Appendix A

Treatment Technologies by Fiscal Year

Treatment Technologies by Fiscal Year

Technology Type	Fiscal Year																					
Ex Situ Source Control Technologies	**82-85**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**TOTALS**
Bioremediation	1	1	0	3	5	2	1	8	3	4	6	6	0	5	6	1	0	1	1	6	0	60
Chemical Treatment	1	0	1	0	0	0	1	1	0	0	1	1	0	0	1	0	1	0	0	1	0	9
Incineration (on-site)	4	3	4	6	6	4	3	3	1	1	2	1	4	0	0	0	0	0	0	0	0	42
Incineration (off-site)	3	2	3	9	9	15	13	6	8	5	9	5	4	3	2	5	1	2	0	1	0	105
Mechanical Soil Aeration	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	4
Neutralization	0	0	0	1	0	0	0	3	0	0	2	0	0	0	0	0	0	1	0	0	0	7
Open Burn/Open Detonation	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	4
Physical Separation	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2	9	3	2	1	0	2	21
Phytoremediation	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Soil Vapor Extraction	0	0	0	0	0	0	0	0	2	1	0	2	0	1	1	0	0	0	0	0	0	7
Soil Washing	0	0	0	0	1	2	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	6
Solidification/Stabilization	3	4	6	7	8	14	20	23	13	13	3	7	4	13	8	5	2	6	1	10	3	173
Solvent Extraction	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	4
Thermal Desorption	2	1	4	4	3	6	8	2	4	4	5	1	5	4	2	4	3	6	1	1	1	71
Vitrification	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	**14**	**11**	**19**	**31**	**33**	**45**	**47**	**47**	**33**	**29**	**29**	**24**	**18**	**28**	**23**	**24**	**10**	**21**	**4**	**19**	**6**	**515**

In Situ Source Control Technologies	82-85	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	TOTALS
Bioremediation	0	0	1	2	1	3	1	4	4	5	4	6	0	6	4	4	3	2	1	2	0	53
Chemical Treatment	1	0	0	0	0	0	1	0	0	0	0	0	0	1	3	1	2	5	0	1	6	20
Multi-Phase Extraction	0	1	0	0	0	0	3	4	1	4	0	2	5	3	3	4	2	6	1	3	3	46
Electrical Separation	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Flushing	1	1	0	0	3	1	1	1	1	4	0	0	0	0	1	1	1	0	0	1	0	17
Thermal Treatment	0	0	0	0	0	1	1	0	0	1	0	2	1	1	1	1	0	0	0	1	4	14
Mechanical Soil Aeration	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3
Neutralization	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	2	1	1	0	0	0	8
Phytoremediation	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	1	1	0	1	0	6
Soil Vapor Extraction	4	2	1	8	21	18	34	19	14	8	11	22	16	12	16	8	7	6	11	6	4	248
Solidification/Stabilization	0	1	3	2	4	2	1	3	5	0	2	4	2	3	3	1	0	3	2	0	3	44
Vitrification	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
TOTALS	**7**	**5**	**5**	**12**	**29**	**25**	**43**	**32**	**25**	**23**	**17**	**37**	**24**	**29**	**33**	**23**	**17**	**25**	**15**	**15**	**21**	**462**

In Situ Groundwater Technologies	82-85	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	TOTALS
Air Sparging	0	1	0	0	1	1	8	3	2	0	4	8	6	10	7	8	4	4	1	2	2	72
Bioremediation	0	0	0	0	4	3	2	2	3	2	2	1	2	3	1	3	12	5	5	5	15	70
Chemical Treatment	0	0	0	0	0	0	0	1	1	0	0	1	1	0	3	5	6	6	1	7	7	39
Multi-Phase Extraction	0	1	0	0	0	0	1	2	0	2	1	1	5	2	1	2	0	3	0	3	2	26
Flushing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
In-Well Air Stripping	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	2	1	0	1	1	0	8
Permeable Reactive Barrier	0	0	0	0	0	0	0	1	0	1	1	1	2	2	2	4	3	1	1	4	1	24
Phytoremediation	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	2	1	0	1	4	0	14
TOTALS	**0**	**2**	**0**	**0**	**5**	**4**	**11**	**9**	**6**	**5**	**9**	**12**	**18**	**19**	**18**	**26**	**28**	**19**	**10**	**26**	**27**	**254**

Ex Situ Groundwater Technologies	1982-85	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	TOTALS
Pump and Treat	11	16	7	26	36	26	48	59	56	70	47	48	64	51	43	41	19	23	11	13	10	725

Appendix C

Definitions of Specific Treatment Technologies

This appendix provides definitions of 17 types of source control (primarily soil) treatment technologies, 9 types of *in situ* groundwater treatment technologies, 8 types of groundwater P&T technologies, and 3 containment technologies. Technologies that are applicable to both source control and groundwater treatment are described only once under the source control treatment section. For P&T technologies, the descriptions focus on the treatment portion of the technology. Groundwater pumping technologies are not addressed in this report. Definitions are based on the Remediation Technologies Screening Matrix and Reference Guide, Version 4.0, which can be viewed at the Federal Remediation Technologies Roundtable (FRTR) web site at http://www.frtr.gov.

SOURCE CONTROL TREATMENT TECHNOLOGIES

BIOREMEDIATION uses microorganisms to degrade organic contaminants in soil, sludge, solids, and groundwater either *in situ* or *ex situ*. It can also be used to make metals or metalloids less toxic or mobile. When treating organic contaminants, the microorganisms break down contaminants by using them as a food source or cometabolizing them with a food source. Aerobic processes require an oxygen source, and the end-products typically are carbon dioxide and water. Anaerobic processes are conducted in the absence of oxygen, and the end-products can include methane, hydrogen gas, sulfide, elemental sulfur, and dinitrogen gas. *Ex situ* bioremediation technologies for groundwater typically involve treating extracted groundwater in a bioreactor or constructed wetland. *In situ* techniques stimulate and create a favorable environment for microorganisms to grow and use contaminants as a food and energy source, or to cometabolize them. Generally, this process involves providing some combination of oxygen, nutrients, and moisture, and controlling the temperature and pH. Microorganisms that have been adapted for degradation of specific contaminants are sometimes applied to enhance the process. For the treatment of metals and metalloids, it involves biological activity that promotes the formation of less toxic or mobile species, by either creating ambient conditions that will cause such species to form, or changing the chemical form of the contaminant directly. The treatment may result in oxidation, reduction, precipitation, coprecipitation, or another transformation of the contaminant.

