty clay layers, IWR's system will remove TCE trapped in sediments beneath a large building.

STATUS:

The technologies, developed at Lawrence Livermore National Laboratory and UC-Berkeley, were nationally licensed to IWR in 1998. Since that time, several large-scale DUS/HPO projects have been successfully realized, including one nearing completion for the U.S. DOE at the Savannah River Site in Aiken, South Carolina. Contaminants at this former solvent storage tank site were removed from as deep as 165' below ground surface, the deepest deployment of this technology to date. Over 55,000 pounds of PCE and 2,000 pounds of TCE were removed from the subsurface during eight months of active operation, more than twice the maximum estimated contaminant mass prior to DUS/HPO deployment.

This technology was accepted into the Superfund Innovative Technology Program (SITE) late 1999. The Interagency DNAPL Consortium, combining the interests of NASA, the Departments of Defense and Energy, and the US EPA, selected IWR to design a system for removal of TCE from a contaminated aquifer at Cape Canaveral Launch Complex 34. The design has since been approved and construction is currently underway. Commencement of active steaming began in July 2001.

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LEWIS ENVIRONMENTAL SERVICES, INC. HICKSON CORPORATION (Chromated Copper Arsenate Soil Leaching Process)

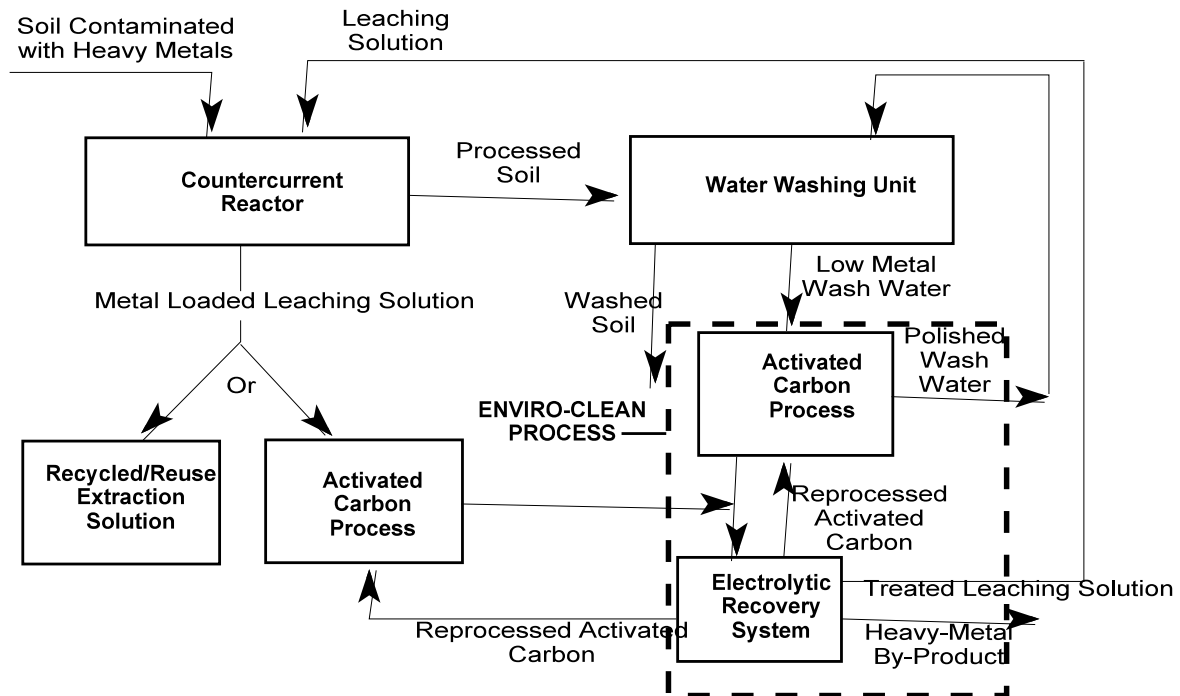
TECHNOLOGY DESCRIPTION:

Lewis Environmental Services, Inc. (Lewis), has developed a soil leaching process to remediate soils contaminated with inorganics and heavy metals including chromium, copper, cadmium, mercury, arsenic, and lead.

The soil leaching process consists of leaching contaminated soil in a countercurrent stirred reactor system (see figure below). A screw feeder delivers the soil into the reactor, where it is leached with sulfuric acid for 30 to 60 minutes. The sulfuric acid solubilizes the inorganics and heavy metals into the leaching solution. Any organic contaminants are separated and decanted from the leaching solution, using strong acid leachate, space separation, and skimming. The processed soil is then washed with water and air-dried.

The wash water is then treated with Lewis' ENVIRO-CLEAN PROCESS, which consists of a granulated activated carbon system followed by an electrolytic recovery system. The ENVIRO-CLEAN PROCESS recovers the heavy metals from the leaching solution and wash water and produces an effluent that meets EPA discharge limits for heavy metals. The treated wash water can then be reused in the soil washing step. The leaching solution can be returned directly to the stirred reactor system, depending on its metals concentration.

Contaminated soil must be properly sized and screened to facilitate leaching in the stirred reactor system. Large pieces of debris such as rocks, wood, and bricks must be removed before treatment. Standard screening and classification equipment, such as that used in municipal waste treatment plants, is suitable for this purpose.



Chromated Copper Arsenate Soil Leaching Process

The soil leaching process does not generate appreciable quantities of treatment by-products or waste streams containing heavy metals. The treated soil meets toxicity characteristic leaching procedure (TCLP) criteria and can be either returned to the site or disposed of at a nonhazardous landfill. The granular activated carbon requires disposal after about 20 to 30 treatment cycles and should also meet TCLP criteria. Heavy metals recovered by the ENVIRO-CLEAN process can be reused by industry.

WASTE APPLICABILITY:

The soil leaching process can treat wastes generated by the wood preserving and metal plating industries, battery waste sites, and urban lead sites.

STATUS:

The soil leaching process was accepted into the Emerging Technology Program in 1993. Laboratory-scale tests have shown that the process successfully treats soil contaminated with chromated copper arsenate (CCA). The evaluation of the technology under the SITE Program was completed in September 1996. Results from the evaluation will be available in 1997.

In 1992, Lewis treated a 5-gallon sample of CCA-contaminated soil from Hickson Corporation (Hickson), a major CCA chemical manufacturer. The treated soil met TCLP criteria, with chromium and arsenic, the two main leaching solution constituents, averaging 0.8 milligram per kilogram (mg/kg) and 0.9 mg/kg, respectively.

Analysis also revealed 3,330 milligrams per liter (mg/L) of chromium, 13,300 mg/L of copper, and 22,990 mg/L of iron in the leaching solution. In addition, analysis indicated 41.4 mg/L of chromium, 94.8 mg/L of copper, and 3.0 mg/L of arsenic present in the wash water. After treatment, the wash water contained metals levels below 0.01 mg/L for copper and chromium and 0.3 mg/L for arsenic.

Lewis plans further laboratory-scale testing at its Pittsburgh, Pennsylvania facility, followed by bench- or pilot-scale testing at Hickson's facility in Conley, Georgia.

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LOCKHEED MARTIN MISSILES AND SPACE CO. and GEOKINETICS INTERNATIONAL, INC. (Electrokinetic Remediation Process)

TECHNOLOGY DESCRIPTION:

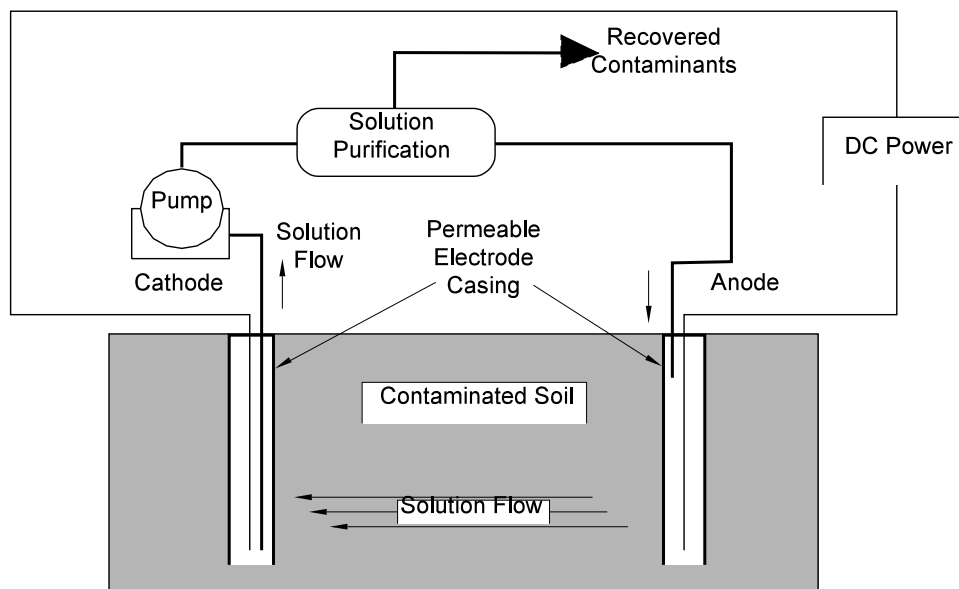
The Electrokinetic Remediation (ER) process removes metals and organic contaminants from soil, mud, sludge, and marine dredgings. ER uses electrochemical and electrokinetic processes to desorb and remove metals and polar organics. The technology may be applied in situ or in the batch mode.

The figure below is a flow diagram of the batch reactor. Waste material is placed into the batch reactor, between Ebonex® ceramic electrodes that are divided into a cathode array and an anode array. A direct current is then applied, causing ions and water to move toward the electrodes. Metal ions, ammonium ions, and positively charged organic compounds move toward the cathode. Anions such as chloride, cyanide, fluoride, nitrate, and negatively charged organic compounds move toward the anode. Two primary mechanisms transport contaminants through the soil: electromigration and electroosmosis. In electromigration, charged particles are transported through the substrate. In contrast, electroosmosis is the movement of a liquid containing ions relative to a stationary

charged surface. Of the two, electromigration is much faster and it is the principle mechanism for the ER process.

The electrodes are positioned inside permeable casings that are inserted into the waste material. After the annulus of each casing is filled with water, the current is turned on. The water passes from the anode casing into the waste and toward the cathode. This procedure (1) supports electrokinetic movement of the contaminants through the soil; (2) helps maintain soil moisture, thereby sustaining the electric field; and (3) enables various chemicals that enhance contaminant removal to be added as required.

As the water accumulates in the annulus of the cathode casing, it is pumped out for processing. Processing involves removal of contaminants by electrochemical means, producing a concentrated contaminant brine that can be either further processed or disposed of as hazardous waste. The water is then returned to the annulus of the anode casing.



Flow Diagram of the Electrokinetic Remediation Process

WASTE APPLICABILITY:

ER is designed to remove heavy metals, anions, and polar organics from soil, mud, sludge, and dredgings. Treatable concentrations range from a few parts per million (ppm) to tens of thousands ppm. The batch technology is most appropriate for sites with contaminated estuarine and river muds and dredgings, sewage processing sludges, and fines remaining after soil washing. The process can be used with virtually any substrate. ER's effectiveness is sharply reduced for wastes with a moisture content of less than 10 percent.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1994. A demonstration of the process will be conducted at the Alameda Naval Air Station in California.

The ER process has been used successfully at several European sites (see table below) on soils contaminated with metals.

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MATRIX PHOTOCATALYTIC INC.

(Photocatalytic Air Treatment)

TECHNOLOGY DESCRIPTION:

Matrix Photocatalytic Inc. is developing a titanium dioxide (TiO₂) photocatalytic air treatment technology that destroys volatile organic compounds (VOC) and semivolatile organic compounds in air streams. During treatment, contaminated air at ambient temperatures flows through a fixed TiO₂ catalyst bed activated by ultraviolet (UV) light. Typically, organic contaminants are destroyed in fractions of a second.

Technology advantages include the following:

- Robust equipment
- No residual toxins
- No ignition source
- Unattended operation
- Low direct treatment cost

The technology has been tested on benzene, toluene, ethylbenzene, and xylene; trichloroethene; tetrachloroethane; isopropyl alcohol; acetone; chloroform; methanol; and methyl ethyl ketone. A field-scale system is shown in the photograph on the next page.

WASTE APPLICABILITY:

The TiO₂ photocatalytic air treatment technology can effectively treat dry or moist air. The technology has been demonstrated to purify contaminant steam directly, thus eliminating the need to condense. Systems of 100 cubic feet per minute have been successfully tested on vapor extraction operations, air stripper emissions, steam from desorption processes, and VOC emissions from manufacturing facilities. Other potential applications include odor removal, stack gas treatment, soil venting, and manufacturing ultra-

pure air for residential, automotive, instrument, and medical needs. Systems of up to about 1,000 cubic feet per minute can be cost- competitive with thermal destruction systems.

STATUS:

The TiO₂ photocatalytic air treatment technology was accepted into SITE Emerging Technology Program (ETP) in October 1992; the evaluation was completed in 1993. Based on results from the ETP, this technology was invited to participate in the SITE Demonstration Program. For further information about the evaluation under the ETP, refer to the journal article (EPA/600/A-93/282), which is available from EPA. A suitable demonstration site is being sought.

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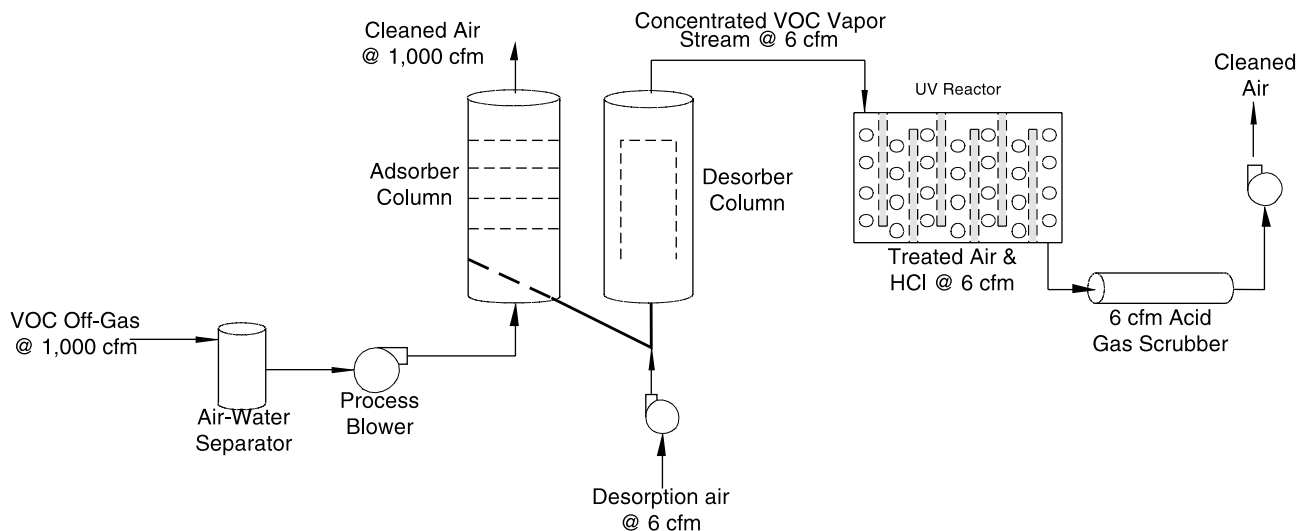
PROCESS TECHNOLOGIES INCORPORATED (Photolytic Destruction of Vapor-Phase Halogens)

The proprietary, nonthermal technology developed by Process Technologies Incorporated (PTI), is a method of photochemically oxidizing gaseous organic compounds within a reaction chamber. PTI's Photolytic Destruction Technology (PDT) uses low-pressure ultraviolet (UV) lamps, with UV emissions primarily at wavelengths in the 185 to 254 nanometer range, located within the reaction chamber. Photons emitted from these lamps break apart the chemical bonds making up the volatile organic compound (VOC) molecule. The process is capable of destroying mixtures of chlorinated and nonchlorinated VOCs.

The PDT system is designed and fabricated in 3- to 12-cubic-feet-per-minute (cfm) modules. The size of the module applied is dependent on the gas flow rate and VOC concentrations in the gas stream. PTI implements a fluid bed concentrator to allow for the treatment of high flow gas streams, or those with rates greater than 1,000 cfm. Significant cost savings can be realized if the gas flow can be reduced, and concentration increased prior to destruction.

PTI uses a proprietary reagent that forms a liner within the process chamber. The reagent reacts chemically with the gaseous degradation products formed during the photolytic destruction of halocarbon molecules to form solid, stable reaction products.

Reagent lifetime depends on flow rate, influent concentrations, and specific chemical composition of destruction targets. PTI has performed tests on spent reagent to determine whether the material would be classified as a hazardous waste under federal regulations. Those tests indicated that the spent reagent is likely nontoxic. The spent reagent is also not reactive, corrosive, or flammable, and thus PTI is confident that it is not a hazardous waste under federal law. PTI accordingly believes that the spent reagent material can be disposed of as ordinary solid waste or used as a feedstock for cement manufacturing. The PTI process is simple in design and easy to operate. The system is designed to run continuously, 24-hours per day.



Simplified Process Flow Diagram
of Photolytic Destruction

WASTE APPLICABILITY:

The technology was developed to destroy a number of groups of compounds, including chlorinated solvents, chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and halons. Example sources of process off-gas that contains chlorinated and nonchlorinated VOCs, CFCs, and HCFCs include steam vapor extraction, tank vents, air strippers, steam strippers, and building vent systems.

The process is capable of destroying as high as 50,000 parts per million by volume VOC streams. The system is capable of achieving greater than 90 percent on-line availability, inclusive of scheduled maintenance activities.

STATUS:

The PTI technology was accepted into the SITE Demonstration Program in summer 1994. The demonstration began in September 1994 at McClellan Air Force Base (AFB) in Sacramento, California. The SITE demonstration was postponed shortly thereafter. Activities under the SITE Program were rescheduled in 1997. Additional tests incorporating an improved design for treating soil vapor extraction off-gas were successfully completed at the AFB in January 1996.

PTI completed a four month demonstration of the combined fluid bed concentrator and PDT system at the U.S. Navy's North Island Site 9 in February, 1998. This demonstration was performed to evaluate the effectiveness and cost to remove and destroy VOC vapor from an existing SVE system. The results of the demonstration at the Navy's North Island Site 9 showed the PTI System was capable of achieving greater than 95 percent destruction and removal efficiency of VOCs in the soil vapor at a 250 standard cfm flow rate. Furthermore, the Navy determined that the PTI System provided a 45 percent cost savings over activated carbon or flameless thermal oxidation.

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RECYCLING SCIENCES INTERNATIONAL, INC. **(Desorption and Vapor Extraction System)**

TECHNOLOGY DESCRIPTION:

The mobile desorption and vapor extraction system (DAVES) uses a low-temperature fluidized bed to remove organic and volatile inorganic compounds from soils, sediments, and sludges. This system can treat materials with 85 percent solids at a rate of 10.5 tons per hour.

Contaminated materials are fed into a co-current, fluidized bed dryer, where they are mixed with hot air (about 1,000 to 1,400°F) from a gas-fired heater. Direct contact between the waste material and the hot air forces water and contaminants from the waste into the gas stream at a relatively low fluidized-bed temperature (about 320°F). The heated air, vaporized water and organics, and entrained particles flow out of the dryer to a gas treatment system.

The gas treatment system removes solid particles, vaporized water, and organic vapors from the air stream. A cyclone separator and baghouse remove most of the particulates. Vapors from the cyclone separator are cooled in a venturi scrubber, countercurrent washer, and chiller section before they are treated in a vapor-phase carbon adsorption system. The liquid residues from the system are centrifuged, filtered, and passed through two activated carbon beds arranged in series (see photograph below).

By-products from the DAVES include (1) treated, dry solids representing about 96 to 98 percent of the solid waste feed, (2) a small quantity of centrifuge sludge containing organics, (3) a small quantity of spent adsorbent carbon, (4) wastewater that may need further treatment, and (5) small quantities of baghouse and cyclone dust that are recycled through the process.



Desorption and Vapor Extraction System (DAVES)

The centrifuge sludge can be bioremediated, chemically degraded, or treated in another manner. Recycling Sciences International, Inc., has patented an electrochemical oxidation process (ECO) and is developing this process as an adjunct to the DAVES. The ECO is designed to detoxify contaminants within the DAVES in a closed-loop system.

This technology removes the following contaminants from soil, sludge, and sediment: volatile and semivolatile organics, including polychlorinated biphenyls (PCB), polynuclear aromatic hydrocarbons, pentachlorophenol, volatile inorganics such as tetraethyl lead, and some pesticides. In general, the process treats waste containing less than 10 percent total organic contaminants and 30 to 95 percent solids. The presence of nonvolatile inorganic contaminants (such as metals) in the waste feed does not inhibit the process; however, these contaminants are not treated.

STATUS:

This technology was accepted into the SITE Program in April 1995. EPA is selecting a demonstration site for this process. Preferred demonstration wastes include harbor or river sediments containing at least 50 percent solids contaminated with PCBs and other volatile or semivolatile organics. Soils with these characteristics may also be acceptable. About 300 tons of waste is needed for a 2-week test. Major test objectives are to evaluate feed handling, decontamination of solids, and treatment of gases generated by the process.

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RKK, LTD. (CRYOCELL®)

TECHNOLOGY DESCRIPTION:

CRYOCELL® is a barrier system which provides real-time monitoring capability, earthquake resiliency, and diffusion-free full enclosure contaminant isolation. The system is repairable in situ and removable upon completion of containment needs.

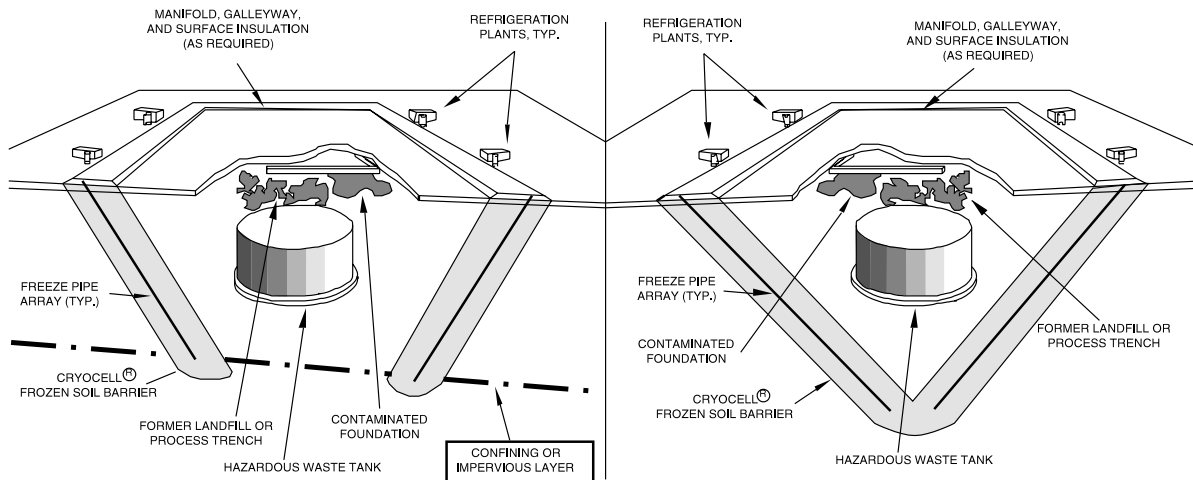
CRYOCELL® design involves installing an array of freeze pipes, using standard well-drilling equipment, which surround the contaminated source or groundwater plume much like the ribs of a canoe. Once installed, the array of freeze pipes is connected to freeze plants by a distributive manifold and supplied with cooled brine at a design temperature of -10°C to -40°C to freeze the volume of soil between the pipes, resulting in a 12- to 16-foot barrier.

The barrier's thickness and temperature may be varied through design to match containment requirements. If no subsurface confining impervious layer is present, the array can be installed using an angled or "V"-shaped configuration beneath the contaminated zone, completely enclosing the site. If additional barrier

thickness is a design requirement, a parallel array of freeze pipes is installed in staggered spacing outside the first array. This configuration allows the entire inner volume of soil between the two arrays to be frozen, thereby increasing barrier thickness per design up to 75 feet. The depth of the containment envelop can be in excess of 500 feet.

CRYOCELL® engineering is site-specific and considers many cost-related factors, including waste type, topography, soil conditions, thermal conductivity, and groundwater movement. A computer program incorporates all site characteristics into a three-dimensional model that engineers use to establish the most efficient design and estimate the cost of CRYOCELL® for a specific site.

A thick frozen soil barrier offers a number of advantages for confining hazardous waste. The barrier does not degrade or weaken over time and is repairable in situ. If ground movement fractures the barrier, the fissures can be filled and resealed quickly. Maintenance costs are extremely low, allowing continued use for extended periods. In addition, the frozen barrier is environmentally benign. When the site is decontaminated, the frozen



Schematic Diagram of CRYOCELL®

soil is allowed to melt and the pipes are removed. The technique is an alternative to conventional containment systems using steel, concrete, slurry walls, or grout curtains. The figure on the previous page illustrates two typical containment systems.

WASTE APPLICABILITY:

RKK, Ltd. (RKK), reports that CRYOCELL® can provide subsurface containment for a variety of sites and waste, including underground tanks; nuclear waste sites; plume control; burial trenches, pits, and ponds; in situ waste treatment areas; chemically-contaminated sites; and spent fuel storage ponds. CRYOCELL® is designed to contain all known biological, chemical, or radioactive contaminants. frozen soil barriers are adaptable to any geometry; drilling technology presents the only constraint.

RKK reports that the technology can isolate sensitive areas within large active operations (for example, sites within chemical and nuclear facilities), smaller raw material and waste management units (for example, tank farms, burial trenches, and waste treatment lagoons), and operational chemically contaminated sites, such as chemical plants, refineries, and substations. The technology can also contain a site or contamination during an in situ remediation project. It can also provide a redundant barrier for cut-off contamination processes, and reduces flow of groundwater into a contaminated zone.

Contaminants are contained in situ, with frozen native soils serving as the containment medium. Frozen soil barriers are impervious to chemical attack and are virtually impermeable at subzero temperatures. In addition, frozen soil barriers have great inertia, so they can remain frozen for as long as two years without refrigeration.

CRYOCELL® is economically favorable for intermediate- and long-term containment at large sites, and maintenance costs are extremely low. CRYOCELL® generates no waste streams or residues.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. A treatability study was completed at the Department of Energy's (DOE) Oak Ridge National Laboratory in 1995. Results from the study are documented in a DOE Innovative Technology Summary Report, titled *Frozen Soil Barrier Technology*, and, *Subsurface Contaminants Focus Area Technology Summary*, (DOE/EM-0296), August 1996.

