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Analysis of Treatability Data for Soil and Debris: Evaluation of Land Ban Impact on Use of Superfund Treatment Technologies **Recommendation 34A**

4. Summary of Directive (include brief statement of purpose)

The purpose of this memo is to transmit an analysis of the effectiveness of treatment technologies for contaminated soil and debris in response to the recommendation in the Superfund Management Review to "carefully evaluate impact of RCRA land ban and other rules on use of alternative technologies.

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This Request Meets OSWER Directives System Format Standards.

9. Signature of Lead Office Directives Coordinator	Date
Betti VanEpps	11-30-89
10. Name and Title of Approving Official	**Date**
Henry L. Longest II	11-30-89

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

NOV 30 1989

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

OSWER Directive 9380.3-04

MEMORANDUM

SUBJECT: Analysis of Treatability Data for Soil and Debris: Evaluation of Land Ban Impact on Use of Superfund Treatment Technologies

Superfund Management Review: Recommendation 34A

FROM: Henry L. Longest II, Director
Office of Emergency and Remedial Response (OS-200)

TO: Addressees

Purpose

The purpose of this memo is to transmit an analysis of the effectiveness of treatment technologies for contaminated soil and debris in response to the recommendation in the Superfund Management Review to "carefully evaluate impact of RCRA land ban and other rules on use of alternative technologies." This analysis will provide support to Regional decisions to employ treatability variances for complying with the RCRA Land Disposal Restrictions as applicable or relevant and appropriate requirements for Superfund actions involving contaminated soil and debris.

Background

The Superfund Management Review acknowledged that Superfund response actions may not be able to meet treatment standards based on "best demonstrated available technology" (BDAT) under the Land Disposal Restrictions (LDR). This may limit the potential treatment technologies available for Superfund clean-ups, with technologies such as soil washing, stabilization, and biological treatment being precluded because they may not meet the highest level of performance required by LDRs. In contrast, the study encouraged the greater use of innovative technologies and urged the reduction of non-technical barriers, such as regulatory and policy constraints, that inhibit use of treatment technologies, while preserving the intent and spirit of applicable RCRA regulations.

OSWER program offices recognized the potential limitation treatment technologies for Superfund actions and developed a process to use LDR treatability variances for soil and debris. Guidance was issued to the Regions in July 1989 through the Superfund LDR Guide 6A, "Obtaining a Soil and Debris Treatability Variance for Remedial Actions" (OSWER Directive 9347.3-06FS). Superfund LDR Guide 6B, "Obtaining a Soil and Debris Treatability Variance for Removal Actions," is scheduled to be issued in December 1989. These guides describe the treatability variance process, include alternate treatment levels to be obtained under treatability variances, and identify treatment technologies which have achieved the recommended levels. OSWER recognizes that the use of treatability variances represents an interim approach and is currently in the process of acquiring additional data for developing a regulation on treatment standards for contaminated soil and debris.

The following analysis summarizes the effectiveness of treatment technologies applied to soils and other environmental wastes and provides support for decisions by the Regions to use treatability variances, when appropriate. The analysis identifies some of the key technical considerations to be evaluated in obtaining a treatability variance when there is a reasonable doubt that a technology operated at full scale cannot consistently meet the BDAT treatment standards for the soil and debris to be treated.

<u>Analysis of Treatment Effectiveness</u>

An extensive effort was undertaken during 1987 and 1988 to collect existing data on treatment of soil, sludge, debris, and related environmental media. The results from several hundred studies were collected and reviewed. All applicable treatment information from 67 studies was extracted, loaded into a data base, and analyzed to determine the effectiveness of technologies to treat different chemical groups (Summary of Treatment Technology Effectiveness for Contaminated Soil, U.S. EPA, EPA/540/2-89/053).

Although some of the data on which the analysis is based have limited quality assurance information, the data, nevertheless, do indicate potential effectiveness (at least 90% to 99% reduction of concentration or mobility of hazardous constituents) of treatment technologies to treat Superfund wastes. Some reductions in organic concentrations or organic mobility of more volatile compounds may actually represent the removal of those compounds as a direct result of volatilization during dechlorination, bioremediation, soil washing, or immobilization, which requires consideration of appropriate emission controls. Percentage removal reductions are not always a good measure of effectiveness, especially when high concentrations remain in the residuals. Some of the performance summarized below is based upon a relatively small number of data points and may not extrapolate well to the broad array of soils requiring treatment.

Based on this analysis, a number of technologies commonly used in the Superfund program provide substantial reduction in mobility and toxicity of wastes as required in Section 121 of the Superfund Reauthorization and Amendments Act of 1986. For example:

- Thermal destruction has been proven effective on all organics compounds, usually accomplishing well over 99% reduction of organics.
- Although the data indicate that PCBs, dioxins, furans, and other aromatic compounds have been dechlorinated to approximately 80%, more recent data indicating that removal efficiencies may approach 99.9%.
- Bioremediation successfully treats many halogenated aliphatic compounds, non-halogenated aromatics, heterocyclics, and other polar compounds with reduction efficiencies in excess of 99%.
- Removal efficiencies for low temperature thermal desorption have been demonstrated with averages up to 99% for non-polar halogenated aromatics and with treatment often exceeding 90% for other polar organics.
- Soil washing data on organic compounds indicate average removal efficiencies of approximately 90% for polar non-halogenated organics and 99% for halogenated aromatics, with treatment often exceeding 90% for polynuclear aromatics. The chemical extraction process, with optimized solvent selection, has demonstrated removal efficiencies often exceeding 90% for volatile and non-volatile metals.
- Immobilization processes, while not actually destroying the organic compounds, reduce the mobility of contaminants an average of 99% for polynuclear aromatic compounds. Immobilization may not effectively stabilize some organic compounds, such as volatile organics, and the long-term effectiveness of immobilization of organics is under evaluation. Immobilization can achieve average reductions in mobility of 93% for volatile metals, with reductions in mobility often exceeding 90% for non-volatile metals.

