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THE MEMPHIS DEPOT TENNESSEE

ADMINISTRATIVE RECORD COVER SHEET

AR File Number <u>5/0</u>

Main Installation

Soils Feasibility Study Report



Memphis Depot Caretaker July 2000 147543.FS.01





U.S. Army Engineering and Support Center, Huntsville

U.S. Army Engineering and Support Center, Huntsville Contract No. DACA87-94-D-0009 Delivery Order No. 11



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August 4, 2000

Mr. Shawn Phillips, P.E. BRAC Environmental Coordinator Memphis Depot Caretaker Division 2163 Airways Blvd. Memphis, TN 38114-5210

Re: Transmittal Letter Replacement Pages for the Final Groundwater and Soil Feasibility Studies Main Installation, Memphis Depot, TN

Dear Mr. Phillips:

Attached please find eight sets of replacement pages for the Final Main Installation Groundwater and Soils Feasibility Studies (FSs). Originals of these sets of replacement pages are being distributed as listed below. Should you require any additional information or have any questions, please contact me at (770) 604-9182, extension 302.

Respectfully submitted,

CH2M HILL

Stephen D. Offner, P.G. Project Manager

Attachments:Final Soils FS, Set of Replacement PagesFinal Groundwater FS, Set of Replacement PagesDistribution:USEPA - Region 4, Federal Facilities/Turpin Ballard (2 sets)TDEC - Div. of Superfund/James Morrison (3 sets)USACE - Huntsville/Dorothy Richards (3 sets)USGS - Nashville/David Ladd (1 set)USACHPPM - Rick Bowlus (1 set)USACE - MRD (2 sets)USACE - WES (1 set)

Soils Feasibility Study for the Main Installation of the Memphis Depot Memphis, Tennessee

Prepared by CH2M HILL

July 2000

7-3-00

David J. Lane, P.E. CH2M HILL Task Manager

Stephen D. Offrer, P.G. CH2M HILL Project Manager

Date

7/3/00

Date

DD FOR 7 Michael R. Harris P.E.

CH2M HILL Senior Consultant

Date

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Acronyms and Abbreviations

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ARAR	Applicable or relevant and appropriate requirement
BaP	Benzo(a)pyrene
BCT	BRAC Cleanup Team
BRA	Baseline risk assessment
BRAC	Base Realignment and Closure
BTEX	Benzene, toluene, ethyl benzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and
	Liability Act
CFR	Code of Federal Regulations
COC	Constituent of concern
COPC	Constituent of potential concern
1.2-DCE	1,2-Dichloroethene
DCE	Dichloroethene
DDD	Dichlorodiphenyldıchloroethane
DDE	1,1,1-Dichloro-2,2-bis(4-chlorophenyl)ethylene
DDMT	Defense Distribution Depot Memphis, Tennessee
DDT	Dichlorodiphenyltrichloroethane
DLA	Defense Logistics Agency
DNAPL	Dense non-aqueous phase liquid
DOI	Department of Interior
EE/CA	Engineering Evaluation/Cost Analysis
ELCR	Excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
°F	Degrees Fahrenheit
FFA	Federal Facilities Agreement
FR	Federal Register
FS	Feasibility Study
ft	Feet
ft²	Square feet
FU	Functional unit
gpm	Gallons per minute
GRA	General Response Action
HHRA	Human Health Risk Assessment
HI	Hazard index
HRS	Hazard Ranking System
HTTD	High temperature thermal desorption
ΓW	Inside worker
LDR	Land disposal restriction
LF	Linear feet
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
MCL	Maximum contaminant level

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MDLMaximum detection limitmg/kgMilligrams per kilogrammg/LMilligrams per kilogrammg/LMilligrams per literMNAMonitoried natural attenuationmslMean sea levelMWMonitoring wellNAPLNon-aqueous phase liquidNCPNational Oil and Hazardous Substances Pollution Contingency PlanNPDESNational Pollutant Discharge Elimination SystemNPLNational Pollutant Discharge Elimination SystemNPLNational Park ServiceO&MOperation and maintenanceOSHAOccupational Safety and Health AdministrationOUOperable unitOWOutside workerPAHPolycyclic aromatic hydrocarbonPCBPolychorinated biphenylPCETetrachloroethylenePCPPentachlorophenolppmParts per millionRAORemedial action objectiveRBCRisk-based concentrationRCRAResource Conservation and Recovery ActRDRemedial designREResultRGORemedial goal optionRI/FSRemedial investigation/feasibility studyRODRecord of DecisionSDWASafe Drinking Water ActSSSurface soilSVOCSemivolatile organic compound1,1,22-TCA1,1,22-TetachloroethaneTCDDTetrachlorodibenzo-p-dioxinTCDFTetrachlorodibenzo-p-dioxin	MCLG	Maximum contaminant level goal
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TCDF Tetrachlorodibenzofuran TCE Trichloroethene	TCDD	Tetrachlorodibenzo-p-dioxin
TCF Trichloroethene	TCDF	Tetrachlorodibenzofuran
	TCE	Trichloroethene
TCLP Toxicity characteristic leaching procedure	TCLP	Toxicity characteristic leaching procedure
TDEC Tennessee Department of Environment and Conservation	TDEC	Tennessee Department of Environment and Conservation
TDS Total dissolved solids	TDS	Total dissolved solids
TM Technical memorandum	TM	Technical memorandum
TSCA Toxic Substances Control Act	TSCA	Toxic Substances Control Act
USC United States Code	USC	United States Code
VOC Volatile organic compound	VOC	Volatile organic compound

MEMPHIS DEPOT MAIN INSTALLATION SOIL FS - 7/3/00

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Executive Summary

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In October 1992, the Memphis Depot (formerly known as the Defense Distribution Depot Memphis, Tennessee [DDMT]), was placed on the National Priorities List (NPL) by the U.S. Environmental Protection Agency (EPA). Subsequently, the Depot conducted a Remedial Investigation/Feasibility Study (RI/FS) to evaluate the nature and extent of contamination; evaluate the risk to human health and the environment; and identify feasible remedial actions. In January 2000, an RI report was accepted by EPA; the Defense Logistics Agency (DLA), the lead agency; and the Tennessee Department of Environment and Conservation (TDEC).

The FS is intended to present an unbiased and non-judgmental evaluation of potential alternatives. This FS develops and presents a range of remedial alternatives to address the contaminants in the surface soil on the Main Installation (MI) at the Depot, and evaluates the probable performance of each alternative according to a set of criteria established by EPA.

The RI showed that the risk posed by contamination of surface soil is due primarily to lead, arsenic, and dieldrin. These chemicals occur within the top one-foot of soil in localized areas throughout the MI. Although no one currently lives in the areas studied, levels of these chemicals exceed those levels calculated to pose a risk to residents. Concentrations of lead exceed the levels calculated to pose a risk to industrial workers in one area of the MI. This FS determined that appropriate remedial action objectives are to prevent exposure of future on-site residents to surface soil contaminated with dieldrin and arsenic in excess of Human Health Risk Assessment (HHRA) criteria, and future on-site residents and industrial workers contaminated with lead in excess of risk-based criteria at the MI.

More than 60 process technologies were evaluated in a series of screening steps to derive a short list of the most practical and potentially effective remedial alternatives. These five alternatives were evaluated in detail to determine their overall effectiveness, cost, and acceptability:

- 1. No action (an alternative required to be considered by CERCLA);
- 2. Institutional controls;
- 3. Soil containment;
- 4. In-situ soil treatment; and
- 5. Excavation, transportation, and off-site disposal.

All alternatives except no action were judged to meet remedial action objectives considering the nine EPA criteria, including overall protection of human health and the environment, compliance with laws and regulations, long-term and short-term effectiveness, reduction in contaminant mass, ease of implementation, and state and local acceptance. The costs of the remedies vary from \$0 (no action) to over \$7.2 million (excavation, transportation, and disposal). The DLA, in consultation with EPA and TDEC, will select a proposed remedy and publish it in a Proposed Plan. The public and regulatory agencies will have an opportunity to comment on the Proposed Plan. The DLA in consultation with EPA and TDEC will weigh all comments received before it selects the final remedy in the Record of Decision (ROD).

MEMPHIS DEPOT MAIN INSTALLATION SOIL FS - 7/31/00

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The Memphis Depot (formerly known as the Defense Distribution Depot Memphis, Tennessee, and referred to in this report as the Depot) is in southeastern Memphis, Tennessee (Figure 1-1). The Depot originated as a military facility in the early 1940s. Its initial mission and function was to provide stock control, materiel storage, and maintenance services for the U.S. Army (Memphis Depot Caretaker, 1998). Storage and distribution of materiel for all U.S. military services and some civil agencies continued until the Depot closed in September 1997. The Depot was placed in 1997 on the list of Department of Defense (DoD) facilities to be closed under Base Realignment and Closure (BRAC).

On October 14, 1992, the Depot was placed on the National Priorities List (NPL) by the U.S. Environmental Protection Agency (EPA), bringing the facility within the Superfund program. As a result of its status as an NPL site, the Depot entered into a Federal Facilities Agreement (FFA) on March 6, 1995. The signatories to that agreement, the Defense Logistics Agency (DLA), EPA, and Tennessee Department of Environment and Conservation (TDEC), agreed that investigating all applicable sites at the Depot would proceed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process for remediation.

1.1 Purpose of This Feasibility Study

This Feasibility Study (FS) represents an important step in the evaluation of a CERCLA site and selection of a remedial action. To put this report in context, the following describes the CERCLA process used to evaluate the Depot and to select a remedy to resolve environmental contamination.

- For the past several years, a series of investigations have been conducted at the Depot to obtain samples of soil, sediment, groundwater, and other impacted environmental media to assess the level of contamination that exists at the Depot, defining the horizontal and vertical extent of contamination in each medium. The Remedial Investigation (RI) report (CH2M HILL, 2000a) summarizes and interprets the results of the investigations at the Depot.
- As part of the RI, a **Baseline Risk Assessment** was prepared to assess the potential risks to human health and the environment represented by contaminants at the site. The baseline risk assessment incorporated EPA approved assumptions regarding exposure of affected individuals under different land use scenarios. The findings of the base remedial assessment are included in the RI report (CH2M HILL, 2000a).
- This **Feasibility Study (FS)** develops and presents a range of remedial alternatives to address the contaminants present at the Depot, and evaluates the probable performance of each alternative in comparison to a set of criteria established by the EPA. The FS is intended to present an unbiased and non-judgmental evaluation of the selected alternative(s). In some cases, additional environmental data are collected or reassessed

during the preparation of the FS in order to understand the applicability of a particular remedial technology, or to determine a better way to remediate a particular area of contamination.

- Following publication of the FS, the cognizant regulatory and lead agencies for the Depot (Defense Logistics Agency [DLA], EPA and TDEC will evaluate the remedies presented in the FS. A **Proposed Plan** will then be prepared documenting the remedy(s) proposed by those agencies and the rationale for the selection of the proposed remedy(s). The Proposed Plan may "pick and chose" among the evaluated alternatives for various locations at the Depot. The Proposed Plan will be presented to the Memphis community and the public, who will be offered the opportunity to comment on the proposed remedy(s).
- After public comments are received on the Proposed Flan, the regulatory and lead agencies will take all comments into consideration, re-evaluate their selection of proposed remedy(s) for the Depot, and publish a **Record of Decision (ROD)** documenting the final remedy(s) selected for the Depot. All public comments are presented and responded to in the Responsiveness Summary of the ROD. The remedy(s) documented in the ROD will then be implemented at the Depot.

1.2 Report Organization

This FS report develops a list of remedial actions that could be implemented for surface soil at the Main Installation (MI) part of the Depot. The FS report for groundwater beneath the MI is addressed in a separate FS report.

This report contains five sections and appendices, which are organized as follows:

- Section 1 provides the purpose and scope of the document, background information about the Depot, and a summary of the nature and extent of contamination, target levels for remedial action, and the baseline risk assessment.
- Section 2 presents the remedual action objectives (RAOs) for groundwater, details general response actions (GRAs), and describes the technologies that may be applicable to remediate groundwater.
- Section 3 combines applicable technologies into alternatives, and then evaluates and screens the alternatives according to the criteria of effectiveness, implementability, and cost.
- Section 4 presents a detailed analysis of the merits of the alternatives that passed the screening steps in Section 3.
- Section 5 provides the references cited.
- Appendix A presents risk calculations on which the RAOs are based.
- Appendix B presents cost estimates for remedial actions.
- **Appendix C** is a memorandum explaining the evaluation of the recreational land use scenario in functional unit (FU) 2.

1.3 Background Information

1.3.1 Facility Description

The Depot covers 642 acres of land (Figure 1-1). The MI comprises 574 acres of the Depot, and is the subject of this report. Dunn Field, to the north of the MI, comprises the balance. Separate RI and FS reports are being prepared for the Dunn Field portion of the Depot. Airways Boulevard borders the Depot on the east and provides primary access to the installation. Dunn Avenue, Ball Road, and Perry Road serve as the northern, southern, and western boundaries of the MI, respectively.

At the time of closure, the Depot included approximately 118 buildings, 26 miles of railroad track, and 28 miles of paved streets, the majority of which lie within the MI. The facility has approximately 5.5 million square feet (ft) of covered storage space and approximately 6 million square ft of open space. As part of the BRAC process, the Depot will be transferred to the City of Memphis for subsequent commercial and recreational development.

1.3.2 Facility Operations

During World War II, the Depot served as an internment center for 800 prisoners of war and performed supply missions for the Army's Signal and Ordnance Corps. From 1963 until closure in September 1997, the facility received, warehoused, and shipped a variety of materials. Stocked items included food; clothing; electronic equipment; petroleum products; construction materials; and industrial, medical, and general supplies. Approximately 4 million line items were received and shipped by the Depot annually. In 1996, total shipments amounted to about 107,000 tons of goods. The Depot employed approximately 1,486 civilians and 9 military personnel (Law Environmental, 1990).

Operations within the southeastern part of the MI included storing and repackaging food and clothing supplies. Small amounts of hazardous materials were used for facility maintenance. Operations in the southwestern part of the MI involved storage and handling of hazardous materials, including acids, bases, industrial-grade solvents (xylene, toluene, methyl ethyl ketone [MEK]), oils (vehicle and rifle/gun), lubricants, pesticides, and herbicides. Operations in the northern part of the MI included storage of hazardous materials, treatment of wood products with pentachlorophenol (PCP), and storage of items awaiting disposal.

During its operational life, the Depot used different areas within the MI to perform maintenance activities. Maintenance activities such as painting and paint sandblasting, vehicle maintenance, and gasoline storage may have released contaminants to the environment. Other activities that may have released contaminants include storing transformers containing polychlorinated biphenyls (PCBs), storing and using pesticides and herbicides, conducting painting and sandblasting operations, and testing fire truck pumps.

1.3.2.1 Regulatory History

The Depot was issued a Resource Conservation and Recovery Act (RCRA) Part B permit (No. TN4 210-020-570) by EPA Region IV and (Tennessee Department of Environment and Conservation) TDEC on September 28, 1990. Subsequently, EPA added the Depot to the NPL (Superfund) by publication in the *Federal Register* (FR), 57 FR 47180 No. 199, on October 14,

1992. As a result of its listing as an NPL site, the Depot entered into an Federal Facilities Agreement on March 6, 1995. The signatories, Defense Logistics Agency (DLA), EPA, and TDEC, agreed that procedures for NPL sites (rather than RCRA) would be followed for investigating and remediating the facility. Prior reports describing investigations at the Depot refer to certain areas (sites) with different names. For example, investigations in the early 1990s used the term Operational Unit (OU) to describe a group of sites used for similar purposes. After the Depot was selected for closure under BRAC, 35 parcels within the MI were identified for property transfer. These parcels were grouped primarily by their ability to be transferred or leased as individual properties (e.g., individual buildings and surrounding grounds of adjacent buildings) rather than by prior use. For the purposes of completing the RI and FS while complying with BRAC requirements, the term "Functional Unit" (FU) was established to identify groups of sites based on both operational history, expected use and location. Figure 1-2 presents FU and parcel boundaries within the MI.

Each FU represents an area where potential human health exposure generally would be uniform because of consistent past and expected future practices within the FU. This report references FUs and parcels rather than the OUs as identified in the 1995 planning documents, and described as follows:

FU No.	Name	Size (acres)	Common Past Land Use	Description
1	Twenty Typical Warehouses	89	Transportation to and storage in closed warehouses	Located in the northeastern area of the MI, consisting of about 20 large warehouses, with interspersed roadways and railroad tracks
2	Southeast Golf Course/ Recreational Area	53	Golf, other recreation	Located in the southeastern corner of the Mi1, consisting of golf course (Parcel 3). This FU also includes a baseball field and a small playground in the southeastern corner. This FU includes two constructed ponds and two concrete-lined drainage ditches from the ponds leading to the off-site area
3	Southwest Open Area	92	Transportation to and storage in open-sided warehouses, painting and sandblasting, open storage	Located in the southwestern corner of the MI, consisting of varied type of parcels and sites.
4	Northern and Open Areas	193	Open storage, and transportation to and storage in closed warehouses	Located in the north-central to northwest area of the MI, covering a large area.
5	Newer Warehouses	109	Transportation to and storage in closed warehouses	Located in the south-central area of the MI and includes 10 large warehouse buildings.
6	Administrative and Residential Areas	33	Offices, equipment storage and maintenance, on- base housing	Located along the property boundary of the Depot along the Airways Boulevard. This FU includes the old Residential Unit Area, parking lots, and other asphalt-paved areas.

The following parcels, depicted on Figure 1-3, were not studied in this FS due to completed or planned removal actions:

- Soils in Parcels 28 and 35 within FU3 are contaminated with metals and polycyclic aromatic hydrocarbons (PAHs) from painting and sandblasting activities. These soils are being removed as part of an ongoing removal action (CH2M HILL, 1999a);
- Surface soil within Parcel 2, surrounding the former base housing area, has been removed due to the presence of the pesticide dieldrin (OHM Remediation Services Corp., 1999a); and
- Surface soil surrounding the former cafeteria (Building 274) within Parcel 5 has been removed due to elevated levels of PCBs (OHM Remediation Services Corp., 1999b).
- The contents of the sumps in Buildings 251 and 265 have been removed and the sumps cleaned; Building 251 and the sump inside were razed in 1999.

In addition, the areas consisting of Building 144 and the adjacent north and south parking lots (i.e., the Administrative Area) in FU6 are eliminated from further evaluation in this FS because they do not require remedial action to facilitate the transfer of property or to meet requirements of CERCLA (Figure 1-3). No historical waste handling activities were conducted in these areas.

1.3.3 Constituent Fate and Transport by Chemical Group

The nature and extent of contamination was assessed for the surface soils, subsurface soils, surface water, sediments, and groundwater across the MI. All media except groundwater were studied in geographic subsets of the MI (the geographic FUs). Groundwater was assessed as one FU (FU7), although it covers the entire MI, and will be addressed in a separate FS report. Nature and extent findings are summarized below by FU and are described in more detail in the RI report (CH2M HILL, 2000a).

1.3.3.1 Soil COPCs

The soil chemicals of potential concern (COPCs) identified for consideration in the FS for soils include two metals (lead and arsenic), PAHs, dieldrin, PCBs, and tetrachlorodibenzo-p-dioxins (TCDD). The fate and transport of each of these COPCs in soils are briefly summarized below from Section 6 of the RI report (CH2M HILL, 2000a).

Metals

Metals have been detected in all media at the Depot, and in general, are persistent in the environment. A direct relationship between the measured total metal concentration in soil and the extractable aqueous concentration cannot be assumed. The metal may be fixed in the interior of the soil and unavailable for exchange or release to water, or an exchangeable metal may be present at the surface of the particles. The potential release and migration of metals in the subsurface environment is a complex process.

Lead has a strong tendency to adsorb to the soil. A significant fraction of lead is insoluble and may be associated with colloidal particles. On the basis of the site data, lead is limited to the surface soils, indicating that it is tightly bound to the soils and paint material and is not leaching. Figure 1-4 shows the distribution of detected lead concentrations across the MI. The adsorption of arsenic onto clays, iron oxides, and ⁱorganic (humic) material is also an important transport pathway Figure 1-5 shows the distribution of detected arsenic concentrations across the MI. None of the inorganic chemicals detected in the surface soil was detected in the subsurface soils at elevated concentrations, indicating that the chemicals they are not mobile in the surface soils at the Depot

Chlorinated Pesticides

Dieldrin was the most commonly detected chlorinated pesticide at the Depot. Figure 1-6 shows the distribution of detected dieldrin concentrations across the MI. This pesticide is not expected to volatilize significantly. Dieldrin-type pesticides (e.g. DDT, 1,1,1-Dichloro-2,2-bis(4-chlorophenyl)ethylene [DDE], and dichlorodiphenyldicloroethane [DDD]) are more likely to sorb to soil and are less mobile in aqueous phases. The most likely migration pathways for chlorinated pesticides are transport in particulate emissions and transport of sorbed materials in surface runoff.

Dieldrin is extremely nonpolar and, therefore, has a strong affinity for organic matter in soil and sorbs tightly to soil particulates. It has low mobility through the soil column and migrates extremely slowly, even under saturated soil conditions. This low mobility is consistent with what was observed at the Depot, where soils deeper than 2 ft are essentially free of dieldrin. Thus, surface runoff and airborne particulate emissions are the potential migration pathways for the chlorinated pesticides.

Use of these chlorinated pesticides has been discontinued in the U.S. for over a decade. The detection of high concentrations in the exposed soil after so many years since the last application indicates that the degradation rates of these pesticides are slower than the rates cited in the literature (Agency for Toxic Substances and Disease Registry, 1992).

PCBs

PCBs are chlorinated organic compounds that are similar to chlorinated pesticides detected in the surface soils at the Depot. Aroclor-1260 was the only PCB detected in surface soil but it was not detected in subsurface soil. PCBs are characterized by low water solubility, low volatility, and a high affinity for organic matter. PCBs are also slow to break down in the environment. At very high temperatures, these chemicals could form poly-chlorinated dibenzofurans and, to a lesser extent, dibenzo-p-dioxins. Similar to chlorinated pesticides, PCBs tend to remain bound to soil particles. The primary migration pathways are surface runoff with soil erosion and dust emission.

PCBs were detected infrequently in surface soils and were not detected in subsurface soils, sediments, or surface water at the Depot. They were not found to migrate through ditches or to the groundwater. EPA has developed three sets of toxicity factors for this group of compounds. Of these, the most conservative set, based on high toxicity and persistence, was used in the risk assessments for the MI. The risks from PCBs at the Depot were within the same acceptable risk limits of 1 to 100 in 1 million.

PAHs

Most of the PAHs detected across the MI were present along the railroad tracks and the roadways, with the most elevated concentrations associated with the railroad tracks. PAHs are relatively persistent, particularly when mixed with asphalt-type materials, and represent a broad class of compounds ranging from low-molecular-weight components, such as

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naphthalene, to high-molecular-weight compounds, such as dibenz(a,h)anthracene. Solubility, volatility, biodegradability, and toxicity vary widely across this class of compounds.

High-molecular-weight PAHs are more likely to be transported via particulate emissions, while low-molecular-weight PAHs have a greater tendency to volatilize. When PAHs are present in tar and oil waste mixtures, their behavior is determined largely by the mobility and behavior of the waste itself. Low-molecular-weight PAHs can migrate from spills and continuous releases of tars and oils, but as weathering occurs, the rate of release decreases. Higher-molecular-weight PAHs would persist in the vicinity of the original release.

Low-molecular-weight PAHs have higher water solubility and are more likely to be released into groundwater than higher-weight PAH compounds, which have an increased tendency for adsorption to soil or other organic matter. A primary fate and transport mechanism is migration of adsorbed PAHs with surface soils and sediment. Erosion of soil and movement of suspended sediments may result in migration of PAHs to surface water. However, because of the low solubility of adsorbed PAHs, they would not partition significantly to water.

Photolysis and biodegradation are two common attenuation mechanisms for PAH compounds. Although all PAHs transform in the presence of light, their rates are highly variable. Photolysis may reduce concentrations of these chemicals in surface soils, but is not relevant for subsurface soils. Biodegradation rates of PAHs in soils are also extremely variable across the chemical class.

Animals and microorganisms can metabolize PAHs to products that ultimately reach complete degradation. PAHs in soil may be assimilated by plants, degraded by soil microorganisms, or accumulated to relatively high levels in soils.

Dioxins

The aromatic heterocyclic compound 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) was not directly detected in the site samples. The reported TCDD equivalents were based on higher chlorinated (hepta and octa) isomers, converted to the TCDD equivalent concentrations. These chemicals have no commercial use and are released into the environment from chemical and combustion processes. The TCDD isomer has a very low solubility and therefore, a very high carbon-based sediment partition coefficient. The airborne TCDD and congeners have long half-lives, with more highly chlorinated congeners reaching further distances because of their longer half-lives. The two processes that are likely to remove TCDD and congeners from water and soil are vaporization and photolysis. TCDD and tetrachlorodibenzofurans (TCDFs) are common in urban environments and are found in background conditions at concentrations similar to those detected in the Depot soils.

1.3.4 Baseline Risk Assessment Summary for the Feasibility Study

A baseline risk assessment was conducted for each of the six soil FUs in the MI. Numerous meetings and communications between EPA, TDEC, and BRAC Cleanup Team (BCT) led to agreement on the methodology used for the human health risk assessment (HHRA). Overall results indicate that, under current (limited) land use conditions at this old industrial storage facility, no threat to human health or ecological receptors exists above acceptable limits. Health risks to industrial workers are within acceptable levels for future industrial use of the property, except for lead in some limited surface soil areas.

A future residential risk scenario was performed for comparison purposes only. The results will not be used for site management decisions because this is unlikely to be a suitable future residential site. It is unlikely that this industrial facility will be used for future residential purposes for several reasons. For example:

- The MI is currently zoned light-industrial;
- Depot redevelopment plans do not include future residential development;
- The large warehouses are still valuable for commercial uses; and
- Industrial/commercial uses offer the potential for employment.

Future residential health risks due to exposure to chemicals in soil are addressed in this FS to assist remedial management decisions. Chemicals introduced into the environment at the Depot are not likely to pose an ecological threat.

1.3.4.1 Ecological Risk Assessment Results

The natural habitat in the MI area is very limited to non-existent. Occasional terrestrial animals visiting the facility or living nearby any of the six FUs are not subject to a significant threat from the site media. A limited number of aquatic species potentially living in the two ponds in the golf course area (FU2) are not threatened by the current sediment and surface water conditions in the ponds. The overall ecological risks from soil, sediment, and surface water concentrations, therefore, are not an ecological concern.

Ecological receptors, like terrestrial or aquatic animals and plants in the ponds and streams, are not being exposed to the site groundwater, and they are not likely to be exposed in the future. This FS, therefore, does not address protection of potential ecological receptors.

1.3.4.2 HHRA Results

The Human Health Risk Assessment (HHRA) compares site- and chemical-specific risk estimates with the acceptable health risks and hazard index (HI) levels. Acceptable risk levels (risks) for NPL sites range from 1 to 100 excess lifetime cancer risks (ELCRs) per 1 million. The acceptable target HI for non-carcinogenic chemicals is 1.0. Table 1-1 summarizes the risks and HIs across the MI for surface soil (FUs 1 through 6). The table summarizes the risk calculations for COPCs considered in the RI. When the cumulative ELCRs are greater than 1 x 10^4 , and/or HIs greater than 1.0, site chemicals contributing to these excess risks and HI are listed as chemicals of concern (COCs) for further evaluation in this FS.

Soil, Sediments, and Surface Water

Direct exposures by human receptors to sediment and surface water in the ponds in FU2 did not present risks above the acceptable levels and are not addressed in this FS.

For surface soils, the acceptable risk levels were not exceeded anywhere on the Depot for industrial workers from organic chemicals, but were exceeded in FU4 for lead.

If the site were ever to be used for residential purposes in the future, the surface soil risks would not be acceptable in some of the areas of the MI. The most common COPCs for excess risks to future residential receptors are the PAHs. PAHs were detected throughout the MI in samples collected near railroad tracks and asphalt-paved roads. Other surface soil COPCs for potential future residential receptors are dieldrin, PCBs, and arsenic. These were detected less frequently or at lower concentrations and thus are considered less significant

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than the PAHs. Also, lead was detected in a few areas at high concentrations; some of these areas are associated with historical paint operations in the southwestern corner of the Depot. Health-based risks from lead are not calculated like cancer and HI risks; father, they are addressed as a separate issue related to blood uptake models. Health-based protective target concentrations for lead in soil (1,536 parts per million [ppm]) were calculated during the RI for an industrial worker and were included in Table 7-16 of the RI report. A similar target value protective of future residential children is estimated to be 300 milligrams per kilogram (mg/kg). The calculations, estimated blood-lead level probability graphs, and the average and maximum lead estimates at FUs 3 and 4 and the individual sites within these FUs are presented in Appendix A.

- Table 1-2 lists remedial goal option (RGO) target concentrations of the COPCs for surface soil, which are protective of industrial workers or future residents. The calculated RGOs address target risks of 1 in 1 million to future industrial workers and potential future residents. The target lead levels are designed to achieve a blood-lead level at or below the target levels of 10 micrograms per deciliter (µg/dL) in 95 percent of the population, following EPA directive (EPA, 1994).
- The COPC identified for future industrial workers is lead. None of the other chemicals present excess risks/HIs.
- The COPCs identified for a potential future resident are PAHs, dieldrin, lead, and arsenic, which contribute cumulative risks above 1 in 10,000 (10⁴) and/or HI>1.0 levels in the MI risk assessment.
- This FS develops alternatives that address the areas with excess lead contamination above worker health protective criteria. The alternatives screening analysis also includes the residential cumulative risks above 10⁻⁴ and HI > 1.0 and lead above residential child health protective levels.
- PCBs and TCDD are COPCs in FU4. PCBs were detected in 1 of 22 samples in FU6, in the area which was remediated as part of the removal action near the cafeteria in this FU. The total TCDD equivalents within FU4 were slightly above background; however, they are below the 1-ppb action level set by EPA, which is an Applicable or Relevant and Appropriate Requirement (ARAR) (EPA, 1998). Therefore, PCB and TCDD will not be further evaluated in this FS.
- A separate risk assessment was performed for FU2 surface soils, assuming a recreational golfer exposure scenario. Alternative unlimited recreational land use scenarios for FU2 were also considered. Appendix C includes a Technical Memorandum (TM) that evaluates risks at the golf course for additional recreational scenarios, such as jogging, playing soccer, and installation of playground equipment associated with use as a public park. The TM evaluates the potential human health risks from using the golf course as a general recreational use area such as a public park. This supplemental risk assessment is not included in the final RI since the alternative unrestricted land use scenario was established after completion of the final RI report. Several exposure scenarios were evaluated for the golf course using the upper confidence limit at 95 percent above the mean value (UCL 95 percent) the maximum detected concentrations as exposure point concentrations, as reported in the streamlined risk assessment. The TM concludes that

the golf course may be used as a golf course, baseball field, playground, and soccer field. It may not be used as a future residential area under the assumed exposure conditions evaluated in this risk assessment without access control or remediation.

1.3.4.3 Summary of Recommendations from Baseline Risk Assessment

The baseline risk assessment recommendations for human health and ecological protection for the MI are as follows:

- Ecological receptors are limited at this urban site. Any receptors present are not being threatened on the basis of site contamination conditions and thus do not require protection.
- Current exposures from all media are limited to workers in the leased properties. The health risks are negligible to workers doing routine maintenance work, such as mowing grass, moving stored materials across the parcels, working indoors doing office work, or doing landscaping, utility maintenance, or construction work.
- Future exposures from all media to workers spending prolonged periods of time in smaller areas also do not present significant (non-lead) risks ("significant" is defined as risks in excess of 1 in 10,000 or HIs >1.0, for a worker) even from the most contaminated areas.
- Future exposure from surface soils to future residents presents an excess health risk due to the presence of PAHs along railroad tracks and asphalt pavement, and the presence of dieldrin in FU2. These PAHs, which are located along railroad tracks and asphalt-paved roads, will likely decrease in concentration with time.
- Future exposures to lead concentrations are considered for this FS. Health-based protective concentrations for lead in surface soil are calculated on the basis of blood-lead levels in workers. The target concentrations were exceeded in surface soils in some areas of the site. Some of the areas with excess lead also have elevated chromium and zinc, which appear to be from paint sandblasting material impacting limited areas of the MI. Subsurface soils do not have these metals, indicating that these metals are bound and not leachable.

The areas with excess lead are:

- Areas associated with the Old Paint Shop (Sites 31, 32, and 33 [sump in the building] and Parcels 35 and 28), all of which are part of the southwestern corner of FU3;
- Southern corner around Building P-949 in FU4; southern end of Building 702 (for future residential scenario); and northwest corner of Building 770 (for future residential scenario); and
- 3) Sump-bottom grit in Buildings 251 and 265 in FU6, which had high levels of lead; however, this material has been removed.
- All these areas have lead levels above the target concentration of 1,536 mg/kg, calculated to be protective of a worker's health using the lead model of EPA's Technical Review Workgroup (TRW) for Lead (EPA, 1996).

- Table 6-8 in the RI report lists all the excess lead concentrations detected across the MI with the associated station and sample identifications. Figure 1-4 shows areas with lead values above target concentrations of 300 mg/kg for a future residential child, calculated on the basis of target blood-lead levels of 10 μ g/dL or less in 95 percent of the population.

1.3.4.4 Chemicals of Concern

The COPCs identified in the RI were evaluated in the HHRA for exceedances above target risk criteria. The chemicals that exceeded those criteria and require remedial action for the protection of human health are identified as chemicals of concern (COCs). These COCs are presented in Table 1-3. Except as noted above and in the table, the COCs are carried forward into the alternatives evaluation and selection processes in the next sections to develop RAOs.

The primary COC in surface soil for workers is lead; the COCs to a potential future resident are lead, arsenic, and dieldrin. Lead occurs in areas in FUs 3 and 4 at concentrations that exceed the health-based criteria protecting industrial workers. Dieldrin occurs at FUs 1, 2, and 4 at concentrations that do not exceed the health-based criteria protecting unlimited recreational uses (see Appendix C). Arsenic occurs in several areas throughout all six FUs.

PAHs compounds are not carried forward as COCs in this FS. The current practice for the Depot is to remove the tracks as portions are developed for industrial land use. In some cases where infrastructure needs influence the reuse of track areas, the surface soil is covered with pavement, clean gravel or fill, thus minimizing the risk of future exposure of the public to PAHs. Also, PAHs are not considered a CERCLA release at the Depot in accordance with the definition of a release under CERCLA 101(22). Since the presence of PAHs is due to the application of asphalt and other common industrial and urban practices to which CERCLA does not give authority to respond, remediation of PAHs are not further addressed in this FS.

Candidate areas for remediation have been determined for arsenic, lead, and dieldrin under the industrial and future residential land use criteria for each FU at the MI. These are presented in Figures 4-1 through 4-6 in Section 4 of this FS.

1.3.5 Summary of COCs in Surface Soil for Each FU

Based on the findings of the RI, including the base remedial assessment, the following subsections describe the surface soil COCs for each of the six FUs at the MI. Each FU and COC are discussed in terms of the land use scenarios.

