FEASIBILITY STUDY/ RECORD OF DECISION ANALYSIS FOR WOOD TREATER SITES WITH CONTAMINATED SOILS, SEDIMENTS, AND SLUDGES

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PREFACE

The Feasibility Study/Record of Decision Analysis For Wood Treater Sites With Contaminated Soils, Sediments, and Sludges is an evaluation of technologies considered in the Feasibility Studies (FSs) and Records of Decision (RODs) of 25 contaminated wood treater sites. This evaluation analyzed technical literature and the results of the remedy selection process from the FSs and RODs. The evaluation concluded that certain technologies were routinely screened out based on effectiveness, implementability, or excessive costs. Therefore, it provides the basis for limiting the analysis of technologies and alternatives when applying the presumptive remedy approach. Because the presumptive remedy approach for wood treater sites is outlined in guidance that is non-binding (Office of Solid Waste and Emergency Response (OSWER) Directive 9200.5-162, entitled *Presumptive Remedies for Soils, Sediments, and Sludges at Wood Treater Sites*), and not a rule, the Administrative Record must contain information that provides the basis for limiting the analysis to only those technologies outlined in the OSWER directive. This document provides the necessary technical basis. The U.S. Environmental Protection Agency (EPA) intends for this document to replace the analysis of the other technologies that would normally be found in a Feasibility Study. Therefore, when the presumptive remedy approach is used for a site, this document is a necessary element of the Administrative Record.

For several reasons, the presumptive remedy approach does not entirely eliminate the analysis of technologies and alternatives. First, the wood treater presumptive remedies include four technologies that may be recommended for consideration and, thus, analyzed -- bioremediation, thermal desorption, and incineration for soils, sediments, and sludges with organic contamination, and immobilization for soils, sediments, and sludges with inorganic contamination. Second, even where only one technology is recommended, there are often various process options or applications of that technology that must be further evaluated. Third, unusual site conditions might justify the consideration of a non-presumptive remedy technology. Finally, this document does not address innovative or developing technologies. Therefore, although EPA expects that at least one of the presumptive remedies will be suitable for a wood treater site with principal threats that require the treatment of contaminated soils, sediments, or sludges, there may be some circumstances under which other approaches may be appropriate. If such circumstances are encountered, additional analyses may be necessary or a conventional RI/FS or EE/CA may be performed.

This document contains information on non-presumptive remedy technologies. Conversely, the OSWER directive contains information on those technologies that were selected as presumptive remedies. Part I of this document contains a general overview of the presumptive remedy process and analysis. This general overview is divided into several parts. Section A is an Introduction. Section B, Background, provides: (1) a brief description of contaminants commonly found at wood treater sites; (2) a description of the presumptive remedies for wood treater sites with contaminated soils, sediments, and sludges; and (3) a summary of the RI/FS remedy selection process. Section C, Methodology, provides an overview of the methodology used to identify and analyze the presumptive remedies for contaminated soils, sediments, and sludges at wood treater sites. Section D, Results, presents a brief summary of the results of this analysis. Section E is the Conclusion.

Part II reviews individual technologies considered at wood treater sites. In each case, the discussion:

- Describes the technology's strengths and weaknesses.

- Identifies factors that may limit its usefulness.

- Presents a statistical review of how often the technology was considered and how it fared in the screening and detailed analysis phases of past Feasibility Studies.

- Draws conclusions regarding the technology's general suitability for wood treater sites with contaminated soil, sediments, and sludges in the context of the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) criteria.

Appendix A provides summary information on the number of cases in which each technology was screened out in past FSs and RODs in both the initial and detailed analysis phases. Appendix B describes in greater detail the reasons given in past FSs and RODs for screening out each technology. Appendix C presents site-specific information from the FSs and RODs concerning remedy selection.

Users of this document should familiarize themselves with all of its contents including its appendices. Much information relevant to justifying the exclusion of non-preferred technologies can be found in the appendices. However, for a complete, detailed discussion of a technology, the user should refer to the FSs/RODs for the analyzed wood treater sites, as well as the technical documents listed in the references section of this document.

It is not anticipated that this document will fully address all the questions about the screening and elimination of particular technologies. At some sites, more sophisticated questions may be raised that may require a more detailed response than this document provides. In that case, a greater amount of site-specific analysis will be required. Nevertheless, it is expected that this document will provide an adequate basis for responding to general questions and comments on the presumptive remedy approach to the remedy selection process for wood treater sites with contaminated soils, sediments, and sludges.

Feasibility Study/Record of Decision Analysis for Wood Treater Sites with Contaminated Soils, Sediments, and Sludges

I. OVERVIEW OF ANALYSIS

EPA analyzed 25 wood treater sites on the National Priorities List (NPL), promulgated under the Comprehensive Environmental Response, Compensation, and Liability Act, as amended (CERCLA). The analysis was based on FS data, ROD data, and technical references on the treatment of soils, sediments, and sludges contaminated with wood treater contaminants. The analysis determined what technologies are consistently included in selected remedies. In addition, the analysis determined what technologies are consistently screened out and the basis for the elimination of these technologies.

Based on this analysis, the Agency has determined that the treatment technologies included in this report can be eliminated from consideration in FSs at wood treater sites where the presumptive remedies of bioremediation, thermal desorption, incineration, and/or immobilization will be appropriate. Therefore, this document should be used as a reference when the technology identification and screening steps of the FS are abbreviated or eliminated at NPL wood treater sites with contaminated soils, sediments, or sludges implementing the presumptive remedy process.

A. Introduction

Presumptive remedies are preferred technologies for common categories of sites, based on EPA's experience and its scientific and engineering evaluation of alternative technologies. The objective of the presumptive remedy initiative is to use the Superfund program's experience to streamline site characterization and speed up the selection of cleanup actions. Over time, presumptive remedies are expected to ensure consistency in remedy selection and reduce the cost and time required to clean up similar types of sites. Presumptive remedies are expected to be used at all appropriate sites except under unusual site-specific circumstances. Conditions at a site also may justify considering other technologies along with the presumptive remedy. These potential alternatives may then be combined with other components of the presumptive remedy to develop a range of alternatives suitable for site-specific conditions.

Note that this document does not address some innovative or developing technologies. As discussed in *Presumptive Remedies: Policy and Procedures (OSWER Directive 9355.047FS)*, the use of presumptive remedies does not preclude considering such technologies.

B. Background

Since the enactment of CERCLA, the Superfund remedial and removal programs have found that certain categories of sites have similar characteristics, such as types of contaminants present, disposal practices performed, or environmental media affected. Based on information acquired from evaluating and cleaning up these sites, the Superfund program is undertaking an initiative to develop presumptive remedies to accelerate future cleanups at these types of sites. The presumptive remedy approach can also be used to streamline remedial decision making for corrective actions conducted under the Resource Conservation and Recovery Act (RCRA).

Selecting presumptive remedies depends upon preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation.

1. CONTAMINANTS AT WOOD TREATER SITES

The three types of contaminants predominantly found at wood treater sites, either alone or in combination with each other (or with total petroleum hydrocarbon (TPH) carrier oils) are creosote, pentachlorophenol (PCP), and chromated copper arsenate (CCA). Creosote is an oily, translucent brown to black liquid that is a very complex mixture of organic compounds, containing approximately 85% polynuclear aromatic hydrocarbons (PAHs), 10% phenolic compounds, and 5% nitrogen-, sulfur-, or oxygen-containing heterocycles. PCP is also an organic contaminant. In its pure form, PCP is a dense non-aqueous phase liquid (DNAPL); however, PCP is commonly found at wood treater sites as a light non-aqueous phase liquid (LNAPL) mixed into fuel oil or other light organic substances. CCA is an inorganic arsenical wood preservative. Other metal-containing preservatives that may be found at wood treater sites include ammoniacal copper arsenate (ACA) and ammoniacal copper-zinc arsenate (ACZA).

Table 1 lists contaminants typically found at wood treater sites. Sources of wood treater contamination include oil-based preservatives at older facilities and water-soluble preservatives usually found at more modern facilities. Water-soluble processes produce little or no wastewater, except for small amounts of metal-containing sludges. Oil-based processes produce sludge wastes and significant quantities of process wastewater. The processes performed at wood treater sites generally will result in contaminated soils, sediments, and sludges, and/or contaminated surface and ground water.

TABLE 1
Contaminants Commonly Found at Wood Treater Sites

TYPE OF CHEMICAL	EXAMPLES OF SPECIFIC CHEMICALS
Organic Contaminants	
Dioxins/furans[1]	• Dibenzo-p-dioxins • Dibenzofurans • Furan
Halogenated phenols[1]	• Pentachlorophenol • Tetrachlorophenol
Simple non-halogenated aromatics[2]	• Benzene • Toluene • Ethylbenzene • Xylene

TYPE OF CHEMICAL	EXAMPLES OF SPECIFIC CHEMICALS
Polynuclear aromatic hydrocarbons[1]	• 2-Methylnaphthalene • Chrysene • Acenaphthene • Fluoranthene • Acenaphthylene • Fluorene • Anthracene • Indeno(1,2,3-cd)pyrene • Benzo(a)anthracene • Naphthalene • Benzo(a)pyrene • Phenanthrene • Benzo(b)fluoranthene • Pyrene • Benzo(k)fluoranthene
Other polar organic compounds	• 2,4-Dimethylphenol[1] • 2-Methylphenol[1] • 4-Methylphenol[1] • Benzoic acid[1] • Di-n-octyl phthalate • N-nitrosodiphenylamine
Inorganic Contaminants	
Non-volatile metals (compounds of)	• Chromium • Copper
Volatile metals (compounds of)	• Arsenic • Cadmium • Lead • Zinc

[1] DNAPL(s) in pure form.
[2] LNAPL(s) in pure form.

2. PRESUMPTIVE REMEDIES DESCRIPTION

The primary presumptive remedy for treating organic contamination of soils, sediments, and sludges at wood treater sites is bioremediation. Bioremediation has been selected as the primary presumptive remedy for treating organic contamination because it has been selected most frequently to address organic contamination at wood treater Superfund sites, and the Agency believes that it effectively treats wood treating wastes at a relatively low cost. If bioremediation is not feasible, thermal desorption may be the more appropriate response technology. In a limited number of situations (e.g., the treatment of "hot spots" such as sludges), incineration may be the more appropriate remedy. Immobilization is the primary presumptive remedy for treating inorganic contamination of soils, sediments, and sludges at wood treater sites.

3. RI/FS Remedy Selection Process

The components of the remedy selection process relevant to this analysis are the remedial investigation/feasibility study (RI/FS), proposed plan, and ROD. The RI, which is generally conducted concurrently with the FS, is designed to determine the nature and extent of contamination. The FS describes and analyzes the potential cleanup alternatives for a site and provides the basis for considering and eliminating technologies.

The FS consists of three major phases: identification and initial screening of technologies, development of alternatives, and detailed analysis of alternatives. During the initial screening, the full range of available technologies is evaluated based on cost, effectiveness, and implementability. Technologies passing this screening step are combined into remedial alternatives, taking into account the scope, characteristics, and complexity of the site problem(s) being addressed. During the detailed analysis, alternatives that appear viable are assessed against each of the nine NCP evaluation criteria. The detailed analysis also compares the relative performance of each alternative against these criteria.

The nine NCP criteria are categorized into three groups: two threshold criteria, five primary balancing criteria, and two modifying criteria. The threshold criteria are first used when evaluating a technology option. The technology must meet these criteria to be eligible for selection. The threshold criteria are:

- Overall protection of human health and the environment; and
- Compliance with applicable or relevant and appropriate requirements (ARARs).

During the next step, the major tradeoffs between alternative technologies are evaluated using the five primary balancing criteria:

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume (TMV) through treatment;
- Short-term effectiveness; and
- Implementability.

The initial screening draws preliminary conclusions as to the maximum extent to which permanent solutions and treatment can be practicably utilized in a cost-effective manner. The alternative that is protective of human health and the environment, complies with ARARS, and affords the best combination of attributes is identified as the preferred alternative in the proposed plan.

After public review of the proposed plan, the two modifying criteria, state and community acceptance, are then factored into the final determination of the remedy. The lead agency then selects the technology considered most effective, given the constraints of the site, and documents the decision in the ROD.

C. Methodology

In order to analyze remedies selected at wood treater sites with contaminated soils, sediments, and sludges, EPA conducted the following activities:

- Identified the universe of NPL wood treater sites;
- Determined the frequency of technology selection for remediation of contaminated soils, sediments, and sludges at wood treater sites;
- Identified sites for the FS/ROD analysis; and
- Conducted the FS/ROD analysis.

The data support bioremediation, thermal desorption, incineration, and immobilization as the presumptive remedies for wood treater sites with contaminated soils, sediments, and sludges.