The RKK technology is being considered by DOE for use at other hazardous waste sites. RKK receives academic, technical, and scientific support through a cooperative and licensing agreement with the University of Washington.

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SELENTEC ENVIRONMENTAL TECHNOLOGIES, INC.
(Selentec MAG*SEPSM Technology)

TECHNOLOGY DESCRIPTION:

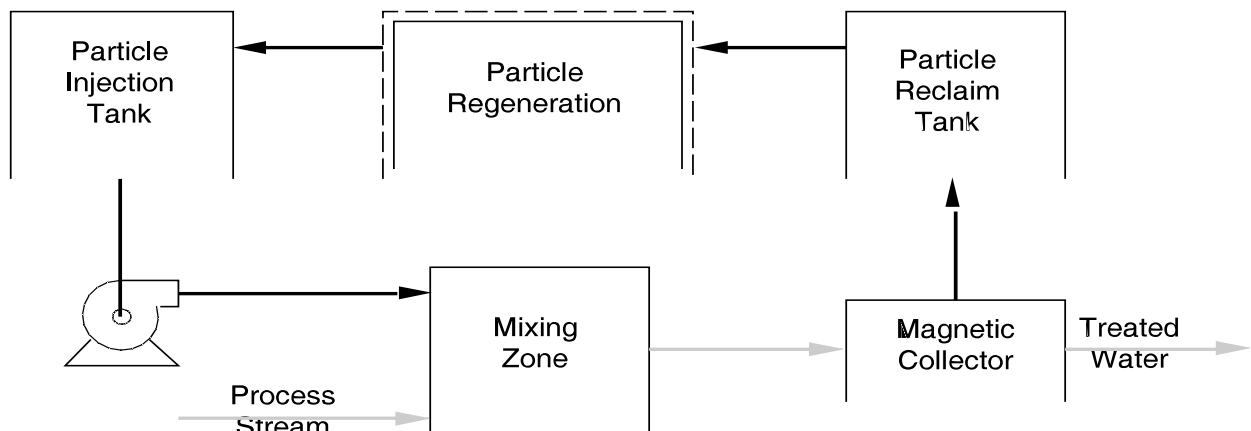
The MAG*SEPSM process uses the principles of chemical adsorption and magnetism to selectively bind and remove heavy metals or radionuclides from aqueous solutions such as groundwater, wastewater, and drinking water. Contaminants are adsorbed on specially formulated particles which have a core made from magnetic material; these particles are then separated (along with the adsorbed contaminants) from the solution using a magnetic filter or magnetic collector. The magnetic core has no interaction with the contaminant.

The proprietary adsorbing particles are made of a composite of organic polymers and magnetite. The particles can be manufactured in two forms: one with an ion exchanger and/or chelating functional group attached to the particle surface (amidoxime functionalized resin), or one with inorganic adsorbers bound to the surface of the particles (clinoptilolite). These particles have high surface areas and rapid adsorption kinetics.

A typical MAG*SEPSM treatment system consists of:

- a particle contact zone
- a particle handling system, including particle injection components, a magnetic separator, and particle reclaim components
- a particle regeneration system (where applicable)

The process stream enters a contact zone (usually a tank - other configurations are used for particular applications) where MAG*SEPSM particles are injected and mixed. The contact zone provides the necessary solution flow characteristics and contact time with the particles to ensure that the contamination will be adsorbed onto the active surface sites of the particles. The mixture then flows through a magnetic collector, where the contaminated particles are retained while the treated process stream passes through (see figure below).



Schematic Diagram of the Mag*SEPSM Treatment System

Depending on the application, type of particle, and contaminant concentration, the particles may be re-injected into the flow stream, collected and disposed of, or regenerated and reused. The regeneration solution is processed to recover (concentrate and remove) the contaminants and may be recycled.

The MAG*SEPSM process is able to selectively remove (either ex situ or in situ) the following contaminants from aqueous solutions: titanium, copper, cadmium, arsenic, cobalt, molybdenum, platinum, selenium, chromium, zinc, gold, iodine, manganese, technetium, mercury, strontium, iron, ruthenium, thallium, cesium, cobalt, palladium, lead, radium, nickel, silver, bismuth, thallium, antimony, zirconium, radium, cerium, and all actinides. The process operates at flow rates up to 2,000 gallons per minute (gpm).

WASTE APPLICABILITY:

The MAG*SEPSM technology reduces heavy metal and radionuclide contamination in water and wastewater. The technology has specific applications in environmental remediation and restoration, treatment of acid mine drainage, resource recovery, and treatment of commercial industrial wastewater. MAG*SEPSM particles can be produced to incorporate any known ion exchanger or sorbing material. Therefore, MAG*SEPSM can be applied in any situation where conventional ion exchange is used.

STATUS:

The MAG*SEPSM technology was accepted into the SITE Program in 1996 and is also one of 10 technologies participating in the White House's Rapid Commercialization Initiative. In addition, in 1997 the MAG*SEPSM technology received a Research and Development (R&D) 100 Award from the R&D trade publication as one of the 100 Most Technologically Significant New Products of 1997.

Selentec has completed a demonstration of the MAG*SEPSM technology at the U.S. Department of Energy's Savannah River Site. Heavy metal concentrations in coal pile runoff water were significantly reduced to below drinking water standards. Another demonstration of the technology is planned for Savannah River whereby radioactive cesium will be removed streams. The technology is also being used to remove mercury from heavy water drums at Savannah River.

The first commercial unit of the MAG*SEPSM technology was put into service on November 18, 1998, at a dairy in Ovruch, Ukraine. For this application, the unit is removing radioactive cesium from contaminated milk produced near the Chernobyl Nuclear Reactor Plant.

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SIVE SERVICES

(Steam Injection and Vacuum Extraction)

TECHNOLOGY DESCRIPTION:

Steam Injection and Vacuum Extraction (SIVE) uses steam injection wells in conjunction with dual-phase extraction wells for in situ treatment of contaminated soil and groundwater. The injected steam strips volatile and semivolatile organic compounds as it permeates the contaminated zones. The steam increases the subsurface temperature, which increases mass transfer and phase exchange rates, reduces liquid viscosities, and accelerates desorption of contaminants from the matrix. The moisture and warmth provided by the steam also accelerates biodegradation of residual contaminants. As a result, contaminants are extracted or degraded at increased rates as compared to conventional isothermal vapor and liquid extraction systems.

SIVE-LF (Linear Flow) is an enhanced SIVE method designed for relatively shallow depths. With the SIVE-LF process, as illustrated in the figure below, steam is forced to flow horizontally and uniformly from one trench, through the contaminant zone, and into another trench, from which the contaminants are extracted. The large open area of the trench faces allow for high injection and extraction rates, which promote low treatment duration. The trenches also allow for installation of an impermeable barrier, such as a polyethylene liner, against one face of the open trench before the trench is backfilled, thus reducing the flow of injected or extracted fluid outside the area of the targeted zones. A surface covering for the treatment area prevents short-circuiting of the flow of injected steam to the atmosphere, and prevents atmospheric air from entering the extraction trench.

Surface equipment for SIVE includes conventional steam generation and delivery systems, and the vacuum extraction system. The vacuum extraction system includes a vacuum blower, steam condenser, other cooling components, and air emission control devices. The condensate generated by the process requires further treatment or off-site disposal. The reliability of the equipment and automatic controls allows SIVE to operate without constant direct supervision.

WASTE APPLICABILITY:

SIVE may be applied to soil or groundwater contaminated with fuels, industrial solvents, oils, and other liquid toxics, and may be applied at any depth. The SIVE-LF process is designed to treat to depths of 30 feet. Because highly volatile contaminants are readily air-stripped without the added effects of steam, the steam-stripping effect will be greatest on the heavier, less volatile contaminants. SIVE also effectively removes floating non aqueous-phase liquids from groundwater.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. A suitable site for the demonstration is being sought, although at this time the project is considered inactive.

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VORTEC CORPORATION (Vitrification Process)

TECHNOLOGY DESCRIPTION:

Vortec Corporation (Vortec) has developed an oxidation and vitrification process for remediating soils, sediments, sludges, and mill tailings contaminated with organics, inorganics, and heavy metals. The process can vitrify materials introduced as dry granulated materials or slurries.

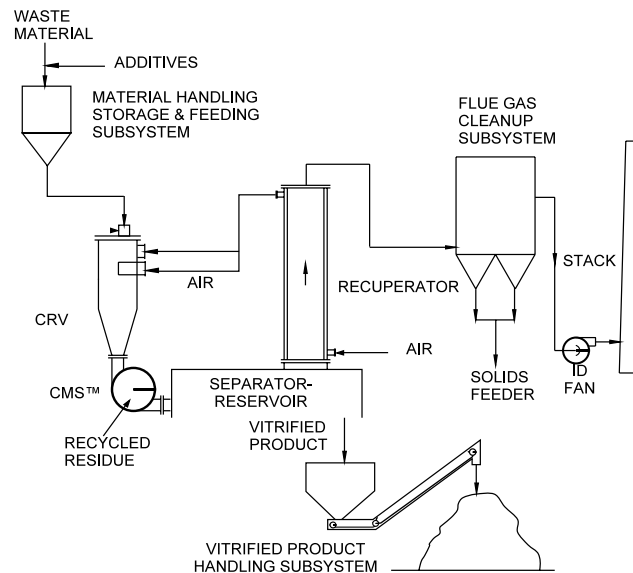
The figure below illustrates the Vortec vitrification process. Its basic elements include (1) a cyclone melting system (CMS™); (2) a material handling, storage, and feeding subsystem; (4) an air preheater (recuperator); (5) an air pollution control subsystem; and (6) a vitrified product handling subsystem.

The Vortec CMS™ is the primary system and consists of two major assemblies: a counterrotating vortex (CRV) reactor and a cyclone melter. First, slurried or dry-contaminated soil is introduced into the CRV. The CRV (1) provides a high temperature environment; (2) preheats the suspended waste material along with any glass-forming additives

mixed with soil; and (3) destroys any organic constituents in the soil. The average temperature of materials leaving the CRV reactor chamber is between 2,200 and 2,800°F, depending on the melting characteristics of the processed soils.

The preheated solid materials exit the CRV and enter the cyclone melter, where they are dispersed to the chamber walls to form a molten glass product. The vitrified, molten glass product and the exhaust gases exit the cyclone melter through the tangential exit channel and enter a glass- and gas-separation chamber.

The exhaust gases then enter an air preheater to heat the incoming air and are subsequently delivered to the air pollution control subsystem for particulate and acid gas removal. The molten glass product exists the glass- and gas-separation chamber through the tap and is delivered to a water quench assembly for subsequent disposal.



Vortec Vitrification Process

Unique features of the Vortec vitrification process include the following:

- Processes solid waste contaminated with both organic and heavy metal contaminants
- Handles waste quantities ranging from 5 or more than 400 tons per day
- Recycles particulate residue collected in the air pollution control subsystem into the CMS™. These recycled materials are incorporated into the glass product.
- Produces a vitrified product that is nontoxic according the EPA toxicity characteristic leaching procedure (TCLP) standards. The product has long-term stability.

WASTE APPLICABILITY:

The Vortec vitrification process treats soils, sediments, sludges, and mill tailings contained organic, inorganic, and heavy metal contamination. Organic materials included with the waste are successfully destroyed by the high temperatures in the CRV. The inorganic constituents in the waste material determine the amount and type of glass-forming additives required to produce a vitrified product. This process can be modified to produce a glass cullet that consistently meets TCLP requirements.

STATUS:

The Vortec vitrification process was accepted into the SITE Emerging Technology Program in May 1991. Research under the Emerging Technology Program was completed in winter 1994, and Vortec was invited to participate in the SITE Demonstration Program.

Construction of a 1.5-ton-per-hour, transportable system for treating contaminated soil at a Department of Energy site in Paducah, Kentucky, was initiated in October 1996. A SITE demonstration was scheduled to occur in early 1999. A 50-ton-per-day system has been purchased by Ormet Aluminum Corporation of Wheeling, West Virginia for recycling aluminum spend pot liners, which are considered cyanide- and fluoride-containing waste (K088). The recycling system became operational in 1996. Vortec is offering commercial systems and licenses for the CMS™ system.

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WESTERN RESEARCH INSTITUTE (Contained Recovery of Oily Wastes)

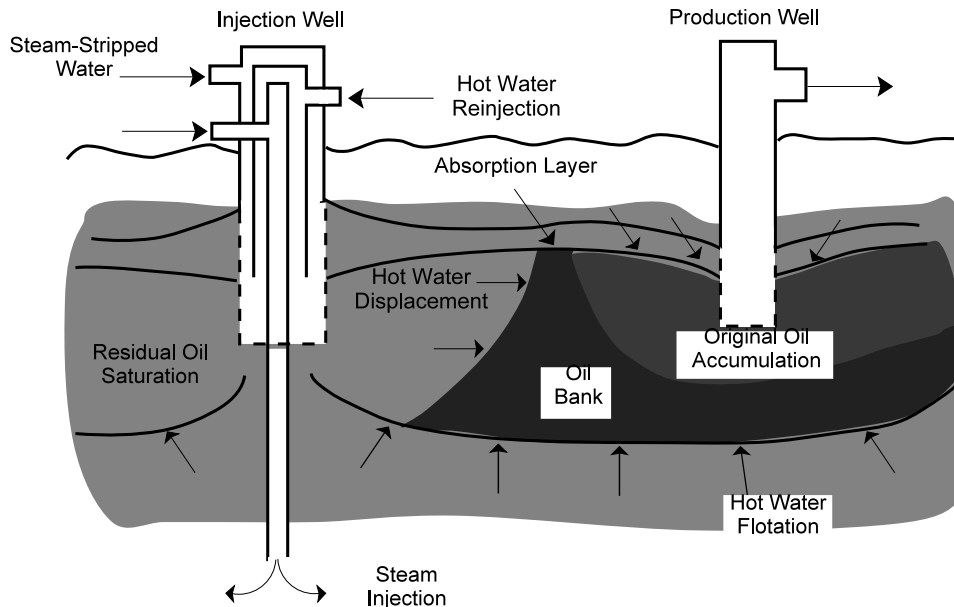
TECHNOLOGY DESCRIPTION:

The contained recovery of oily wastes (CROW®) process recovers oily wastes from the ground by adapting a technology used for secondary petroleum recovery and primary production of heavy oil and tar sand bitumen. Steam or hot water displacement moves accumulated oily wastes and water to production wells for aboveground treatment.

Injection and production wells are first installed in soil contaminated with oily wastes (see figure below). If contamination has penetrated into or below the aquifer, low-quality steam can be injected below the organic liquids to dislodge and sweep them upward into the more permeable aquifer soil regions. Hot water is injected above the impermeable regions to heat and mobilize the oily waste accumulation. The mobilized wastes are then recovered by hot water displacement.

When the organic wastes are displaced, organic liquid saturation in the subsurface pore space increases, forming a free-fluid bank. The hot water injection displaces the free-fluid bank to the production well. Behind the free-fluid bank, the contaminant saturation is reduced to an immobile residual saturation in the subsurface pore space. The extracted contaminant and water are treated for reuse or discharge.

During treatment, all mobilized organic liquids and water-soluble contaminants are contained within the original boundaries of waste accumulation. Hazardous materials are contained laterally by groundwater isolation and vertically by organic liquid flotation. Excess water is treated in compliance with discharge regulations.



CROW® Subsurface Development

The CROW® process removes large portions of contaminant accumulations; stops the downward and lateral migration of organic contaminants; immobilizes any remaining organic wastes as a residual saturation; and reduces the volume, mobility, and toxicity of the contaminants. The process can be used for shallow and deep areas, and can recover light and dense nonaqueous phase liquids. The system uses readily available mobile equipment. Contaminant removal can be increased by adding small quantities of selected biodegradable chemicals in the hot water injection.

In situ biological treatment may follow the displacement, which continues until groundwater contaminants are no longer detected in water samples from the site.

WASTE APPLICABILITY:

The CROW® process can be applied to manufactured gas plant sites, wood-treating sites, petroleum-refining facilities, and other areas with soils and aquifers containing light to dense organic liquids such as coal tars, pentachlorophenol (PCP) solutions, chlorinated solvents, creosote, and petroleum by-products. Depth to the contamination is not a limiting factor.

STATUS:

The CROW® process was tested in the laboratory and at the pilot-scale level under the SITE Emerging Technology Program (ETP). The process demonstrated the effectiveness of hot water displacement and the benefits of including chemicals with the hot water. Based on results from the ETP, the CROW® process was invited to participate in the SITE Demonstration Program. The process was demonstrated at the Pennsylvania Power and Light (PP&L) Brodhead Creek Superfund site at Stroudsburg, Pennsylvania. The site contained an area with high concentrations of by-products from past operations. The demonstration began in July 1995; field work was completed in June 1996. Closure of the site was completed in late 1998.

The CROW® process was applied to a tar holder at a former MGP site in Columbia, Pennsylvania. The work was complete in 1998 and documentation for site closure has been submitted to the EPA.

A pilot-scale demonstration was completed at an active wood treatment site in Minnesota. Over 80 percent of nonaqueous-phase liquids were removed in the pilot test, as predicted by treatability studies, and PCP concentrations decreased 500%. The full-scale, multiphase remediation is presently underway. Results indicate that organic removal is greater than twice that of pump-and-treat. The project is operating within the constraints of an active facility. Treatability studies, pilot testing, and full-scale projects are planned.

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WHEELABRATOR TECHNOLOGIES INC. (WES-PHix® Stabilization Process)

TECHNOLOGY DESCRIPTION:

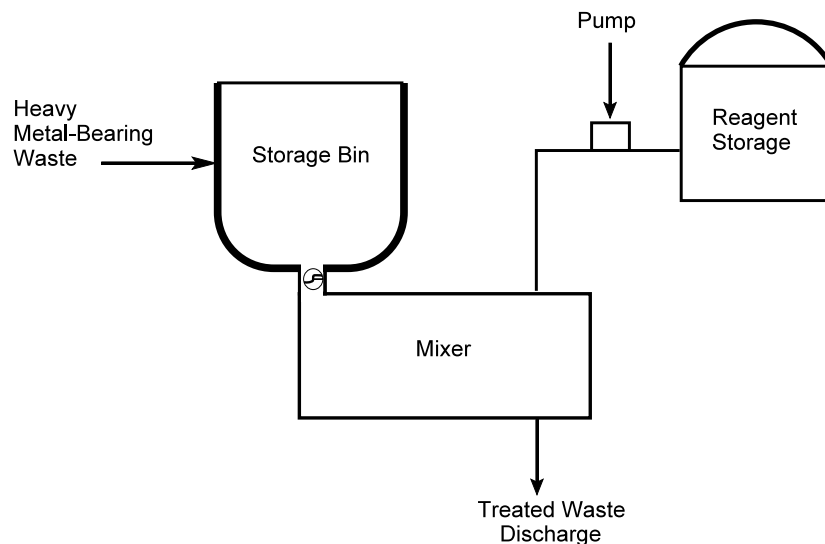
WES-PHix® is a patented stabilization process that significantly reduces the solubility of certain heavy metals in solid waste streams by altering the chemical composition of the waste material. The process does not produce a solidified mass, unlike most other stabilization technologies.

The figure below illustrates the process. First, waste is fed at a controlled rate into a mixing device, such as a pug mill. The full-scale WES-PHix® process uses a pug mill with a capacity of 40 to 200 tons per hour. The stabilization reagent is then added to and mixed with the waste for about 1 minute. Once stabilized, the waste is removed by a conveyor from the end of the mixer. For some wastes containing cadmium, small amounts of lime must also be added. The WES-PHix® Process uses a proprietary form of soluble phosphate to form insoluble and highly stable metal phosphate minerals. Reaction kinetics are rapid; thus, no curing step is necessary. As a result, metal concentrations in the treated waste are less than toxicity characteristic leaching procedure (TCLP) regulatory limits. In addition, the use of small quantities of liquid phosphate reagent creates only a minimal increase in the weight of the stabilized waste.

Equipment requirements include a metering device for feeding the waste stream to the mixer, and a storage tank for the liquid reagent. Over-sized items such as boulders or wood debris require crushing or removal by screens before treatment. No posttreatment is necessary with this process. Treated residuals can be transported for final disposal with dump trucks or roll-off container vehicles.

WASTE APPLICABILITY:

This process was originally developed to treat municipal waste combustion ash containing heavy metals. The commercial-scale process has treated over 7 million tons of ash. However, laboratory treatability data indicate that the technology can also treat contaminated soils, slags, sludges, foundry sands, and baghouse dusts. Recent research indicates that the process is particularly effective at stabilizing lead, cadmium, copper, and zinc in a variety of media, as measured by TCLP and other laboratory leaching tests.



WES-PHix® Stabilization Process

STATUS:

The WES-PHix[®] process was accepted into the SITE Demonstration Program in spring 1993. The demonstration, which was scheduled to occur at the Jack's Creek site in Maitland, Pennsylvania, has been postponed.

FOR FURTHER INFORMATION:

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TRADE NAME INDEX

Company/Technology Name	Volume
2-PHASE™ EXTRACTION Process	V1
ABB Environmental Services, Inc. (see Harding ESE)	V2
Accutech Remedial Systems, Inc. (see ARS Technologies)	V1
Acid Extraction Treatment System	V2
Acoustic Barrier Particulate Separator	V2
Active Environmental Technologies, Inc.	V1
Active Environmental Technologies, Inc. (formerly EET, Inc.)	V2
Adsorption-Integrated-Reaction Process	V2
Adsorptive Filtration	V2
Advanced Remediation Mixing, Inc. (formerly Chemfix Technologies, Inc.)	V1
AEA Technology Environment (see United Kingdom Atomic Energy Authority)	V2
AIR-II (Adsorption-Integrated-Reaction) Process	V1
AIR-II (Adsorption-Integrated-Reaction) Process	V2
Air-Sparged Hydrocyclone	V2
AirSentry Fourier Transform Infrared Spectrometer	V3
ALCOA Separation Technology, Inc. (see Media & Process Technology)	V2
AlgaSORB® Biological Sorption	V2
Alternative Cover Assessment Program	V1
Alternating Current Electrocoagulation Technology	V2
Aluminum Company of America (see Media & Process Technology)	V2
Ambersorb® 563 Adsorbent	V1
Ambersorb® 563 Adsorbent	V2
American Combustion, Inc.	V1
AMEC Earth and Environmental (formerly Geosafe Corporation)	V1
AMST™ Dual-Tube Liner Soil Sampler	V3
Anaerobic-Aerobic Sequential Bioremediation of PCE	V2
Anaerobic Thermal Processor.	V1
Analytical and Remedial Technology, Inc.	V3
Anodic Stripping Voltammetry for Mercury in Soil	V3
Argonne National Laboratory	V1
AquaDetox®/SVE System	V1
Aquatic Research Instruments	V3
Arctic Foundations, Inc.	V1
Arizona State University/Zentox Corporation	V2
ARS Technologies, Inc. (formerly Accutech Remedial Systems, Inc.)	V1
ART International, Inc. (formerly Enviro-Sciences, Inc.)	V2
Art's Manufacturing and Supply (AMST™ Dual-Tube Liner Soil Sampler)	V3
Art's Manufacturing and Supply (Sediment Core Sampler)	V3
ASC/EMR WPAFB (U.S. Air Force)	V1
Atomic Energy of Canada, Limited (Chemical Treatment and Ultrafiltration)	V2
Atomic Energy of Canada, Limited (Ultrasonic-Aided Leachate Treatment)	V2
Augmented In Situ Subsurface Bioremediation Process	V1
Automated Sampling and Analytical Platform	V3
AWD Technologies, Inc.	V1
Babcock & Wilcox Co. (see BWX Technologies, Inc.)	V1
Base-Catalyzed Decomposition Process	V1
Batch Steam Distillation and Metal Extraction	V2
Battelle Memorial Institute	V2
Bergmann, A Division of Linatex, Inc.	V1
Berkeley Environmental Restoration Center	V1
B.E.S.T. Solvent Extraction Technology	V1
Billings and Associates, Inc.	V1
BiMelyze® Mercury Immunoassay	V3
Binax Corporation, Antox Division (see Idetek, Inc.)	V3

TRADE NAME INDEX (Continued)

Company/Technology Name	Volume
Bioaugmentation Process	V1
Bio-Recovery Systems, Inc. (see Resource Management & Recovery)	V2
Bio-Rem, Inc.	V1
Biofilm Reactor for Chlorinated Gas Treatment	V2
BioGenesis Enterprises, Inc.	V1
BioGenesis SM Soil and Sediment Washing Process	V1
Biological Aqueous Treatment System	V1
Biological/Chemical Treatment	V2
Biological Denitrification Process	V1
Biom mineralization of Metals	V2
Bionebraska, Inc.	V3
Bioscrubber	V2
Bioslurry Reactor	V1
Biotherm Process TM	V1
Biotherm, LLC (formerly Dehydro-Tech Corporation)	V1
BioTrol [®] (Biological Aqueous Treatment System)	V1
BioTrol [®] (Soil Washing System)	V1
BioTrol [®] (Methanotrophic Bioreactor System)	V2
Bioventing	V1
Brice Environmental Services Corporation	V1
Bruker Analytical Systems, Inc.	V3
BWX Technologies, Inc.	V1
BWX Technologies, Inc.	V2
Calcium Sulfide and Calcium Polysulfide Technologies	V1
Calgon Carbon Advanced Oxidation Technologies (formerly Vulcan Peroxidation Systems, Inc.)	V1
Campbell Centrifugal Jig (CCJ)	V2
Canonie Environmental Services Corporation (see Smith Environmental Technologies Corporation)	V1
Carver-Greenfield Process [®] for Solvent Extraction of Wet, Oily Wastes (see Biotherm Process)	V1
CAV-OX [®] Process	V1
Cement-Lock Technology	V1
Center for Hazardous Materials Research (Acid Extraction Treatment System) (see Concurrent Technologies)	V2
Center for Hazardous Materials Research (Organics Destruction and Metals Stabilization) (see Concurrent Technologies)	V2
Center for Hazardous Materials Research (Acid Extraction Treatment System) (see Concurrent Technologies)	V2
Center Pivot Spray Irrigation System	V1
CF Systems Corporation	V1
Chelation/Electrodeposition of Toxic Metals from Soils	V2
CHEMetrics, Inc.	V3
Chemfix Technologies, Inc. (see Advanced Remediation Mixing, Inc.)	V1
Chemical and Biological Treatment	V2
Chemical Treatment	V2
Chemical Treatment and Ultrafiltration	V2
Chemical Waste Management, Inc. (see OHM Remediation Services Corp.)	V1
Chemical Waste Management, Inc. (see Wheelabrator Clean Air Systems, Inc.)	V1
Chromated Copper Arsenate Soil Leaching Process	V2
Circulating Bed Combustor	V1
Clay-Based Grouting Technology	V1
Clean Berkshires, Inc. (see Maxymillian Technologies, Inc.)	V1
Clements, Inc.	V3
Cognis, Inc. (TERRAMET [®] Soil Remediation System)	V1