1.3.5.1 FU1 – 20 Typical Warehouses

There are no surface soils in FU1 that present an unacceptable risk to Industrial workers.

If FU1 were ever developed for residential or day care use, a number of specific areas with surface soil concentrations of dieldrin and arsenic would exceed acceptable risk levels.

There are no surface soils in FU2 (southeast golf course/recreational area) that present an unacceptable risk to recreational users of this site.

If FU2 were ever developed for residential or day care use, surface soil across much of the site contains dieldrin and arsenic concentrations that would exceed acceptable risk levels. A total of 45 acres have dieldrin concentrations exceeding acceptable levels under a residential scenario.

1.3.5.2 FU3 – Southwest Open Warehouses

There are no surface soils in FU3 that present an unacceptable risk to industrial workers.

If FU3 were ever developed for residential or day care use, a number of specific areas with surface soil concentrations of arsenic would exceed acceptable risk levels.

1.3.5.3 FU4 - Northern and Central Open Areas

There are surface soil concentrations of lead that exceed acceptable levels for industrial workers.

If FU4 were ever developed for residential or day care use, a number of specific areas with surface soil concentrations of lead, dieldrin, and arsenic would exceed acceptable risk levels.

1.3.5.4 FU5 - Newer Warehouses

There are no surface soils in FU5 that present an unacceptable risk to industrial workers.

If FU5 were ever developed for residential or day care use, a number of specific areas with surface soil concentrations of dieldrin and arsenic would exceed acceptable risk levels.

1.3.5.5 FU6 – Administrative and Residential Areas

There are no surface soils in FU6 that present an unacceptable risk to industrial workers.

If FU6 were ever developed for residential or day care use, a number of specific areas with surface soil concentrations of arsenic would exceed acceptable risk levels.

			Risk Asse	ssment Resul	ts ^a				
Functional Unit (FU)	COPCs	Max. Lead (Pb) Conc. (mg/kg)	ELCR- Industrial Worker	Industrial HI	ELCR- Residential Risks	Residential HI	Above Target ELCR 1X10 ⁻⁴ and HI 1 Industrial	Above Target ELCR 1X10 ⁻⁴ and HI 1 Residential	Is Lead Above Ind. Target?
FU1	PAHs, PCB, Dieldrin, Arsenic	297	8 x 10 ⁻⁵	0.09	1 x 10 ⁻³	0.08	No	Yes	Ŷ
FU1 - Site 64	PAHs		7 x 10 ^{.5}	0.02	NA	٩N	No	AN	
FU2	PAHs, Dieldrin, Arsenic	150 ^b	3 x 10 ⁵	0.2	2 x 10 ⁴	27	٩	Yes	No
FU2 - Site 59	Dieldrin		2 x 10 ⁶	0 008	NA	ΝA	No	NA	
FU3	PAHs, Arsenic, Lead	4150 (at RHA012)	9 x 10 ⁶	0.6	6 x 10 ⁴	0.6	No	Yes	Yes
FU3-Site 34	PAHs, Arsenic		4 x 10 ⁵	0.1	NA	AN	No	NA	
FU4	PAHs, PCB, Dieldrin, TCDD, Arsenic, Lead	2800 (SGA286)	4 x 10 ⁵	0.1	3 x 10 ⁵	0 01	οN	No	Yes
FU4 - Site 36	Dieldrin, Arsenic		8 x 10 ⁶	0 06	NA	AN	No	NA	
FUS	PAHs, Dieldrin, Arsenic	109	3 x 10 ⁵	0.05	4 x 10 ⁻⁴	NA	No	Yes	No
FU5 - Site77	PAHs, Arsenic		8 x 10 ⁵	0.05	NA	NA	No	AN	
FUG	PAHs, PCB, Dieldrin, Arsenic, Lead	3570 (A21, sumps in Bldgs Sump contents removed in 1999)	3 x 10 ⁵	0.5	1 x 10 ⁴	AN	°N N	Yes	° N
FU6-Site 66	PAHs		2 x 10 ⁵	NA	NA	NA	No	AN	
ELCH Excess II Note Target values	ifetime cancer risks estimated for lead are 1,536 mg/kg fi	or industrial worker and 30	00 mg/kg for resid	entral chitd health p	protection using bloo	d-lead uptake mod	els		

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SOILS

^a This table summarzes the most conservative future land use scenarios (industrial and residential). Recreational risk results are presented in Appendix C ^b Lead was detected in sample SS-51D in FU2 at 318 ppm and 34 6 ppm in a duplicate sample, therefore, the value of 318 ppm was not used

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TABLE 1-2

Remedial Goal Options for Surface Soil

Memphis Depot Main Installation Soils FS - 7/31/00

	Industrial	Worker	Reside	ential
Chemical	TR = 1E-06 (mg/kg)	THI =1 (mg/kg)	TR = 1E-06 (mg/kg)	THI =1 (mg/kg)
Metals		· · · · · ·		
Arsenic	3 ⁶	549	2 ⁶	197
Lead ^a	1536	1536	300	300
Pesticides	0.27	77	0 21	168
Dieldrin				
Semivolatiles	5	NC	43	NC
Benzo(a)Anthracene	0.5	NC	0.41	NC
Benzo(a)Pyrene	5	NC	4.3	NC
Benzo(b)Fluoranthene	52	NC	43	NC
Benzo(k)Fluoranthene	516	NC	428	NC
Chrysene	0.5	NC	0.43	NC
Dibenz(a,h)Anthracene	5	NC	4 28	NC
Indeno(1,2,3-c,d)Pyrene	5	NC	4 28	NC

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Note: Site average lead concentrations should be compared with target criteria

^a Lead target values were calculated using blood-lead uptake models.

^b Arsenic background value of 20 μ g/kg is the target value (RGO) in Section 2.

NC A value not calculated

TR Target Risk

THI Target Hazard Index

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TABLE 1-3 Selection of COCs from COPCs Identified During Risk Assessment for Each Functional Unit at Main Installation Memphis Depot Main Installation Soils FS – 7/31/00

Functions Unit	d copcs	Max. Lead (Pb) Conc. (mg/kg)	Above Target ELCR 1X10-4 and HI 1 Industrial	Above Target ELCR 1X10-4 and Hi 1 Residential	Is Lead Above ≀nd. Target?	COCs ^a Industrial Scenario	Comment	COCsa Residential Scenario ^b	Comment
FU-1	PAHs, PCB, Dieldrin, Arsenic, and Lead	297	°N N	Yes	Ŷ	None	The cumulative risks were below 10-4 for industrial receptors, therefore, no COCs at FU-1	Arsenic, Dieldrin and PAHs ⁴	Chemicals contributing to total risk at >1 × 10 ⁻⁴ levels for hypothetical residential receptors
FU-2	PAHs, Dieldrin, Arsenic	150 ^c	o Z	Yes	Š	None	No individual chemicals contributing to >10-4 risk level to an industrial worker	Arsenuc, Dieldrin, PAHs ⁴	Arsenic at 29 mg/kg, die/drin at 2 2 mg/kg and B(a)P at 0 25 mg/kg (below a PQL of 0 33 mg/kg) contribute to >10 ³ risk level to a future hypothetical resident
FU-3	PAHs, Arsenic, Lead	4150 (at RHA012)	Š	Xes	Yes	Lead	Lead is above industrial health protective level of 1,536 mg/kg around old paint shops No other individual chemicals contributing to >10-4 risk levei to an industrial worker	Arsenic, Lead, PAHs ⁴	Lead is above residential child health protective level of 300 mg/kg around the old paint shops PAHs from raifroad tracks (sample from raifroad tracks (avenple frocation B126 21) present >10 ⁴ cumulative risk level to a hypothetical resident
FU-4	PAHs, PCB, Dreidrin, TCDD, Arsenic, Lead	2800 (SGA286)	°Z	°Z	Yes	Lead	Lead is above industrial health protective level of 1536 mg/kg No other individual chemicals contributing to >10-4 risk level to an industrial worker	Arsenic, Lead, Dieldrin, PAHs ^d	Lead is above residential child health protective level of 300 mg/kg The cumulative risks from other chemicals were befow 10 ⁻⁴ level to a hypothetical resident TCDDs were below an ARAR of 1 ppb
FU-5	PAHs, Dieldrin, Arsenic	109	Ň	Yes	No	None	Lead levels were below criteria No individual chemicals contributing to >10-4 risk level to an industrial worker	Arsenic, Dieldrin, and PAHs ^d	PAHs from railroad tracks (Sample location SS77C) present >10 ⁴ risk level to a hypothetical resident
9°0-	PAHs, PCB, Dieldrin, Arsenic, Lead	3570 (A21, sumps in Bldgs contents removed in 1999)	Ŷ	Yes	Ž	None	Lead is above industrial health protective level of 1,536 mg/kg, however the contents of the sumps were removed in 1999 No other individual chemicals contributing to >10 ⁴ risk level to an industrial worker	Arsenic, PAHs ^d	Lead is above residential child health protective level of 300 mg/kg, however the contents of the sumps were removed in 1999 PAHs from railroad tracks (Sample location SS66A) present >10 ⁴ insk level to a resident. PCBs were in 1 of 22 samples analyzed, however, the soil was removed as part of the remedial action at the Catelena

Yes Responses bolded, and italicozed are above the target risk critena ELCR Excess interme cancer risk Target Values estimated for lead are 1,536 mg/kg for industrial worker, and 300 mg/kg for a residential child health protection using blood-lead uptake models * CCCs are the Rin report and COCs in the Draft FS were based on surrogate site sample locations, in this FS report COCs are based on FU-wide UCL 95% risks to residential receptors (See Appendix A) * CCCs in the RI report and COCs in the Draft FS were based on surrogate site sample locations, in this FS report COCs are based on FU-wide UCL 95% risks to residential receptors (See Appendix A) * CCPCs in the RI report and COCs in the Draft FS were based on surrogate site sample, therefore, the value of 318 ppm was not used * CCPCs in the RI report and COCs in the Draft FS were based on surrogate stere sample, therefore, the value of 318 ppm was not used * PAHs across the main installation are associated with raircoad tracks and are not CERCLA releases. Ongoing development at the site includes removal of the tracks

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RDD //Thor/Cart//ddmt/FS_ddmt.apr 6/26/00



RDD //Thor/Cart1/ddmf/FS_ddmf.apr 6/26/00



RDO //Thor/Cart1/ddmt/FS_ddmt.apr 6/26/00

TAB

Sectiona

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2.0 Identification and Screening of Technologies

This section describes the initial steps in development of potential remedial alternatives for surface soils at the Depot. This section begins by developing a list of applicable or relevant and appropriate requirements (ARARs). Next, remedial action objectives are defined so that various technologies can be identified and screened to meet the objectives. The screening process involves identifying general response actions, remedial technologies, and processes for implementing the technologies. This section concludes with a summary table of remedial technologies that are evaluated in more detail in Sections 3 and 4.

2.1 ARARs

ARARs are federal and state standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements. There are three types of ARARs. chemical-specific, action-specific, and location-specific.

2.1.1 Chemical-specific ARARs

Chemical-specific ARARs are health- or risk-based requirements or methodologies that result in the establishment of numerical values for surface soil that would meet the National Contingency Plan (NCP) threshold criterion of overall protection of human health and the environment. The chemical-specific ARARs for the surface soil at the MI are as follows:

- There are no chemical-specific ARARs for the soils. Therefore, chemical-specific RGOs developed in the risk analysis are used for the remedial alternatives analysis.
- There are no natural surface water bodies within the Depot or in the vicinity. Therefore, the surface water ARARs were included in the risk assessment for comparison purposes, but were not included as ARARs for the screening of alternatives due to the lack of risks indicated during the risk assessment.
- Sediments do not have ARARs.

2.1.2 Action-specific ARARs

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous waste. The action-specific ARARs for the soils at the Depot are as follows:

 Discharges to surface water have action-specific ARARs that require on-site direct discharges from CERCLA sites to surface waters to meet the substantive requirements of the National Pollutant Discharge Elimination System (NPDES). These substantive requirements include discharge limitations (both technology- and water quality-based), certain monitoring requirements, and best management practices. For an on-site discharge from a CERCLA site, these substantive requirements must be identified and complied with, even though on-site discharges are not required to have an NPDES permit. An NPDES permit will be obtained if necessary, and proper treatment facilities will be provided if required. The Depot currently has an NPDES permit and there are associated monitoring requirements, in the form of surface water samples for surface water discharges. Any discharges to surface water must comply with these existing monitoring requirements.

- The excavation, on-site ex situ solidification, and placement of soil that contains RCRA-• restricted waste may trigger the RCRA land disposal restrictions (LDRs). In general, RCRA's LDRs were established for waste streams that differ significantly from Superfund wastes. Because the LDRs are not based on treating wastes that contain soil and debris, a treatability variance may be appropriate Under a treatability variance, alternative treatment levels based on data from actual treatment of soil, or best management practices (BMPs) for debris, become the "treatment standard" that must be met. To determine if the soils are to be disposed of in a hazardous or solid waste landfill, a toxicity characteristic leaching procedure (TCLP) test is conducted on representative soil samples to determine if a waste is characterized as hazardous per Title 40 of the *Code* of Federal Regulations Part 261 Subpart C (40 CFR 261C). The excavation and off-site disposal of soil and debris that contain a RCRA hazardous waste must comply with transporter regulations under 40 CFR 263C). A transporter under Subtitle C is defined as any person engaged in off-site transportation of hazardous waste within the United States. Such transportation requires a manifest under 40 CFR 262.
- In an effort to control more diffuse sources of water pollution, as from stormwater . runoff, EPA promulgated rules regulating activities that generate stormwater runoff, such as construction activities Phase I of the NPDES stormwater permit program addresses discharges from large construction activities disturbing 5 acres or more of land (cumulative at a site). CERCLA on-site remedial actions are required to comply only with the substantive requirements of the NPIDES stormwater permit program (e.g., BMPs to minimize the discharge of pollutants from the site) and not the administrative requirements (e.g., submittal of a Notice of Intent, a Storm Water Pollution Prevention Plan, and Notice of Termination). The Phase II rule was published on December 8, 1999, and addresses construction activities disturbing greater than 1 acre and less than 5 acres of land. The effective date of the rule is February 7, 2000; however, operators of small construction activities (less than 5 acres) are not required to obtain permit coverage until March 10, 2003. Remedial actions at the MI may disturb 5 acres or more of land and may need to comply with the substantive requirements of the NPDES Phase I stormwater permit program.
- The closure and post closure care of solid waste disposal areas on the site must comply with Tennessee Rule 1200-1-7, which includes requirements for control of access, cover, monitoring, run-on, run-off, and erosion control, and inspections.
- Emissions to air during excavation and/or on-site treatment may require compliance with the substantive requirements of Tennessee Rule 1200-3-1, which includes requirements for the control of fugitive dust emissions, among others.

2.1.3 Location-specific ARARs

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Location-specific ARARs identify requirements that must be addressed during remedial activities because the activities occur in "special" locations. Location-specific ARARs include activities on and near wetlands and floodplains, archeological and natural resources, historical landmarks, critical habitats of endangered or threatened species, existing land use controls, etc. A search for possible location-specific ARARs applicable to the Depot was conducted by Law Environmental (1990), and no significant changes have occurred since then around the Depot (e.g., no new wetlands were created). This status generally does not change for a site. No federal, state, or local natural resources were found to be near the site (less than ½ mile). The closest jurisdictional wetland habitats to the Depot are the various wetlands associated with Nonconnah Creek, approximately 1 mile to the south. There are no releases occurring from the site to the off-site ditches, so no releases to the more distant areas such as the wetlands referenced here are occurring.

Currently, the MI is zoned as Light Industrial (I-L). The principal uses permitted are manufacturing, wholesaling, or warehousing. According to Section 24 of the Memphis and Shelby County zoning regulation, single family, or multi-family residential uses are prohibited.

Under the Federal Property Management Regulations, FU2 is slated for transfer from the Department of Defense (Army) to the Department of Interior (DOI)/National Park Service (NPS). It will then be transferred by public benefit conveyance to the City of Memphus for use as a park. According to 41 CFR 101-47.308-7, property for use as a public park or recreational area must be used and maintained for the purpose for which it was conveyed in perpetuity, or be returned to the United States (24 CFR 51D).

2.2 RAOs

RAOs are medium-specific goals that the remedial actions are expected to accomplish to protect human health and the environment; they are used to help identify the feasible alternatives. RAOs express both a contaminant level and exposure route. The baseline risk assessment identified certain contaminants that pose unacceptable risks to industrial workers and potential on-site residents when the Depot is re-developed (RGOs). These RGOs are chemical specific criteria based on calculated risk (see Table 1-2). The residential scenario considered in the baseline risk assessment satisfies the requirement that an alternative is developed that eliminates or minimizes long term management.

RAOs guide the formulation and evaluation of remedial alternatives. They consider the HHRA RGOs (Section 1.3.4.2) (allowable exposures), COCs, and clean-up concentrations associated with the RGOs. The following RAOs have been developed for the MI surface soils:

- For protection of future industrial workers
 - Prevent direct contact/ingestion of surface soils contaminated with lead in excess of industrial worker risk-based criteria.
- For protection of future on-site residents

- Prevent direct contact/ingestion of surface soils contaminated with dieldrin and arsenic in excess of HHRA criteria for residents; and
- Prevent direct contact/ingestion of surface soils contaminated with lead in excess of risk-based criteria for protection of residential children.

Table 2-1 summarizes RAOs for surface soils.

2.3 General Response Actions

GRAs describe remedial activities that potentially satisfy the RAOs and goals, either independently or in combination with other GRAs. GRAs to be considered for surface soil at the MI include the following:

- No action
- Institutional controls
- Containment
- Treatment
- Removal
- Disposal (Off-site)

Table 2-2 summarizes the GRAs and their approach to meeting remedial goals. Often there are several technologies that may be applied to each CRA. These technologies are discussed and screened for potential effectiveness below.

2.4 Identification and Screening of Technology Types and Process Options

2.4.1 Identification and Initial Screening of Technologies

Table 2-3 identifies and describes potentially applicable technologies and process options for soil remediation. As part of the initial screening process, certain technologies and/or process options are identified as clearly inappropriate for the physical features of the site and/or the chemical characteristics of the surface soil. These inappropriate technologies are shaded in Table 2-3 and are not evaluated further.

2.4.2 Evaluation and Selection of Representative Technologies

Technologies and process options retained after preliminary screening are further evaluated on the basis of their relative effectiveness, difficulty to implement, and cost. These factors are evaluated as follows:

- The judgment of the relative effectiveness of a technology is based on its estimated capability to meet one or more of the RAOs, its estimated protectiveness of human health and the environment during operation, and its estimated reliability to function considering the contaminants and site conditions;
- The difficulty in implementing a technology considers both the technical and administrative aspects of construction and operation; and

• The cost evaluation focuses on relative capital (initial) and operation and maintenance (O&M) costs. Detailed cost analyses are not performed at this level of screening.

Table 2-4 presents the secondary screening of technologies and process options for surface soil. Technologies and/or process options that were rejected on the basis of effectiveness, implementability, or cost are shaded in the table and were not evaluated further.

2.4.3 Selection of Representative Process Options

Technologies and process options that were retained after the secondary screening were further evaluated, relative to other process options within the technology type, to identify one representative option for use in the developing alternatives. Effectiveness was the primary consideration for the process option assessment. Process options considered to be similarly effective were further evaluated on the basis of relative implementability and relative cost, resulting in the selection of the best process option for the technology.

Similarly, effective process options within various technologies were also evaluated to select the best representative process option. Identifying a representative process option for each technology was not intended to limit the process options that could be used in remedial design, but to provide a basis for evaluating a manageable number of remedial alternatives.

In some cases, multiple process options were retained because of their ability to complement other technologies. For example, institutional control process options were retained because they would most likely be used during the implementation of potential remedial alternatives.

Table 2-5 presents the selection of representative process options for surface soils.

Table 2-6 summarizes the GRAs and associated process options for surface soil retained after the screening process. These process options are used to develop remedial alternatives in Section 3.

					Re	medial Goal Op	tions ^a
Media/COC Group	coc	Exposure Route	Receptors	Industrial Criteria ^b	Unlimited Recreational Criteria ^b	Residential Criteria ^b	Areas Affected ^c
Sol/Metals	Lead	Ingestion	Adult Workers and Residents	1536		300	Hot spots outside of Parcels 35 and 28 ^d (per RI figure 6-3) and other exceedance areas
Soil/Metals	Arsenic	ingestion	Residents	-	÷	20	Exceedance areas ^e
Soil/Pesticides	Dieldrin	Ingestion	Recreators and Residents	÷	-	0.21	Exceedance areas, including entire golf course and recreational area
^a ppm (mg/kg) ^b Target concentrat uptake models for _t	tions develope adult workers	ed based on risk a and children (See	ssessment Lead targ	et values were de	sveloped using blo	od-lead	

Remedial Action Objectives – Surface Soils Memphis Depot Main Installation Soils FS - 7/3/00

TABLE 2-1

^c Areas considered for alternatives analyses

^d Draft-final EE/CA Old Paint Shop and Maintenance Area, April 1999

Exceedance areas have contaminant concentrations above background in the FU with risks greater than one in a million for residential use

⁴ Area-wide averaging within the FUs indicate these contaminants do not present significant risk to industrial workers or unrestricted recreational users.

TABLE 2-2

General Response Actions and Typical Goals Met Memphis Depot Main Installation Soils FS 7/3/00

Medium	General Response Action	Remedial Goals Met
Surface Soil	No Action	Relies on natural attenuation of contaminant concentrations
	Institutional Controls	Reduces the likelihood of direct contact with or ingestion or inhalation of contaminated soil.
	Containment	Minimizes the exposure to contaminated soil Confines contamination for possible removal or treatment and reduces mobility of contamination
	Removal	Prevents direct contact with or ingestion or inhalation of contaminated soil or sediment. Eliminates chance of release of contaminants to groundwater
	Treatment	Reduces mobility, toxicity, or volume of contaminated media.
	Disposal	Minimizes the likelihood of exposure to contaminants by placing them in a controlled environment.

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Ye Bidrin, arsenic, Ye Bidrin, arsenic, Ye	Yes Pldrin, arsenic, Yes	Yes eldrin, arsenic, Yes	eldrin, arsenic, Yes eldrin, arsenic, Yes eldrin, arsenic, Yes atble with Yes Yes	Idrin, arsenic, Yes Idrin, arsenic, Yes Idrin, arsenic, Yes atible with Yes Yes	Idrin, arsenic, Yes Idrin, arsenic, Yes Idrin, arsenic, Yes atible with Yes Yes	Idrin, arsenic, Yes Idrin, arsenic, Yes Idrin, arsenic, Yes atible with Yes Yes	Idrin, arsenic, Yes Idrin, arsenic, Yes Idrin, arsenic, Yes atible with Yes Yes	Idrin, arsenic, Yes Idrin, arsenic, Yes Idrin, arsenic, Yes atible with Yes Yes	Idrin, arsenic, Yes Idrin, arsenic, Yes Idrin, arsenic, Yes atible with Yes Yes	Idrin, arsenic, Yes Idrin, arsenic, Yes Idrin, arsenic, Yes atible with Yes Yes No	Idrin, arsenic, Yes Idrin, arsenic, Yes atible with Yes Yes No No No	Idrin, arsenic, Yes Idrin, arsenic, Yes atible with Yes No No No
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Synthetic membrane placed		Compacted clay placed ove or sandy soil to maintain the	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c Cap may be composed of n	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c cap may be composed of n asphalt concrete, or Portlan designed, will meet RCRA r Water dispersible emutsic reduces water and wind o	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c cap may be composed of n asphalt concrete, or Portlan designed, will meet RCRA r Water dispersible emutsic reduces water and wind o cover only	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c Cap may be composed of <i>n</i> asphalt concrete, or Portian designed, will meet RCRA r Water dispersible emutsio cover only.	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c Cap may be composed of ni asphalt concrete, or Portlani designed, will meet RCHA r Water-dispersible emutsip rench around contamina trench around contamina Cement sets and forms th	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c cap may be composed of ni asphalt concrete, or Portlann designed, will meet RCHA rr designed, will meet RCHA rr Materidispersible emutsion trench around contamina with a soil-bentonite mix Trench around contamina trench around contamina with a soil-bentonite mix trench around contamina cover only.	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c cap may be composed of n asphalt concrete, or Portlani designed, will meet RCRA r designed, will meet RCRA r with a soll-bentonite mix trench around contamina with a soll-bentonite mix trench around contamina with a soll-bentonite as be cover only force used to ad cement sets and forms th Vibratory force used to ad cement or bentonite as be Steel sheet piling driven a	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c Cap may be composed of ni asphalt concrete, or Portlani designed, will meet RCRA n designed, will meet RCRA n designed, will meet RCRA n trench around contamina trench around around contamina trench around	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c Cap may be composed of n asphalt concrete, or Portiani designed, will meet RCHA r designed, will meet RCHA r Water-dispersible enuisio reduces water and wind of cover only. Trench around contamina trench around contamina Cement sets and forms th Vibratory force used to ad cement or bentonite as be Steel sheet piling driven a Centenit chemital process opt Centenit chemital process opt Conventional ground free monitored ice barrier that	Synthetic membrane placed The membrane is seamed b present Paving grade asphalt or con evaluated in considering a c Cap may be composed of n asphalt concrete, or Portlann designed, will meet RCHA ri asphalt concrete, or Portlann designed, will meet RCHA ri with a soll-bentonite mix trench around contamina trench around contamination Conventional ground free monitored ice barrier that contamination. Experimen
Membranes			Aembranes Concrete Cap d Cap	Aembranes Concrete Cap d Cap	Aembranes Concrete Cap d Cap Sealant/Stabilizers	Aembranes Concrete Cap d Cap	Aembranes Concrete Cap d Cap Sealant/Stabilizers Sealant/Stabilizers	fembranes Concrete Cap d Cap brinte Sturry Walt Beam Barrier	fembranes Concrete Cap d Cap Beam Barrier Main Beam Barrier	fembranes Concrete Cap d Cap Sealant/Stabilizers Sealant/Stabilizers fig fith Barrier fith Reduction Agents	fembranes Concrete Cap d Cap acan fine Sturry Wall fine Sturry Wall fine Sturry Wall fine Sturry Wall fine Sturry Wall fine Sturry Wall	fembranes Concrete Cap d Cap d Cap bite Sturry Wall fighter Abring Wall fighter Agents fighter Agents fighter Agents
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				-	Verticat.Barriers	Verticat Barriers	Vertical Barriers	Vertical Barriers	Vertical Barrers		vertical Barriers	Vertical Barriers
		<u></u>										Horizo

SOILS

 TABLE 2-3

 Primary Screening of Remedial Technologues and Process Options for Soil Contaminants: Dieldrin, Arsenic, and Lead

 Memphis Depot Main Installation Soils FS - 7/3/00

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Pass Primary Screen?	No	ON	Yes	Yes	Yes	Yes	lem	ljem, No	No No	ljem.	Yes	No		ON IN	Yes	Tes Yes Yes Yes Yes Yes Yes Yes Yes Yes Y	In (as shown Yes
Primary Screening Comments	Mobility not an issue	Mobility not an issue	Applicable to dieldrin, arsenic, and lead.	Cap maintenance option	Cap maintenance option	Cap maintenance option	Not applicable, airborne particles not a probl	Not applicable, airborne particles not a probl	Not applicable, airborne particles not a probl	Not applicable, airborne particles not a prob	Applicable to dieldrin, arsenic, and lead.	Not applicable to site contamination.		Not applicable to site contamination.	Not applicable to site contamination. Applicable for arsenic and lead.	Not applicable to site contamination. Applicable for arsenic and lead. Venture's biological process applicable for dield in bench-scale treatability study)	Not applicable to site contamination. Applicable for arsenic and lead. Venture's biological process applicable for dield in bench-scale treatability study) Not applicable to site contamination.
Descriptions	Similar to vertical barriers by ground freezing. Experimental process option	Liners placed to restrict vertical flow can be constructed of the same materials considered for cap construction.	Reshaping of topography to manage surface water infiltration and runoff to control erosion.	A systematic revegetation plan includes selection of a suitable plant species, seedbed preparation, seeding/planting, mulching and/or chemical stabilization, fertilization, and maintenance.	Natural or man-made materials used to prevent erosion and subsequent exposure to /transport of contaminated soils	Diversion and collection structures installed upslope or at perimeter of the site to control drainage of stormwater runoff System can also be implemented to collect contaminated surface water from excavations for remediation	Water sprayed over area of concern to prevent dust generation.	Organic agents/polymers/foams sprayed over area of concern to prevent dus/wapor generation	Membranes or tarps are spread over area of concern to prevent dust/vapor generation	Hygroscopic salts absorb moisture into the soil in which they are mixed	Excavation of contaminated solids can use ordinary construction equipment backhoes, buildozers, and front-end loaders(s).	Injection of water containing inducers and electron acceptors (oxygen) to enhance aerobic biodegradation. Inducers serve as carbon sources that activate aerobic enzyme systems known to degrade chlorinated VOCs (fortuitious cometabolism).		Subsurface delivery of electron donors within the target zone to stimulate anaerobic biodegradation of chlorinated compounds by reductive dechlorination.	Subsurface delivery of electron donors within the target zone to stimulate anaerobic biodegradation of chlorinated compounds by reductive dechlorination. Use of plants and their associated rhizospheric mocroorganisms to remove, degrade, or contain chemical contaminants in soil.	Subsurface delivery of electron donors within the target zone to stimulate anaerobic biodegradation of chlorinated compounds by reductive dechlorination. Use of plants and their associated rhizospheric mocroorganisms to remove, degrade, or contain chemical contaminants in soil. Use of various process options (thermal, physical, and/or biochemical) to optimize in-situ anaerobic or aerobic biodegradation.	Subsurface delivery of electron donors within the target zone to stimulate anaerobic biodegradation of chlorinated compounds by reductive dechlorination. Biodegradation of chlorinated compounds by reductive dechlorination. Use of plants and their associated rhizospheric mocroorganisms to remove, degrade, or contain chemical contaminants in soil. Use of various process options (thermal, physical, and/or biochemical) to optimize in-situ anaerobic or aerobic biodegradation.
Process Options	Ground Freezing	Linèrs	Grading	Revegetatation	Erosion Control	Diversion and Collection Systems	Water	Organic Agents/Polymers/Foams	Mèmbranes/Tarps	Hygroscopic Agents	Excavation	Aerobic Cometabolic Bioremediation	uniter and the tracker		Phytoremediation	Phytoremediation Bioremediation Enhancements	Phytoremediation Bioremediation Enhancements
Technology Types			Surface Controls				Dust and Vapor Suppression				Excavation	In-situ Biological Treatment.		<u></u>			·
General Response Actions	Containment (continued)					ng					Removal	Treatment					

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Page 2 of 5

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Pass Primary Screen?	No.	Q	QN	No	Yes	Ņ	ON	PN0	Na	NO	PN	¢N	QN	Yes
Primary Screening Comments	Not applicable to surface contamination	Not applicable to surface contamination.	Not applicable to surface contamination	Not applicable to surface contamination.	Applicable for dieldrin, arsenic, and lead.	Not applicable to surface confamination.	Not applicable for site contaminants	Not applicable for contaminants present.	Not applicable to subsurface contamination.	Not applicable to subsurface contamination.	Not applicable to subsurface contamination.	Not applicable to subsurface contamination.	Not applicable to subsurface contamination.	Applicable for dieldrin, arsenic, and lead
Decriptions	High-pressure injection of fluids. followed by granular slurry, to create subsurface fracture patterns that minimize contaminant travel time via diffusion. Complements vapor or fluid extraction technologies.	Use of large-diameter augers to physically disturb the subsurface, with the introduction of hot air, steam. peroxide, or other fluids to promote contaminant removal during the mixing process. Complements vapor extraction or in-situ chemical oxidation technologies	Greation of electrical fields through application of low-voltage DC power to subsurface electrodes that affect contaminant transport through electromigration and/or electro-osmosis. Complements vapor extraction technologies.	Vacuum is applied through extraction wells to create a pressure/concentration gradient that induces gas phase volatiles to diffuse through soil to extraction wells. Includes a system for handling off-gases.	Solidification agents physically bind contaminants within a stabilized mass. Stabilizing agents react with contaminants to reduce their mobility. Auger/caisson systems and injector head systems are used to apply S/S agents to in-situ soils	Electro-osmosis is used to mobilize contaminants to installed in-situ freatment zones, where contaminants are removed by adsorption, stabilization, or chemical degradation.	Delivery of a solution that enhances the transport of the targeted contaminants by physical displacement, solubilization, desorption, with subsequent recovery of both the solution and target contaminants.	Aqueous injection of an oxidizing agent (peroxide/iron, permanganate, or ozone) to promote abiolic in-situ oxidation of chlormated organic compounds.	The introduction of polyphase AC electricity to a specially-configured array of subsurface electrodes that promotes in-situ generation of steam to vaporize target contaminants. Complements vapor extraction applications	The introduction of radio frequency energy to heat the subsurface and vaporize target contaminants. Complements vapor extraction applications.	The introduction of electrical energy to heat the subsurface and vaporize target contaminants. Complements vapor extraction applications.	The introduction of steam to heat the subsurface and vaporize target contaminants. Complements vapor and liquid extraction applications.	A combination of in-situ steam injection, electrical resistance heating and fluid extraction to enhance contaminant removal from the subsurface. Contaminants are volatilized, driven to centrally-located extraction wells, removed to surface, and treated	Electrodes are used to melt contaminated soils at high temperature to form a glass and crystalline structure with very low feaching characteristics.
Process Ontions	Hydraulic Fracturing	In-Situ Soli Mizing	Electrokinetic Treatment	Soil Vapor Extraction	Solidification/Stabilization (S/S)	LASAGNA ^{TII} Process	Surfactant/Cosolvent Flushing	In-Situ Chemical Oxidation	Six-Phase Soil Heating	Radio Frequency Heating	Electrical Resistance Heating	Steam Heating	Dynamic: Underground Stripping (DUS)	Vitrification
Remedial Technology Types	In-situ Physical- Chemical Treatment (continued)								In-situ Thermal Treatment			<u></u>		
General Response Actions	Treatment (continued)								•••••••					

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 TABLE 2-3

 Primary Screening of Remedial Technologies and Process Options for Soil Contaminants' Dieldrin, Arsenic, and Lead