These data, along with the scientific and engineering analysis of the performance data on technology application, also support the decision to eliminate the initial alternatives identification and screening step for applicable wood treater sites. These technical reviews found that certain technologies are appropriately screened out based on effectiveness, implementability, and/or cost, and additional alternatives are consistently eliminated based on a review of the technologies against the first seven of the nine NCP criteria (this analysis did not consider the two modifying criteria, state and community acceptance, because these criteria are site-specific).

1. Universe of Wood Treater Sites

EPA identified the universe of wood treater sites listed on the National Priorities List from information contained in the following two sources: (1) *Contaminants and Remedial Options at Wood Preserving Sites*, U.S. EPA, EPA/600/R-92/182, 1992; and (2) *Innovative Treatment Technologies: Annual Status Report (Sixth Edition)*, U.S. EPA, EPA 542-R-94-005, 1994. The first source contained comprehensive lists of NPL and non-NPL wood treater sites prior to 1992. The second source contained information, current as of 1994, on the status of the implementation of innovative treatment technologies at a wide range of sites, including wood treater sites. By cross-checking the information in both of these documents, an overall list of 58 NPL wood treater sites was identified.

2. Frequency of Technology Selection for Wood Treater Sites

Table 2 presents the distribution of remedial technologies selected at 52 of the 58 NPL wood treater sites (data on remedy selection were not available for the remaining six sites). These data were obtained from the two sources cited above and EPA's *Superfund Records of Decision CD-ROM Data Base* (March 1995). Table 2 demonstrates that the four wood treater site presumptive remedies (bioremediation, thermal desorption, incineration, and immobilization) together were selected more often (39 out of the 50 sites for which remedy selection information was available, or approximately 78% of the time) than the other applicable technologies. Bioremediation, the primary presumptive remedy for treating organic contamination, was the remedy selected more often than any other technology (18 out of the 50 sites, or approximately 36% of the time).

TABLE 2
Remedies Selected at NPL Wood Treater Sites

Primary Technologies Selected to Address Contaminated Soils, Sediments, and Sludges at Wood Treater Sites	Total Number of Sites Selecting Technology[1]
Bioremediation	18
Thermal Desorption	3
Incineration	13
Immobilization	13
Dechlorination	2
Solvent Extraction	1
Soil Flushing/Washing	6
Landfilling	4
Institutional Controls/Monitoring	2
To Be Determined[2]	2

[1] The total number of primary technologies selected is greater than the total of 50 sites for which remedy selection data were available because several sites selected more than one primary technology to address the principal threat of contaminated soils, sediments, and sludges (e.g., bioremediation to treat organic contamination and immobilization to treat inorganic contamination). Secondary technologies selected as part of a treatment train are not documented in this table.

[2] Remedial technology for contaminated soils, sediments, and/or sludges not yet selected.

3. IDENTIFICATION OF SITES FOR THE FS/ROD ANALYSIS

The purpose of the FS/ROD analysis was to document the technology screening step and the detailed analysis in the FSs/RODs of wood treater sites, and to identify the principal reasons given for eliminating technologies from further consideration. To achieve a representative sample of FSs/RODs for the analysis, sites were selected according to the following criteria:

- Sites were chosen to ensure a balanced distribution among the primary technologies for addressing contaminated soils, sediments, and sludges at wood treater sites (i.e., bioremediation, thermal desorption, incineration, immobilization, dechlorination, solvent extraction, soil flushing/washing, landfilling, and institutional controls/monitoring); and

- Sites were chosen to ensure an even distribution in geographic location and ROD signature date.

Using these criteria, a set of 25 NPL wood treater sites was chosen for the FS/ROD analysis; this represents approximately 43% of the total universe of NPL wood treater sites.

4. TECHNOLOGY SCREENING AND REMEDIAL ALTERNATIVE ANALYSIS

The FS/ROD analysis involved a review of the technology screening phase, including any pre-screening steps, followed by a review of the detailed analysis and comparative analysis phases in each of the 25 FSs and RODs. Information derived from each review was documented on site-specific data collection forms (Appendix C).

For the screening phase, the full range of technologies considered was listed on the data collection forms, along with the key reasons given for eliminating technologies from further consideration. These reasons were categorized according to the three initial screening criteria: cost, effectiveness, and/or implementability. The frequency with which specific reasons were given for eliminating a technology from further consideration was then tallied and compiled into a screening phase summary table (Appendix A).

For the detailed analysis and comparative analysis, information on the relative performance of each technology/alternative with respect to the first seven NCP criteria was documented on the site-specific data collection forms. In most cases, several different remedial technologies were combined in the FSs and RODs to form a remedial alternative or cleanup option. The disadvantages of a technology/alternative were then compiled into a detailed analysis/comparative analysis summary table, under the assumption that these disadvantages contributed to non-selection. The advantages and disadvantages associated with each cleanup option were highlighted. Appendix A provides the summary information for the detailed analysis and comparative analysis phases.

Tables in Appendix B demonstrate that non-presumptive remedy technologies are consistently eliminated from further consideration in the screening phase due to effectiveness, implementability, and/or excessive costs. In addition, the FS/ROD analysis indicates that, although certain technologies routinely passed the screening phase, these technologies were selected infrequently because they did not provide the best overall performance with respect to the first seven NCP criteria. These data will support a decision by site managers to bypass the technology identification and screening step for a particular wood treater site and select one or more of the presumptive remedies for contaminated soils, sediments, and sludges. As previously discussed, this document and the wood treater presumptive remedy guidance document should be part of the Administrative Record for the site. Additional supporting materials not found in the Regional files can be provided by Headquarters, as needed.

D. Results

The technology screening and remedial alternative analyses (summarized in Appendices A and B) demonstrate that bioremediation, thermal desorption, incineration, and immobilization are frequently selected to address contaminated soils, sediments, and sludges at NPL wood treater sites. The analyses demonstrate that technologies other than the presumptive remedies are consistently eliminated from further consideration in the initial screening phase due to short-term effectiveness, implementability, or costs. In addition, the analysis indicates that, although certain technologies routinely passed the initial screening phase, they were selected infrequently because they did not provide the best overall performance with respect to the first seven NCP criteria in the detailed screening phase.

At least one of the four presumptive remedies was considered at all of the 25 FSs and RODs analyzed. Furthermore, at 20 of the 25 wood treater sites analyzed (80 percent), at least one of the four presumptive remedies was selected as a final component of the remedy. In addition, over a third of these 20 sites selected two or more of the four wood treater presumptive remedies as complementary components of a treatment train. When multiple primary technology selections per site are included (for example, a site that selects bioremediation, immobilization and soil washing as primary alternatives is considered to select three technologies), the presumptive remedies represent approximately 84 percent of the remedies selected in the 25 FSs/RODs analyzed.

E. Conclusions

The results reported above, along with the scientific analysis of performance data (see the documents listed in the references section, including *Contaminants and Remedial Options at Wood Preserving Sites* and *Full-Scale Performance Data on the Use of Bioremediation at Wood Treater Sites*) support bioremediation, thermal desorption, incineration, and immobilization, as the presumptive remedies for wood treater sites with contaminated soils, sediments, and sludges. These results also support the decision to eliminate the initial technology identification and screening step. Most supporting materials for this analysis may be found in EPA Regional files; others can be provided by EPA Headquarters as needed. Technologies other than the presumptive remedies, however, may be considered on a site-specific basis.

II. SUMMARY ANALYSIS AND CONCLUSIONS FOR NON-PRESUMPTIVE REMEDY TECHNOLOGIES

This analysis examined the technical literature and the technology screening and remedy selection processes for 25 wood treater sites with contaminated soils, sediments, or sludges. All of these sites had soils, sediments, and/or sludges contaminated with wood treater-type chemicals. Other contaminants, as well as ground water and/or surface water contamination, were also present at some sites. A variety of organic and inorganic wood treater contaminants are amenable to the presumptive remedies. For sites containing a mixture of wood treater and non-wood treater-type contaminants (or mixtures of organic and inorganic contaminants in general), it may be appropriate to consider the presumptive remedies in combination with each other or with other non-presumptive remedies in a treatment train.

This study supports the conclusion that the presumptive remedies for contaminated soils, sediments, and sludges at wood treater sites -- bioremediation, thermal desorption, incineration, and immobilization -- are the technologies "of choice" for this type of site. In addition, this study concludes that most other technologies (or classes of technologies) are consistently screened out due to the various reasons presented in this section.

The following sections describe each technology that is not a presumptive remedy for wood treater sites with contaminated soils, sediments, and sludges. Each section is further divided into six parts:

- A general narrative describing the technology.

- A limitations section describing generic limits to the technology's applicability and effectiveness.

- A target contaminant section specifying those contaminants that the technology aims or targets to treat. The major contaminant groups for wood treater sites are:

  (1) Organic wood treater contaminants (e.g., PAHs, PCP)
  (2) Inorganic wood treater contaminants (e.g., chromium, arsenic)

- For the initial screening phase, a discussion of the results from the analysis of the 25 FSs and RODs studied and a summary of the specific reasons for screening out a particular technology during the initial screening phase.

- For the detailed screening phase, a discussion of the results from the analysis of the 25 FSs and RODs studied and a summary of the specific reasons for screening out a particular technology during the detailed screening phase.

- General conclusions as to why the technology may be eliminated from consideration at wood treater sites with contaminated soils, sediments, and sludges.

- A summary, by NCP criteria, of the factors contributing to the elimination of this technology.

Throughout this document, site name codes are used to identify specific sites as necessary. Table 3 provides an index of the site name codes and full site names.

TABLE 3
Index of Site Name Codes

Code	Site Name
AC	American Crossarm, WA
ACF	American Creosote Works, FL
ACT	American Creosote Works, TN
BD	Broderick Wood Products, CO
BW	Brown Wood Preserving, FL
CE	Coleman-Evans, FL
CF	Cape Fear Wood Preserving, NC
I	Idaho Pole Company, MO
K	Koppers, NC
LG	Libby Ground Water, MT
LP	Louisiana-Pacific, CA
MB	MacGillis/Bell, MN
MI	Mid-Atlantic Wood Preserving, MD
MO	Moss America, WI
NC	North Cavalcade, TX
P	Palmetto Wood Preserving, SC
R	Rentokil, VA
SA	Saunders Supply, VA
SE	Selma Treating, CA
SM	Southern Maryland Wood, MD
T	Texarkana, TX
UC	United Creosoting, TX
UP	Union Pacific Railroad Yard, ID

TABLE 3
Index of Site Name Codes
(Continued)

Code	Site Name
V	Valley Wood Preserving, CA
W	Wrigley Charcoal, TN

A. INSTITUTIONAL CONTROLS

Technology Description

Institutional controls may be used to reduce current or potential human exposure at a site via direct contact with contaminated soils, sediments, and sludges. Institutional controls include the use of physical barriers, such as fences and warning signs, and the use of administrative restrictions, such as deed or lease restrictions. When vigorously enforced, institutional controls limit direct contact with and ingestion of soils, sediments, and sludges. Monitoring is generally needed to determine the effectiveness of institutional controls.

Limitations

Unlike some engineering controls (e.g., caps), institutional controls alone do not reduce the potential for wind dispersal and inhalation of contaminants. The source of soil, sediment, or sludge contamination is not eliminated, therefore the mobility, toxicity, and volume of the contaminants is not reduced. Surface and subsurface soils, sediments, and sludges may experience degradation due to continued contaminant migration from rainwater runoff and/or infiltration or ground-water movement. Furthermore, off-site migration of contaminants may create long term public health risks for residents and businesses in the vicinity of the site.

Target Contaminant Groups

Institutional controls are applicable to the complete range of contaminant groups with no particular target group.

1. RESTRICTIONS/MONITORING

Initial Screening

Restrictions/monitoring was considered at 23 sites. It was screened out in the initial screening one time (4 percent) and passed the initial screening 22 times (96 percent). The specific reason cited for screening out restrictions/monitoring at the single site was that this option would not satisfy the remedial objectives established for the site (1 FS: K).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
23	22	1
Site Name Code:	AC, ACF, ACT, BD, BW, CE, CF, I, LG, LP, MB, MI, MO, P, R, SA, SE, SM, T, UP, V, W	K

Detailed Analysis

Of the 22 times restrictions/monitoring was considered in the detailed analysis, this technology option passed the detailed screening and was considered as a component of a remedial alternative 22 times (100 percent). However, at 20 of the 22 sites selecting institutional actions, another technology option was selected to treat the contaminated soils, sediments, and/or sludges first, followed by institutional actions. In these cases, institutional actions are not a *primary* component of the remedial alternative, but remain a selected component of the treatment train.