The attachment contains a more detailed summary of the data which is extracted from the "Summary of Treatment Technology Effectiveness for Contaminated Soil."

Technology Limitations to be Considered

The data available suggest that treatment of soil and debris with organic contamination by technologies other than thermal destruction will not be able to consistently achieve BDAT standards. Therefore, other technologies should be used for those wastes, only if approved under a treatability variance.

The residual concentrations in contaminated soil treated by technologies other than thermal destruction is highly dependent upon the concentrations in the untreated soil. Therefore, when evaluating technologies other than thermal destruction, the ability of those technologies to treat high concentrations of organics should be considered.

The Regions need to carefully review the site conditions and characteristics in designing and operating materials handling, pretreatment, and treatment requirements. High variability in contaminant concentrations of untreated soil may have an adverse effect on the ability to achieve treatment levels at higher concentrations using technologies other than thermal destruction. Consideration should be given to the need for blending wastes.

In selecting technologies for contaminated soils and sludges, the number and types of contaminants must be carefully screened, and, in some cases, different technologies may be necessary for soils and sludges.

<u>Implementation</u>

The data indicate potential limitations of treatment technologies to meet BDAT standards for Superfund wastes. Superfund LDR Guide 6A outlines the treatability variance process for Superfund soil and debris and identifies alternate treatment levels. Guide 6A should be followed, when appropriate, until OSWER completes a regulation with treatment standards for contaminated soil and debris. The limitations on technologies identified in this memorandum should be taken into account when evaluating, selecting, designing, and implementing Superfund response actions.

Attachment

Addressees:

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Region II
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Director, Toxic and Waste Management Division
    Region IX
Director, Hazardous Waste Division
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Attachment

TECHNOLOGY CONCLUSIONS ON SOIL TREATMENT

Extracted from "Summary of Treatment Technology Effectiveness for Contaminated Soil" EPA /540/2-89/053

For each treatability group, the effectiveness of various technologies was evaluated and is summarized in Figure 1. The following ratings were used:.

- Demonstrated Effectiveness: A significant percentage of the data, 20%, are from pilot or full scale operations, the average removal efficiency for all of the data exceeds 90%, and there are at least ten data pairs.
- Potential Effectiveness: The average removal efficiency for all of the data exceeds 70%.
- No Expected Effectiveness: The average removal efficiency for all of the data is less than 70% and no interference is expected to this process as a result of this group.

  No Expected Effectiveness: Potential adverse effects to the environment or the treatment process may occur. For example, high concentrations of metals may interfere with biological treatment.

In some cases, a different rating was selected when additional qualitative information and engineering judgment warranted.

Two symbols were used if the compounds within a treatability group were so variable that a range of conclusions could be drawn for a particular technology.

TECHNOLOGY CONCLUSIONS ON SOIL TREATMENT

Extracted from "Summary of Treatment Technology Effectiveness for Contaminated Soil" EPA /540/2-89/053

Thermal Destruction (See Figure 2)

Principle of Operation

- o Thermal destruction uses high temperatures to incinerate and destroy hazardous wastes, usually by converting the contaminants to carbon dioxide, water, and other combustion products in the presence of oxygen.

Effectiveness on Organics

- o This technology has been proven effective on all organic compounds, usually accomplishing well over 99% removal.
- o Thermal destruction technologies are equally effective on halogenated, non-halogenated, nitrated, aliphatic, aromatic, and polynuclear compounds.
- o Incineration of nitrated compounds such as trinitrotoluene (TNT) may generate large quantities of nitrous oxides.

Effectiveness on Inorganics

- o Thermal destruction is not an effective technology for treating soils contaminated with high concentrations of some metals.
- o High concentrations of volatile metal compounds (lead) present a significant emissions problem, which cannot be effectively contained by conventional scrubbers or electrostatic precipitators due to the small particle size of metal-containing particulates.
- o Non-volatile metals (copper) tend to remain in the soil when exposed to thermal destruction; however, they may slag and foul the equipment.

Dechlorination (See Figure 3)

Principle of Operation

- o Dechlorination is a destruction process that uses a chemical reaction to replace chlorine atoms in the chlorinated aromatic molecules with an ether or hydroxyl group. This reaction converts the more toxic compounds into less toxic, more water-soluble products. The transformation of contaminants within the soil produces compounds that are more readily removed from the soil. An evaluation of the end products is necessary to determine whether further treatment is required.

Effectiveness on Organics

- o PCBs, dioxins, furans, and other aromatic compounds (such as pentachlorophenol) have been dechlorinated to approximately 80% removal, with more recent data indicating that removal efficiencies may approach 99.9%.
- o Other limited laboratory data suggest potential applicability to other halogenated compounds including straight-chain aliphatics (such as 1,2-dichloroethane). The removal indicated by the data may be due in part to volatilization.
- o Although no data were available for halogenated cyclic aliphatics (such as dieldrin), it is expected that dechlorination will be effective on these compounds as well.
- o When non-halogenated compounds are subjected to this process, volatilization may occur.

Effectiveness on Inorganics

- o Dechlorination is not effective on metals, and high concentrations of reactive metals (such as aluminum), under very alkaline conditions, hinder the dechlorination process.

Bioremediation (See Figure 4)

Principle of Operation

- o Bioremediation is a destruction process that uses soil microorganisms including bacteria, fungi, and yeasts to chemically degrade organic contaminants.

Effectiveness on Organics

- o Bioremediation appears to successfully treat many halogenated aliphatic compounds (1,1-dichloroethane), non-halogenated aromatics (benzene), heterocyclics (pyridine), and other polar compounds (phenol) with removal efficiencies in excess of 99%; however, the high removal implied by the available data may be a result of volatilization in addition to bioremediation.
- o More complex halogenated (4-4'DDT), nitrated (triazine), and polynuclear aromatic (phenanthrene) compounds exhibited lower removal efficiencies, ranging from approximately 50% to 87%.
- o Poly-halogenated compounds may be toxic to many microorganisms.