 Memohis Denot Main Installation Soils FS - 7/3/00

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Pass Primary Screen?	Yes	9	Mo	Yes	op	e e	Yes	QN	Yes	Yes	Yes	Yes
Primary Screening Comments	Applicable for dieldrin.	Not applicable for contaminants present.	Not applicable for contaminants present.	Applicable for dieldrin.	Halogenated compounds are not a COC for soils	Halogenated compounds are not a COC for soli	Applicable for dieldrin, arsenic, and lead.	Not applicable to site contamination.	Applicable for arsenic, and lead	Applicable for die/drin	Applicable for dieldrin	Applicable for dieldrin
Descriptions	Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are allowed to reduce contaminant concentrations to acceptable levels.	Bioreactor combining contaminants, inducers and electron acceptor (oxygen) to enhance aerobic biodegradation. Inducers serve as carbon sources that activate aerobic enzyme systems known to degrade chlorinated VOCs (fortuitous cometabolism).	Bioreactor containing contaminants and electron donors to stimulate anaerobic biodegradation of chlorinated compounds by reductive dechlorination.	Chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert Reducing/oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide.	Containinated solh is screened, processed with a crusher and pug mill, and mixed with NaOH and catalysts. The mixture is heated in a rotary reactor to dehalogenate and partially volatilize the contaminants.	Used for halogenated aromatic compounds. Soils and an alkaline polyethylene glycol (APEG) reagent are mixed and heated in a treatment vessel, causing polyethylene glycol to replace halogens and render the compounds nonhazardous.	Contaminants sorbed onto fine soil particles and separated from bulk soil in an aqueous-based system. Wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals	Vacuum is applied to a network of aboveground piping to promote volatilization of organics from the excavated media. Includes a system for handling off gases.	Contaminants are physically bound or enclosed within a stabilized mass (solidification) , or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization)	Soil and solvent are mixed in an extractor, dissolving the organic contaminant into the solvent. The extracted organics and solvent are then placed in a separator, where the contaminants and solvent are separated for treatment and further use.	Soils are heated to target temperatures (up to 1000 F) to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system.	Soils are heated to very high temperatures 1,600 - 2,200 F (871-1,204 C) to combust organic constituents in the presence of oxygen.
Process Options	Natural Attenuation	Aerobic Cometabolic Bioremediation	Anaerobic Bioremediation	Chemical Oxidation	Reductive Dehalogenation: Based-Catalyzed (BCD)	Reductive Dehalogenation: Glycolate	Soil Washing	Soil Vapor Extraction	Solidification/Stabilization	Solvent Extraction	Thermal Desorption	Incineration
Remedial Technology Types	Other In-situ Treatment	Ex-situ Biological Treatment		Ex-situ Physical/Chemical Treatment							Ex-situ Thermal Treatment	
General Response Actions	Treatment (continued)								-			

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 TABLE 2-3

 Primary Screening of Remedial Technologies and Process Options for Soil Contaminants Dieldrin, Arsenic, and Lead

 Memphis Depot Main Installation Soils FS - 7/3/00

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Treatment Ex-situ Therma (continued) Treatment (continued)	Pvrolvsis	nescriptions		Screen?
	, ,	Chemical decomposition is induced in organic materials by heat in the absence of oxygen Organic materials are transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash	Applicable for dieldrin.	Yes
	Vitrification	Contaminated soils are melted at high temperature to form a glass and crystalline structure with very low leaching charactenstics	Applicable for dieldrin, arsenic, and lead	Yes
Disposal Land Applicatio	Land Application	Solid wastes that are primarily organic are incorporated into the upper soil honzon so they can be degraded, transformed, or immobilized	Can be used in conjunction with in-situ biological treament.	Yes
Landfill	Hazardous Waste Landfill	Solid hazardous wastes are permanently disposed of in a RCRA-permitted landfill.	Applicable for arsenic, dieldrin, and lead, in conjunction with removal.	Yes
	Non-Hazardous Waste Landfill	Solid nonhazardous wastes are permanently disposed of in a non-hazardous RCRA-permitted landfill.	Applicable for arsenic, dieldrin, and lead, in conjunction with removal.	Yes

TABLE 2-3 Primary Screening of Remedial Technologies and Process Options for Soil Contaminants⁻ Dieldrin, Arsenic, and Lead *Memphis Depot Main Installation Soils FS - 7/3/00*

General Response	Remedial				Pass Secondary
Actions	Technology Types	Process Options	Descriptions	Secondary Screening Comments	Screen?
No Action	None	None	No further actions to address contaminated soils.	Retained per CERCLA	Yes
Institutional Controls	Access and Use Restrictions	Deed Restrictions	Deed restrictions issued for property within potentially contaminated areas to restrict property use. Property transfer documents will include use restrictions.	Transfer documents will include use restrictions.	Yes
		Fences	Security fences installed around potentially contaminated areas to limit access The Memphis Redevelopment Plan states that current fences will be maintained.	Limit access to planned users.	Yes
Containment	Capping ·	Native Soil	Uncontaminated native soil placed over contaminated areas.	Native soil with erosion contol, Applicable for As, Pb, dieldrin.	Yes
		Clay Cap	Compacted clay placed over contaminated area. Clay should be covered by at least a foot of sithy sand or sandy soil to maintain the integrity of the clay cap.	More expensive than native soil option.	ON
		Synthetic Membranes	Synthetic membrane placed over prepared soil or geotextile surface that is over a contaminated area. The membrane is seamed by a variety of methods. The membrane must be compatible with the wastes present.	More expensive than native soil option	MO
		Asphalt or Concrete Cap	Paving grade asphalt or concrete placed over prepared contaminated area. Fill settlement must be evaluated in considering a concrete cap design.	More expensive than native soil or clay, but would become part of required infrastructure Would require deed restrictions to prevent removal	Yes
		Muttilayered Cap	Cap may be composed of natural soils, soil admixtures, clay, synthetic membranes, spray-on asphalts, asphalt concrete, or Portland cement concrete and placed over contaminated areas. If property designed, will meet RCRA requirements.	More expensive than native soil or clay	PIO
	Surface Controls	Grading	Reshaping of topography to manage surface water infiltration and runoff to control erosion.	Supports other technologies.	Yes
		Revegetation	A systematic revegetation plan includes selection of a suitable plant species, seedbed preparation, seeding/planting, mulching and/or chemical stabilization, fertilization, and maintenance	Supports other technologies.	Yes
		Erosion Control	Natural or man-made materials used to prevent erosion and subsequent exposure to /transport of contaminated soils.	Supports other technologies	Yes
		Diversion and Collection Systems	Diversion and collection structures installed upslope or at perimeter of the site to control drainage of stormwater runoff. System can also be implemented to collect contaminated surface water from excavations for remediation.	Supports other technologies.	Yes
Removal	Excavation	Excavation	Excavation of contaminated solids can use ordinary construction equipment backhoes, bulldozers, and front-end loaders(s)	Applicable to dieldrin, arsenic, and Pb, supports other technologies.	Yes
Treatment	In-situ Biological Treatment	Phytoremediation	Use of plants and their associated rhizospheric mocroorganisms to remove, degrade, or contain chemical contaminants in soil.	Applicable for As, Pb	Yes
		Bioremediation Enhancements	Use of various process options (thermal, physical, and/or biochemical) to optimize in-situ anaerobic or aerobic biodegradation.	Venture's biological process applicable for dieldrin.	Yes

General Response	Remediat				Pass Secondary
Actions	Technology Types	Process Options	Descriptions	Secondary Screening Comments	Screen?
Treatment (continued)	In-situ Physical- Chemical Treatment	Solidification/Stabilization (S/S)	Solidification agents physically bind contaminants within a stabilized mass Stabilizing agents react with contaminants to reduce their mobility. Auger/caisson systems and injector head systems are used to apply S/S agents to in-situ soils	Applicable for dieldrin, As, and Pb.	Yes
	Other In-situ Treatment	Natural Attenuation	Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are allowed to reduce contaminant concentrations to acceptable levels.	Applicable for dieldrin	Yes
	Ex-situ Physical/Chemical Treatment	Chemical Oxidation	Chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. Reducing/oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide.	More expensive than other treatment actions.	ON
		Soil Washing	Contaminants sorbed onto fine soil particles and separated from bulk soil in an aqueous-based system. Wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals.	Applicable for arsenic, dieldrin, and Pb	Yes
		Solidification/Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification) , or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Applicable for arsenic, dieldrin, and Pb	Yes
		Solvent Extraction	Soil and solvent are mixed in an extractor, dissolving the organic contaminant into the solvent. The extracted organics and solvent are then placed in a separator, where the contaminants and solvent are separated tor treatment and further use.	Generates a second waste to have to manage onsite.	Mo
	Ex-stu Thermal Treatment	Thermal Desorption	Soils are heated to target temperatures (up to 1000 F) to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system.	Expensive, but effective and proven.	Yes
		Incineration	Soils are heated to very high temperatures 1,600 - 2,200 F (871-1,204 C) to combust organic constituents in the presence of oxygen.	More expensive than other treatment actions	ON
		Pyrolysis	Chemical decomposition is induced in organic materials by heat in the absence of oxygen. Organic materials are transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash.	More expensive than other treatment actions	No.
		Vitrification	Contaminated soils are melted at high temperature to form a glass and crystalline structure with very low leaching characteristics.	More expensive than other treatment actions.	ON
Disposal	Land Application	Land Application	Solid wastes that are primarily organic are incorporated into the upper soil horizon so they can be degraded, transformed, or immobilized.	Applicable for dieldrin and can be used in conjunction with in- situ biological treatment.	Yes
	Landfill	Hazardous Waste Landfill	Solid hazardous wastes are permanently disposed of in a RCRA-permitted landfill	Applicable for dieldrin, arsenic, and Pb, in conjunction with removal.	Yes
		Non-Hazardous Waste Landfill	Solid nonhazardous wastes are permanently disposed of in a non-RCRA landfill	Arsenic, dieldrin and Pb - TCLP, in conjunction with removal	Yes

 TABLE 2-4

 Secondary Screening of Remedial Technologies and Process Options for Soil Contaminants: Dieldrin, Arsenic, and Lead

 Memphis Depot Main Installation Soils FS - 7/3/00

General Response Actions	Remedial Technology Types	Process Options	Descriptions
No Action	None	None	No further actions to address contaminated soils
Institutional Controls	Access and Use Restrictions	Deed Restrictions	Deed restrictions issued for property within potentially contaminated areas to restrict property use
		Fences	Security fences installed around potentially contaminated areas to limit access.
Containment	Capping	Native Soil	Uncontaminated native soil placed over contaminated areas
		Asphalt or Concrete Cap	Paving grade asphalt or concrete placed over prepared contaminated area Fill settlement must be evaluated in considering a concrete cap design
	Surface Controls	Grading	Reshaping of topography to manage surface water infiltration and runoff to control erosion
		Revegetation	A systematic revegetation plan includes selection of a suitable plant species, seedbed preparation, seeding/planting, mulching and/or chemical stabilization, fertilization, and maintenance.
		Erosion Control	Natural or man-made materials used to prevent erosion and subsequent exposure to /transport of contaminated soils
		Diversion and Collection Systems	Diversion and collection structures installed upslope or at perimeter of the site to control drainage of stormwater runoff System can also be implemented to collect contaminated surface water from excavations for remediation
Removal	Excavation	Excavation	Excavation of contaminated solids can use ordinary construction equipment backhoes, buildozers, and front-end loaders(s)
Treatment	In-situ Biological Treatment	Phytoremediation	Use of plants and their associated rhizospheric mocroorganisms to remove, degrade, or contain chemical contaminants in soil
		Bioremediation Enhancements	Use of various process options (thermal, physical, and/or biochemical) to optimize in-situ anaerobic or aerobic biodegradation.
	In-situ Physical- Chemical Treatment	Solidification/Stabilization (S/S)	Solidification agents physically bind contaminants within a stabilized mass Stabilizing agents react with contaminants to reduce their mobility Auger/caisson systems and injector head systems are used to apply S/S agents to in-situ soils

TABLE 2-5 Final Remedial Technologies and Process Options for Soil Contaminants' PAH, Dieldrin, Arsenic, and Lead

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General Response Actions	Remedial Technology Types	Process Options	Descriptions
	Other in-situ treatment	Natural Attenuation	Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are allowed to reduce contaminant concentrations to acceptable levels
	Ex-situ Physical/Chemical	Soil Washing	Contaminants sorbed onto fine soit particles and separated from bulk soil in an aqueous-based system. Wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals
		Solidification/Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization)
	Ex-situ Thermal Treatment	Thermal Desorption	Soils are heated to target temperatures (up to 1000 F) to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system.
Dısposal	Land Application	Land Application	Solid wastes that are primarily organic are incorporated into the upper soil horizon so they can be degraded, transformed, or immobilized
	Landill	Hazardous Ŵaste Landíli	Solio nazaroous wastes are permanentiy disposed of in a RCHA-permitteo landili
		Non-Hazardous Waste Landfill	Solid nonhazardous wastes are permanently disposed of in a non-RCRA landfill

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TABLE 2-6

Screening Summary of GRAs and Process Options Retained for Alternative Development	
Memphis Depot Main Installation Soils FS – 7/3/00	

Medium	General Response Action	Remedial Technology Type	Process Option
Surface Soil	No Action	None	None
	Institutional Controls	Access and Use Restrictions	Deed Restrictions Fences
	Containment	Capping	Native Soil
		Surface Controls	Grading Revegetation Erosion Control Diversion and Collection Systems
	Removal	Excavation	Excavation
	Treatment	In-situ Biological Treatment	Phytoremediation Bioremediation Enhancements
		In-situ Physical-Chemical Treatment	Solidification/Stabilization
		Other In-situ Treatment	Natural Attenuation
		Ex-situ Physical/Chemical Treatment	Soil Washing Solidification/Stabilization
		Ex-situ Thermal Treatment	Thermal Desorption
	Disposal	Land Application	Land Application
			RCRA Landfill Non-RCRA Landfill

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TAB

Section 3

3.0 Development and Screening of Alternatives

This section develops preliminary and potential remedial alternatives for surface soil at the MI. This alternative development phase of the FS process occurs in three segments:

- Development of preliminary alternatives (Section 3.1);
- Screening of the preliminary alternatives to arrive at final alternatives (Section 3.2); and,
- Detailed analysis of final alternatives (Section 4).

The primary objective of alternative development and screening is to produce an appropriate range of (surface soil) contaminant management options that will be analyzed more fully in the detailed analysis phase of the FS (Section 4).

Remedial alternatives are developed and screened on their ability to achieve RAOs. The first screening is on the basis of relative effectiveness, implementability, and cost, thereby determining which alternatives will be evaluated in detail in the final phase of the FS (Section 4). The three steps of the process include:

- 1. Create an initial list of preliminary alternatives and define them using applicable technologies;
- 2. Screen the preliminary alternatives for redundancy to develop a smaller list of potential alternatives; and
- 3. Screen the potential alternatives for effectiveness, implementability, and cost to develop a smaller list of final alternatives that are carried forward for detailed evaluation in Section 4.

3.1 Development of Preliminary Alternatives

For CERCLA actions, the range of alternatives should include the following:

- A no action alternative;
- One or more alternatives that involve containment with little or no treatment; and
- A range of alternatives in which treatment addresses the principal threat and eliminates or minimizes the need for long-term management (EPA, 1988).

Section 121(b) of CERCLA identifies the following statutory preferences when developing and evaluating remedial alternatives:

- Remedial actions involving treatment that permanently and significantly reduces the toxicity, mobility, and volume of the COCs are preferred;
- Off-site transport and disposal of COCs without treatment is considered the least favorable remedial action when practical treatment technologies are available; and

• Remedial actions that use permanent solutions, alternative treatment technologies, or resource recovery technologies are to be assessed.

Based on an evaluation of process options retained after the screening processes presented in Section 2, appropriate technology process options were combined to provide preliminary remedial alternatives These are shown in Table 3-1.

In this section, preliminary alternatives are initially developed that address site COCs, irrespective of the FUs they may be found in. In Section 4. specific COCs within each FU are considered as they apply to the alternative. Many remedial alternatives could have been generated for surface soil by exhaustively combining all technologies. However, for this FS, only a limited number of alternatives representing reasonable and practical remedial approaches were developed. These preliminary remedial alternatives are not intended to preclude consideration of other similar remedial alternatives that may also be suitable. Rather, they are proposed as the most common and implementable on the basis of recent experience in the remediation industry. For example, phytoremediation is relatively less proven than bioremediation, so it is not specifically included in an alternative. If, during the process of remedy selection and implementation, this or other technologies emerge as better applications than those developed herein, each should be reevaluated.

3.1.1 Alternative 1 – No Action

The no action alternative would leave contaminated surface soil in place. Some biodegradation of dieldrin and chemical reactions with subsurface materials would be expected to occur naturally over time However, this contaminant reduction would not be monitored as part of this alternative.

3.1.2 Alternative 2 – Institutional Controls

Alternative 2 would leave contaminated soil in place, but would involve deed restrictions limiting the use/sale of the property or portions of the property; regulation of intrusive activities during which potential receptors could encounter COCs; maintenance of access barriers to limit entry into contaminated areas; and periodic inspection for soil disturbance or migration of COCs. Some biodegradation of dieldrin and chemical reactions with subsurface materials would be expected to occur naturally over time.

3.1.3 Alternative 3 – Soil Containment

Alternative 3 involves the placement of a soil or pavement protective cover over contaminated surface soil to act as a physical barrier against direct contact. Natural clean soil, asphalt, concrete or other material from off-site would be placed over contaminated areas. Surface controls would be necessary to prevent erosion damage to a soil cover. This alternative would require deed restrictions limiting the use/sale of the property or portions of the property; regulation of intrusive activities during which potential receptors could encounter COCs; maintenance of access barriers to limit entry into contaminated areas; and periodic inspection for cover disturbance. Some biodegradation of dieldrin would be expected to occur naturally over time.

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3.1.4 Alternative 4 – In-situ Soil Treatment

Alternative 4 includes treatment for pesticide- and metal-contaminated surface soils. Dieldrin-contaminated surface soil would be treated with nutrients to enhance bioremediation, as recommended by Venture Capital Associates (1999) as a result of the bench-scale treatability study. Surface soil contaminated with metals (arsenic and lead) would be treated with a stabilizing chemical to fix (immobilize) the constituents. These stabilizing agents physically bind constituents within a stabilized mass. Tilling and injector head systems are used to apply stabilizing agents to in-situ soil. Some form of institutional controls would be necessary to limit site use during implementation.

3.1.5 Alternative 5 – Excavation and Ex-situ Biological Treatment

Alternative 5 also includes treatment for pesticide- and metal-contaminated surface soils, but the soil is excavated first and treated in piles or reactor cells. For dieldrin, the technology is similar to composting: combining constituents, inducers, and electron acceptors (oxygen) to enhance aerobic biodegradation. For arsenic- and lead-impacted soil, chemicals are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and chemicals to reduce their mobility (stabilization). All treated material would be returned to the excavated areas or otherwise incorporated into the upper soil horizon on-site. Some form of institutional controls would be necessary to limit site use during implementation.

3.1.6 Alternative 6 – Excavation and Ex-situ Thermal Treatment

Alternative 6 also includes treatment for pesticide- and metal-contaminated surface soils, but the soil is excavated first and treated in piles or reactor cells. For dieldrin, the soil is heated to target temperatures (up to 1,000 degrees Fahrenheit [°F]) to volatilize water and organic chemicals. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system. For arsenic- and lead-impacted soil, chemicals are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and chemicals to reduce their mobility (stabilization). All treated material would be returned to the excavated areas or otherwise incorporated into the upper soil horizon on-site.

3.1.7 Alternative 7– Excavation, Transportation, and Off-site Disposal

Alternative 7 includes excavation of contaminated surface soil, and transportation and permanent off-site disposal in a RCRA-permitted landfill as an industrial waste or hazardous waste, depending on levels of contamination and landfill requirements. Thus, all COCs are disposed of off-site.

3.2 Screening of Preliminary Alternatives

In this section, the initial list of surface soil remediation preliminary alternatives presented in Table 3-1 and described above is screened for redundancy and elimination of similar technologies. The following table and discussion documents this initial screening process and presents the list of potential alternatives for more detailed screening.

Alternative	Retained for Further Evaluation	Eliminated from Consideration	Key Screening Comments
1	v	· ·· · · · · · · · · · · · · · · · · ·	Keep per CERCLA
2	~		Controls are viable
3	~		Cover is viable
4	~		Viable and includes treatment
5	~		Viable and includes treatment
6	~		Viable and includes treatment
7	~		Permanent removal

All seven preliminary surface soil alternatives are retained for further screening as potential alternatives.

Alternative 1, No Action, is retained per CERCLA requirements.

Alternative 2, Institutional Controls, and Alternative 3, Soil Containment, are both viable and are therefore retained.

Alternative 4, In-situ Soil Treatment; Alternative 5, Excavation and Biological Treatment; and Alternative 6, Excavation and Thermal Treatment, have similarities. In Alternative 4, the soil is treated in place. Alternatives 5 and 6 involve excavation and ex-situ treatment to immobilize the metals-contaminated soil with fixation. However, the pesticide-contaminated soil is treated biologically ex-situ in Alternative 5 and thermally ex-situ in Alternative 6. All three alternatives satisfy the CERCLA preference for treatment. They are all retained for further screening.

Alternative 7, Excavation, Transportation, and Off-site Disposal, is retained as the alternative that permanently removes the risk from the site by transferring it to an off-site facility.

3.3 Screening of Potential Alternatives

3.3.1 Screening Criteria

This section defines each of the screening criteria used for this phase of the screening process — relative effectiveness, implementability, and cost. Potential alternatives with the most favorable composite appraisal of effectiveness, implementability, and cost are carried forward as final alternatives for detailed analysis in Section 4. Alternatives that are considered effective and implementable are not eliminated on the basis of cost alone.

3.3.1.1 Effectiveness

Effectiveness is the degree to which an alternative safeguards human health by reducing potential human exposure to contaminated media, and protects the environment by preventing further transport of the constituents. Alternatives that meet this criterion are

considered effective; alternatives that are relatively less effective or not effective are eliminated from further consideration.

3.3.1.2 Implementability

Implementability refers to the technical and administrative feasibility of implementing the option.

Technical feasibility refers to the ability of process options to be constructed and reliably operated, and to meet technology-specific regulations until a remedial action is complete; the term also includes operations and maintenance (O&M), replacement, and monitoring of technical components after the remedial action is complete, if such monitoring is required.

Administrative feasibility refers to the ability to obtain approvals from other offices and agencies; the availability of treatment, storage, and disposal services and capacity; and the requirements for, and availability of, specific equipment and technical specialists. Options that are technically or administratively difficult may be eliminated from further consideration.

3.3.1.3 Cost

Cost refers to the present worth of construction and long-term O&M costs. At this stage of analysis, costs are discussed qualitatively. Detailed cost analyses for the final alternatives remaining after screening appear in Section 4.

3.3.2 Alternative 1 – No Action

3.3.2.1 Description

The no action alternative leaves contaminated soil in place. Biodegradation of dieldrin is expected to occur naturally over time. Some risks are reduced if future development includes significant pavement of contaminated areas, but with "no action" there are no assurances or controls.

3.3.2.2 Evaluation

Alternative 1 does not guarantee any reduction in the toxicity, mobility, or volume of any contamination at the site. Under Alternative 1, the potential pathways continue to exist, and the COCs in soil may migrate. Because the concentrations of COCs in soil exceed risk-based RGOs, and there is no action to limit potential exposure, the no action alternative is not considered viable. However, as required by CERCLA, it will be retained as an alternative.

Effectiveness. The no action alternative relies entirely on natural attenuation processes to remediate dieldrin contamination at the site, and on existing land use controls to prevent residential use. Dieldrin 18 known to be persistent and is not expected to attenuate rapidly. Lead or arsenic contamination would not be remediated under these conditions. The effectiveness of this alternative is unpredictable.

Implementability. Implementability is not an issue for the no action alternative because nothing is implemented.

Cost. Alternative 1 has no associated costs.

3.3.3 Alternative 2 – Institutional Controls

3.3.3.1 Description

The institutional controls alternative leaves contaminated surface soil in place, but involves deed restrictions prohibiting the future use/sale of the property or portions of the property for residential use. These restrictions could be part of the Depot reuse implementation plans. Under this alternative, the site would have to be inspected periodically to ensure that restricted site development does not occur. Biodegradation of dieldrin is expected to occur naturally over time.

3.3.3.2 Evaluation

With Alternative 2, organic dieldrin contamination at the site is expected to attenuate over time. However, dieldrin is known to be persistent and is not expected to attenuate rapidly. Institutional controls do not guarantee any reduction in the toxicity, mobility, or volume of arsenic and lead contamination at the site, except that future pavement would reduce the mobility of contaminated soil. Otherwise, under this alternative, the potential pathways continue to exist and COCs could continue to migrate.

Effectiveness. The institutional controls alternative relies primarily on natural attenuation processes to remediate dieldrin contamination at the site. Lead or arsenic contamination is not remediated under these conditions. The time required for constituents to attenuate below target levels is difficult to predict; therefore, protectiveness depends on preventing access to the site constituents. Long-term protectiveness 15 uncertain.

Implementability. Institutional controls involve legal instruments such as deed restrictions, and long-term custodial care. These services are not difficult to obtain, but long-term care is not always reliable.

Cost. Costs for the institutional controls alternative are relatively low. Some ongoing maintenance costs are associated with periodic site inspections and remedy evaluations to verify access limitations and continued remedy effectiveness.

3.3.4 Alternative 3 – Soil Containment

3.3.4.1 Description

The soil containment alternative includes some institutional controls, but also involves the placement of a cover material over contaminated soil to act as a physical barrier against direct contact. Pavement can be incorporated into areas requiring a cover. This alternative requires deed restrictions limiting the use/sale of the property or portions of the property; regulation of intrusive activities through which potential receptors could encounter constituents; and maintenance of access barriers to limit entry into contaminated areas. These restrictions could be part of the Depot reuse implementation plans. Under this alternative, site soil containment systems have to be inspected periodically for disturbance. Biodegradation of dieldrin and chemical reactions with subsurface materials is expected to occur naturally over time.

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3.3.4.2 Evaluation

With Alternative 3, organic dieldrin contamination at the site is expected to attenuate over time. However, dieldrin is known to be persistent and is not expected to attenuate rapidly. The soil cover or pavement provides a barrier, preventing direct exposure to contamination. It does not guarantee any reduction in the toxicity or volume of lead or arsenic contamination, but would reduce its mobility somewhat.

Effectiveness. The soil containment alternative protects human health by preventing direct contact with contaminated soil. Soil containment relies primarily on a physical barrier preventing exposure to contaminated soil. Natural attenuation processes may remediate dieldrin contamination at the site, but the time required for constituents to attenuate below target levels is difficult to predict.

Implementability. Institutional controls involve legal instruments such as deed restrictions and long-term custodial care. These services are not difficult to obtain, but long-term care is not always reliable.

Material from off-site is used for the soil cover or pavement. Dust control would be considered, and surface controls are necessary to prevent erosion damage to a soil cover. Routine O&M is required to maintain integrity of the cover, as well as periodic site inspections and cover evaluations to verify access limitations and continued remedy effectiveness.

Cost. Costs for soil containment are moderately low. They include excavation, hauling, and placement of natural soil or paving on top of contaminated soil. Costs may range from \$5 to \$50 per ton of cover material, with the lower end of the range corresponding to a large volume of excavated soil not requiring extensive transport. Some ongoing maintenance costs are associated with site inspection and maintenance of cover material.

3.3.5 Alternative 4 – In-situ Soil Treatment

3.3.5.1 Description

The in-situ soil treatment alternative leaves contaminated soil in place and provides in-situ treatment for pesticide- and metal-contaminated soils. In this alternative, the soil is treated to increase the bioremediation rate or immobilize constituents. Alternative 4 includes several potential processes. For example, soil may be treated with water-based solutions or dry powders containing nutrients, oxygen, microorganisms, or other amendments to optimize in-situ anaerobic or aerobic biodegradation. Water-based solutions may be injected or sprayed over dieldrin-contaminated soil. Concentrated dry powders can be broadcast like dry fertilizer and then irrigated with water. This method is referred to as "enhanced biodegradation."

Dieldrin-contaminated surface soil would typically be aerated with a rolling aerator to increase the biodegradation rate. Alternately, the soil may be tilled in place to achieve aeration. Tilling the soil also provides a method for introducing amendments, such as nutrients and microorganisms, to the soil. This latter method is referred to as "land treatment." Either of the above methods may be used alone or in combination to achieve the best conditions for in-situ bioremediation at a particular site.

Metal-contaminated soil is treated with a stabilizing chemical to fix (immobilize) the soil. These stabilizing agents physically bind constituents within a stabilized mass. Chemicals may be applied using methods similar to those used for fertilizer and tilled into the soil. This technology is known as "stabilization."

Soil contaminated with both organic compounds and metals requiring fixation is treated first for organics, and then fixed to immobilize the metals

3.3.5.2 Evaluation

With Alternative 4, dieldrin contamination at the site attenuates over time and the mobility of the lead and arsenic is reduced due to treatments. A site-based pilot study has shown success with bioremediation of pesticide-contaminated soil (Venture, 1999).

Effectiveness. This alternative effectively safeguards human health through treatment of contaminated soil. The in-situ soil treatment alternative relies on enhanced bioremediation processes to remediate dieldrin contamination at the site. The rate of enhanced biodegradation is relatively high in comparison to natural degradation processes, but may still require several years to implement. Land treatment and aeration may have faster results than simply enhanced biodegradation. In pilot studies, in-situ bioremediation of pesticides in soil has achieved cleanup efficiencies exceeding 80 percent (Venture, 1999). Values for insitu biodegradation in the field are often close to or above this value and are highest when a combination of land treatment, irrigation, and enhanced biodegradation is used.

The in-situ soil treatment alternative also relies on the physical/chemical treatment process of stabilization to immobilize lead and arsenic contamination. The in-situ soil treatment may take 2 to 3 years to reduce the volume and toxicity of dieldrin contamination and several months to stabilize lead or arsenic contamination.

Implementability. For enhanced biodegradation, the use of water-based solutions or the irrigation of dry powders may increase the mobility of some constituents. For land treatment, depth of treatment is limited to the depth of available tilling equipment. Dust control must be considered, and soil conditions may need to be controlled. Adequate monitoring and environmental safeguards are required, especially for runoff from the site. Monitoring of the biological processes is required to confirm biodegradation rates and process adjustments that may be needed.

The stabilization process can result in solidified material that may affect future use of the site. Some processes within this treatment may result in a significant increase in volume.

Substantive requirements of the NPDES permit must also be addressed with this alternative. These include control of sediment runoff in stormwater during the removal/remedial actions, and may include collecting stormwater samples to verify if any contamination is migrating offsite during these actions. Additionally, the site must be reasonably returned to its pre-action status by replacing sod and performing other landscaping as necessary.

Cost. Costs for Alternative 4 are moderately low and depend on initial and target concentrations, quantity of soil treated, depth of contamination, soil characteristics, amount of debris, characteristics of any residual, site preparation, and equipment needs.

Typically, costs for in-situ biological treatment range from \$16 to \$80 per ton of treated soil to a depth of 1 foot. The lower end of that range corresponds to a small site with shallow contaminated soil, a small difference between initial and target concentrations, adequate soil moisture and permeability, and few equipment requirements.

Typical costs for in-situ stabilization are \$64 to \$96 per ton of treated soil to a depth of 1 foot with a mixing/auger technique.

Costs for preventing sediment runoff, monitoring stormwater runoff, and post-action landscaping vary with the size of the site and the type of action. Stormwater runoff costs are assumed to be minimal, by using passive controls such as hay bales and silt screens. Costs for post-action landscaping also vary with pre-vegetation and the size of the site, but are assumed to average \$5,000 per acre.

3.3.6 Alternative 5 – Excavation and Ex-situ Biological Treatment

3.3.6.1 Description

The excavation and ex-situ biological treatment alternative also includes treatment for pesticide- and metal-contaminated soils, but the soil is excavated first and treated in piles or reactor cells to biodegrade or immobilize constituents. All treated material is then incorporated into the upper soil horizon on-site.

Alternative 5 could involve a number of techniques. For example, excavated soil could be mixed with bulking agents, soil amendments, or wood chips, hay, manure, or vegetative wastes. This mixture could then be formed into piles and aerated (biopiles), mechanically agitated, or placed into long piles and turned periodically. This method is referred to as "composting."

Excavated soil could be placed into lined beds and periodically tilled to achieve aeration. Contaminated soil would be treated in lifts. This method is referred to as "landfarming."

Alternatively, excavated soil could be combined with water and other additives to create an aqueous slurry, which is mixed within a bioreactor. After treatment, the soil is dewatered. This method is referred to as "slurry phase biological treatment."

Excavated soil could be mixed with a specially cultivated fungus, such as white rot fungus. This mixture is placed in a reactor or on a plastic liner, as in composting.

Metal-contaminated soil would be treated ex-situ with a stabilizing chemical to fix (immobilize) the soil. These stabilizing agents physically bind constituents within a stabilized mass. Chemicals may be applied with methods similar to those used for fertilizer and tilled into the soil. This technology is known as "solidification/stabilization."

Soil contaminated with both organic compounds and metals requiring fixation are treated first for organics, and then fixed to immobilize the metals.

3.3.6.2 Evaluation

With Alternative 5, dieldrin-contamination at the site attenuates over time and the mobility of the lead and arsenic is reduced due to treatments. A site-based pilot study has shown success with bioremediation of pesticide-contaminated soil (Venture, 1999). Because soil is

excavated, the potential pathways for chemical migration are removed during the period of treatment.

Effectiveness. This alternative effectively safeguards human health through treatment of contaminated soil.

Similar to Alternative 4 in effectiveness, the excavation and ex-situ biological treatment alternative relies on enhanced bioremediation processes on excavated soil to remediate dieldrin contamination at the site. Because biodegradation is enhanced by the ex-situ mixing, it should occur at higher rates.

Composting or slurry phase biological treatment may produce faster results than landfarming or fungal bioremediation

This alternative relies on the physical/chemical treatment process of stabilization to immobilize lead and arsenic contamination. The excavation and biological treatment alternative may take several weeks to a few years to reduce the volume and toxicity of dieldrin contamination and several months to stabilize lead or arsenic contamination.

Implementability. All contaminated soil is excavated and treated.

Both composting and landfarming require a large amount of space to implement. Further, composting results in a volumetric increase in material, and landfarming may require the use of dust controls. Slurry phase treatment requires a sizing of soil particles before the slurry can be placed in the reactor. White rot fungus may be subject to competition from native bacterial populations, toxicity inhibition, and chemical sorption.

The stabilization process can result in solidified material that may affect future use of the site. Some processes of this treatment may produce a significant increase in volume.

Substantive requirements of the NPDES permit must also be addressed with this alternative. These include control of sediment runoff in stormwater during the removal/remedial actions, and may include collecting stormwater samples to verify if any contamination is migrating off-site during these actions. Additionally, the site must be reasonably returned to its pre-action status, by replacing sod and performing other landscaping as necessary.

Cost. Costs for this alternative are moderate to moderately high and depend on initial and target concentrations, the quantity of soil treated, the depth of contamination, soil characteristics, the amount and characteristics of any residual contamination, site preparation, equipment needs, methods for excavation, and transportation.

Excavation and hauling costs may range from \$5 to \$50 per ton, with the lower end of that range corresponding to a large amount of soil that does not have to be transported a long distance.

Typical costs for ex-situ stabilization on excavated soil are generally less than \$100 per ton of treated soil, including excavation costs.