TRADE NAME INDEX (Continued)

Company/Technology Name	Volume
Cognis, Inc. (TERRAMET® Soil Remediation System)	V2
Cognis, Inc. (Biological/Chemical Treatment)	V2
Cold Top Ex Situ Vitrification of Chromium-Contaminated Soils	V1
Colloid Polishing Filter Method® (CPFM®)	V1
Colorado School of Mines (see Colorado Department of Public Health and Environment)	V1
Colorado Department of Public Health and Environment	V1
Colorado Department of Public Health and Environment	V2
Commodore Advanced Sciences, Inc.	V1
Compact Gas Chromatograph	V3
Concentrated Chloride Extraction and Recovery of Lead	V2
Concurrent Technologies (formerly Center for Hazardous Materials Research) (Organic Destruction and Metals Stabilization)	V2
Concurrent Technologies (formerly Center for Hazardous Materials Research) (Acid Extraction Treatment System)	V2
Concurrent Technologies (formerly Center for Hazardous Materials Research) (Smelting Lead-Containing Waste)	V2
Constructed Wetlands-Based Treatment	V1
Constructed Wetlands-Based Treatment	V2
Contained Recovery of Oil Wastes (CROW™)	V1
Contained Recovery of Oil Wastes (CROW™)	V2
Coordinate, Chemical Bonding, and Adsorption Process	V2
Core Barrel Soil Sampler	V3
Cross-Flow Pervaporation System	V1
Cross-Flow Pervaporation System	V2
Cryogenic Barrier	V1
CRYOCELL®	V1
C-THRU Technologies Corporation (see Edax Portable Products Division)	V3
CURE® - Electrocoagulation Wastewater Treatment System	V1
CURE International, Inc.(see General Environmental, Inc.)	V1
Current Environmental Solutions	V1
Cyclone Furnace	V1
DARAMEND™ Bioremediation Technology	V1
Davy International Environmental Division (see Kvaerner Energy & Environment)	V2
Debris Washing System	V1
Dechlorination and Immobilization	V1
Dehydro-Tech Corporation (see Biotherm, LLC)	V1
Desorption and Vapor Extraction System (DAVES)	V1
Dexsil Corporation (Emulsion Turbidimetry)	V3
Dexsil Corporation (Environmental Test Kits)	V3
DOW Environmental, Inc. (see Radian International LLC)	V1
Duke Engineering and Services, Inc.	V1
E.I. Dupont de Nemours and Company, and Oberlin Filter Company	V1
Dynamic Underground Stripping and Hydrous Pyrolysis Oxidation	V1
Dynaphore, Inc.	V1
Earthsoft	V1
Earth Tech., Inc.	V1
Earth Tech/Westinghouse Savannah River Co.	V1
Eberline Services, Inc. (formerly Thermo Nutech,Inc/TMA Thermo Analytical, Inc.)	V2
EcoMat, Inc	V1
Ecova Corporation	V1
Ecova Europa (see Gruppo Italimpresse)	V1
E&C Williams, Inc.	V1

TRADE NAME INDEX (Continued)

Company/Technology Name Volume

Edax Portable Products Division (formerly C-Thru Technologies Corporation)	V3
Edenspace, Inc. (formerly Phytotech)	V1
EET, Inc. (see Active Environmental Technologies, Inc.)	V2
EG&G Environmental, Inc. (see Mactec-SBP Technologies Company, LLC)	V1
Electro- Kinetically Aided Remediation (EKAR)	V1
Electro-Petroleum, Inc.	V1
Electro-Pure Systems, Inc. (see RECRA Environmental, Inc.)	V2
Electrochemical Peroxidation of PCB-Contaminated Sediments and Waters	V2
ElectroChemical Remediation Technologies [ECRTs]	V1
Electroheat-Enhanced Nonaqueous-Phase Liquids Removal	V1
Electrokinetic Remediation Process	V1
Electrokinetic Soil Processing	V2
Electrokinetics for Lead Recovery	V2
Electrokinetics, Inc. (Electrokinetic Soil Processing)	V1
Electrokinetics, Inc. (Electrokinetic Soil Processing)	V2
Electrokinetics, Inc. (In Situ Bioremediation by Electrokinetic Injection)	V2
Electrokinetics for Lead Recovery	V1
Electron Beam Research Facility, Florida International University and University of Miami (see High Voltage Environmental Applications, Inc.)	V1
ELI Eco Logic Inc.	V1
Emflux® Soil-Gas Survey System	V3
EmTech Environmental Services (formerly Hazcon, Inc.)	V1
Emulsion Turbidimetry	V3
Energia, Inc. (Reductive Photo-Dechlorination Treatment)	V2
Energia, Inc. (Reductive Thermal and Photo- Thermal Oxidation Processes for Enhance Conversion of Chlorocarbons)	V2
Energy and Environmental Engineering, Inc. (see UV Technologies Inc.)	V2
Energy and Environmental Research Corporation (Hybrid Fluidized Bed System)	V2
Energy and Environmental Research Corporation (Reactor Filter System)	V2
Enhanced In Situ Bioremediation of Chlorinated Compounds in Groundwater	V1
ENSR Consulting and Engineering (see New York State Department of Environmental Conservation)	V1
EnSys Penta Test System	V3
EnSys Environmental Products, Inc. (see Strategic Diagnostics, Inc.)	V3
Enviro-Sciences, Inc. (see ART International, Inc.)	V2
Envirobond™ Solution	V1
EnviroGard Corporation (see Strategic Diagnostics, Inc.)	V3
EnviroGard™ PCB Immunoassay Test Kit	V3
EnviroMetal Technologies, Inc. (In Situ and Ex Situ Metal-Enhanced Abiotic Degradation of Dissolved Halogenated Organic Compounds in Groundwater)	V1
EnviroMetal Technologies, Inc. (Reactive Barrier)	V1
Environmental BioTechnologies, Inc.	V2
Environmental Systems Corporation	V3
Environmental Technologies Group, Inc.	V3
Environmental Test Kits	V3
EPOC Water, Inc.	V1
Equate® Immunoassay	V3
EQuIS Software	V1
Excavation Techniques and Foam Suppression Methods	V1
Ex Situ Biovault	V1
Ferro Corporation	V2
Field Analytical Screening Program-PCB Method	V3
Field Analytical Screening Program-PCP Method	V3

TRADE NAME INDEX (Continued)

Company/Technology Name Volume

Field Portable X-Ray Fluorescence Analyzers	V3
Filter Flow Technology, Inc.	V1
Flame Reactor	V1
Fluid Extraction-Biological Degradation Process	V2
Fluidized-Bed/Cyclonic Agglomerating Combustor	V2
FORAGER® Sponge	V1
Frequency-Tunable Pulse Combustion System	V1
Fugro Geosciences, Inc. (formerly Loral Corporation)	V3
Funderburk & Associates (see EmTech Environmental Services)	V1
Fungal Degradation Process	V2
Fungal Treatment Technology	V1
Gas-Phase Chemical Reduction Process	V1
Gas Technology Institute (Cement-Lock Technology)	V1
Gas Technology Institute (Chemical and Biological Treatment)	V2
Gas Technology Institute (Fluid Extraction-Biological Degradation Process)	V2
Gas Technology Institute (Fluidized-Bed/Cyclonic Agglomerating Combustor)	V2
Gas Technology Institute (Supercritical Extraction/Liquid Phase Oxidation)	V2
General Atomics, Nuclear Remediation Technologies Division	V2
General Atomics (formerly Ogden Environmental)	V1
General Environmental, Inc. (formerly Hydrologies, Inc./Cure International, Inc.)	V1
Geo-Con, Inc.	V1
Geo-Microbial Technologies, Inc.	V2
Geokinetics International, Inc. (Electroheat-Enhanced Nonaqueous-Phase Liquids Removal)	V1
Geokinetics International, Inc. (Electrokinetics for Lead Recovery)	V1
Geokinetics International, Inc. (Electrokinetic Remediation Process)	V1
GeoMelt Vitrification	V1
Geoprobe Systems (Large Bore Soil Sampler)	V3
Geoprobe Systems (Geoprobe Soil Conductivity Sensor)	V3
Geosafe Corporation (see AMEC Earth and Environmental)	V1
Geotech Development Corporation	V1
GHEA Associates Process	V2
GIS\KEY™ Environmental Data Management System	V1
GIS\Solutions, Inc.	V1
Glass Furnace Technology for Dredged Sediments	V1
W.L. Gore and Associates, Inc.	V3
GORE-SORBER® Screening Survey	V3
Grace Bioremediation Technologies	V1
Graseby Ionics, Ltd., and PCP, Inc.	V3
Groundwater Circulation Biological Treatment Process	V1
Gruppo Italimprese	V1
Hanby Environmental Laboratory Procedures, Inc.	V3
Harding ESE, a Mactec Company (formerly ABB Environmental Services, Inc.)	V1
Harding ESE, a Mactec Company (formerly ABB Environmental Services, Inc.)	V2
Hazcon, Inc. (see Emtech Environmental Services)	V1
Hewlett-Packard Company	V3
High Voltage Environmental Applications, Inc. (formerly Electron Beam Research Facility, Florida International University and University of Miami) (High-Energy Electron Irradiation)	V1
High Voltage Environmental Applications, Inc. (formerly Electron Beam Research Facility, Florida International University and University of Miami) (High-Energy Electron Beam Irradiation)	V2
High-Energy Electron Beam Irradiation	V2
High Energy Electron Irradiation	V1

TRADE NAME INDEX (Continued)

Company/Technology Name	Volume
HNU Systems Inc. (HNU Source Excited Fluorescence Analyzer-Portable [SEFA-P] X-Ray Fluorescence Analyzer)	V3
HNU Systems Inc. (HNU GC 311D Portable Gas Chromatograph)	V3
HNU Source Excited Fluorescence Analyser-Portable [SEFA-P] X-Ray Fluorescence Analyzer	V3
HNU GC 311D Portable Gas Chromatograph	V3
Horiba Instruments, Inc.	V3
Horsehead Resource Development Co., Inc	V1
HRUBETZ Environmental Services, Inc.	V1
HRUBOUT® Process	V1
Hughes Environmental Systems, Inc.	V1
Hybrid Fluidized Bed System	V2
Hydraulic Fracturing	V1
Hydrologies, Inc. (see General Environmental, Inc.)	V1
Idetek, Inc. (formerly Binax Corporation, Antox Division)	V3
IIT Research Institute	V1
Immunoassay and Colorimetry	V3
Infrared Analysis (Horiba Instruments, Inc.)	V3
Infrared Analysis (Wilks Enterprise, Inc)	V3
Infrared Thermal Destruction	V1
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In Situ and Ex Situ Vacuum Extraction	V1
In Situ Bioremediation by Electrokinetic Injection	V2
In Situ Bioventing Treatment System	V1
In Situ Electrokinetic Extraction System	V1
In Situ Electroacoustic Soil Decontamination	V2
In Situ Enhanced Bioremediation of Groundwater	V1
In Situ and Ex Situ Vacuum Extraction	V1
In Situ Mitigation of Acid Water	V2
In Situ Reactive Barrier	V1
In Situ Soil Treatment (Steam and Air Stripping)	V1
In Situ Solidification and Stabilization Process	V1
In Situ Steam Enhanced Extraction Process	V1
In-Situ Thermal Destruction	V1
In Situ Thermally Enhanced Extraction (TEE) Process	V1
In Situ Vittrification	V1
Institute of Gas Technology (see Gas Technology Institute)	V1
Institute of Gas Technology (see Gas Technology Institute)	V2
Integrated AquaDetox Steam Vacuum Stripping and Soil Vapor Extraction/Reinjection	V1
Integrated Water Resources, Inc.	V1
International Waste Technologies	V1
Ion Mobility Spectrometry	V3
Ionics RCC.	V1
IT Corporation (Batch Steam Distillation and Metal Extraction)	V2
IT Corporation (Chelation/Electrodeposition of Toxic Metals from Soils)	V2
IT Corporation (Mixed Waste Treatment Process)	V2
IT Corporation (Photolytic and Biological Soil Detoxification)	V2
IT Corporation (KMnO ₄ [Potassium Permanganate] Oxidation of TCE)	V1
IT Corporation (formerly OHM Remediation Services Corporation) (Oxygen Microbubble In Situ Bioremediation)	V2
IT Corporation (Tekno Associates Bioslurry Reactor)	V2
IT Corporation (formerly OHM Remediation Services Corp., formerly Chemical Waste Management, Inc.) (X*TRAX™ Thermal Desorption)	V1

TRADE NAME INDEX (Continued)

Company/Technology Name	Volume
ITT Night Vision (see Earth Tech, Inc.)	V1
JMC Environmentalist's Subsoil Probe	V3
KAI Technologies, Inc.	V1
KSE, Inc.	V1
KSE, Inc.	V2
Kvaerner Energy & Environment (formerly Davy International Environmental Division)	V2
Large Bore Soil Sampler	V3
Larsen Engineers (see New York State Department of Environmental Conservation)	V1
Lasagna™ In Situ Soil Remediation	V1
Lasagna™ In Situ Soil Remediation	V2
Lewis Environmental Services, Inc./Hickson Corporation	V2
Liquid and Soils Biological Treatment	V1
Liquified Gas Solvent Extraction (LG-SX) Technology	V1
Lockheed Martin Missiles and Space Co. and Geokinetics International, Inc.	V1
Loral Corporation (see Fugro Geosciences, Inc.)	V3
Low Temperature Thermal Aeration (LTTA®)	V1
Low Temperature Thermal Treatment System (LT3®)	V1
Low-Energy Extraction Process (LEEP®)	V2
MAECTITE® Chemical Treatment Process	V1
Mactec-SBP Technologies Company, L.L.C. (formerly EG&G Environmental, Inc.)	V1
Mae Corp, Inc. (see Severson Environmental Services, Inc.)	V1
Magnum Water Technology	V1
MatCon™ Modified Asphalt Cap	V1
Matrix Photocatalytic Inc. (Photocatalytic Aqueous Phase Organic Destruction)	V1
Matrix Photocatalytic Inc. (Photocatalytic Aqueous Phase Organic Destruction)	V2
Matrix Photocatalytic Inc. (Photocatalytic Air Treatment)	V1
Matrix Photocatalytic Inc. (Photocatalytic Air Treatment)	V2
Maxymillian Technologies, Inc. (formerly Clean Berkshires, Inc.)	V1
Media & Process Technology (formerly Aluminum Company of America and Alcoa Separation Technology, Inc.)	V2
Membrane Filtration and Bioremediation	V1
Membrane Microfiltration	V1
Membrane Technology and Research, Inc	V2
Metal Analysis Probe (MAP®) Portable Assayer (Edax Portable Products Division)	V3
Metal Analysis Probe (MAP®) Spectrum Assayer	V3
Metals Immobilization and Decontamination of Aggregate Solids (MeIDAS)	V2
Metals Release and Removal from Wastes	V2
Methanotrophic Bioreactor System	V2
Metorex, Inc.	V3
Metso Minerals Industries, Inc. (formerly Svedala Industries, Inc.)	V2
Micro-Bac International, Inc	V1
Microbial Composting Process	V2
Microbial Degradation of PCBs	V1
Microsensor Systems, Incorporated	V3
Millipore Corporation	V3
Minergy Corp.	V1
Mixed Waste Treatment Process	V2
Mobile Environmental Monitor	V3
Mobile Volume Reduction Unit	V1
Molecular Bonding System®	V1
Monsanto/DuPont (see Pharmacia Corporation)	V1
Monsanto/DuPont (see Pharmacia Corporation)	V2
Montana College of Mineral Science and Technology (Air-Sparged Hydrocyclone)	V2

TRADE NAME INDEX (Continued)

Company/Technology Name	Volume
Montana College of Mineral Science and Technology (Campbell Centrifugal Jig)	V2
Morrison Knudsen Corporation/Spetstamponazhgeologia Enterprises	V1
MoTech, Inc. (see Remediation Technologies, Inc.)	V1
MSI-301A Vapor Monitor	V3
MTI Analytical Instrument, Inc. (see Hewlett-Packard Company)	V3
Multiple Innovative Passive Mine Drainage Technologies	V1
National Risk Management Research Laboratory (Base-Catalyzed Decomposition Process)	V1
National Risk Management Research Laboratory (Volume Reduction Unit)	V1
National Risk Management Research Laboratory (Bioventing)	V1
National Risk Management Research Laboratory and Intech 180 Corporation	V1
National Risk Management Research Laboratory and IT Corporation	V1
National Risk Management Research Laboratory, University of Cincinnati, and FRX, Inc.	V1
New Jersey Institute of Technology	V2
New Jersey Institute of Technology hazardous Substances Management Research Center (formerly Hazardous Substance Management Research Center at New Jersey Institute of Technology and Rutgers, the State University of New Jersey)	V2
New York State Department of Environmental Conservation/ENSR Consulting and Engineering and Larsen Engineers	V1
New York State Department of Environmental Conservation/SBP Technologies, Inc.	V1
New York State Department of Environmental Conservation/R.E. Wright Environmental, Inc.	V1
New York State Department of Environmental Conservation/Science Applications International Corporation	V1
Niton Corporation	V3
North American Technologies Group, Inc.	V1
Novaterra Associates (formerly Toxic Treatment, Inc.)	V1
NoVOCs™ In-Well Stripping Technology	V1
Ogden Environmental (see General Atomics)	V1
OHM Remediation Services Corporation (see IT Corporation)	V1
OHM Remediation Services Corporation (see IT Corporation)	V2
Ohmicron Corporation (see Strategic Diagnostics, Inc.)	V3
Oleophilic Amine-Coated Ceramic Chip	V1
Organic Stabilization and Chemical Fixation/Solidification	V1
Organics Destruction and Metals Stabilization	V2
Oxygen Microbubble In Situ Bioremediation	V2
Oxidation and Vitrification Process	V2
PCB- and Organochlorine-Contaminated Soil Detoxification	V2
PE Photovac International, Inc. (formerly Photovac International, Inc.)	V3
PE Photovac Voyager Portable Gas Chromatograph	V3
PENTA RISC Test System (see Ensys Penta Test System)	V3
Precipitation, Microfiltration, and Sludge Dewatering	V1
perox-pure™ Chemical Oxidation Technology	V1
Pharmacia Corporation (formerly Monsanto/DuPont)	V1
Pharmacia Corporation (formerly Monsanto/DuPont)	V2
Photocatalytic Air Treatment	V2
Photocatalytic Aqueous Phase Organic Destruction	V1
Photocatalytic Aqueous Phase Organic Destruction	V2
Photocatalytic Oxidation with Air Stripping	V2
Photoelectrocatalytic Degradation and Removal	V2
Photolytic and Biological Soil Detoxification	V2
Photolytic Destruction of Vapor-Phase Halogens	V1
Photolytic Oxidation Process	V2
Photothermal Detoxification Unit	V2
Photovac International, Inc. (see PE Photovac International, Inc.)	V3

TRADE NAME INDEX (Continued)

Company/Technology Name Volume

Photovac Monitoring Instruments (see PE Photovac International, Inc)	V3
Phytokinetics, Inc. (Phytoremediation Process)	V1
Phytokinetics, Inc. (Phytoremediation of Contaminated Soils)	V2
Phytoremediation of Contaminated Soils	V2
Phytoremediation of TCE-Contaminated Shallow Groundwater	V1
Phytoremediation of TCE in Groundwater	V1
Phytoremediation (Argonne National Laboratory)	V1
Phytoremediation Process	V1
Phytoremediation Technology	V1
Phytotech (see Edenspace, Inc.)	V1
Pintail Systems, Inc. (Spent Ore Bioremediation Process)	V1
Pintail Systems, Inc. (Biomining of Metals)	V2
Plasma Arc Vitrification	V1
Pneumatic Fracturing and Bioremediation Process	V2
Pneumatic Fracturing Extraction SM and Catalytic Oxidation	V1
PO*WW*ER TM Technology	V1
Portable Gas Analyzer/HP Micro GC	V3
KMnO ₄ (Potassium Permanganate) Oxidation of TCE	V1
Praxis Environmental Technologies, Inc.	V1
Precipitation, Microfiltration, and Sludge Dewatering	V1
Process Technologies Incorporated	V1
PSI Technologies, A Division of Physical Sciences Inc.	V2
Pulse Sciences, Inc. (X-Ray Treatment of Aqueous Solutions)	V2
Pulse Sciences, Inc. (X-Ray Treatment of Organically Contaminated Soils)	V2
Purus, Inc. (see Thermatrix, Inc.)	V2
PYRETRON [®] Thermal Destruction	V1
Pyrokiln Thermal Encapsulation Process	V2
Quadrel Services, Inc.	V3
Radian International LLC	V1
Radio Frequency Heating (from ITT Research Institute/Brown and Root Environmental)	V1
Radio Frequency Heating (from KAI Technologies, Inc./Brown and Root Environmental)	V1
Radiometer American	V3
Rapid Optical Screening Tool	V3
RaPID Assay [®]	V3
Reactive Barrier	V1
Reactor Filter System	V2
RECRA Environmental, Inc. (formerly Electro-Pure Systems, Inc.)	V2
Recycling Sciences International, Inc.	V1
Reductive Photo-Dechlorination Treatment	V2
Reductive Thermal and Photo-Thermal Oxidation Processes for Enhanced Conversion of Chlorocarbons	V2
Regenesis	V1
Region 8 and State of Colorado	V1
RemediAid TM (see Total Petroleum Hydrocarbon Field Soil Test Kit)	V3
Remediation Technologies, Inc. (Biofilm Reactor for Chlorinated Gas Treatment)	V2
Remediation Technologies, Inc. (formerly Motech, Inc.) (Liquid and Solids Biological Treatment)	V1
Resources Conservation Company	V1
Resource Management & Recovery (formerly Bio-Recovery Systems, Inc.)	V2
Retech M4 Environmental Management Inc.	V1
Reverse Osmosis: Disc Tube TM Module Technology	V1
RKK, LTD.	V1
Rochem Disc Tube TM Module System	V1

TRADE NAME INDEX (Continued)

Company/Technology Name	Volume
Rochem Separation Systems, Inc.	V1
Rocky Mountain Remediation Services, LLC	V1
The SABRE™ Process	V1
Sandia National Laboratories	V1
SBP Technologies, Inc. (Groundwater Circulation Biological Treatment Process)	V1
SBP Technologies, Inc. (Membrane Filtration and Bioremediation)	V1
SCAPS Cone Penetrometer	V3
Science Applications International Corporation (In Situ Bioventing Treatment System)	V1
Scentograph Plus II Portable Gas Chromatograph	V3
SCITEC Corporation	V3
Sediment Core Sampler (Art's Manufacturing and Supply)	V3
Sediment Core Sampler (Aquatic Research Instruments)	V3
SEFA-P (Source Excited Fluorescence Analyzer-Portable)	V3
Segmented Gate System	V2
Selentec Environmental Technologies, Inc.	V1
Selentec MAG*SEP SM Technology	V1
Sentex Sensing Technology, Inc.	V3
Sevenson Environmental Services, Inc. (formerly Mae Corp, Inc.)	V1
Shirco Infrared Systems, Inc. (see Gruppo Italimpresse)	V1
Silicate Technology Corporation (see STC Remediation, Inc.)	V1
J.R. Simplot Company (see U. Of Idaho Research Foundation)	V1
Simulprobe® Technologies, Inc.	V3
Site Characterization and Analysis Penetrometer System (SCAPS)	V3
Site-Lab Corporation	V3
SIVE Services	V1
Six-Phase Heating™ of TCE	V1
Smelting Lead-Containing Waste	V2
Smith Environmental Technologies Corporation (formerly Canonie Environmental Services Corporation)	V1
Soil and Sediment Washing	V1
Soil Recycling	V1
Soil Rescue Remediation Fluid	V1
Soil Separation and Washing Process	V2
Soiltech ATP Systems, Inc	V1
Soil Washing Process	V1
Soil Washing System	V1
Solidification and Stabilization (from Advanced Remediation Mixing, Inc.)	V1
Solidification and Stabilization (from Soliditech, Inc.)	V1
Solidification and Stabilization (from Wastech, Inc.)	V1
Soliditech, Inc.	V1
Solvated Electron Technology, SET™ Remediation System	V1
Solvent Extraction Treatment System	V1
SOLUCORP Industries	V1
Sonotech, Inc.	V1
Space and Naval Warfare Systems Center	V3
Spent Ore Bioremediation Process	V1
SRI Instruments	V3
Star Organics, LLC	V1
State University of New York at Oswego, Environmental Research Center	V2
Steam Enhanced Remediation (SER) (at Loring AFB)	V1
Steam Enhanced Remediation (SER) (at Ridgefield, WA)	V1
Steam Enhanced Recovery Process	V1
Steam Injection and Vacuum Extraction	V1

TRADE NAME INDEX (Continued)

Company/Technology Name	Volume
SteamTech Environmental Services(Steam Enhanced Remediation (SER) at Loring AFB)	V1
SteamTech Environmental Services(Steam Enhanced Remediation (SER) at Ridgefield, WA)	V1
STC Remediation, Inc. (formerly Silicate Technology Corporation)	V1
Steam Enhanced Recovery Process	V1
Strategic Diagnostics, Inc. (Formerly EnSys Environmental Products, Inc.) (EnSys Penta Test System)	V3
Strategic Diagnostics, Inc. (EnviroGard™ PCB Immunoassay Test Kit)	V3
Strategic Diagnostics, Inc. (Immunoassay and Colorimetry)	V3
Strategic Diagnostics, Inc. (formerly Ohmicron Corporation) (RaPID Assay®)	V3
Subsurface Volatilization and Ventilation System (SVVS®)	V1
Supercritical Extraction/Liquid Phase Oxidation	V2
Surfactant Enhanced Aquifer Remediation of Nonaqueous Phase Liquids	V1
Svedala Industries, Inc. (see Metso Minerals Industries Inc.)	V2
TechXtract® Decontamination Process	V1
Tekno Associates Bioslurry Reactor	V2
Terra-Kleen Response Group, Inc	V1
TERRAMET® Soil Remediation System	V1
TerraTherm, Inc.	V1
Terra Vac	V1
Test Kits for Organic Contaminants in Soil and Water	V3
Texaco Gasification Process	V1
Texaco Inc	V1
Thermal Desorption System	V1
Thermal Desorption Unit	V1
Thermal Desorption & Vapor Extraction System	V1
Thermal Gas Phase Reduction Process and Thermal Desorption Unit	V1
Thermatrix, Inc. (formerly Purus, Inc.)	V2
THERM-0-DETOX® System	V1
Thermo Noran	V3
Thermo Nutech, Inc. (see Eberline Services, Inc.)	V2
Time Release Electron Acceptors and Donors for Accelerated Natural Attenuation	V1
TMA Thermo Analytical, Inc. (see Eberline Services.)	V2
TN 9000 and TN Pb X-Ray Fluorescence Analyzers	V3
TN Spectrace (see Thermo Noran)	V3
Toronto Harbour Commission	V1
Total Petroleum Hydrocarbon Field Soil Test Kit	V3
Toxic Treatment, Inc. (see Novaterra Associates)	V1
Tri-Services	V3
Trinity Environmental Technologies, Inc.	V2
Two-Zone, Plume Interception, In Situ Treatment Strategy	V2
Ultrasonic-Aided Leachate Treatment	V2
Ultraviolet Fluorescence Spectrometer	V3
Ultraviolet Radiation and Oxidation	V1
Ultrox, A Division of Zimpro Environmental, Inc. (see U.S. Filter/WTS Ultrox)	V1
United States Environmental Protection Agency (Excavation Techniques and Foam Suppression Methods)	V1
United Kingdom Atomic Energy Authority (formerly AEA Technology Environment)	V2
United States Environmental Protection Agency (Field Analytical Screening Program-PCB Method)	V3
United States Environmental Protection Agency (Field Analytical Screening Program-PCP Method)	V3
University of Houston	V2
University Of Idaho Research Foundation (formerly licensed to J.R. Simplot Company)	V1