Effectiveness on Inorganics

- o Bioremediation is not effective on metals.
- o Metal salts may be inhibitory or toxic to many microorganisms.

Low Temperature Thermal Desorption (See Figure 5)

Principle of Operation

- o Low temperature thermal desorption is a physical transfer process that uses air, heat, and/or mechanical agitation to volatilize contaminants into a gas stream, where the contaminants are then subjected to further treatment. The degree of volatility of the compound rather than the type of substituted group is the limiting factor in this process.

Effectiveness on Organics

- o Removal efficiencies have been demonstrated by these units at bench, pilot, and full scales, ranging from approximately 65% for polynuclear aromatics (naphthalene), to 82% for other polar organics (acetone) and 99% for non-polar halogenated aromatics (chlorobenzene).

Effectiveness on Inorganics

- o Low temperature thermal desorption is not effective on metals.
- o Only mercury has the potential to be volatilized at the operating temperatures of this technology.

Chemical Extraction and Soil Washing (See Figure 6)

Principle of Operation

- o Chemical extraction and soil washing are physical transfer processes in which contaminants are disassociated from the soil, becoming dissolved or suspended in a liquid solvent. This liquid waste stream then undergoes subsequent treatment to remove the contaminants and the solvent is recycled, if possible.

- o Soil washing uses water as the solvent to separate the clay particles, which contain the majority of the contaminants, from the sand fraction.
- o Chemical extraction processes use a solvent which separates the contaminants from the soil particles and dissolves the contaminant in the solvent.

Effectiveness on Organics

- o The majority of the available soil washing data on organic compounds indicates removal efficiencies of approximately 90% for polar non-halogenated organics (phenol) to 99% for halogenated aromatics (chlorobenzene), with lower values of approximately 71% for PCBs to 82% for polynuclear aromatics (anthracene).
- o The reported effectiveness for these compounds could be due in part to volatilization for compounds with higher vapor pressures (such as acetone).
- o This process is least effective for some of the less volatile and less water soluble aromatic compounds.

Effectiveness on Inorganics

- o The chemical extraction process, with optimized solvent selection, has demonstrated removal efficiencies of 85% to 89% for volatile metals (lead) and non-volatile metals (copper), respectively.

Immobilization (See Figure 7)

Principle of Operation

- o Immobilization processes reduce the mobility of contaminants by stabilizing them within the soil matrix, without causing significant contaminant destruction or transfer to another medium.
- o Volatile organics will often volatilize during treatment, therefore an effort should be made to drive off these compounds in conjunction with an emission control system.

Effectiveness on Organics

- o Reductions in mobility for organics range from 61% for halogenated phenols (pentachlorophenol) to 99% for polynuclear aromatic compounds (anthracene).
- o Immobilization is also effective (84% reduction) on halogenated aliphatics (1,2-dichloroethane).
- o Some organic mobility reductions of more volatile compounds may actually be removals as a direct result of volatilization during the exothermic mixing process and throughout the curing period.
- o The immobilization of organics is currently under investigation, including an evaluation of the applicability of analytical protocols (EP, TCLP, total analysis) for predicting long-term effectiveness of immobilization of organics. The preliminary available data indicate that significant bonding takes place between some organic contaminants and certain organophilic species in the binding matrix; however, immobilization may not effectively stabilize some organic compounds, such as volatile organics.

Effectiveness on Inorganics

- o Immobilization can accomplish reductions in mobility of 81% for non-volatile metals (nickel) to 93% for volatile metals (lead).

FIGURE 1: PREDICTED TREATMENT EFFECTIVENESS FOR CONTAMINATED SOIL

TECHNOLOGY / TREATABILITY GROUP	THERMAL DESTRUCTION	DECHLORINATION	BIOREMEDIATION [4]	LOW TEMPERATURE THERMAL DESORPTION	CHEMICAL EXTRACTION AND SOIL WASHING	IMMOBILIZATION [4]
NON-POLAR HALOGENATED AROMATICS (W01)	●	◓	◓ [3]	● ◓	◓	◓
PCBs, HALOGENATED DIOXINS, FURANS, AND THEIR PRECURSORS (W02)	●	◓	◓ [3]	○ [1]	◓	◓ [1]
HALOGENATED PHENOLS, CRESOLS, AMINES, THIOLS, AND OTHER POLAR AROMATICS (W03)	● [3]	◓	◓	◓	◓	◓ [3]
HALOGENATED ALIPHATIC COMPOUNDS (W04)	●	◓ [2]	◓ [2]	●	◓	◓ [2]
HALOGENATED CYCLIC ALIPHATICS, ETHERS, ESTERS, AND KETONES (W05)	●	◓ [1]	◓ [1]	○ [1]	◓ [1]	◓ [1]
NITRATED COMPOUNDS (W06)	●	○ [1]	◓	○ [1]	◓	◓ [1]
HETEROCYCLICS AND SIMPLE NON-HALOGENATED AROMATICS (W07)	●	○ [2]	◓ [2]	●	◓	◓ [2]
POLYNUCLEAR AROMATICS (W08)	●	○ [2]	◓	○	◓	◓
OTHER POLAR NON-HALOGENATED ORGANIC COMPOUNDS (W09)	●	○ [2]	◓ [2]	◓	◓	◓ [2]
NON-VOLATILE METALS (W10)	○ [1]	○ [1]	○ X [1]	○ [1]	◓	● [3]
VOLATILE METALS (W11)	X [1]	○ [1]	○ X [1]	○ [1]	◓	●

11/29/88

● Demonstrated Effectiveness

◓ Potential Effectiveness

○ No Expected Effectiveness (no expected interference to process)

X No Expected Effectiveness (potential adverse effects to environment or process)

1 Data were not available for this treatability group. Conclusions are drawn from data for compounds with similar physical and chemical characteristics.