The predominant criteria cited for not selecting institutional actions as a primary component were overall protectiveness, compliance with ARARs, reduction of TMV, and long-and short-term effectiveness. Specifically, it was noted that this option does not reduce on-site risks and does not attain ARARs (4 FSs: ACF, UP, V, W); allows existing contaminant sources and migration pathways to remain in place (3 FSs: ACT, SM, UP); would not be effective or reliable enough as a sole remedy option (5 FSs: BD, I, K, LG, T); and produces short and long-term risks (2 FSs: LG, MO).

No. FSs Technology Passed Screening	No. RODs Technology Selected	No. RODs Technology Not Selected
22	22*	0
Site Name Code:	AC, ACF, ACT, BD, BW, CE, CF, I, LG, LP, MB, MI, MO, P, R, SA, SE, SM, T, UP, V, W	--

*Note that at 20 out of 22 of these sites, another technology option was selected to treat the contaminated soils, sediments, and/or sludges first, followed by institutional actions. In these cases, off-site disposal is not a *primary* component of the remedial alternative, but is a selected component of the overall treatment train.

Appendices A and B only tabulate the number of times a technology was *selected*, and do not differentiate between technologies selected as a primary component of the alternative or not. However, for the purposes of this section, it is worthwhile to track whether or not a technology was selected as a primary component of the remedial action. In this section, unless otherwise noted, numbers indicate technologies selected/not selected as a primary component of the remedial action.

Conclusion

Institutional controls, i.e., restrictions/monitoring, are generally an inadequate remediation method *as a stand-alone remediation method* for contaminated soils, sediments, and sludges at wood treater sites due primarily to a lack of effectiveness and overall protectiveness. However, institutional controls can be an effective interim remedy and/or a component of a full treatment train. The preference for treatment and the need to reduce on-site risks makes institutional controls ineffective as a sole remedy option for contaminated soils, sediments, and sludges at wood treater sites. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option:

NCP Criteria	Key Factors
Overall Protectiveness	• Does not reduce on-site risks.
Compliance with ARARs	• Does not attain ARARs.
Reduction of Toxicity, Mobility, or Volume	• Allows existing contaminant sources and migration pathways to remain in place.
Long Term Effectiveness and Permanence	• Would not be effective or reliable enough as a sole remedy option; produces long-term risks.
Short Term Effectiveness	• Would not be effective or reliable enough as a sole remedy option; produces short-term risks.
Implementability*	
Cost*	

* Criterion did not contribute to eliminating the technology.

A single "technology description," "limitations," and "target contaminant groups" section applies to all of the capping systems considered in this analysis (i.e., asphalt/concrete caps, soil/bentonite/clay caps, multi-level cover systems, and unspecified caps), in addition to a single "conclusions" section. However, individual analyses of the initial and detailed screening results for each of these categories of caps are provided.

Technology Description

Capping systems reduce surface-water infiltration, control gas and odor emissions, improve aesthetics, provide a stable surface over the waste, and prevent human exposure from direct contact. Caps can range from a simple native soil cover to a full RCRA Subtitle C composite cover. A variety of caps were considered in the FSs and RODs studied for this analysis, including single layer caps (asphalt/concrete and soil/bentonite/clay caps) and multi-layer cover systems (RCRA caps). RCRA multi-level cover systems must be constructed in accordance with performance standards established by the Resource Conservation and Recovery Act. These standards require the following: (1) three feet of compacted clay; (2) 80 millimeter high density polyethylene (HDPE) synthetic liner placed above the clay; (3) one foot of top soil above the synthetic liner; and (4) vegetative cover. Note that some of the FSs/RODs analyzed did not specify what particular type of cap was being considered.

Limitations

The following factors may limit the applicability and effectiveness of capping options:

- Capping costs escalate as a function of topographic relief.
- Capping does not treat contamination; contamination is left in place.
- Capping may slow down natural bioremediation processes.
- Caps requires long-term maintenance to ensure cap integrity.
- Capping does not reduce the toxicity or volume of the contaminants.
- The short-term effectiveness of caps is limited by increased traffic, dust, and other disturbances caused by construction activities during excavation.
- Native soil areas must have sufficient stability to support the cap.

Target Contaminant Groups

Capping is applicable to the complete range of contaminant groups with no particular target group.

1. ASPHALT/CONCRETE CAP

Initial Screening

Asphalt/concrete caps were considered at 10 sites. In the initial screening, this type of cap was screened out six times (60 percent) and retained for the detailed analysis four times (40 percent).

Asphalt/concrete caps were screened out for factors related to cost, effectiveness, and implementability. For example, asphalt/concrete caps were screened out because of their general high cost (1 FS: LP), their requirements for high capital and operation and maintenance costs (1 FS: SM), and because they are not implementable in some areas (2 FSs: BD, LP). This type of cap was also screened out because oxidation, viscous deformation, and chemical compatibility all lessen the effectiveness of asphalt caps and render them susceptible to cracking (3 FSs: BD, MO, SM).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
10	4	6
Site Name Code:	AC, MI, UP, V	BD, I, LP, MO, SM, T

Detailed Analysis

Of the four times asphalt/concrete caps were retained for consideration in the detailed analysis for a remedial alternative, this type of cap was selected as a primary component of the final remedy two times (50 percent). Asphalt/concrete caps were not selected as a primary component of the remedial alternative two times (50 percent). The criteria used for non-selection were overall protectiveness, reduction of TMV, and long-term effectiveness. Reasons noted included that this option would not be protective considering assumed future land use (1 FS: V) and it would not reduce the toxicity or volume of hexavalent chromium- or arsenic-contaminated soil (1 FS: V). In addition, it was noted that asphalt/concrete caps may allow contaminants to migrate underneath the cap as a result of flooding (1 FS: AC) and may not be effective enough or permanent enough in the long term (2 FSs: AC, V).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
4	2	2
Site Name Code:	MI, UP	AC, V

2. SOIL/BENTONITE/CLAY CAP

Initial Screening

Soil/bentonite/clay caps were considered at 13 sites. In the initial screening, this type of cap was screened out five times (38 percent) and retained for the detailed analysis eight times (62 percent).

Soil/bentonite/clay caps were screened out for factors related to cost and implementability. For example, soil/bentonite/clay caps were screened out because of their general high costs (2 FSs: LP, SM) and because they are not practical in all areas (2 FSs: LP, NC). In addition, this type of cap was screened out because it may not attain ARARs (1 FS: SM) and it may be difficult to maintain (1 FS: BD).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
13	8	5
Site Name Code:	AC, ACT, CF, K, MO, SE, T, UC	BD, LP, NC, SM, UP

Detailed Analysis

Of the eight times soil/bentonite/clay caps were retained for consideration in the detailed analysis for a remedial alternative, this option was selected as a primary component of the final remedy four times (50 percent). Soil/bentonite/clay caps were not selected as a primary component of the remedial alternative four times (50 percent). The criteria used for non-selection were overall protectiveness, compliance with ARARs, reduction of TMV, long-term effectiveness, and cost. Examples of the reasons noted were that this option would not be protective and/or ground water would continue to be impacted (2 FSs: K, UC) and that RCRA Land Disposal Restrictions (LDS) might cause ARARs issues (1 FS: K). Regarding TMV, it was noted that this option would not reduce the toxicity or volume of contaminants in soil, that it would provide only minimal reduction in TMV, and that the mobility of contaminants in ground water would not be reduced (3 FSs: K, UC, CF). In addition, it was also noted that this option may not be effective enough or permanent enough in the long term (3 FSs: K, SE, UC) and that maintenance costs would need to be incurred for an indefinite amount of time (1 FS: UC).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
8	4	4
Site Name Code:	AC, MO, SE, T	ACT, CF, K, UC

3. Multi-Level Cover System

Initial Screening

Multi-level cover systems (e.g., RCRA caps) were considered at 14 sites. In the initial screening, this type of cap was screened out three times (21 percent) and retained for the detailed analysis 11 times (79 percent).

Multi-level cover systems were screened out for factors related to cost, effectiveness, and implementability. For example, multi-level cover systems were screened out because of their general high cost (1 FS: UP). This type of cap was also screened out because high water tables may interfere with their effectiveness (1 FS: MO). It was noted that constructing this type of cap increases short-term exposure for workers and may interfere with *in situ* remediation technologies (1 FS: UP). This type of cap was also screened out because of implementation difficulties such as the fact that it may not meet ARARs (1 FS: SM) and it may require additional excavation and grading on site (1 FS: UP).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
14	11	3
Site Name Code:	AC, ACF, BD, I, K, LG, LP, P, SE, T, W	MO, SM, UP

Detailed Analysis

Of the 11 times multi-level cover systems were retained for consideration in the detailed analysis for a remedial alternative, this option was selected as a primary component of the final remedy five times (46 percent). Multi-level cover systems were not selected as a primary component of the remedial alternative six times (54 percent). The predominant criteria used for non-selection were overall protectiveness, reduction of TMV, and long-term effectiveness. Other criteria were compliance with ARARs, implementability, and cost. Examples of reasons noted for screening out this technology were that this option would not be protective enough by itself (3 FS: I, K, P) and that there might be ARARs issues associated with LDS (1 FS: K). It was also noted that this option would not reduce the TMV of the contaminants (6 FSs: ACF, I, K, LP, P, T). Further examples of reasons for non-selection were that multi-level cover systems have questionable long-term effectiveness (3 FSs: K, P, T), require long-term maintenance and ground-water monitoring (1 FS: K), and interrupt continuing on-site operations (1 FS: LP). It was also noted that multi-level cover systems were relatively costly compared to institutional actions (1 FS: LP).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
11	5	6
Site Name Code:	AC, BD, LG, SE, W	ACF, I, K, LP, P, T

4. UNSPECIFIED CAP

Initial Screening

Caps that were not specified by type were considered at five sites. In the initial screening, this type of cap was screened out zero times (0 percent) and retained for the detailed analysis five times (100 percent).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
5	5	0
Site Name Code:	CE, LP, MI, R, SA	-

Detailed Analysis

Of the five times unspecified caps were retained for consideration in the detailed analysis for a remedial alternative, this option was selected as a primary component of the final remedy two times (40 percent). Unspecified caps were not selected as a primary component of the remedial alternative three times (60 percent). The predominant criterion for non-selection was reduction of TMV. Other reasons were overall protectiveness, compliance with ARARs, long- and short-term effectiveness, implementability, and cost. Examples of reasons noted were that this option does not prevent leaching of contaminants (1 FS: MI) and that it fails to meet the Federal ARAR for RCRA closure (1 FS: MI). Further reasons were that this type of cap does not reduce TMV of contaminants and does not meet the CERCLA preference for treatment (2 FSs: LP, SA). Furthermore, this type of cap requires routine maintenance (1 FS: MI), generates dust and creates a short-term hazard (1 FS: MI), and interrupts continuing on-site operations (1 FS: LP). It was also noted that this type of cap is more costly than institutional actions (1 FS: LP).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
5	2	3
Site Name Code:	CE, R	LP, MI, SA

Conclusion

Caps are generally an inadequate remediation method *as a stand-alone remediation method* for contaminated soils, sediments, and sludges at wood treater sites. This option does not meet the CERCLA preference for treatment of hazardous materials. Specifically, across all the types of caps considered, lack of sufficient reduction in TMV and questionable long-term effectiveness and permanence appeared to be the predominant factors in the non-selection of this technology option. Caps require long-term maintenance and monitoring, and may not prevent migration of contaminants in the capped soils into ground water. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option:

NCP Criteria	Key Factors
Overall Protectiveness	• Not protective based on future land use assumptions • Ground water may continue to be impacted • Not protective enough as a stand-alone technology
Compliance with ARARs	• LDS may causes compliance issues • May not meet ARAR for RCRA closure
Reduction of Toxicity, Mobility, or Volume	• Does not reduce toxicity or volume • In some cases may not reduce mobility, in addition to not reducing toxicity or volume • Does not meet preference for treatment
Long Term Effectiveness and Permanence	• May not be effective or permanent enough in the long term
Short Term Effectiveness	• Generates dust and causes a short-term hazard for on-site personnel
Implementability	• Long-term maintenance and monitoring required • Interrupts continuing on-site operations
Cost	• Maintenance costs will be incurred for an indefinite period of time • Higher cost than institutional actions for similar reduction in risk

A single "technology description," "limitations," and "target contaminant groups" section applies to all of the on-site containment systems considered in this analysis (i.e., closure-in-place/encapsulation, temporary on-site storage pile, and long-term on-site landfill), in addition to a single "conclusions" section. However, individual analyses of the initial and detailed screening results for each of these categories of on-site containment are provided.