TRADE NAME INDEX (Continued)

Company/Technology Name	Volume
University of Dayton Research Institute	V2
University of Miami (see High Voltage Environmental Applications, Inc.)	V1
University of Nebraska-Lincoln	V1
University of South Carolina	V2
University of Washington	V2
University of Wisconsin-Madison	V2
U.S. Air Force	V1
U.S. EPA (Field Analytical Screening Program - PCB Method)	V3
U.S. EPA NRMRL (Alternative Cover Assessment Program)	V1
U.S. EPA NRMRL (Base-Catalyzed Decomposition Process)	V1
U.S. EPA NRMRL (Bioventing)	V1
U.S. EPA NRMRL (Mobile Volume Reduction Unit)	V1
U.S. EPA NRMRL and IT Corporation	V1
U.S. EPA NRMRL and Intech 180 Corporation	V1
U.S. EPA NRMRL, U. of Cincinnati, and FRX, Inc.	V1
U.S. EPA Region 8 and State of Colorado	V1
U.S. EPA Region 9	V1
U.S. Filter (formerly Ultrox International, Inc.)	V1
U.S. Filter/Zimpro Inc. (see U.S. Filter)	V1
UV Technologies, Inc. (formerly Energy and Environmental Engineering, Inc.)	V2
UVB - Vacuum Vaporizing Well	V1
UV CATOXJ Process	V2
Vacuum-Vaporized Well System	V1
VaporSep® Membrane Process	V2
Vitrification Process	V1
Volume Reduction Unit	V1
Vortec Corporation	V1
Vulcan Peroxidation Systems, Inc. (see Calgon Carbon Advanced Oxidation Technologies)	V1
W.L. Gore and Associates, Inc.	V3
Waste Vitrification Through Electric Melting	V2
Wastech, Inc.	V1
Weiss Associates	V1
WES-PHix® Stabilization Process	V1
Western Product Recovery Group, Inc.	V2
Western Research Institute	V1
Western Research Institute	V2
Roy F. Weston, Inc. (Low Temperature Thermal Treatment System)	V1
Roy F. Weston, Inc. (Ambersorb® 563 Adsorbent)	V1
Roy F. Weston, Inc. (Ambersorb® 563 Adsorbent)	V2
Roy F. Weston, Inc./IEG Technologies	V1
Wetlands-Based Treatment	V2
Wilder Construction Company	V1
Weiss Associates	V1
Wilks Enterprise, Inc.	V3
Wheelabrator Clean Air Systems, Inc. (formerly Chemical Waste Management, Inc.)	V1
Wheelabrator Technologies, Inc.	V1
X-19 Biological Products	V1
Xerox Corporation	V1
X-Ray Treatment of Aqueous Solutions	V2
X-Ray Treatment of Organically Contaminated Soils	V2
X*TRAX® Thermal Desorption	V1
XL Spectrum Analyzer	V3
Xontech Incorporated	V3

TRADE NAME INDEX (Continued)

Company/Technology Name Volume

XonTech Sector Sampler	V3
ZenoGem™ Process	V1
Zenon Environmental Inc. (ZenoGem™ Process)	V1
Zenon Environmental Inc. (Cross-flow Pervaporation System)	V1
Zenon Environmental Inc. (Cross-flow Pervaporation System)	V2