2 High removal efficiencies implied by the data may be due to volatilization or soil washing.

3 The predicted effectiveness may be different than the data imply, due to limitations in the test conditions.

4 These technologies may have limited applicability to high levels of organics.

FIGURE 2: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
THERMAL DESTRUCTION

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS		GENERAL OBSERVATIONS
		AVERAGE CONCENTRATIONS (ppm)	AVERAGE REMOVAL EFFICIENCY	
NON-POLAR HALOGENATED AROMATICS (W01)	32 PAIRS 6 % BENCH 94 % PILOT 0 % FULL	INFLUENT 590 EFFLUENT 0.024	>99 %	• This technology works very well at optimum operating conditions on a variety of initial concentrations. • Brominated compounds will inhibit flame propagation. • High levels of acid gases produced in the presence of oxygen will attack the refractory walls and exposed metal surfaces.
PCBs, HALOGENATED DIOXINS, FURANS, AND THEIR PRECURSORS (W02)	161 PAIRS 3 % BENCH 83 % PILOT 14 % FULL	INFLUENT 1,100 EFFLUENT 0.055	>99 %	• This technology works very well at optimum operating conditions on a variety of initial concentrations. • High levels of acid gases produced in the presence of oxygen will attack the refractory walls and exposed metal surfaces.
HALOGENATED PHENOLS, CRESOLS, AMINES, THIOLS, AND OTHER POLAR AROMATICS (W03)	61 PAIRS 92 % BENCH 2 % PILOT 6 % FULL	INFLUENT 550 EFFLUENT 0.70	96 %	• This technology works well at optimum operating conditions on a variety of initial concentrations. • Oxides of nitrogen and sulfur can create potential serious cross media impacts if not removed from gas emissions. • High concentrations of acid gases produced in the presence of oxygen will attack the refractory walls and exposed metal surfaces.
HALOGENATED ALIPHATIC COMPOUNDS (W04)	92 PAIRS 21 % BENCH 79 % PILOT 0 % FULL	INFLUENT 41 EFFLUENT 0.016	>99 %	• This technology works well at optimum operating conditions on a variety of initial concentrations. • If this is the only treatability group present, low temperature thermal desorption may be more cost effective. • High levels of acid gases produced in the presence of oxygen will attack the refractory walls and exposed metal surfaces.
HALOGENATED CYCLIC ALIPHATICS, ETHERS, ESTERS, AND KETONES (W05)	118 PAIRS 67 % BENCH 33 % PILOT 0 % FULL	INFLUENT 790 EFFLUENT 17	99 %	• This technology works well at optimum operating conditions on a variety of initial concentrations.
NITRATED COMPOUNDS (W06)	142 PAIRS 73 % BENCH 27 % PILOT 0 % FULL	INFLUENT 98,000 EFFLUENT 200	99 %	• This technology works well at optimum operating conditions on a variety of initial concentrations. • High amounts of nitrous gases may be released into the atmosphere if not controlled by a nitrous oxide burner.

FIGURE 2: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
THERMAL DESTRUCTION (CONT.)

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (PPM) AND % REMOVALS		GENERAL OBSERVATIONS
		AVERAGE CONCENTRATIONS (ppm)	AVERAGE REMOVAL EFFICIENCY	
HETEROCYCLICS AND SIMPLE NON-HALOGENATED AROMATICS (W07)	42 PAIRS 7 % BENCH 88 % PILOT 5 % FULL	INFLUENT 740 EFFLUENT 0.077	>99 %	• This technology works very well at optimum operating conditions on a variety of initial concentrations. • Low temperature thermal desorption may be more cost effective.
POLYNUCLEAR AROMATICS (W08)	24 PAIRS 33 % BENCH 59 % PILOT 8 % FULL	INFLUENT 1,000 EFFLUENT 0.32	>99 %	• This technology works very well at optimum operating conditions on a variety of initial concentrations.
OTHER POLAR NON-HALOGENATED ORGANIC COMPOUNDS (W09)	34 PAIRS 35 % BENCH 65 % PILOT 0 % FULL	INFLUENT 600 EFFLUENT 0.28	98 %	• This technology works well at optimum operating conditions on a variety of initial concentrations.
NON-VOLATILE METALS (W10)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	INFLUENT 0 EFFLUENT 0	0 %	• The physical and/or chemical characteristics of the constituents of this treatability group indicate that this technology would not be effective. • Pyrolysis and infrared thermal destruction of wastes with metal concentrations over 500 ppm may possibly reduce the mobility of these metals by binding the metals into the solid residue.
VOLATILE METALS (W11)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	INFLUENT 0 EFFLUENT 0	0 %	• This technology is not recommended if the waste contains high concentrations of volatile metals, due to potential volatilization of these metals with subsequent cross media impacts. • Pyrolysis and infrared thermal destruction may reduce the mobility of these metals by binding the metals into the solid residue.