CHEMICAL TREATMENT, also known as chemical reduction/oxidation, typically involves reduction/oxidation (redox) reactions that chemically convert hazardous contaminants to compounds that are nonhazardous, less toxic, more stable, less mobile, or inert. Redox reactions involve the transfer of electrons from one compound to another. Specifically, one reactant is oxidized (loses electrons) and one is reduced (gains electrons). The oxidizing agents used for treatment of hazardous contaminants in soil include ozone, hydrogen peroxide, hypochlorites, potassium permanganate, Fenton's reagent (hydrogen peroxide and iron), chlorine, and chlorine dioxide. This method may be applied *in situ* or *ex situ* to soils, sludges, sediments, and other solids, and may also be applied to groundwater *in situ* or *ex situ* (P&T). P&T chemical treatment may also include the use of ultraviolet (UV) light in a process known as UV oxidation.

ELECTROKINETICS is based on the theory that a low-density current will mobilize contaminants in the form of charged species. A current passed between electrodes is intended to cause aqueous media, ions, and particulates to move through the soil, waste, and water. Contaminants arriving at the electrodes can be removed by means of electroplating or electrodeposition, precipitation or coprecipitation, adsorption, complexing with ion exchange resins, or by the pumping of water (or other fluid) near the electrode.

For **FLUSHING**, a solution of water, surfactants, or cosolvents is applied to the soil or injected into the subsurface to treat contaminated soil or groundwater. When treating soil, the injection is often designed to raise the water table into the contaminated soil zone. Injected water and treatment agents are recovered together with flushed contaminants.

Both on-site and off-site **INCINERATION** use high temperatures (870 to 1,200°C or 1,600 to 2,200°F) to volatilize and combust (in the presence of oxygen) organics in hazardous wastes. Auxiliary fuels are often employed to initiate and sustain combustion. The destruction and removal efficiency (DRE) for properly operated incinerators exceeds the 99.99% requirement for hazardous waste and can be operated to meet the 99.9999% requirement for polychlorinated biphenyls (PCB) and dioxins. Off-gases and combustion residuals generally require treatment. On-site incineration typically uses a transportable unit; for off-site

incineration, waste is transported to a central facility.

MECHANICAL SOIL AERATION agitates contaminated soil, using tilling or other means to volatilize contaminants.

MULTI-PHASE EXTRACTION uses a vacuum system to remove various combinations of contaminated groundwater, separate-phase petroleum product, and vapors from the subsurface. The system typically lowers the water table around the well, exposing more of the formation. Contaminants in the newly exposed vadose zone are then accessible to vapor extraction. Once above ground, the extracted vapors or liquid-phase organics and groundwater are separated and treated.

NEUTRALIZATION is a chemical reaction between an acid and a base. The reaction involves acidic or caustic wastes that are neutralized (pH is adjusted toward 7.0) using caustic or acid additives.

OPEN BURN (OB) and **OPEN DETONATION (OD)** operations are conducted to destroy excess, obsolete, or unserviceable (EOU) munitions and energetic materials. In OB operations, energetics or munitions are destroyed by self-sustained combustion, which is ignited by an external source, such as a flame, heat, or a detonation wave. In OD operations, explosives and munitions are destroyed by detonation, which generally is initiated by an energetic charge.

PHYSICAL SEPARATION processes use physical properties to separate contaminated and uncontaminated media, or separate different types of media. For example, different-sized sieves and screens can be used to separate contaminated soil from relatively uncontaminated debris. Another application of physical separation is the dewatering of sediments or sludge.

PHYTOREMEDIATION is a process that uses plants to remove, transfer, stabilize, or destroy contaminants in soil, sediment, or groundwater. The mechanisms of phytoremediation include enhanced rhizosphere biodegradation (takes place in soil or groundwater immediately surrounding plant roots), phytoextraction (also known as phytoaccumulation, the uptake of contaminants by plant roots and the translocation/accumulation of contaminants into plant shoots and leaves), phytodegradation (metabolism of contaminants within plant tissues), and phytostabilization (production of chemical compounds by plants to immobilize contaminants at the interface of roots and soil). Phytoremediation applies to all biological, chemical, and physical processes that are influenced by plants (including the rhizosphere) and that aid in the cleanup of contaminated substances. Phytoremediation may be applied *in situ* or *ex situ* to soils, sludges, sediments, other solids, or groundwater.

SOIL VAPOR EXTRACTION (SVE) is used to remediate unsaturated (vadose) zone soil. A vacuum is applied to the soil to induce the controlled flow of air and remove volatile and some semivolatile organic contaminants from the soil. SVE usually is performed *in situ*; however, in some cases, it can be used as an *ex situ* technology.

For **SOIL WASHING**, contaminants sorbed onto fine soil particles are separated from bulk soil in a water-based system on the basis of particle size. The wash water may be augmented with a basic leaching agent, surfactant, or chelating agent, or by adjusting the pH to help remove contaminants. Soils and wash water are mixed *ex situ* in a tank or other treatment unit. The wash water and various soil fractions are usually separated using gravity settling.

SOLIDIFICATION/STABILIZATION (S/S) reduces the mobility of hazardous substances and contaminants in the environment through both physical and chemical means. The S/S process physically binds or encloses contaminants within a stabilized mass. S/S is performed both *ex situ* and *in situ*. *Ex situ* S/S requires excavation of the material to be treated, and the resultant material must be disposed. *In situ* S/S uses auger/caisson systems and injector head systems to add binders to the contaminated soil or waste without excavation, leaving the resultant material in place.

SOLVENT EXTRACTION uses an organic solvent as an extractant to separate contaminants from soil. The organic solvent is mixed with contaminated soil in an extraction unit. The extracted solution then is passed through a separator, where the contaminants and extractant are separated from the soil.