APPLICABILITY INDEX

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Air	Aromatic VOCs	Biological Degradation	Media & Process Technology	Bioscrubber	2
			Remediation Technologies, Inc.	Biofilm Reactor for Chlorinated Gas Treatment	2
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical	ARS Technologies Inc.	Pneumatic Fracturing Extraction and Catalytic Oxidation	1
			ENERGIA, Inc.	Reductive Thermal and Photo-Thermal Oxidation for Enhanced Conversion of Chlorocarbons	2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Matrix Photocatalytic Inc	Photocatalytic Air Treatment	1/2
			Membrane Technology and Research, Inc.	VaporSep® Membrane Process	2
			Xerox Corporation	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Microsensor Systems, Inc.	MSI-301A Vapor Monitor	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Systems Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
Air (Cont.)	Aromatic VOCs (Cont.)	Spectrometers	Graseby Ionics, Ltd. and PCP Inc.	Ion Mobility Spectrometry	3
			XonTech, Inc.	XonTech Sector Sampler	3
		Thermal Destruction	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Air (Cont.)			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Dioxins	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Air Treatment	1/2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Spectrometers	Graseby Ionics Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
			Energy and Environmental Research Corp.	Reactor Filter System	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Furans	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Matrix Photocatalytic, Inc.	Photocatalytic Air Treatment	1/2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
			Energy and Environmental Research Corp.	Reactor Filter System	2
	Furans (Cont.)	Thermal Destruction	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Halogenated VOCs	Biological Degradation	Remediation Technologies, Inc.	Biofilm Reactor for Chlorinated Gas Treatment	2
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Air (Cont.)		Physical/Chemical Thermal Desorption	Process/Technologies, Inc.	Photolytic Destruction of Vapor-Phase Halogens	1
		Physical/Chemical Treatment	ARS Technologies Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Arizona State U./ Zentox Corp.	Photocatalytic Oxidation with Air Stripping	2
			ENERGIA, Inc.	Reductive Photo-Dechlorination Treatment	2
			ENERGIA, Inc.	Reductive Thermal and Photo-Thermal Oxidation Processes for Enhanced Conversion of Chlorocarbons	2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Air Treatment	1/2
			Membrane Technology and Research, Inc.	VaporSep® membrane Process	2
			Thermatrix Inc.	Photolytic Oxidation Process	2
			Roy F. Weston, Inc.	Ambersorb® 563 Adsorbent	2
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
	Halogenated VOCs (Cont.)	Portable Gas Chromatographs	Sentex Systems Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
			XonTech, Inc.	XonTech Sector Sampler	3
		Thermal Destruction	U. of Dayton Research Institute	Photothermal Detoxification Unit	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
	Herbicides	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Metals	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	General Atomics, Nuclear Remediation Technologies Division	Acoustic Barrier Particulate Separator	2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
		Portable Gas Chromatographs	HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Microsensor Systems, Inc.	MSI-301A Vapor Monitor	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
		Thermal Destruction	American Combustion, Inc.	PYRETRON® Thermal Destruction	1
Air (Cont.)	Metals (Cont.)	Thermal Destruction (Cont.)	Energy and Environmental Research Corp.	Reactor Filter Systems	2
	PAHs	Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			SRI Instruments	Compact Gas Chromatograph	3
	PCBs	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			Microsensor Systems, Inc.	MSI-301A Vapor Monitor	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
			Sentex Systems Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Graseby Ionics, Ltd., and PCP Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Pesticides	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Sentex Systems Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
Air (Cont.)	Pesticides (Cont.)	Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Petroleum Hydrocarbons	Portable Gas Chromatographs	SRI Instruments	Compact Gas Chromatographs	3
	SVOCs	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Process Technologies, Inc.	Photolytic Destruction of Vapor-Phase Halogens	1
		Physical/Chemical Treatment	ARS Technologies Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			ENERGIA, Inc.	Reductive Thermal and Photo-Thermal Oxidation Processes for Enhanced Conversion of Chlorocarbons	2
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
			XonTech, Inc.	XonTech Sector Sampler	3
		Thermal Destruction	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	VOCs	Biological Degradation	Media & Process Technologies Inc.	Bioscrubber	2
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Process Technologies, Inc.	Photolytic Destruction of Vapor-Phase Halogens	1
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
	Air (Cont.)	VOCs (Cont.)	Physical/Chemical Treatment (Cont.)	Arizona State U./ Zentox Corp.	Photocatalytic Oxidation with Air Stripping
ENERGIA, Inc.				Reductive Photo-Dechlorination Treatment	2
ENERGIA, Inc.				Reductive Thermal and Photo-Thermal Oxidation Processes for Enhanced Conversion of Chlorocarbon	2
KSE, Inc.				Adsorption-Integrated-Reaction Process	1
Matrix Photocatalytic Inc.				Photocatalytic Aqueous Phase Organic Destruction	1/2
Matrix Photocatalytic Inc.				Photocatalytic Air Treatment	1/2
Membrane Technology and Research, Inc.				VaporSep® Membrane Process	2
Thermatrix, Inc.				Photolytic Oxidation Process	2
Roy F. Weston, Inc.				Ambersorb® 563 Adsorbent	2
Xerox Corp.				2-PHASE™ EXTRACTION Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Air (Cont.)		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Microsensor Systems, Inc.	MSI-301A Vapor Monitor	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
	VOCs	Spectrometers	Environmental Technologies Group, Inc.	AirSentry Fourier Transform Infrared Spectrometer	3
			Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
			XonTech, Inc.	XonTech Sector Sampler	3
		Thermal Destruction	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
Gas	Aromatic VOCs	Biological Degradation	Media & Process Technology	Bioscrubber	2
			Remediation Technologies, Inc.	Biofilm Reactor for Chlorinated Gas Treatment	2
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			ENERGIA, Inc.	Reductive Thermal and Photo-Thermal Oxidation Processes for Enhanced Conversion of Chlorocarbons	2
			KSE, Inc.	Adsorption-Integrated-Reaction process	2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Air Treatment	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Gas (Cont.)			Membrane Technology and Research, Inc.	VaporSep® Membrane Process	2
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Microsensor Systems, Inc.	MSI-301A Vapor Monitor	3
	Aromatic VOCs (Cont.)	Portable Gas Chromatographs (Cont.)	Hewlett-Packard Company	Portable Gas Analyzer	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Graseby Ionics, Ltd.	Ion Mobility Spectrometry	3
			XonTech, Inc.	XonTech Sector Sampler	3
		Thermal Destruction	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Dioxins	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Air Treatment	1/2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	Energy and Environmental Research Corp.	Reactor Filter System	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
	Furans	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Air Treatment	1/2
Gas (Cont.)	Furans (Cont.)	Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	Energy and Environmental Research Corp.	Reactor Filter System	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Halogenated VOCs	Biological Degradation	Remediation Technologies, Inc.	Biofilm Reactor for Chlorinated Gas Treatment	2
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Process Technologies, Inc.	Photolytic Destruction of Vapor-Phase Halogens	1
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Arizona State U./ Zentox Corp.	Photocatalytic Oxidation with Air Stripping	2
			ENERGIA, Inc.	Reductive Photo-Dechlorination Treatment	2
			ENERGIA, Inc.	Reductive Thermal and Photo-Thermal Oxidation process for Enhanced Conversion of Chlorocarbons	2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Air Treatment	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Gas (Cont.)			Membrane Technology and Research, Inc.	VaporSep® Membrane Process	2
			Thermatrix, Inc.	Photolytic Oxidation Process	2
	Halogenated VOCs (Cont.)	Physical/Chemical Treatment (Cont.)	Roy F. Weston, Inc.	Ambersorb® 563 Adsorbent	2
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
			XonTech, Inc.	XonTech Sector Sampler	3
		Thermal Destruction	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Heavy Metals	Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
	Herbicides	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Metals	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	General Atomics, Nuclear Remediation Technologies Div.	Acoustic Barrier Particulate Separator	2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Gas (Cont.)	Metals (Cont.)	Portable Gas Chromatographs	HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Microsensor Systems, Inc.	MSI-301A Vapor Monitor	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
		Thermal Destruction	American Combustion, Inc.	PYRETRON® Thermal Destruction	1
			Energy and Environmental Research Corp.	Reactor Filter System	2
	PAHs	Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			SRI Instruments	Compact Gas Chromatograph	3
	PCBs	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Treatment	Matrix Photocatalytic, Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Microsensor Systems, Inc.	MSI-301A Vapor Monitor	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
			Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Pesticides	Material Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
Gas (Cont.)	Pesticides (Cont.)	Physical/Chemical Treatment	Matrix Photocatalytic, Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Gas (Cont.)		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Petroleum Hydrocarbons	Portable Gas Chromatograph	SRI Instruments	Compact Gas Chromatograph	3
	SVOCs	Material Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Process Technologies, Inc.	Photolytic Destruction of Vapor-Phase Halogens	1
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	2
			ENERGIA, Inc.	Reductive Thermal and Photo-Thermal Oxidation Processes for Enhanced Conversion of Chlorocarbons	2
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
			XonTech, Inc.	XonTech Sector Sampler	3
		Thermal Destruction	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	VOCs	Biological Degradation	Media & Process Technology	Bioscrubber	2
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Gas (Cont.)		Physical/Chemical Thermal Desorption	Process Technologies, Inc.	Photolytic Destruction of Vapor-Phase Halogens	1
		Physical/Chemical Treatment	ARS Technologies, inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Arizona State U/ Zentox Corp.	Photocatalytic Oxidation with Air Stripping	2
			AWD Technologies, Inc.	Aqua Detox®/SVE System	1
			ENERGIA, Inc.	Reductive Photo-Dechlorination Treatment	2
			ENERGIA, Inc.	Reductive Thermal and Photo-Thermal Oxidation Processes for Enhanced Conversion of Chlorocarbons	2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Air Treatment	1/2
			Membrane Technology and Research, Inc.	VaporSep® Membrane Process	2
			Thermatrix, Inc.	Photolytic Oxidation Process	2
			Roy F. Weston, Inc.	Ambersorb® 563 Adsorbent	2
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.,	HNU GC 311D Portable Gas Chromatograph	3
	VOCs (Cont.)	Portable Gas Chromatographs (Cont.)	Microsensor Systems, Inc.	MSI-301A Vapor Monitor	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Environmental Technologies Group, Inc.	AirSentry Fourier Transform Infrared Spectrometer	3
			Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
			XonTech, Inc.	XonTech Sector Sampler	3
		Thermal Destruction	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
Ground water	Aromatic VOCs	Biological Degradation	Billings and Associates, inc.	Subsurface Volatilization and Ventilation Systems (SVVS®)	1
			Bio-Rem, Inc.	Augmented in Situ Subsurface Bioremediation Process	1
			BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			New York State Department of Environmental Conservation/R.E. Wright Environmental Inc.	In Situ Bioventing Treatment System	1
			Harding ESE, a MacTech Co.	Two-Zone, Plume Interception, Inc Situ Treatment Technology	1/2
			IT Corporation	Oxygen Microbubbles In Situ Bioremediation	2
Ground water (Cont.)	Aromatic VOCs (Cont.)	Biological Degradation (Cont.)	ZENON Environmental Inc.	ZenoGem™ Process	1
		Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
		Physical/Chemical Thermal Desorption	Hughes Environmental Systems, Inc.	Steam Enhanced Recovery Process	1
			NOVATERRA, Associates	In Situ Soil Treatments (Steam/Air Stripping)	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Western Research Institute	Contained Recovery of Oily Wastes (CROW™)	2
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	2
			Terra Therm Inc. age Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Thermatrix, Inc.	X-ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
	Aromatic VOCs (Cont)	Physical/Chemical Treatment (Cont)	Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			U. of Nebraska - Lincoln	Center Pivot Spray Irrigation System	1
			Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
			ZENON Environmental Inc.	Cross-Flow Pervaporation System	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
		Thermal Destruction	Texaco Inc.	Texaco Gasification Process	1
	Aromatic VOCs (Cont)	Thermal Destruction (Cont)	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Cyanide	Biological Degradation	Pintail Systems, Inc.	Spent Ore Bioremediation Process	1/2
		Physical/Chemical Treatment	E & C Williams, Inc.	Calcium Sulfide and Calcium Polysulfide Technologies	3
	Diesel	Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
		Physical/Chemical Thermal Desorption	Integrated Water Resources, Inc.	Dynamic Underground Stripping of TCE	1
			Steam Tech Environmental Services	Steam Enhanced Remediation	1
		Spectrometers	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
	Dioxins	Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	GAS-Phase Chemical Reduction Process	1
			Integrated Water Resources	Dynamic Underground Stripping of TCE	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			SteamTech Environmental Services	Steam Enhanced Remediation	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			IT Corporation	KMnO4 Oxidation of TCE	1
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
Ground water (Cont)	Dioxins	Physical/Chemical Treatment (Cont)	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Explosives	Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
	Furans	Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	3
	Furans (Cont)	Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Gasoline	Materials Handling	Integrated Water Resources Inc.	Dynamic Underground Stripping of TCE	1
			National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
			SteamTech Environmental Services	Steam Enhanced Remediation	1
		Spectrometers	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Halogenated VOCs	Biological Degradation	ASC/EMR Wright-Patterson AFB	Phytoremediation of TCE-Contaminated Shallow Groundwater	2
			Bio-Rem, Inc.	Augmented in Situ Subsurface Bioremediation Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)			BioTrol, Inc.	Methanotrophic Bioreactor System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			Harding ESE, a MacTech Co.	Two-Zone, Plume Interception, In Situ Treatment Technology	1/2
			New York State Department of Environmental Conservation/Science Applications International Corp.	In Situ Bioventing Treatment System	1
			ZENON Environmental Inc.	ZenoGem™ Process	1
	Halogenated VOCs (Cont)	Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
		Physical Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1/2
		Physical/Chemical Thermal Desorption	Hughes Environmental Systems, Inc.	Steam Enhanced Recovery Process	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			NOVATERRA Associates	In Situ Soil Treatments (Steam/Air Stripping)	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Western Research Institute	Contained Recovery of Oily Wastes (CROW™)	2
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Arizona State U./ Zentox Corp.	Photocatalytic Oxidation with Air Stripping	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground Water (Cont)			EnviroMetal Technologies, Inc.	In Situ and Ex Situ Metal Enhanced Abiotic Degradation of Dissolved Halogenated Organic Compounds in Groundwater	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
	Halogenated VOCs (Cont)	Physical/Chemical Treatment	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
			U. of Nebraska - Lincoln	Center Pivot Spray Irrigation System	4
			UV Technologies, Inc.	PhotoCAT™ Process	2
			Roy F. Weston, Inc.	Ambersorb® 563 Adsorbent	2
			Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
			ZENON Environmental Inc.	Cross-Flow Pervaporation System	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
	Halogenated VOCs (Cont)	Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	Texaco Inc.	Texaco Gasification Process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Heavy Metals	Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Thermal Destruction	Terra Therm, Inc.	In-Situ Thermal Destruction	1
	Herbicides	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	1/2
			Phytokinetics, Inc.	Phytoremediation of Contaminated Soils	2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Physical Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ in Situ Soil Remediation	1/2
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)	Herbicides (Cont)	Physical/Chemical Treatment (Cont)	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics Inc.	RaPID Assay®	1
		Thermal Destruction	BWX Technologies Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Metals	Biological Degradation	Colorado Dept. of Public Health and Environment	Wetlands-Based Treatment	2
			Pintail Systems, Inc.	Biominalization of Metals	1/2
			Pintail Systems, Inc.	Spent Ore Bioremediation Process	1/2
			Resource Management & Recovery	AlgaSORB® Biological Sorption	2
		Field Portable X-ray Fluorescence	Metorex, Inc.	Field Portable X-ray Fluorescence Analysis	3
		Physical Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1/2
		Physical/Chemical Radioactive Waste Treatment	Filter Flow Technology, Inc.	Colloid Polishing Filter Method®	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
Ground water (Cont)	Metals	Physical/Chemical Treatment	Atomic Energy of Canada, Ltd.	Chemical Treatment and Ultrafiltration	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			E.I. DuPont de Nemours and Co. and Oberlin Filter Co.	Membrane Microfiltration	1
			Dynaphore, Inc.	FORAGER® Sponge	1
			EPOC Water, Inc.	Precipitation, Microfiltration, and Sludge Dewatering	1
			E & C Williams, Inc.	Calcium Sulfide and Calcium Polysulfide Technologies	3
			General Environmental Corp.	CURE® Electrocoagulation Wastewater Treatment System	1
			Geokinetics International, Inc.	Electrokinetics For NSFO Mobilization	1
			Geokinetics, International, Inc.	Electrokinetic Remediation Process	1
			Lockheed Martin Missiles and Space Co. And Geokinetics International, Inc.	Electrokinetic Remediation Process	1
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Morrison Knudsen Corp./Spetstamonazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			RECRA Environmental, Inc.	Alternating Current Electrocoagulation Technology	2
			Selentec Environmental Technologies, Inc.	Selentec MAG*SEP Technology	1
			U. of Washington	Adsorptive Filtration	2
			U. of Wisconsin - Madison	Photoelectrocatalytic Degradation and Removal	2
		Portable Gas Chromatographs	E&C Williams	Chemical Stabilization Of Mercury Mining Wastes	1
Ground water (Cont)	Metals (Cont)	Portable Gas Chromatographs (Cont)	HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	2
			Hewlett-Packard Company	Portable Gas Analyzer	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)		Solidification/Stabilization	E&C Williams	Chemical Stabilization of Mercury Mining Wastes	1
			Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Thermal Destruction	BWX Technologies Inc.	Cyclone Furnace	1/2
	Organics	Biological Degradation	ASC/EMR Wright-Patterson AFB	Phytoremediation of TCE in Shallow Groundwater	1
			Harding ESE, a MacTech Company	Two-Zone, Plume Interception, In Situ Treatment Strategy	1/2
			Regenesis	Time Released Electron Acceptors & Donors for Accelerated Natural Attenuation	1
		Physical/Chemical Treatment	Current Environmental Solutions	Six-Phase Heating of TCE	1
			IT Corporation	KMnO4 (Potassium Permanganate) Oxidation of TCE	1
			Geokinetics International, Inc.	Electrokinetics for NSFO Mobilization	1
			Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1/2
		Thermal Destruction	Current Environmental Solutions	Six-Phase Heating of TCE	1
			Terra Therm, Inc	In Situ Thermal Destruction	1
	PAHs	Physical/ Chemical Treatment	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			SRI Instruments	Compact Gas Chromatograph	3
	PAHs (Cont)	Spectrometers	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	PCBs	Biological Degradation	Gas Technology Institute	Chemical and Biological Treatment	2
			Phytokinetics, Inc.	Phytoremediation of Contaminated Soils	2
			Phytokinetics, Inc.	Phytoremediation Process	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)			ZENON Environmental Inc.	ZenoGem™ Process	1
		Field Portable X-ray Fluorescence	Metorex, Inc.	Field portable X-ray Fluorescence Analysis	3
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High Energy Beam Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
	PCBs (Cont)	Physical/Chemical Treatment (Cont)	Morrison Knudsen Corp./Spetstamponazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidations	1
			U. of Wisconsin - Madison	Photoelectrocatalytic Degradation and Removal	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
			Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Hanby Environmental Laboratory Procedures, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	PCP	Physical/Chemical Treatment	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
	PCP (Cont)	Physical/Chemical Treatment (Cont)	U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
			Strategic Diagnostics, Inc.	PENTA RISC Test System	3
		Test Kits	Strategic Diagnostics Inc.	RaPID Assay®	3
	Pesticides	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injections	2
			Gas Technology Institute	Chemical and Biological Treatment	2
			Phytokinetics, Inc.	Phytoremediation of Contaminated Soils	3
			Phytokinetics, Inc.	Phytoremediation Process	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)			ZENON Environmental Inc.	ZenoGem™ Process	1
			ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency heating	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Process	1
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
	Pesticides (Cont)	Physical/Chemical Treatment (Cont)	Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Morrison Knudsen Corp./Spetstamonazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
			U. of Wisconsin - Madison	Photoelectrocatalytic Degradation and Removal	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	PENTA RISC Test System	3
			Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Petroleum Hydrocarbons	Biological Degradation	Regenesis	Time Released Electron Acceptors & Donors for Accelerated Natural Attenuation	1
	Petroleum Hydrocarbons (Cont)	Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1/2
		Portable Gas Chromatographs	SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Horiba Instruments, Inc.	Infrared Analysis	3
			SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
			Wilks Enterprise, Inc.	Infrared Analysis	3
		Test Kits	Idetek, Inc.	Equate® Immunoassay	3
	Radionuclides	Physical/Chemical Radioactive Waste Treatment	Filter Flow Technology, Inc.	Colloid Polishing Filter Method(R)	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)		Physical/Chemical Treatment	Atomic Energy of Canada, Ltd.	Chemical Treatment and Ultrafiltration	2
			Selentec Environmental Technologies, Inc.	Selentec MAG* SEP Technology	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
	SVOCs	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			Harding ESE, a MacTech Company	Two-Zone, Plume Interception, In Situ Treatment Technology	1/2
	SVOCs (Cont)	Biological Degradation	Gas Technology Institute	Chemical and Biological Treatment	2
			New York State Dept. of Environmental/ Science Applications International Corp.	In Situ Bioventing Treatment System	1
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			NOVATERRA Associates	In Situ Soil Treatments (Steam/Air Stripping)	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Western Research Institute	Contained Recovery of Oily Wastes (CROW™)	2
		Physical/Chemical Treatment	ARS Technologies Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
	SVOCs	Physical/Chemical Treatment (Cont)	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			U. of Wisconsin - Madison	Photoelectrocatalytic Degradation and Removal	2
			Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies Inc.	Cyclone Furnace	1/2
			Texaco Inc.	Texaco Gasification process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)		Other	Berkeley Environmental Restoration Center	In Situ Steam Enhanced Extraction Process	1
	VOCs	Biological Degradation	Argonne National Laboratory	Development of Phytoremediation	1
			ASC/EMR Wright-Patterson AFB	Phytoremediation of TCE in Shallow Groundwater	1
	VOCs (Cont)	Biological Degradation (Cont)	Billings and Associates, Inc.	Subsurface Volatilization and Ventilation System (SVVS®)	1
			Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			BioTrol, Inc.	Biological Aqueous Treatment System	1
			Earth Tech/Westinghouse Savannah River Company	Enhanced In Situ Bioremediation of Chlorinated Compounds in Groundwater	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			Earth Tech, Inc.	In Situ Enhanced Bioremediation of Groundwater	1
			New York State Dept. of Environmental/Science Applications International Corp.	In Situ Bioventing Treatment System	1
			New York State Dept. of Environmental Conservation/SBP Technologies, Inc.	Groundwater Circulation Biological Treatment Process	1
			Phytokinetics, Inc.	Phytoremediation of Contaminated Soils	2
			Phytokinetics, Inc.	Phytoremediation Process	1/2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)		Physical/Chemical Thermal Desorption	Hughes Environmental Systems, Inc.	Steam Enhanced Recovery Process	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
	VOCs (Cont)	Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
			NOVATERRA Associates	In Situ Soil Treatments (Steam/Air Stripping)	1
			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Western Research Institute	Contained Recovery of Oily Wastes (CROW™)	2
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Arizona State U./ Zentox Corp.	Photocatalytic Oxidation with Air Stripping	2
			AWD Technologies, Inc.	Aqua Detox(R)/SVE Systems	1
			Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Radian International LLC	Integrated AquaDetox Steam Vacuum Stripping and Soil Vapor Extraction/Reinjection	1
			Mactec-SBP Technologies Company, LLC	No VOCs™ In-Well Stripping Technology	1
			EnviroMetal Technologies, Inc.	In Situ and Ex Situ Metal Enhanced Abiotic Degradation of Dissolved Halogenated Organic Compounds in Groundwater	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Ground water (Cont)	VOCs (Cont)	Physical/Chemical Treatment	IT Corporation	KMnO ₄ Oxidation of TCE	1
			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Morrison Knudsen Corp./Spetstamonazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
			U. of Nebraska - Lincoln	Center Pivot Spray Irrigation System	1
			UV Technologies, Inc.	PhotoCAT™ Process	2
			Roy F. Weston, Inc.	Ambersorb® 563 Adsorbent	2
			Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
			ZENON Environmental Inc.	Cross-Flow Pervaporation System	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Hewlett-Packard Company	Portable Gas Analyzer	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
Ground water (Cont)	VOCs (Cont)	Portable Gas Chromatographs (Cont)	Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
			Strategic Diagnostics Inc.	RaPID Assay®	3
		Thermal Destruction	Texaco, Inc.	Texaco Gasification Process	1
	Not Applicable	Capping/Containment	U.S. EPA NRMRL	Alternative Cover Assessment Program (ACAP)	1
	Other	Physical/Chemical Treatment	North American Technologies Group, Inc.	Oleophilic Amine-Coated Ceramic Chip	1
			RECRA Environmental, Inc.	Alternating Electrocoagulation Technology	2
Leachate	Aromatic VOCs	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	NOVATERRA Associates	In Situ Soil Treatments (Steam/Air Stripping)	1
			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
		Physical/Chemical Treatment	CF Systems, Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
Leachate (Cont)	Aromatic VOCs (Cont)	Physical/Chemical Treatment (Cont)	High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)			Magnum Water Technology	CA-OX® Process	1
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			ZENON Environmental Inc.	Cross-Flow Pervaporation System	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Sentex Systems, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Methods	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Hanby Environmental Laboratory procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
	Cyanide	Biological Degradation	Pintail Systems, Inc.	Spent Ore Bioremediation Process	1/2
	Diesel	Spectrometers	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Dioxins	Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies Inc.	Cyclone Furnace	1/2
	Explosives	Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
	Furans	Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
	Furans (Cont)	Physical/Chemical Treatment	High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Aqueous Phase Organic Destruction	1/2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)		Test Kits	Strategic Diagnostics Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies Inc.	Cyclone Furnace	1/2
	Gasoline	Spectrometers	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Halogenated VOCs	Biological Degradation	BioTrol, Inc.	Methanotrophic Bioreactor System	2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
			NOVATERRA Associates	In-Situ Soil Treatments (Steam/Air Stripping)	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			EnviroMetal Technologies Inc.	In Situ and Ex Situ Metal Enhanced Abiotic Degradation of Dissolved Halogenated Organic Compounds in Groundwater	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
	Halogenated VOCs (Cont)	Physical/Chemical Treatment (Cont)	High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Magnum Water Technology	CAV-OX® Process	1
			Matrix Photocatalytic Aqueous Phase Organic Destruction	Photocatalytic Aqueous Phase Organic Destruction	1/2
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
			UV Technologies, Inc.	PhotoCAT™ Process	2
			Roy F. Weston, Inc.	Ambersorb® 563 Adsorbent	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)			ZENON Environmental Inc.	Cross-Flow Pervaporation System	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Sentex Systems, Inc	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
	Halogenated VOCs (Cont)	Thermal Destruction	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
	Heavy Metals	Thermal Destruction	IGT	Thermal Sediment Reuse Technologies	1
	Herbicides	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			Magnum Water Technology	CAV-OX® Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	Inorganics	Thermal Destruction	IGT	Thermal Sediment Reuse Technology	1
	Metals	Biological Degradation	Colorado Dept. Of Public Health and Environment	Wetlands-Based Treatment	1
			Pintail Systems, Inc.	Biominalization of Metals	2
			Pintail Systems, Inc.	Spent Ore Bioremediation Process	1
		Field Portable X-ray Fluorescence	Metorex, Inc.	Field Portable X-ray Fluorescence Analysis	3
		Physical/Chemical Radioactive Waste Treatment	Filter Flow Technology, Inc.	Heavy Metals and Radionuclide Polishing Filter	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
		Physical/Chemical Treatment	Atomic Energy of Canada, Ltd.	Chemical Treatment and Ultrafiltration	2
			Atomic Energy of Canada, Ltd.	Ultrasonic-Aided Leachate Treatment	2
			E.I. DuPont de Nemours and Co., and Oberlin Filter Co.	Membrane Microfiltration	1
			Dynaphore, Inc.	FORAGER® Sponge	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)			EPOC Water, Inc.	Precipitation, Microfiltration, and Sludge Dewatering	1
			General Environmental Corp.	CURE [®] Electrocoagulation Wastewater Treatment System	1
			Geokinetics, International, Inc.	Electrokinetic Remediation Process	1
			Lewis Environmental Services, Inc./ Hickson Corp.	Chromated Copper Arsenate Soil Leaching Process	2
	Metals (Cont)	Physical/Chemical Treatment (Cont)	Lockheed Martin Missiles and Space Co. and Geokinetics International, Inc.	Electrokinetic Remediation Process	1
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Morrison Knudsen Corp./Spetstamonazh geologia Enterprises/ STG Technologies	Clay-Base Grouting Technology	1
			RECRA Environmental, Inc.	Alternating Current Electrocoagulation Technology	2
			Region 8 and State of Colorado	Multiple Innovative Passive Mine Drainage Technologies	1
			Selentec Environmental Technologies, Inc.	Selentec MAG*SEP Technology	1
			U. of Washington	Adsorption Filtration	2
		Portable Gas Chromatographs	HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
		Solidification/Stabilization	Wheelabrator Clean Air System, Inc.	PO*WW*ER [™] Technology	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
	Organics	Thermal Destruction	IGT	Thermal Sediment Reuse Technology	1
	PAHs	Physical/Chemical Treatment	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	PAHs (Cont)	Thermal Destruction (Cont)	IGT	Thermal Sediment Reuse Technology	1
	PCBs	Biological Degradation	ZENON Environmental Inc.	ZenoGem™ Process	1
		Field Portable X-ray Fluorescence	Metorex, Inc.	Field Portable X-ray Fluorescence Analysis	3
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			Magnum Water Technology	CAV-OX® Process	1
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Morrison Knudsen Corp./Spetstamponazh geologia Enterprises/ STG Technologies	Clay-Base Grouting Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
Leachate (Conte)	PCBs (Cont)	Portable Gas Chromatographs (Cont)	Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Methods	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	PENTA RISC Test Systems	3
			Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
		Thermal Destruction	IGT	Thermal Sediment Reuse Technology	1
	PCP	Physical/Chemical Treatment	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
		Test Kits	Strategic Diagnostics, Inc.	PENTA RISC Test System	3
			Strategic Diagnostics, Inc.	RaPID Assay®	3
	Pesticides	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)	Pesticides (Cont)	Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			Magnum Water Technology	CAV-OX® Process	1
			Photocatalytic Air Treatment Photocatalytic Inc.	Photocatalytic Water Treatment	1
			Morrison Knudsen Corp./Spetstamponazh geologia Enterprises/ STG Technologies	Clay-Base Grouting Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/ Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	PENTA RISC Test System	3
Leachate (Cont)	Pesticides (Cont)	Test Kits (Cont)	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)			Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
	Petroleum Hydrocarbons	Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatments	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Horiba Instruments, Inc.	Infrared Analysis	3
			SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Radionuclides	Physical/Chemical Radioactive Waste Treatment	Filter Flow Technology, Inc.	Heavy Metals and Radionuclide Polishing Filter	1
		Physical/Chemical Treatment	Atomic Energy of Canada, Ltd.	Chemical Treatment and Ultrafiltration	2
			Atomic Energy of Canada, Ltd.	Ultrasonic-Aided Leachate Treatment and Ultrafiltration	3
			Selentec Environmental Technologies, Inc.	Selentec MAG*SEP Technology	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Terra Therm	In Situ Thermal Destruction	1
	SVOCs	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			ZENON Environmental Inc.	ZenoGem™ Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			Novaterra Associates	In Situ Soil Treatments (Steam/Air Stripping)	1
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
	SVOCs (Cont)	Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	VOCs	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Leachate (Cont)			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
			Novaterra Associates	In Situ Soil Treatment (Steam/Air Stripping)	1
			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			EnviroMetal Technologies Inc.	In Situ and Ex Situ Metal Enhanced Abiotic Degradation of Dissolved Halogenated Organic Compounds in Groundwater	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Morrison Knudsen Corp./Spetstamponazh geologia Enterprises/ STG Technologies	Clay-Base Grouting Technology	1
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
	VOCs (Cont)	Physical/Chemical Treatment (Cont)	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
			UV Technologies, Inc.	PhotoCAT™ Process	2
			Roy F. Weston, Inc.	Ambersorb® 563 Adsorbent	2
			ZENON Environmental, Inc.	Cross-Flow Pervaporation System	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
			Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
	Not Applicable	Capping/Containment	Wilder Construction Co.	Matcon Modified Asphalt Cap	1
Leachate (Cont)	Other	Physical/Chemical Treatment	North American Technologies Group, Inc.	Oleophilic Amine-Coated Ceramic Chip	1
	Other (Cont)	Physical/Chemical Treatment (Cont)	RECRA Environmental, Inc.	Alternating Current Electrocoagulation Technology	2
Liquid	Aromatic VOCs	Biological Degradation	Billings and Associates, Inc.	Subsurface Volatilization and Ventilation System (SVVS®)	1
			Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			Harding ESE, a Mactec Co.	Two-Zone Plume Interception, In Situ Treatment Technology	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)			New York State Dept. Of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
			IT Corporation	Oxygen Microbubble In Situ Bioremediation	2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
		Physical/Chemical Thermal Desorption	Hughes Environmental Systems, Inc.	Steam Enhanced Recovery Process	1
			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Western Research Institute	Contained Recovery of Oil Wastes (CROW™)	2
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
	Aromatic VOCs (Cont)	Physical/Chemical Treatment (Cont)	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			U. of Nebraska - Lincoln	Center Pivot Spray Irrigation System	1
			Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
			ZENON Environmental Inc.	Cross-Flow Pervaporation System	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
	Aromatic VOCs (Cont)	Portable Gas Chromatographs (Cont)	SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
		Thermal Destruction	Texaco Inc.	Texaco Gasification Process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Cyanide	Biological Degradation	Pintail Systems, Inc.	Spent Ore Bioremediation Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)	Diesel	Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
		Spectrometer	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Dioxins	Physical/Chemical Thermal Desorption	ELI Eco Logic International, Inc.	Gas-Phase Chemical Reduction Process	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
	Dioxins (Cont)	Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Explosives	Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
	Furans	Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
	Furans (Cont)	Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Gasoline	Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
		Spectrometer	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Halogenated VOCs	Biological Degradation	ASC/EMR Wright-Patterson AFB	Phytoremediation of TCE-Contaminated Shallow Groundwater	1
			Harding ESE, a Mactec Co.	Two-Zone Plume Interception, In Situ Treatment Technology	1/2
			Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			BioTrol, Inc.	Methanotrophic Bioreactor System	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)			New York State Dept. Of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
			IT Corporation	Oxygen Microbubble In Situ Bioremediation	2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
	Halogenated VOCs (Cont)	Physical Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1/2
		Physical/Chemical Thermal Desorption	Hughes Environmental Systems, Inc.	Steam Enhanced Recovery Process	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Process	1
			Western Research Institute	Contained Recovery of Oily Wastes (CROW™)	2
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Arizona State U/Zentox Corp.	Photocatalytic Oxidation with Air Stripping	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
	Halogenated VOCs (Cont)	Physical/Chemical Treatment (Cont)	Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
			U. of Nebraska - Lincoln	Center Pivot Spray Irrigation System	1
			UV Technologies, Inc.	PhotoCAT™ Process	2
			Roy F. Weston, Inc./IEG Technologies	Ambersorb 563 Adsorbent	2
			Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
			ZENON Environmental Inc.	Cross-Flow Pervaporation System	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	Texaco Inc.	Texaco Gasification Process	1
	Halogenated VOCs (Cont)	Thermal Destruction (Cont)	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Heavy Metals	Chemical Treatment	Concurrent Technologies	Organics Destruction and Metals Stabilization	2
		Field Portable X-ray Fluorescence	HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P) X-ray Fluorescence Analyzer	3
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Herbicides	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			ZENON Environmental Inc.	ZenoGem™ Process	1
		Physical Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1/2
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	4
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)	Herbicides (Cont)	Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	Inorganics	Chemical Treatment	Kvaerner Energy & Environment	Chemical Treatment	2
		Field Portable X-ray Fluorescence	HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P) X-ray Fluorescence Analyzer	3
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Metals	Biological Degradation	Colorado Dept. of Public Health and Environment	Wetlands-Based Treatment	2
			Pintail Systems, Inc.	Biominalization of Metals	2
			Pintail Systems, Inc.	Spent ore Bioremediation Process	1
			Resource Management & Recovery	AlgaSORB® Biological Sorption	2
		Field Portable X-ray Fluorescence	HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P) X-ray Fluorescence Analyzer	3
			Metorex, Inc.	Field Portable X-ray Fluorescence Analysis	3
		Physical/Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)	Metals (Cont)	Physical/Chemical Radioactive Waste Treatment	Filter Flow Technology, Inc.	Heavy Metals and Radionuclide Polishing Filter	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
			Rochem Separation Systems, Inc.	Rochem Disc TUBE™ Module System	1
		Physical/Chemical Treatment	Atomic Energy of Canada, Ltd.	Chemical Treatment and Ultrafiltration	2
			E.I. DuPont de Nemours and Co. and Oberlin Filter Co.	Membrane Microfiltration	1
			Dynaphore, Inc.	FORAGER® Sponge	1
			EPOC Water, Inc.	Precipitation, Microfiltration, and Sludge Dewatering	1
			General Environmental Corp.	CURE® Electrocoagulation Wastewater Treatment System	1
			Geokinetics, International, Inc.	Electrokinetic Remediation Process	1
			Lewis Environmental Services, Inc./ Hickson Corp.	Chromated Copper Arsenate Soil Leaching Process	2
			Lockheed Martin Missiles and Space Co. and Geokinetics International, Inc.	Electrokinetic Remediation process	2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Morrison Knudsen Corp./Spetstamonazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			RECRA Environmental, Inc.	Alternating Current Electrocoagulation Technology	2
			Selentec Environmental Technologies, Inc.	Selentec MAG*SEP Technology	1
Liquid (Cont)	Metals (Cont)	Physical/Chemical Treatment (Cont)	U. of Washington	Adsorptive Filtration	2
			U. of Wisconsin - Madison	Photoelectrocatalytic Degradation and Removal	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)		Portable Gas Chromatographs	HUN Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
			Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Gas Technology Institute	Cement-Lock Technology	1
	Organics	Chemical Treatment	Concurrent Technologies	Organics Destruction and Metals Stabilization	2
			Kvaerner Energy & Environment	Chemical Treatment	2
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	PAHs	Physical/Chemical Treatment	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatograph	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometer	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	PCBs	Biological Degradation	ZENON Environmental Inc.	ZenoGem™ Process	1
		Field Portable X-ray Fluorescence	Metorex, Inc.	Field Portable X-ray Fluorescence Analysis	3
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
	PCBs (Cont)	Physical/Chemical Thermal Desorption (Cont)	KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High Energy Beam Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Morrison Knudsen Corp./Spetstamonazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidations	1
			U. of Wisconsin - Madison	Photoelectrocatalytic Degradation and Removal	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Sentex Sensing Technology, inc.	Scentograph Plus II Portable Gas Chromatograph	3
Liquid (Cont)	PCBs (Cont)	Portable Gas Chromatographs (Cont)	SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
			Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)		Test Kits	Strategic Diagnostics, Inc.	PENTA RISC Test System	3
			Hanby Environmental Laboratory Procedures, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Gas Technology Institute	Cement-Lock Technology	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
	PCP	Physical/Chemical Treatment	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
		Test Kits	Strategic Diagnostics, Inc.	PENTA RISC Test System	3
			Strategic Diagnostics, Inc.	RaPID Assay®	3
	Pesticides	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injections	3
			ZENON Environmental Inc.	ZenoGem™ Process	1
	Pesticides (Cont)	Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency heating	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Process	1
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Beam Irradiation	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Morrison Knudsen Corp./Spetstamonazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
			U. of Wisconsin - Madison	Photoelectrocatalytic Degradation and Removal	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
	Pesticides (Cont)	Portable Gas Chromatographs (Cont)	U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	PENTA RISC Test System	3
			Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
			Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
	Petroleum Hydrocarbons	Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	SRI Instruments	Compact Gas Chromatograph	3
		Spectrometers	Horiba Instruments, Inc.	Infrared Analysis	3
			SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
Liquid (Cont)	Radionuclides	Physical/Chemical Radioactive Waste Treatment	Filter Flow Technology, Inc.	Heavy Metals and Radionuclide Polishing Filter	1
		Physical/Chemical Treatment	Atomic Energy of Canada, Ltd.	Chemical Treatment and Ultrafiltration	2
			Selentec Environmental Technologies, Inc.	Selentec MAG*SEP Technology	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	SVOCs	Biological Degradation	BioTrol, Inc.	Biological Aqueous Treatment System	1
			Harding ESE, a Mactec Co.	Two-Zone, Plume Interception, In Situ Treatment Technology	1/2
			New York State Dept. Of Environmental Conservation/R.E. Wright Environmental Inc.	In Situ Bioventing Treatment System	1
			IT Corporation	Oxygen Microbubble In Situ Bioremediation	2
			ZENON Environmental Inc.	ZenoGem™ Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Western Research Institute	Contained Recovery of Oily Wastes (CROW™)	2
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
	SVOCs (Cont)	Physical/Chemical Treatment (Cont)	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1/2
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			U. of Wisconsin - Madison	Photoelectrocatalytic Degradation and Removal	2
			Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
	SVOCs (Cont)	Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Texaco Inc.	Texaco Gasification process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
		Other	Berkeley Environmental Restoration Center	In Situ Steam Enhanced Extraction Process	1
	VOCs	Biological Degradation	ASC/EMR Wright-Patterson AFB	Phytoremediation of TCE-Contaminated Shallow Groundwater	1
			Billings and Associates, Inc.	Subsurface Volatilization and Ventilation System (SVVS®)	1
			Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			BioTrol, Inc.	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			New York State Dept. of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
			IT Corporation	Oxygen Microbubble In Situ Bioremediation	2
			ZENON Environmental Inc.	ZenoGem™ Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)		Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX, Inc.	Hydraulic Fracturing	1
		Physical/Chemical Thermal Desorption	Hughes Environmental Systems, Inc.	Steam Enhanced Recovery Process	1
	VOCs (Cont)	Physical/Chemical Thermal Desorption (Cont)	KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Western Research Institute	Contained Recovery of Oily Wastes (CROW™)	2
		Physical/Chemical Treatment	ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Arizona State U./ Zentox Corp.	Photocatalytic Oxidation with Air Stripping	2
			Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Radian International LLC	Integrated AquaDetox Steam Vacuum Stripping and Soil Vapor Extraction/Reinjection	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	2
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)			Morrison Knudsen Corp./Spetstamonazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			Pulse Sciences, Inc.	X-ray Treatment of Aqueous Solutions	2
	VOCs (Cont)	Physical/Chemical Treatment (Cont)	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			U.S. Filter/Zimpro Inc.	Ultraviolet Radiation and Oxidation	1
			U. of Nebraska - Lincoln	Center Pivot Spray Irrigation System	1
			UV Technologies, Inc.	PhotoCAT™ Process	2
			Roy F. Weston, Inc.	Ambersorb® 563 Adsorbent	2
			Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
			ZENON Environmental Inc.	Cross-Flow Pervaporation System	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Liquid (Cont)		Test Kits	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
			Strategic Diagnostics, Inc.	RaPID Assay®	3
	VOCs (Cont)	Thermal Destruction	Texaco Inc.	Texaco Gasification Process	1
		Other	Berkeley Environmental Restoration Center	In Situ Steam Enhanced Extraction Process	1
	Other	Physical/Chemical Treatment	North American Technologies Group, Inc.	Oleophilic Amine-Coated Ceramic Chip	1
			RECRA Environmental, Inc.	Alternating Electrocoagulation Technology	2
Mine Tailings	Heavy Metals	Thermal Destruction	Terra Therm, Inc	In-Situ Thermal Destruction	1
	Metals	Materials Handling	U. of South Carolina	In Situ Mitigation of Acid Water	2
	Organics	Thermal Destruction	Terra Therm, Inc	In-Situ Thermal Destruction	1
	Radionuclides	Thermal Destruction	Terra Therm, Inc	In-Situ Thermal Destruction	1
Sediment	Aromatic VOCs	Biological Degradation	Bio-Rem Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			New York State Dept. Of Environmental Conservation/ENSR Consulting and Larsen Engineers	Ex Situ Biovault	1
			New York State Dept. Of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			IT Corporation	Oxygen Microbubble In Situ Bioremediation	2
Sediment (Cont)	Aromatic VOCs (Cont)	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
			Biotherm, LLC	Carver-Greenfield Process® for Solvent Extraction of Wet, Oily Wastes	1
		Physical/Chemical Thermal Desorption	Maxymillian Technologies, Inc.	Thermal Desorption System	1
			Novaterra Associates	In-Situ Soil Treatments (Steam/Air Stripping)	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ^{3®}) System	1
		Physical/Chemical Treatment	Bergmann, A Division of Linatex, Inc.	Soil and Sediment Washing	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Gas Technology Institute	Supercritical Extraction/Liquid Phase Oxidation	2
			Ionics/Resources Conservation Co.	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
Sediment (Cont)	Aromatic VOCs (Cont)	Solidification/Stabilization	Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			WASTECH, Inc.	Solidification and Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
			Texaco Inc.	Texaco Gasification Process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Oxidation and Vitrification Process	1
	Cyanide	Biological Degradation	Pintail Systems, Inc.	Spent Ore Bioremediation Process	1
		Physical/Chemical Treatment	E & C Williams, Inc.	Calcium Sulfide and Calcium Polysulfide Technologies	3
	Diesel	Physical/Chemical Thermal Desorption	Integrated Water Resources, Inc.	Dynamic Underground Stripping of TCE	1
	Dioxins	Biological Degradation	BioTrol, Inc.	Soil Washing System	1
		Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic International Inc.	Thermal Desorption Unit	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ^{3®}) System	1
	Dioxins (Cont)	Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Ionics/Resources Conservation Co.	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory and IT Corp.	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			Terra-Kleen Response Group	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Geosafe Corp.	In Situ Vitrification	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Desorption	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Reactor Filter system	2
	Dioxins (Cont0	Thermal Desorption (Cont)	Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Oxidation and Vitrification Process	1
		Thermal Destruction	Terra Therm, Inc.	In-Situ Thermal Destruction	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
	Explosives	Biological Degradation	U. of Idaho Research Foundation	The SABRE™ Process	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
	Furans	Biological Degradation	BioTrol, Inc.	Soil Washing System	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic International Inc.	Thermal Desorption Unit	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ^{3®}) System	1
		Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Ionics/Resources Conservation Co.	B.E.S.T. Solvent Extraction Technology	1
	Furans (Cont)	Physical/Chemical Treatment (Cont)	IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory and IT Corp.	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			Terra-Kleen Response Group	Solvent Extraction Treatment System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Geosafe Corp.	In Situ Vittrification	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Desorption	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Reactor Filter system	2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Oxidation and Vittrification Process	1
	Gasoline	Physical/Chemical Thermal Desorption	Integrated Water Resources Inc.	Dynamic Underground Stripping of TCE	1
	Halogenated VOCs	Biological Degradation	BioTrol, Inc.	Soil Washing System	1
	Halogenated VOCs (Cont)	Biological Degradation (Cont)	Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			U. of Idaho Research Foundation	The SABRE™ Process	1
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)		Physical Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1/2
		Physical/Chemical Thermal Desorption	ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic International Inc.	Thermal Desorption Unit	1
			Maxymillian Technologies, Inc.	Thermal Desorption System	1
			IT Corporation	X*TRAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ³ ®) System	1
		Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			Bergmann, A Division of Linatex, Inc.	Soil and Sediment Washing	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
	Halogenated VOCs (Cont)	Physical/Chemical Treatment (Cont)	Ionics/Resources Conservation Co.	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Retech, M4 Environmental Management, Inc.	Plasma Arc Vitrification	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Oxidation and Vitrification Process	1
	Heavy Metals	Physical/Chemical Treatment	Geokinetics International, Inc.	Electrokinetics for Lead Recovery	1
		Solidification/ Stabilization	Institute of Gas Technology	Cement-Lock Technology	1
		Thermal Destruction	Institute of Gas Technology	Cement-Lock Technology	1
			Institute of Gas Technology	Thermal Sediment Reuse Technology	1
	Inorganic	Physical/Chemical Treatment	Weiss Associates	Electro Chemical Remediation Technologies	1
		Solidification/ Stabilization	Institute of Gas Technology	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
			Gas Technology Institute	Thermal Sediment Reuse Technology	1
	Mercury	Physical/Chemical Treatment	Weiss Associates	Electro Chemical Remediation Technologies	1
	Metals	Biological Degradation	Geo-Microbial Technologies, Inc.	Metals Release and Removal from Wastes	1
			Edenspace, Inc.	Phytoremediation Technology	1
			Pintail Systems, Inc.	Biominalization of Metals	2
			Pintail Systems, Inc.	Spent ore Bioremediation Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)		Field Portable X-ray Fluorescence	NITON Corp.	XL Spectrum Analyzer	3
			Edax Portable Products Division Corp.	Metal Analysis Probe (MAP®) Portable Assayer	3
			Thermo Measure Tech	9000 X-Ray Fluorescence Analyzer and Lead X-Ray Fluorescence Analyzer	3
		Materials Handling	AEA Technology, PLC, National Environmental Technology Centre	Soil Separation and Washing Process	2
			Montana College of Mineral Science and Technology	Campbell Centrifugal Jig	2
			U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
			U. of South Carolina	In Situ Mitigation of Acid Water	2
	Metals (Cont)	Physical Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1/2
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	Bergmann, A Division of Linatex, Inc.	Soil and Sediment Washing	1
			BioGenesis Enterprises, Inc.	BioGenesis™ Soil and Sediment Washing	1
			COGNIS, Inc.	Chemical Treatment	1
			Concurrent Technologies	Acid Extraction Treatment System	2
			Dynaphore, Inc.	FORAGER® Sponge	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			E & C Williams, Inc.	Calcium Sulfide and Calcium Polysulfide Technologies	3
			Geokinetics International, Inc.	Electrokinetic Remediation Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			General Atomics, Nuclear Remediation Technologies Div.	Acoustic Barrier Particulate Separator	2
			IT Corp.	Batch Steam Distillation and Metal Extraction	2
			IT Corp.	Chelation/Electrodeposition of Toxic Metals from Soils	2
			IT Corp.	Mixed Waste Treatment Process	2
			Lockheed Martin Missiles and Space Co. And Geokinetics International, Inc.	Electrokinetic Remediation Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
	Metals (Cont)	Physical/Chemical Treatment (Cont)	Selentec Environmental Technologies, Inc.	Selentec MAG*SEP Technology	1
			Toronto Harbor Commission	Soil Recycling	1
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			Ferro Corp.	Waste Vitrification Through Electric Melting	2
			EmTech Environmental Services	Dechlorination and Immobilization	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			Geosafe Corp.	In Situ Vitrification	1
			Institute of Gas Technology	Cement-Lock Technology	1
			Sevenson Environmental Services, Inc.	MAECTITE® Chemical Treatment Process	1
			Soliditech, Inc.	Solidification and Stabilization	1
			SOLUCORP Industries	Molecular Bonding System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			STC Remediation, A Division of Omega Environmental, Inc.	Organic Stabilization and Chemical Fixation/ Solidification	1
			WASTECH, Inc.	Solidification and Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
			Wheelabrator Technologies Inc.	WES-PHix® Stabilization Process	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
Sediment (Cont)	Metals (Cont)	Thermal Destruction (Cont)	Energy and Environmental Research Corp.	Reactor Filter System	2
			Gas Technology Institute	Cement-Lock Technology	1
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Horsehead Resource Development Co., Inc.	Flame Reactor	1
			Minergy Corp.	Glass Furnace Technology for Dredged Sediments	1
			Retech, M4 Environmental Management, Inc.	Plasma Arc Vitrification Combustor	1
			Vortec Corp.	Oxidation and Vitrification Process	1
	Organics	Physical/Chemical Treatment	Weiss Associates	Electro Chemical Remediation Technologies	1
		Thermal Destruction	Gas Technology Institute	Thermal Sediment Reuse Technology	1
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
		Thermal Destruction	Gruppo Italimpresse	Infrared Thermal Destruction	1
	PAHs	Biological Degradation	Ecova Corp.	Bioslurry Reactor	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
		Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
		Physical/Chemical Thermal Desorption	Maxymillian Technologies, Inc.	Thermal Desorption and Vapor Extraction System	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
		Physical/Chemical Treatment	Bergmann, a Division of Linatex, Inc.	Soil and Sediment Washing	1
	PAHs (Cont)	Physical/Chemical Treatment (Cont)	BioGenesis Enterprises, Inc.	BioGenesis™ Soil and Sediment Washing Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Thermal Destruction	Gas Technology Institute	Thermal Sediment Reuse Technology	1
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
	PCBs	Biological Degradation	Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Integrated Water Resources, Inc.	Dynamic Underground Stripping of TCE	1
			Phytokinetics, Inc.	Phytoremediation Process	1
		Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Carver-Greenfield Process® for Solvent Extraction of Wet, Oily Wastes	1
			ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic International Inc.	Thermal Desorption Unit	1
			KAI Technologies, Inc./ Brown and Root Environmental	Radio Frequency Heating	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			New Jersey Institute of Technology	GHEA Associates Process	2
			IT Corporation	X*TRAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ^{3®}) System	1
	PCBs (Cont)	Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			Bergmann, A Division of Linatex, Inc.	Soil and Sediment Washing	1
			BioGenesis Enterprises, Inc.	BioGenesis™ Soil and Sediment Washing Process	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Commodore Environmental Services, Inc.	Solvated Electron Remediation System	1
			General Atomics	Circulating Bed Combustor	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Ionics/Resources Conservation Co.	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			State U. of New York at Oswego, Environmental Research Center	Photocatalytic Degradation of PCB-Contaminated Sediments and Waters	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
	PCBs (Cont)	Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			EmTech Environmental Services	Dechlorination and Immobilization	1
			Gas Technology Institute	Cement-Lock Technology	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			Geosafe Corp.	In Situ Vitrification	1
			Minergy	Thermal Sediment Reuse Technology	1
			Soliditech, Inc.	Solidification and Stabilization	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Millipore Corporation	EnviroGard™ PCP Immunoassay Test Kit	3
			Strategic Diagnostics, Inc.	EnSys Penta Test System	3
			Strategic Diagnostics Inc.	EnviroGard(TM) PCB Immunoassay Test Kit	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Gas Technology Institute	Cement-Lock Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)	PCBs (Cont)	Thermal Destruction (Cont)	Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Gas Technology Institute	Thermal Sediment Reuse Technology	1
			Minergy Corp.	Glass Furnace Technology for Dredged Sediments	1
			Retech, M4 Environmental Management, Inc.	Plasma Arc Vitrification	1
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Oxidation and Vitrification Process	2
	PCP	Biological Degradation	Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
		Physical/Chemical Thermal Desorption	Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
		Physical/Chemical Treatment	Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Test Kits	Strategic Diagnostics, Inc.	ENSYS Penta Test System	3
			Strategic Diagnostics, Inc.	RaPID Assay®	3
	Pesticides	Biological Degradation	BioTrol, Inc.	Soil Washing System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
Sediment (Cont)	Pesticides (Cont)	Biological Degradation (Cont)	Phytokinetics, Inc.	Phytoremediation Process	1
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Carver-Greenfield Process® for Solvent Extraction of Wet, Oily Wastes	1
			ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic International Inc.	Thermal Desorption Unit	1
			KAI Technologies, Inc./ Brown and Root Environmental	Radio Frequency Heating	1
			IT Corporation	X*TRAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ³ ®) System	1
		Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			Bergmann, A Division of Linatex, Inc.	Soil and Sediment Washing	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Commodore Environmental Services, Inc.	Solvated Electron Remediation System	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			General Atomics	Circulating Bed Combustor	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
Sediment (Cont)	Pesticides (Cont)	Physical/Chemical Treatment (Cont)	High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Ionics/Resources Conservation Co.	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			State U. of New York at Oswego, Environmental Research Center	Photocatalytic Degradation of PCB-Contaminated Sediments and Waters	2
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program PCB Method	2
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			EmTech Environmental Services	Dechlorination and Immobilization	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			Geosafe Corp.	In Situ Vittrification	1
			Soliditech, Inc.	Solidification and Stabilization	1
			WASTECH, Inc.	Solidification and Stabilization	1
Sediment (Cont)	Pesticides (Cont)	Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	EnSys Penta Test System	3
			Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Retech, M4 Environmental Management, Inc.	Plasma Arc Vitrification	1
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Oxidation and Vitrification Process	1
	Petroleum Hydrocarbons	Biological Degradation	Ecova Corp.	Bioslurry Reactor	1
			Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Association process	2
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
		Thermal Destruction	Terra Therm, Inc.	In-Situ Thermal Destruction	1
		Solidification/Stabilization	Soliditech, Inc.	Solidification and Stabilization	1
	Radionuclides	Materials Handling	Eberline Services	Segmented Gate System	2
		Physical/Chemical Treatment	Bergmann, A Division of Linatex, Inc.	Soil and Sediment Washing	1
Sediment (Cont)	Radionuclides (Cont)	Physical/Chemical Treatment (Cont)	IT Corp.	Mixed Waste Treatment Process	2
			Selentec Environmental Technologies, Inc.	Selentec MAG*SEP Technology	1
		Solidification/Stabilization	Sevenson Environmental Services, Inc.	MAECTITE® Chemical Treatment Process	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	SVOCs	Biological Degradation	BioTrol, Inc.	Soil Washing System	1
			Ecova Corp.	Bioslurry Reactor	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
			IT Corp.	Tekno Associates Bioslurry Reactor	2
			New York State Dept. Of Environmental Conservation/ENSR Consulting and Larsen Engineers	Ex Situ Biovault	1
			New York State Dept. Of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
			IT Corporation	Oxygen Microbubble In Situ Bioremediation	2
			Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
	SVOCs (Cont)	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Carver-Greenfield Process® for Solvent Extraction of Wet, Oily Wastes	1
			ELI Eco Logic International Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic International Inc.	Thermal Desorption Unit	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			Maxymillian Technologies, Inc.	Thermal Desorption System	1
			New Jersey Institute of Technology	GHEA Association process	2
			NOVATERRA Associates	In-Situ Soil Treatments (Steam/Air Stripping)	1
			IT Corporation	X*TRAX™ Thermal Desorption	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA [®])	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ^{3®}) System	1
		Physical/Chemical Treatment	Bergmann, A Division of Linatex, Inc.	Soil and Sediment Washing	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	1/2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Ionics/Resources Conservation Co.	B.E.S.T. Solvent Extraction Technology	1
	SVOCs (Cont)	Physical/Chemical Treatment (Cont)	IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			Toronto Harbor Commission	Soil Recycling.	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			STC Remediation, a Division of Omega Environmental, Inc.	Organic Stabilization and Chemical Fixation/ Solidification	1
			WASTECH, Inc.	Solidification and Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
	SVOCs (Cont)	Thermal Destruction (Cont)	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
			Texaco Inc.	Texaco Gasification Process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Oxidation and Vitrification Process	1
	VOCs	Biological Degradation	Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			Ecova Corp.	Bioslurry Reactor	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			New York State Dept. Of Environmental Conservation/ENSR Consulting and Larsen Engineers	Ex Situ Biovault	1
			New York State Dept. Of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			IT Corporation	Oxygen Microbubble In Situ Bioremediation	2
			Phytokinetics, Inc.	Phytoremediation Process	2
		Materials Handling	AEA Technology, PLC, National Environmental Technology Centre	Soil Separation and Washing Process	2
			U.S. EPA	Excavation Techniques and Foam Suppression methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Carver-Greenfield Process® for Solvent Extraction of Wet, Oily Wastes	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
Sediment (Cont)	VOCs (Cont)	Physical/Chemical Thermal Desorption (Cont)	Maxymillian Technologies, Inc.	Thermal Desorption System	1
			New Jersey Institute of Technology	GHEA Association process	2
			NOVATERRA Associates	In-Situ Soil Treatments (Steam/Air Stripping)	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ³ ®) System	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1/2
			Gas Technology Institute	Supercritical Extraction/Liquid Phase Oxidation	2
			Ionics/Resources Conservation Co.	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Batch Steam Distillation and Metal Extraction	2
			IT Corp.	Mixed Waste Treatment Process	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sediment (Cont)			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program PCB Method	3
		Solidification/Stabilization	Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			WASTECH, Inc.	Solidification and Stabilization	1
	VOCs (Cont)	Solidification/Stabilization (Cont)	Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Retech, M4 Environmental Management, Inc.	Plasma Arc Vitrification	1
			Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
			Texaco Inc.	Texaco Gasification Process	1
			Vortec Corp.	Oxidation and Vitrification Process	1
	Other	Samplers	Aquatic Research Instruments	Sediment Core Sampler	3
		Solidification/Stabilization	STC Remediation, A Division of Omega Environmental, Inc.	Organic Stabilization and Chemical Fixation/Solidification	1
			U.S. EPA NRMRL	Alternative Cover Assessment Program	1
	Not Applicable	Sampler	Art's Manufacturing and Supply	Sediment Core Sampler	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge	Aromatic VOCs	Biological Degradation	Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			Electrokinetics, Inc.	In Situ Bioremediation By Electrokinetic Injection	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
Sludge (Cont)	Aromatic VOCs (Cont)	Biological Degradation (Cont)	New York State of Dept. of Environmental Conservation/ENSR Consulting and Larsen Engineers	Ex Situ Biovault	1
			New York State Dept. of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
			IT Corp.	Oxygen Microbubble In Situ Bioremediation	2
		Materials Handling	United States Environmental Protection Agency	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			Maxymillian Technologies, Inc.	Thermal Desorption System	1
			Novaterra Associates	In-Situ Soil Treatments (Steam/Air Stripping)	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Beam Irradiation	