Technology Description

On-site containment options encompass a set of process options for the removal of contaminated materials to on-site disposal facilities, including temporary on-site storage piles, long-term on-site landfills, on-site encapsulation, closure-in-place, and on-site vaults. On-site encapsulation, closure-in-place, and on-site vaults are usually temporary measures, and may involve placing a dirt or other cover over the contaminated materials in place, or excavating the contaminated materials and placing them in a secured vault or lined and covered ditch. In the case of long-term on-site landfills, some pre-treatment of the contaminated media is usually required to meet RCRA LDS. For all of these on-site containment options, the mobility of the contaminated media is reduced by physically containing the media on site.

Limitations

The following factors may limit the applicability and effectiveness of on-site containment options:

- Fugitive emissions may be generated during excavation and pose potential health and safety risks to site workers. Personal protective equipment at a level commensurate with the contaminants is normally required.

- For long-term disposal, most hazardous wastes must still be treated to meet either RCRA or non-RCRA treatment standards prior to land disposal. Compliance with applicable RCRA LDS may be difficult, particularly if dioxins/furans are involved.

- Adverse site conditions may hinder construction of on-site facilities.

- Overall costs associated with landfill disposal are relatively high. Although the process is relatively simple with proven procedures, it is a labor-intensive practice with little potential for further automation. Once disposal is completed and operation and maintenance costs are no longer incurred, no capital investment is required.

- Location-specific ARARs will impact the construction of landfills or other on-site containment measures.

Target Contaminant Groups

On-site containment is applicable to the complete range of contaminant groups with no particular target group.

1. CLOSURE-IN-PLACE/ON-SITE

Initial Screening

Closure-in-place/on-site encapsulation was considered at 10 sites. In the initial screening, this on-site containment option was screened out six times (60 percent) and retained for the detailed analysis four times (40 percent).

Closure-in-place/on-site encapsulation was initially screened out for factors related to cost, effectiveness, and implementability. Specifically, this option was screened out because of its high cost compared to caps (1 FS: CF), its questionable effectiveness (3 FSs: CE, I, P, SA), and its lack of reduction of toxicity or volume of contaminants (1 FS: CE). There were also several implementation problems noted concerning closure-in-place/on-site encapsulation, such as: difficulties with landfilling below a low site ground-water table (1 FS: CF); the potential for liner failure (1 FS: CE); inability to meet RCRA standards (2 FSs: BW, SA); and the need for highly specialized labor and equipment (1 FS: SA).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
10	4	6
Site Name Code:	BD, MB, P, V	BW, CE, CF, I, SA, W

Detailed Analysis

Of the four times closure-in-place/on-site encapsulation was retained for consideration in the detailed analysis for a remedial alternative, this option was selected as a component of the final remedy three times (75 percent) and was not selected as a component of the remedial alternative one time (25 percent). In several cases, this option was retained as a component of a treatment train with other technologies that meet the CERCLA preference for treatment. The criteria used for non-selection were reduction of TMV, long-term effectiveness, and implementability. The reasons noted were that this option would not reduce toxicity or volume (1 FS: P); contaminated soil would remain on site (1 FS: P); and that this option would require an intensive excavation effort (1 FS: P).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
4	3	1
Site Name Code:	BD, MB, V	P

2. TEMPORARY ON-SITE STORAGE PILE

Initial Screening

Temporary on-site storage piles were considered at nine sites. In the initial screening, this type of on-site containment was screened out two times (22 percent) and retained for the detailed analysis seven times (78 percent). Reasons were not provided in the FSs that initially screened out temporary on-site storage piles (2 FSs: MO, UC).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
9	7	2
Site Name Code:	AC, BD, BW, K, MB, R, W	MO, UC

Detailed Analysis

Of the seven times temporary on-site storage piles were retained for consideration in the detailed analysis for a remedial alternative, this option was selected as a primary component of the final remedy six times (86 percent) and was not selected as a primary component of the remedial alternative one time (14 percent). The criteria used for non-selection were overall protectiveness, reduction of TMV, and cost. The reasons noted were that this option would be less protective than other options (1 FS: K), it would not reduce the toxicity or volume of contaminants in soil (1 FS: K), and that future treatment costs were unknown (1 FS: K). Note that in five of the six cases where on-site storage was selected, this option was selected as a step in a multiple-technology treatment train.

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
7	6	1
Site Name Code:	AC, BD, BW, MB, R, W	K

3. LONG-TERM ON-SITE LANDFILL

Initial Screening

Long-term on-site landfills were considered at 16 sites. In the initial screening, this type of on-site containment was screened out seven times (444 percent) and retained for the detailed analysis nine times (56 percent).

Long-term on-site landfills were screened out for factors related to cost, effectiveness, and implementability. The predominant factor eliminating long-term on-site landfills was implementability. Specifically, issues were raised regarding the need for pretreatment of the wastes (1 FS: I), site-specific conditions (3 FSs: P, SA, SE), and RCRA and/or state requirements (2 FSs: SA, SM). In addition, this option was screened out because of its very high costs (1 FS: SM). Other reasons noted were that this option minimizes (but does not eliminate) long-term risks (1 FS: I) and that removal operations would expose contaminated subsoil (1 FS: LP).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
16	9	7
Site Name Code:	ACF, ACT, BD, K, LG, NC, R, T, UP	I, LP, MO, P, SA, SE, SM

Detailed Analysis

Of the nine times long-term on-site landfills were retained for consideration in the detailed analysis for a remedial alternative, this option was selected as a primary component of the final remedy one time (11 percent) and was not selected as a primary component of the remedial alternative eight times (89 percent). The criteria used for non-selection were overall protectiveness, compliance with ARARs, reduction of TMV, long- and short-term effectiveness, implementability, and cost. The predominant reasons for non-selection were no reduction in toxicity and volume of the contaminants (3 FSs: ACF, K, NC) and the fact that this option would involve difficult disposal/permit issues (4 FS: K, NC, T, UP).

Other reasons noted were that this option would be less protective than other options (1 FS: K) and that LDS might cause ARARs issues. It was also cited that this option does not meet the CERCLA preference for treatment (2 FSs: ACF, K), and that this option is not permanent enough in the long term (1 FS: NC). Another reason for non-selection was that this option presents a short-term risk of exposure to contaminants (1 FS: NC). Related to cost, it was noted that this option has high operation and maintenance costs and is more costly than an off-site landfill (2 FSs: BD, K).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
9	1	8
Site Name Code:	R	ACF, ACT, BD, K, LG, NC, T, UP

Conclusion

On-site containment options are generally an inadequate remediation method *as a stand-alone remediation method* for contaminated soils, sediments, and sludges at wood treater sites. This option does not meet the CERCLA preference for treatment of hazardous materials. The most prevalent reasons for non-selection of this technology category across all of the types of on-site containment options considered were: (1) the fact that this option does not reduce toxicity or volume of contaminated materials; and (2) concerns about implementability (in particular, difficult permitting issues). The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option:

NCP Criteria	Key Factors
Overall Protectiveness	• Not protective enough as a stand-alone technology
Compliance with ARARs	• LDS may cause compliance issues • Does not meet preference for treatment
Reduction of Toxicity, Mobility, or Volume	• Will not reduce toxicity or volume
Long Term Effectiveness and Permanence	• Not a permanent, long-term remedy • Contaminated soil would remain on site
Short Term Effectiveness	• Short-term risk of exposure to contaminants for on-site personnel due to excavation
Implementability	• Requires an intensive excavation effort • Difficult disposal/permit issues
Cost	• Unknown future treatment costs (in the case of temporary on-site containment measures) • High operation and maintenance costs for on-site landfills; on-site landfills may have higher costs than off-site landfills

Because of the variability in the types of technologies considered under the thermal treatment category, separate "technology description," "limitations," "target contaminants," and "conclusions" sections are provided for each of the five categories of thermal technologies examined in this analysis (i.e., pyrolysis, vitrification, wet air oxidation, infrared treatment, and other thermal technologies).

1. PYROLYSIS

Technology Description

Pyrolysis is an *ex situ* process that induces chemical decomposition by heat in the absence of oxygen. Organic materials are transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash. Pyrolysis is currently a pilot-scale technology.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- Specific feed size and materials handling requirements may impact applicability and/or cost.
- The technology requires low moisture soil.
- Highly abrasive feed may damage the processing unit.
- The overall cost for pyrolysis is relatively high.

Target Contaminant Groups

The target contaminant groups for pyrolysis are all halogenated and non-halogenated semi-volatile organic compounds (semi-VOCs) and pesticides. The technology has been used to treat halogenated and non-halogenated volatile organic compounds (VOCs) and fuel hydrocarbons but may be less effective for these types of contaminants. This technology is not applicable to inorganic contaminants.

Initial Screening

Pyrolysis was considered at nine sites. In the initial screening, it was screened out nine times (100 percent) and thus was retained for the detailed analysis zero times (0 percent).

Pyrolysis was screened out for factors related to effectiveness and implementability. For example, it was screened out because it is not effective for dioxins or chlorinated organic carbons and it is not a well-proven technology (5 FSs: ACF, I, SA, SE, SM). Pyrolysis was also screened out because it is not a well-developed technology (1 FS: UP), it cannot accept sludge-type material, and it has not been tested on dioxin or polychlorinated biphenyls (PCBs) (1 FS: SM). In addition, this option was screened out because it is not certain this technology will be commercially available (1 FS: BW) and it requires relatively sophisticated equipment (1 FS: W).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
9	0	9
Site Name Code:	--	ACF, BW, I, SA, SE, SM, T, UP, W

Detailed Analysis

Pyrolysis was not considered in any remedial alternatives.

Conclusion

Problems with implementability and a lack of demonstrated effectiveness were the primary reasons for screening out pyrolysis. These problems with pyrolysis were particularly apparent when comparing this technology to more established thermal treatment processes such as rotary kiln incineration. Specifically, the obstacle of obtaining field-scale equipment is a major factor. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option:

NCP Criteria	Key Factors
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume*	
Long Term Effectiveness and Permanence	• Not a well-proven technology • Not effective for dioxins or chlorinated organic carbons • Cannot accept sludge-type material and it has not been tested on dioxin or PCBs
Short Term Effectiveness*	
Implementability	• Not certain this technology will be commercially available • Requires relatively sophisticated equipment • Not a well-developed technology
Cost*	

* Criterion did not contribute to eliminating the technology.

2. VITRIFICATION

Technology Description

Vitrification of soils is a thermal treatment process that converts contaminated soil into a chemically inert, stable glass and crystalline product. *In situ* vitrification is a relatively complex, high-energy technology requiring a high degree of skill and training. An array of electrodes is inserted into the ground to the desired treatment depth. An electrical current heats the soil to approximately 2,000^{o}C, well above the initial melting temperature (e.g., fusion) of soils. The pyrolyzed byproducts migrate to the surface of the vitrified zone, where they combust in the presence of oxygen. A vacuum hood placed over the treated area collects off gases, which are treated before release. The off-gas treatment system consists typically of a glycol cooling system, a wet scrubbing system and condenser, and carbon filters. *In situ* vitrification is currently considered an innovative technology in the pilot stage of development.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- *In situ* vitrification is effective only to a depth of approximately 30 feet (9 meters).

- *In situ* vitrification is limited in the vadose zone above the ground-water table.

- Community acceptability of this technology is very low.

- Fugitive emissions may be generated and pose potential health and safety risks to site workers. Personal protective equipment and appropriate off-gas collection systems at a level commensurate with the contaminants is required.

- The high voltage used in *in situ* vitrification, as well as the control of off gases, present potential health and safety risks.

- This process is in the innovative stage, is highly complex, and has not been proven to be effective on a large scale.

- Implementation is difficult, especially when site-specific conditions such as topography and depth of contaminated soil are considered.

Target Contaminant Groups

While vitrification is used primarily to encapsulate non-volatile inorganic contaminants, the process does achieve temperatures of approximately 3,000^{o}F (1,600^{o}C) that should destroy organic contaminants.

Initial Screening

Vitrification was considered at 14 sites. In the initial screening, it was screened out 12 times (86 percent) and retained for the detailed analysis two times (14 percent).

Vitrification was screened out for factors related to cost, effectiveness, and implementability. Related to cost, it was screened out because of its general high cost and intensive energy and capital costs (3 FSs: CF, UP, W). It was also screened out because its effectiveness is hindered by site-specific conditions such as the presence of non-sandy soil, a high water table, and debris/wood chips (4 FSs: I, MO, R, V). This option was also screened out because it is a new, unproven technology (2 FSs: CF, SE) and because of implementation difficulties such as the need for intensive site preparation, special equipment, and significant electrical supplies (10 FSs: AC, CF, I, K, MO, MI, T, UP, V, W).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
14	2	12
Site Name Code:	SA, SM	AC, CF, I, K, MI, MO, R, SE, T, UP, V, W

Detailed Analysis

Of the two times vitrification was retained for consideration in the detailed analysis for a remedial alternative, it was selected as a primary component of the final remedy zero times (0 percent). Vitrification was not selected as a primary component of the remedial alternative two times (100 percent). The criteria used for non-selection were reduction of TMV, long-term effectiveness, implementability, and cost. Factors related to implementability were the major problems cited regarding this option. Specifically, vitrification requires special equipment and trained personnel, entails a degree of risk because of its innovative nature, requires a long implementation period, and requires bench/pilot studies (2 FSs: SA, SM).