Typical costs for ex-situ biological treatment may range from \$40 to \$600 per ton of treated soil, with slurry phase biological treatment and white rot fungus being the most expensive. The lower end of that cost range corresponds to a site treated with the landfarming technique, with shallow contaminated soil, a small difference between initial and target

concentrations, adequate soil moisture, high permeability, the presence of microorganisms, and low requirements for materials and monitoring.

Costs for preventing sediment runoff, monitoring stormwater runoff, and post-action landscaping vary with the size of the site and the type of action. Stormwater runoff costs are assumed to be minimal, by using passive controls such as hay bales and silt screens. Costs for post-action landscaping also vary with pre-vegetation and the size of the site, but is assumed to average \$5,000 per acre.

3.3.7 Alternative 6 – Excavation and Ex-situ Thermal Treatment

3.3.7.1 Description

The excavation and ex-situ thermal treatment alternative also includes treatment for pesticide- and metal-contaminated soils, but the dieldrin-contaminated soil is excavated and thermally treated in enclosed ovens, piles, or reactor cells. Metal-contaminated soil is treated the same as in Alternative 5. All treated material is then incorporated into the upper soil horizon on-site.

For dieldrin, the soil is usually treated with high temperature thermal desorption (HTTD), which uses temperatures of 600 to 1,000 °F to volatilize water and organic chemicals. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system, which removes particulate and chemicals. The particulate is removed with conventional equipment, such as wet scrubbers or fabric filters. Constituents may be removed through condensation and carbon adsorption or in a secondary combustion chamber or catalytic oxidizer. After treatment, the gas can be released to the air. Potential air monitoring may be required.

Metal-contaminated soil is ex-situ with a stabilizing chemical to fix (immobilize) the soil. These stabilizing agents physically bind chemicals within a stabilized mass. Chemicals may be applied with methods similar to those used for fertilizer and tilled into the soil. This technology is known as "solidification/stabilization."

Soil contaminated with both organic compounds and metals requiring fixation is treated first for organics, and then fixed to immobilize the metals.

3.3.7.2 Evaluation

With Alternative 6, dieldrin-contaminated soil at the site is treated thermally and the dieldren is removed from the soil. The mobility of the lead and arsenic is reduced due to treatments. Because soil is excavated, the potential pathways for chemical migration are removed during the period of treatment.

Effectiveness. This alternative effectively safeguards human health through treatment of contaminated soil.

Similar to Alternatives 4 and 5 in effectiveness, the excavation and thermal treatment alternative relies on thermal processes to remediate dieldrin contamination. Removal efficiencies for excavation and thermal treatment of soil have been documented at greater than 90 percent. Any residual concentrations in treated soils would continue to degrade naturally with time

This alternative relies on the physical/chemical treatment process of stabilization to immobilize lead and arsenic contamination. The excavation and thermal treatment alternative may take several weeks to a year to reduce the volume and toxicity of dieldrin contamination and several months to stabilize lead or arsenic contamination.

Implementability. All contaminated soil is excavated and treated.

Thermal treatment requires specific soil sizes and materials handling methods. If the soil moisture is too high, dewatering may be necessary. Also, clay, silty soil, and highly humic soil may increase the reaction time required as a result of binding.

The capacity of HTTD ovens is limited, and their installation at a site requires substantial mobilization and setup time. Off-gases, even when treated, may be unacceptable to the community or local regulators.

The stabilization process can result in solidified material that may affect future use of the site. Some processes of this treatment may produce a significant increase in volume.

Substantive requirements of the NPDES permit must also be addressed with this alternative. These include control of sediment runoff in stormwater during the removal/remedial actions, and may include collecting stormwater samples to verify if any contamination is migrating off-site during these actions. Additionally, the site must be reasonably returned to its pre-action status, by replacing sod and performing other landscaping as necessary.

Cost. Costs for Alternative 6 would be moderately high to high because this technology requires a large startup cost. Costs depend on initial and target concentrations, the quantity of soil treated, the depth of contamination, soil characteristics, the amount and characteristics of any residual, site preparation, equipment needs, and methods for excavation and transportation.

Excavation and hauling costs to move excavated soil to the thermal treatment device may range from \$5 to \$50 per ton, with the lower end of that range corresponding to a large amount of soil that does not have to be transported a long distance.

Typical costs for ex-situ stabilization of excavated soil are generally less than \$100 per ton of treated soil, including excavation costs.

Typical costs for thermal treatment range from \$40 to \$300 per ton of treated soil. The lower end of that range corresponds to treatment at a site with a large amount of shallow soil, low soil moisture, and a small difference between initial and target concentrations.

Costs for preventing sediment runoff, monitoring stormwater runoff, and post-action landscaping vary with the size of the site and the type of action. Stormwater runoff costs are assumed to be minimal, by using passive controls such as hay bales and silt screens. Costs for post-action landscaping also vary with pre-vegetation and the size of the site, but are assumed to average \$5,000 per acre.

3.3.8 Alternative 7 – Excavation, Transportation, and Off-site Disposal

3.3.8.1 Description

The excavation, transportation, and off-site disposal alternative removes all contaminated soil and permanently disposes of pesticide-, arsenic- and lead-contaminated soil in a RCRA-permitted landfill as an industrial or hazardous waste.

3.3.8.2 Evaluation

With Alternative 7, contaminated soil is removed, reducing the possibility for COC migration or exposure.

Effectiveness. Alternative 7 effectively safeguards human health through the removal and controlled disposal of contaminated soil. This alternative relies on excavation to remove contamination at the site. The duration of this alternative depends on the quantity of soil, the number of loaders and trucks operating, and the availability of adequate containers to transport contaminated soil to a disposal facility. This alternative may take several months to implement.

Implementability. Implementation requires the use of on-site heavy equipment, an off-site landfill facility that can be used for soil disposal, transportation to the facility, and containers for contaminated soil. Confirmation sampling is required after excavation.

Substantive requirements of the NPDES permit must also be addressed with this alternative. These include control of sediment runoff in stormwater during the removal/remedial actions, and may include collecting stormwater samples to verify if any contamination is migrating off-site during these actions. Additionally, the site must be reasonably returned to its pre-action status, by replacing sod and performing other landscaping as necessary.

Cost. Costs for excavation, transportation, and off-site disposal can be moderate to high, and are dependent on the nature of the hazardous materials, methods used for excavation, transportation costs, and costs for disposal at the particular type of RCRA-permitted facility.

Typically, costs for hazardous waste landfill transportation and disposal range from \$270 to \$460 per ton. The costs for nonhazardous waste landfill transportation and disposal range from \$25 to \$150 per ton. The lower end of the ranges correspond to soil contaminated with less hazardous materials, an effective method of excavation, and a nearby disposal facility.

Costs for preventing sediment runoff, monitoring stormwater runoff, and post-action landscaping vary with the size of the site and the type of action. Costs for post-action landscaping also vary with pre-vegetation and the size of the site, but are assumed to average \$5,000 per acre.

3.4 Summary of Alternatives Screening

The relative merits of the potential alternatives were compared and screened on the basis of effectiveness, implementability, and cost. The following discussion documents this final screening.

Alternative	Retained for Further Evaluation	Eliminated from Consideration	Key Screening Comments
1	v		Keep per CERCLA
2	~		Quick and inexpensive
3	~		Cover could be an element of future infrastructure
4	v		Proven by pilot tests
5		\checkmark	Expensive and difficult to implement
6		~	Expensive and difficult to implement
7	~		Costly, but quicker than treatment

Thus, the final list of alternatives retained for further analysis are as follows:

- Alternative 1: No Action (required per CERCLA)
- Alternative 2: Institutional Controls
- Alternative 3: Soil Containment
- Alternative 4: In-situ Soil Treatment
- Alternative 7: Excavation, Transportation, and Off-site Disposal

These final surface soil alternatives are carried forward for detailed analyses in Section 4.

						Preliminary	Alternatives		
		f I	-	5	m	4	2	9	<u> </u>
	General Response Action	Technology Type	No Action	Institutional Controls	Containment (Capping)	In-situ Soll Treatment	Soil Excavation and Biological Treatment	Soil Excavation and Thermal Treatment	Soil Excavation and Off-site Disposal
Medium Surtace Soil	No Action	None	•						
	Institutional Controls	Access and Use Restrictions		•	•	•	•		
	Containment	Capping			•				
		Surface Controls			•				
	Removal	Excavation					•	•	•
	Treatment	In-situ Biological				•			
		In-situ Physical-Chemical				•			
		Other In-situ (Natural Attenuation)	•	•	•				
		Ex-situ Biological					•		
		Ex-situ Physical-Chemical					•	•	
•		Ex-situ Thermal						•	
·	Disposal	Land Application							
- 1		Landfill					•	•	•

TABLE 3-1 Summary of Preliminary Surface Soil Remedial Alternatives Memphis Depot Main Installation Soils FS –7/3/00

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Section 4

4.1 Approach

This section is intended to help decision-makers evaluate, and ultimately select, action alternatives for the surface soil in each FU at the MI of the Depot. The detailed analysis in this section follows the development and screening of alternatives presented in Section 3 and precedes the actual selection of alternatives in the Proposed Plan. Different alternative actions may be selected for the various FUs because of differences in the distribution and concentration of contaminants in the surface soil at each FU.

The final surface soil alternatives retained for detailed analysis in Section 3 are described and evaluated in this section. The components of this evaluation include the following:

- Further definition of each alternative, including volumes, technologies, and associated performance requirements;
- An assessment and summary profile of each alternative in comparison to the nine criteria prescribed by EPA pursuant to CERCLA (42 U.S. Code [U.S.C.] Sections 9601 through 9675); and
- A comparative analysis of the remedial alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.

A definition of the evaluation criteria and a detailed description of each alternative are presented in this section. Next, a detailed evaluation of the alternatives is presented for each alternative in narrative form, and for each FU in Tables 4-3 through 4-7. The narrative and tables describe how each alternative would perform in comparison to the evaluation criteria, and identify alternative-specific issues within the criteria. Finally, a comparative analysis is presented, evaluating each alternative in relation to one another for each of the nine evaluation criteria.

4.2 Evaluation Criteria

Pursuant to CERCLA and the NCP (40 CFR 300), a range of remedial action alternatives was developed and included in Section 3. Section 4 evaluates each alternative, describing its performance relative to the following NCP criteria:

- Protect human health and the environment;
- Comply with ARARs or define criteria for invoking a waiver;
- Be cost-effective;
- Use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and
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• Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element or explain why this is not attainable.

Since these requirements must be specifically addressed in the ROD, the alternatives are evaluated to show how remedial actions support these requirements. An alternative will not necessarily fulfill all requirements.

There are also statutory (CERCLA 121(b)(1)(A)) considerations that emphasize evaluating long-term effectiveness for each alternative, including:

- Long-term uncertainties associated with land disposal;
- Goals, objectives, and requirements of the Solid Waste Disposal Act;
- Persistence, toxicity, and mobility of hazardous substances and their constituents, and their propensity to bioaccumulate;
- Short- and long-term potential for adverse health effects from human exposure;
- Long-term maintenance costs;
- Potential for future remedial action costs if the alternative were to fail; and
- Potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment.

Nine standard EPA evaluation criteria were used in the detailed analyses to address the statutory considerations and additional technical and policy considerations. The alternatives are evaluated in comparison to these criteria, which are grouped into the following categories: threshold, balancing, and modifying.

4.2.1 Threshold Criteria

Threshold criteria must be met or complied with by the selected remedial action alternative. These criteria include overall protection of human health and the environment, and compliance with ARARs.

4.2.1.1 Overall Protectiveness (Criterion 1)

Under this criterion, each alternative is evaluated to determine its ability to reduce risk to human health and the environment. The evaluation is also used to assess whether the alternative poses unacceptable short-term or cross-media impacts. For each alternative, the evaluation includes the following determinations:

- How the source of contamination is to be reduced or controlled; and
- How the site-related risks to human health and the environment are to be reduced and whether target levels are attained.

4.2.1.2 Compliance with ARARs (Criterion 2)

Remedial actions for the cleanup of hazardous substances must comply with the requirements, criteria, standards, and limitations under federal or more stringent state environmental laws that are legally applicable, or relevant and appropriate, to the

hazardous substances or circumstances at a site. Regulations considered during this FS include the following:

- RCRA Applicable to the generation, transportation, storage, treatment, and disposal of hazardous waste during remedial action;
- Occupational Safety and Health Administration (OSHA) Applicable to the protection of site workers during remedial action; and
- Clean Air Act Applicable to local air quality requirements.
- Existing land use controls (LUCs) Currently, the MI is zoned as Light Industrial (I-L). The principal uses permitted are manufacturing, wholesaling, or warehousing. According to Section 24 of the Memphis and Shelby County zoning regulation, single family, or multi-family residential uses are prohibited. Under the Federal Property Management Regulations, FU2 is slated for transfer from the Department of Defense (Army) to the Department of Interior (DOI)/National Park Service (NPS). It will then be transferred by public benefit conveyance to the City of Memphis for use as a park. According to 41 CFR 101-47.308-7, property for use as a public park or recreational area must be used and maintained for the purpose for which it was conveyed in perpetuity, or be returned to the United States (24 CFR 51D).

4.2.2 Balancing Criteria

Balancing criteria are the five primary criteria on which analyses of remedial actions are based. The criteria provide decision-makers with a means to determine which alternative best achieves the remedial objectives. The balancing criteria are described in the following paragraphs.

4.2.2.1 Long-Term Effectiveness and Permanence (Criterion 3)

Long-term effectiveness and permanence are evaluated on the basis of magnitude of residual risk and the adequacy and reliability of controls used to manage remaining waste over the long term. Alternatives that afford the highest degree of long-term effectiveness and permanence are those that leave little or no waste at the site, make long-term maintenance and monitoring unnecessary, and minimize the need for institutional controls. The assessment of long-term effectiveness should include the following factors:

- Magnitude of the residual risk to human and environmental receptors remaining from untreated waste or treatment residues at the completion of remedial activities;
- Assessment of the type, degree, and adequacy of long-term management required for untreated waste or treatment residues remaining at the site;
- Assessment of the long-term reliability of engineering and/or institutional actions to provide continued protection from untreated waste or treatment residues; and
- Potential need to replace the action and the continuing need for repairs to maintain the performance of the action.

4.2.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment (Criterion 4)

The statutory preference is to select a remedial action that employs treatment to reduce the toxicity, mobility, or volume of hazardous substances. This criterion addresses the anticipated performance of the technologies that may be used to achieve treatment goals. Alternatives that do not include treatment technologies are not considered to reduce the toxicity, mobility, or volume of chemicals. This criterion considers the following:

- Treatment processes;
- Amount of hazardous substances that will be treated or destroyed;
- Degree of expected reduction in toxicity, mobility, or volume through treatment, including how the principal threat is addressed through treatment;
- Degree to which the treatment will be irreversible;
- Type and quantity of residuals that will remain following treatment; and
- Statutory preference for treatment.

4.2.2.3 Short-Term Effectiveness (Criterion 5)

The short-term effectiveness of an alternative is evaluated relative to its short-term effect on human health and the environment. The short-term effectiveness assessment is based on the following key factors:

- Short-term risks that might be posed to the community during implementation of an alternative;
- Potential for impact on workers during construction, and the effectiveness and reliability of protective measures;
- Potential for adverse environmental impacts that may result from the action, and the effectiveness and reliability of mitigation measures in preventing or reducing the potential impact; and
- Time frame for achieving remedial objectives.

4.2.2.4 Implementability (Criterion 6)

Implementability deals with the difficulties of constructing and operating an alternative, and the availability of materials and services required. The following factors are considered:

- Ability to construct and operate;
- Ease of doing more action, if needed;
- Ability to monitor effectiveness;
- Ability to obtain approvals and coordinate with other agencies;
- Availability of services and capacities;
- Availability of necessary equipment, specialists, and materials; and
- Availability of technologies.

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4.2.2.5 Cost (Criterion 7)

Preliminary cost estimates, for both industrial use and residential use, are presented for each remedial alternative. Details of these estimates are included in Appendix B. These cost estimates are intended to aid in making project evaluations and comparisons between alternatives. These are rough, order-of-magnitude estimates (i.e., they have an expected accuracy of -30 percent to +50 percent for the scope of action described for each alternative).

The estimates are divided into capital costs and O&M costs, and are based on information provided by vendors, regulators, and experience on similar projects. The present worth of the capital cost and 30 years of O&M are included, unless otherwise indicated.

4.2.3 Modifying Criteria

State and community acceptance of a proposed remedial action is an important element in the decision to select and to implement. Concerns of state regulators and the local community must be addressed during the selection process and are generally termed "modifying criteria."

4.2.3.1 State Acceptance (Criterion 8)

The State of Tennessee (TDEC) will review and comment on this FS. TDEC comments on this FS become part of the Administrative Record and are considered by EPA and the BCT in selection of the remedy.

4.2.3.2 Community Acceptance (Criterion 9)

Community acceptance issues are an integral component of the CERCLA FS process. Consistent with the NCP, community input on the selection of the remedy will be solicited during the community review of the Proposed Plan.

4.3 Definition of Surface Soil Alternatives

The EPA guidance for conducting an RI/FS (EPA, 1988) recommends that each alternative be defined in sufficient detail to apply the evaluation criteria and to determine order-ofmagnitude costs. The definition may include preliminary design calculations and drawings, as well as addressing the limitations, assumptions, and uncertainties about each alternative. However, the definition step is not a remedial design. Complete details of how an alternative would be implemented are not necessary (or required by CERCLA) for the comparative analyses performed.

The following alternatives were retained after the screening process presented in Section 3, and are analyzed in detail in this section:

- Alternative 1: No Action (required to be retained per CERCLA)
- Alternative 2: Institutional Controls
- Alternative 3: Soil Containment
- Alternative 4: In-situ Soil Treatment
- Alternative 7: Excavation, Transportation, and Off-site Disposal

In the detailed analyses presented in this section, these alternatives are further refined with respect to each FU, intended land use, and associated COCs. Different future land use scenarios will require differing levels of remedial action to be protective of human health and the environment.

Table 4-1 shows COCs for each FU for each of the land use criteria for which RGOs were developed in Section 2 (Table 2-1): industrial, unlimited recreational, and residential. The need for remedial action at the six FUs under various land use scenarios can be summarized as follows:

- **Industrial**: Only FU4 requires some remedial activity to be protective under the industrial land use scenario.
- Unlimited Recreational: Only FU2 was evaluated for unlimited recreational land use, and was found to be acceptable for unlimited recreational use without limitation other than fishing and swimming in the two lakes, which are currently prohibited. After transfer of the property, the fishing/swimming prohibition will be monitored by the owner of the property.
- **Residential:** All FUs require some remedial activity if future residential use (including day care operations) is permitted. Existing zoning and other land use controls would have to be lifted or altered to permit residential use at the MI.

The COCs for which remediation is required are also shown in Table 4-1 under each alternative land use scenario.

Soil contaminated above RGOs for potential land uses is composed of a number of discrete areas scattered throughout the FUs (Figures 4-4 through 4-8). The number of individual areas of concern and the total affected areas of contaminated surface soil are summarized in Table 4-2 to show the general magnitude of remediation required for each COC under each potential land use scenario. These areas were used to develop quantities for estimating the costs of remedial alternatives (Appendix B).

Each of the retained alternatives is described in detail in the following paragraphs.

4.3.1 Surface Soil Alternative 1 – No Action

This alternative includes no remedial activities, but is required by CERCLA to be retained as a baseline for comparison. It applies to all FUs and potential land uses. Under this alternative, no land use restrictions (over and above the existing land use controls) would be implemented. If the existing restrictions were ever modified, it is possible that future residential development could occur. The no action alternative would:

- Employ no technologies,
- Not be protective in FU4 for industrial use in areas in which lead is present in the surface soil at concentrations exceeding risk-based criteria (≥ 1,536 mg/kg), and
- Not add any protective layer of institutional controls prohibiting residential development in FU1 through 6, due to the concentrations of dieldrin exceeding residential risk-based criteria (≥ 0.21 mg/kg), arsenic exceeding background (≥ 20

mg/kg) and/or lead exceeding residential risk-based criteria (\geq 300 kg/kg) in surface soil.

4.3.2 Surface Soil Alternative 2 – Institutional Controls

The institutional controls alternative can be an effective remedial alternative for future industrial use at FU1, FU3 through 6, and for future unlimited recreational use of FU2. It would leave contaminated surface soils in place, but would provide deed restrictions, in addition to the existing land use controls, limiting the future use by the Depot.

Deed (including lease) restrictions would prevent certain land uses where dieldrin, arsenic, and/or lead in the surface soils pose an unacceptable risk. Currently, risks are unacceptable for industrial use in a portion of FU4 and for future residential use in portions of FU1 through 6 (Table 4-2 summarizes areas in each FU under each land use scenario). Controls would prevent industrial use in a portion of FU4, and future residential use in all of FU1 through 6. Residential use controls would include preventing day care operations in all FUs, and fishing and swimming in the existing lakes in FU2 for safety reasons. In addition, a boundary fence surrounding FU2 would be maintained to preclude casual access from adjacent off-site residents.

Restrictions and controls would be coordinated with the Depot reuse implementation plans, and would be included in all deeds and leases. Controls could apply to an entire FU, or to areas within an FU that exceed levels acceptable for applicable land use. Under this alternative, controls would have to be inspected periodically for effectiveness.

FU	Deed Restrictions Preventing Residential Land Use ^a	Deed Restrictions Preventing Industrial Land Use	Site Controls
1	X		
2	Х		Хр
3	x		
4	x	X (lead-contaminated areas [≥ 1,536 mg/kg] only)	X°
5	Х		
6	Х		

The deed restriction and site controls, in addition to the existing land use controls, to be applied under this alternative are as follows.

^a Includes day care restriction ^b Continuation of signage preventing swimming and fishing in lakes.^c Site controls (fencing and signage) as part of the industrial use deed restrictions.

Institutional controls contemplated for this alternative would:

 Be marginally protective in FU4 for industrial use by controlling access to areas with lead exceeding levels acceptable under an industrial land use scenario (≥ 1,536 mg/kg). However, even with deed restrictions and fencing/signage, future occupants of FU4 could remove the fencing and risk exposure to the lead-contaminated surface soil; MEMPHIS DEPOT MAIN INSTALLATION SOILS FS - 7/31/00

- Prevent future residential land use in FU1 through 6, eliminating the risks associated with that land use scenario;
- Prevent casual access from adjacent off-site residents through maintenance of a boundary fence surrounding FU2;
- Prevent day care operations in FU1 through 6; and
- Prevent fishing and swimming in the lakes in FU2.

Applying contemplated institutional controls would result in the following in each FU:

- FU1 is acceptable for industrial use without controls; however, it has numerous areas of surface soil contamination (total of 206,300 square feet [ft²][Figure 4-1]) that would present unacceptable risks under a future residential land use scenario. With institutional controls in place to prevent future residential development, FU1 could be used for industrial purposes with no further action.
- FU2 is acceptable for unlimited recreational use without controls; however, it has numerous areas of surface soil contamination (total of 1,960,200 ft² [Figure 4-2]) that present unacceptable risks under a future residential land use scenario. With institutional controls in place to prevent future residential development, FU2 could be used for recreational purposes with no further action.
- FU3 is acceptable for industrial use without controls; however, it has areas of surface soil contamination (total of 5,500 ft² [Figure 4-3]) that would present unacceptable risks under a future residential land use scenario. With institutional controls in place to prevent residential development, FU3 could be used for industrial purposes with no further action.
- FU4 has 7,200 ft² of lead-contaminated surface soil that would require deed restrictions and access control to prevent industrial worker. Also, FU4 has an additional area of surface soil contamination (total of 386,200 ft² including the 7,200 ft² exceeding industrial criteria [Figures 4-4]) that would present unacceptable risks under a future residential land use scenario With institutional controls in place to prevent residential development, FU4 could be used for industrial purposes with only the restricted access to the 7,200 ft² of lead-contaminated surface soil.
- FU5 is acceptable for industrial use without controls; however, it has some areas of surface soil contamination (total of 39,500 ft² [Figure 4-5]) that would present unacceptable risks under a future residential land use scenario. With institutional controls in place to prevent residential development, FU5 could be used for industrial purposes with no further action.
- FU6 is acceptable for industrial use without controls, but has a small area of arsenic (400 ft² [Figure 4-6]) contamination that would present unacceptable risks under a future residential land use scenario. With institutional controls in place to prevent residential development, FU6 could be used for industrial purposes with no further action.

The assumptions used in developing the cost estimate for this alternative were as follows:

- All areas identified as exceeding the RGOs would be specifically restricted:
 - No industrial activities in the identified portion of FU4 because of lead surface soil contamination; and

- No future residential use in FU1, 2, and 5 because of dieldrin and arsenic; in FU3 because of arsenic and lead; in FU4 because of arsenic, lead, and dieldrin; and in FU6 because of arsenic.
- The estimated cost for this alternative assumes that institutional controls are applied to the entire MI of the Depot. The cost would be similar, even if institutional controls were applied to only selected FUs.
- The extent of lead, arsenic, and dieldrin contamination in the surface soils are adequately defined.
- An annual evaluation of administrative controls is necessary to prevent future land use changes.
- Periodic 5-year reviews by regulatory agencies would be required as long as hazardous substances, pollutants, or contaminants remain at the site. Present worth costs use 30 years as a costing period.

4.3.3 Surface Soil Alternative 3 – Soil Containment

This alternative includes constructing a protective cover of soil or pavement over contaminated surface soils coupled with deed restrictions preventing disturbance of the cover. Contaminated soils would be left in place, and a 1-ft-thick cover of soil or asphalt/concrete pavement would be installed over contaminated surface soils. In addition, deed restrictions preventing future disturbance of the cover would be provided. These restrictions would be coordinated with the Depot reuse implementation plans, and would be included in all deeds and leases. Figures 4-1 through 4-6 depict the various areas that this alternative would address for surface soils contaminated with lead, dieldrin, and arsenic, respectively.

The cover would be applied to individual surface soil areas within an FU that exceeds levels acceptable for applicable land use (Table 4-2 summarizes the areas in each FU under each land use scenario). The following controls and areas in each FU are included:

	Industrial	Use	Unlimited Recrea	tional Use	Residential	Use
FU	Deed Restrictions Preventing Cover Disturbance	Area to be Covered (ft ²)	Deed Restrictions Preventing Cover Disturbance	Area to be Covered (ft ²)	Deed Restrictions Preventing Cover Disturbance	Area to be Covered (ft ²)
1	NR	NR			x	206,300
2			NR	NR	х	1,960,200
3	NR	NR			х	5,500
4	X ^a	7,200			x	386,200 ^b
5	NR	NR			x	39,500
6	NR	NR			x	400

NR Not required

^a Includes site controls (fencing and signage)

^b Includes the 7,200 ft² included in Industrial Use.

Implementation of this alternative would

- Be marginally protective in FU4 for industrial use by covering surface soil areas with lead exceeding levels acceptable under an industrial land use scenario, however, even with deed restrictions and covers, future occupants of the FU could remove the cover and risk exposure to the lead-contaminated soil.
- Be marginally protective in FU1 through 6 for future residential use by covering surface soil areas with lead, arsenic, and/or dieldrin exceeding levels acceptable for residential users, however, even with deed restrictions and covers, future occupants of the FU could remove the cover and risk exposure to the contaminated soil.

Application of the contemplated soil containment measures would result in the following in each FU:

- FU1 is acceptable for industrial use without a cover; however, it has numerous areas of surface soil contamination (total of 206,300 ft² [Figure 4-1]) that would require a soil cover or pavement to be protective for a future residential land use scenario. With the covers installed and institutional controls in place, the FU would be acceptable for future residential use; however, long-term control to prevent future residents from disturbing the covers would be difficult.
- FU2 is acceptable for unlimited recreational use without a cover or controls; however, it has numerous areas of surface soil contamination (total of 1,960,200 ft² [Figure 4-2]) that would require a cover to be protective for exposure for future residential land use scenario. Because the dieldrin contamination is so widespread (1,960,200 ft² = 45 acres), most of the FU would be covered, rather than individual areas. Some of the dieldrin contamination in this FU also has arsenic at levels unacceptable to future residential use, but the cover over dieldrin-contaminated soil would also reduce these risks to acceptable levels for future residential use. With the covers installed and institutional controls in place, the FU would be acceptable for a future residential land use scenario; however, long-term control to prevent future residents from disturbing the covers would be difficult. Future residential development in this FU would be cause the majority of the area would be covered.
- FU3 is acceptable for industrial use without a cover; however, it has areas of surface soil contamination (total of 5,500 ft² [Figure 4-3]) that would require a cover of soil or pavement to be protective for exposure for a future residential land use scenario. With the covers installed and institutional controls in place, the FU would be acceptable for future residential use; however, long-term control to prevent future residents from disturbing the covers would be difficult.
- FU4 has 7,200 ft² of lead-contaminated surface soil that would require a cover of soil or pavement to be protective for exposure under an industrial land use scenario. Also, FU4 has an additional area of surface soil contamination (total of 386,200 ft² including the 7,200 ft² exceeding industrial criteria [Figure 4-4]) that would require a soil cover or pavement to be protective for exposure for a future residential land use scenario. With the covers installed and institutional controls in place, the FU would be acceptable for future residential use; however, long-term control to prevent future residents from disturbing the covers would be difficult.

- FU5 is acceptable for industrial use without a cover; however, it has some areas of surface soil contamination (total of 39,500 ft² [Figure 4-5]) that would require a soil cover or pavement to be protective for exposure for future residential land use scenario. With the covers installed and institutional controls in place, the FU would be acceptable for future residential use; however, long-term control to prevent future residents from disturbing the covers would be difficult.
- FU6 is acceptable for industrial use without a cover; however, it has a small area of arsenic (400 ft² [Figure 4-6]) contamination that would require a soil cover or pavement to be protective for exposure for a future residential land use scenario. With the covers installed and institutional controls in place, the FU would be acceptable for future residential use; however, long-term control to prevent future residents from disturbing the covers would be difficult.

The assumptions used in developing the cost estimate for this alternative were as follows:

- Areas identified as exceeding the RGOs would be covered as follows:
 - For industrial activities in portions of FU4, excessive lead; and
 - For residential use in FU1, 2, and 5, excessive dieldrin and arsenic; in FU3, excessive arsenic and lead; in FU4, excessive arsenic, lead, and dieldrin; and in FU6, excessive arsenic.
- The extents of lead, arsenic, and dieldrin contamination in the surface soils are adequately defined.
- Maintenance of the cover would be required.
- An annual evaluation of administrative and other controls is necessary to prevent disturbance to the cover.
- Periodic 5-year reviews by regulators would be required as long as hazardous substances, pollutants, or contaminants remain at the site; present worth costs use 30 years as a costing period.

4.3.4 Surface Soil Alternative 4 – In-situ Soil Treatment

This alternative includes treatment of contaminated surface soils (bioremediation for dieldrin, stabilization for lead and arsenic), and institutional controls prohibiting residential use during implementation of the remedial action. These restrictions would be coordinated with the Depot reuse implementation plans, and would be included in all deeds and leases. Under this alternative, site surface soils would have to be evaluated through laboratory analyses during the treatment process to confirm that concentrations meet RGOs. Figures 4-1 through 4-6 depict the various areas that this alternative would address for surface soils contaminated with lead, dieldrin, and arsenic, respectively. For an industrial use scenario in FU4, the deed restrictions barring future residential development would have to be permanent.

Biological amendments and/or stabilization chemicals would be added to contaminated surface soils to biodegrade and stabilize surface soil contaminated with dieldrin or metals, respectively. Soils contaminated with both dieldrin and metals would not be treated with a

stabilizing chemical for lead and arsenic until dieldrin is reduced to RGOs. The treatments would be applied to individual areas within an FU that exceed levels acceptable for applicable land use. Biological amendments would be used to enhance the biotreatment of the surface soil to effectively reduce dieldrin concentrations. Stabilization would effectively immobilize lead and arsenic contamination.

	· - · · · · · · · · · · · · · · · · · ·	Industrial Us	2		Residential Us	ie
FU	Permanent Deed Restrictions	Area of Soil Stabilization (ft ²)	Area of Soil Bioremediation (ft ²)	Temporary Deed Restrictions	Area of Soil Stabilization (ft ²)	Area of Soil Bioremediation (ft ²)
1	NR	NR	NR	X	45,300 ^a	176,000 ^a
2	NR	NR	NR	Х	56,600 ^b	1,960,200 ^b
3	NR	NR	NR	Х	5,500	NR
4	X°	7,200	NR	х	274,700 ^{d,e}	121,500 ^d
5	NR	NR	NR	х	7,500	32,000
6	NR	NR	NR	х	400	NR

Table 4-2 shows the areas of surface soil requiring treatment for each COC. This alternative would include the following controls and treatment in each FU:

NR Not required

^a 15,000 ft² of FU1 contains both arsenic and dieldrin; therefore, the 15,000-ft² area must receive both soil stabilization and remediation treatment. Total area in FU1 = 206,300 ft²

^b The 56,600-ft² area contains arsenic and dieldrin, therefore the area must receive both soil stabilization and remediation treatment. Total area in FU2 = 1,960,200 ft²

^c Includes site controls (fencing and signage).

^d 10,000 ft² of FU4 contains both arsenic and dieldrin; therefore, the 10,000-ft² area must receive both soil stabilization and remediation treatment. Total area in FU4 = 386,200 ft²

^e Includes the 7,200 ft² included in Industrial Use.

Implementation of this alternative would:

- Be fully protective in FU4 for industrial use by eliminating risk of exposure to surface soil areas with lead exceeding levels acceptable for industrial workers; and
- Be fully protective in FU1 through 6 for future residential use, with some temporary restrictions, by eliminating risk of exposure to contaminated surface soil areas exceeding levels acceptable for future residential use.

Application of the contemplated in-situ soil treatment measures would result in the following in each FU:

• FU1 is acceptable for industrial use without treatment; however, it has numerous areas of surface soil contamination (total of 206,300 ft² [Figure 4-1]) that would require treatment to reduce exposure for future residential land use scenario. Dieldrin-contaminated soil would be treated with an enhanced bioremediation process that would reduce dieldrin contamination to levels acceptable for future residential use. Arsenic-contaminated soil would be treated with a chemical admixture that would

stabilize contaminated soil, decreasing risk to levels acceptable to future residential use. Areas that have both dieldrin and arsenic contamination in the soil would require both processes; bioremediation would be implemented first, after which the soibwould be stabilized. At the completion of treatment, the FU would be acceptable for future residential use.