FIGURE 3: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
DECHLORINATION

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS	GENERAL OBSERVATIONS
NON-POLAR HALOGENATED AROMATICS (W01)	8 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 190; EFFLUENT 1.6 AVERAGE REMOVAL EFFICIENCY: 98 %	• Data were for chlorobenzene only. These data suggest that this technology is potentially effective in certain situations.
PCBs, HALOGENATED DIOXINS, FURANS, AND THEIR PRECURSORS (W02)	31 PAIRS 97 % BENCH 3 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 180; EFFLUENT 1.6 AVERAGE REMOVAL EFFICIENCY: 83 %	• This technology is potentially effective, especially for sandy soils. • Data on sludges show better removal due to more uniform distribution of contaminants and better reagent contact. • Lower initial concentrations give lower removal efficiencies. • Moisture content over 4 to 7% deactivates the NaPEG reagent. • Particle size and soil matrix affect reagent penetration and process effectiveness. • Recent data indicate that greater than 99% of PCBs and furans can be destroyed (des Rosiers, 1988).
HALOGENATED PHENOLS, CRESOLS, AMINES, THIOLS, AND OTHER POLAR AROMATICS (W03)	8 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 98; EFFLUENT 2.4 AVERAGE REMOVAL EFFICIENCY: 96 %	• Data were for pentachlorophenol only. These data suggest that this technology is potentially effective in certain situations. • Recent data indicate that greater than 99% of contaminants can be destroyed (des Rosiers, 1988).
HALOGENATED ALIPHATIC COMPOUNDS (W04)	16 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 330; EFFLUENT 0.44 AVERAGE REMOVAL EFFICIENCY: 98 %	• These data suggest that this technology is potentially effective in certain situations. • Some halogenated aliphatics react with the APEG reagents to form explosive compounds, especially in the presence of heavy metals. The potential for this to occur should be evaluated in the laboratory before dechlorination treatment is selected. • The high removal efficiency may be the result of volatilization or the APEG process acting as a soil washing process.
HALOGENATED CYCLIC ALIPHATICS, ETHERS, ESTERS, AND KETONES (W05)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 0; EFFLUENT 0 AVERAGE REMOVAL EFFICIENCY: 0 %	• Data were not available for this treatability group. Data for compounds with similar physical and chemical characteristics suggest that this technology is potentially effective in certain situations. Treatability studies will be needed to confirm the technology's effectiveness.
NITRATED COMPOUNDS (W06)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 0; EFFLUENT 0 AVERAGE REMOVAL EFFICIENCY: 0 %	• Data were not available available for this treatability group. • The physical and/or chemical characteristics of the constituents of this treatability group indicate that this technology would not be effective.

FIGURE 3: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
DECHLORINATION (CONT.)

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA				AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS			GENERAL OBSERVATIONS*
	PAIRS	% BENCH	% PILOT	% FULL	AVERAGE CONCENTRATIONS (ppm) INFLUENT	AVERAGE CONCENTRATIONS (ppm) EFFLUENT	AVERAGE REMOVAL EFFICIENCY	
HETEROCYCLICS AND SIMPLE NON-HALOGENATED AROMATICS (W07)	[illegible]	100	0	0	2,200	23	99 %	• The physical and/or chemical characteristics of the constituents of this treatability group suggest that this technology would <u>not</u> be effective. • The high removal efficiency may be the result of volatilization or the APEG process acting as a soil washing process.
POLYNUCLEAR AROMATICS (W08)	5	100	0	0	3,600	180	91 %	• The physical and/or chemical characteristics of the constituents of this treatability group suggest that this technology would <u>not</u> be effective. • The high removal efficiency may be the result of volatilization or the APEG process acting as a soil washing process.
OTHER POLAR NON-HALOGENATED ORGANIC COMPOUNDS (W09)	15	100	0	0	1,700	30	98 %	• The physical and/or chemical characteristics of the constituents of this treatability group suggest that this technology would <u>not</u> be effective. • The high removal efficiency may be the result of volatilization or the APEG process acting as a soil washing process.
NON-VOLATILE METALS (W10)	0	0	0	0	0	0	0 %	• The physical and/or chemical characteristics of the constituents of this treatability group suggest that this technology would <u>not</u> be effective.
VOLATILE METALS (W11)	0	0	0	0	0	0	0 %	• The physical and/or chemical characteristics of the constituents of this treatability group suggest that this technology would <u>not</u> be effective.

FIGURE 4: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
BIOREMEDIATION

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS		GENERAL OBSERVATIONS
		AVERAGE CONCENTRATIONS (ppm)	AVERAGE REMOVAL EFFICIENCY	
NON-POLAR HALOGENATED AROMATICS (W01)	66 PAIRS 95 % BENCH 5 % PILOT 0 % FULL	INFLUENT 2.9 EFFLUENT 0.79	53 %	• This technology is not effective for all contaminants in this class; however, there is potential for effectiveness for low initial concentrations with further development. • The presence of these contaminants at low concentrations is not expected to interfere with the treatment of applicable wastes. • The effectiveness of this technology may be different than the data imply, because the initial concentrations in these tests were so low.
PCBs, HALOGENATED DIOXINS, FURANS, AND THEIR PRECURSORS (W02)	1 PAIRS 0 % BENCH 100 % PILOT 0 % FULL	INFLUENT 2,000 EFFLUENT 0.12	99 %	• The lone data pair is PCBs. • Ongoing research suggests that this technology may be potentially effective for this group.
HALOGENATED PHENOLS, CRESOLS, AMINES, THIOLS, AND OTHER POLAR AROMATICS (W03)	3 PAIRS 0 % BENCH 100 % PILOT 0 % FULL	INFLUENT 83 EFFLUENT 17	74 %	• This technology is potentially effective for low initial concentrations. • Bioremediation requires uniformly mixed media with small particle sizes. • Toxic compounds such as cyanides, arsenic, heavy metals, and some organics adversely affect the treatment. • Preprocessing includes mixing and nutrient and organism addition. • Bioremediation is a slow process. • Bioremediation has low costs relative to other technologies.
HALOGENATED ALIPHATIC COMPOUNDS (W04)	27 PAIRS 0 % BENCH 100 % PILOT 0 % FULL	INFLUENT 23 EFFLUENT 0.027	>99 %	• This technology is potentially effective for low initial concentrations. • Bioremediation requires uniformly mixed media with small particle sizes. • Toxic compounds such as cyanides, arsenic, heavy metals, and some organics adversely affect the treatment. • Preprocessing includes mixing and nutrient and organism addition. • Bioremediation is a slow process. • Bioremediation has low costs relative to other technologies. • Removal may actually represent volatilization during preprocessing and treatment.
HALOGENATED CYCLIC ALIPHATICS, ETHERS, ESTERS, AND KETONES (W05)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	INFLUENT 0 EFFLUENT 0	0 %	• Data were not available for this treatability group. Data for compounds with similar physical and chemical characteristics suggest that this technology may be potentially effective in certain situations with low initial concentrations.
NITRATED COMPOUNDS (W06)	22 PAIRS 0 % BENCH 100 % PILOT 0 % FULL	INFLUENT 13,000 EFFLUENT 1,400	82 %	• This technology is potentially effective on these contaminants, especially at low concentrations. • Some of the available data for this treatability group were based on very high initial concentrations; however consideration should be given to the ability of the technology to treat high initial concentrations. • Bioremediation requires uniformly mixed media with small particle sizes. • Toxic compounds such as cyanides, arsenic, heavy metals, and some organics adversely affect the treatment. • Preprocessing includes mixing and nutrient and organism addition. • Bioremediation is a slow process. • [illegible]

FIGURE 4: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
BIOREMEDIATION (CONT.)