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)	Aromatic VOCs (Cont)	Physical/Chemical Treatment (Cont)	High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Gas Technology Institute	Supercritical Extraction/Liquid Phase Oxidation	2
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			United States Environmental Protection Agency	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			WASTECH, Inc.	Solidification/Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Absorption Treatment	2
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
			Texaco, Inc.	Texaco Gasification Process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	Cyanide	Biological Degradation	Pintail Systems, Inc.	Spent Ore Bioremediation Process	1
	Dioxins	Biological Degradation	Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
		Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
		Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic International Inc.	Thermal Desorption Unit	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
Sludge (Cont)	Dioxins (Cont)	Physical/Chemical Thermal Desorption (Cont)	Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3®) Systems	1
		Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory	Debris Washing System	1
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Geosafe Corp.	GeoMelt Vitrification	1
			WASTECH, Inc.	Solidification/Stabilization	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Reactor Filter System	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
Sludge (Cont)	Dioxins (Cont)	Thermal Destruction (Cont)	Vortec Corp.	Vitrification Process	1
	Explosives	Biological Degradation	U. of Idaho Research Foundation	The SABRE™ Process	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Solidification/Stabilization	Retech, Inc.	Plasma Heat	1
		Thermal Desorption	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Reactor Filter System	2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	Halogenated VOCs	Biological Degradation	Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			New York State Dept. of Environmental Conservation/ENSR Consulting and Larsen Engineers	Ex Situ Biovault	1
			New York State Dept. of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
			IT Corp.	Oxygen Microbubble In Situ Bioremediation	2
		Materials Handling	United States Environmental Protection Agency	Excavation Techniques and Foam Suppression Methods	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)	Halogenated VOCs (Cont)	Physical/Chemical Treatment - Biological Degradation	Lasagna™ Public-Private Partnership	Lasagna™ In Situ Soil Remediation	1
		Physical/Chemical Thermal Desorption	KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			NOVATERRA Associates	In-Situ Soil Treatments (Steam/Air Stripping)	1
			IT Corporation	X*TRAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3®) System	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Commodore Environmental Services, Inc.	Solvated Electron Remediation System	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Gas Technology Institute	Supercritical Extraction/Liquid Phase Oxidation	2
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
	Halogenated VOCs (Cont)	Physical/Chemical Treatment (Cont)	Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			United States Environmental Protection Agency	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			WASTECH, Inc.	Solidification/Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Texaco, Inc.	Texaco Gasification Process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	Heavy Metals	Field Portable X-Ray Fluorescence	HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P) X-Ray Fluorescence Analyzer	3
		Chemical Treatment	Concurrent Technologies	Organic Destruction and Metal Stabilization	1
		Physical/Chemical Treatment	Active Environmental, Inc.	TechXtract® Decontamination Process	1
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Heavy Minerals	Materials Handling	Montana College of Mineral Science and Technology	Campbell Centrifugal Jig	2
		Solidification/Stabilization	Retech, Inc.	Plasma Heat	1
	Herbicides	Biological Degradation	Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			U. of Idaho Research Foundation	The SABRE™ Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)	Herbicides (Cont)	Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical Chemical Treatment - Biological Degradation	Lasagna™ Public - Private Partnership	Lasagna™ In Situ Soil Remediation	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic Inc.	Thermal Desorption Unit	1
			Maxymillian Technologies, Inc.	Thermal Desorption System	1
			IT Corporation	X*TRAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA3)	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3®)	1
		Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SC) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
		Physical/Chemical Treatment (Cont)	IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			WASTECH, Inc.	Solidification and Stabilization	1
		Test Kits	Strategic Diagnostics, Inc. Corp	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	Inorganics	Field Portable X-Ray Fluorescence	HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P)	3
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
			Retech, Inc.	Plasma Heat	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Mercury	Physical/Chemical Treatment	Active Environmental Inc.	TechXtract® Decontamination Process	1
			Geokinetics	Electrokinetics for NSFO Mobilization	1
		Solidification/Stabilization	Retech, Inc.	Plasma Heat	1
	Metals	Biological Degradation	Geo-Microbial Technologies, Inc.	Metals Release & Removal from Waste	2
			Phytotech	Phytoremediation Technology	1
			Pintail Systems, Inc.	Biominalization of Metals	2
			Pintail Systems, Inc.	Spent Ore Bioremediation Process	1
		Field Portable X-Ray Fluorescence	HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P) X-Ray Fluorescence Analyzer	3
			NITON Corp.	XL Spectrum Analyzer	3
			TN Spectrace	9000 X-Ray Fluorescence Analyzer and Lead X-Ray Fluorescence Analyzer	3
		Materials Handling	AEA Technology Environment	Soil Separation and Washing Process	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			Montana College of Mineral Science and Technology	Campbell Centrifugal Jig	2
			United States Environmental Protection Agency	Excavation Techniques and Foam Suppression Methods	1
			U. of South Carolina	In Situ Mitigation of Acid Water	2
		Physical Chemical Treatment - Biological Degradation	Lasagna™ Public-Private Partnership	Lasagna™ In Situ Soil Remediation	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	BioGenesis Enterprises, Inc.	BioGenesis SM Soil & Sediment Washing Process	1
			Center for Hazardous Materials Research	Acid Extraction Treatment System	2
			COGNIS, Inc.	TERRAMET Soil Remediation System	1
			Dynaphore, Inc.	FORAGER® Sponge	1
	Metals (Cont)	Physical/Chemical Treatment (Cont)	Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			General Atomics, Nuclear Remediation Technologies Division	Acoustic Barrier Particulate Separator	2
			IT Corp.	Batch Steam Distillation and Metal Extraction	2
			IT Corp.	Chelation/Electrodeposition of Toxic Metals from Soils	2
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			Selentec Environmental Technologies, Inc.	Selentec MAG*SEP Technology	1
			Toronto Harbor Commission	Soil Recycling	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			Ferro Corp.	Waste Vittrification through Electric Melting	2
			Funderburk & Associates	Dechlorination and Immobilization	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			Gas Technology Institute	Cement-Lock Technology	1
			Geosafe Corp.	GeoMelt Vittrification	1
			Metso Minerals Industries, Inc.	Pyrkiln Thermal Encapsulation Process	2
			Rocky Mountain Remediation Services, LLC	Envirobond Solution	1
	Metals (Cont)	Solidification/Stabilization (Cont)	Sevenson Environmental Services, Inc.	MAECTITE® Chemical Treatment Process	1
			Soliditech, Inc.	Solidification and Stabilization	1
			Star Organics, LLC	Soil Rescue Remediation Fluid	1
			STC Remediation, A Division of Omega Environmental, Inc.	Organic Stabilization and Chemical Fixation/ Solidification	1
			WASTECH, Inc.	Solidification and Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Absorption Treatment	2
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Energy and Environmental Research Corp.	Reactor Filter System	2
			Gas Technology Institute	Cement-Lock Technology	1
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			Horsehead Resource Development Co., Inc.	Flame Reactor	1
			PSI Technologies, A Division of Physical Sciences Inc.	Metals Immobilization and Decontamination of Aggregate Solids	2
			Vortec Corp.	Vitrification Process	1
	Organics	Chemical Treatment	Concurrent Technologies	Organic Destruction & Metals Stabilization	2
		Physical/Chemical Treatment	Geokintetics	Electrokinetics for NSFO Mobilization	1
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
	Organics (Cont0	Solidification/Stabilization (Cont)	Retech, Inc.	Plasma Heat	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	PAHs	Biological Degradation	Ecova Corp.	Bioslurry Reactor	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation process	2
			Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
		Chemical Treatment Desorption	Biotherm, LLC	Biotherm Process™	1
		Physical/Chemical Thermal Desorption	Maxymillian Technologies, Inc.	Thermal Desorption System	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
		Physical/Chemical Treatment	BioGenesis Enterprises, Inc.	BioGenesis SM Soil & Sediment Washing Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
	PCBs	Biological Degradation	Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)		Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
		Materials Handling	United States Environmental Protection Agency	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic, Inc.	Thermal Desorption Unit	1
	PCBs (Cont)	Physical/Chemical Thermal Desorption (Cont)	KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			IT Corporation Remediation Services Corp.	X*TRAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3®) System	1
		Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			BioGenesis Enterprises, Inc.	BioGenesis SM Soil & Sediment Washing Process	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Commodore Environmental Service, Inc.	Solvated Electron Remediation System	1
			General Atomics	Circulating Bed Combustor	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
	PCBs (Cont)	Physical/Chemical Treatment (Cont)	National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			State U. of New York at Oswego, Environmental Research Center	Electrochemical Peroxidation of PCB-Contaminated Sediments and Waters	2
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			United States Environmental Protection Agency	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			Funderburk & Associates	Dechlorination and Immobilization	1
			Gas Technology Institute	Cement-Lock Technology	1
			Geo-Con Inc.	In Situ Solidification and Stabilization Process	1
			Geosafe Corp.	GeoMelt Vittrification	1
			Soliditech, Inc.	Solidification and Stabilization	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	Ensys Penta Test System	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)	PCBs (Cont)	Thermal Destruction (Cont)	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Gas Technology Institute	Cement Lock Technology	1
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	PCP	Biological Degradation	Remediation Technology, Inc.	Liquid and Solids Biological Treatment	1
		Physical/Chemical Thermal Desorption	Recycling Sciences International Inc.	Desorption and Vapor Extraction System	1
		Physical/Chemical Treatment	Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Test Kits	Strategic Diagnostics, Inc.	Ensys Penta Test System	3
			Strategic Diagnostics, Inc.	RaPID Assay [®]	3
	Pesticides	Biological Degradation	Electrokinetics, Inc.	In Situ Bioremediation By Electrokinetic Injection	2
			Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Grace Bioremediation Technologies	DARAMEND [™] Bioremediation Technology	1
		Materials Handling	United States Environmental Protection Agency	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process [™]	1
Sludge (Cont)	Pesticides (Cont)	Physical/Chemical Thermal Desorption (Cont)	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic Inc.	Thermal Desorption Unit	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			IT Corporation	X*TRAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3®) System	1
		Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			CF Systems Corp.	Liquefied Gas Solvent Extraction (LG-SX) Technology	1
			Commodore Environmental Services, Inc.	Solvated Electron Remediation System	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			General Atomics	Circulating Bed Combustor	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
	Pesticides (Cont)	Physical/Chemical Treatment (Cont)	National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			State U. of New York at Oswego, Environmental Research Center	Electrochemical Peroxidation of PCB-Contaminated Sediments and Waters	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			United States Environmental Protection Agency	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			Funderburk & Associates	Dechlorination and Immobilization	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			Geosafe Corp.	GeoMelt Vittrification	1
			Soliditech, Inc.	Solidification and Stabilization	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd. and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	Ensys Penta Test System	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
	Pesticides (Cont)	Thermal Destruction (Cont)	Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	PCP	Biological Degradation	Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
		Physical/Chemical Thermal Desorption	Recycling Sciences International Inc.	Desorption and Vapor Extraction System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)		Physical/Chemical Treatment	Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Test Kits	Strategic Diagnostics, Inc.	Ensys Penta Test System	3
			Strategic Diagnostics, Inc. Corp.	RaPID Assay®	3
	Pesticides	Biological Degradation	Electrokinetics, Inc.	In Situ Bioremediation By Electrokinetic Injection	2
			Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
		Materials Handling	United States Environmental Protection Agency	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic, Inc. Inc.	Thermal Desorption Unit	1
			KAI Technology, Inc./Brown and Root Environmental	Radio Frequency Heating	1
	Pesticides (Cont)	Physical/Chemical Thermal Desorption (Cont)	IT Corporation	X*TRAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3®) System	1
		Physical/Chemical Treatment	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			Commodore Environmental Services, Inc.	Solvated Electron Remediation System	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			General Atomics	Circulating Bed Combustor	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			State U. of New York at Oswego, Environmental Research Center	Electrochemical Peroxidation of PCB-Contaminated Sediments and Waters	2
	Pesticides (Cont)	Physical/Chemical Treatment (Cont)	Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			United States Environmental Protection Agency	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			Funderburk & Associates	Dechlorination and Immobilization	1
			Geo-Con Inc.	In Situ Solidification and Stabilization Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			Geosafe Corp.	GeoMelt Vitrification	1
			Soliditech, Inc.	Solidification and Stabilization	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	Ensys Penta Test System	3
			Strategic Diagnostics, Inc. Corp.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy & Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	Petroleum Hydrocarbons	Biological Degradation	Ecova Corp.	Bioslurry Reactor	1
			Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
		Solidification/Stabilization	Soliditech, Inc.	Solidification and Stabilization	1
	Radio Nuclides	Materials Handling	Thermo Nutech, Inc.	Segmented Gate System	2
		Physical/Chemical Treatment	Active Environmental Technologies, Inc.	Tech Xtract® Decontamination Process	1
			IT Corp.	Mixed Waste Treatment Process	2
			Selentec Environmental Technologies, Inc.	Selentec MAG*SEP Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)		Solidification/ Stabilization	Sevenson Environmental Services, Inc.	MAECTITE® Chemical Treatment Process	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	SVOCs	Biological Degradation	Ecova Corp.	Bioslurry Reactor	1
			Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
			IT Corp.	Tekno Associates Bioslurry Reactor	2
	SVOCs (Cont)	Biological Degradation (Cont)	New York State Dept. of Environmental Conservation/ENSR Consulting and Larsen Engineers	Ex Situ Biovault	1
			New York State Dept. of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
			IT Corp.	Oxygen Microbubble In Situ Bioremediation	2
			Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
		Materials Handling	United States Environmental Protection Agency	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic, Inc.	Thermal Desorption Unit	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			Maxymillian Technologies, Inc.	Thermal Desorption System	1
			New Jersey Institute of Technology	GHEA Associates Process	1
			NOVATERRA Associates	In Situ Soil Treatments (Stream/Air Stripping)	1
			IT Corporation	X*TRAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
	SVOCs (Cont)	Physical/Chemical Thermal Desorption (Cont)	Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3®) System	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory and IT Corp.	Debris Washing System	1
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			Toronto Harbor Commission	Soil Recycling	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			United States Environmental Protection Agency	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
Sludge (Cont)	SVOCs (Cont)	Solidification/Stabilization (Cont)	STC Remediation, a Division of Omega Environmental, Inc.	Organic Stabilization and Chemical Fixation/Solidification	1
			WASTECH, Inc.	Solidification and Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Absorption Treatment	2
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc. Corp.	RaPID Assay®	3
		Thermal Desorption	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
			Texaco, Inc.	Texaco Gasification Process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	VOCs	Biological Degradation	Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			Ecova Corp.	Bioslurry Reactor	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			New York State Dept. of Environmental Conservation/ENSR Consulting and Larsen Engineering	Ex Situ Biovault	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			New York State Dept. of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
Sludge (Cont)	VOCs (Cont)	Biological Degradation (Cont)	IT Corp.	Oxygen Microbubble In Situ Bioremediation	2
		Materials Handling	AEA Technology Environment	Soil Separation and Washing Process	2
			United States Environmental Protection Agency	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			Maxymillian Technologies, Inc.	Thermal Desorption System	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			NOVATERRA Associates	In-Situ Soil Treatments (Steam/Air Stripping)	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3®) System	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Gas Technology Institute	Supercritical Extraction/Liquid Phase Oxidation	2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Batch Steam Distillation and Metal Extraction	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Sludge (Cont)			IT Corp.	Mixed Waste Treatment Process	2
	VOCs (Cont)	Physical/Chemical Treatment (Cont)	Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			United States Environmental Protection Agency	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			WASTECH, Inc.	Solidification and Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics Inc.	RaPID Assay®	3
		Thermal Destruction	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
			Texaco, Inc.	Texaco Gasification Process	1
			Vortec Corp.	Vitrification Process	1
	Other	Solidification/Stabilization	STC Remediation, A Division of Omega Environmental, Inc.	Organic Stabilization and Chemical Fixation/ Solidification	1
Soil	Aromatic VOCs	Biological Degradation	Billings and Associates, Inc.	Subsurface Volatilization and Ventilation System (SVVS)	1
			Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
Soil (Cont)	Aromatic VOCs (Cont)	Biological Degradation (Cont)	Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
			Harding Lawson Associates	Two Zone, Plume Interception. In Situ Treatment Technology	2
			Hazardous Substance Management Research Center at New Jersey Institute of Technology, and Rutgers, the State U. of New Jersey	Pneumatic Fracturing and Bioremediation Process	2
			Micro-Bac International Inc.	Microbial Degradation PCBs	1
			National Risk Management Research Laboratory	Bioventing	1
			New York State Dept. of Environment Conservation/ENSR Consulting and Larson Engineers	Ex Situ Biovault	1
			New York State Dept. of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
			IT Corp.	Oxygen Microbubble In Situ Bioremediation	2
		Contaminant Survey Systems	W.L. Gore and Associates, Inc.	GORE-SORBER Screening Survey	2
		Materials Handling	National Risk Management Research Laboratory, the U of Cincinnati and FRX, Inc.	Hydraulic Fracturing	1
	Aromatic VOCs (Cont)	Materials Handling (Cont)	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			Hughes Environmental Systems, Inc.	Steam Enhanced Recovery Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			Maxymillian Technologies, Inc.	Thermal Desorption System	1
			NOVATERRA Associates	In-Situ Soil Treatments, (Steam/Air Stripping)	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3™) System	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Bergmann, a Division of Linatex, Inc.	Soil and Sediment Washing	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			Energia, Inc.	Reductive Thermal and Photo-Thermal Oxidation for Enhanced Conversion of Chlorocarbons	2
			Gas Technology Institute	Supercritical Extraction/Liquid Phase Oxidation	2
			High Voltage Environmental Application, Inc.	High-Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
	Aromatic VOCs (Cont)	Physical/Chemical Treatment (Cont)	IT Corp.	Mixed Waste Treatment Process	2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	1/2
			Pulse Sciences, Inc.	X-Ray Treatment of Organically Contaminated Soils	2
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
			Roy F. Weston, Inc./JEG Technologies	UVB - Vacuum Vaporizing Well	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Samplers	Geoprobe Systems	Large Bore Soil Sampler	3
		Sensors	Fugro Geosciences, Inc.	Rapid Optical Screening Tool	3
		Solidification/Stabilization	Geo Con, Inc.	In Situ Solidification and Stabilization Process	1
			WASTECH, Inc.	Solidification and Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Hanby Environmental Laboratory Procedures, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
		Thermal Destruction	Sonotech, Inc.	Frequency Tunable Pulse Combustion System	1
	Aromatic VOCs (Cont)	Thermal Destruction (Cont)	Texaco, Inc.	Texaco Gasification Process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	Cyanide	Biological Degradation	Pintail Systems, Inc.	Spent Ore Bioremediation Process	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			E&C Williams, Inc.	Calcium Sulfide & Calcium Polysulfide Technologies	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)	Diesel	Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati, and FRX Inc.	Hydraulic Fracturing	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			Geokinetics International, Inc.	Electroheat-Enhanced Nonaqueous-Phase Liquids Removal	1
			SIVE Services	Steam Injection and Vacuum Extraction	1
		Spectrometer	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Dioxins	Biological Degradation	Biotrol®	Soil Washing System	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
		Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic, Inc.	Thermal Desorption Unit	1
	Dioxins (Cont)	Physical/Chemical Thermal Desorption (Cont)	Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3™) System	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Samplers	Geoprobe Systems	Large Bore Soil Sampler	3
		Solidification/Stabilization	Geosafe Corp.	GeoMelt Vittrification	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	Dioxins (Cont)	Thermal Destruction (Cont)	Energy and Environmental Research Corp.	Reactor Filter System	2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Oxidation and Verification Process	1
	Explosives	Biological Degradation	U. of Idaho Research Foundation	The SABRE™ Process	1
		Contaminant Survey Systems	Quadrel Services, Inc.	Emflux Soil-Gas Survey System	3
			W.L. Gore and Associates, Inc.	GORE-SORBER Screening Survey	3
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)	Furans	Thermal Destruction	Terra Therm, Inc.	In-Situ Thermal Destruction	1
		Biological Degradation	Biotrol®	Soil Washing System	1
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
		Materials Handling	U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic, Inc.	Thermal Desorption Unit	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processors	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3™) System	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
	Furans (Cont)	Physical/Chemical Treatment (Cont)	ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base, Catalyzed Decomposition Process	1
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Samplers	Geoprobe Systems	Large Bore Soil Sampler	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)		Solidification/ Stabilization	Geosafe Corp.	GeoMelt Vitrification	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Reactor Filter System	2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	Gasoline	Contaminant Survey Systems	W.L. Gore and Associates, Inc.	GORE-SORBER Screening Survey	3
		Materials Handling	National Risk Management Research Laboratory, U. of Cincinnati and FRX, Inc.	Hydraulic Fracturing	1
		Physical/Chemical Thermal Desorption	SIVE Services	Steam Injection and Vacuum Extraction	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
		Samplers	Geoprobe Systems	Large Bore Soil Sampler	3
		Spectrometer	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Halogenated VOCs	Biological Degradation	Harding Lawson Associates	Two Zone, Plume Interception. In Situ Treatment Technology	2
			Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			New York State Dept. of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
			U.S. EPA	Excavation Techniques and Foam Suppression Methods	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)		Physical/Chemical Treatment - Biological Degradation	Lasagna™ Public Private Partnership	Lasagna™ In Situ Soil Remediation	1
		Physical/Chemical Thermal Desorption	Hughes Environmental Systems, Inc.	Steam Enhanced Recovery Process	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
	Halogenated VOCs (Cont)	Physical/Chemical Thermal Desorption (Cont)	NOVATERRA Associates	In Situ Soil Treatments, (Steam/Air Stripping)	1
			IT Corporation	X*TAX* Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3™) System	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Samplers	Geoprobe Systems	Large Bore Soil Sampler	3
		Solidification/ Stabilization	Geo Con, Inc.	In Situ Solidification and Stabilization Process	1
			Geosafe Corp.	GeoMelt Vittrification	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)		Test Kits	Dexsil Corporation	Environmental Test Kits	3
		Thermal Destruction	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Svedala Industries, Inc.	Pyrokiln Thermal Encapsulation Process	2
			Texaco, Inc.	Texaco Gasification Process	1
	Halogenated VOCs (Cont)	Thermal Destruction (Cont)	U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	Heavy Metals	Chemical Treatment	Concurrent Technologies	Organics Destruction Metals Stabilization	2
		Field Portable X-Ray Fluorescence	Edax Portable Products Division	Metal Analysis Probe (MAP®) Portable Assays	3
		Physical/Chemical Thermal Desorption	Electrokinetics, Inc.	Electrokinetic Extraction	1
		Physical/Chemical Treatment	Geokinetics International, Inc.	Electrokinetics for Lead Recovery	1
		Solidification/Stabilization	Rocky Mountain Remediation Services, LLC	Envirobond Solution	1
			Star Organics, LLC	Soil Rescue Remediation Fluid	1
	Heavy Minerals	Materials Handling	Montana College of Mineral Science and Technology	Campbell Centrifugal Jig	2
		Samplers	Art's Manufacturing and Supply	AMST™ Dual-Tube Liner Soil Sampler	3
			Simulprobe Technologies, Inc.	Core Barrel Soil Sampler	3
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Herbicides	Biological Degradation	Biotrol®	Soil Washing System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)	Herbicides (Cont)		Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
		Biological Degradation (Cont)	Phytokinetics, Inc.	Phytoremediation of Contaminated Soils	2
			U. of Idaho Research Foundation	The SABRE™ Process	1
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic, Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic, Inc.	Thermal Desorption Unit	1
			Maxymillion Technologies, Inc.	Thermal Desorption System	1
			IT Corporation	X*TAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA®)	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processors	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3™) System	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			Bergmann, a Division of Linatex, Inc.	Soil and Sediment Washing	1
			Center for Hazardous Materials Research	Organics Destruction and Metals Stabilization	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)	Herbicides (Cont)	Physical/Chemical Treatment (Cont)	High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Samplers	Geoprobe Systems	Large Bore Soil Samplers	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc., Corp.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortex Corp.	Vitrification Process	1
	Inorganics	Chemical Treatment	Kvaerner Energy & Environmental	Chemical Treatment	2
		Physical/Chemical Treatment	Electrokinetics, Inc.	Electrokinetic Extraction	1
			Electro-Petroleum, Inc.	Electro-Kinetically Aided Remediation	1
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Mercury	Contaminant Survey Systems	Quadrel Services, Inc.	Emflux Soil-Gas Survey System	3
Soil (Cont)	Mercury (Cont)	Contaminant Survey Systems (Cont)	Radiometer Analytical Group	Anodic Voltammetry of Mercury in Soil	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
		Physical/Chemical Treatment	Bionebraska, Inc.	BiMelyze® Mercury Immunoassay	3
	Metals	Biological Degradation	COGNIS, Inc.	Biological/Chemical Treatment	1
			Geo-Microbial Technologies, Inc.	Metals Release and Removal of Wastes	2
			Phytotech	Phytoremediation Technology	1
			Pintail Systems, Inc.	Biominalization of Metals	2
			Pintail Systems, Inc.	Spend Ore Bioremediation Process	1
		Contaminant Survey Systems	W.L. Gore and Associates, Inc.	GORE-SORBER Screening Survey	3
		Field Portable X-Ray Fluorescence	Metorex, Inc.	Field Portable X-Ray Fluorescence Analysis	3
			TN Spectrace	9000 X-Ray Fluorescence Analyzer and Lead X-Ray Fluorescence Analyzer	3
		Materials Handling	AEA Technology Environment	Soil Separation and Washing Process	2
			Montana College of Mineral Science and Technology	Air-Sparged Hydrocyclone	2
			Montana College of Mineral Science and Technology	Campbell Centrifugal Jig	2
			U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
			U. of South Carolina	In Situ Mitigation of Acid Water	2
		Physical Chemical Treatment - Biological Degradation	Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
Soil (Cont)	Metals (Cont)	Physical/Chemical Thermal Desorption (Cont)	Geotech Development Corp.	Cold Top Ex Situ Verification of Chromium-Contaminated Soils	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			Battelle Memorial Institute	In Situ Electroacoustic Soil Decontamination	2
			Bergmann, a Division of Linatex, Inc.	Soil and Sediment Washing	1
			BioGenesis Enterprises, Inc.	BioGenesis SM Soil & Sediment Washing Process	1
			Brice Environmental Services, Corp.	Soil Washing Process	1
			Center for Hazardous Materials Research	Acid Extraction Treatment System	2
			COGNIS, Inc.	TERRAMET Soil Remediation System	1
			E&C Williams, Inc.	Calcium Sulfide & Calcium Polysulfide Technology	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			General Atomics, Nuclear Remediation Technologies Division	Acoustic Barrier Particulate Separator	2
			Geokinetics International, Inc.	Electrokinetics for NSFO Mobilization	1
			IT Corp.	Batch Steam Distillation Metal Extraction	2
			IT Corp.	Chelation/Electrodeposition of Toxic Metals from Soils	2
			IT Corp.	Mixed Treatment Process	2
			Lewis Environmental Services, Inc./Hickson Corp.	Chromated Copper Arsenate Soil Leaching Process	2
Soil (Cont)	Metals (Cont)	Physical/Chemical Treatment (Cont)	Morrison Knudsen Corp./Spetstamponazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			National Risk Management Research Laboratory	Volume Reduction Unit	1
			Sandia National Laboratory	In Situ Electrokinetic Extraction System	1
			Toronto Harbor Commission	Soil Recycling	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			U. of Houston	Concentrated Chlorine Extraction and Recovery of Lead	2
		Portable Gas Chromatographs	HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
		Samplers	Art's Manufacturing and Supply	AMS™ Dual-Tube Liner Soil Sampler	3
			Geoprobe Systems	Large Bore Soil Sampler	3
			Simulprobe Technologies, Inc.	Core Barrel Soil Sampler	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			E&C Williams, Inc.	Chemical Stabilization of Mercury Mining Wastes	1
			Ferro Corp.	Waste Vitrification Through Electric Melting	2
			Funderburk & Associates	Dechlorination and Immobilization	1
			Gas Technology Institute	Cement-Lock Technology	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			Geosafe Corp.	GeoMelt Vitrification	1
			Metso Minerals Industries, Inc.	Phyrokiln Thermal Encapsulation Process	2
	Metals (Cont)	Solidification/Stabilization (Cont)	Minergy	Thermal Sediment Reuse Technology	1
			Rocky Mountain Remediation Services, LLC	Envirobond Solution	1
			Sevenson Environmental Services, Inc.	MAECTITE® Chemical Treatment Process	1
			Soliditech, Inc.	Solidification and Stabilization	1
			Star Organics, LLC	Soil Rescue Remediation Fluid	1
			STC Remediation a Division of Omega Environmental, Inc.	Organic Stabilization and Chemical Fixation/ Solidification	1
			WASTECH, Inc.	Solidification and Stabilization	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
		Thermal Destruction	American Combustion, Inc.	PYRETRON® Thermal Destruction	1
			BWX Technologies, Inc.	Cyclone Furnace	1/2
			Concurrent Technologies	Smelting Lead-Containing Wastes	2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Energy and Environmental Research Corp.	Reactor Filter System	2
			Horsehead Resource Development Co., Inc.	Flame Reactor	1
			Gas Technology Institute	Cement-Lock Technology	1
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Minergy Corporation	Glass Furnace Technology for Dredged Sediments	1
	Metals (Cont)	Thermal Destruction (Cont)	PSI Technologies, A Division of Physical Sciences Inc.	Metals Immobilization and Decontamination of Aggregate Solids	2
			Svedala Industries, Inc.	Pyrokiln Thermal Encapsulation Process	2
			Vortec Corp.	Vitrification Process	1
	Organics	Biological Degradation	Harding ESE, a MacTech Co.	Two-Zone, Plume Interception. In Situ Treatment Strategy	1/2
			Micro-Bac International, Inc.	Microbial Degradation of PCBs	1
		Chemical Treatment	Concurrent Technologies	Organic Destruction & Metals Stabilization	2
			Kaverner Energy & Environment	Chemical Treatment	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			Current Environmental Solutions	Six-Phase Heating of TCE	1
			Electro-Petroleum, Inc.	Electro-Kinetically Aided Remediation	1
			IT Corporation	KMnO ₄ (Potassium Permanganate Oxidation of TCE)	1
			Pharmacia Corporation	Lasagna™ In Situ Soil Remediation	1
		Sensors	Geoprobe Systems	Geoprobe Conductivity System	3
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
			RKK, Ltd.	CRYOCELL®	1
		Thermal Destruction	Current Environmental Solutions	Six-Phase Heating of TCE	1
			Gas Technology Institute	Cement-Lock Technology	1
			Gruppo Italimpresse	Infrared Thermal Destruction	1
	Organics (Cont)	Thermal Destruction (Cont)	Terra Therm, Inc.	In Situ Thermal Destruction	1
	PAHs	Biological Degradation	X-19 Biological Products	Microbial Degradation of PCBs	1
			COGNIS, Inc.	Biological/Chemical Treatment	2
			Ecova Corp.	Bioslurry Reactor	1
			Environmental BioTechnologies, Inc.	Fungal Degradation Process	2
			Gas Technology Institute	Fluid Extraction Biological Degradation Process	2
			Micro-Bac® International, Inc.	Bioaugmentation Process	1
			Remediation Technology, Inc.	Liquid and Solids Biological Treatment	1
		Chemical Thermal Desorption	Biotherm, L.C.C.	Biotherm Process™	1
		Cone Penetrometers	Space and Naval Warfare Systems Center	SCAPS Cone Penetrometer	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)		Contaminant Survey	Fugro Geosciences, Inc.	Rapid Optical Screening Tools	3
		Contaminant Survey Systems	W.L. Gore and Associates, Inc.	GORE-SORBER Screening Survey	3
		Physical/Chemical Thermal Desorption	Geokinetics International, Inc.	Electroheat-Enhanced Nonaqueous Phase Liquids Removal	1
			Maxymillian Technologies, Inc.	Thermal Desorption System	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			Bergmann. A Division of Linatex, Inc.	Soil and Sediment Washing	1
	PAHs (Cont)	Physical/Chemical Treatment (Cont)	BioGenesis Enterprises, Inc.	BioGenesis™ Soil & Sediment Washing Process	1
		Portable Gas Chromatograph	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Samplers	Clements, Inc.	JMC Environmental Subsoil Probe	3
		Sensors	Fugro Geosciences, Inc.	Rapid Optical Screening Tool	3
		Spectrometer	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	PCBs	Biological Degradation	X-19 Biological Products	Microbial Degradation of PCBs	1
			Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Micro-Bac® International, Inc.	Bioaugmentation Process	1
			Phytokinetics, Inc.	Phytoremediation of Contaminated Soils	2
			Phytokinetics, Inc.	Phytoremediation Process	1
		Field Portable X-Ray Fluorescence	Metorex, Inc.	Fluid Portable X-Ray Fluorescence Analysis	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic, Inc.	Thermal Desorption Unit	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			IT Corporation	X*TAX™ Thermal Desorption	1
	PCBs (Cont)	Physical/Chemical Thermal Desorption (Cont)	Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processors	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3™) System	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			Bergmann, a Division of Linatex, Inc.	Soil and Sediment Washing	1
			BioGenesis Enterprises, Inc.	BioGenesis SM Soil & Sediment Washing Process	1
			Center for Hazardous Materials Research	Organics Destruction and Metals Stabilization	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Commodore Environmental Services, Inc.	Solvated Electron Remediation System	1
			General Atomics	Circulating Bed Combustor	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			IT Corp.	Photolytic and Biological Soil Detoxification	2
			Morrison Knudsen Corp./Spetstamponazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
Soil (Cont)	PCBs (Cont)	Physical/Chemical Treatment (Cont)	National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			State U. of New York at Oswego, Environmental Research Center	Electrochemical Peroxidation of PCB-Contaminated Sediments and Waters	2
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technology, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Samplers	Clements, Inc.	JMC Environmental Subsoil Probe	3
			Geoprobe Systems	Large Bore Soil Sampler	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			Funderburk & Associates	Dechlorination and Immobilization	1
			Gas Technology Institute	Cement-Lock Technology	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			Geosafe Corp.	GeoMelt Vittrification	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			Minergy	Thermal Sediment Reuse Technology	1
			Soliditech, Inc.	Solidification and Stabilization	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Test Kits	Dexsil Corporation	Environmental Test Kits	3
	PCBs (Cont)	Test Kits (Cont)	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
			Millipore Corporation	EnviroGard™ PCP Immunoassay Test Kit	3
			Strategic Diagnostics, Inc.	EnviroGard™ PCB Immunoassay Test Kit	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Gas Technology Institute	Cement-Lock Technology	1
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Minergy Corp.	Glass Furnace Technology for Dredged Sediments	1
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
	PCP	Biological Degradation	X-19 Biological Products	Microbial Degradation of PCBs	1
			Remediation Technology, Inc.	Liquid and Solids Biological Treatment	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
		Portable Gas Chromatographs	U.S. EPA	Field Analytical Screening Program - PCP Method	3
		Physical/Chemical Thermal Desorption	Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)	PCP (Cont)	Physical/Chemical Treatment	National Risk Management Research Laboratory	Volume Reduction Unit	1
		Physical/Chemical Treatment (Cont)	Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-Contaminated Soil Detoxification	2
		Test Kits	Strategic Diagnostics, Inc.	Ensys Penta Test System	3
			Strategic Diagnostics, Inc.	EnviroGard™ PCB Immunoassay Test Kit	3
			Strategic Diagnostics, Inc.	(RaPID Assay®)	3
	Pesticides	Biological Degradation	X-19 Biological Products	Microbial Degradation of PCBs	1
			Biotrol®	Soil Washing System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
			Phytokinetics, Inc.	Phytoremediation of Contaminated Soils	2
			Phytokinetics, Inc.	Phytoremediation Process	1
		Contaminant Survey Systems	W.L. Gore and Associates, Inc.	GORE-SORBER Screening Survey	3
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic, Inc.	Thermal Desorption Unit	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			OHM Remediation Services, Corp.	X*TAX™ Thermal Desorption	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)	Pesticides (Cont)	Physical/Chemical Thermal Desorption (Cont)	Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA)	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processors	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ^{3TM}) System	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			ART International, Inc.	Low-Energy Extraction Process (LEEP)	2
			Bergmann, a Division of Linatex, Inc.	Soil and Sediment Washing	1
			Center for Hazardous Materials Research	Organics Destruction and Metals Stabilization	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Commodore Environmental Services, Inc.	Solvated Electron Remediation System	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			General Atomics	Circulating Bed Combustor	1
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			IT Corp.	Photolytic and Biological Soil Detoxification	2
			Morrison Knudsen Corp./Spetstamonazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
Soil (Cont)	Pesticides (Cont)	Physical/Chemical Treatment (Cont)	National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			State U. of New York at Oswego, Environmental Research Center	Electrochemical Peroxidation of PCB-Contaminated Sediments and Waters	2
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Trinity Environmental Technologies, Inc.	PCB- and Organochlorine-contaminated Soil Detoxification	2
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Samplers	Art's Manufacturing and Supply	AMS™ Dual-Tube Liner Soil Sampler	3
			Clements, Inc.	JMC Environmental Subsoil Probe	3
			Geoprobe Systems	Large Bore Soil Sampler	3
			Simulprobe Technologies, Inc.	Core Barrel Soil Sampler	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			Funderburk & Associates	Dechlorination and Immobilization	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			Soliditech, Inc.	Solidification and Stabilization	1
			WASTECH, Inc	Solidification and Stabilization	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Dexsil Corporation	Environmental Test Kits	3
			Strategic Diagnostics, Inc.	Ensys Penta Test System	3
Soil (Cont)	Pesticides (Cont)	Test Kits (Cont)	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
			Strategic Diagnostics, Inc.	RaPID Assay®	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			VORTEC Corp.	Vitrification Process	1
	Petroleum Hydrocarbons	Biological Degradation	X-19 Biological Product	Microbial Degradation of PCBs	1
			COGNIS, Inc.	Biological/Chemical Treatment	2
			Ecova Corp.	Bioslurry Reactor	1
			Hazardous Substance Management Research Center at New Jersey Institute of Technology, and Rutgers, the State U. of New Jersey	Pneumatic Fracturing and Bioremediation Process	2
			Micro-Bac® International, Inc.	Bioaugmentation Process	1
			Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
		Cone Penetrometers	Space and Naval Warfare Systems Center	SCAPS Cone Penetrometer	3
			Tri-Services	Site Characterization Analysis Penetrometer System (SCAPS)	3
		Contaminant Survey Systems	W.L. Gore and Associates, Inc.	GORE-SORBER Screening Survey	3
		Materials Handling	National Risk Management Research Laboratory. U. of Cincinnati and FRX, Inc.	Hydraulic Fracturing	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)		Physical/Chemical Treatment	SIVE Services	Steam Injection and Vacuum Extraction	1
			Smith Environmental Technologies, Corp.	Low, Temperature Thermal Aeration (LTTA [®])	1
			Arctic Foundations, Inc.	Cryogenic Barrier	1
		Portable Gas Chromatographs	SRI Instruments	Compact Gas Chromatograph	3
		Spectrometer	Environmental Systems Corporation	Ultraviolet Fluorescence Spectroscopy	3
			SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
			Strategic Diagnostics, Inc.	Immunoassay and Colorimetry	2
			Wilks Enterprise, Inc.	Infrared Analysis	3
		Solidification/Stabilization	Soliditech, Inc.	Solidification and Stabilization	1
		Test Kits	CHEMetrics Inc. and AZUR Environmental Ltd.	Friedel-Crafts Alkylation Reaction & Colorimetry	3
	Radionuclides	Materials Handling	Thermo Nutech, Inc.	Segmented Gate System	2
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			Bergmann, a Division of Linatex, Inc.	Soil and Sediment Washing	1
			Electrokinetics, Inc.	Electrokinetic Extraction	1
	Radionuclides (Cont)	Physical/Chemical Treatment (Cont)	IT Corp.	Mixed Waste Treatment Process	2
		Solidification/Stabilization	Sevenson Environmental Services, Inc.	MAECTITE [®] Chemical Treatment Process	1
			WASTECH, Inc.	Solidification and Stabilization	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Terra Therm, Inc.	In-Situ Thermal Destruction	1
	SVOCs	Biological Degradation	Harding Lawson Associates	Two Zone, Plume Interception, In Situ Treatment Technology	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			Biotrol®	Soil Washing System	1
			Ecova Corp.	Bioslurry Reactor	1
			Gas Technology Institute	Chemical and Biological Treatment	2
			Gas Technology Institute	Fluid Extraction - Biological Degradation Process	2
			Grace Bioremediation Technologies	DARAMEND™ Bioremediation Technology	1
			National Risk Management Research Laboratory	Bioventing	1
			National Risk Management Research Laboratory and INTECH 180 Corp.	Fungal Treatment Technology	1
			New York State Dept. of Environment Conservation/ENSR Consulting and Larson Engineers	Ex Situ Biovault	1
			New Yew State Dept. of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
	SVOCs (Cont)	Biological Degradation (Cont)	IT Corp.	Oxygen Microbubble In Situ Bioremediation	2
			Remediation Technologies, Inc.	Liquid and Solids Biological Treatment	1
		Contaminant Survey Systems	Quadrel Services, Inc.	Emflux Soil-Gs Survey System	3
			W.L. Gore and Associates, Inc.	GORE-SORBER Screening Survey	3
		Materials Handling	U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			ELI Eco Logic, Inc.	Gas-Phase Chemical Reduction Process	1
			ELI Eco Logic, Inc.	Thermal Desorption Unit	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			IIT Research Institute/Brown and Root Environmental	Radio Frequency Heating	1
			KAI Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
			Maxymillian Technologies, Inc.	Thermal Desorption System	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			NOVATERRA Associates	In-Situ Soil Treatments, (Steam/Air Stripping)	1
			IT Corporation	X*TAX™ Thermal Desorption	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			SIVE Services	Steam Injection and Vacuum Extraction	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration(LTTA®)	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processors	1
	SVOCs (Cont)	Physical/Chemical Thermal Desorption (Cont)	Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT3™) System	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			ARS Technologies, Inc.	Pneumatic Fracturing Extraction™ and Catalytic Oxidation	1
			Bergmann, a Division of Linatex, Inc.	Soil and Sediment Washing	1
			Center for Hazardous Materials Research	Organics Destruction and Metals Stabilization	2
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Electrokinetics, Inc.	Electrokinetic Soil Processing	1
			Energia, Inc.	Reductive Thermal and Photo-Thermal Oxidation Processes for Enhanced Conversation of Chlorocarbons	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Hrubetz Environmental Services, Inc.	HRUBOUT [®] Process	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Mixed Waste Treatment Process	2
			National Risk Management Research Laboratory	Base-Catalyzed Decomposition Process	1
			National Risk Management Research Laboratory	Volume Reduction Unit	1
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1
	SVOCs (Cont)	Physical/Chemical Treatment (Cont)	Toronto Harbor Commission	Soil Recycling	1
			Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE [™] Extraction Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Samplers	Art's Manufacturing and Supply	AMST [™] Dual-Tube Liner Soil Sampler	3
			Geoprobe Systems	Large Bore Soil Sampler	3
			Simulprobe Technologies, Inc.	Core Barrel Soil Sampler	3
		Solidification/Stabilization	Chemfix Technologies, Inc.	Solidification and Stabilization	1
			Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			STC Remediation. A Division of Omega Environmental, Inc.	Organic Stabilization and Chemical Fixation/ Solidification	1
			WASTECH, Inc.	Solidification and Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc. Corp.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
			Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1
	SVOCs (Cont)	Thermal Destruction (Cont)	Svedala Industries, Inc.	Pyrokiln Thermal Encapsulation Process	2
			Terra Therm, Inc.	In-Situ Thermal Destruction	
			Texaco, Inc.	Texaco Gasification Process	1
			U. of Dayton Research Institute	Photothermal Detoxification Unit	2
			Vortec Corp.	Vitrification Process	1
		Other	Berkeley Environmental Restoration Center	In Situ Stream Enhanced Extraction Process	1
	VOCs	Biological Degradation	X-19 Biological Products	Microbial Degradation of PCBs	1
			Billings and Associates, Inc.	Subsurface Volatilization and Ventilation System (SVVS®)	1
			Bio-Rem, Inc.	Augmented In Situ Subsurface Bioremediation Process	1
			Ecova Corp.	Bioslurry Reactor	1
			Electrokinetics, Inc.	In situ Bioremediation by Electrokinetic Injection	2
			IT Corp.	Oxygen Microbubble in Situ Bioremediation	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)			National Risk Management Research Laboratory	Bioventing	1
			New York State Dept. of Environment Conservation/ENSR Consulting and Larson Engineers	Ex Situ Biovault	1
			New York State Dept. of Environmental Conservation/R.E. Wright Environmental, Inc.	In Situ Bioventing Treatment System	1
	VOCs (Cont)	Biological Degradation (Cont)	New York State Dept. of Environmental Conservation/SBP Technologies, Inc.	Groundwater Circulation Biological Treatment Process	1
			New York State Dept. of Environmental Conservation/SBP Technologies, Inc.	Vacuum-Vaporized Well System	1
			Phytokinetics, Inc.	Phytoremediation of Contaminated Soils	2
			Phytokinetics, Inc.	Phytoremediation Process	1
		Contaminant Survey Systems	Quadrel Services, Inc.	Emflux Soil-Gas Survey System	3
			W.L. Gore and Associates, Inc.	GORE-SORBER Screening Survey	3
		Materials Handling	AEA Technology Environment	Soil Separation and Washing Process	2
			National Risk Management Research Laboratory. U. of Cincinnati and FREX, Inc.	Hydraulic Fracturing	1
			U.S. EPA	Excavation Techniques and Foam Suppression Methods	1
		Physical/Chemical Thermal Desorption	Biotherm, LLC	Biotherm Process™	1
			Current Environmental Solutions	Six Phase Heating at TCE	1
			Geokinetics International, Inc.	Electroheat-Enhanced Nonaqueous Phase Liquids Removal	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)	VOCs (Cont)		Hughes Environmental Systems, Inc.	Steam Enhanced Recovery Process	1
			IIT Research Institute/Brown and Root Environmental	Radio Frequency Heating	1
			Kai Technologies, Inc./Brown and Root Environmental	Radio Frequency Heating	1
		Physical/Chemical Thermal Desorption (Cont)	Maxymillian Technologies, Inc.	Thermal Desorption System	1
			New Jersey Institute of Technology	GHEA Associates Process	2
			NOVATERRA Associates	In-Situ Soil Treatments, (Steam/Air Stripping)	1
			Praxis Environmental Technologies, Inc.	In Situ Thermally Enhanced Extraction (TEE) Process	1
			Recycling Sciences International, Inc.	Desorption and Vapor Extraction System	1
			SIVE Services	Steam Injection and Vacuum Extraction	1
			Smith Environmental Technologies Corp.	Low Temperature Thermal Aeration (LTTA [®])	1
			SoilTech ATP Systems, Inc.	Anaerobic Thermal Processor	1
			Roy F. Weston, Inc.	Low Temperature Thermal Treatment (LT ^{3®}) System	1
		Physical/Chemical Treatment	Arctic Foundations, Inc.	Cryogenic Barrier	1
			ARS Technologies, Inc.	Pneumatic Fracturing Extraction [™] and Catalytic Oxidation	1
			Arizona State U./ Zentox Corp.	Photocatalytic Oxidation with Air Stripping	2
			AWD Technologies, Inc.	Aqua Detox [®] /SVE System	1
			Berkeley Environmental Restoration Center	In Situ Stream Enhanced Extraction Process	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)	VOCs (Cont)	Physical/Chemical Treatment (Cont)	Energia, Inc.	Reductive Photo-Dechlorination Treatment	2
			Energia, Inc.	Reductive Thermal and Photo-Thermal Oxidation Processes for Enhanced Conversion of Chlorocarbons	2
			Gas Technology Institute	Supercritical Extraction/Liquid Phase Oxidation	2
			High Voltage Environmental Applications, Inc.	High-Energy Electron Irradiation	1
			Hrubetz Environmental Services, Inc.	HRUBOUT® Process	1
			Ionics RCC	B.E.S.T. Solvent Extraction Technology	1
			IT Corp.	Batch Steam Distillation and Metals Extraction	2
			IT Corp.	(KMnO ₄ (Potassium Permanganate) Oxidation of TCE)	1
			IT Corp.	Mixed Waste Treatment Process	2
			KSE, Inc.	Adsorption-Integrated-Reaction Process	1/2
			Morrison Knudsen Corp./Sptstamponazh geologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			National Risk Management Research Laboratory	Volume Reduction Unit	1
			Pulse Sciences, Inc.	X-Ray Treatment of Organically Contaminated Soils	2
			Radian International LLC	Integrated Vapor Extraction and Steam Vacuum Stripping and Soil Vapor Extraction/ Reinjection	1
			Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
			Terra Vac, Inc.	In Situ and Ex Situ Vacuum Extraction	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Soil (Cont)	VOCs (Cont)	Physical/Chemical Treatment (Cont)	Roy F. Weston, Inc./IEG Technologies	UVB - Vacuum Vaporizing Well	1
			Xerox Corp.	2-PHASE™ EXTRACTION Process	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Photovac Monitoring Instruments	PE Photovac Voyager Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Samplers	Clements, Inc.	JMC Environmentalist's Subsoil Probe	3
			Simulprobe Technologies, Inc.	Core Barrel Soil Sampler	3
		Sensors	Dexsil Corporation	Emulsion Turbidimetry	3
			Fugro Geosciences, Inc.	Rapid Optical Screening Tool	3
			Geoprobe Systems	Geoprobe Conductivity System	3
		Solidification/Stabilization	Geo-Con, Inc.	In Situ Solidification and Stabilization Process	1
			WASTECH, Inc.	Solidification and Stabilization	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Absorption Treatment	2
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
		Thermal Destruction	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
			Gas Technology Institute	Fluidized-Bed/Cyclonic Agglomerating Combustor	2
Soil (Cont)	VOCs (Cont)	Thermal Destruction (Cont)	Sonotech, Inc.	Frequency-Tunable Pulse Combustion System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			Svedala Industries, Inc.	Pyrokiln Thermal Encapsulation Process	2
			Texaco, Inc.	Texaco Gasification Process	1
			Vortec Corp.	Vitrification Process	1
	Other	Cone Penetrometers	Tri-Services	Site Characterization Analysis Penetrometer System (SCAPS)	3
		Samplers	ART's Manufacturing and Supply	Sediment Core Sampler	3
		Solidification/Stabilization	STC Remediation, a Division of Omega Environmental, Inc.	Organic Stabilization and Chemical Fixation/ Solidification	1
Solids	Dioxins	Physical/Chemical Treatment	Active Environmental Technologies, Inc.	TechXtract™ Process	1
	Furans	Physical/Chemicals Treatment	Active Environmental Technologies, Inc.	TechXtract™ Process	1
	Heavy Metals	Physical/Chemical Treatment	Active Environmental Technologies, Inc.	TechXtract™ Process	1
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Inorganics	Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Metals	Physical/Chemical Treatment	Active Environmental Technologies, Inc.	TechXtract™ Process	1
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Mercury	Physical/Chemical Treatment	Bionebraska, Inc.	BiMelyze® Mercury Immunoassay	3
Solids (Cont)	Organics	Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
	PCBs	Physical/Chemical Treatment	Active Environmental Technologies, Inc.	TechXtract™ Process	1
			Active Environmental Technologies, Inc.	TechXtract™ Process	1
		Solidification/Stabilization	Gas Technology Institute	Cement-Lock Technology	1
		Thermal Destruction	Gas Technology Institute	Cement-Lock Technology	1
	Pesticides	Physical/Chemical Treatment	Active Environmental, Inc.	TechXtract™ Process	1
	Radionuclides	Physical/Chemical Treatment	Active Environmental Technologies, Inc.	Tech Xtract Decontamination Process	1
	Other	Solidification/Stabilization	U.S. EPA NRMRL	Alternative Cover Assessment Program	1
Waste Water	Aromatic VOCs	Biological Degradation	Biotrol®	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			ZENON Environmental, Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
Waste water (Cont)	Aromatic VOCs (Cont)	Physical/Chemical Treatment (Cont)	Magnum Water Technology	CAV-OX® Process	1
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Pulse Sciences, Inc.	X-Ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Waste water (Cont)			ZENON Environmental Inc.	Cross Flow Pervaporation System	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
	Cyanide	Biological Degradation	Pintail Systems, Inc.	Spent Ore Bioremediation Process	1
	Diesel	Spectrometer	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Dioxins	Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
	Dioxins (Cont)	Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Waste water (Cont)		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	Explosives	Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	U.S. Filter/WTS ULtrox	Ultraviolet Radiation and Oxidation	1
		Solidification/Stabilization	Retech, Inc.	Plasma Heat	1
	Furans	Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Matrix Photocatalytic	Photocatalytic Water Treatment	1/2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
	Furans (Cont)	Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	Gasoline	Spectrometer	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	Halogenated VOCs	Biological Degradation	Biotrol®	Biological Aqueous Treatment System	1
			ZENON Environmental, Inc.	ZenoGem™ Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Waste water (Cont)		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			EnviroMetal Technologies, Inc.	In Situ and Ex Situ Metal Enhanced Abiotic Degradation of Dissolved Halogenated Organic Compounds in Groundwater	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Magnum Water Technology	CAV-OX [®] Process	1
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Pulse Sciences, Inc.	X-Ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
	Halogenated VOCs (Cont)	Physical/Chemical Treatment (Cont)	U.S. Filter/WTS Ultrox	Ultraviolet Radiation and Oxidation	1
			UV Technologies, Inc.	PhotoCAT [™] Process	2
			Roy F. Weston, Inc.	Ambersorb [™] 563 Absorbent	2
			ZENON Environmental Inc.	Cross Flow Pervaporation System	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Waste water (Cont)		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Thermal Destruction	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
	Heavy Metals	Field Portable X-Ray Fluorescence	HNU Systems, Inc.	HNU Source Excited Fluorescence analyzer-Portable (SEFA-P) X-Ray Fluorescence Analyzer	3
		Portable Gas Chromatograph	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
	Heavy Minerals	Solidification/Stabilization	Retech, Inc.	Plasma Heat	1
	Herbicides	Biological Degradation	Biotrol®	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
	Herbicides (Cont)	Biological Degradation (Cont)	ZENON Environmental, Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	ELI ECO Logic Inc.	Gas-Phase Chemical Reduction Process	1
		Physical/Chemical Treatment	CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			Geokinetics International, Inc.	Electrokinetics for NSFO Mobilization	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Magnum Water Technology	CAV-OX® Process	1
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Waste water (Cont)		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	Inorganics	Field Portable X-Ray Fluorescence	HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P) X-Ray Fluorescence Analyzer	3
		Solidification/Stabilization	Retech, Inc.	Plasma Heat	1
	Mercury	Solidification/Stabilization	Retech, Inc.	Plasma Heat	1
	Metals	Biological Degradation	Colorado Dept. of Public Health and Environmental	Constructed Wetlands-Based Treatment	1
			Pintail Systems, Inc.	Biominalization of Metals	2
			Pintail Systems, Inc.	Spent Ore Bioremediation Process	1
		Field Portable X-Ray Fluorescence	HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P) X-Ray Fluorescence Analyzer	3
			Metorex, Inc.	Field Portable X-Ray Fluorescence Analysis	3
		Physical/Chemical Radioactive Waste Treatment	Filter Flow Technology, Inc.	Colloid Polishing Filter Method	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1
		Physical/Chemical Treatment	Atomic Energy of Canada, Limited	Chemical Treatment and Ultrafiltration	2
			Atomic Energy of Canada, Limited	Ultrasonic-Aided Leachate Treatment	2
			E.I. DuPont De Nemours and Company, and Oberlin Filter Co.	Membrane Microfiltration	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			Dynaphore, Inc.	FORAGER [®] Sponge	1
			EnviroMetal Technologies, Inc.	Reactive Barrier	1
			EPOC Water, Inc.	Precipitation Microfiltration, and Sludge Dewatering	1
			General Environmental Corporation	CURE [®] Electrocoagulation Wastewater Treatment System	1
			Lewis Environmental Services, Inc./ Hickson Corp.	Chromated Copper Arsenic Soil Leaching Process	2
Waste water (Cont)	Metals (Cont)	Physical/Chemical Treatment (Cont)	Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Morrison Knudsen Corporation/Spetstam ponazhgeologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			RECRA Environmental, Inc.	Alternating Current Electrocoagulation Technology	2
			Region 8 and State of Colorado	Multiple Innovative Passive Mine Drainage Technologies	1
			Selentec Environmental, Inc.	Selentec MAG*SEP Technology	1
			U. of Washington	Adsorptive Filtration	2
		Portable Gas Chromatographs	HNU Systems, Inc.	HNU GC 311D Portable Gas Chromatograph	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER [™] Technology	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
	Organic	Physical/Chemical Treatment	Geokinetics International, Inc.	Electrokinetics for NSFO Mobilization	1
		Solidification/Stabilization	Retech, Inc.	Plasma Heat	1
	PAHs	Physical/Chemical Treatment	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			SRI Instruments	Compact Gas Chromatograph	3
		Spectrometer	SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
	PCBs	Biological Degradation	ZENON Environmental, Inc.	ZenoGem™ Process	1
Waste water (Cont)	PCBs (Cont)	Field Portable X-Ray Fluorescence	Metorex, Inc.	Field Portable X-Ray Fluorescence Analysis	3
		Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Magnum Water Technology	CAV-OX® Process	1
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Morrison Knudsen Corporation/Spetstam ponazhgeologia Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/WTS Ultrox	Ultraviolet Radiation and Oxidation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Waste water (Cont)			HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P) X-Ray Fluorescence Analyzer	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
	PCBs (Cont)	Portable Gas Chromatographs (Cont)	SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
		Test Kits	Strategic Diagnostics, Inc.	Ensys Penta Test System	3
			Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research corp.	Hybrid Fluidized Bed System	2
	PCP	Physical/Chemical Treatment	SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/WTS Ultrox	Ultraviolet Radiation and Oxidation	1
		Test Kits	Strategic Diagnostics, Inc.	Ensys Penta Test System	3
			Strategic Diagnostics, Inc.	EnviroGard™ PCP Immunoassay Test Kit	3
			Strategic Diagnostics, Inc.	RaPID Assay®	3
	Pesticides	Biological Degradation	Biotrol®	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			ZENON Environmental, Inc.	ZenoGem™ Process	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Waste water (Cont)		Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
	Pesticides (Cont)	Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Magnum Water Technology	CAV-OX® Process	1
			Matrix Photocatalytic Inc.	Photocatalytic Water Treatment	1/2
			Morrison Knudsen Corporation/Spetstam ponazhgeolo Enterprises/STG Technologies	Clay-Base Grouting Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/WTS Ultrox	Ultraviolet Radiation and Oxidation	1
		Portable Gas Chromatographs	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program-PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER™ Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3
Waste water (Cont)	Pesticides (Cont)	Test Kits	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			Strategic Diagnostics, Inc.	Ensys Penta Test System	3
			Strategic Diagnostics, Inc. Corp.	RaPID Assay®	3
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
			Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
	Petroleum Hydrocarbons	Physical/Chemical Thermal Desorption	New Jersey institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	SRI Instruments	Compact Gas Chromatograph	3
		Spectrometer	Horiba Instruments, Inc.	Infrared Analysis	3
			SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
			Wilks Enterprise, Inc.	Infrared Analysis	3
		Test Kits	Idetek, Inc.	Equate® Immunoassay	3
	Radionuclides	Physical/Chemical Radioactive Waste Treatments	Filter Flow Technology, Inc.	Colloid Polishing Filter Method	1
		Physical/Chemical Treatment	Atomic Energy of Canada, Limited	Chemical Treatment and Ultrafiltration	2
			Atomic Energy of Canada, Limited	Ultrasonic-Aided Leachate Treatment	2
Waste water (Cont)	Radionuclides (Cont)	Physical/Chemical Treatment (Cont)	Selentec Environmental, Inc.	Selentec MAG*SEP Technology	1
		Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	SVOCs	Biological Degradation	Biotrol®	Biological Aqueous Treatment System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
			ZENON Environmental, Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			New Jersey Institute of Technology	GHEA Associates Process	2
		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	SRI Instruments	Compact Gas Chromatograph	3
		Spectrometer	Horiba Instruments, Inc.	Infrared Analysis	3
			SiteLAB Corporation	Ultraviolet Fluorescence Spectroscopy	3
			Wilks Enterprise, Inc.	Infrared Analysis	3
		Test Kits	Idetek, Inc.	Equate® Immunoassay	3
	Radionuclides	Physical/Chemical Radioactive Waste Treatments	Filter Flow Technology, Inc.	Colloid Polishing Filter Method	1
		Physical/Chemical Treatment	Atomic Energy of Canada, Limited	Chemical Treatment and Ultrafiltration	2
			Atomic Energy of Canada, Limited	Ultrasonic-Aided Leachate Treatment	2
			Selentec Environmental, Inc.	Selentec MAG*SEP Technology	1
Waste water (Cont)	Radionuclides (Cont)	Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1/2
	SVOCs	Biological Degradation	Biotrol®	Biological Aqueous Treatment System	1
			ZENON Environmental, Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	ELI Eco Logic Inc.	Gas-Phase Chemical Reduction Process	1
			New Jersey Institute of Technology	GHEA Associates Process	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Waste water (Cont)		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Beam Irradiation	2
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Pulse Sciences, Inc.	X-Ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
		Portable Gas Chromatographs	Analytical and Remedial Technology, Inc.	Automated Sampling and Analytical Platform	3
			Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER Technology	1
		Test Kits	Strategic Diagnostics, Inc., Corp.	RaPID Assay®	3
	SVOCs (Cont)	Thermal Destruction	BWX Technologies, Inc.	Cyclone Furnace	1
	VOCs	Biological Degradation	Biotrol®	Biological Aqueous Treatment System	1
			Electrokinetics, Inc.	In Situ Bioremediation by Electrokinetic Injection	2
			ZENON Environmental, Inc.	ZenoGem™ Process	1
		Physical/Chemical Thermal Desorption	New Jersey Institute of Technology	GHEA Associates Process	2
			Rochem Separation Systems, Inc.	Rochem Disc Tube™ Module System	1