- FU2 is acceptable for unlimited recreational use without treatment; however, it has
 numerous areas of dieldrin and arsenic surface soil contamination (total of 1,960,200 ft²
 [Figure 4-2]) that would require treatment to reduce exposure for future residential land
 use scenario. Because the dieldrin contamination is so widespread (1,960,200 ft² = 45
 acres), most of the FU would be treated, rather than individual areas. Some of the
 dieldrin contamination in this FU also have arsenic at levels unacceptable for future
 residential use. The contaminated soil would be treated as described for FU1. At the
 completion of treatment, the FU would be acceptable for future residential use.
- FU3 is acceptable for industrial use without treatment; however, it has areas of surface soil contamination (total of 5,500 ft²; Figure 4-3) that would require treatment to reduce exposure for future residential land use scenario. Both the arsenic- and lead-contaminated soil would be treated with a chemical that would stabilize the contaminated soil, decreasing risk to levels acceptable to future residential use. At the completion of treatment, the FU would be acceptable for future residential use.
- FU4 has 7,200 ft² of lead-contaminated surface soil that would require treatment to
 reduce exposure under an industrial land use scenario. FU4 has an additional area of
 surface soil contamination (total of 386,200 ft² including the 7,200 ft² exceeding
 industrial criteria [Figure 4-4]) that would require treatment to reduce exposure for
 future residential land use. Dieldrin-contaminated soil would be treated with an
 enhanced bioremediation process that would reduce dieldrin contaminated soil would
 be treated with a chemical admixture that would stabilize the contaminated soil,
 decreasing risk to levels acceptable to future residential use. Areas that have both
 dieldrin and arsenic or lead contamination in the soil would require both processes;
 bioremediation would be implemented first, after which the soil would be stabilized. At
 the completion of treatment, the FU would be acceptable for future residential use.
- FU5 is acceptable for industrial use without treatment; however, it has some areas of surface soil contamination (total of 39,500 ft² [Figure 4-5]) that would require treatment to reduce exposure for future residential land use. The contaminated soil would be treated as described previously in FU1. At the completion of treatment, the FU would be acceptable for future residential use.
- FU6 is acceptable for industrial use without treatment; however, it has a small area of arsenic (400 ft² [Figure 4-6]) surface soil contamination that would require treatment to reduce exposure for future residential use. Contaminated soil would be treated with a chemical admixture that would stabilize the contaminated soil, decreasing the risk to levels acceptable to future residential use. At the completion of treatment, the FU would be acceptable for future residential use.

The assumptions used in developing the cost estimate for this alternative were as follows:

- Areas identified as exceeding the RGOs would be treated as follows.
 - For industrial activities in portions of FU4, excessive lead; and
 - For future residential use in FU1, 2, and 5, excessive dieldrin and arsenic; in FU3, excessive arsenic and lead; in FU4, excessive arsenic, lead, and dieldrin; and in FU6, excessive arsenic.
- The extent of lead, arsenic, and dieldrin contamination in the surface soil are adequately defined.
- Dieldrin-contaminated surface soil would be aerated with a rolling aerator, and bioremediation growth constituents would be spread by using a tractor and fertilizer distributor. Treatments would be applied twice per year until RGOs were met.
- Landscaping would be required following treatment to restore the site to acceptable conditions.
- Dieldrin-contaminated surface soils would be effectively treated in approximately 3 years. Arsenic- and lead-contaminated soils would be treated in about 6 months independently, or an additional 3 months after treatment of dieldrin.
- An annual evaluation of treatment applicability and effectiveness would be performed until treatment was complete.
- Periodic 5-year reviews by regulators would not be required.

4.3.5 Surface Soil Alternative 7 – Excavation, Transportation, and Off-site Disposal

This alternative includes the excavation, transportation, and off-site disposal of contaminated surface soil. One foot of contaminated surface soils would be removed from all areas on the MI of the Depot exceeding applicable RGOs and disposed of at an appropriate off-site landfill. Excavation operations would be conducted at individual areas of surface soil within an FU that exceed levels acceptable for applicable land use, as summarized in Table 4-2. Following excavation of the contaminated soil, 1 ft of clean backfill would be placed in all areas excavated, and the entire area landscaping would be restored to its original condition.

Excavation, transportation, and off-site disposal would require temporary controls that would limit the use of the Depot during implementation. These restrictions would be coordinated with the Depot reuse implementation plans. Under this alternative, excavation confirmation sampling and analyses would be required to confirm that RGOs were met. Figures 4-1 through 4-6 depict the various areas that this alternative would address for surface soils contaminated with lead, dieldrin, and arsenic, respectively. This alternative would include the following controls and treatment in each FU.

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		Industrial Us	9		Residential Us	e
FU	Permanent Deed Restrictions	Area of Soil Stabilization (ft ²)	Area of Soil Bioremediation (ft ²)	Temporary Deed Restrictions	Area of Soil Stabilization (ft ²)	Area of Soil Bioremediation (ft ²)
1	NR	NR	NR	x	45,300°	176,000 ^ª
2	NR	NR	NR	х	56,600 ^b	1,960,200 ^b
3	NR	NR	NR	х	5,500	NR
4	X°	7,200	NR	х	274,700 ^{d, e}	121,500 ^d
5	NR	NR	NR	х	7,500	32,000
6	NR	NR	NR	х	400	NR

NR Not required

^a 15,000 ft² of FU1 contains both arsenic and dieldrin; therefore, the 15,000-ft² area must receive both soil stabilization and remediation treatment. Total area in FU1 = 206,300 ft²

^b The 56,600-ft² area contains arsenic and dieldrin; therefore the area must receive both soil stabilization and remediation treatment. Total area in FU2 = 1,960,200 ft².

^c Includes site controls (fencing and signage)

^d 10,000 ft² of FU4 contains both arsenic and dieldrin; therefore, the 10,000-ft² area must receive both soil stabilization and remediation treatment. Total area in FU4 = 386,200 ft².

^e Includes the 7,200 ft² included in Industrial Use

Implementation of this alternative would:

- Be fully protective in FU4 for industrial use by eliminating risk of exposure to areas of surface soil with lead exceeding levels acceptable under an industrial land use scenario, and
- Be fully protective in FU1 through 6 for future residential use by eliminating risk of exposure to contaminated surface soil areas exceeding levels acceptable for future residential use.

Application of the contemplated in-situ soil treatment measures would result in the following in each FU:

- FU1 is acceptable for industrial use without soil remediation; however, it has numerous areas of surface soil contamination (total of 206,300 ft² [Figure 4-1]) that would require remediation to reduce exposure for future residential land use. Contaminated soil removal and clean backfill replacement would be required to eliminate risk of exposure exceeding limits for future residential use.
- FU2 is acceptable for unlimited recreational use without soil remediation; however, it has numerous areas of surface soil contamination (total of 1,960,200 ft² [Figure 4-2]) that would require remediation to reduce exposure for future residential land use. Because the dieldrin contamination is so widespread (1,960,200 ft² = 45 acres), most of the FU would require surface soil removal and replacement with clean backfill. Some of the dieldrin contamination in this FU also has arsenic at levels unacceptable to future residential use, but the dieldrin remediation would include this contaminated soil and

reduce these risks to acceptable levels for future residential use. Contaminated soil removal and clean backfill replacement would be required to eliminate risk of exposure exceeding limits for future residential use. At the completion of removal, the FU would be acceptable for future residential use.

- FU3 is acceptable for industrial use without remediation; however, it has areas of surface soil contamination (total of 5,500 ft² [Figure 4-3]) that would require remediation to reduce exposure for future residential land use. Contaminated soil removal and clean backfill replacement over a total area of 5,500 ft² would be required to eliminate risk of exposure exceeding limits for future residential use. At the completion of removal, the FU would be acceptable for future residential use.
- FU4 has lead-contaminated surface soil that would require removal and clean backfill replacement over a total area of 7,200 ft² to eliminate risk of exposure exceeding limits for industrial land use. FU4 has an additional area of lead and numerous areas of arsenic and dieldrin surface soil contamination that would require remediation to reduce exposure for future residential land use (Figure 4-4). Contaminated soil removal and clean backfill replacement over a total area of 386,200 ft² (including the 7,200 ft² exceeding industrial criteria) would be required to eliminate the risk of exposure exceeding limits for future residential use. At the completion of removal, the FU would be acceptable for future residential use.
- FU5 is acceptable for industrial use without remediation; however, it has some areas of surface soil contamination (total of 39,500 ft² [Figure 4-5]) that would require remediation to reduce exposure for future residential land use. Contaminated soil removal and clean backfill replacement would be required to eliminate the risk of exposure exceeding limits for future residential use. At the completion of removal, the FU would be acceptable for future residential use.
- FU6 is acceptable for industrial use without remediation; however, it has a small area of arsenic (400 ft² [Figure 4-6]) surface soil contamination that would require remediation to reduce exposure for future residential use. Contaminated soil removal and clean backfill replacement would be required to eliminate the risk of exposure exceeding limits for future residential use. At the completion of removal, the FU would be acceptable for future residential use.

The assumptions used in developing the cost estimate for this alternative were as follows:

- Areas identified as exceeding the RGOs would be removed and disposed of as follows:
 - For industrial activities in portions of FU4, excessive lead; and
 - For future residential use in FU1, 2, and 5, excessive dieldrin and arsenic; in FU3, excessive arsenic and lead; in FU4, excessive arsenic, lead, and dieldrin; and in FU6, excessive arsenic.
- The extent of lead, arsenic, and dieldrin contamination in the surface soils are adequately defined.
- Contaminated soils would be excavated to a depth of 1 ft and replaced with compacted clean (as determined by analytical testing) backfill. All disturbed sites would be reseeded with grass.

- Excavated lead-contaminated soils could require special handling and disposal at a RCRA Subtitle C hazardous waste landfill; however, disposal characterization samples would be analyzed prior to disposal. If the soil were determined to be non-hazardous, it could be disposed of at a local Subtitle D landfill. Based on the concentrations of lead, it is conservatively assumed that all of the lead-excavated soil would be hazardous and would be disposed of at a hazardous waste RCRA Subtitle C landfill. Based on the concentrations of arsenic, it is assumed that all of the arsenic-excavated soil would be non-hazardous and would be disposed of at a local that all of the arsenic-excavated soil would be non-hazardous and would be disposed of at a local non-hazardous.
- Excavated dieldrin-contaminated soils would be non-hazardous and would be disposed of at a local non-hazardous RCRA Subtitle D landfill.
- Periodic 5-year reviews by regulators would not be required.

4.4 Individual Analysis of Surface Soil Alternatives

The following detailed analyses are provided to give decision-makers a basis for selecting a remedial action alternative. The analyses include narrative text for each alternative and evaluation tables (following this section). The text compares each alternative against each of the nine criteria.

The tabular evaluations address each FU separately with the following exceptions: Table 4-3 includes both FU1 and FU5 because both have the same intended use and COCs (the costs for the two FUs are shown separately in the table), and Table 4-6 is split into two separate tables (Tables 4-6A and B) to address the industrial and residential scenarios in FU4.

4.4.1 Surface Soil Alternative 1 - No Action

Alternative 1 provides no control of exposure to the contaminated soil for industrial workers in FU4, nor for potential future residents in FU1 through 6.

- The overall baseline risk assessment results indicate that health risks under an industrial land use scenario are within acceptable levels for future industrial use of the property, except for lead in some limited surface soil area in FU4. This alternative, therefore, would not protect human health in FU4 from lead contamination under the industrial land use scenario. There are no current controls to prevent industrial use.
- FU1 through 6 all contain surface soil contaminated above levels acceptable for future residential use. Although existing land use restrictions (see Section 4.2.1) currently prohibit residential development at the Depot, the existing restrictions could be removed or altered at some time in the future. The no action alternative does not add any protective layer of institutional controls prohibiting residential development.

Because no action is being taken, there are no ARARs.

This alternative includes no controls for exposure and no long-term management measures. All current and future potential risks would remain under this alternative to industrial workers in FU4 and residents. This alternative provides no reduction in toxicity, mobility, or volume of the contaminated soil through treatment.

There would be no additional risks posed to the community, remediation workers, or the environment as a result of this alternative being implemented.

There are no implementability concerns posed by this remedy since no action would be taken.

The present worth cost and capital cost of Alternative 1 are estimated to be \$0 since there would be no action.

This alternative is not likely to be accepted by the regulatory agencies or the community for any of the FUs at the MI; however, it is retained and presented for detailed evaluation as required by CERCLA.

4.4.2 Surface Soil Alternative 2 – Institutional Controls

Institutional controls would be protective of human health since exposure to contamination would be controlled. Deed restrictions would provide an extra layer of prevention against residential use. Workers would be prohibited from the contaminated area in FU4 by fencing, signs, and periodic oversight. Deed restrictions prohibiting residential use would be added to the existing zoning controls.

Alternative 2 complements the existing zoning and land use controls described in Section 4.2.1, prohibiting residential use in all FUs.

To remain effective, institutional controls depend on periodic monitoring and maintenance of fences and signs to keep industrial workers out of the contaminated area in FU4. The proposed deed restrictions would add a layer of protection against industrial use of FU4 or future residential use of FU1 through 6. Because contamination remains on-site, a review would be conducted at least every 5 years.

This alternative provides no reduction in toxicity, mobility, or volume of the contaminated soil through treatment.

There is no increase in risk to the community or to workers due to implementation of this alternative because there are no site activities that would affect exposure. Controls and restrictions would take an estimated 6 months to implement. Institutional controls are easy to implement and require no special equipment or materials. The action could be enhanced by extending the areas of control and related fencing.

	To Prevent Residential Use in FU1 through 6 Combined	To Prevent Industrial Use in FU4 and Residential Use in FU1 through 6 Combined
Capital Cost	\$14,000	\$19,000
Annual O&M Cost	\$3,800	\$4,300
30-year Present Worth Cost	\$71,100	\$83,000

The cost of Alternative 2, Institutional Controls, is estimated as follows.

The capital cost is primarily for establishing deed restrictions and fencing. The annual O&M cost is for overseeing the continuation of and adherence to controls, and maintenance.

4.4.3 Surface Soil Alternative 3 – Soil Containment

The containment alternative is protective of human health and the environment by preventing residential and industrial worker exposure to contaminated soil.

ARARs do not apply to cover installation since actions would not involve the disposal of waste. Controls that would be required include deed restrictions and fencing. These controls would complement the existing zoning and land use controls described in Section 4.2.1, prohibiting residential use in all FUs.

For this alternative to remain effective over the long term, the cover would require careful maintenance of landscaping and controls that would help prevent industrial worker or residential intrusion below the cover. Because contamination remains on-site, a review would be conducted at least every 5 years to ensure that the remedy continues to provide adequate protection of human health and the environment in accordance with CERCLA 121(c).

This alternative provides no reduction in toxicity, mobility, or volume of the contaminated soil through treatment. The cover reduces the mobility of contaminants by physical containment.

Site engineering controls would be required to minimize fugitive dust and stormwater releases during site preparation and installation of the cover. Site workers might be required to wear dermal and respiratory protection to minimize the likelihood of exposure during intrusive activities in the lead-contaminated areas of FU4. The cover and controls would be completed in less than 1 year.

The containment alternative is easily implemented and monitored. No special techniques, materials, equipment, or skills are required. Native soil is available locally for cover. The containment action could be enhanced by enlarging the cover if more contamination were discovered.

The 30-year present worth cost of this alternative is estimated to be \$4,569,000, with a capital cost of \$3,764,000, and an annual O&M cost of \$53,300 to cover areas exceeding residential RGOs in FU1 through 6; and the 30-year present worth cost is estimated to be \$361,000, with a capital cost of \$51,000, and an annual O&M cost of \$4,300 to cover areas exceeding industrial RGOs in FU4. The capital cost is primarily for constructing the cover and establishing deed restrictions and fencing. The annual O&M cost is for maintaining integrity of the cover and overseeing the continuation of and adherence to controls.

4.4.4 Surface Soil Alternative 4 – In-situ Soil Remediation

In-situ soil remediation is protective of human health and the environment by treating contaminated surface soil. Treatment reduces residential and industrial worker exposures to levels that are acceptable to appropriate land use.

This alternative complies with ARARs. It would be conducted entirely in-situ and would not involve the disposal of waste. If this alternative were implemented for future residential land use, some existing land use controls would have to be lifted to allow future residential development.

This alternative remains effective after completion because the treatments destroy dieldrin and/or immobilizes lead and arsenic. Treatment is reliable and permanent. No monitoring or management beyond the implementation period would be required. Since the implementation would take less than 5 years, no 5-year review would be required.

Bioremediation is an irreversible process that reduces the toxicity of dieldrin-contaminated soil. Stabilization is also irreversible by fixing arsenic and lead in the soil matrix so it will not be ingested or inhaled. This alternative meets the statutory preference for using treatment as a principal element since the principal threats are addressed through treatment.

Site engineering controls would be required to minimize fugitive dust and stormwater releases during site preparation and treatment activities. Site workers might be required to wear dermal and respiratory protection to minimize the likelihood of exposure during intrusive activities in the lead-contaminated areas of FU4 Temporary controls would be required to prevent exposure or disturbance to contaminated soil during the treatment period. Bioremediation is expected to take 3 years, and stabilization should be completed within 6 months.

The in-situ soil treatment alternative is reasonably easy to implement and both treatment processes use proven technologies. In addition to initial bench-scale testing, some progress monitoring and engineering judgement would be required during implementation of the bioremediation to adjust treatment additives and application rates. One biological amendment is a proprietary product currently available from only one source. The treatment actions could be enhanced by enlarging the treatment areas if more contamination were discovered.

The 30-year present worth cost of this alternative is estimated to be \$4,696,000, with a capital cost of \$1,903,000, and an annual O&M cost of \$965,200 to treat areas exceeding residential RGOs in FU1 through 6; and the 30-year present worth cost is estimated to be \$123,000, with a capital cost of \$51,000, and an annual O&M cost of \$18,200 to treat areas exceeding industrial RGOs in FU4. The capital cost is primarily for the first year of treatment and establishing controls. The annual O&M cost is primarily for continuing biological treatment and adherence to controls.

4.4.5 Surface Soil Alternative 7 – Excavation, Transportation, and Off-site Disposal

Excavation, transportation, and off-site disposal is protective of human health and the environment by removing contaminated soil. Removing contaminants reduces residential and industrial worker exposure to levels that are acceptable to appropriate land use.

This alternative does comply with ARARs. Land disposal restrictions are potential ARARs for disposal of hazardous waste and would require special handling, limiting the disposal options of lead-contaminated soils. Dieldrin- and arsenic-contaminated surface soils are not listed wastes and are not likely to exceed TCLP criteria at levels found on the Depot; therefore, they are not considered RCRA hazardous wastes. They would be tested prior to

disposal and if they exceed TCLP criteria, they would be disposed of as a hazardous waste. If this alternative were implemented for future residential land use, some existing land use controls would have to be lifted to allow future residential development.

This alternative remains effective after completion because contaminated soil is removed. Removal is reliable and permanent. No monitoring or management beyond the implementation period would be required. Since the implementation would take less than 5 years, no 5-year review would be required.

This alternative provides no reduction in toxicity, mobility, or volume of the contaminated soil through treatment. Disposal in an off-site landfill reduces the mobility of contaminants by physical containment.

Site engineering controls would be required to minimize fugitive dust and stormwater releases during periods of soil disturbance such as excavation and hauling. Site workers might be required to wear dermal and respiratory protection to minimize the likelihood of exposure during intrusive activities in the lead-contaminated areas of FU4. This alternative would take about 6 months to complete.

This alternative is easily implemented and monitored. No special techniques, materials, equipment, or skills are required. Native soil is available locally for backfill. Off-site transportation may require special controls on trucking operations. The removal action could be enhanced by enlarging the excavated area if more contamination were discovered.

The 30-year present worth cost and capital cost of this alternative is estimated to be \$7,289,000, with an annual O&M cost of \$0 to remove areas exceeding residential RGOs in FU1 through 6; and the 30-year present worth cost and capital cost is estimated to be \$240,000, with an annual O&M cost of \$0 to remove areas exceeding industrial RGOs in FU4. All remedy costs are capital costs; this alternative has no annual O&M cost.

4.5 Comparative Analysis of Surface Soil Alternatives

In the following analysis, the alternatives are evaluated in relation to one another for each of the evaluation criteria. To enable a balanced selection, this analysis identifies the advantages and disadvantages of each alternative relative to the Depot MI and the FU or FU group considered. FU-specific comparisons are presented if different from the Depot overall.

4.5.1 Overall Protection of Human Health and the Environment

4.5.1.1 General

All of the alternatives protect human health and the environment except Alternative 1 (No Action).

4.5.1.2 Industrial Use

FU1, 2, 3, 5, and 6 are acceptable for an industrial land use scenario without any action. FU4 has some lead in the surface soil in excess of human health criteria, which would be remediated in preparation for industrial use. Alternative 1 is not protective of the industrial worker in FU4, but all other alternatives provide adequate protection because they protect

the industrial worker from lead exposure. Alternative 2 achieves protection by establishing institutional and site controls limiting access; Alternative 3 covers the lead-contaminated soil and provides deed restrictions preventing future disturbance of the cover; Alternative 4 treats the soil to immobilize the lead; and Alternative 7 removes the lead from the Depot area.

4.5.1.3 Residential Use

For future residential use, all six FUs require some action to be protective from dieldrin, arsenic, and/or lead in surface soil. Alternative 1 is not protective, but all other alternatives provide some protection because they protect the future resident from dieldrin, lead, and arsenic exposure. Alternative 2 (Institutional Controls), is designed to prevent future residential use at most FUs and is therefore not applicable to the future residential use scenario. Alternative 3 covers/paves over the dieldrin and lead/arsenic soils; Alternative 4 treats the dieldrin soil by enhancing bioremediation and the lead/arsenic soil by stabilization; and Alternative 7 removes the dieldrin and lead/arsenic soils from the MI of the Depot.

4.5.2 Compliance with ARARs

All alternatives meet all respective ARARs except for Alternative 1 (No Action) for which there are no ARARs; however, existing land use restrictions on Depot property would have to be modified to permit future residential use of the property.

4.5.3 Long-term Effectiveness and Permanence

4.5.3.1 General

Alternatives 4 (In-situ Soil Treatment) and 7 (Excavation, Transportation, and Off-site Disposal) afford the highest degree of long-term effectiveness and permanence; Alternative 4 provides treatment to reduce the toxicity of dieldrin-contaminated surface soil and the fixation of lead- and arsenic-contaminated surface soil to levels acceptable for intended land use. Alternative 7 removes all contamination with unacceptable risk. Both alternatives reduce risk to levels in accordance with RAOs, but Alternative 7 can be implemented in 6 months; Alternative 4 requires up to 3 years for dieldrin-contaminated soil, but only 6 months if soil contamination is limited to lead and/or arsenic. Neither alternative requires long-term maintenance or 5-year reviews, but Alternative 7 relies on an off-site land disposal facility for long-term storage of contaminated soil.

The long-term effectiveness and permanence of Alternative 3 (Soil Containment) is less reliable because contaminated soil remains on-site and long-term controls are necessary to prevent disturbance to the cover. The cover takes longer to implement than bioremediation treatment but about the same amount of time as institutional controls, removal, or stabilization. Long-term maintenance of the cover and 5-year reviews are required as long as hazardous substances, pollutants, or contaminants remain at the site; present worth costs use 30 years as a costing period. Alternative 2 (Institutional Controls) is not as effective compared to the other active alternatives for the long term because there is no physical barrier between potential receptors and contaminated soil, except fences and signs. Alternative 2 requires long-term maintenance and 5-year reviews are required as long as

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hazardous substances, pollutants, or contaminants remain at the site; present worth costs use 30 years as a costing period.

4.5.3.2 Industrial Use

FUs 1, 2, 3, 5, and 6 are suitable for an industrial land use scenario without any action.

FU4 has lead-contaminated soil in excess of human health criteria, which should be remediated in preparation for industrial use by implementing one of the remediation alternatives. Alternatives 4 and 7 are the most effective for FU4 because they would treat or remove contamination, respectively. Alternative 4 is more permanent for lead; it reduces mobility by stabilization as opposed to disposing it in a landfill. Alternative 7 is slightly more effective for lead because it contains the material off-site in a regulated landfill facility. Alternative 3 is less effective because it leaves the lead in place by covering the lead-contaminated soil with clean fill or pavement. Alternative 2 is the least effective (besides Alternative 1, No Action) because it relies on institutional controls to prevent exposure in an industrial setting, which requires continued monitoring and control. Alternative 1 is not effective at reducing industrial risk.

4.5.3.3 Residential Use

All six FUs require some action to be suitable because of the dieldrin, arsenic, and lead in the surface soil. All alternatives (except Alternative 1, No Action) provide some long-term effectiveness for future residents. Alternatives 4 and 7 are the most effective because they treat or remove contamination, respectively. Alternative 4 is more permanent for dieldrin; it reduces the toxicity and volume of contamination through biological treatment as opposed to disposing it and it is fairly permanent for lead/arsenic because it stabilizes the soil mass that contains the lead/arsenic and immobilizes the chemicals. Alternative 7 is permanent for dieldrin/lead/arsenic because it contains the material off-site in a regulated landfill facility, but the chemicals are not destroyed. Alternative 3 is less effective because it leaves the chemicals in place by covering the dieldrin/lead/arsenic-contaminated soil with clean fill or pavement. Alternative 2 (Institutional Controls), is designed to prevent future residential use at all FUs and is therefore not applicable to the future residential use scenario. Although there are existing land use restrictions prohibiting residential development on the Depot area, Alternative 1 1s not completely effective at reducing future residential risk because the existing restrictions could be lifted or altered at some time in the future.

4.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

4.5.4.1 General

Alternative 4 is the only action that includes treatment of surface soil to reduce the risks posed by soil contamination. Enhanced bioremediation is used to treat dieldrin to levels acceptable for future residential land use. Stabilization of arsenic- and lead-contaminated soil is used to reduce the mobility of metals in the soil to residual levels acceptable for residential and industrial land uses. Alternative 4 satisfies the statutory preference for treatment as a principal element. None of the other alternatives uses treatment technologies, although dieldrin would attenuate over time. Although Alternative 3 (Soil Containment) and Alternative 7 (Excavation, Transportation, and Off-site Disposal) reduce the mobility of chemicals, the reduction is not achieved through treatment

4.5.4.2 Industrial Use

Alternative 4 uses stabilization to reduce the mobility of lead in soil in FU4. No other alternatives use treatment technologies.

4.5.4.3 Residential Use

For future residents in FU1 through 6, Alternative 4 would provide both bioremediation and stabilization to treat dieldrin, lead, and arsenic in the surface soil. No other alternatives use treatment technologies.

4.5.5 Short-Term Effectiveness

4.5.5.1 General

Alternative 2 (Institutional Controls) has the greatest short-term effectiveness because it presents the least risk to workers, the community, and the environment. Alternative 2 is the quickest way to short-term protection (within 6 months). Alternative 3 (Soil Containment) requires some engineering controls during construction of the cover to minimize impacts from fugitive dust emissions and stormwater runoff. It also takes longer to implement, although less than 1 year. Alternatives 4 (In-situ Soil Treatment) and 7 (Excavation, Transportation and Off-site Disposal) have the same short-term effectiveness, but Alternative 7 may cause traffic impacts due to transportation of excavated material and backfill. Alternative 7 and Alternative 2 can be implemented in less than 6 months, whereas Alternative 4 can take over 3 years to implement. Alternative 1 has no short-term impacts because no action is taken.

4.5.5.2 Industrial Use

Alternative 2 can be effected quickly and presents no implementation risk to workers. Alternative 3 presents minimal risks to workers (dust) and environment (stormwater) and can be implemented quickly (much less than 1 year) for lead (FU4). Alternatives 4 and 7 both present limited risk during implementation because of short-term exposure to dust during treatment, or excavation and transport within the area of elevated lead in FU4, respectively. Alternative 4 for the lead only (FU4) can be implemented in the same timeframe as Alternative 7 (within 6 months).

4.5.5.3 Residential Use

All six FUs require some action to be suitable for future residential use because of dieldrin, arsenic, and lead in the surface soil. Alternative 2 (Institutional Controls) is designed to prevent future residential use at all FUs and is therefore not applicable to the future residential use scenario. Alternative 3 presents minimal risks to workers (dust) and environment (stormwater) and can be implemented quickly (much less than 1 year) for lead. Alternatives 4 and 7 both present limited risk during implementation because of short-term exposure to dust during treatment, or excavation and transport within the area of elevated lead in FU4, respectively. Alternative 4 takes longer to implement (over 3 years) than Alternative 7 (less than 6 months).

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4.5.6 Implementability

4.5.6.1 General

Alternative 2 (Institutional Controls) is the simplest to implement. Additional remedial action can be readily implemented if more effectiveness becomes necessary, as long as significant industrial use infrastructure has not been added. Land use controls and monitoring would be applied to prevent unacceptable land use. Alternative 3 (Soil Containment) is also simple to implement, but requires significant materials and handling. The materials and equipment required are common and would be available locally. Expansion of the cover is relatively easy if the areal limits of remediation need to be extended. Monitoring is necessary to ensure the cover is not disturbed. Construction requirements for Alternative 7 (Excavation, Transportation, and Off-site Disposal) are also simple and the required equipment is readily available, but limitations on landfill space may impact cost and construction time. Expansion of the excavation areas to accommodate extensions in areal contamination is relatively easily accommodated, and no monitoring after implementation is required. Alternative 4 (In-situ Soil Treatment) is most difficult to implement because of the treatment processes and time required. Dieldrin treatment, as demonstrated in bench-scale testing, requires a proprietary product available from only one source and takes 3 years to complete. Stabilization is a proven and readily available technology and easily expanded if additional lead/arsenic contamination is found.

4.5.6.2 Industrial Use

FUs 1, 2, 3, 5, and 6 are suitable for industrial workers without any action. FU4 has some lead in the surface soil in excess of human health criteria, which would be remediated in support of continued industrial use. Alternative 1 has no implementability issues. Alternative 2 is simplest to implement because the site already has access controls and an active caretaker, and is already zoned industrial. Alternative 3 is easy to construct in FU4, requiring only pavement (or a soil cover) over the few lead areas. Alternatives 4 and 7 both require intrusive activities during implementation for lead-impacted soils, requiring significant materials handling and disruption to other Depot activities. Alternative 4 for the lead-impacted soil (stabilization) at FU4 could also result in a volume increase, potentially interfering with some industrial uses.

4.5.6.3 Residential Use

All six FUs require some action to be suitable for future residential use because of dieldrin, arsenic, and lead in the surface soil. Alternative 1 has no implementability issues because no action is taken. Alternative 2 (Institutional Controls) is designed to prevent future residential use at most FUs and is therefore not applicable to the future residential use scenario. Alternative 3 is more difficult to construct because a pavement (or a soil cover) is required over extensive areas of contaminated soil, and is not likely to be compatible with future residential use. This extensive cover requires periodic monitoring to ensure it is not disturbed. Alternatives 4 and 7 both require extensive intrusive activities and are the most difficult to implement, requiring significant materials handling and disruption to other Depot activities. Alternatives 3, 4, and 7 require lifting or alteration of existing deed restrictions to allow future residential land use.

4.5.7 Cost

4.5.7.1 General

There are no costs associated with Alternative 1 (No Action) Alternative 2 (Institutional Controls) is typically the least expensive of the active remediation alternatives because it is a fixed cost for all FUs. Costs for this alternative include implementation plans and deed (and lease) restrictions preventing unacceptable land use and fencing to protect industrial workers or future residents. The cost for controls are assumed the same whether for one or all FUs since the cost of establishing the land use restrictions is relatively independent of the anticipated number of parcels involved.

4.5.7.2 Industrial Use

With present worth cost of \$123,000, Alternative 4, In-situ Treatment, is the least expensive to implement to make FU4 acceptable for industrial use. If not remediated, Alternative 2 (Institutional Controls) would be the least expensive to implement at FU4 for a present worth cost of \$83,000. If FU4 is remediated by Alternative 3, 4, or 7, the present worth cost for institutional controls in FU1 through 6 is only \$71,000 because less controls would be required in FU4 after remediation. Alternative 4 (Treatment) is the least expensive active remediation at \$123,000. Alternative 7 (Excavation, Transportation, and Off-site Disposal) with a capital cost of \$240,000 is more expensive than Alternative 4 due to the assumed hazardous waste disposal required. Containment of contaminated soil in FU4 (Alternative 3) is the most expensive at \$361,000 due to the long-term O&M cost associated with monitoring of the cover.

4.5.7.3 Residential Use

Alternative 2 (Institutional Controls) is designed to prevent future residential use at the FUs and is therefore not applicable to the future residential use scenario. Typically, costs to implement other alternatives to make FU1 through 6 acceptable for residential use are greater and can be generalized as follows: Alternative 3 (Soil Containment) and Alternative 4 (In-situ Soil Treatment) are about the same cost for most FUs. These greater costs are due mostly to long-term maintenance of the cover for Alternative 3 and long-term maintenance for the bioremediation of Alternative 4. Alternative 7 (Excavation, Transportation, and Offsite Disposal) is the most expensive because of the off-site disposal cost. Present worth costs are summarized for each FU and alternative as follows.

	Capital Cost	Present Worth O&M Cost	Total Present Worth Cost
FU1			, , , , , , , , , , , , , , , , , , ,
Alternative 3, Soil Containment	\$305,000	\$63,000	\$368,000
Alternative 4, In-situ Soil Treatment	\$146,000	\$249,000	\$395,000
Alternative 7, Excavation, Transportation, and Off-site Disposal	\$608,000	\$0	\$608,000
FU2			
Alternative 3, Soil Containment	\$2,799,000	\$576,000	\$3,375,000
Alternative 4, In-situ Soil Treatment	\$1,608,000	\$1,762,000	\$3,370,000

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	Capital Cost	Present Worth O&M Cost	Total Present Worth Cost
Alternative 7, Excavation, Transportation, and Off-site Disposal	\$5,097,000	\$0	\$5,097,000
FU3			
Alternative 3, Soil Containment	\$18,000	\$18,000	\$36,000
Alternative 4, in-situ Soil Treatment	\$5,000	÷َرَّ \$17,000	\$22,000
Alternative 7, Excavation, Transportation, and Off-site Disposal	\$106,000	\$0	\$106,000
FU4			
Alternative 3, Soil Containment	\$560,000	\$112,000	\$672,000
Alternative 4, In-situ Soil Treatment	\$113,000	\$718,000	\$831,000
Alternative 7, Excavation, Transportation, and Off-site Disposal	\$1,293,000	\$0	\$1,293,000
FU5			
Alternative 3, Soil Containment	\$67,000	\$18,000	\$85,000
Alternative 4, In-situ Soil Treatment	\$26,000	\$44,000	\$70,000
Alternative 7, Excavation, Transportation, and Off-site Disposal	\$152,000	\$0	\$152,000
FU6			
Alternative 3, Soil Containment	\$15,000	\$18,000	\$33,000
Alternative 4, in-situ Soil Treatment	\$5,000	\$3,000	\$8,000
Alternative 7, Excavation, Transportation, and Off-site Disposal	\$33,000	\$0	\$33,000

4.5.8 State Acceptance

State acceptance is likely for all alternatives except Alternative 1 (No Action) and Alternative 3 (Soil Containment) for both residential and industrial use scenarios.

4.5.9 Community Acceptance

The community may be willing to accept all alternatives except no action, and may be less willing to accept soil containment because the contaminants are left in place, untreated, and the applicable land use is allowed.