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS	GENERAL OBSERVATIONS
HETEROCYCLICS AND SIMPLE NON-HALOGENATED AROMATICS (W07)	64 PAIRS 0 % BENCH 100 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 220, EFFLUENT 0.025 AVERAGE REMOVAL EFFICIENCY: >99 %	• This technology is potentially effective for low initial concentrations. • Bioremediation requires uniformly mixed media with small particle sizes. • Toxic compounds such as cyanides, arsenic, heavy metals, and some organic compounds adversely affect treatment. • Preprocessing includes mixing and nutrient and organism addition. • Bioremediation is a slow process. • Bioremediation has low costs relative to other technologies. • Removal may actually represent volatilization during preprocessing and treatment.
POLYNUCLEAR AROMATICS (W08)	37 PAIRS 19 % BENCH 81 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 120, EFFLUENT 3.8 AVERAGE REMOVAL EFFICIENCY: 87 %	• This technology is potentially effective for low initial concentrations. • Bioremediation requires uniformly mixed media with small particle sizes. • Toxic compounds such as cyanides, arsenic, heavy metals, and some organic compounds adversely affect treatment. • Preprocessing includes mixing and nutrient and organism addition. • Bioremediation is a slow process. • Bioremediation has low costs relative to other technologies.
OTHER POLAR NON-HALOGENATED ORGANIC COMPOUNDS (W09)	22 PAIRS 0 % BENCH 100 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 64, EFFLUENT 0.32 AVERAGE REMOVAL EFFICIENCY: >99 %	• This technology is potentially effective for low initial concentrations. • Bioremediation requires uniformly mixed media with small particle sizes. • Toxic compounds such as cyanides, arsenic, heavy metals, and some organic compounds adversely affect treatment. • Preprocessing includes mixing and nutrient and organism addition. • Bioremediation is a slow process. • Bioremediation has low costs relative to other technologies. • Removal may actually represent volatilization during preprocessing and treatment.
NON-VOLATILE METALS (W10)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 0, EFFLUENT 0 AVERAGE REMOVAL EFFICIENCY: 0 %	• High concentrations of heavy metals may adversely affect particular organisms. • The physical and/or chemical characteristics of the constituents of this treatability group suggest that the technology would <u>not</u> be effective.
VOLATILE METALS (W11)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 0, EFFLUENT 0 AVERAGE REMOVAL EFFICIENCY: 0 %	• High concentrations of heavy metals may adversely affect particular organisms. • The physical and/or chemical characteristics of the constituents of this treatability group suggest that the technology would <u>not</u> be effective.

FIGURE 5: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
LOW TEMPERATURE THERMAL DESORPTION

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS	GENERAL OBSERVATIONS
NON-POLAR HALOGENATED AROMATICS (W01)	29 PAIRS 48 % [illegible] 4 % PILOT 48 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY INFLUENT 130 / 99 % EFFLUENT 0.07	• Although this technology was not expected to perform well on this treatability group, the data from studies which utilized higher operating temperatures and longer residence times indicate that many of the compounds in this group may be treated by this technology with potential effectiveness. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled. • This technology has demonstrated effectiveness on some of the more volatile contaminants in this group, and it is potentially effective on the remaining contaminants.
PCBs, HALOGENATED DIOXINS, FURANS, AND THEIR PRECUSORS (W02)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY INFLUENT 0 / 0 % EFFLUENT 0	• No data were available. • The physical and/or chemical characteristics of the constituents of this treatability group suggest that this technology would not be effective. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.
HALOGENATED PHENOLS, CRESOLS, AMINES, THIOLS, AND OTHER POLAR AROMATICS (W03)	14 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY INFLUENT 260 / 72 % EFFLUENT 67	• Although the data suggest that this technology is not as effective with this treatability group, the technology, if operated at higher temperatures and residence times, may successfully treat many of the compounds in this group. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.
HALOGENATED ALIPHATIC COMPOUNDS (W04)	132 PAIRS 27 % BENCH 50 % PILOT 23 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY INFLUENT 590 / 94 % EFFLUENT 18	• This technology works well on this treatability group. • Removal efficiencies are not as high with soils having extremely elevated concentrations. A longer residence time may remedy this situation. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.
HALOGENATED CYCLIC ALIPHATICS, ETHERS, ESTERS, AND KETONES (W05)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY INFLUENT 0 / 0 % EFFLUENT 0	• No data were available for this treatability group. • The physical and/or chemical characteristics of the constituents of this treatability group suggest that this technology would not be effective. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.
NITRATED COMPOUNDS (W06)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY INFLUENT 0 / 0 % EFFLUENT 0	• No data were available for this treatability group. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.

FIGURE 5: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
LOW TEMPERATURE THERMAL DESORPTION (CONT.)