For **THERMAL DESORPTION**, wastes are heated so that organic contaminants and water volatilize. Typically, a carrier gas or vacuum system transports the volatilized water and organics to a gas treatment system, typically a thermal oxidation or recovery system. Based on the operating temperature of the desorber, thermal desorption processes can be categorized into two groups: high temperature thermal desorption (320 to 560°C or 600 to 1000°F) and low temperature thermal desorption (90 to 320°C or 200 to 600°F). Thermal desorption is an *ex situ* treatment process. *In situ*

thermal desorption processes are discussed below as *in situ* thermal treatment.

***IN SITU* THERMAL TREATMENT** is a treatment process that uses heat to facilitate extraction through volatilization and other mechanisms or to destroy contaminants *in situ*. Volatilized contaminants are typically removed from the vadose zone using SVE. Specific types of *in situ* thermal treatment techniques include conductive heating, electrical resistive heating, radio frequency heating, hot air injection, hot water injection, and steam enhanced extraction.

VITRIFICATION uses an electric current to melt contaminated soil at elevated temperatures (1,600 to 2,000°C or 2,900 to 3,650°F). Upon cooling, the vitrification product is a chemically stable, leach-resistant, glass and crystalline material similar to obsidian or basalt rock. The high temperature component of the process destroys or removes organic materials. Radionuclides and heavy metals are retained within the vitrified product. Vitrification may be conducted *in situ* or *ex situ*.

IN SITU GROUNDWATER TREATMENT TECHNOLOGIES

AIR SPARGING involves the injection of air or oxygen into a contaminated aquifer. Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes volatile and semivolatile organic contaminants by volatilization. The injected air helps to flush the contaminants into the unsaturated zone. SVE usually is implemented in conjunction with air sparging to remove the generated vapor-phase contamination from the vadose zone. Oxygen added to the contaminated groundwater and vadose-zone soils also can enhance biodegradation of contaminants below and above the water table.

BIOREMEDIATION - See Source Control Treatment Technologies.

CHEMICAL TREATMENT - See Source Control Treatment Technologies.

ELECTROKINETICS - See Source Control Treatment Technologies.

FLUSHING - See Source Control Treatment Technologies.

For **IN-WELL AIR STRIPPING**, air is injected into a double-screened well, causing the volatile organic compounds (VOC) in the contaminated groundwater to transfer from the dissolved phase to the vapor phase in air bubbles. As the air bubbles rise to the surface of the water, the vapors are drawn off and treated by a SVE system.

MULTI-PHASE EXTRACTION - See Source Control Treatment Technologies.

PERMEABLE REACTIVE BARRIERS (PRB), also known as passive treatment walls, are installed across the flow path of a contaminated groundwater plume, allowing the water portion of the plume to flow through the wall. These barriers allow the passage of water while prohibiting the movement of contaminants by employing treatment agents within the wall such as zero-valent metals (usually zero-valent iron), chelators, sorbents, compost, and microbes. The contaminants are either degraded or retained in a concentrated form by the barrier material, which may need to be replaced periodically.

PHYTOREMEDIATION - See Source Control Treatment Technologies.

PUMP AND TREAT TECHNOLOGIES (EX SITU TREATMENT)

In **ADSORPTION**, contaminants concentrate at the surface of a sorbent, thereby reducing their concentration in the bulk liquid phase. This technology is typically applied by passing extracted groundwater through a column containing granular adsorbent. The most common adsorbent is granulated activated carbon. Other natural and synthetic adsorbents include activated alumina, lignin adsorption, sorption clays, and synthetic resins.

AIR STRIPPING partitions volatile organics from extracted groundwater by increasing the surface area of the contaminated water exposed to air. Aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.

BIOREMEDIATION - See Source Control Treatment Technologies.

CHEMICAL TREATMENT - See Source Control Treatment Technologies.

FILTRATION is the physical process of mechanical separation based on particle size, whereby particles suspended in a fluid are separated by forcing the fluid through a porous medium. As fluid passes through the medium, the suspended particles are trapped on the surface of the medium and/or within the body of the medium.

ION EXCHANGE removes ions from the aqueous phase by the exchange of cations or anions between the contaminants and the exchange medium. Ion exchange materials may consist of resins made from synthetic organic materials that contain ionic functional groups to which exchangeable ions are attached.

METALS PRECIPITATION transforms dissolved contaminants into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration. The process usually uses pH adjustment, addition of a chemical precipitant, and flocculation.

MEMBRANE FILTRATION separates contaminants from water by passing it through a semipermeable barrier or membrane. The membrane allows water and other low molecular weight chemicals to pass, while blocking contaminants with a higher molecular weight. Membrane filtration processes include microfiltration, ultrafiltration, nanofiltration, and reverse osmosis.

MONITORED NATURAL ATTENUATION (MNA) FOR GROUNDWATER

Groundwater **MNA** is the reliance on natural attenuation processes (within the context of a carefully controlled and monitored approach to site cleanup) to achieve site-specific remediation objectives within a time frame that is reasonable, compared with that offered by other, more active methods. The "natural attenuation processes" include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These *in situ* processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants. Guidance on MNA is available from the document "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (OSWER Directive 9200.4-17P, EPA, April 21, 1999.").

CONTAINMENT TECHNOLOGIES

COVER SYSTEMS, also known as caps or covers, are surface barriers composed of one of more layers of impermeable material designed to contain contaminated source material. COVER SYSTEMS can be used to prevent direct contact with the source material or minimize leachate creation by preventing surface water infiltration into the contained source material.

A **BOTTOM LINER** is a subsurface impermeable barrier designed to prevent the spread of leachate from contaminated source material. They are often used in conjunction with COVER SYSTEMS in the containment of source material.

VERTICAL ENGINEERED BARRIERS (VEB) are subsurface barriers made of an impermeable material designed to contain or divert groundwater. VEBs can be used to contain contaminated groundwater, divert uncontaminated groundwater from a contaminated area, or divert contaminated groundwater from a drinking water intake or other protected resource. VEBs can also be used for the containment of source material.

Appendix F

Identification of Remedy and Record of Decision Types for Superfund Remedial Actions

F.1 BACKGROUND

On December 11, 1980, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which is known as the "Superfund" act. The act created the Superfund program, which was established to clean up abandoned hazardous waste sites around the United States. Section 105(a)(8)(B) of CERCLA, as amended, requires that the U.S. Environmental Protection Agency (EPA) prepare a list of national priorities among the known sites throughout the United States at which releases or threatened releases of hazardous substances, pollutants, or contaminants may occur. This list is known as the National Priorities List (NPL).