TABLE 4-1COCs Associated with Alternate Land Uses for Each FUMemphis Depot Main Installation Soils FS - 7/3/00

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		COCs for	Alternate Land Uses
FU	Industrial	Unlimited Recreational	Residential
1 (20 Typical Warehouses)	None	NI	Dieldrin, Arsenic
2 (Golf Course)	NI	None	Dieldrin, Arsenic
3 (SW Open Area)	None	NI	Arsenic, Lead
4 (N and Open Area)	Lead	NI	Arsenic, Lead, Dieldrin
5 (Newer Warehouses)	None	NI	Dieldrin, Arsenic
6 (Administration/Residential)	None	NI	Arsenic

None No COCs for this land use. FU is acceptable for this land use without remediation. NI Land use scenario not intended for this FU

					Areas of Cont	aminated Surf	face Soil (ft²)		
	and Use Scenario	Number of Areas Requiring Remediation	Lead Only	Arsenic Only	Diełdrin Only	Lead and Arsenic	Lead and Dieldrin	Dieldrin and Arsenic	Total in FU
	Industrial Use								
	FU4	~	7,200	NA	NA	AN	AN	AN	7,200
	Residential Use								
	FU1	17	NA	30,300	161,000	NA	NA	15,000	206,300
	FU2	+	NA	NA	1,903,600	NA	AN	56,600	1,960,200
	FU3	4	1,700	2,900	NA	006	NA	NA	5,500
	FU4	20	10,600 ^a	251,500	111,500	2,600	AN	10,000	386,200 ^ª
	FUS	8	NA	7,500	32,000	NA	NA	NA	39,500
	FUG	-	NA	400	NA	NA	NA	NA	400
¥.	Not applicable								

 TABLE 4-2

 Areas Requiring Remediation

 Memphis Depot Main Installation Soils FS – 7/3/00

Includes the 7,200 ${\rm ft}^2$ exceeding Industrial Use criteria

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TABLE 4-3 FU1-Twenty Typical Warehouses and FU5-Nei Memphis Depot Main Installation Soils FS – 7/;	wer Warehouses: Summary of Individual Detailed Ar	alysis of Surface Soil Alternatives			210 100
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Atternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
	This alternative includes no remediation activities for FU1 and FU5.	This alternative includes deed restrictions and site controls preventing residential land use, including daycare, for FU1 and FU5.	This alternative includes a cover of soil or pavement over areas of dieldrin- contaminated surface soil and arsenic- contaminated surface soil in FU1 and FU5 (a total of 245,800 ft [*]), and institutional control preventing disturbance of the cover.	This alternative includes enhanced bioremediation of dieldrin-contaminated surface soil, stabilization of arsenic- contaminated soil (a total of 245,800 ft ²) and institutional controls prohibiting residential use during implementation o the remedial action at FU1 and FU5.	• This alternative includes the excavation, off-site transportation, and disposal of dieldrin-contaminated surface soil and arsenic-contaminated surface soil (a total of 245,800 ff ²)from FU1 and FU5.
OVERALL PROTECTIVENESS					
Human Health Protection (Direct Contact/Soil Ingestion)	There would be no reduction in risk to human health from exposure (direct contact and soil ingestion) to dieldrin and arsenic in the surface soil under this alternative. Currently such risks are acceptable for industrial use but not for future residential use.	Risk would be reduced because institutional controls can prevent future residential use, and exposure to dleldrin and arsenic in the surface soil Ongoing risks from industrial use of the site are acceptable.	This alternative <u>does</u> protect human health for future residential use by covering dieldrin- and arsenic- contaminated surface soil with a protective cover. A cover would reduce direct contact risk and soil ingestion risk for future residential users	This alternative <u>does</u> protect human health for future residential use. Enhanced bioremediation of contaminated surface soil decreases direct contact risk al soil ingestion risk of dieldrin to levels acceptable for future residential use. Stabilization decreases direct contact risk a	This alternative <u>does</u> protect human health for future residential use. Excavation and off-site disposal of contaminated soil at a permitted, controlled landfill removes direct contact risk and soil ingestion risk of dieldrin- and arsenic-contaminated surface soil.
• _	This alternative <u>does not</u> provide additional institutional controls and other restrictions, and relies on existing land use controls to prevent future residential use.		Long-term institutional controls preventing disturbance of the cover are necessary to maintain protection of human health.	soil ingestion risk of arsenic to levels acceptable for future residential use. Institutional controls preventing future residential use of the site until the remedia action is complete are necessary to mainta protection for human health.	F
Environmental Protection	Existing concentrations of dieldrin and arsenic do not present unacceptable environmental risks. Sensitive ecological populations are not present at FU1 and FU5.	See Alternative 1.	See Alternative 1	See Alternative 1.	See Alternative 1.
COMPLIANCE WITH ARARS					
Chemical-Specific ARARs	There are no chemical-specific ARARs for surface soil.	See Alternative 1.	See Alternative 1.	See Alternative 1.	See Alternative 1.
Location-Specific ARARs	Currently, FU1 and FU5 are zoned as Light Industrial (I-L). This zoning designation prevents residential use. However, this zoning prohibition is not permanent and could change in the future	Deed restrictions precluding future residential use reinforce and add a layer of protectiveness over and above the existing land use controls (see Alternative 1).	Existing land-use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1).	Existing land-use restrictions would have to be lifted or altered to allow future residenti use (see Alternative 1).	Existing land-use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1)
Action-Specific ARARs	This alternative would not meet action- specific ARARs since there is no action.	See Alternative 1	Compliance with Tennessee Rule 1200-3- 1 would be required on fugitive dust emissions during construction of the cover Existing NPDES compliance of stormwater in contact with contaminated soil during construction of the cover would also be required	Compliance with Tennessee Rule 1200-3-1 would be required on fugitive dust emission during remedial activities. Existing NPDES compliance of stormwater in contact with contaminated soil during remedial activities would also be required.	Disposal characterization of the excavated soil would be conducted in accordance with 40 CFR 261. Disposal of contaminated soil would meet RCRA land disposal restrictions; however, it is anticipated that excavated soil from FU1 and FU5 will be disposed of at a local RCRA Subtitle D landfill as a non- hazardous waste.

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of Individual Detailed Analysis of Surface Soil Alternatives

	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
				Compliance with Tennessee Rule 1200-3- 1 would be required on fugitive dust emissions during excavation, transportation, and backfilling operation. Existing NPDES compliance of stormwater in contact with contaminated soil during construction activities would be required.
neet chemical- sidential use ndustriat use.	This alternative is compliant with industrial risk-based criteria. Compliance with residential risk criteria is not applicable since future residential use is prevented by the use of institutional controls.	By covering the dieldrin- and arsenic- contaminated surface soil, the site will meet surface soil RAOs for future residential use Any imported soit to be used for the cover would be confirmed clean by laboratory testing prior to placement on-site.	By bioremediating the dieldrin-contaminated surface soil and stabilization of the arsenic- contaminated surface soil, the site would meet surface soil RAOs for future residential use	By removing contaminated surface soil and disposing off-site, the site would meet surface soil RAOs for future residential use. Imported soil for backfill would be confirmed clean by laboratory testing prior to placement on-site.
imoved in for future ik is acceptable	The source would not be removed; however, unacceptable risk for future residential use would be prevented	Future residential nsk at the site is acceptable as long as the protective cover is maintained Because the source is only	Future residential use risk at the site from contaminated surface soil is reduced to acceptable levels by treatment that destroys	Future residential risk at the site from contaminated soil is eliminated because soil contaminated above levels acceptable
nay decrease odegradation.	through institutional controls. The existing risk is acceptable for industrial use. Concentrations of dieldrin may decrease with time through natural biodegradation.	contained, some inherent risk remains if the cover is breached by intrusion. Long-term control of activities that could potentially disturb the cover would be difficult in a residential setting. Therefore, risk could increase over time.	dieldrin and stabilizes arsenic.	for residential use would be removed from the site.
rols; therefore, Surface soil	Institutional controls are less effective and reliable than permanent treatment. Contaminated surface soil would remain as a potential risk for future residential use. Long-term oversight by the lead agency would be required to maintain protective layers of institutional and land-use controls to <u>prevent</u> future residential use.	This alternative would contain contaminated surface soil in place and minimize potential exposure for future residential use The reliability of this alternative is marginal because long-term oversight by the fead agency would be required to <u>prevent</u> intrusive activities in the cover.	This alternative controls contamination by bioremediating dieldrin and by immobilizing arsenic through stabilization of surface soil. Reliability is very high for future residential use. A bench-scale treatability study indicates that bioremediation is effective for dieldrin. Stabilization of arsenic is a proven technology for the fixation of arsenic- contaminated soil Therefore, no management beyond the remedial	Excavation and off-site disposal effectively removes surface soil contaminated above levels acceptable for future residential use within the FU boundaries. Reliability is very high for future residential use. No site management beyond the remedial implementation period is required The reliability of a permitted off-site disposal facility is high
o ensure the an health and isers of the site.	Review would be required to ensure that institutional controls are still in place for the adequate protection of human health and the environment for future users of the site.	Institutional controls would still be required to prevent disturbance of the surface soil cover Therefore, review would be required to ensure that covers are intact and provide adequate protection of human health for future residential use	Contaminated soil would be effectively Contaminated soil would be effectively biorerrjediated and/or stabilized in less than 5 years, therefore, no review would be required.	Not applicable. Contaminated soil would be removed in less than 5 years; therefore, no review would be required.

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~	TABLE 4-3 FU1-Twenty Typical Warehouses and FU5-Ne Memphis Depot Main Installation Soils FS – 7/	rer Warehouses: Summary of Ind
	Evaluation Criteria	Alternative 1 No Action
	Other Criteria and Guidance	This alternative would not mis specific RAOs for future resibut would meet RAOs for inc
	LONG-TERM EFFECTIVENESS AND PEN	MANENCE
	Magnitude of Residual Risk (Direct Contact/Soil Ingestion)	The source has not been ren Unacceptable risk will remair residentia l use. Existing risk for industrial use.
	-	Concentrations of dieldrin ma with time through natural bio
	Adequacy and Reliability of Controls	There are no action or contro reliablitty is not applicable. Si would remain in place.
	Need for 5-Year Review	Review would be required to adequate protection of huma the environment for future us

TABLE 4-3 FU1-Twenty Typical Warehouses and FU5-N Memphis Depot Main Installation Soils FS - ;	ewer Warehouses: Summary of Individual Detailed Ar	nalysis of Surface Soil Alternatives			
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
REDUCTION OF TOXICITY, MOBILITY,	OR VOLUME THROUGH TREATMENT				
Treatment Process Used	This alternative does not include active treatment of contaminated soil.	See Alternative 1.	See Alternative 1.	Enhanded bioremediation is used to treat dieldrin-contaminated surface soil, and stabilization is used to treat arsenic- contaminated soil.	See Alternative 1.
Amount Destroyed or Treated	No soil contaminants are treated or destroyed under this alternative.	See Alternative 1.	See Alternative 1.	Approximately 6,520 and 1,190 in-place cubic yards of dieldrin-contaminated surface soil will be bioremediated in FU1 and FU5, respectively, and approximately 1,680 and 280 in-place cubic yards of arsenic- contaminated surface soil will be stabilized in FU1 and FU5, respectively.	See Alternative 1.
Reduction of Toxicity, Mobility, or Volume	There is no reduction in toxicity, mobility, or volume through treatment under this alternative.	See Alternative 1.	See Alternative 1.	Bioremediation of dieldrin-contaminated surface soil would reduce the toxicity to residual levels acceptable for future residential use. Stabilization of arsenic- contaminated surface soil would reduce the mobility of arsenic to residual levels acceptable for future residential use.	See Alternative 1
Irreversible Treatment	There is no irreversible treatment under this alternative.	See Alternative 1.	See Alternative 1.	Both treatment processes are irreversible: dieldrnitis destroyed and arsenic is stabilized.	See Alternative 1.
Type and Quantity of Residuals Remaining After Treatment	There is no treatment, therefore, no residuals are generated in this alternative.	See Alternative 1.	See Alternative 1.	Arsenic stabilized surface soil would remain on-site, Approximately 1,850 and 310 cubic yards of stabilized soil would remain on-site in FU1 and FU5, respectively	See Alternative 1.
Statutory Preference for Treatment	This alternative does not satisfy the statutory preference for treatment.	See Alternative 1.	See Alternative 1.	This alternative satisfies the statutory preference for treatment.	See Alternative 1.
SHORT-TERM EFFECTIVENESS					
Community Protection	Risk to the community is not increased by remedy implementation, but risk is unacceptable if the site is used in the future for residential use.	Risk to the community is not increased by the remedy implementation.	Temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls	See Alternative 3.	Temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by engineering controls Transportation of excavated soil and clean backfill through the community may require special controls such as restrictions on truck routing and hours of operation.
Worker Protection	There is no action, therefore, there is no risk to workers.	There is no physical on-site action; therefore, there is no risk to workers	The site is currently acceptable for the industrial worker, however, the remedial contractor's health and safety program could require engineering controls or protective personnel equipment for workers during construction.	See Alternative 3.	See Alternative 3
Environmental Impacts	There is no action; therefore, no environmental impacts	There is no physical on-site action; therefore, there is no impact to the environment.	Fugitive dust emissions and stormwater runoff during implementation could cause environmental impacts; therefore, they would be managed by standard construction industry engineering controls.	See Alternative 3	See Alternative 3.
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TABLE 4-3 FU1-Twenty Typical Warehouses and FU5-Ne Memphis Depot Main Installation Soils FS – 7/	wer Warehouses' Summary of Individual Detailed A	nalysis of Surface Soil Atternatives			
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Time Until Action is Complete	This criterion is not applicable.	Deed restrictions would be implemented within 6 months to add a layer of protection precluding future residential use.	A cover would be placed and institutional controls enacted in less than 1 year allowing future residential use after implementation.	Biological treatment would be applied initially within approximately 6 months. Biodegradation of dieldrin would begin to be effective quickly; amendments and monitoring would be continued for 3 years allowing residential use after implementation. Stabilization amendments for arsenic would require up to an additional 3 months after biological treatment	Soil would be excavated and transported from the site within 6 months allowing residential use after implementation.
IMPLEMENTABILITY					
Ability to Construct and Operate	There is no construction or operation under this alternative.	Institutional controls are readily implemented to preclude future residential use.	Covers are easily constructed and maintained, allowing future residential use.	This alternative is fairly easy to construct and operate, allowing future residential use. Bioremediation has been demonstrated on a bench-scale level; stabilization is a proven, known technology.	Excavation, transportation, and disposal are easily implemented.
Ease of Doing More Action if Needed	If more action becomes necessary, the FS/ROD process may need to be repeated.	No future remedial action is contemplated unless future residential use of the site is required. This alternative does not restrict any future remedial action. If remedial action becomes necessary, alternatives 3, 4, or 7 could easily be implemented, provided there has not been significant resurfacing or grading of the land surface from light industrial operations.	It would be easy to extend the limits of covered areas, but future treatment or remediation of contaminated soil would require excavation and disposal of the covers.	The volume of treated soil could be increased and the technologies could be modified For example, the nutnent amendments or the stabilization admixture could be altered. This alternative could also be combined with other remedial technologies and with remedial actions at other FUs.	It would be easy to extend the limits of remedial areas or to add treatment.
Ability to Monitor Effectiveness	No monitoring of soil is included in this alternative	See Alternative 1.	Periodic monitoring by the lead agency would be necessary to ensure that the covers are not disturbed. Initial surface soil sampling and analysis for dieldrin and arsenic would be required at the perimeter of the soil cover to confirm that the impacted area has been contained.	Progress and confirmation sampling, and laboratory analyses would be an integral part of the remedial action.	See Alternative 4.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approval is applicable to this alternative.	This alternative would require deed restrictions to prevent future residential use. Long-term coordination with Shelby County-City of Memphis is necessary to maintain existing land-use controls to provide layers of protectiveness with the deed restrictions	Existing zoning and other land use controls would have to be lifted or altered to allow future residential use. There would be no other approval necessary to implement this alternative for future residential use Long-term coordination with Shelby County-City of Memphis is necessary to maintain institutional controls to prevent disturbance of the covers.	Existing zoning and other land use controls would have to be lifted or altered to allow future residential use. There would be no other approval necessary to implement this alternative for future residential use. After implementation of the remedial action allowing future residential use, no institutional controls would be required since the site would be cleaned up to residential use oriteria	See Alternative 4
Availability of Services and Capacities	No services or capacities are required under this alternative.	See Alternative 1.	Services are readify available to construct and maintain covers, allowing future residential use.	Implementation services for both technologies are readily available in the commercial market	Services are readily available for excavation, transportation, and off-site disposal

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TABLE 4-3 FU1-Twenty Typical Warehouses and FU5- Memphis Depot Main Installation Soils FS –	Newer Warehouses: Summary of Individual Detailed / 7/3/00	Analysis of Surface Soil Alternatives					01 010
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment		Aiterna Excavation, Tran Off-site D	tive 7 sportation, and lisposal
Availability of Necessary Equipment, Specialists, and Materials	No equipment, specialists, or materials are required under this atternative.	See Alternative 1.	Equipment and materials are readily available to construct and maintain covers, allowing future residential use.	Equipment and most materials are available for enhanced biodegrada dieldrin-contaminated soil and stab arsenio-contaminated soil. The bench-scale tested biological amendment is a proprietary produc available from only one source. A n stabilization amendments are avails commercial market.	readily tion of ilization of t currently tumber of able in the	Equipment and materi- available for excavatio and off-site disposal. T landfills may be limitec	als are readily in, transportation, The capacity of local 1.
Availability of Technologies	No technology is required under this alternative.	See Alternative 1.	Soil cover technology is readily available, allowing future residential use.	The treatment technologies are rea available, allowing future resident i	tdily al use.	The excavation, transp disposal technologies allowing future reside i	oortation, and are readily available ntial use.
COST	FU1 and FU5	All FUS ^a	FU1 FU5	FU1 FU	15	FU1	FUS
<u>Industrial Use</u> : Capital Cost	\$0	\$14,000	This alternative is <u>not necessary</u> for industrial use; therefore, there are no	This atternative is not necessary for industrial use; therefore, there are	r no costs.	This alternative is <u>not i</u> industrial use; therefo	<u>necessary</u> for ore, there are no
First-Year Annual O&M Cost	\$0	\$3,800	COSIS.			costs.	
Present Worth O&M Cost	\$0	\$57,000					
Total Present Worth Cost	\$0	\$71,000					
<u>Residential Use</u> :		This alternative is designed to prevent					
Capital Cost	\$0	residential use. Costs are included under the Industrial theo	\$305,000 \$67,000	\$146,000 \$26,0	000	\$608,000	\$152,000
First-Year Annual O&M Cost	\$0		\$4,200 \$1,200	\$74,400 \$13,6	600	\$0	\$0
Present Worth O&M Cost	\$0		\$63,000 \$18,000	\$249,000 \$44,(000	\$0	\$0
Total Present Worth Cost	\$0		\$368,000 \$85,000	\$395,000 \$70,0	000	\$608,000	\$152,000
STATE ACCEPTANCE	This alternative would not likely be acceptable to state regulators. Although industrial use risks are acceptable without action, this alternative does not adequately prevent future residential use.	Institutional controls are likely to be acceptable to state regulators. Industrial use risks are acceptable without action, and this alternative adequately prevents future residential use	This alternative would not likely be acceptable to state regulators for future residential use since long-term effectiveness is marginal and ongoing monitoring of the covers and land use is required.	In-situ treatment would likely be act state regulators, allowing future res use since all on-site soil would be ti meet residential use criteria.	ceptable to sidential reated to	Excavation, transporta disposal would likely b state regulators, allown residential use since exceeding residential be removed, and soil v of in a permitted off-sit	titon, and off-site e acceptable to ing future all on-site soil use criteria would would be disposed te location.
COMMUNITY ACCEPTANCE	This atternative would not likely be acceptable to the community. Although industrial use risks are acceptable without action, this alternative does not adequately prevent future residential use.	The community may be willing to accept this alternative for industrial use by preventing future residential use through establishment of institutional controls.	The community may be willing to accept this as the selected alternative for future residential use, but would likely insist on strong, ongoing institutional controls, and monitoring of the covers and land use.	In-situ treatment may likely be acce the community, allowing future resi use, since all on-site soil would be t meet residential use criteria.	potable to dential treated to	Excavation, transporta disposal may likely be community, allowing fu use since all on-site sc residential use criteria removed, and soil wou a permitted off-site loco	tton, and off-site acceptable to the inter residential oil exceeding a would be a would be atton
^a The cost to implement institutional controls a	ipplies to all FUs combined.						
Costs are expressed as order-of-magnitude ex	stimates						
The basis for the cost estimates is included in	Appendix B of this FS						
For industrial use, there are no COCs for FU For residential use, dieldrin and arsenic are C	1 or FU5 CCs for FU1 and FU5.						

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Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
	This alternative includes no remedial activities for FU2.	This alternative includes deed restrictions and site controls preventing residential land use, including daycare, for FU2. Signs will continue to be posted preventing fishing and swimming in the lake and pond in FU2. A maintained fence surrounding FU2 will preclude casual access from off-site residents.	This alternative includes a protective cover of soil or pavement over areas of dieldrin-contaminated surface soil and arsenic-contaminated soil in FU2 (a total area of 45 acres), coupled with institutional controls preventing disturbance of the cover.	This alternative includes enhanced bioremediation of dieldrin-contaminated soil, solidification of arsenic-contaminate soil (a total of 45 acres), and institutional controls prohibiting residential use durin, implementation of the remedial action at FU2.	This alternative includes the excavation, and off-site transportation and disposal of dieldrin-contaminated surface soil and arsenic-contaminated surface soil (a total of 45 acres) from FU2.
OVERALL PROTECTIVENESS					
Human Health Protection (Direct Contact/Soil Ingestion)	There would be no reduction in risk to human health from exposure (direct contact and soil indestion) to dialdro and areanic in	There would be a reduction in risk because institutional controls can prevent future residential use and exposure to dialdrip	This alternative <u>does</u> provide future residential use through the protection of himse beath hy coverne disiding and	This alternative <u>does</u> protect human health for future residential use.	This alternative <u>does</u> protect human health for future residential use.
	the surface soil under this alternative Currently such risks are acceptable for recreational use but not for future residential use.	and arsenic in the surface soil. Ongoing risks from recreational use of the site are acceptable	arrent react by covering decument and arsente-contaminated surface soil with a protective cover. A cover would reduce direct contact risk and soil ingestion risk for future residential use.	Enhanced bioremediation of contaminated soil decreases direct contact risk and soil ingestion risk of dieldrin to levels acceptable for future residential use. Stabilization	Excavation, transportation and off-site disposal of contaminated surface soil at a permitted, controlled landfill removes direct contact risk and soil ingestion risk of
	This alternative <u>does not</u> provide additional institutional controls and other restrictions,		Long-term institutional controls preventing disturbance of the cover are necessary to	ingestion risk of arsenic to levels acceptable for future residential use	ureidinir and abenic-contantinated surface soil
	and relies on existing land use controls to prevent future residential use.		maintain protection of human health.	Institutional controls preventing future residential use of the site until the remedial action is complete are necessary to maintain protection of human health	
Environmental Protection	Existing concentrations of dieldrin and arsenic do not present unacceptable environmental risks Sensitive ecological populations are not present at FU2.	See Alternative 1	See Alternative 1.	See Alternative 1.	See Alternative 1.
COMPLIANCE WITH ARARs				- - 	
Chemical-Specific ARARs	There are no chemical-specific ARARs for surface soil.	See Alternative 1.	See Alternative 1.	See Alternative 1.	See Alternative 1.
Location-Specific ARARs	Currently, FU2 is zoned as Light Industrial (I-L), which allows parks and recreational use This zoning designation prevents residential use but is not permanent and could change in the future FU2 is slated for transfer to the U.S. Department of the Interior use as a public park or recreational area. According to 41 CFR 101-47 308-7, property for use as a public park or recreational area must be used and maintained for the purpose for which it was conveyed in perpetuity. This excludes residential use.	Deed restrictions precluding future residential use reinforce and add a layer of protectiveness over and above the existing land use controls (see Alternative 1).	Existing fand use restrictions would have to be litted or altered to allow future residential use (see Alternative 1).	Existing land, use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1).	Existing land use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1).

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Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Action-Specific ARARs	This alternative would not meet action specific ARARs since there is no action.	See Alternative 1.	Compliance with Tennessee Rule 1200-3- 1 on fugitive dust emissions during construction of the cover would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during construction of the cover would also be required	Compliance with Tennessee Rule 1200-3-1 on fugitive dust emissions during remedial activities would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during remedial activities would also be required.	Disposal characterization of the excavated soil would be conducted in accordance with 40 CFR 261 Disposal of contaminated soil would meet RCRA land disposal restrictions; however, it is anticipated that excavated soil from FU2 will be disposed of at a local RCRA Subtitle D landfill as a non-hazardous waste.
					Compliance with Tennessee Rule 1200-3- 1 on fugitive dust emissions during excavation, transportation, and backfilling operation would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during construction activities would also be required.
Other Criteria and Guidance	This alternative would not meet chemical- specific RAOs for future residential use but would meet RAOs for recreational use.	This alternative is compliant with recreational risk-based criteria. Compliance with residential risk criteria is not applicable since future residential use is prevented by the use of institutional controls.	By covering the dieldrin- and arsenic- contaminated surface soil, the site will meet surface soil RAOs for future residential use. Any imported soil to be used for the cover would be confirmed clean by laboratory testing prior to placement on-site.	By bioremediating the dieldrin-contaminated surface soil and stabilization of the arsenic- contaminated surface soil, the site would meet surface soil RAOs for future residential use.	By removing contaminated surface soil and disposing off-site, the site would meet surface soil RAOs for future residential use. Imported soil for backfill would be use. Imported soil for backfill would be confirmed clean by laboratory testing prior to placement on-site.
LONG-TERM EFFECTIVENESS AND PE	RMANENCE				
Magnitude of Residual Risk (Direct Contact/Soil Ingestion)	The source has not been removed. Unacceptable risk will remain for future residential use. The existing risk is acceptable for recreational use.	The source would not be removed, however, unacceptable risk for future residential use would be prevented through institutional controls. The existing risk is acceptable for recreational use.	Future residential nsk at the site is acceptable as long as the cover is maintained. Because the source is only contained, some inherent risk remains if the cover is breached by intrusion	The future residential use risk at the site from contaminated surface soil is reduced to acceptable levels by treatment that destroys dieldrin and stabilizes arsenic.	The future residential risk at the site from contaminated surface soil is eliminated because soil contaminated above levels acceptable for residential use would be removed from the site
	with time through natural biodegradation	Concentrations of dieldrin may decrease with time through natural biodegradation.	Long-term control of activities that could potentially disturb the cover would be difficult in a residential setting. Therefore, the nsk could increase over time. Since the majority of FU2 would be covered, residential development would be problematic	۰ 	
Adequacy and Reliability of Controls	There are no action or controls; therefore, reliability is not applicable. The surface soil would remain in place.	Institutional controls are less effective and reliable than permanent treatment. Contaminated surface soil would remain a potential risk for future residential use. Long-term oversight by the lead agency would be required to maintain protective layers of institutional and land-use controls to <u>prevent</u> future residential use	This alternative would contain contaminated surface soil in place and minimize the potential exposure for future residential use. The reliability of this afternative is marginal because long-term oversight by the lead agency would be required to <u>prevent</u> intrusive activities in the cover	This alternative controls contamination in soil by bioremediating dieldrin and by immobilizing arsenic by stabilizing the surface soil. The reliability is very high for future residential use. A bench-scale treatability study indicates that bioremediation is effective for dieldrin. Stabilization of arsenic is a proven technology for the fixation of arsenic-contaminated soil. Therefore, no management beyond the remedial implementation period is required.	Excavation and off-site disposal effectively remove surface soil contaminated above levels acceptable for future residential use within the FU boundaries. The reliability is very high for future residential use. No site management beyond the remedial implementation period is required The reliability of permitted off- site disposal facility is high.

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 TABLE 4-4

 FU2-Southeast Golf Course Area. Summary of Individual Detailed Analysis of Surface Soil Alternatives

 Memphis Depot Main Installation Soils FS-7/3/00

FU2-Southeast Golf Course Area' Summary Memphis Depot Main Installation Soits FS- 7,	of Individual Detailed Analysis of Surface Soil Alterna	tives			NT NTC
Evaluation Criteria	Atternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Need for 5-Year Review	Review would be required to ensure adequate protection of human health and the environment for future users of the site.	Review would be required to ensure that institutional controls are still in place for the adequate protection of human health and the environment for future users of the site.	Institutional controls would still be required to prevent disturbance of the surface soil cover. Therefore, review would be required to ensure that the covers are intact and provide adequate protection of human health for future residential use.	Contaminated soil would be effectively biotreated and/or solidified in less than 5 years; therefore, no review would be required.	Not applicable. Contaminated soil would be removed in less than 5 years, therefore, no review would be required.
REDUCTION OF TOXICITY, MOBILITY,	OR VOLUME THROUGH TREATMENT				
Treatment Process Used	This alternative does not include active treatment of contaminated soil.	See Atternative 1.	See Alternative 1.	Enhanced bioremediation is used to treat dieldrin-contaminated surface soil, and stabilization is used to treat arsenic- contaminated surface soil.	See Alternative 1.
Amount Destroyed or Treated	No soil contaminants are treated or destroyed under this alternative.	See Alternative 1.	See Alternative 1.	Approximately 72,600 in-place cubic yards of dieldrin-contaminated surface soil will be bioremediated, and approximately 2,090 in- place cubic yards of arsenic-contaminated surface soil will be stabilized.	See Alternative 1.
Reduction of Toxicity, Mobility, or Volume	There is no reduction in toxicity, mobility, or volume through treatment under this alternative.	See Alternative 1.	See Alternative 1	Biotreatment of dieldrin-contaminated soil would reduce the toxicity to residual levels acceptable for future residential use. Stabilization of arsenic-contaminated soil would reduce the mobility of arsenic to acceptable residual levels for future residentiat use.	See Alternative 1.
Irreversible Treatment	There is no irreversible treatment under this alternative.	See Alternative 1	See Alternative 1	Both treatment processes are irreversible dieldrin is destroyed and arsenic is stabilized.	See Alternative 1
Type and Quantity of Residuals Remaining After Treatment	There is no treatment; therefore, no residuals are generated in this alternative.	See Alternative 1.	See Alternative 1.	Approximately 2,300 cubic yards of arsenic stabilized soil would remain on-site.	See Alternative 1.
Statutory Preference for Treatment	This alternative does not satisfy the statutory preference for treatment.	See Alternative 1.	See Alternative 1.	This alternative satisfies the statutory preference for treatment.	See Alternative 1.
SHORT-TERM EFFECTIVENESS					
Community Protection	The risk to the community is not increased by remedy implementation, but the risk is unacceptable if the site is used in the future for residential use.	The risk to the community is not increased by remedy implementation.	A temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls.	See Alternative 3	A temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls. The transportation of excavated soil and clean backfill through the community may require special controls such as restrictions on truck routing and hours of operation
Worker Protection	There is no action, therefore, there is no risk to workers	There is no physical on-site action, therefore there is no risk to workers.	The site is currently acceptable for the recreational user and the industrial worker; however, the remedial contractor's health and safety program could require engineering controls or protective personnel equipment for workers during construction	See Alternative 3.	See Alternative 3.
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TABLE 4-4

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TABLE 4-4 EU2-Southeast Golf Course Area' Summary of Memphis Depot Main Installation Soils FS-7/3	Individual Detailed Analysis of Surface Soil Alternal	tives			510 108
Evaluation Criteria	Aiternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Environmental Impacts	There is no action, therefore, there are no environmental impacts.	There is no physical on-site action; therefore there is no impact to the environment.	Fugitive dust emissions and stormwater runoff during implementation could cause environmental impacts; therefore, they would be managed by standard construction industry engineering controls.	See Alternative 3.	See Alternative 3.
Time Until Action is Complete	This criterion is not applicable.	Deed restrictions would be implemented within 6 months to add a layer of protection precluding future residential use.	A protective cover would be placed and institutional controls enacted in less than 1 year, allowing future residential use after implementation	Biological treatment would be applied initially within approximately 6 months. Biodegradation of dieldrin would begin to be effective quickly, amendments and monitoring would be continued for 3 years, allowing residential use after implementation Stabilization amendments for arsenic would require up to an additional 3 months after biological treatment.	Soil would be excavated and transported from the site within 6 months, allowing residential use after implementation.
IMPLEMENTABILITY					
Ability to Construct and Operate	There is no construction or operation under this alternative.	Institutional controls are readily implemented to preclude future residential use.	Covers are easily constructed and maintained, allowing future residential use.	This alternative is fairly easy to construct and operate, allowing future residential use Bioremediation has been demonstrated on a bench-scale level; stabilization is a known, proven technology.	Excavation, transportation, and off-site disposal are easily implemented.
Ease of Doing More Action if Needed	If more action becomes necessary, the FS/ROD process may need to be repeated.	No future remedial action is contemplated unless future residential use of the site is required. This alternative does not restrict any future remedial action. If remedial action becomes necessary, alternatives 3, 4, or 7 could easily be implemented, provided there has not been significant resurfacing or grading of the land surface from recreational operations.	It would be easy to extend the limits of covered areas, but future treatment or remediation of contaminated soil would require excavation and disposal of the covers	The volume of treated soil could be increased and the technologies modified. For example, the nutrient amendments or the stabilization admixture could be altered. This alternative could also be combined with other remedial technologies and with remedial actions at other FUs	It would be easy to extend the limits of remedial areas or to add treatment.
Ability to Monitor Effectiveness	There is no monitoring of soil included in this alternative.	See Alternative 1.	Periodic monitoring by the lead agency would be necessary to ensure that the covers are not disturbed. Initial surface soil sampling and analysis for dieldrin and arsenic would be required at the perimeter of the soil cover to confirm that the impacted area has been contained	Progress and confirmation sampling, and laboratory analyses would be an integral part of the remedial action	See Alternative 4.
Ability to Obtain Approvals and Coordinate with Other Agencies	There is no approval applicable to this alternative	This alternative would require deed restrictions to prevent future residential use. Long-term coordination with Shelby County-City of Memphis and/or the Department of the Interior is necessary to maintain existing land-use controls to provide layers of protectiveness with the deed restrictions.	Existing land use controls would have to be lifted or altered to allow future residential use. No other approval would be necessary to implement this alternative for future residential use Long-term coordination with Shelby County-City of Memphis and/or the Department of the Interior is necessary to maintain institutional controls to prevent disturbance of the covers.	Existing land use controls would have to be lifted or altered to allow future residential use. There would be no other approval necessary to implement this alternative for future residential use. After implementation of the remedial action allowing future residential use, no institutional controls would be required since the site would be cleaned up to residential use criteria.	See Alternative 4.
Availability of Services and Capacities	No services or capacities are required under this alternative	See Alternative 1	Services are readily available to construct and maintain covers, allowing future residential use.	Implementation services for both technologies are readily available in the commercial market	Services are readily available for excavation, transportation, and off-site disposal.