Other reasons noted were that this option would require treatability testing to establish its effectiveness in destroying organic contaminants and immobilizing inorganic contaminants (1 FS: SA) and that it would not reduce the volume of contaminants (1 FS: SM). In addition, it was noted that this is not a well-proven technology and that the *in situ* nature of this technology would make it difficult to monitor during treatment and to establish QA/QC procedures (2 FSs: SA, SM). Finally, it was noted that this technology is more expensive than incineration for a similar reduction in risks (1 FS: SM).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
2	0	2
Site Name Code:	--	SA, SM

Conclusion

Implementability issues were the primary reason for screening out vitrification. Specifically, the unproven nature of this technology and the obstacle of obtaining field-scale equipment were major factors. In addition, air emissions from the operation of this thermal technology pose short-term risks to on-site workers. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option:

NCP Criteria	Key Factors
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume	• Vitrification does not reduce the volume of contaminants
Long Term Effectiveness and Permanence	• Requires treatability testing to establish its effectiveness in destroying organic contaminants and immobilizing inorganic contaminants
Short Term Effectiveness	• Air emissions from the operation of this thermal technology pose short-term risks to on-site workers
Implementability	• Requires special equipment (which is available from only one vendor) and trained personnel • Entails a degree of risk because of its innovative nature • Requires a long implementation period due to the need for bench/pilot studies • Not a well-proven technology • Difficult to monitor during treatment and to establish QA/QC procedures
Cost	• More costly than incineration

* Criterion did not contribute to eliminating the technology.

3. Wet Air Oxidation

Technology Description

Wet air oxidation is an *ex situ* thermal treatment technology that breaks down organic materials by oxidation. Contaminated media are excavated and mixed in an oxidation unit with water and air. At elevated temperature and pressure, aqueous phase oxidation occurs that destroys many of the contaminants. In this process, liquids or sludges are mixed with compressed air. The waste-air mixture is preheated in a heat exchanger before entering the corrosion-resistant reactor where exothermic reactions increase the temperature to the desired value. The exit steam from the reactor is used as the heating medium in the heat exchanger before it enters a separator where the spent process vapors (i.e., non-condensable gases consisting primary of air and carbon dioxide) are separated from the oxidized liquid phase. Effluent from the process is generally biodegradable.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- The effluent requires additional treatment prior to discharge.
- High costs are associated with this process.
- Transportation of the contaminated media can pose additional risks.

Target Contaminant Groups

Wet air oxidation is an effective technology in the treatment of most organic contaminants, including chlorinated organic liquids or sludges found at wood treater sites. However, its effectiveness is limited in the treatment of inorganic contaminants or chlorinated VOCs.

Initial Screening

Wet air oxidation was considered at five sites. In the initial screening, this type of thermal treatment was screened out five times (100 percent) and thus was retained for the detailed analysis zero times (0 percent).

Wet air oxidation was screened out for factors related to effectiveness and implementability. For example, this option was screened out because it is not effective on solid waste streams or heavy metals (2 FSs: ACF, MI) and it is not recommended for halogenated organic aromatics (1 FS: SM). In addition, it was noted that this option is not technically feasible (1 FS: SE) and that limited information is available regarding its application to hazardous wastes (1 FS: SM).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
5	0	5
Site Name Code:	--	ACF, MI, SE, SM, T

Detailed Analysis

Wet air oxidation was not considered in any remedial alternatives.

Conclusion

Problems with implementability and the lack of demonstrated effectiveness were the primary reasons for screening out wet air oxidation. Specifically, the unproven nature of this technology and the obstacle of obtaining field-scale equipment were major factors. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option:

NCP Criteria	Key Factors
Overall Protectiveness*	

NCP Criteria	Key Factors
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume*	
Long Term Effectiveness and Permanence	• Not a well-proven technology • Wet air oxidation is not effective on solid waste streams or heavy metals • Not recommended for halogenated organic aromatics • Limited information is available regarding its application to hazardous wastes
Short Term Effectiveness*	
Implementability	• Uncertain technology will be commercially available • Technical feasibility problems with innovative thermal technologies • Innovative thermal technologies may require a longer implementation period due to the need for bench/pilot studies
Cost*	

* Criterion did not contribute to eliminating the technology.

4. INFRARED TREATMENT

Technology Description

Infrared incineration systems are designed to destroy hazardous wastes through tightly controlled process parameters with infrared energy as the primary heat source. Wastes are conveyed through the furnace for a very precise residence time on a woven metal alloy conveyor belt that passes the wastes under infrared heating elements. These elements are spaced over the length of the ceramic fiber insulated furnace.

At the discharge end of the furnace, ash residue is discharged to a hopper where it is conveyed to the collection system. Off gases from the primary furnace are exhausted to a secondary chamber equipped with a propane-fired burner or infrared heating elements to ensure complete combustion of any remaining organic contaminants. Before discharge to the stack, exhaust gases from the secondary chamber pass through air pollution control equipment for removal of particulates and other emissions such as HCl and SO_2. Pilot-scale and full-scale units are available and have been successfully demonstrated at Superfund sites.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- Air emissions from on-site units could have an adverse impact on air quality.

- Infrared incineration is a relatively new technology. Demonstrated applications of this technique for on-site use are limited. Trial burns are required to estimate full-scale requirements.

- Stack tests would be necessary to verify that 99.9999% destruction of chlorinated dioxins is accomplished.

Target Contaminant Groups

Infrared incineration is an effective technology in the treatment of most organic contaminants. However, its effectiveness is limited in the treatment of inorganic contaminants.

Initial Screening

Infrared treatment was considered at nine sites. In the initial screening, this type of thermal treatment was screened out seven times (78 percent) and retained for the detailed analysis two times (22 percent).

Infrared treatment was screened out for factors related to cost, effectiveness, and implementability. For example, infrared treatment was screened out because of its general high costs (2 FSs: AC, LG). It was also screened out because this option may fail to meet the 99.99% DRE requirements (1 FS: SE) and because rotary kilns are more effective (1 FS: BD). Finally, this option was screened out because this technology is still in the development phase and as a result it will have higher costs and lower processing rates than more established technologies (1 FS: AC).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
9	2	7
Site Name Code:	BW, SA	AC, ACF, BD, I, LG, SE, T

Detailed Analysis

Of the two times infrared treatment was retained for consideration in the detailed analysis for a remedial alternative, this option was selected as a primary component of the final remedy zero times (0 percent) and thus was not selected as a primary component of the remedial alternative two times (100 percent). The criterion used for non-selection was implementability. The reasons noted were: (1) this option involves exposure to air emissions; (2) mobile infrared incinerators are not readily available and therefore delays may result in obtaining a unit; (3) this option requires extensive construction; (4) a test burn will be required and it must meet RCRA performance standards; and (5) this option has low administrative feasibility (1 FS: BW).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
2	0	2
Site Name Code:	--	BW, SA

Conclusion

Problems with implementability and the lack of demonstrated effectiveness are the primary reasons for screening out infrared treatment, especially compared with more established thermal treatment processes such as rotary kiln incineration. Specifically, the unproven nature of this technology and the obstacle of obtaining field-scale equipment are major factors. In addition, air emissions from the operation of this thermal technology pose short-term risks. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option:

NCP Criteria	Key Factors
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume*	
Long Term Effectiveness and Permanence	• Fails to meet the 99.99% DRE requirements • Rotary kiln incinerators are more effective
Short Term Effectiveness	• Air emissions from the operation of this thermal technology pose short-term risks
Implementability	• Uncertain commercial availability • Higher costs and lower processing rates since technology is still in the development stage
Cost	• Generally high costs • More expensive than other thermal incineration technologies

* Criterion did not contribute to eliminating the technology.

5. Other Thermal Treatments

Technology Description

Other thermal treatments considered in this analysis included the advanced electric reactor (AER), plasma arc, molten salt incinerator, and molten glass incinerator.

The AER is a relatively new thermal technology being developed specifically for the detoxification of contaminated soils, although other solid and liquid wastes may also be destroyed. The AER is distinguished from other thermal destruction technologies in that energy is transferred to the incoming waste through radiation instead of through combustion, conduction, or convection. Destruction is achieved by thermolysis (i.e., pure heating) at high temperatures in a reactor vessel where materials are reported to break down to carbon, carbon monoxide, and hydrogen. Pilot- scale units with a capacity of 3,000 pounds per hour are available; however, commercial scale units are not presently available.

Plasma arc technology involves breaking the bonds between organic constituents. This is accomplished in an atomization zone where a co-linear electrode generates a plasma or electric arc that is stabilized by field coil magnets. As low pressure air passes through the arc, the electrical energy is converted to thermal energy by the activation of the air molecules into their ionized atomic states. When the excited atoms and molecules relax to lower energy states, intense ultraviolet light is emitted. The energy from the breakdown of the plasma is transferred to passing atomized waste materials, reducing them to their elemental constituents. An equilibrium zone is provided for the controlled cooling and recombination of the atomic species to form simple non-hazardous molecules such as hydrogen, carbon, carbon monoxide, and hydrogen chloride. Pilot-scale units are available for treating liquids but no units are currently available for handling soils.

Molten salt and molten glass incinerators may be used for the destruction of hazardous liquids and solids. Molten salt incinerators maintain molten salt at a temperature between 1382^0F and 1832^0F; wastes that come into contact with this salt are catalytically destroyed. Hot gases rise through the molten salt, pass through a secondary reaction zone, and then move through an off-gas cleanup system before being discharged to the atmosphere. Supplemental fuel may be necessary when wastes are not sufficiently combustible to maintain required temperatures. Liquids, free-flowing powders, sludges, and shredded solid wastes may be fed directly to the incinerator. The technology has been effective for chlorinated hydrocarbons and chlorinated solvents. Field-scale units are not presently available.

Limitations

The following factors may limit the applicability and effectiveness of other thermal treatment options:

- Air emissions from on-site units could have an adverse impact on air quality.

- All of the other thermal treatment technologies considered in this subsection are relatively new technologies. Demonstrated applications of these techniques are limited.

- Data on the effectiveness of these technologies on dioxin-containing wastes are not currently available.

- Field-scale units for soils are not commercially available.
- Molten salt incinerators are sensitive to materials containing high ash content or high chlorine content.
- Advanced electric reactors are not feasible for large quantities of soil.

Target Contaminant Groups

Other thermal treatments target the destruction of most organic contaminants. However, their effectiveness is limited in the treatment of inorganic contaminants. In general, however, full-scale effectiveness data for these technologies for either inorganic or organic contaminants are not available.

Initial Screening

Other thermal treatments were considered at two sites. In the initial screening, this option was screened out two times (100 percent) and thus was retained for the detailed analysis zero times (0 percent).

Other thermal treatments were screened out for factors related to effectiveness and implementability. From the effectiveness standpoint, other thermal treatments were screened out because they were not well-suited for large volumes of soil and were not effective for dioxins. In addition, it was noted that the metal content in the waste stream must be limited and that molten glass is generally inappropriate for soils because of their high ash content (1 FS: SA). Regarding implementability, other thermal treatments were screened out because commercial and mobile/transportable units are not available (2 FSs: SA, T).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
2	0	2
Site Name Code:	--	SA, T

Detailed Analysis

Other thermal treatments were not considered in any remedial alternatives.

Conclusion

Problems with implementability and the lack of demonstrated effectiveness were the primary reasons for screening out the other thermal treatment options analyzed in this section. Specifically, the unproven nature of these technologies and the obstacle of obtaining field-scale equipment were major factors. In addition, air emissions from the operation of these thermal technologies pose short-term risks. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this option:

NCP Criteria	Key Factors
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume*	
Long Term Effectiveness and Permanence	• Not well-proven technologies • Not effective for dioxins • Metal content in the waste stream must be limited • Molten glass is generally inappropriate for soils because of their high ash content
Short Term Effectiveness	• Air emissions from the operation of this thermal technology pose short-term risks
Implementability	• Uncertain commercial availability • Not well-suited for large volumes of soil • Mobile/transportable units are not available
Cost*	

* Criterion did not contribute to eliminating the technology.