The remedies selected for an NPL site are documented in a record of decision (ROD). Remedies implemented at NPL sites or NPL equivalent sites in accordance with RODs are known as Superfund remedial actions, and such sites are known as Superfund remedial action sites. Because selected remedies vary in the type of media addressed and the methods used to address those media, confusion can arise when assigning a type to a particular remedy. Categorizing remedies by types can facilitate the transfer of experience and technology by making it easier to identify sites at which similar remedies are applicable. Establishing and applying a methodology for classifying remedy types can provide a consistent and comprehensive approach for reviewing and comparing remedies used in RODs. In addition, use of such an approach can lead to more consistent data collection and reporting and assist remedial project managers (RPMs), On-Scene Coordinators (OSCs), and other regulatory and remediation professionals in the transfer of experience and technology among Superfund sites and in identifying sites implementing similar remedies. This Appendix describes the approach used to classify remedies and RODs for the ASR.

Remedies were classified by reviewing the remedies selected in RODs. Although RODs are written using an overall format that is consistent, RODs are prepared by individual RPMs and other staff of the 10 EPA regions. In addition, the management practices and techniques used to remediate sites have evolved over time and continue to evolve. Therefore, the words, phrases, and descriptions applied to the same or similar remedies may differ from ROD to ROD. To facilitate the identification of remedy types, this appendix includes both descriptive definitions of remedy types and lists of key words and phrases that may be used to refer to each remedy type.

The definitions of remedy types provided in this document are based on a review of definitions and lists of media, remedies, and technologies provided in the following resources:

- The CERCLA Information System (CERCLIS 3) database
- ROD Annual Reports for fiscal years (FY) 1989 through 2005
- The Federal Remediation Technologies Roundtable (FRTR) Technology Screening Matrix
- Treatment Technologies for Site Cleanup: Annual Status Report (Twelfth Edition) (ASR)

The remedy type definitions were reviewed and augmented by a working group of personnel of the EPA Office of Solid Waste and Emergency Response (OSWER) who are experienced in site remediation and ROD preparation and review.

F.2 CLASSIFYING REMEDIES AND RODs

Remedy types were identified by first dividing remedies into three categories (source control, groundwater, and no action) based on the media treated and the type of action. Within each of these categories, the remedies were then further divided into the following 10 specific remedy types:

Source Control Remedies:

1. Source control treatment
2. Source control containment
3. Source control other
4. Source control monitored natural attenuation

Groundwater Remedies:

5. Groundwater *in situ* treatment
6. Groundwater pump and treat
7. Groundwater containment barriers
8. Groundwater other
9. Groundwater monitored natural attenuation

No Action Remedies:

10. No action or no further action (NA/NFA)

RODs were classified using the 10 remedy types listed above. When more than one remedy type was selected in the same ROD, the ROD was assigned all of the remedy types that are identified.

The definitions that were used to identify each remedy type are provided in the "Definitions" section below. When definitions include specific technologies and those technologies commonly are referred to by more than one word or phrase, the most commonly used word or phrase is listed first, followed by synonyms in parentheses.

F.3 DEFINITIONS USED TO IDENTIFY REMEDY TYPES

F.3.1 General Definitions

The definitions of treatment technology and the different types of treatment technologies (physical, chemical, thermal, and biological treatment) apply to both source control and groundwater remedies.

Treatment Technology - Any unit operation or series of unit operations that alters the composition of a hazardous substance, pollutant or contaminant through chemical, biological, or physical means so as to reduce toxicity, mobility, or volume of the contaminated materials being treated. Treatment technologies are an alternative to land disposal of hazardous wastes without treatment (Federal Register, volume 55, page 8819, 40 CFR 300.5: Definitions). Treatment technologies are grouped into five categories. The definitions for four of the categories (physical treatment, chemical treatment, thermal treatment, and biological treatment) are based on definitions provided in the FRTR Technology Screening Matrix. The fifth category, other or unspecified treatment, includes those technologies that do not fit into the first four categories. The five treatment technology categories are:

Physical Treatment - Uses the physical properties of the contaminants or the contaminated medium to separate or immobilize the contamination.

Chemical Treatment - Chemically converts hazardous contaminants to non-hazardous or less toxic compounds or compounds that are more stable, less mobile, and/or inert. Even though a chemical reaction is not always involved in chemical precipitation, chemical precipitation is typically included in this category.

Thermal Treatment - Uses heat to: separate contaminants from contaminated media by increasing their volatility; destroy contaminants or contaminated media by burning, decomposing, or detonating the contaminants or the contaminated media; or immobilize contaminants by melting and solidifying the contaminated media.

Biological Treatment - Includes adding or stimulating the growth of microorganisms, which metabolize contaminants or create conditions under which contaminants will chemically convert to non-hazardous or less toxic compounds or compounds that are more stable, less mobile, and/or inert. Phytoremediation, the use of plants to remove, stabilize, or destroy contaminants, is included within the definition of biological treatment.

Other or Unspecified Treatment - Treatment that cannot be classified as physical treatment, chemical treatment, thermal treatment, or biological treatment. For example, some RODs select physical/chemical treatment of a source without specifying the particular physical/chemical treatment. In such cases, the ROD was not definitively classified as physical or chemical treatment and was classified as other or unspecified treatment, unspecified physical/chemical treatment.

F.3.2 Source Control Remedies

Source Media - A source medium is defined as a material that acts as a reservoir, either stationary or mobile, for hazardous substances. Source media include or contain hazardous substances, pollutants, or contaminants that may migrate to the groundwater, to surface water, to air, (or to other environmental media) or act as a source for direct exposure. Contaminated groundwater generally is not considered to be a source material although nonaqueous phase liquids (NAPLs [occurring either as residual- or free-phase]) may be viewed as source materials. (A Guide to Principal Threat and Low Level Threat Wastes, Superfund publication 9355.3-02FS, USEPA OSWER 1991). Source media include soil, sediment, sludge, debris, solid-matrix wastes, surface water, NAPLs, equipment, drums, storage tanks, leachate, landfill gas, and any other contaminated media other than groundwater that can act as a potential source of contamination.