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TABLE 4-4 FU2-Southeast Golf Course Area Summary Memphis Depot Main Installation Soils FS- 7	of Individual Detailed Analysis of Surface Soil Alterna 73/00	threes			
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Availability of Necessary Equipment, Specialists, and Materials	No equipment, specialists, or materials are required under this alternative.	See Alternative 1.	Equipment and materials are readify available to construct and maintain covers, allowing future residential use.	Equipment and most materials are readily available for enhanced biodegradation of dieldrin-contaminated surface soil and stabilization of arsenic-contaminated surface soil The bench-scale tested biological amendment is a proprietary product currently available from only one source. There are a number of stabilization amendments available in the commercial market.	Equipment and materials are readily available for excavation, transportation, and off-site disposal. The capacity of local landfills may be limited.
Availability of Technologies	There is no technology required under this alternative.	See Alternative 1.	Soil cover technology is readily available, allowing future residential use.	The treatment technologies are readily available, allowing future residential use.	The excavation, transportation, and disposal technologies are readily available, allowing future residential use.
COST	FU2	All FUS ^a	FU2	FU2	FU2
Recreational Use:			This alternative is not necessary for	This atternative is <u>not necessary</u> for	This alternative is not necessary for
Capital Cost First-Vear Annual O&M Cost	\$0 \$	\$14,000 *******	recreational use, merenore, mere are no costs.	recreational use; ineretore, inere are no costs	recreauorial use; mereiore, mere are no costs.
Present Worth O&M Cost	00	\$4,000 \$47,000			
Total Present Worth Cost	0 %	000'/20¢			
Residential Use:		This alternative is designed to prevent			
Capital Cost	0\$	residential use. Costs are included under	\$2,799,000	\$1,608,000	\$5,097,000
First-Year Annual O&M Cost	\$0	nie lituustriat Ose.	\$38,100	\$831,900	0\$
Present Worth O&M Cost	\$0		\$576,000	\$1,762,000	ŝ
Total Present Worth Cost	\$0	-	\$3,375,000	\$3,370,000	\$5,097,000
STATE ACCEPTANCE	This alternative would not likely be acceptable to state regulators. Aithough recreational use risks are acceptable without action, this alternative does not adequately prevent future residential use.	Institutional controls are likely to be acceptable to state regulators. Recreational use risks are acceptable without action, and this alternative adequately prevents future residential use.	This alternative would not likely be acceptable to state regulators for future residential use since long-term effectiveness is marginal and ongoing monitoring of the covers and land use is required.	In-situ treatment would likely be acceptable to state regulators, allowing future residential use since all on-site soil would be treated to meet residential use criteria	Excavation, transportation, and off-site disposal would likely be acceptable to state regulators, allowing future residential use since all on-site soil exceeding residential use criteria would be removed. The soil would be disposed of in a permitted off-site location.
COMMUNITY ACCEPTANCE	This alternative would not likely be acceptable to the community. Although recreational use risks are acceptable without action, this alternative does not adequately prevent future residential use	The community may be willing to accept this alternative for recreational use by preventing future residential use through establishment of institutional controls.	The community may be willing to accept this alternative for future residential use, but would likely insist on strong, ongoing institutional controls, and monitoring of the covers and land use. The probable loss of recreational use of this site, coupled with the limited area available for residential use may be a concern to the community	In-situ treatment may be acceptable to the community, allowing future residential use since all on-site soil would be treated to meet residential use criteria.	Excavation, transportation, and off-site disposal may be acceptable to the community, allowing future residential use since all on-site soil exceeding residential use criteria would be removed. The soil would be disposed of in a permitted off-site location.
^a The cost to implement institutional contru	ols applies to all FUs combined				
Costs are expressed as order-of-magnituc	le estimates.				
The basis for the cost estimates is include	d in Appendix B of this FS			1 6 -	

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For recreational use, there are no COCs for FU2 For residential use, dieldrin and arsenic are COCs for FU2.

Memphis Depot Main Installation Soils FS	- 7/3/00				
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
	This alternative includes no remedial activities for FU3.	This alternative includes deed restrictions and site controls preventing residential land use, including daycare, for FU3.	This alternative includes a protective cover of soil or pavement over areas of lead-contaminated surface soil and arsenic-contaminated surface soil (a total area of 5,500 ft ²) in FU3, coupled with institutional controls preventing disturbance of the cover.	This alternative includes stabilization of lead-contaminated surface soil and arsenic-contaminated surface soil (a total of 5,500 ft ²), and institutional controls prohibiting residential use during implementation of the remedial action at FU3.	This alternative includes the excavation and off-site transportation and disposal of lead-contaminated surface soil and arsenic-contaminated surface soil (a total of 5,500 ft ²) in FU3.
OVERALL PROTECTIVENESS					
Human Health Protection (Direct Contact/Soil Ingestion)	There would be no reduction in risk to human health from exposure (direct contact and soil ingestion) to lead and arsenic in the surface soil under this alternative. Currently such risks are acceptable for industrial use but not for future residential use This alternative <u>does not</u> provide additional institutional controls and other restrictions, and relies on existing land use controls to	There would be a reduction in risk because institutional controls can prevent future residential use of FU3, and exposure to lead and arsenic in the surface soil Ongoing risks from industrial use of FU3 are acceptable	This alternative <u>does</u> provide future residential use in FU3 through the protection of human health by covering lead- and arsenic-contaminated surface soil with a protective cover. A cover would reduce direct contact risk and soil ingestion risk for future residential users. Long-term institutional controls preventing disturbance of the cover are necessary to maintan protection of human health	This alternative <u>does</u> protect human health for future residential use in FU3. Stabilization decreases direct contact risk and surface soil ingestion risk of lead and arsenic to levels acceptable for future residential use in FU3. Institutional controls preventing future residential use in FU3 until the remedial action is complete are necessary to maintain	This alternative <u>does</u> protect human health for future residential use in FU3. Excavation, transportation, and off-site disposal of contaminated surface soil at a permitted, controlled landfill removes direct contact risk and soil ingestion risk of lead- and arsenic-contaminated surface soil.
	prevent future residential use			protection of human health.	
Environmental Protection	Existing concentrations of lead and arsenic do not present unacceptable environmental risks Sensitive ecological populations are not present at FU3.	See Alternative 1.	See Alternative 1.	See Alternative 1.	See Alternative 1.
COMPLIANCE WITH ARARS					
Chemical-Specific ARARs	There are no chemical-specific ARARs for surface soil.	See Alternative 1	See Alternative 1	See Alternative 1.	See Atternative 1.
Location-Specific ARARs	Currently, FU3 is zoned as Light Industnal (I-L) This zoning designation prevents residential use. However, this zoning prohibition is not permanent and could change in the future	Deed restrictions precluding future residential use reinforce and add a layer of protectiveness over and above the existing land use controls (see Alternative 1).	Existing land use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1)	Existing fand use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1).	Existing land use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1).
Action-Specific ARARs	This alternative would not meet action- specific ARARs since there is no action.	See Alternative 1	Compliance with Tennessee Rule 1200-3- 1 on fugitive dust emissions during construction of the cover would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during construction of the cover would also be required.	Compliance with Tennessee Rule 1200-3-1 on fugitive dust emissions during remedial activities would be required. Existing NPDES compliance of stomwater in contact with contaminated soil during remedial activities would also be required	Disposal characterization of the excavated soil would be conducted in accordance with 40 CFR 261. Disposal of contaminated soil would meet RCRA land disposal restrictions; however, it is anticipated that excavated soil from FU3 would be disposed of at a local RCRA Subtitle D landfill as a non-hazardous waste Compliance with Tennessee Rule 1200-3-1 on fugitive dust emissions during excavation, transportation, and backfilting operation would be required. Existing NPDES compliance of stortwater in contact with contaminated soil during construction activities would also be required
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TABLE 4-5 FU3-Southwest Open Area: Summary of Indiv Memphis Depot Main Installation Soils FS – 7/	dual Detailed Analysis of Surface Soil Alternatives 3/00				510 111
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Other Criteria and Guidance	This alternative would not meet chemical- specific RAOs for future residential use, but would meet RAOs for industrial use of FU3	This alternative is compliant with industrial risk-based critena for FU3. Compliance with residential risk criteria for FU3 is not applicable since future residential use is prevented by the use of institutional controls	By covering the lead- and arsenic- contaminated surface soil, the site will meet surface soil RAOs for future residential use of FU3 Any imported soil to be used for the cover would be confirmed clean by laboratory testing prior to placement on-site.	By stabilization of the lead- and arsenic- contaminated surface soil, the site would meet surface soil RAOs for future residential use of FU3.	By removing contaminated surface soil and disposing off-site, the site would meet surface soil RAOs for future residential use of FU3 Imported soil for backfill would be confirmed clean by laboratory testing prior to placement on-site.
LONG-TERM EFFECTIVENESS AND PE	RMANENCE				
Magnitude of Residual Risk (Direct Contact/Soil Ingestion)	The source has not been removed. Unacceptable risk will remain for future residential use. The existing risk is acceptable for industrial use.	The source would not be removed; however, unacceptable risk for future residential use would be prevented through institutional controls. The existing risk is acceptable for industrial use.	Future residential risk at the site is acceptable as long as a cover is maintained. Because the source is only contained, some inherent risk remains if the cover is breached by intrusion.	Future residential use risk at the site from contaminated surface soil is reduced to acceptable levels by treatment that fixes arsenic and lead.	Future residential risk at the site from contaminated soil is eliminated because surface soil contaminated above levels acceptable for residential use would be removed from the site.
			Long-term control of activities that could potentially disturb the cover would be difficult in a residential setting. Therefore, the risk could increase over time.		
Adequacy and Reliability of Controls	There are no actions or controls; therefore, reliability is not applicable Surface soil would remain in place.	Institutional controls are less effective and reliable than permanent treatment Contaminated surface soil would remain as a potential risk for future residential use. Long-term oversight by the lead agency would be required to maintain protective layers of institutional and land use controls to <u>prevent</u> future residential use.	This alternative would contain contaminated surface soil in place and minimize potential exposure for future residential use. The reliability of this alternative is marginal because long-term oversight by the lead agency would be required to <u>prevent</u> intrusive activities in the cover	This alternative controls contamination in soil by immobilizing lead and arsenic through stabilization of surface soil Reliability is very high for future residential use. Stabilization of lead and arsenic is a proven technology for the fixation of contaminated soil. Therefore, no management beyond the remedial implementation period is required.	Excavation, transportation, and off-site disposal effectively removes surface soil contaminated above levels acceptable for future residential use within the FU boundaries. Reliability is very high for future residential use. No site management beyond the remedial implementation period is required. The reliability of a permitted off-site disposal facility is high.
Need for 5-Year Review	Review would be required to ensure adequate protection of human health and the environment for future users of the site.	Review would be required to ensure that institutional controls are still in place for the adequate protection of human health and the environment for future users of the site.	Institutional controls would still be required to prevent disturbance of the surface soil cover Therefore, review would be required to ensure that the covers are intact and provide adequate protection of human health for future residential use.	Contarinnated surface soil would be effectively stabilized in less than 5 years; therefore, no review would be required.	Not applicable. Contaminated soil would be removed in less than 5 years; therefore, no review would be required.
REDUCTION OF TOXICITY, MOBILITY, C	A VOLUME THROUGH TREATMENT				
Treatment Process Used	This alternative does not include active treatment of contaminated soil.	See Alternative 1.	See Alternative 1	Stabilization is used to treat lead- and arsenic-contaminated surface soil.	See Alternative 1.
Amount Destroyed or Treated	No soil contaminants are treated or destroyed under this alternative.	See Alternative 1.	See Alternative 1.	Approximately 200 in-place cubic yards of lead- and arsenic-contaminated surface soil would be stabilized.	See Alternative 1.
Reduction of Toxicity, Mobility, or Volume	There is no reduction in toxicity, mobility, or volume through treatment under this alternative.	See Alternative 1.	See Alternative 1	Stabilization of lead- and arsenic- contaminated surface soil would reduce the mobility of lead and arsenic to residual levels acceptable for future residential use	See Alternative 1

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TABLE 4-5 FU3-Southwest Open Area. Summary of Indiv Memohis Denot Main Installation Soils FS - 7/	idual Detailed Analysis of Surface Soil Alternatives				510 112
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Irreversible Treatment	There is no irreversible treatment under this alternative.	See Alternative 1.	See Alternative 1.	The treatment process is trreversible as the lead and arsenic are stabilized.	See Alternative 1.
Type and Quantity of Residuals Remaining After Treatment	There is no treatment; therefore, no residuals are generated in this alternative.	See Alternative 1.	See Alternative 1.	Lead- and arsenic-stabilized soil would remain on-site as a "cemented" mass. Approximately 220 cubic yards of stabilized soil would remain on-site.	See Alternative 1.
Statutory Preference for Treatment	This alternative does not satisfy the statutory preference for treatment.	See Alternative 1.	See Alternative 1.	This alternative satisfies the statutory preference for treatment	See Alternative 1.
SHORT-TERM EFFECTIVENESS					
Community Protection	The risk to the community is not increased by remedy implementation, but the risk is unacceptable if the site is used in the future for residential use.	The risk to the community is not increased by remedy implementation.	Temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls.	See Alternative 3.	A temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls. Transportation of excavated soil and clean backfill through the community might require special controls such as restrictions on truck routing and hours of operation.
Worker Protection	There is no action; therefore, there is no risk to workers.	There is no physical on-site action; therefore, there is no risk to workers.	The site is currently acceptable for the industrial worker, however, the remedial contractor's health and safety program could require engineering controls or protective personnel equipment for workers during construction	See Alternative 3.	See Alternative 3.
Environmental Impacts	There is no action; therefore, there are no environmental impacts.	There is no physical on-site action; therefore, there is no impact to the environment	Fugitive dust emissions and stormwater runoff during implementation could cause environmental impacts, therefore, they would be managed by standard construction industry engineering controls.	See Alternative 3.	See Atternative 3.
Time Until Action is Complete	This criterion is not applicable.	Deed restrictions would be implemented within 6 months to add a layer of protection precluding future residential use.	A protective cover would be placed and institutional controls enacted in less than 1 year, allowing future residential use after implementation.	Stabilization amendments for arsenic and lead would require up to 6 months, allowing residential use after implementation.	Soil would be excavated and transported from the site within 6 months, allowing residential use after implementation.
IMPLEMENTABILITY					
Ability to Construct and Operate	There is no construction or operation under this alternative.	Institutional controls are readify implemented to preclude future residential use	Covers are easily constructed and maintained, allowing future residential use.	This alternative is reasonably easy to construct and operate, allowing future residential use. Stabilization is a known, proven technology.	Excavation, transportation, and disposal are easily implemented.
Ease of Doing More Action if Needed	If more action becomes necessary, the FS/ROD process may need to be repeated	No future remedial action is contemplated unless future residential use of the site is required This alternative does not restrict any future remedial action. If remedial action becomes necessary, Alternative 3, 4, or 7 could easily be implemented, provided there has not been significant resurfacing or grading of the land surface from light industrial operations.	It would be easy to extend the limits of covered areas, but future treatment or remediation of contaminated soil would require excavation and disposal of the covers	The volume of treated soil could be increase and the technologies could be modified. For example, the stabilization admixture could b attered This alternative could also be combined with other remedial technologies and with remedial actions at other FUs	d It would be easy to extend the limits of remedial areas, or add treatment.

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tive 1 tion	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
of soil included in	See Atternative 1.	Periodic monitoring by the lead agency would be necessary to ensure that the covers are not disturbed Initial surface soil sampling and analysis for lead and arsenic would be required at the perimeter of the soil cover to confirm that the impacted area has been contained.	Progress and confirmation sampling, and laboratory analyses would be an integral pai of the remedial action	See Alternative 4.
pplicable to this	This alternative would require deed restrictions to prevent future residential use Long-term coordination with Shelby County-City of Memphis is necessary to maintain existing land use controls to provide layers of protectiveness with the deed restrictions.	Existing land use controls would have to be lifted or altered to allow future residential use. There would be no other approval necessary to implement this alternative for future residential use. Long-term coordination with Shelby County-City of Memphis is necessary to	Existing land use controls would have to be lifted or altered to allow future residential use. There would be no other approval necessary to implement this alternative for future residential use. After implementation of the remedial action allowing future residential use, no	See Alternative 4.
		disturbance of the covers.	institution controls would be required since the site would be cleaned up to residential use criteria.	
r capacities rnative.	See Alternative 1.	Services are readily available to construct and maintain covers, allowing future residential use	Implementation services for both technologies are readily available in the commercial market.	Services are readily available for excavation, transportation, and off-site disposal.
t, specialists, or r this alternative.	See Alternative 1.	Equipment and materials are readify available to construct and maintain covers, allowing future residential use	Equipment and most materials are readily available for stabilization of lead- and arsenic-contaminated surface soil. There are a number of stabilization amendments available in the commercial market	Equipment and materials are readily available for excavation, transportation, and off-site disposal. The capacity of local landfills may be limited.
required under this	See Alternative 1.	Soil cover technology is readily available, allowing future residential use.	The treatment technologies are readily available, allowing future residential use	The excavation, transportation, and disposal technologies are readily available allowing future residential use.
_		FU3	FU3	FU3
	\$14,000 \$3,800	This alternative is <u>not necessary</u> for industrial use; therefore, there are no costs.	This alternative is not necessary for industrial use; therefore, there are no costs.	This alternative is <u>not necessary</u> for industrial use; therefore, there are no costs.
	\$57,000 \$71,000			
	This alternative is designed to prevent residential use. Costs are included under the Industrial Lee	\$18,000	\$5,000	\$106,000
		\$1,200	\$1,750	\$0
		\$18,000	\$17,000	\$0
		\$36,000	\$22,000	\$106,000

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TABI	TABLE 4-5 FU3-Southwest Open Area: Summary of Indivic Memphis Depot Main Installation Soils FS – 7/5	tual Detailed Analysis of Sur
	Evaluation Criteria	Alternat No Aci
	Ability to Monitor Effectiveness	There is no monitoring this alternative.
	Ability to Obtain Approvals and Coordinate with Other Agencies	There is no approval ap alternative.
	Availability of Services and Capacities	There are no services o required under this after
J	Availability or necessary Equipment, Specialists, and Materials	i nere are no equipmen materials required unde
	Availability of Technologies	There is no technology r alternative
	COST	FU3
	<u>Industrial Use:</u> Capital Cost	0\$
	First-Year Annual O&M Cost	\$0
	Present Worth O&M Cost	\$0
	Total Present Worth Cost	\$0
	<u>Residential Use:</u> Canital Cost	C H
	First-Year Annual O&M Cost	\$0
	Present Worth O&M Cost	\$0
,	Total Present Worth Cost	\$0

Alternative 7 Excavation, Transportation, and Off-site Disposal	Excavation, transportation, and off-site disposal would likely be acceptable to state regulators, allowing future residential use since all on-site surface soil exceeding residential use criteria would be removed. The soil would be disposed of in a permitted off-site location.	Excavation, transportation, and off-site disposal may be acceptable to the community, allowing future residential use since all on-site surface soil exceeding residential use criteria would be removed. The soil would be disposed of in a permitted off-site location.	
Alternative 4 In-situ Soil Treatment	situ treatment would likely be acceptable to ite regulators, allowing future residential e since all on-site soil would be treated to tet residential use criteria.	situ treatment may be acceptable to the mmunity, allowing future residential use ce all on-site soil would be treated to meet idential use criteria.	
Alternative 3 Soil Containment	This alternative would not likely be In-s acceptable to state regulators for future sta residential use since long-term use effectiveness is marginal and ongoing me monitoring of the covers and land use is required.	The community may be willing to accept In-s this as the selected alternative for future con residential use, but would likely insist on sind strong, ongoing institutional controls and res monitoring of the covers and land use.	
Alternative 2 Institutional Controls	Institutional controls are likely to be acceptable to state regulators. Industrial use risks are acceptable without action, and this alternative adequately prevents future residential use	The community may be willing to accept this alternative for industrial use by preventing future residential use through establishment of institutional controls.	sed as order-of-magnitude estimates.
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Jividual Detailed Analysis of Surface Soil Alternat	Alternative 1 No Action	This alternative would not likely be acceptable to state regulators. Although industrial use risks are acceptable with action, this alternative does not adequa prevent future residential use.
TABLE 4-5 FU3-Southwest Open Area: Summary of Inc Memphis Depot Main Installation Soils FS -	Evaluation Criteria	STATE ACCEPTANCE

COMMUNITY ACCEPTANCE

This alternative would not likely be acceptable to the community. Although industrial use risks are acceptable with action, this alternative does not adequal prevent future residential use.

^a The cost to implement institutional controls applies to all FUs combined. Costs arr The basis for the cost estimates is included in Appendix B of this FS. For residential use, lead and arsenic are COCs for FU3 For industrial use, there are no COCs for FU3

rue-thormen and central Open Area. Sum Memphis Depot Main Installation Soils FS –	mary of Individual Detailed Analysis of Surface Soil Al - 7/3/00	Iternatives for Industrial Land Use Scenario			
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
	This alternative includes no remedial activities for FU4.	This alternative includes deed restrictions and site controls (fencing and signage) preventing (1) industrial use at the southeast corner of Building 949 where lead in the surface soil is ≥1,536 mg/kg and (2) residential land use, including daycare, for all of FU4.	This alternative includes a protective cover of soil or pavement over the area of lead-contaminated surface soil (a total area of 7,200 ft ²), coupled with institutional controls preventing disturbance of the cover. Future residential use is prevented by the use of institutional controls.	This alternative includes stabilization of lead-contaminated surface soil (a total area of 7,200 ft ²), and institutional controls prohibiting industrial use during implementation of the remedial action at FU4. Future residential use is prevented by the use of institutional controls.	This alternative includes the remediation and off-site transportation and disposal of lead-contaminated surface soil (a total of 7,200 ff ² or 270 cubic yards) for industrial use. Future residential use is prevented by the use of institutional controls.
OVERALL PROTECTIVENESS					
Human Health Protection (Direct Contact/Soil Ingestion)	There would be no reduction in risk to human health from exposure (direct contact and soil ingestion) to lead in the surface soil under this alternative. Currently such risks <u>are not</u> acceptable for industrial use. This alternative <u>does not</u> provide additional institutional controls and other restrictions, and relies on existing controls to prevent future residential use.	There would be a reduction in risk because institutional controls (deed restriction and site controls) would prevent industrial use in the area where lead is ≥1,536 mg/kg in the surface soil. Site controls such as fencing and signage would be used to control access to this area. Institutional controls would also reduce the risk of exposure to dieldrin, lead, and arsenic in the surface soil by prohibiting residential use through deed restrictions.	This alternative <u>does</u> provide for the protection of human health for industrial use by covering lead-contaminated surface soil with a protective cover. A cover would reduce direct contact nsk and soil ingestion risk for industrial workers Long-term institutional controls preventing disturbance of the cover are necessary to maintain protection of human health.	This alternative <u>does</u> provide protection of human health for industrial use by treatment. Stabilization of lead-contaminated surface soil decreases direct contact risk and soil ingestion risk of lead to levels acceptable for industrial use. Institutional controls preventing industrial use in the area of concern until the remedial action is complete are necessary to maintain protection of human health.	This alternative <u>does</u> protect human health for industrial use Excavation, transportation, and off-site disposal at a permitted, controlled landfilt removes direct contact risk and soil ingestion risk of lead-contaminated surface soil
Environmental Protection	Existing concentrations of surface soil contaminants do not present unacceptable environmental risks Sensitive ecological populations are not present at FU4.	See Alternative 1.	See Alternative 1	See Alternative 1.	See Alternative 1
COMPLIANCE WITH ARARS					
Chemical-Specific ARARs	There are no chemical-specific ARARs for surface soil.	See Alternative 1	See Alternative 1.	See Alternative 1.	See Alternative 1
Location-Specific ARARs	Currently, FU4 is zoned as Light Industrial (I-L). This zoning designation prevents residential use. However, this zoning allows industrial use, and is not permanent and could change in the future.	Deed restrictions precluding industrial use in the area where lead is ≥1,536 mg/kg in the surface soil or future residential use across FU4 reinforce and add a layer of protectiveness over and above the existing land use controls (see Alternative 1).	See Alternative 1.	See Alternative 1	See Alternative 1.
Action-Specific ARARs	This alternative would not meet action specific ARARs since there is no action	See Alternative 1.	Compliance with Tennessee Rule 1200-3- 1 on fugitive dust emissions during construction of the cover would be required. Existing NPDES compliance of stormwater in contact with contaminated stormwater in contact with contaminated also be required.	Compliance with Tennessee Rule 1200-3-1 on fugitive dust emissions during remedial activities would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during remediation activities would also be required.	Disposal characterization of the excavated soil would be conducted in accordance with 40 CFR 261. Disposal of contaminated soil would meet RCRA land disposal restrictions The disposal characterization sampling and analysis may determine that the lead-contaminated soil is a hazardous waste (D008) per 40 CFR 261 24, and would be required to be treated and disposed of in a RCRA Subtitle C hazardous waste landfill

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TABLE 4-6A FU4-Northern and Central Open Area: Sumn Memphis Depot Main Installation Soils FS –	ary of Individual Detailed Analysis of Surface Soil A 7/3/00	Iternatives for Industrial Land Use Scenario			510 116
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Afternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
					Compliance with Tennessee Rule 1200-3- 1 on fugitive dust emissions during excavation, transportation, and backfilling operation would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during construction activities would also be required
Uther Criteria and Guidance	Would not meet the lead RAOs for industrial use.	This alternative is compliant with industrial risk-based criteria if controls are implemented that limit industrial use of lead-contaminated areas (≥1,536 mg/kg) of the site. Compliance with residential nsk criteria is not applicable since future residential use is prevented by the use of institutional controls.	By covering the lead-contaminated surface soil, the site would meet surface soil RAOs for industrial use. Any imported soil to be used for the cover would be confirmed clean by laboratory testing prior to placement on-site.	By stabilization of the fead-contaminated soil, the site would meet surface soil RAOs for industrial use.	By removing contaminated surface soil and disposing off-site, the site would meet surface soil RAOs for industrial use. Imported soil for backfill would be confirmed clean by laboratory testing prior to placement on-site.
LONG-TERM EFFECTIVENESS AND PI	ERMANENCE				
Magnitude of Residual Risk (Direct Contact/Soil Ingestion)	The source has not been removed. Unacceptable risk will remain for future industrial use.	The source would not be removed; however, unacceptable risk for industrial use would be prevented through institutional controls.	Industrial use risk at the site is acceptable as long as a cover is maintained Because the source is only contained, some inherent risk remains if the cover is breached by intrusion.	Industrial use risk at the site from contaminated surface soil is reduced to acceptable levels by treatment that fixes fead.	Industrial use risk at site from contaminated surface soil is eliminated because surface soil contaminated above levels acceptable for industrial use would be removed from the site.
			Long-term control of activities that could potentially disturb the cover would be difficult in an industrial setting; therefore, risk could increase over time		
Adequacy and Reliability of Controls	There are no action or controls, therefore, reliability is not applicable Surface soil would remain in place.	Institutional controls are less effective and reliable than permanent treatment. Contaminated surface soil would remain as a potential risk for industrial use. Long- term oversight by the lead agency would be required to maintain protective layers of institutional and land use controls to <u>prevent</u> industrial use in the area of concern and <u>prevent</u> residential use across FU4.	This alternative would contain contaminated surface soil and minimize potential exposure for industrial use The reliability of this alternative is marginal because long-term oversight by the lead agency would be required to <u>prevent</u> intrusive activities in the cover.	This alternative controls contamination in surface soil by immobilizing lead through stabilization of surface soil. Reliability is very high for industrial use. Stabilization of lead is a known, proven technology for the fixation of contaminated soil Therefore, no management beyond the remedial implementation period is required.	Excavation, transportation, and off-site disposal effectively removes soil contaminated above levels acceptable for industrial use within the FU boundaries. Reliability is very high for industrial use. No site management beyond the remedial implementation period is required The reliability of a permitted off-site disposal facility is high.
Need for 5-Year Review	Review would be required to ensure adequate protection of human health and the environment for future users of the site.	Review would be required to ensure that institutional controls are still in place for the adequate protection of human health and the environment for future users of the site.	Institutional controls would be required to prevent disturbance of the cover. Therefore, review would be required to ensure that covers are intact and provide adequate protection of human health for industrial use	Contaminated surface soil would be effectively stabilized in less than 6 months; therefore, no review would be required.	Not applicable. Contaminated surface soil would be removed in less than 5 years; therefore, no review would be required.
REDUCTION OF TOXICITY, MOBILITY,	OR VOLUME THROUGH TREATMENT				
Freatment Process Used	This alternative does not include active treatment of contaminated surface soil	See Alternative 1.	See Alternative 1.	Stabilization is used to treat lead- contaminated surface soil	See Alternative 1
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TABLE 4-6A FU4-Northern and Central Open Area: Sumr Memphis Depot Main Installation Soils FS - ;	rary of Individual Detailed Analysis of Surface Soil Alt 7/3/00	ernatives for Industrial Land Use Scenario			510 117
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Amount Destroyed or Treated	No soil contaminants are treated or destroyed under this alternative.	See Alternative 1.	See Alternative 1.	Approximately 270 in-place cubic yards of lead-contaminated surface soil would be stabilized.	See Alternative 1.
Reduction of Toxicity, Mobility, or Volume	There is no reduction in toxicity, mobility, or volume through treatment under this alternative.	See Alternative 1.	See Alternative 1.	Stabilization of lead-contaminated surface soil would reduce the mobility of lead to residual levels acceptable for future industrial use.	See Alternative 1.
Irreversible Treatment	There is no irreversible treatment under this alternative.	See Alternative 1.	See Alternative 1.	The stabilization process is effectively irreversible.	See Alternative 1
Type and Quantity of Residuals Remaining After Treatment	There is no treatment; therefore, no residuals are generated in this alternative.	See Alternative 1	See Alternative 1.	Lead-stabilized surface soil would remain on- site. Approximately 300 cubic yards of stabilized soil would remain on-site.	See Alternative 1.
Statutory Preference for Treatment	This alternative does not satisfy the statutory preference for treatment.	See Alternative 1.	See Alternative 1.	This alternative satisfies the statutory preference for treatment.	See Alternative 1.
SHORT-TERM EFFECTIVENESS					
Community Protection	The risk to the community is not increased by remedy implementation, but the risk is unacceptable if the entire site is used for industrial use.	The risk to the community is not increased by remedy implementation	A temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls.	See Alternative 3.	A temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by engineering controls. The transportation of excavated soil and clean backfill through the community may require special controls such as restrictions on truck routing and hours of operation
Worker Protection	There is no action; therefore, there is no risk to workers.	There is no physical on-site action; therefore, there is no risk to workers.	The remedial contractor's health and safety program would require engineering controls or protective personnel equipment for workers during construction.	See Alternative 3.	See Alternative 3.
Environmental Impacts	There is no action; therefore, there are no environmental impacts.	There is no physical on-site action; therefore, there is no impact to the environment.	Fugitive dust emissions and stormwater runoff during implementation could cause environmental impacts; therefore, they would be managed by standard construction industry engineering controls.	See Alternative 3.	See Alternative 3
Time Until Action is Complete	This criterion is not applicable.	Deed restrictions and site controls would be implemented within 6 months to add a layer of protection precluding industrial use in the area of concern and residential use across FU4.	A protective cover would be placed and institutional controls enacted in less than 1 year, allowing industrial use after implementation	For industrial use, stabilization amendments for lead would require up to 6 months.	Surface soil would be excavated and transported from the site within 6 months allowing industrial use after implementation.
IMPLEMENTABILITY					
Ability to Construct and Operate	There is no construction or operation under this alternative	Institutional controls are readily implemented to preclude industriat use in the area of concern and residential use across FU4.	Protective covers are easily constructed and maintained, allowing industrial use.	This alternative is reasonably easy to construct and operate, allowing future industrial use Stabilization is a known, proven technology	Excavation, transportation, and disposal are easily implemented.
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Ability to Construct and Operate

IMPLEMENTABILITY

Memphis Depot Main Installation Soils FS - 7.	13/00				
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Ease of Doing More Action if Needed	If more action becomes necessary, the FS/ROD process may need to be repeated	This alternative does not restrict any future remedial action. If remedial action becomes necessary, Alternative 3, 4, or 7 could easily be implemented, provided there has not been significant resurfacing or grading of the land surface from light industrial operations.	It would be easy to extend limits of the covered area, but future treatment or remediation of contaminated soil would require excavation and disposal of the cover.	The volume of treated soil could be increased and the technology could be modified. For example, the stabilization admixture could be altered. This alternative could also be combined with other remedial technologies and with remedial actions at other FUs.	It would be easy to extend the limits of remedial areas, or to add treatment.
Ability to Monitor Effectiveness	There is no monitoring of soil included in this alternative.	See Alternative 1	Periodic monitoring by the lead agency would be necessary to ensure that the cover is not disturbed Initial surface soil sampling and analysis for lead would be required at the perimeter of the soil cover to confirm that the impacted area has been contained	Progress and confirmation sampling would be an integral part of the remedial action.	See Alternative 4.
Ability to Obtain Approvals and Coordinate with Other Agencies	There is no approval applicable to this alternative.	This alternative would require deed restrictions to prevent industrial use in the area of concern and residential use across FU4. Long-term coordination with Shelby County-City of Memphis is necessary to maintain existing land use controls to provide layers of protectiveness with the deed restrictions.	Long-term coordination with Shelby County-City of Memphis is necessary to maintain institutional controis to prevent disturbance of the covers.	There would be no approval necessary to implement this alternative for future industrial use After implementation of the remedial action allowing industrial use, no institutional controls would be required since the site would be cleaned up to industrial use	See Alternative 4
Availability of Services and Capacities	No services or capacities are required under this alternative	See Alternative 1	Services are readily available to construct and maintain covers, allowing industrial use	Implementation services for the technology are readily available in the commercial market	Services are readily available for excavation, transportation, and off-site disposal.
Availability of Necessary Equipment, Specialists, and Materials	No equipment, specialists, or materials are required under this alternative.	See Alternative 1.	Equipment and materials are readily available to construct and maintain covers, allowing industrial use.	Equipment and most materials are readily available for stabilization of lead- contaminated surface soil There are a number of stabilization amendments available in the commercial market	Equipment and materials are readily available for excavation, transportation, and off-site disposal. The capacity of local landfills may be limited.
Availability of Technologies	There is no technology required under this alternative	See Alternative 1.	Soil cover technology is readily available, allowing industrial use.	The treatment technologies are readily available, allowing industrial use	The excavation, transportation, and disposal technologies are readily available, allowing industrial use.
COST	FU4	FU4	FU4	FU4	FU4
<u>Industrial Use:</u> Capital Cost	ŝ	\$19,000	\$51,000	\$51,000	\$183,000
First-Year Annual O&M Cost	\$0	\$4,300	\$4,300	\$18,200	\$3,800
Present Worth O&M Cost	\$0	\$64,000	\$310,000	\$72,000	\$57,000
Total Present Worth Cost	\$0	\$83,000	\$361,000	\$123,000	\$240,000
		-			
GNV/003673664-SLH2051 DOC		30	SII		PAGE 4 OF 5

sis of Surface Soil	Alternatives for Industrial Land Use Scenario			510 119
ve 1 on	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
ot likely be lators. This uce the nsk for	Institutional controls are likely to be acceptable to state regulators to prevent residential use across FU4; however, this alternative would not likely be acceptable to state regulators for industrial use since long-term effectiveness is marginal and ongoing monitoring of the land use controls in the area of concern is required.	This alternative would not likely be acceptable to state regulators for future industrial use since long-term effectiveness is marginal and ongoing monitoring of the covers and land use is required.	In-situ treatment would likely be acceptable to state regulators, allowing industrial use since all on-site soil would be treated to meet industrial use criteria.	Excavation, transportation, and off-site disposal would likely be acceptable to state regulators, allowing industrial use since all on-site soil exceeding industrial use criteria would be removed. The soil would be disposed of in a permitted off-site location.
st likely be unity. This toe the risk for e entire site.	institutional controls may be acceptable to the community to prevent residential use across FU4; however, this alternative would not likely be acceptable to community for industrial use since long- term effectiveness is marginal and ongoing monitoring of the land use controls in the area of concern is required	The community may be willing to accept this as the selected alternative for industrial use, but would likely insist on strong, ongoing institutional controls, and monitoring of the covers and land use.	In-situ treatment may be acceptable to the community, allowing industrial use since all on-site soil would be treated to meet industrial use criteria.	Excavation, transportation, and off-site disposal may be acceptable to the community, allowing industrial use since all on-site soil exceeding industrial use criteria would be removed. The soil would be disposed of in a permitted off-site location.
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PAGE 5 OF 5

STATE ACCEPTANCE This alternative would not likely be acceptable to state regulators. The alternative does not reduce the native does not native does native does not native does	STATE ACCEPTANCE This alternative would not likely b acceptable to state regulators. The alternative does not reduce the na industrial use. COMMUNITY ACCEPTANCE This alternative would not likely b acceptable to the community. This alternative does not reduce the na industrial use across the entire s industrial use across the entire s for the basis for the cost estimates in cluded in Appendix B of this FS For industrial use, lead is the COC for FU4.	STATE ACCEPTANCE This alternative would not likely b acceptable to state regulators. Th alternative does not reduce the in industrial use. COMMUNITY ACCEPTANCE This alternative would not likely b acceptable to the community. This alternative does not reduce the in industrial use across the entire s industrial use across the entire s for industrial use, lead is the COC for FU4.
COMMUNITY ACCEPTANCE This alternative would not likely be acceptable to the community. This acceptable to the community. This alternative does not reduce the ns industrial use across the entire s industrial use across the entire s. Costs are expressed as order-of-magnitude estimates Industrial use across the entire s. Costs are expressed as order-of-magnitude estimates For the cost estimates is included in Appendix B of this FS For industrial use, lead is the COC for FU4. For industrial use, lead is the COC for FU4.	COMMUNITY ACCEPTANCE This alternative would not likely be acceptable to the community. This alternative does not reduce the ns industrial use across the entire s industrial use across the entire s. Costs are expressed as order-of-magnitude estimates Industrial use across the entire s. Costs are expressed as order-of-magnitude estimates For industrial use, lead is the COC for FU4.	COMMUNITY ACCEPTANCE This alternative would not likely b acceptable to the community. This alternative does not reduce the in alternative does not reduce the in industrial use across the enture s Costs are expressed as order-of-magnitude estimates The basis for the cost estimates is included in Appendix B of this FS For industrial use, lead is the COC for FU4.
Costs are expressed as order-of-magnitude estimates The basis for the cost estimates is included in Appendix B of this FS For industrial use, lead is the COC for FU4.	Costs are expressed as order-of-magnitude estimates The basis for the cost estimates is included in Appendix B of this FS For industrial use, lead is the COC for FU4.	Costs are expressed as order-of-magnitude estimates The basis for the cost estimates is included in Appendix B of this FS For industrial use, lead is the COC for FU4.