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS		GENERAL OBSERVATIONS
		AVERAGE CONCENTRATIONS (ppm)	AVERAGE REMOVAL EFFICIENCY	
HETEROCYCLICS AND SIMPLE NON-HALOGENATED AROMATICS (W07)	111 PAIRS 37 % BENCH 39 % PILOT 24 % FULL	INFLUENT 820 EFFLUENT 1.7	96 %	• This technology works well on this treatability group. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.
POLYNUCLEAR AROMATICS (W08)	62 PAIRS 27 % BENCH 60 % PILOT 13 % FULL	INFLUENT 1,400 EFFLUENT 130	65 %	• This technology is not generally effective as a treatment for this group, but individual compounds may be treated effectively at higher operating temperatures and longer residence times. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.
OTHER POLAR NON HALOGENATED ORGANIC COMPOUNDS (W09)	34 PAIRS 82 % BENCH 6 % PILOT 12 % FULL	INFLUENT 1,900 EFFLUENT 170	82 %	• This technology is potentially effective on some contaminants in this group. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.
NON-VOLATILE METALS (W10)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	INFLUENT 0 EFFLUENT 0	0 %	• The physical and/or chemical characteristics of the constituents of this treatability group indicate that this technology would not be effective. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.
VOLATILE METALS (W11)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	INFLUENT 0 EFFLUENT 0	0 %	• The physical and/or chemical characteristics of the constituents of this treatability group indicate that this technology would not be effective. • This technology is not recommended for the treatment of waste mixtures which contain high concentrations of metallic and/or organic forms of mercury, unless emissions are controlled.

FIGURE 6: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY CHEMICAL EXTRACTION AND SOIL WASHING

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS	GENERAL OBSERVATIONS
NON-POLAR HALOGENATED AROMATICS (W01)	20 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 170; EFFLUENT 0.30 AVERAGE REMOVAL EFFICIENCY: >99 %	• This technology is potentially effective on these contaminants but all data are from bench scale. • Surfactants may adhere to the soil and reduce soil permeability. • Possible volatile emission losses may occur during treatment.
PCBs, HALOGENATED DIOXINS, FURANS, AND THEIR PRECURSORS (W02)	22 PAIRS 82 % BENCH 4 % PILOT 14 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 9,900; EFFLUENT 4,000 AVERAGE REMOVAL EFFICIENCY: 71 %	• This technology is potentially effective on these contaminants with further development. • Some of the available data for this treatability group were based on very high initial concentrations; however consideration should be given to the ability of the technology to treat high initial concentrations. • The presence of oil in the matrix enhances removal. • The removal efficiency decreases as the percent of clays and clayey silts increases. • Surfactants may adhere to the soil and reduce soil permeability.
HALOGENATED PHENOLS, CRESOLS, AMINES, THIOLS, AND OTHER POLAR AROMATICS (W03)	20 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 67; EFFLUENT 18 AVERAGE REMOVAL EFFICIENCY: 72 %	• Data were from pentachlorophenol only. • This technology is potentially effective on these contaminants, especially for treating sandy soils. • Surfactants may adhere to the soil and reduce soil permeability.
HALOGENATED ALIPHATIC COMPOUNDS (W04)	40 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 290; EFFLUENT 0.22 AVERAGE REMOVAL EFFICIENCY: >99 %	• This technology is potentially effective on these contaminants, but all data are from bench scale. • This technology may be more applicable to sandy soils. • Surfactants may adhere to the soil and reduce soil permeability. • Volatile emissions may occur during treatment.
HALOGENATED CYCLIC ALIPHATICS, ETHERS, ESTERS, AND KETONES (W05)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 0; EFFLUENT 0 AVERAGE REMOVAL EFFICIENCY: 0 %	• Data were not available for this treatability group. Data for compounds with similar physical and chemical characteristics suggest that this technology is potentially effective in certain situations. • Surfactants may adhere to the soil and reduce soil permeability.
NITRATED COMPOUNDS (W06)	3 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 6,900; EFFLUENT 47 AVERAGE REMOVAL EFFICIENCY: >99 %	• This technology is potentially effective on these contaminants. However, data are limited and testing was conducted at bench scale.

FIGURE 6: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY CHEMICAL EXTRACTION AND SOIL WASHING (CONT.)

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS	GENERAL OBSERVATIONS
HETEROCYCLICS AND SIMPLE NON-HALOGENATED AROMATICS (W07)	55 PAIRS 98 % BENCH 0 % PILOT 2 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 1,700; EFFLUENT 3.8 AVERAGE REMOVAL EFFICIENCY: >99 %	• This technology is potentially effective on these contaminants but nearly all data are from bench scale. • Volatile emissions may occur during treatment. • Surfactants may adhere to the soil and reduce soil permeability.
POLYNUCLEAR AROMATICS (W08)	24 PAIRS 71 % BENCH 0 % PILOT 29 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 1,600; EFFLUENT 380 AVERAGE REMOVAL EFFICIENCY: 82 %	• This technology is potentially effective on these contaminants with further development. • Some of the available data for this treatability group were based on very high initial concentrations; however, consideration should be given to the ability of the technology to treat high initial concentrations. • Surfactants may adhere to the soil and reduce soil permeability.
OTHER POLAR NON HALOGENATED ORGANIC COMPOUNDS (W09)	58 PAIRS 95 % BENCH 0 % PILOT 5 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 70,000; EFFLUENT 15,000 AVERAGE REMOVAL EFFICIENCY: 91 %	• This technology is potentially effective on these contaminants. • Some of the available data for this treatability group were based on very high initial concentrations; however, consideration should be given to the ability of the technology to treat high initial concentrations. • Treatment effectiveness should be evaluated on a case-by-case basis. • Surfactants may adhere to the soil and reduce soil permeability. • Volatile emissions may occur during treatment.
NON-VOLATILE METALS (W10)	34 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 34; EFFLUENT 1.1 AVERAGE REMOVAL EFFICIENCY*: 89 %	• This technology is potentially effective on these contaminants. • Water and H_2SO_4 at a pH of 1.0 and a 3:1 molar ratio of EDTA at a pH of 12.0 can both achieve good levels of extraction. • Iron (1-2%) may cause solvent regeneration problems.
VOLATILE METALS (W11)	54 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 71; EFFLUENT 10 AVERAGE REMOVAL EFFICIENCY*: 85 %	• This technology is potentially effective on these contaminants, especially for sandy soils. • Silty and clayey soils are not as effectively treated. • Arsenic may be difficult to extract due to low solubility.