Source Control Remedy - any removal, treatment, containment, or management of any contaminant source or contaminated medium other than groundwater.

1. Source Control Treatment

Any process meant to separate and remove, destroy, or bind contaminants in a source medium. Key words used in RODs to identify these processes are listed below. Additional detail about these technologies can be found in the ASR at http://clu-in.org/asr or on the Federal Remediation Technologies Roundtable Web site at http://www.frtr.gov.

Physical Treatment

- Acid extraction
- Air stripping
- Carbon adsorption (liquid-phase carbon adsorption)
- Clarification (sedimentation)
- Decontamination
- Dewatering
- Electrical separation (electrokinetic separation)
- Evaporation
- Filtration
- Flushing (soil flushing and surfactant flushing)
- Ion exchange
- Magnetic separation
- Membrane filtration (microfiltration, nanofiltration, reverse osmosis, ultrafiltration)
- Multi-phase extraction (free product recovery)
- Oil/water separation (free product recovery)
- Physical separation (component separation and materials handling)
- Soil vapor extraction (vacuum extraction and vapor extraction)
- Soil washing
- Solidification/stabilization (asphalt batching, immobilization, and microencapsulation)
- Solid-phase extraction
- Solvent extraction (chemical stripping)
- Steam stripping
- Super-critical fluid extraction
- Volatilization (aeration, mechanical soil aeration, and tilling)

Chemical Treatment

- Chemical oxidation (cyanide oxidation, oxidation, and peroxidation)
- Chemical reduction (reduction)
- Chemical treatment (chemical reduction/oxidation and remedy type not further specified)
- Dehalogenation (dechlorination)
- Flocculation
- Metals precipitation
- Neutralization (pH neutralization)
- Permeable reactive barrier (chemical reactive barrier, chemical reactive wall, leachate reactive wall, and passive treatment wall)
- Ultraviolet (UV) oxidation

Thermal Treatment

- Flaring (gas flaring)
- High energy corona
- Open burning/open detonation
- Plasma high-temperature recovery (fuming gasification and high-temperature metals recovery)
- Thermal desorption
- Thermal destruction (incineration and pyrolysis)
- Thermal treatment (remedy type not further specified)
- *In situ* thermal treatment (conductive heating, Contained Recovery of Oily Wastes [CROW®], dynamic underground stripping, electrical resistance heating, hot air injection, *in situ* thermal desorption, microwave heating, radio frequency heating, steam injection, and thermally enhanced soil vapor extraction)
- Vitrification (slagging)

Biological Treatment

- Aeration (for purpose of bioremediation, tilling)
- Biopile
- Bioreactor
- Bioremediation (biological treatment, remedy type not further specified)
- Bioslurping
- Bioventing
- Co-metabolic treatment
- Composting
- Controlled solid phase
- Fixed film reactors
- Landfarming
- Microbial injection (addition of microorganisms)
- Nitrate enhancement
- Nutrient injection
- Oxygen enhancement with air sparging (biosparging)

Biological Treatment (continued)

- Oxygen enhancement with hydrogen peroxide (H_2O_2)
- Permeable treatment bed (for purpose of bioremediation)
- Phytoremediation
- Slurry-phase bioremediation (bioslurry, activated sludge)
- White rot fungus

Other or Unspecified Treatment

- Air emission treatment
- Fracturing (pneumatic fracturing, hydraulic fracturing)
- Gas collection and treatment (off-gas treatment)
- Hot gas decontamination
- Leachate treatment
- Publicly owned treatment works (POTW)
- Recycling
- Surface water treatment
- Treatment of residuals
- Unspecified physical/chemical treatment
- Unspecified treatment

2. Source Control Containment

Any process or structure designed to prevent contaminants from migrating from a source media into groundwater, to surface water, to air, (or to other environmental media) or acting as a source for direct exposure. Key words used in RODs to identify source control containment remedies are listed below:

Capping and Cover

- Cap (impermeable barrier)
- Cover material
- Evapotranspiration cover

Bottom Liner

- Clay
- Geosynthetic material
- Liner (impermeable barrier)

Drainage and Erosion Control

- Engineering control (remedy type not further specified)
- Hydraulic control
- Impermeable barrier
- Revegetation
- Slope stabilization
- Subsurface drain (leachate control)
- Surface water control (dike, berm, drainage controls, drainage ditch, erosion control, flood protection, and levee)

On-Site Landfilling

- On-site consolidation
- On-site disposal
- On-site landfilling (remedy type not further specified)

Off-Site Landfilling

- Off-site consolidation
- Off-site disposal
- Off-site landfilling (remedy type not further specified)

Vertical Engineered Barrier

(When used as a remedy for a source medium [including subsurface NAPLs]. Vertical subsurface engineered barriers used to control or contain groundwater should not be considered source control containment.)

- Grout (grout curtain)
- Impermeable barrier
- Sheet piling
- Slurry wall
- Subsurface barrier
- Vertical barrier

Other or Unspecified Containment

- Containment (consolidation, disposal, landfilling, and removal)
- Encapsulation (overpacking)
- Leachate control (leachate collection, leachate discharge, leachate recovery wells, leachate reinjection)
- Liquid waste management (liquid waste collection, liquid waste discharge, liquid waste recovery wells, liquid waste reinjection)
- Permanent storage
- Repair (pipe repair, sewer repair, and tank repair)
- Surface water management (surface water collection, surface water discharge, surface water recovery wells, surface water reinjection)

3. Source Control Other

Source control remedies that do not fall into the categories Source Control Treatment or Source Control Containment.

Institutional Control

The classification of institutional controls has been revised based on Institutional Controls: A Site Manager's Guide to Identifying, Evaluating, and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups, OSWER 9355.0-74FS-P, EPA 540-F-00-005, September 2000. The remedy definitions outlined in this guidance differ from those historically used to classify institutional control remedies. This classification system groups institutional controls into 4 categories. Listed below are these four categories. Beneath each category, the terms historically applied to institutional controls that are most likely to fall under the categories are listed. The list below also adds a fifth category, "Institutional control (remedy type not further specified)" for cases where the particular institutional control selected is not recorded in a ROD.