Because of the variability in the types of technologies considered under the chemical treatment category, separate "technology description," "limitations," "target contaminants," and "conclusion" sections are provided for each of the three categories of chemical technologies examined in this analysis (i.e., dechlorination, solvent extraction, and other chemical treatment technologies).

1. DECHLORINATION

Technology Description

Dechlorination, also known as dehalogenation, uses a chemical reaction to remove chlorine atoms from chlorinated molecules. This converts the more toxic compounds into less toxic, sometimes more water soluble products, leaving compounds that are more readily separated from the soil and treated. Dechlorination of halogenated aromatic compounds uses a nucleophilic substitution reaction to replace a chlorine atom with an ether or hydroxyl group. Dechlorination of chlorinated aliphatic compounds occurs though an elimination reaction and the formation of a double or triple carbon-carbon bond.

Field and laboratory tests have identified several types of solutions that can dechlorinate PCBs, dioxins, and furans. These solutions include potassium polyethylene glycolate (KPEG), sodium polyethylene glycolate (NAPEG), and methoxypolyethylene glycolate (MPEG). These are generally classified as alkali polyethylene glycolate solutions (APEG). The base-catalyzed decomposition process (BCDP) uses sodium bicarbonate in a heated reactor to effectively treat halogenated compounds.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- This process generates three residuals -- treated soil, washwater, and air emissions. The washwater may require treatment prior to discharge. Volatile air emissions, if captured by condensation or activated carbon adsorption, can be thermally regenerated.

- If the influent materials include heavy metals or certain non-halogenated VOCs, these contaminants will not be destroyed by this process. The presence of contaminants for which this process is not suited may require additional, post-treatment, technologies.

- In the case of BCD dechlorination, high clay and moisture content will increase treatment costs.

- In the case of glycolate dechlorination techniques, concentrations of chlorinated organics greater than five percent require large volumes of reagent.

- Glycolate dechlorination techniques are not suitable for large volumes of waste.

- The treated soils that result from glycolate dechlorination have poor physical characteristics.

Target Contaminant Groups

Chemical dechlorination can treat halogenated aromatic contaminants in a waste matrix consisting of soil, sludge, or sediment. This technology has achieved high removal efficiencies in bench-scale studies for PCB contaminants and PCP. This technology is not applicable to metals or non-halogenated substances.

Initial Screening

Dechlorination was considered at 12 sites. In the initial screening, it was screened out eight times (67 percent), and was retained for the detailed analysis four times (33 percent).

Dechlorination was screened out for factors related to cost, effectiveness, and implementability. For example, effectiveness issues related to this option were: highly-chlorinated dioxins may be converted to more toxic, less chlorinated dioxins, creating a hazardous waste stream (2 FSs: I, LG); this technology has not been adequately demonstrated on PCP, dioxins, and/or PAHs (3 FSs: AC, LG, SE); and the process is still in the developmental stage (1 FS: MB). Implementation problems associated with this option were: it requires installation of on-site equipment or transportation to a permitted facility (1 FS: MB); scaling this technology to the full site remediation stage has yet to be tested (1 FS: LG); heavy metals in soil cause a problem in handling dewatering liquids (1 FS: SE); and it is difficult to contact sludge constituents with solvents (1 FS: MB). Dechlorination was also screened out because it entails high costs (2 FSs: I, W).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
12	4	8
Site Name Code:	K, R, SA, T	AC, I, LG, MB, SE, SM, UP, W

Detailed Analysis

Of the four times dechlorination was retained for consideration in the detailed analysis as a potential component of a remedial alternative, this option was selected as a primary component of the final remedy four times (75 percent) and was not selected as a primary component of the remedial alternative one time (25 percent). One of the four sites that selected dechlorination in this analysis selected it only on a conditional basis -- if treatability studies for other technologies proved unsuccessful, than the site would implement dechlorination. At this site, the reasons dechlorination was not selected as a first option were because this option requires pilot studies, takes the longest time to complete, and was more costly than other options (1 FS: K). The criterion used for non-selection of this technology at the one site that did not select this technology at all was related to reduction of TMV: specifically, it was noted that this technology might not meet action levels for PAHs (1 FS: T).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
4	3	1
Site Name Code:	K*, R, SA	T

* Note: This site selected this technology only on a conditional basis.

Conclusion

Dechlorination is generally an inadequate remediation method for contaminated soils, sediments, and sludges at most wood treater sites. Factors related to cost, effectiveness, and implementability were the primary reasons for screening out dechlorination. Although this technology can successfully treat halogenated aromatic contaminants, its effectiveness was an issue because this technology is still in the developmental stage, its washwater residuals may be hazardous, and it is unable to treat the full range of wood treater site contaminants. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option:

NCP Criteria	Key Factors
Overall Protectiveness	• Highly-chlorinated dioxins may be converted to more toxic, less chlorinated dioxins, creating a hazardous waste stream
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume	• Might not meet action levels for PAHs
Long Term Effectiveness and Permanence	• This technology has not been adequately demonstrated on PCP, dioxins, and/or PAHs
Short Term Effectiveness*	
Implementability	• Technology is still in the development stage, and requires pilot studies • Remediation takes the longest time to complete using this technology • Requires installation of on-site equipment or transportation to a permitted facility • Heavy metals in soil cause a problem in handling dewatering liquids • It is difficult to contact sludge constituents with solvents
Cost	• High costs

* Criterion did not contribute to eliminating the technology.

2. Solvent Extraction

Technology Description

Solvent extraction isolates contaminants from soil, sludge, or sediment using a chemical process involving an organic solvent. Unlike soil washing, solvent extraction does not involve the use of water or water-based solutions. Solvent extraction reduces contaminant volume by concentrating contaminants in the extraction phase. There are three general categories of solvent extraction: conventional solvent extraction, critical fluid extraction, and supercritical fluid extraction.

Conventional solvent extraction uses organic solvents to selectively extract the contaminants of concern. This process may require several passes to reduce contamination to the desired level. The extracted solvent from this process can be stripped of the contaminants, condensed, recycled, and reused.

Critical fluid extraction uses solvents that are miscible with water at one temperature and insoluble with water at another temperature. Triethylamine is an example of a critical solution temperature solvent.

Supercritical fluid extraction uses highly compressed gases (e.g., CO_2) raised above their critical temperatures to extract contaminants that generally resist extraction by conventional solvents. The highly compressed, gaseous fluid provides the additional diffusive/solvating power that is required to extract contaminants from hard-to-reach places in the environmental medium. Supercritical extraction uses higher pressure and temperature than conventional solvent extraction. The extraction fluid used in this process may also be recycled and reused.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- Solvent extraction generates three residual waste streams -- concentrated contaminants, treated soil or sludge, and separated solvent.

- Depending on the metal content or other inorganic contaminants remaining, the concentrated contaminants may need additional treatment prior to disposal.

- The soil or sludge may require drying prior to disposal.

Target Contaminant Groups

Solvent extraction is more appropriate for organic contaminants found at wood treater sites, such as halogenated phenols and cresols, simple non-halogenated aromatics, PAHs, and other polar organic compounds. This technology generally does not treat nonvolatile/volatile metals or other inorganic contaminants.

Initial Screening

Solvent extraction was considered at 14 sites. In the initial screening, it was screened out eight times (57 percent) and retained for the detailed analysis six times (43 percent).

Solvent extraction was screened out for factors related to cost, effectiveness, and implementability. Implementability issues were raised the most often, followed closely by effectiveness reasons. For example, implementation problems with solvent extraction were that it is only applicable for oils removal from sludges/soils (1 FS: K) and a way is needed recycle these oils (1 FS: BW). Furthermore, site-specific conditions such as heterogeneous soils, low permeability soils, and high clay/silt content of soils limit the effectiveness of this option (2 FSs: MO, SA). It was also noted that this option is an innovative, untested technology requiring very specialized equipment and personnel, that it has an uncertain regulatory status, and that its commercial availability is limited (4 FSs: BD, BW, SA, SM).

Numerous reasons were also raised regarding the effectiveness of this option. For example, complex mixtures of soil contaminants make it hard to select an effective solvent -- the fine fraction of the soil (which does not separate well from the solvent) may remain contaminated (1 FS: SA) and dense sludge does not permit adequate contact with the solvent (1 FS: UP). It was also noted that this option may not achieve remediation goals, because process performance is specific to site conditions and the solvent used (1 FS: MO). Furthermore, it was noted that this option is not a well proven technology (1 FS: SM).

Concerning cost, this technology was not selected because it was more expensive than other treatment options (2 FSs: BD, CE), and because it has high capital and O&M costs, including energy use (2 FSs: BW, SA).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
14	6	8
Site Name Code:	AC, ACT, I, R, T, UC	BD, BW, CE, K, MO, SA, SM, UP

Detailed Analysis

Of the six times solvent extraction was retained for consideration in the detailed analysis for a remedial alternative, it was selected as a primary component of the final remedy two times (33 percent). Solvent extraction was not selected as a primary component of the remedial alternative four times (67 percent). The criteria used for non-selection were reduction of TMV, implementability, and cost. Specifically, solvent extraction does not reduce the overall waste volume due to the production of contaminated effluent (1 FS: I) and there is only a limited number of qualified vendors for this technology (1 FS: T). Furthermore, it was noted that difficulties were encountered in previous attempts with this process (1 FS: R) and that this option is generally expensive (2 FSs: I, R).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
6	2	4
Site Name Code:	AC, UC	ACT, I, R, T

Conclusion

Solvent extraction is generally an inadequate remediation method for contaminated soils, sediments, and sludges at wood treater sites. Problems with implementability were the primary reason for screening out solvent extraction. Specifically, its limitations caused by site-specific conditions (e.g., because it requires soil to be finely ground and treated as an aqueous solution); its limited commercial availability; and its innovative status were major impediments. The high costs of this option and problems with effectiveness were also factors. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option as a primary remedial option:

NCP Criteria	Key Factors
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume	• Does not reduce contaminant volume due to production of effluent
Long Term Effectiveness and Permanence	• May not achieve remediation goals • Not a well-proven technology
Short Term Effectiveness*	
Implementability	• Site conditions, such as soil heterogeneities, limit efficiency • Requires extensive design/treatability studies • Dense sludge does not permit adequate contact
Cost	• High cost • High capital and operation/maintenance costs

* Criterion did not contribute to eliminating the technology.

3. Other Chemical Treatment Options

Technology Description

Several "other chemical treatment options" were also considered as remediation options, including supercritical fluid extraction, steam/air stripping, ultraviolet/photolysis, stream-enhanced vacuum extraction, radio frequency, alkaline hydrolysis, and supercritical oxidation. This category was established for data compilation purposes.

Limitations

This discussion does not apply to this category.

Target Contaminant Groups

This discussion does not apply to this category.

Initial Screening

Other chemical treatment options were considered at four sites. In the initial screening, this type of treatment was screened out four times (100 percent) and thus, was retained for the detailed analysis zero times (0 percent).

Other chemical treatment options were screened out for factors primarily related to effectiveness. Implementability problems also played a role. For example, effectiveness problems were as follows: (1) stream-enhanced vacuum extraction will not achieve cleanup goals for metals and dioxins, and low permeability of soil and variable soil conditions reduces steam contact and overall effectiveness for PCP removal (3 FSs: AC, R, SA); (2) steam/air stripping will not achieve cleanup goals for metals or dioxins (1 FS: SA); (3) steam stripping, soil vapor extraction, and chemical reduction are not effective for PAHs and metals (1 FS: MO); (4) alkaline hydrolysis/supercritical oxidation data on sludge treatment are unavailable (1 FS: T); and (5) alkaline hydrolysis/supercritical oxidation are not proven against dioxins (1 FS: T). Regarding implementability, the availability of commercial equipment may be limited due to the emerging status of critical fluid extraction for soil treatment (1 FS: SA). In addition, steam stripping, soil vapor extraction, and chemical reduction are not applicable to organic substances (1 FS: MO).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
4	0	4
Site Name Code:	--	AC, MO, SA, T

Detailed Analysis

Other chemical treatment options were not considered in any remedial alternatives.

Conclusion

Other chemical treatment options are an inadequate remediation method for contaminated soils, sediments, and sludges at wood treater sites because they were not proven effective in remediating these contaminants and can be difficult to implement. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option as a primary remedial option:

NCP Criteria	Key Factors
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume*	
Long Term Effectiveness and Permanence	• Stream-enhanced vacuum extraction may not achieve cleanup goals for metals and dioxins • Low permeability of soil and variable soil conditions reduces steam contact and overall effectiveness for PCP removal of stream-enhanced vacuum extraction • Steam/air stripping will not achieve cleanup goals for metals or dioxins • Steam stripping, soil vapor extraction, and chemical reduction are not effective for PAHs and metals • Alkaline hydrolysis/supercritical oxidation data on sludge treatment are unavailable • Alkaline hydrolysis/supercritical oxidation are not proven against dioxins
Short Term Effectiveness*	
Implementability	• Availability of commercial equipment may be limited due to the emerging status of critical fluid extraction for soil treatment • Steam stripping, soil vapor extraction, and chemical reduction are not applicable to organic substances
Cost*	

* Criterion did not contribute to eliminating the technology.