* Reduction in Mobility

FIGURE 7: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
IMMOBILIZATION

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS*	GENERAL OBSERVATIONS
NON POLAR HALOGENATED AROMATICS (W01)	4 PAIRS 100 % [illegible] 0 % [illegible] 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY* INFLUENT 3.1 / 83 % EFFLUENT 0.65	• Data were for chlorobenzene only. • These data suggest that this technology is potentially effective in certain situations, particularly where the initial concentration is low. • The treatment mechanism for the more volatile compounds may be volatilization as opposed to immobilization. Air pollution control systems may be necessary to minimize cross media impacts from these volatile emissions. • It is not recommended that this technology be selected if this is the only treatability group present.
PCBs, HALOGENATED DIOXINS, FURANS, AND THEIR PRECURSORS (W02)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY* INFLUENT 0 / 0 % EFFLUENT 0	• Incomplete quantitative data were available to evaluate treatment effectiveness. These quantitative data and additional qualitative information suggest that this technology is potentially effective in certain situations, particularly where the initial concentration is low. • It is not recommended that this technology be selected if this is the only treatability group present.
HALOGENATED PHENOLS, CRESOLS, AMINES, THIOLS, AND OTHER POLAR AROMATICS (W03)	4 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY* INFLUENT 2.5 / 61 % EFFLUENT 1.1	• Data were from pentachlorophenol only. These data suggest that this technology is potentially effective in certain situations, particularly where the initial concentration is low. • The effectiveness of this technology on these contaminants may be different than the data imply, due to limitations in the test conditions. • It is not recommended that this technology be selected if this is the only treatability group present.
HALOGENATED ALIPHATIC COMPOUNDS (W04)	9 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY* INFLUENT 11 / 98 % EFFLUENT 0.24	• Though these data suggest that this technology is potentially effective in certain situations, particularly where the initial concentration is low. • The reductions in mobility may be due to volatilization of the volatile compounds during treatment. • Air pollution control systems may be necessary to minimize cross media impacts from these volatile emissions. • It is not recommended that this technology be selected if this is the only treatability group present.
HALOGENATED CYCLIC ALIPHATICS, ETHERS, ESTERS, AND KETONES (W05)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY* INFLUENT 0 / 0 % EFFLUENT 0	• Data were not available for this treatability group. Data for compounds with similar physical and chemical characteristics suggest that this technology is potentially effective in certain situations, particularly where the initial concentration is low. • It is not recommended that this technology be selected if this is the only treatability group present.
NITRATED COMPOUNDS (W06)	0 PAIRS 0 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm) / AVERAGE REMOVAL EFFICIENCY* INFLUENT 0 / 0 % EFFLUENT 0	• Data were not available for this treatability group. Data for compounds with similar physical and chemical characteristics suggest that this technology is potentially effective in certain situations, particularly where the initial concentrations are low.

* Reduction in Mobility

FIGURE 7: FINAL CONCLUSIONS BY TREATMENT TECHNOLOGY
IMMOBILIZATION (CONT.)

TREATABILITY GROUP	NUMBER AND SCALE OF AVAILABLE DATA	AVERAGE CONCENTRATIONS (ppm) AND % REMOVALS*	GENERAL OBSERVATIONS
HETEROCYCLICS AND SIMPLE NON-HALOGENATED AROMATICS (W07)	12 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 23; EFFLUENT 5.8 AVERAGE REMOVAL EFFICIENCY*: 73 %	• Though these data suggest that this technology is potentially effective in certain situations, particularly where the initial concentration is low, the reductions in mobility may be due to the volatilization of volatile organic compounds during treatment. • Air pollution control systems may be necessary to minimize cross media impacts from these volatile emissions. • It is not recommended that this technology be selected if this is the only treatability group present.
POLYNUCLEAR AROMATICS (W08)	2 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 3.0; EFFLUENT 0.03 AVERAGE REMOVAL EFFICIENCY*: 99 %	• These limited data suggest that this technology is potentially effective in certain situations, particularly where the initial concentration is low.
OTHER POLAR NON-HALOGENATED ORGANIC COMPOUNDS (W09)	7 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 20; EFFLUENT 5.6 AVERAGE REMOVAL EFFICIENCY*: 77 %	• These limited data suggest that this technology is potentially effective in certain situations, particularly where the initial concentration is low. • The treatment mechanism for the more volatile compounds may be volatilization as opposed to immobilization. Air pollution control systems may be necessary to minimize cross media impacts from these volatile emissions. • It is not recommended that this technology be selected if this is the only treatability group present.
NON-VOLATILE METALS (W10)	24 PAIRS 67 % BENCH 33 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 28; EFFLUENT 0.34 AVERAGE REMOVAL EFFICIENCY*: 81 %	• This technology works well on these contaminants. • High levels of oil and grease may interfere with the process. • Soluble salts of Mg, Sb, Zn, Cu, and Pb may interfere with the pozzolan reaction. • High levels of sulfates may interfere with the process. • Pretreatment may be required to increase pH.
VOLATILE METALS (W11)	33 PAIRS 100 % BENCH 0 % PILOT 0 % FULL	AVERAGE CONCENTRATIONS (ppm): INFLUENT 610; EFFLUENT 1.4 AVERAGE REMOVAL EFFICIENCY*: 93 %	• Based on the pilot scale data this technology works well on these contaminants. Some bench scale data was not representative of optimum conditions. • High levels of oil and grease may interfere with the process. • Soluble salts of Mg, Sb, Zn, Cu, and Pb may interfere with the pozzolan reaction. • High levels of sulfates may interfere with the process. • Pretreatment may be required to increase pH.

* Reduction in Mobility