1. **Governmental control**
   - Access restriction
   - Drilling restriction
   - Fishing restriction
   - Guard (security)
   - Recreational restriction
   - Surface water restriction
   - Swimming restriction
   - Water supply use restriction
2. **Proprietary control**
   - Deed notification
   - Deed restriction
   - Land use restriction
3. **Enforceable agreement**
   - Access agreement
4. **Informational device**
5. **Institutional control (remedy type not further specified)**

Engineering Control

- Dust suppression
- Engineering control (remedy type not further specified)
- Fencing
- Water table adjustment
- Wetland replacement

Source Monitoring

- Monitoring
- Sampling

Population Relocation

- Population relocation

Surface Water Supply Remedies

- Alternate water supply (alternate drinking water and bottled water)
- Carbon at tap
- Well-head treatment

4. Source Control Monitored Natural Attenuation (MNA)

The reliance on natural attenuation processes (within the context of a carefully controlled and monitored approach to site cleanup) to achieve site-specific remediation objectives within a timeframe that is reasonable, compared with that offered by other, more active methods. The "natural attenuation processes" that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These *in situ* processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants (Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, USEPA, Office of Solid Waste and Emergency Response, Directive Number 9200.4-17P, 1999).

A remedy should be considered source control MNA if it includes "natural attenuation" or "monitored natural attenuation" for a source (e.g., contaminated soil).

F.3.3. Groundwater Remedies

Groundwater Remedy - Management of groundwater. Groundwater remedies can include *in situ* treatment, pump and treat, containment using vertical engineered barriers, MNA, and other measures to address groundwater.

Groundwater Media - One or more aquifers beneath or proximal to a source medium, contaminated by migration of contaminants, such as leachate, or by other sources.

5. Groundwater In Situ Treatment

Treatment of groundwater without extracting it from the ground. Key words used in RODs to identify groundwater *in situ* treatment remedies are listed below:

Physical Treatment

- Air sparging
- Electrical separation (electrokinetic separation)
- In-well air stripping (well aeration and air stripping)
- Multi-phase extraction (free product recovery)
- Surfactant flushing
- Vapor extraction

Chemical Treatment

- Chemical oxidation (cyanide oxidation, oxidation, and peroxidation)
- Chemical reduction (reduction)
- Chemical treatment (chemical reduction/ oxidation and remedy type not further specified)
- Dehalogenation (dechlorination)
- Permeable reactive barrier (chemical reactive barrier, chemical reactive wall, and passive treatment wall)

Biological Treatment

- Aeration (for purpose of bioremediation)
- Bioremediation (biological treatment, remedy type not further specified)
- Bioslurping
- Bioventing
- Co-metabolic treatment
- Microbial injection (addition of microorganisms)
- Nitrate enhancement
- Nutrient injection
- Oxygen enhancement with air sparging (biosparging)
- Oxygen enhancement with hydrogen peroxide (H_2O_2)
- Phytoremediation

Other or Unspecified Treatment

- Fracturing (pneumatic fracturing, hydraulic fracturing)
- Treatment of residuals
- Unspecified physical/chemical treatment
- Unspecified treatment

6. Groundwater Pump and Treat

Extraction of groundwater from an aquifer followed by treatment above ground. Key words used in RODs to identify groundwater pump and treat remedies are listed below:

Physical Treatment

- Aeration (air stripping)
- Carbon adsorption (liquid phase carbon adsorption)
- Clarification (sedimentation)
- Coagulation
- Component separation
- Equalization
- Evaporation
- Filtration
- Ion exchange
- Membrane filtration (microfiltration, nanofiltration, reverse osmosis, ultrafiltration)
- Oil/water separation (free product recovery)

Chemical Treatment

- Chemical oxidation (cyanide oxidation, oxidation, and peroxidation)
- Chemical reduction
- Chemical treatment (chemical reduction/oxidation and remedy type not further specified)
- Flocculation
- Metals precipitation
- Neutralization (pH neutralization)
- Ultraviolet (UV) oxidation

Biological Treatment

- Biological treatment (remedy type not further specified)
- Bioreactors
- Fixed film reactors
- Oxygen enhancement with hydrogen peroxide (H_2O_2)
- Wetlands treatment

Other or Unspecified Treatment

- Centralized waste treatment facility
- Fracturing (pneumatic fracturing, hydraulic fracturing)
- Publicly owned treatment works (POTW)
- Pumping and unspecified ex-situ treatment
- Treatment of residuals
- Unspecified ex-situ physical/chemical treatment
- Unspecified treatment

Groundwater Extraction

The process of removing groundwater from beneath the ground surface, including the following methods of groundwater extraction:

- Directional well (horizontal well)
- Pumping (recovery well, vertical well)
- Recovery trench (horizontal drain)
- Subsurface drain

Groundwater Discharge and Management

A method of discharging or otherwise managing extracted groundwater, including the following discharge methods and receptors:

- Deep well injection (Class I well)
- Recycling
- Reuse as drinking water
- Reuse as irrigation water
- Reuse as process water
- Surface drain reinjection (infiltration basin, infiltration trench)
- Surface water discharge (National Pollutant Discharge Elimination System [NPDES] discharge)
- Vertical well reinjection (into contaminated aquifer)

7. Groundwater Containment

Containment of groundwater, typically through the use of vertical engineered barriers. Key words used in RODs to identify groundwater containment remedies are listed below:

Vertical Engineered Barrier

- Deep soil mixing (barrier installation technique)
- Geosynthetic wall
- Grout (grout curtain)
- High-density polyethylene (HDPE) wall
- Impermeable barrier
- Sheet piling
- Slurry wall
- Subsurface vertical engineered barrier (subsurface barrier, subsurface vertical barrier)

Other or Unspecified Containment

- Plume containment (hydraulic containment of plume, plume management, plume migration control)

8. Groundwater Other

Groundwater remedies that do not fall into the categories Groundwater *In situ* Treatment, Groundwater Pump and Treat, Groundwater Containment, or Groundwater Monitored Natural Attenuation.

