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 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 in accordance with RODs are known as Superfund remedial actions, and such sites are known as Superfund remedial action sites.

Selected remedies vary in the type of media addressed and the methods used to address those media. Classifying remedies into types can facilitate the transfer of experience and technology by making it easier to identify sites at which similar remedies are applicable. In addition, identifying remedy types can streamline the collection of the data needed to track the progress of the remediation of sites on the NPL and to identify trends in site remediation.

Because of the variety of media, contaminants, and potential remedies, confusion can arise when assigning a type to a particular remedy. Establishing and applying a comprehensive methodology for identifying remedy types can reduce potential confusion about remedy types and lead to more consistent data collection and reporting, thereby assisting in the transfer of experience and technology among similar sites.

This appendix describes the approach used to identify remedy and ROD types used in the document *Treatment Technologies for Site Cleanup: Annual Status Report (Tenth Edition)* (ASR). The methodology presented here is intended to provide a consistent and comprehensive approach to identifying remedy types, and, based on those remedy types, identifying ROD types. This approach can assist in the transfer of experience and technology among Superfund sites by helping remedial project managers (RPMs), On-Scene Coordinators (OSCs), and other regulatory and remediation professionals identify sites implementing similar remedies.

Remedy and ROD types are determined 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 appendix were 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 1995
- The Federal Remediation Technologies Roundtable (FRTR) Technology Screening Matrix
- The ASR

The remedy type definitions were reviewed and augmented by a working group of personnel of the U.S. Environmental Protection Agency (EPA) Technology Innovation Office (TIO) and Office of Emergency and Remedial Response (OERR) who are experienced in site remediation and ROD preparation and review.

This appendix includes remedy types and technologies that are not discussed in the ASR. The ASR focuses on source control treatments and in situ groundwater treatments. Additional remedy and technology types are described in this appendix so that it may be used for purposes beyond the limited scope of the ASR.

F.2 IDENTIFICATION OF REMEDY AND ROD TYPES

This appendix describes the methodology used to classify remedies selected at Superfund remedial action sites into specific types. 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 12 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
8. Groundwater other
9. Groundwater monitored natural attenuation
10. Groundwater extraction
11. Groundwater discharge

No Action Remedies:

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

Each ROD may select multiple remedy types. When multiple remedy types are selected in a single ROD, the overall ROD type is the one that appears first in the list above.

The definitions 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

Definitions used to identify remedy types are presented below. The definitions of treatment technology and the different types of treatment technologies (physical, chemical, thermal, and bioremediation treatment) apply to both source control and groundwater remedies. Because these definitions apply to both source control and groundwater remedies, they are presented once here rather than being duplicated everywhere they apply.

Treatment Technology - Any unit operation or series of unit operations that alters the composition of a hazardous substance or 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 contain 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.

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 the contaminated media.

Bioremediation Treatment - Stimulates 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.

Other or Unspecified Treatment - Treatment that cannot be classified as physical treatment, chemical treatment, thermal treatment, or bioremediation treatment.

F.3.1 Source Control

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

Source Media - "Source material is defined as material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir [either stationary or mobile] for migration of contamination to the groundwater, to surface water, to air, [or to other environmental media] or act as a source for direct exposure. Contaminated ground water generally is not

considered to be a source material although non-aqueous 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 OERR 1991). Source media include soil, sediment, sludge, debris, solid-matrix wastes, surface water, non-aqueous phase liquids (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.

1. Source Control Treatment

Any process meant to separate, destroy, or bind contaminants in a source medium. Key words used in RODs to identify these processes are listed below. More detailed descriptions of most of the technologies can be found in the ASR or at *http://www.frtr.gov*.

Physical Treatment

- Acid extraction
- Air sparging
- Air stripping
- Carbon adsorption (liquid-phase carbon adsorption)
- Clarification
- Decontamination
- Dewatering
- Dual-phase extraction
- Electrical separation (electrokinetic separation)
- Evaporation
- Filtration
- Flocculation
- Flushing (soil flushing and surfactant flushing)
- Ion exchange
- Magnetic separation
- Oil-water separation
- Physical separation (component separation and materials handling)
- Reverse osmosis (membrane separation)
- Soil flushing (in situ flushing and surfactant flushing)
- Soil vapor extraction (vacuum extraction and vapor extraction)
- Soil washing
- Solidification/stabilization (asphalt batching, immobilization, and microencapsulation)
- Solid-phase extraction
- Solvent extraction (chemical stripping)
- Super-critical fluid extraction
- Volatilization (aeration, mechanical soil aeration, and tilling)

Chemical Treatment

- Chemical treatment
- Chemical oxidation (cyanide oxidation, oxidation, and peroxidation)
- Chemical reduction (reduction)
- Dehalogenation (dechlorination)
- Neutralization
- Metals precipitation
- 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)
- Thermally enhanced recovery (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, and steam injection)
- Thermal treatment
- Vitrification (slagging)

1. Source Control Treatment (continued)

Bioremediation

- Aeration
- Bioremediation
- Biological treatment
- Bioreactor
- Bioventing
- Biopile
- Composting
- Controlled solid phase
- Fixed film
- Landfarming
- Nitrate enhancement
- Nutrient injection
- Oxidation enhancement with air sparging
- Oxidation enhancement with hydrogen peroxide (H_2O_2)
- Slurry-phase bioremediation (bioslurry, activated sludge)
- White rot fungus

Other or Unspecified Treatment

- Air emission treatment
- Gas collection and treatment (off-gas treatment)
- Hot gas decontamination
- Leachate treatment
- Physical-chemical treatment
- Phytoremediation
- Recycling
- Surface water 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
- Cover material
- Evapotranspiration cover
- Revegetation

Bottom Liner

- Liner
- Clay
- Geosynthetic material

Drainage and Erosion Control

- Engineering control
- Hydraulic control
- Impermeable barrier
- Subsurface drain
- Surface water control (dike, berm, drainage controls, drainage ditch, erosion control, flood protection, and levee)
- Water table adjustment

On-Site Landfilling

- On-site consolidation
- On-site landfilling
- On-site disposal

Off-Site Landfilling

- Off-site consolidation
- Off-site landfilling
- Off-site disposal

Vertical Engineered Barrier

(Must apply to source medium. A vertical subsurface engineered barrier used to control or contain groundwater is not 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
- Leachate control (leachate collection)
- Overpacking
- Permanent storage
- Repair (pipe repair, sewer repair, and tank repair)

3. Source Control Other

Source control other than treatment or containment.