Because of the variability in the types of technologies considered under the physical treatment category, separate "technology description," "limitations," "target contaminants," and "conclusion" sections are provided for each of the six categories of physical technologies examined in this analysis (i.e., soil flushing, soil washing, attenuation, aeration/soil venting, macroencapsulation/overpacking, and other physical treatment technologies).

1. SOIL FLUSHING

Technology Description

In the process of *in situ* soil flushing, water (or water containing an additive to enhance contaminant solubility) is applied to the soil or injected into the ground water to raise the water table into the contaminated soil zone. Contaminants are leached into the ground water. Subsequently, the ground water is extracted and the leached contaminants are captured and treated and/or removed before the ground water is recirculated. Soil flushing is a pilot scale technology.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- This technology is applicable only to sites with favorable hydrology, where flushed contaminants and soil flushing fluid can be contained and re-captured.
- Low-permeability soil is difficult to treat.
- Surfactants can adhere to soil and reduce soil porosity.
- Solvent reactions with soil can reduce contaminant treatability.
- Soil flushing does introduce potential hazardous materials (e.g., the flushing solution) into the soil, which may also alter the physical/chemical properties of the soil system.

Target Contaminant Groups

The target contaminant groups for soil flushing are halogenated and non-halogenated volatile organic compounds and inorganics. The technology can also be used to treat halogenated and non-halogenated semi-VOCs, fuel hydrocarbons, and pesticides. Compatible surfactants may be added to increase the solubility of some compounds. The technology offers the potential for recovery of metals and can clean a wide range of organic and inorganic contaminants from coarse-grained soil.

Initial Screening

Soil flushing was considered at 14 sites. In the initial screening, it was screened out nine times (64 percent), and was retained for the detailed analysis five times (36 percent).

Soil flushing was screened out for factors related to cost, effectiveness, and implementability. In particular, effectiveness issues were emphasized. For example, soil flushing was screened out because it is less effective than capping for deep contaminated soils (1 FS: LP), and because there is the potential for ground-water contamination from the flushing agents used (1 FS: BD). In addition, it was noted that this option has low removal rates for semi-volatile contaminants in low permeability soils and that it is not effective on non-highly water soluble contaminants such as PAHs (3 FSs: AC, CF, R). Regarding difficulties with the solvents used in this process, it was noted that strong acids for leaching heavy metals may cause increased contaminant migration (1 FS: MI), and that solvents for leaching both organic contaminants and heavy metals are unavailable (1 FS: R). Finally, it was noted that this option is not effective in non-homogeneous or low permeability soils (1 FS: R).

Implementation problems were also associated with soil flushing. For example, it was noted that this option has uncertain implementability (1 FS: BD), and that high partition coefficient/low permeability soils makes collection of added solvents difficult (2 FSs: AC, K). In addition, it was noted that implementation of an effective extraction system is difficult at sites with shallow ground-water tables (1 FS: CF), and that ARARs may restrict injection of chemicals into the ground (1 FS: MO). Regarding cost, soil flushing was screened out because this option costs more than capping (1 FS: LP).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
14	5	9
Site Name Code:	I, NC, SM, UP, V	AC, BD, CF, K, LP, MI, MO, R, SA

Detailed Analysis

Of the five times soil flushing was retained for consideration in the detailed analysis for a remedial alternative, this option was selected as a primary component of the final remedy one time (20 percent) and was not selected as a primary component of the remedial alternative four times (80 percent). The criteria used for non-selection were overall protectiveness, long-term effectiveness, implementability, and cost. Specifically, it was noted that this technology might induce spreading of the LNAPL plume (1 FS: I), and that this option is not a well-proven technology and it has uncertain long-term effectiveness (3 FSs: I, SM, V). It was also noted that site conditions, such as soil heterogeneities and low hydraulic conductivity, limit the efficiency of this technology (3 FSs: I, SM, V), and that uncertain technical difficulties are possible due to the innovative status of this option (2 FSs: I, SM). In addition, it was noted that this option would require extensive design/treatability studies (1 FS: SM) and that it costs more than *in situ* biodegradation for a similar reduction in risk (1 FS: NC).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
5	1	4
Site Name Code:	UP	I, NC, SM, V

Conclusion

Problems with implementability and the lack of demonstrated effectiveness are the primary reasons for screening out soil flushing. Specifically, the unproven nature of this technology, its uncertain long-term effectiveness, and efficiency limitations caused by site-specific conditions are major factors. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option:

NCP Criteria	Key Factors
Overall Protectiveness	• Might induce spreading of LNAPL plume on-site
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume*	
Long Term Effectiveness and Permanence	• Not a well-proven technology • Uncertain long-term effectiveness
Short Term Effectiveness*	
Implementability	• Site conditions, such as soil heterogeneities and low hydraulic conductivity, may limit efficiency • Uncertain technical difficulties are possible due to innovative status • Requires extensive design/treatability studies
Cost	• Costs more than *in situ* biodegradation for a similar reduction in risk

* Criterion did not contribute to eliminating the technology.

2. Soil Washing

Technology Description

Soil washing is an *ex situ* process. Contaminants sorbed onto soil particles are separated from the soil with washwater. The water may be augmented with a basic leaching agent, surfactant, pH adjusting agent, or chelating agent to help remove organics or heavy metals. Soil washing is a full-scale technology.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- Fine soil particles (e.g., silts, clays) are difficult to remove from the washwater.

- High humus content in soil inhibits desorption.

- Washed soil containing additives and wastewater treatment sludge can pose difficult disposal problems.

- Complex waste mixtures (e.g., metals with organics) make it difficult to formulate the washwater.

Target Contaminant Groups

The targeted contaminant groups for soil washing are halogenated and non-halogenated semi-VOCs, fuel hydrocarbons, and inorganics. The technology can be used but may be less effective against halogenated and non-halogenated VOCs and pesticides. The technology offers the potential for recovery of metals and can clean a wide range of organic and inorganic contaminants from coarse-grained soils.

Initial Screening

Soil washing was considered at 19 sites. In the initial screening, it was screened out 12 times (63 percent) and retained for the detailed analysis seven times (37 percent).

Soil washing was screened out for factors related to cost, effectiveness, and implementability. Effectiveness issues were raised the most frequently. For example, this technology was screened out because it is not efficient on fine-grained soils and does not remove low concentrations of arsenic and chromium (3 FSs: AC, R, SE). In addition, it was noted that this technology does not remove tightly absorbed metals efficiently (1 FS: MI), and that there is a lack of overall demonstrated effectiveness for this technology (1 FS: SE). Other effectiveness problems that were noted were that the separated silt/clay has higher concentrations of contaminants than the original feed soil (1 FS: LG), and that this option has a low recovery rate on variable wastes and clay soils containing semi-volatile contaminants (1 FS: W).

Implementation problems were also noted, such as that this option produces large volumes of sludge (1 FS: T) and that it requires extensive equipment and vapor recovery treatment as well as solvent recovery and treatment of the washing fluid (2 FSs: NC, W). Regarding cost, it was noted that soil washing has high capital costs and produces large residual volumes, which increase overall costs (2 FSs: BD, LP).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
19	7	12
Site Name Code:	ACT, CE, CF, I, MO, P, SM	AC, BD, K, LG, LP, MI, NC, R, SA, SE, T, W

Detailed Analysis

Of the seven times soil washing was retained for consideration in the detailed analysis for a remedial alternative, it was selected as a primary component of the final remedy five times (71 percent). Soil washing was not selected as a primary component of the remedial alternative two times (29 percent). The criteria used for non-selection were reduction of TMV and implementability. Specifically, soil washing does not reduce toxicity (1 FS: SM) and requires extensive design/treatability studies (1 FS: SM). In addition, there are uncertainties regarding its application to wood treater contaminants (1 FS: SM).

No. FSs Technology Passed Screening	No. RODs Technology Selected (as a Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
7	5	2
Site Name Code:	CE, CF, I, MO, P	ACT, SM

Conclusion

Problems with effectiveness were the primary reasons for screening out soil washing. Specifically, its uncertain long-term effectiveness and efficiency limitations caused by site-specific conditions (e.g., because it is inefficient on fine-grained soils and because it does not remove low concentrations of arsenic and chromium) were major factors. This option also has implementation drawbacks, such as the difficulty inherent in formulating complex washwaters and the generation of large volumes of wastewater. However, this technology offers the potential for recovery of metals and can clean a wide range of organic and inorganic contaminants from coarse-grained soils, and can be appropriate as a secondary technology in a treatment train. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option as a primary remedial option:

NCP Criteria	**Key Factors**
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume	• Does not reduce toxicity
Long Term Effectiveness and Permanence	• Uncertainties regarding its application to wood treater contaminants
Short Term Effectiveness*	

NCP Criteria	Key Factors
Implementability	• Site conditions, such as soil heterogeneities, may limit efficiency • Requires extensive design/treatability studies
Cost*	

* Criterion did not contribute to eliminating the technology.

3. ATTENUATION

Technology Description

Attenuation is the process of mixing contaminated soil with clean soil to reduce concentrations below cleanup goals. Bentonite may be used as the clean soil mix. This technology has been reported as potentially applicable in treating wastes with metals. Liming and re-liming may be necessary to maintain the soil pH above 8.0 and thereby reduce the mobility of the metals.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- Attenuation is limited to the upper two feet of soil.
- Attenuation does not reduce contaminant mobility, toxicity, or volume.
- Attenuation is not considered a permanent remedy in accordance with SARA.

Target Contaminant Groups

Attenuation has been reported as potentially applicable in treating wastes contaminated with inorganics (e.g., metals).

Initial Screening

Attenuation was considered at two sites. In the initial screening, this type of treatment was screened out two times (100 percent) and thus was retained for the detailed analysis zero times (0 percent).

Attenuation was screened out for factors related to cost, effectiveness, and implementability. For example, this option was screened out because it would be too costly to treat the entire contaminated area with this process (1 FS: P). In addition, it was noted that this option does not reduce TMV, it is not considered a permanent remedy, and it is not effective for soils deeper than two feet (1 FS: CF). Furthermore, if this technology were implemented other treatment options would need to be selected for contaminated soils deeper than two feet (2 FSs: CF, P).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
2	0	2
Site Name Code:	--	CF, P

Detailed Analysis

Attenuation was not considered in any remedial alternatives.

Conclusion

Attenuation is generally an inadequate remediation method for contaminated soils, sediments, and sludges at wood treater sites due primarily to problems with effectiveness and implementation. Specifically, it is not considered a permanent remedy and is not effective for soils deeper than two feet. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option as a primary remedial option:

NCP Criteria	Key Factors
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume	• Does not reduce toxicity, mobility, or volume
Long Term Effectiveness and Permanence	• Not considered a permanent remedy • Not effective for soils deeper than two feet
Short Term Effectiveness*	
Implementability	• Another treatment would be necessary below the maximum effective depth of two feet, posing implementability problems
Cost	• Too costly to treat the entire contaminated area with this process

* Criterion did not contribute to eliminating the technology.

4. Aeration/Soil Venting

Technology Description

Aeration/soil venting takes advantage of the volatility of contaminants in soil. Enclosed mechanical soil aeration, both *ex situ* and *in situ*, uses air stripping to detoxify soil contaminated with VOCs. Aerated (*in situ*) or excavated (*ex situ*) soil is mixed, increasing air/soil contact and allowing for the release of VOCs trapped in the soil. VOC emissions are captured as air is forced through the system and carried to an air pollution control device (e.g., scrubber or vapor phase carbon adsorption unit) for treatment.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- Further pilot testing will be required to determine the effectiveness of this method.

- Excavation of soil may increase air emissions and the potential for associated health risks.

Target Contaminant Groups

Target contaminants for soil aeration are VOCs and semi-VOCs. The process has uncertain effectiveness in the removal of VOCs to desired cleanup levels and is not effective for PCBs and dioxins.

Initial Screening

Aeration/soil venting was considered at five sites. In the initial screening, this type of treatment was screened out five times (100 percent) and thus, was retained for the detailed analysis zero times (0 percent).