Institutional Control

The classification of institutional controls has been revised based on Institutional Controls: A Site Manager's Guide to Identifying, Evaluating, and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups, OSWER 9355.0-74FS-P, EPA 540-F-00-005, September 2000. The remedy definitions outlined in this guidance differ from those historically used to classify institutional control remedies. This classification system groups institutional controls into 4 categories. Listed below are these four categories. Beneath each category, the terms historically applied to institutional controls that are most likely to fall under the categories are listed. The list below also adds a fifth category, "Institutional control (remedy type not further specified)" for cases where the particular institutional control selected is not recorded in a ROD.

1. **Governmental control**
   - Access restriction
   - Drilling restriction
   - Fishing restriction
   - Groundwater restriction
   - Guard (security)
   - Recreational restriction
   - Surface water restriction
   - Swimming restriction
   - Water supply use restriction
2. **Proprietary control**
   - Deed notification
   - Deed restriction
   - Land use restriction
3. **Enforceable agreement**
   - Access agreement
4. **Informational device**
5. **Institutional control (remedy type not further specified)**

Engineering Control

- Engineering control (berm, dike, drainage ditch, levee)
- Water table adjustment
- Wetland replacement

Groundwater Monitoring

- Monitoring
- Sampling

Population Relocation

- Population Relocation

Water Supply Remedies

- Alternate water supply (alternate drinking water and bottled water)
- Carbon at tap
- Extend piping to existing water main
- Install new surface water intake
- Install new water supply wells
- Seal well (close well)
- Treat at use location
- Well-head treatment

9. Groundwater MNA

The reliance on natural attenuation processes (within the context of a carefully controlled and monitored approach to site cleanup) to achieve site-specific remediation objectives within a time frame that is reasonable, compared with that offered by other, more active methods. The "natural attenuation processes" that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These *in situ* processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants (Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, USEPA, Office of Solid Waste and Emergency Response, Directive Number 9200.4-17P, 1999).

A remedy should be considered groundwater MNA if it includes "natural attenuation" or "monitored natural attenuation" of groundwater.

F.3.4 No Action Remedies

10. NA/NFA

The designation used for remedies that indicate no action or no further action will be taken. When determining overall ROD type, the designation was used only for RODs under which NA/NFA is the only remedy selected. If a ROD selected NA/NFA for only part of a site and another remedy for another part of a site, the ROD was given the classification corresponding to that selected remedy and was not given an NA/NFA designation.

F.4 SPECIAL CASES

This subsection provides a list of some special cases and descriptions of how remedy types should be assigned in those cases:

Decontamination

- The remedy type for decontamination of buildings, equipment, tanks, debris, boulders, rocks, or other objects was considered source control treatment. For example, abrasive blasting or scarifying a concrete pad to remove the contaminated surface layer of the pad was identified as source control treatment.
- Decontamination of equipment used to clean up a Superfund site is a normal activity that occurs at many Superfund sites and was not considered a remedy. For example, high-pressure water washing of a front end loader used to excavate contaminated soil was not considered a remedy and was not given a remedy type.

Phytoremediation

- Phytoremediation involves the use of macroscopic plants to destroy, remove, immobilize, or otherwise treat contaminants. While this technology may include the use of microorganisms in conjunction with plants, it is distinguished from bioremediation in that bioremediation does not use macroscopic plants. Remedies that used microorganisms without macroscopic plants were identified as bioremediation.
- The use of plants to control surface water drainage at a site is not phytoremediation. Such remedies were identified as engineering controls (source control other or groundwater other).

Remedies Based on Site Characteristics - If a ROD indicates that a certain remedy be implemented based on certain site characteristics, the ROD should be considered to have selected the remedy. For example, a ROD may specify that if soils exceed a certain level of contamination they will be incinerated, but if they do not exceed that level, no further action will be taken. In such a case, the ROD was considered to have selected incineration and therefore was considered a source control treatment ROD.

Vertical Engineered Barriers - Some of the technologies used for vertical engineered barriers are also used to control surface water and surface drainage (for example, slurry walls and sheet piles). Where these remedies were used to contain groundwater, they were identified as groundwater containment.

Solidification/Stabilization - Some of the technologies used for solidification/stabilization can be used for either treatment or containment. For example, "encapsulation" of a waste in plastic drums is source control containment. "Encapsulation" of a waste by mixing with a monomer and then causing it to polymerize, resulting in microencapsulation, is source control treatment. In general, containment involves isolating bulk wastes, while solidification/stabilization involves incorporating the contaminants into a matrix so that their leachability is reduced.

Water Table Adjustment - Where water table adjustment is used to prevent the groundwater from coming into contact with a contaminated source medium, it was identified as source control other, engineering control. Where water table adjustment was used to treat groundwater, it was classified as groundwater other, engineering control.

Subsurface Drain - When a subsurface drain was used in order to prevent contact of precipitation runoff with a source or to prevent erosion, it was considered source control containment, drainage and erosion control. When a subsurface drain was used to extract groundwater prior to treatment of the groundwater, it was classified as groundwater pump and treat, groundwater extraction.

Treatment of Residuals - Residuals are the matter that results from a treatment process. For example, the residuals from incineration of soil can include ash, off-gasses, and scrubber blowdown from off-gas treatment. In the preceding example, treatment of off-gasses using a scrubber was classified as treatment of residuals. Where treatment of residuals was specified in a ROD, the existence of residuals treatment was identified, but additional information on the treatment of residuals was not collected.

Air Media - Air media include sources that are in a gaseous form, such as landfill gas or hazardous gasses stored in compressed gas cylinders. When remedies for air media were selected in a ROD they were identified as source control remedies. For example, collection and treatment of landfill gas was classified as source control treatment. Air emissions from equipment used to treat sources or groundwater are not air media. For example, a ROD may specify that groundwater will be extracted and treated by air stripping, and the off-gas generated by the air stripping must be treated by activated carbon adsorption. In such a case, the ROD was classified as groundwater pump-and-treat (both physical treatment, aeration [air stripping]; and other or unspecified treatment, treatment of residuals), but was not classified as a source control treatment ROD.