Institutional Control

- Access restriction
- Deed restriction
- Drilling restriction
- Fishing restriction
- Guard (security)
- Institutional control
- Land use restriction
- Recreational restriction
- Swimming restriction

Engineering Control

- Engineering control
- Fencing
- Wetland replacement

Source Monitoring

- Monitoring
- Sampling

Population Relocation

- Population relocation

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

F.3.2 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 of contamination contaminated by migration of a contaminant, 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
- Dual-phase extraction
- Free product recovery
- In-well air stripping (well aeration and air stripping)
- Vapor extraction

Chemical Treatment

- Chemical oxidation (oxidation and peroxidation)
- Chemical reduction
- Chemical treatment
- Dechlorination
- Permeable reactive barrier (chemical reactive barrier, chemical reactive wall, and passive treatment wall)

5. Groundwater In Situ Treatment (continued)

Thermal Treatment

Thermally enhanced recovery (conductive heating, CROW®, dynamic underground stripping, electrical resistance heating, hot air injection, hot water or steam flushing and stripping, in-situ thermal desorption, microwave heating, radio frequency heating, and steam injection)

Bioremediation

- Aeration
- Biological treatment
- Bioremediation
- Biosparging
- Bioslurping
- Bioventing
- Co-metabolic treatment
- Oxygen enhancement with air sparging
- Oxygen enhancement with H_2O_2
- Nitrate enhancement
- Nutrient injection

Other or Unspecified Treatment

- Physical/chemical treatment
- Phytoremediation

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
- Clarification (sedimentation)
- Coagulation
- Component separation
- Equalization
- Evaporation
- Filtration
- Flocculation
- Ion exchange
- Oil/water separation
- Metals precipitation
- Reverse osmosis (microfiltration and ultrafiltration)
- Vapor extraction

Chemical Treatment

- Chemical reduction
- Chemical oxidation (oxidation, cyanide oxidation, and peroxidation)
- Neutralization
- Ultraviolet (UV) oxidation

Biological Treatment

- Biological treatment
- Bioreactors
- Fixed film
- Oxygen enhancement with H_2O_2

Other or Unspecified Treatment

- Pump and treat
- Physical/chemical treatment

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
- Geosynthetic wall
- Grout (grout curtain)
- High-density polyethylene (HDPE) wall
- Impermeable barrier
- Sheet pile
- Slurry wall
- Subsurface vertical engineered barrier (subsurface barrier, subsurface vertical barrier)

Other or Unspecified Containment

- Plume containment

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, including:

Institutional Control

- Deed restriction
- Drilling restriction
- Institutional control
- Water supply use restriction

Engineering Control

- Extended piping
- Engineering control

Groundwater Monitoring

- Monitoring
- Sampling

Water Supply Remedies

- Alternate water supply (alternate drinking water and bottled water)
- Carbon at tap
- 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 is considered groundwater MNA if it includes "natural attenuation" or "monitored natural attenuation" of groundwater.

10. Groundwater Extraction

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

- Directional well (horizontal well)
- Pumping (vertical well)
- Recovery trench (horizontal drain)

11. Groundwater Discharge and Management

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

- Centralized waste treatment facility
- Deep well injection
- Publicly owned treatment works (POTW)
- Recycling
- Reuse as drinking water
- Reuse as irrigation water
- Reuse as process water
- Surface drain reinjection
- Surface water discharge [National Pollutant Discharge Elimination System (NPDES) discharge]
- Vertical well reinjection

F.3.3 No Action Remedies

12. 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 is used only for RODs under which NA/NFA is the only remedy selected. If a ROD selects NA/NFA for only part of a site and another remedy for another part of a site, the ROD is given the classification corresponding to that selected remedy and is not given an NA/NFA designation.

F.4 SPECIAL CASES

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

Decontamination:

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

Phytoremediation:

- Phytoremediation involves the use of macroscopic plants to destroy, remove, immobilize, or otherwise treat contaminants. The process does not use microorganisms. Processes that use microorganisms are bioremediation.
- The use of plants to control water drainage at a site is not phytoremediation, but is an engineering control (source control other or groundwater other).

Conditional Remedies - If a ROD indicates that a certain remedy will be implemented under specific conditions, the ROD is considered to have selected the conditional remedy. For example, a ROD may specify that, if soils exceed a certain levels 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 is considered to have selected incineration and therefore would be 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). The selected remedy should be analyzed carefully to determine whether the containment is source control or groundwater containment.

Solidification/Stabilization - Some of the technologies used for solidification/stabilization are used for containment, as well. For example, encapsulation could mean placing a waste in plastic drums, an approach that would be classified as source control containment. Encapsulation of a waste by mixing it with a monomer and then causing the mixture to polymerize, resulting in microencapsulation, would be classified as source control treatment (solidification/stabilization). In general, containment involves isolating bulk wastes, while solidification/stabilization involves incorporating the waste into a medium so that the leachability of the contaminants is reduced. The selected remedy should be analyzed carefully to determine whether it is a containment or a treatment process.