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Waste water (Cont)		Physical/Chemical Treatment	Calgon Carbon Oxidation Technologies	perox-pure™ Chemical Oxidation Technology	1
			CF Systems Corp.	Liquified Gas Solvent Extraction (LG-SX) Technology	1
			EnviroMetal Technologies, Inc.	In Situ and Ex Situ metal Enhanced Abiotic Degradation of Dissolved Halogenated Organic Compounds in Groundwater	1
			EnviroMetal Technologies, Inc.	Reactive Barrier	1
			High Voltage Environmental Applications, Inc.	High Energy Electron Irradiation	1
			Pulse Sciences, Inc.	X-Ray Treatment of Aqueous Solutions	2
			SBP Technologies, Inc.	Membrane Filtration and Bioremediation	1
			U.S. Filter/WTS Ultrox	Ultraviolet Radiation and Oxidation	1
			UV Technologies, Inc.	PhotoCAT™ Process	2
			Roy F. Weston,, Inc.	Ambersorb™ 563 Absorbent	2
			ZENON Environmental Inc.	Cross Flow Pervaporation System	1
	VOCs (Cont)	Portable Gas Chromatograph	Bruker Analytical Systems, Inc.	Mobile Environmental Monitor	3
			HNU Systems, Inc.	HNU Source Excited Fluorescence Analyzer-Portable (SEFA-P) X-Ray Fluorescence Analyzer	3
			Sentex Sensing Technology, Inc.	Scentograph Plus II Portable Gas Chromatograph	3
			SRI Instruments	Compact Gas Chromatograph	3
			U.S. EPA	Field Analytical Screening Program - PCB Method	3
		Solidification/Stabilization	Wheelabrator Clean Air Systems, Inc.	PO*WW*ER Technology	1
		Spectrometers	Graseby Ionics, Ltd., and PCP, Inc.	Ion Mobility Spectrometry	3