Appendix G

Reasons for Shut Down of 73 Groundwater Pump and Treat Systems

Reasons for Shut Down of 73 Groundwater Pump and Treat Systems

EPA Region	Site Name, State	Reasons for Shut Down
1	Hocomonco Pond, MA	Due to technical/operational problems
1	McKin Co., ME	Replaced with MNA
1	Naval Station Newport, RI	Met project goals (either restoration or containment)
1	Norwood PCBs, MA	Met project goals (either restoration or containment)
1	Pinette's Salvage Yard, ME	Replaced with institutional controls
1	Sylvester Dump, NH	Met project goals (either restoration or containment)
1	Tinkham Garage, NH	Replaced with MNA
1	Union Chemical Co Inc., ME	Replaced with in situ treatment
1	Winthrop Landfill, ME	Shutdown for evaluation/monitoring
2	Fulton Terminals, NY	Met project goals (either restoration or containment)
2	Mannheim Avenue Dump, NJ	Met project goals (either restoration or containment)
2	Tabernacle Drum Dump, NJ	Met project goals (either restoration or containment)
2	Universal Oil Products, NJ	Met project goals (either restoration or containment)
3	Old City of York Landfill, PA	Replaced with MNA
3	Southern Maryland Wood Treating, MD	Met project goals (either restoration or containment)
4	Celanese Fiber Corp., NC	Due to technical/operational problems and to investigate MNA
4	Gold Coast Oil Corp., FL	Met project goals (either restoration or containment)
4	Harris Corp. (Palm Bay Plant) (OU 1), FL	Replaced with MNA
4	Harris Corp. (Palm Bay Plant) (OU 2), FL	Replaced with MNA
4	Hipps Road Landfill, FL	Replaced with MNA
4	Hollingsworth Solderless, FL	Due to technical/operational problems
4	Palmetto Wood Preserving, SC	Replaced with MNA
4	Sydney Mine Sludge Pond, FL	Replaced with MNA
4	Townsend Saw Chain Company, SC	Replaced with in situ treatment
5	Avenue "E" Groundwater Contamination, MI	Met project goals (either restoration or containment)
5	Belvidere Municipal Landfill, IL	Met project goals (either restoration or containment)
5	Big D Campground, OH	Replaced with MNA
5	Burrows Sanitation, MI	Met project goals (either restoration or containment)
5	Cross Brothers Pail Recycling (Pembroke), IL	Met project goals (either restoration or containment)
5	Delavan Municipal Well #4 (Chip Storage Extraction System), WI	Due to technical/operational problems
5	Delavan Municipal Well #4 (Southeast Extraction System), WI	Due to technical/operational problems
5	Hagen Farm, WI	Replaced with in situ treatment
5	Lehillier/Mankato Site, MN	Met project goals (either restoration or containment)
5	Lemberger Transport & Recycling Inc., WI	Replaced with MNA
5	New Brighton/Arden Hills (OU 3), MN	Met project goals (either restoration or containment)
5	New Lyme Landfill, OH	Due to technical/operational problems
5	Oconomowoc Electroplating, WI	Replaced with MNA
5	Onalaska Muncipal Landfill, WI	Replaced with MNA
5	Rasmussens Dump, MI	Replaced with in situ treatment
5	Roto-Finish Co, Inc., MI	Replaced with MNA
5	Seymour Recycling Corp., IN	Replaced with MNA
5	Spiegelberg Landfill, MI	Met project goals (either restoration or containment)
5	Tri-State Plating, IN	Met project goals (either restoration or containment)
5	U.S. Aviex, MI	Replaced with in situ treatment and MNA
5	University of Minnesota (Rosemount Research Center), MN	Met project goals (either restoration or containment)
5	Waite Park Wells (EM Site), MN	Shutdown for evaluation/monitoring

MNA = Monitored natural attenuation

Reasons for Shut Down of 73 Groundwater Pump and Treat Systems (continued)

EPA Region	Site Name, State	Reasons for Shut Down
5	Whittaker Corp., MN	Due to technical/operational problems
5	Windom Dump, MN	Met project goals (either restoration or containment)
6	Cimarron Mining Corporation, NM	Due to technical/operational problems
6	French Limited, TX	Replaced with MNA
6	Geneva Industries/Fuhrmann Energy, TX	Due to technical/operational problems
6	Odessa Chromium #1, TX	Replaced with in situ treatment
6	Odessa Chromium #2 (Andrews Highway) (North Plume), TX	Replaced with in situ treatment
6	Odessa Chromium #2 (Andrews Highway) (South Plume), TX	Replaced with in situ treatment
6	Sol Lynn/Industrial Transformers, TX	Replaced with in situ treatment and MNA
7	Fairfield Coal Gasification Plant, IA	Met project goals (either restoration or containment)
8	Intermountain Waste Oil Refinery (OU 2), UT	Met project goals (either restoration or containment)
8	Marshall Landfill, CO	Met project goals (either restoration or containment)
8	Mystery Bridge Road/Highway 20 (DOW/DSI), WY	Due to technical/operational problems
8	Mystery Bridge Road/Highway 20 (Kinder/Morgan), WY	Met project goals (either restoration or containment)
8	Ogden Defense Depot (DLA) (OU 2), UT	Replaced with in situ treatment
8	Rocky Flats Plant (881 Hillside, OU 1), CO	Met project goals (either restoration or containment)
9	Barstow Marine Corps Logistics Base - OU 02 Nebo North, CA	Shutdown for evaluation/ monitoring
9	Coast Wood Preserving, CA	Replaced with in situ treatment
9	Del Norte County Pesticide Storage Area, CA	Due to technical/operational problems
9	Fairchild Semiconductor (South San Jose), CA	Met project goals (either restoration or containment)
9	Firestone Tire & Rubber Co. (Salinas Plant), CA	Met project goals (either restoration or containment)
9	Norton AFB (Base Boundary Area), CA	Met project goals (either restoration or containment)
9	Norton AFB (Central Base Area), CA	Shutdown for evaluation/ monitoring
9	Sola Optical USA, Inc., CA	Replaced with MNA
9	Southern California Edison, Visalia Pole Yard, CA	Shutdown for evaluation monitoring
9	U.S. DOE Lawrence Livermore National Laboratory - TFF, CA	Met project goals (either restoration or containment)
9	Western Pacific Railroad Co., CA	Replaced with in situ groundwater and source control treatment

MNA = Monitored natural attenuation