Aeration/soil venting was screened out for factors related to cost, effectiveness, and implementability. Most frequently, this technology was screened out due to reasons related to effectiveness. For example, this option was screened out because it is not effective for shallow, impermeable surface/subsurface soils (1 FS: BD) and it is only effective for VOCs and not chlorinated organic compounds (2 FSs: I, K). Implementability problems were also noted with this technology; for example, it was noted that this technology is not technically feasible (1 FS: SE) and dense sludge is not permeable enough to permit vapor diffusion (1 FS: UP). Finally, this technology was found to be more costly than *in situ* surface bioremediation for a similar reduction in risk (1 FS: BD).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
5	0	5
Site Name Code:	--	BD, I, K, SE, UP

Detailed Analysis

Aeration/soil venting was not considered in any remedial alternatives.

Conclusion

Aeration/soil venting is generally an inadequate remediation method for contaminated soils, sediments, and sludges at wood treater sites due primarily to problems with effectiveness and implementation. Specifically, it does not address any of the non-VOC types of contamination at wood treater sites. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option as a primary remedial option:

NCP Criteria	Key Factors
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume*	
Long Term Effectiveness and Permanence	• Not effective for shallow, impermeable surface/subsurface soils • Only effective for VOCs, and not chlorinated organic compounds
Short Term Effectiveness*	
Implementability	• Not technically feasible • Dense sludge is not permeable enough to permit vapor diffusion
Cost	• More costly than *in situ* surface bioremediation for a similar reduction in risk

* Criterion did not contribute to eliminating the technology.

5. Macro-Encapsulation/Overpacking

Technology Description

Encapsulation encompasses a set of process options that stabilize contaminated debris using agents that reduce the leachability of contaminants. Macroencapsulation is the application of surface coating materials (e.g., resins and plastics) or the use of a jacket of inert inorganic materials to reduce surface exposure to potential leachate.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- The encapsulating material must completely surround the wastes.
- The encapsulating material must be resistant to degradation by the waste material, its contaminants, and materials it may contact after placement (e.g., leachate, other wastes, and microbes).
- Free liquids cannot be present in the encapsulated debris.
- The debris surface must be free of caked soil, waste, or other non-debris material.

Target Contaminant Groups

Encapsulation is generally used to stabilize solid (organic or inorganic) debris to reduce the leachability of the contaminants.

Initial Screening

Macro-encapsulation/overpacking was considered at one site. In the initial screening, this type of treatment was screened out one time (100 percent) and thus, was retained for the detailed analysis zero times (0 percent).

Macro-encapsulation/overpacking was screened out due to effectiveness. For example, this option was screened out because leaching problems would potentially exist from the presence of free liquid product, and it may present risks to local public health or the environment (1 FS: SM).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
1	0	1
Site Name Code:	--	SM

Detailed Analysis

Macro-encapsulation/overpacking was not considered in any remedial alternatives.

Conclusion

Macro-encapsulation/overpacking is generally an inadequate remediation method for contaminated soils, sediments, and sludges at wood treater sites due primarily to problems with effectiveness. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option as a primary remedial option:

NCP Criteria	Key Factors
Overall Protectiveness	• Potential leaching problems from the presence of free liquid product exist, presenting risks to local public health or the environment
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume*	
Long Term Effectiveness and Permanence	• Potential leaching problems from the presence of free liquid product exist, presenting risks to local public health or the environment
Short Term Effectiveness*	
Implementability*	
Cost*	

* Criterion did not contribute to eliminating the technology.

6. OTHER PHYSICAL TREATMENTS

Technology Description

Other physical treatment processes include the continuous evaporation technology. Continuous evaporation separates materials into their constituent solid, oil (including oil-soluble substances), and water wastes. The evaporation process uses food-grade "carrier oil" to extract the oil-soluble contaminants. The carrier oil is mixed with waste sludge or soil and introduced into the evaporation system, where water is removed. Once the waste and carrier oil are mixed, oil-soluble constituents of interest are extracted from the wastes. After the water is evaporated from the mixture, the dried slurry product is sent to a centrifuging section where most of the carrier oil is removed from the solids and is recovered by evaporation or steam stripping. Distillation is used to remove constituents from carrier oil. This stream can be incinerated or reclaimed, as appropriate. This technology is not yet a pilot-scale technology.

Limitations

The following factors may limit the applicability and effectiveness of this option:

- Further pilot testing will be required to determine the effectiveness of this method.
- Pretreatment is necessary to particle sizes of less than 1/4-inch.
- Residuals require treatment.

Target Contaminant Groups

This process is potentially applicable for treating sludges, soils, and other water-bearing wastes containing oil-soluble compounds, including dioxins.

Initial Screening

Continuous evaporation technology was considered at one site. In the initial screening, this type of treatment was screened out one time (100 percent) and thus, was retained for the detailed analysis zero times (0 percent).

Continuous evaporation was screened out for factors related to effectiveness and implementability. Specifically, this technology was screened out because the effectiveness of this technology is unproven (1 FS: K) and its implementability is unproven (1 FS: K).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
1	0	1
Site Name Code:	--	K

Detailed Analysis

Other physical treatment technologies (i.e., continuous evaporation) were not considered in any remedial alternatives.

Conclusion

Other physical treatment processes (i.e., continuous evaporation) are generally an inadequate remediation method for contaminated soils, sediments, and sludges at wood treater sites due primarily to problems with effectiveness and implementability. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option as a primary remedial option:

NCP Criteria	Key Factors
Overall Protectiveness*	
Compliance with ARARs*	
Reduction of Toxicity, Mobility, or Volume*	
Long Term Effectiveness and Permanence	• Effectiveness of this technology is unproven
Short Term Effectiveness*	
Implementability	• Implementability is unproven
Cost*	

* Criterion did not contribute to eliminating the technology.

D. OFF-SITE OPTIONS

Technology Description

Off-site options encompass a set of process options for the removal of contaminated material to permitted off-site disposal facilities. Some pre-treatment of the contaminated medial is usually required to meet the RCRA LDRs. The mobility of the contaminated media is reduced, however, by moving the media from the unsecured site to a disposal facility that will contain it physically. The two off-site landfill options discussed in this section are off-site nonhazardous landfills (e.g., sanitary) and off-site hazardous (e.g., RCRA) landfills. Transportation to off-site reclamation/recycling facilities was also considered in this section.

Limitations

The following factors may limit the applicability and effectiveness of these options:

- Most hazardous wastes must still be treated to meet either RCRA or non-RCRA (e.g., state regulations) treatment standards prior to land disposal. Compliance with applicable RCRA LDRs may be difficult.

- Off-site landfill disposal and off-site reclamation/recycling alleviate the contaminant problem at the site but transfers the risk off site.

- Transportation to an off-site facility introduces a potential risk to the community via accidental releases.

- Long distances from the contaminated site to the nearest disposal facility may increase costs.

- Overall costs associated with landfill disposal are relatively high. Although the process is relatively simple with proven procedures, it is a labor intensive practice with little potential for further automation. Once the disposal is completed and no operation and maintenance costs are incurred, no capital investment is required.

Target Contaminant Groups

Off-site landfill disposal is applicable to the complete range of contaminant groups with no particular target group.

1. OFF-SITE HAZARDOUS LANDFILL

Initial Screening

Off-site hazardous landfills were considered at 23 sites. In the initial screening, this type of off-site containment was screened out four times (17 percent) and retained for the detailed analysis 19 times (83 percent).

The predominant factors for screening out off-site hazardous landfills were cost, lack of effectiveness, and implementability. Specific reasons were ineffectiveness in excavating all contaminated soil (1 FS: LP), difficulties in implementation due to land ban regulations (1 FS: V), and cost (2 FSs: SM,NC).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
23	19	4
Site Name Code:	AC, ACT, BW, BD, CE, CF, I, K, LG, MB, MI, MO, P, SA, SE, T, W, UC, UP	LP,NC,SM,V

Detailed Analysis

Of the 19 times off-site hazardous landfills were retained for consideration in the detailed analysis for a remedial alternative, this option was selected as a component of the final remedy 10 times (53 percent) and was not selected as a component of the remedial alternative nine times (47 percent). However, at seven of the ten sites selecting off-site hazardous landfill disposal, another technology option was selected to treat the contaminated soils, sediments, and/or sludges first, followed by off-site disposal. In these cases, off-site disposal is not a *primary* component of the remedial alternative, but is a selected component of the treatment train.

The criteria used for non-selection were overall protectiveness, compliance with ARARs, reduction of TMV, long-term effectiveness, implementability, and cost. The predominant reasons for non-selection were unavailable or inadequate landfills (3 FSs: CE, MI, SE); future disposal problems from LDRs (1 FS: K); preference for on-site treatment (1 FSs: LG); lack of compliant facilities for land disposal of wood treater wastes (1 FSs: T) and cost (3 FSs: CE, P, MI).

Other reasons noted for non-selection were that this option could: (1) cause potential contamination at the new disposal site (1 FSs: CE); (2) does not destroy contaminants (1 FSs: K); (3) potentially conflicts with LDRs (1 FS: K); (4) does not result in a reduction of TMV (2 FSs: SE, MI); and (5) does not provide a permanent solution (1 FS: P).

No. FSs Technology Passed Screening	No. RODs Technology Selected	No. RODs Technology Not Selected
19	10*	9
Site Name Code:	BD, BW, CF, MB, MI, MO, SA, UP, UC, W	AC, ACT, CE, I, K, LG, P, SE, T

*Note that at seven out of ten of these sites, another technology option was selected to treat the contaminated soils, sediments, and/or sludges first, followed by off-site disposal to a landfill permitted to accept hazardous wastes. In these cases, off-site disposal is not a *primary* component of the remedial alternative, but is a selected component of the overall treatment train.

2. OFF-SITE SANITARY LANDFILL

Initial Screening

Off-site sanitary landfills were considered at three sites. In the initial screening, this type of off-site containment was screened out two times (67 percent) and retained for the detailed analysis one time (33 percent).

The predominant factor eliminating off-site sanitary landfills was implementability. Specifically, issues were raised regarding the potential impediment caused by LDRs when trying to obtain a permit (1 FS: MO) and the ability of sanitary landfills to be able to accept site soils (1 FS: MI).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
3	1	2
Site Name Code:	I	MI, MO

Detailed Analysis

The single time the off-site sanitary landfill option was selected for detailed analysis, it was not selected as a primary component of the remedial alternative. However, this option was retained as a secondary option for this site; the reasons noted for non-selection were that this option requires pilot studies, takes the longest to complete, and is the most costly.

No. FSs Technology Passed Screening	No. RODs Technology Selected (as Primary Component of Alternative)	No. RODs Technology Not Selected (as a Primary Component of Alternative)
1	0	1
Site Name Code:	--	I*

*Option retained as a secondary site option.

3. OFF-SITE RECLAMATION/RECYCLING

Initial Screening

Off-site reclamation/recycling was considered at three sites. In the initial screening, this type of off-site treatment was screened out two times (67 percent) and retained for the detailed analysis one time (33 percent).

Off-site reclamation/recycling was screened out for factors related to effectiveness and implementability. Specifically, issues were raised regarding the inability of a specific technology to be identified which recovers useable constituents (1 FSs: UP). Similarly, no useable product would be recovered (1 FSs: K).

No. FSs Where Technology Considered	No. FSs Technology Passed Screening	No. FSs Technology Screened Out
3	1	2
Site Name Code:	BD	K, UP

Detailed Analysis

The one off-site reclamation/recycling facility selected for detailed analysis was selected as a component of the remedial alternative.

No. FSs Technology Passed Screening	No. RODs Technology Selected	No. RODs Technology Not Selected
1	1	0
Site Name Code:	BD*	--

*Option retained as a minor component of overall treatment train.

Conclusion

Off-site disposal options are generally inadequate as *stand-alone remediation methods* for wood treater sites due to lack of effectiveness and implementability. Problems with this option were noted under all of seven of the NCP criteria analyzed, although implementability issues were particularly prevalent. The following table provides a breakdown by NCP criteria of the factors contributing to the elimination of this technology option as a primary remedial option:

NCP Criteria	Key Factors
Overall Protectiveness	• Potential contamination at the new disposal site • Contaminants are not destroyed
Compliance with ARARs	• Potential issues with LDRs
Reduction of Toxicity, Mobility, or Volume	• Does not reduce volume, toxicity, or mobility
Long Term Effectiveness and Permanence	• Not a permanent solution
Short Term Effectiveness	• Short-term risk of exposure to contaminants for off-site personnel
Effectiveness	• Subsoil that would be left exposed in the excavation contains equal or even greater arsenic concentrations than the excavated soil • No useable product would be recovered
Implementability	• Landfill unavailable, or inadequate • Future LDRs may cause disposal problems • Preference for on-site treatment • No identified compliant facilities for land disposal of wood treater wastes • Sanitary landfills may not accept site soils • Process not identified which recovers useful constituents
Cost	• High transportation costs • Higher costs than on-site RCRA landfill

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