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
		Test Kits	Hanby Environmental Laboratory Procedure, Inc.	Test Kits for Organic Contaminants in Soil and Water	3
		Thermal Destruction	Energy and Environmental Research Corp.	Hybrid Fluidized Bed System	2
	Other	Biological Degradation	EcoMat, Inc.	Biological Denitrification Process	
		Physical/Chemical Treatment	North American Technologies, Group, Inc.	Oleophilic Amine-Coated Ceramic Chip	1
			RECRA Environmental, Inc.	Alternating Current Electrocoagulation Technology	2
Other	Aromatic VOCs	Solidification/Stabilization	Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
Other (Cont)	Dioxins	Physical/Chemical Treatment	Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
		Solidification/Stabilization	Geosafe Corp.	GeoMelt Vittrification	1
	Furans	Physical/Chemical Treatment	Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
	Furans (Cont)	Solidification/Stabilization	Geosafe Corp.	GeoMelt Vittrification	1
	Halogenated VOCs	Physical/Chemical Treatment	Process Technologies, Inc.	Photolytic Destruction of Vapor-phase Halogens	1
		Solidification/Stabilization	Geosafe Corp.	GeoMelt Vittrification	1
	Metals	Field Portable X-Ray Fluorescence	NITON Corp.	XL Spectrum Analyzer	3
			TN Spectrace	9000 X-Ray Fluorescence Analyzer and Lead X-Ray Fluorescence Analyzer	3
		Materials Handling	AEA Technology Environment	Soil Separation and Washing Process	2
		Solidification/Stabilization	Geosafe Corp.	GeoMelt Vittrification	1
			Western Product Recovery Group, Inc.	Coordinate, Chemical bonding, and Adsorption Treatment	2
		Thermal Destruction	Concurrent Technologies	Smelting Lead-Containing Wastes	2

APPLICABILITY INDEX (CONTINUED)

Media	Contaminants	Treatment Type	Technology Vendor	Technology	Volume
Other (Cont)	PCBs	Physical/Chemical Treatment	Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
		Solidification/Stabilization	Geosafe Corp.	GeoMelt Vittrification	1
	Pesticides	Physical/Chemical Treatment	Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
		Solidification/Stabilization	Geosafe Corp.	GeoMelt Vittrification	1
	SVOCs	Physical/Chemical Thermal Desorption	Process Technologies, Inc.	Photolytic Destruction of Vapor-Phase Halogens	1
		Physical/Chemical Treatment	Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
		Solidification/Stabilization	Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
	VOCs	Materials Handling	AEA Technology Environment	Soil Separation and Washing Process	2
	VOCs (Cont)	Physical/Chemical Thermal Desorption	Process Technologies, Inc.	Photolytic Destruction of Vapor-Phase Halogens	1
		Physical/Chemical Treatment	Terra-Kleen Response Group, Inc.	Solvent Extraction Treatment System	1
		Solidification/Stabilization	Western Product Recovery Group, Inc.	Coordinate, Chemical Bonding, and Adsorption Treatment	2
	Not Applicable	Capping/Containment	Wilder Construction Co.	Matcon Modified Asphalt Cap.	1
		Containment Survey Systems	Earthsoft	Equis Environmental Data Management System	1
		Data Management Systems	Earthsoft	Equis Environmental Data Management System	1
			GIS/Solutions, Inc.	GIA/Key™ Environmental Data Management System	1