FU4-Northern and Central Open Areas: St Memphis Depot Main Installation Soils FS	mmary of Individual Detailed Analysis of Surface Soil A - 7/3/00	Alternatives for <i>Residential Land Use</i> Scenario			21015
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
	This alternative includes no remedial activities for FU4.	This alternative <u>does not apply</u> to the residential use scenario, because residential use, including day care, would be prohibited by institutional controls in FU4. See Table 4-6A.	This alternative includes a protective cover of soil or pavement over areas of dieldrin-contaminated, lead- contaminated, and arsenic- contaminated surface soil (a total area of 386,200 ft ²) in FU4, coupled with institutional controls preventing disturbance of the cover for residential use.	This alternative includes enhanced bioremediation of dieldrin, stabilization of lead and arsenic-contaminated surface soil (a total area of 386,200 ff ²), and institutional controls prohibiting residential use during implementation of the remedial action at FU4.	This alternative includes the excavtion and off-site transportation and disposal of dieldrin-, lead-, and arsenic-contaminated surface soil (a total area of 386,200 ft ²) for residential use.
OVERALL PROTECTIVENESS					
Human Health Protection (Direct Contact/Soil Ingestion)	There would be no reduction in risk to human health from exposure (direct contact and soil ingestion) to dieldrin, lead, and arsenic in the surface soil under this alternative. Currently such risks <u>are not</u> acceptable residential use.	Alternative 2 does not apply to the residential use scenario.	This alternative <u>does</u> provide for the protection of human health for future residential use by covering dieldnn-, lead-, and arsenic-contaminated surface soil with a cover. A protective cover would reduce direct contact risk and soil ingestion risk for future residential users. Long-term institutional controls preventing disturbance of the cover are necessary to maintain protection of human health.	This alternative <u>does</u> provide protection of human health for future residential use by treatment. Enhanced bioremediation of contact nusk and surface soil decreases direct contact risk and soil ingestion risk of dieldrin to levels acceptable for future residential use Stabilization decreases direct contact risk and soil ingestion risk of lead and arsenic to levels acceptable for future residential use. Institutional controls preventing future residential use until the remedial action is complete are necessary to maintain	This alternative <u>does</u> protect human health for future residential use. Excavation, transportation, and off-site disposal at a permitted, controlled landfill removes direct contact risk and soil ingestion risk of dieldrin-, lead-, and arsenic-contaminated surface soil.
Environmental Protection	Existing concentrations of lead, dieldrin, and arsenic do not present unacceptable environmental risks. Sensitive ecological populations are not present at FU4	Alternative 2 does not apply to the residential use scenano	See Alternative 1.	See Alfernative 1	See Alternative 1.
COMPLIANCE WITH ARARS					
Chemical-Specific ARARs	There are no chemical-specific ARARs for surface soil.	Alternative 2 does not apply to the residential use scenario.	See Alternative 1.	See Alternative 1.	See Atternative 1,
Location-Specific ARARs	Currently, FU4 is zoned as Light Industrial (I-L). This zoning designation prevents residential use, but is not permanent and could change in the future.	Alternative 2 does not apply to the residential use scenario.	Existing land use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1).	Existing land use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1).	Existing land use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1).
Action-Specific ARARs	This alternative would not meet action- specific ARARs since there is no action.	Alternative 2 does not apply to the residential use scenario.	Compliance with Tennessee Rule 1200-3- 1 on fugitive dust emissions during construction of the cover would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during construction of the cover would also be required.	Compliance with Tennessee Rule 1200-3-1 on fugitive dust emissions during remedial activities would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during remediation activities would also be required.	Disposal characterization of the excavated soil would be conducted in accordance with 40 CFR 261. Disposal of contaminated soil would meet RCRA land disposal restrictions; however, it is anticipated that excavated dieldrm- and arsenic-contaminated soil from FU4 will be disposed of at a local RCRA Subtitle D landfill as a non-hazardous waste The disposal characterization sampling and analysis may determine that the lead contaminated soil is a hazardous waste (D008) per 40 CFR 261 24, and would be required to be treated and disposed of in a RCRA Subtitle C hazardous waste landfill.

SOILS

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etailed Analysis of Surface Soil /	Alternatives for <i>Residential Land Use</i> Scenario			
Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
				Compliance with Tennessee Rule 1200-3- 1 on fugitive dust emissions during excavation, transportation, and backfilling operations would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during construction activities would also be required.
et chemical-specific RAOs foi tial use.	Alternative 2 does not apply to the residential use scenario.	By covering the dieldrin-, lead-, and arsenic-contaminated surface soil, the site would meet surface soil RAOs for future residential use of FU4. Any imported soil to be used for the cover would be confirmed clean by laboratory testing prior to placement on-site.	By bioremediating the dieldrin-contaminated surface soil and stabilization of the lead and arsenic-contaminated surface soil, the site would meet surface soil RAOs for future residential use of FU4.	By removing, transporting, and disposing off-site, the site would meet surface soif RAOs for future residential use of FU4. Imported soil for backfill would be confirmed clean by laboratory testing prior to placement on-site.
s not been removed. risk will remain for future e. 5 of dieldrin may decrease gh natural biodegradation.	Alternative 2 does not apply to the residential use scenario.	Future residential risk at the site is acceptable as long as a cover is maintained. Because the source is only contained, some inherent risk remains if the cover is breached by intrusion. Long-term control of activities that could	Future residential use risk at the site from contaminated surface soil is reduced to acceptable levels by treatment that destroys dieldrin and fixes lead and arsenic.	Future residential use risk at the site from contaminated surface soil is eliminated because soil contaminated above levels acceptable for future residential use would be removed from the site.
ctions or controls; therefore, applicable Surface soil n place.	Atternative 2 does not apply to the residential use scenario.	poterniany disturb the cover would be difficult in a residential setting; therefore, risk could increase over time. This alternative would contain contaminated surface soil and minimize potential exposure for future residential use. The reliability of this alternative is marginal because long-term oversight by the lead agency would be required to <u>prevent</u> intrusive activities in the cover.	This alternative controls contamination in soil by bioremediating dieldrin and by immobilizing lead and arsenic through stabilization of surface soil. Reliability is very high for future residential use A bench-scale treatability study indicates that bioremediation is effective for dieldrin Stabilization of lead and arsenic is a known, proven technology for the fixation of contaminated surface soil.	Excavation, transportation, and off-site disposal effectively removes soit contaminated above levels acceptable for future residential use within the FU boundaries Reliability is very high for residential use. No site management beyond the remedial implementation period is required. The reliability of a permitted off-site disposal facility is high.
be required to ensure ection of human heatth and it for future users of the site.	Alternative 2 does not apply to the residential use scenario.	Institutional controls would still be required to prevent disturbance of the cover Therefore, review would be required to ensure that covers are intact and provide adequate protection of human health for future residential use.	riferencie, no management beyond the remedial implementation period is required. Contaminated soil would be effectively biotreated and/or stabilized in fess than 5 years; therefore, no review would be required.	Not applicable. Contaminated soil would be removed in less than 5 years; therefore, no review would be required.
IOUGH TREATMENT does not include active ntaminated surface soil	Alternative 2 does not apply to the residential use scenario	See Atternative 1	Enhanced bioremediation is used to treat dieldrin-contaminated surface soil, and stabilization is used to treat lead- and arsenic-contaminated surface soil	See Alternative 1.
		Soils		PAGE 2 OF 5

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GNV/003673666-SLH2052 DOI	

This alternative does not treatment of contaminated

Treatment Process Used

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TH

Review would be required adequate protection of hu the environment for future

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Need for 5-Year Review

LONG-TERM EFFECTIVENESS AND PERMANENCE Magnitude of Residual Risk

(Direct Contact/Soil Ingestion)

The source has not been Unacceptable risk will rer residential use.

Concentrations of dieldrir with time through natural

Adequacy and Reliability of Controls

There are no actions or co reliability is not applicable would remain in place.

Would not meet chemical-future residential use.

Evaluation Criteria

 TABLE 4-6B

 FU4-Northern and Central Open Areas: Summary of Individual Detailed Analy

 Memphis Depot Main Installation Soils FS - 7/3/00

Other Criteria and Guidance

FU4-Northern and Central Open Areas: Sum Memphis Depot Main Installation Soils FS - 7,	nary of Individual Detailed Analysis of Surface Soil A (3/00	Iternatives for <i>Residential Land Use</i> Scenario			510 122
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Amount Destroyed or Treated	No soil contaminants are treated or destroyed under this alternative.	Alternative 2 does not apply to the residential use scenario.	See Alternative 1.	Approximately 4,500 in-place cubic yards of dieldrin-contaminated surface soil will be bioremediated and approximately 10,180 in- place cubic yards of lead- and arsenic- contaminated surface soil will be stabilized.	See Alternative 1.
Reduction of Toxicity, Mobility, or Volume	There is no reduction in toxicity, mobility, or volume through treatment under this alternative	Alternative 2 does not apply to the residential use scenario.	See Alternative 1.	Bioremediation of dieldrin-contaminated surface soil would reduce the toxicity to residual levels acceptable for future residentiat use. Stabilization of lead- and arsenic-contaminated surface soit would reduce the mobility of lead and arsenic to residual levels acceptable for future residential use.	See Alternative 1.
Irreversible Treatment	There is no irreversible treatment under this alternative.	Alternative 2 does not apply to the residential use scenario.	See Alternative 1.	Both treatment processes are irreversible: dieldrin/is destroyed, and lead and arsenic are stabilized.	See Alternative 1.
Type and Quantity of Residuals Remaining After Treatment	There is no treatment; therefore, no residuals are generated in this alternative.	Alternative 2 does not apply to the residential use scenario.	See Alternative 1.	Lead- and arsenic-stabilized surface soil would remain on-site. Approximately 11,200 cubic yards of stabilized soil would remain on-site.	See Alternative 1
Statutory Preference for Treatment	This alternative does not satisfy the statutory preference for treatment	Alternative 2 does not apply to the residential use scenario.	See Alternative 1.	This alternative satisfies the statutory preference for treatment.	See Alternative 1.
SHORT-TERM EFFECTIVENESS					
Community Protection	The risk to the community is not increased by remedy implementation, but the risk is unacceptable if the site is used in the future for residential use.	Alternative 2 does not apply to the residential use scenario.	A temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls.	See Alternative 3.	A temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls. The transportation of excavated soil and clean backfill through the community may require special controls such as restrictions on truck routing and hours of operation.
Worker Protection	There is no action, therefore, there is no risk to workers.	Alternative 2 does not apply to the residential use scenario.	The remedial contractor's health and safety program could require engineering controls or protective personnel equipment for workers during construction.	See Alternative 3.	See Alternative 3.
Environmental Impacts	There is no action; therefore, there are no environmental impacts.	Alternative 2 does not apply to the residential use scenario.	Fugitive dust emissions and stormwater runoff during implementation could cause environmental impacts, therefore, they would be managed by standard construction industry engineering controls.	See Allernative 3	See Atternative 3.

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SOILS

TABLE 4-6B FU4-Northern and Central Open Areas: Summ Memphis Depot Main Installation Soils FS - 7/5	ary of Individual Detailed Analysis of Surface Soil Al	Iternatives for Residential Land Use Scenario			510 123
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Atternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Time Until Action is Complete	This criterion is not applicable.	Alternative 2 does not apply to the residential use scenario.	A protective cover would be placed and institutional controls enacted in less than 1 year, allowing future residential use after implementation.	Biological treatment would be applied initially within approximately 6 months. Biodegradation of dieldrin would begin to be effective quickly; amendments and monitoring would be continued for 3 years allowing residential use after implementation Stabilization amendments for lead and arsenic would require up to an additional 3	Soil would be excavated and transported from the site within 1 year allowing residential use after implementation.
IMPLEMENTABILITY				months after biological treatment for residential use.	
Ability to Construct and Operate	There is no construction or operation under this alternative.	Alternative 2 does not apply to the residential use scenario	Protective covers are easily constructed and maintained, allowing future residential use.	This alternative is faurly easy to construct and operate, allowing future residential use. Bioremediation has been demonstrated on a bench-scale level, stabilization is a known, proven technology.	Excavation, transportation, and disposal are easily implemented.
Ease of Doing More Action if Needed	If more action becomes necessary, the FS/ROD process may need to be repeated.	Alternative 2 does not apply to the residential use scenario.	It would be easy to extend the limits of covered areas, but future treatment or remediation of contaminated surface soil would require excavation and disposal of the covers.	The volume of treated soil could be increased and the technologies could be modified. For example, the nutrient amendments or the stabilization admixture could be altered. This alternative could also be combined with other remedial technologies and with remedial actions at other FUs.	It would be easy to extend the limits of remedial areas, or to add treatment
Ability to Monitor Effectiveness	There is no monitoring of soil included in this alternative.	Alternative 2 does not apply to the residential use scenario.	Periodic monitoring by the lead agency would be necessary to ensure that the covers are not disturbed. Initial surface soil sampling and analysis for dieldrin, lead, and arsenic would be required at the perimeter of the soil cover to confirm that the impacted area has been contained.	Progress and confirmation sampling, and laboratory analyses would be an integral part of the remedial action.	See Alternative 4
Ability to Obtain Approvals and Coordinate with Other Agencies	There is no approval applicable to this alternative.	Alternative 2 does not apply to the residential use scenario.	Existing land use controls would have to be lifted or altered to allow future residential use. There would be no other approval necessary to implement this alternative for future residential use. Long-term coordination with Shelby County-City of Memphis is necessary to maintain existing institutional controls to prevent disturbance of the covers.	Existing land use controls would have to be lifted of altered to allow future residential use. There would be no other approval necessary to implement this alternative for future residential use. After implementation of the remedial action allowing future residential use, no institutional controls would be required since the site would be cleaned up to residential use criteria.	See Alternative 4.
Availability of Services and Capacities	No services or capacities are required under this alternative.	Alternative 2 does not apply to the residential use scenario.	Services are readily available to construct and maintain covers, allowing future residential use	Implementation services for both technologies are readily available in the commercial market.	Services are readily available for excavation, transportation, and off-site disposal

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SOILS

TABLE 4-6B FU4-Northern and Central Open Areas: Sumn Memphis Depot Main Installation Soils FS - 7/	hary of Individual Detailed Analysis of Surface Soll A	Iternatives for <i>Residential Land Use</i> Scenario			510 124
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Availability of Necessary Equipment, Specialists, and Materials	No equipment, specialists, or materials are required under this atternative.	Alternative 2 does not apply to the residential use scenario.	Equipment and materials are readily available to construct and maintain covers, allowing future residential use.	Equipment and most materials are readily available for enhanced biodegradation of dieldrin-contaminated surface soil and stabilization of lead- and arsenic- contaminated surface soil.	Equipment and materials are readify available for excavation, transportation, and off-site disposal. The capacity of local landfills may be limited.
				The bench-scale tested biological amendment is a proprietary product currently available from only one source. There are a number of stabilization amendments available in the commercial market.	
Availability of Technologies	There is no technology required under this alternative.	Alternative 2 does not apply to the residential use scenario.	Soil cover technology is readily available, allowing future residential use.	The treatment technologies are readily available, allowing future residential use.	The excavation, transportation, and disposal technologies are readily available, allowing future residential use
COST	FU4		FU4	FU4	FU4
Residential Use:		Alternative 2 does not apply to the residential use scenario.			
Capital Cost	60 0		\$560,000	\$113,000	\$1,293,000
First-Year Annual O&M Cost	\$0		\$7,400	\$59,800	\$0
Present Worth O&M Cost	\$0		\$112,000	\$718,000	\$0
Total Present Worth Cost	\$0		\$672,000	\$831,000	\$1,293,000
STATE ACCEPTANCE	This alternative would not likely be acceptable to state regulators This alternative does not adequately prevent future residential use.	Alternative 2 does not apply to the residential use scenario.	This alternative would not likely be acceptable to state regulators for future residential use since long-term effectiveness is marginal and ongoing monitoring of the covers and land use is required.	In-situ treatment would likely be acceptable to state regulators, allowing future residential use since all on-site soil would be treated to meet residential use criteria.	Excavation, transportation, and off-site disposal would likely be acceptable to state regulators, allowing future residential use since all on-site surface soil exceeding residential use criteria would be removed. The soil would be disposed of in a permitted off-site location.
COMMUNITY ACCEPTANCE	This alternative would not likely be acceptable to the community. This alternative does not adequately prevent future residential use.	Alternative 2 does not apply to the residential use scenario.	The community may be willing to accept this as the selected alternative for future residential use, but would likely insist on strong, ongoing institutional controls and monitoring of the covers and land use.	In-situ treatment may be acceptable to the community, allowing future residential use since all on-site soil would be treated to meet residential use criteria.	Excavation, transportation, and off-site disposal may be acceptable to the community, allowing future residential use since all on-site surface soil exceeding residential use criteria would be removed. The soil would be disposed of in a permitted off-site location.
Costs are expressed as order-of-magnitud The basis for the cost estimates is included For residential use, dieldrin, lead, and ars	e estimates. I in Appendix B of this FS enic are COCs for FU4.	_			

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SOILS

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TABLE 4-7 FU6-Administrative Area*: Summary of Individt Memphis Depot Main Installation Soils FS – 7/	al Detailed Analysis of Surface Soil Alternatives				510 125
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
	This alternative includes no remedial activities for FU6.	This alternative includes deed restrictions and site controls preventing residential land use, including daycare, for FU6.	This alternative includes a protective cover of soil or pavement over an area of arsenic-contaminated surface soil in FU6 (a total area of 400 ft [*]), coupled with institutional controls preventing disturbance of the cover.	This alternative includes stabilization of arseniç-contaminated surface soil (a total area of 400 ft [*]) and institutional controls prohibiting residential use during implementation of the remedial action at FUG.	This alternative includes the excavation and off-site transportation and disposal of arsenic-contaminated surface soil (a total area of 400 ft ²) from FU6.
OVERALL PROTECTIVENESS					
Human Health Protection (Direct Contact/Soil Ingestion)	There would be no reduction in risk to human health from exposure (direct contact and soil ingestion) to arsenic in the surface soil under this alternative. Currently such risks are acceptable for industrial use but not for future residential use.	There would be a reduction in risk because institutional controls can prevent future residential use and exposure to arsenic in the surface soil. Ongoing risks from industrial use of the site are acceptable.	This alternative <u>does</u> provide future residential use through the protection of human health by covering arsenic- contaminated surface soil with a protective cover. A cover would reduce direct contact isk and soil ingestion risk	This atternative <u>does</u> protect human health for future residential use Stabilization decreases direct contact risk and the soil ingestion risk of arsenic to levels acceptable for future residential use.	This alternative <u>does</u> protect human health for future residential use. Excavation and off-site disposal of contaminated soil at a permitted, controlled landfill removes direct contact
	This alternative <u>does not</u> provide additional institutional controls and other restrictions, and relies on existing controls to prevent future residential use		tor ruture residential users. Long-term institutional controls preventing disturbance of the cover are necessary to maintain protection of human health		contaminated surface soil.
Environmental Protection	Existing concentrations of arsenic do not present unacceptable environmental risks. Sensitive ecological populations are not present at FU6.	See Alternative 1.	See Alternative 1	See Affernative 1	See Alternative 1.
COMPLIANCE WITH ARARS					
Chemical-Specific ARARs	There are no chemical-specific ARARs for surface soil.	See Alternative 1.	See Alternative 1.	See Alternative 1.	See Alternative 1.
Location-Specific ARARs	Currently, FU6 is zoned as Light Industrial (I-L). This zoning designation prevents residential use. However, this zoning prohibition is not permanent and could change in the future	Deed restrictions precluding future residential use reinforce and add a layer of protectiveness over and above the existing land use controls (see Alternative 1).	Existing fand use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1)	Existing land use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1)	Existing land use restrictions would have to be lifted or altered to allow future residential use (see Alternative 1).
Action-Specific ARARs	This alternative would not meet action- specific ARARs since there is no action.	See Alternative 1.	Compliance with Tennessee Rule 1200-3- 1 on fugitive dust emissions during construction of the cover would be required Existing NPDES compliance of stormwater in contact with contaminated soil during construction of the cover would also be required	Compliance with Tennessee Rule 1200-3-1 on fugitive dust emissions during remedial activities would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during remedial activities would also be required.	Disposal characterization of the excavated soil would be conducted in accordance with 40 CFR 261. The disposal of contaminated soil would meet RCRA land disposal restrictions; however, it is anticipated that excavated soil from FU6 would be disposed of at a local RCRA Subtitle D landfill as non-hazardous waste.
					Compliance with Tennessee Rule 1200-3- 1 on fugitive dust emissions during excavation, transportation, and backfilling operations would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during construction activities would also be required

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Memphis Depot Main Installation Soils FS	1/3/00				
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Other Criteria and Guidance	This alternative would not meet chemical- specific RAOs for future residential use, but would meet RAOs for industrial use.	This alternative is compliant with industrial risk-based criteria. Compliance with residential risk criteria is not applicable since future residential use is <u>prevented</u> by the use of institutional controls.	By covering the arsenic-contaminated surface soil, the site will meet surface soil RAOs for future residential use. Any imported soil to be used for the cover would be confirmed clean by laboratory testing pror to placement on-site.	By stabilization of the arsenic-contaminated surface soil, the site would meet surface soil RAOs for future residential use.	By removing and disposing contaminated soil off-site, the site would meet surface soil RAOs for future residential use. Imported soil for backfill would be confirmed clean by testing prior to placement on-site.
LONG-TERM EFFECTIVENESS AND PI	ERMANENCE				
Magnitude of Residual Risk (Direct Contact/Soil Ingestion)	The source has not been removed Unacceptable risk will remain for future residential use The existing risk is acceptable for industrial use.	The source would not be removed; however, unacceptable risk for future residential use would be prevented through institutional controls The existing risk is acceptable for industrial use	Future residential risk at the site is acceptable as long as the cover is maintained. Because the source is only contained, some inherent risk remains if the cover is breached by intrusion.	The future residential use risk at the site from contaminated surface soil is reduced to acceptable levels by treatment that fixes arsenic.	The future residential risk at the site from contaminated soil is eliminated because soil contaminated above levels acceptable for residential use would be removed from the site.
			Long-term control or activities that could potentially disturb the cover would be difficult in a residential setting, therefore, the risk could increase over time		
Adequacy and Reliability of Controls	There are no actions or controls; therefore, reliability is not applicable. Surface soil would remain in place.	Institutional controls are less effective and reliable than permanent treatment. Contaminated surface soil would remain a potential risk for future residential use. Long-term oversight by the lead agency would be required to maintain protective layers of institutional and long-term controls to <u>prevent</u> future residential use	This alternative would contain contaminated surface soil and minimize the potential exposure for future residential use. The rehability of this alternative is marginal because long-term oversight by the lead agency would be required to <u>prevent</u> intrusive activities in the cover.	This alternative controls contamination in soil by immobilizing arsenic through stabilization of the surface soil. The reliability is very high for future residential use. The stabilization of arsenic is a proven technology for the fixation of arsenic- contaminated surface soil. Therefore, no management beyond the remedial implementation period is required.	Excavation and off-site disposal effectively removes surface soil contaminated above levels acceptable for future residential use within the FU boundaries Reliability is very high for future residential use. No site management beyond the remedial implementation period is required The reliability of a permitted off-site disposal facility is high.
Need for 5-Year Review	Review would be required to ensure adequate protection of human health and the environment for future users of the site.	Review would be required to ensure that institutional controls are still in place for the adequate protection of human health and the environment for future users of the site.	Institutional controls would still be required to prevent disturbance of the surface soil cover. Therefore, review would be required to ensure that the covers are intact and provide adequate protection of human health for future residential use.	The contaminated surface soil would be effectively stabilized in less than 5 years; therefore, no review would be required	Not applicable. Contaminated soil would be removed in less than 5 years; therefore, no review would be required.
REDUCTION OF TOXICITY, MOBILITY,	OR VOLUME THROUGH TREATMENT				
Treatment Process Used	This alternative does not include active treatment of contaminated surface soil.	See Alternative 1.	See Alternative 1.	Stabilization is used to treat arsenic- contaminated surface soil.	See Alternative 1.
Amount Destroyed or Treated	No soil contaminants are treated or destroyed under this atternative.	See Alternative 1.	See Alternative 1.	Approximately 15 in-place cubic yards of arsenic-contaminated surface soil would be stabilized.	See Alternative 1.
Reduction of Toxicity, Mobility, or Volume	There is no reduction in toxicity, mobility, or volume through treatment under this alternative	See Alternative 1.	See Alternative 1.	The stabilization of arsenic-contaminated surface soil would reduce the mobility of arsenic to residual levels acceptable for future residential use	See Alternative 1.
rreversible Treatment	There is no irreversible treatment under this alternative	See Alternative 1.	See Alternative 1.	The treatment process in which arsenic is stabilized is irreversible.	See Alternative 1

SOILS

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TABLE 4-7 FU6-Administrative Area*. Summary of Individi Memphis Depot Main Installation Soils FS – 7/,	al Detailed Analysis of Surface Soil Alternatives 3/00				
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Solf Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
Type and Quantity of Residuals Remaining After Treatment	There is no treatment; therefore, no residuals are generated in this alternative.	See Alternative 1.	See Alternative 1.	Approximately 17 cubic yards of arsenic- stabilized soil would remain on-site	See Alternative 1.
Statutory Preference for Treatment	This alternative does not satisfy the statutory preference for treatment.	See Alternative 1.	See Alternative 1.	This alternative satisfies the statutory preference for treatment.	See Alternative 1.
SHORT-TERM EFFECTIVENESS					
Community Protection	The risk to the community is not increased by remedy implementation, but the risk is unacceptable if the site is used in the future for residential use.	The risk to the community is not increased by the remedy implementation.	The temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls.	See Alternative 3.	The temporary increase in fugitive dust emissions and stormwater runoff during implementation would be managed by standard construction industry engineering controls.
Worker Protection	There is no action; therefore, there is no risk to workers.	There is no physical on-site action; therefore, there is no risk to workers.	The site is currently acceptable for the industrial worker, however, the remedial contractor's health and safety program could require engineering controls or protective personnel equipment for workers during construction.	See Alternative 3.	See Atternative 3.
Environmental Impacts	There is no action, therefore, there are no environmental impacts.	There is no physical on-site action; therefore, there is no impact to the environment.	Fugitive dust emissions and stormwater runoff during implementation could cause environmental impacts; therefore, they would be managed by standard construction industry engineering controls.	See Alternative 3.	See Alternative 3
Time Until Action is Complete	This criterion is not applicable.	Deed restrictions would be implemented within 6 months to add a layer of protection precluding future residential use.	A protective cover would be placed and institutional controls enacted in less than 1 year, allowing future residential use after implementation.	Stabilization amendments for arsenic would require up to 6 months, allowing residential use after implementation	Soil would be excavated and transported from the site within 6 months, allowing residential use after implementation.
IMPLEMENTABILITY					
Ability to Construct and Operate	There is no construction or operation under this alternative.	Institutional controls are readily implemented to preclude future residential use.	Covers are easily constructed and maintained, allowing future residential use.	This alternative is reasonably easy to construct and operate, allowing future residential use Bioremediation has been demonstrated on a bench-scale level; stabilization is a known, proven technology	Excavation, transportation, and disposal are easily implemented.
Ease of Doing More Action if Needed	If more action becomes necessary, the FS/ROD process may need to be repeated.	No future remedial action is contemplated unless future residential use of the site is required. This alternative does not restrict any future remedial action. If remedial action becomes necessary, Alternative 3, 4, or 7 could easily be implemented, provided there has not been significant resurfacing or grading of the fand surface from light industrial operations.	It would be easy to extend the limits of covered areas, but future treatment or remediation of contaminated soil would require excavation and disposal of the covers.	The volume of treated soil could be increased and the technologies could be modified. For example, the stabilization admixture could be altered. This alternative could also be combined with other remedial technologies and with remedial actions at other FUs.	It would be easy to extend the limits of remediation areas or to add treatment.

SOILS

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ce Soil Alternatives				
ive 1 ion	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
of soul included in	See Alternative 1.	Periodic monitoring by the lead agency would be necessary to ensure that the covers are not disturbed. Initial surface soil sampling and analysis for arsenic would be required at the perimeter of the soil cover to confirm that the impacted area is contained.	Progress and confirmation sampling, and laboratory analyses would be an integral part of the remedial action.	See Alternative 4.
plicable to this	This alternative would require deed restrictions to prevent future residential use. Long-term coordination with Shelby County-City of Memphis is necessary to maintain existing long-term controls to	Existing land use controls would have to be lifted or altered to allow future residential use. There would be no other approval necessary to implement this alternative for future residential use.	Existing land use controls would have to be lifted or attered to allow for future residential use. There would be no other approval necessary to implement this alternative for future residential use.	See Alternative 4.
	provide layers of protectiveness with the deed restrictions.	Long-term coordination with Shelby County-City of Memphis is necessary to maintain institutional controls to prevent disturbance of the covers	After implementation of the remedial action allowing future residential use, no institutional controls would be required since the site would be cleaned up to residential use criteria	
s are required	See Alternative 1.	Services are readily available to construct and maintain covers, allowing future residential use.	Implementation services for stabilization technology are readily available in the commercial market.	Services are readily available for excavation, transportation, and off-site disposal.
s, or matenals are native.	See Alternative 1.	Equipment and materials are readily available to construct and maintain covers, allowing future residential use	Equipment and most materials are readily available for stabilization of arsenic- contaminated surface soil.	Equipment and materials are readily available for excavation, transportation, and off-site disposal. The capacity of local
			The bench-scale tested biological amendment is a proprietary product currently available from only one source. There are a number of stabilization amendments available in the commercial market.	landfills may be limited.
d under this	See Alternative 1.	Soil cover technology is readily available, allowing future residential use.	The treatment technology is readily available, altowing future residential use.	The excavation, transportation, and disposal technologies are readily available, allowing future residential use.
	All FUs ^a	FUG	FUG	FUG
	\$14,000	This alternative is <u>not necessary</u> for industrial use; therefore, there are no costs.	This alternative is <u>not necessary</u> for industrial use; therefore, there are no costs.	This alternative is not necessary for industrial use; therefore, there are no costs.
	\$3,800			
	\$57,000		_	
	\$71,000		_	
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ice Soil Alter

TABLE 4-7 FU6-Administrative Area*: Summary of Individu Memphis Depot Main Installation Soils FS - 7/3	al Detailed Analysis of Surfac 3/00
Evaluation Criteria	Alternati No Acti
Ability to Monitor Effectiveness	There is no monitoring o this alternative.
Ability to Obtain Approvals and Coordinate with Other Agencies	There is no approval appatemative.
Availability of Services and Capacities	No services or capacities under this alternative.
Availability of Necessary Equipment, Specialists, and Materials	No equipment, specialist required under this alterr
Availability of Technologies	No technology is required alternative
COST	FUG
Industrial Use:	
Capital Cost	\$0
First Year Annual O&M Cost	\$0
Present Worth O&M Cost	\$0
Total Present Worth Cost	\$0



TABLE 4-7 FU6-Administrative Area*: Summary of Indivic Memphis Depot Main Installation Soils FS – 7	tual Detailed Analysis of Surface Soil Alternatives				510 129
Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Containment	Alternative 4 In-situ Soil Treatment	Alternative 7 Excavation, Transportation, and Off-site Disposal
<u>Residential Use:</u> Capital Cost	0\$	This alternative is designed to <u>prevent</u> residential use Costs are included under the Industrial Use.	\$15,000	\$5.000	\$33.000
First Year Annual O&M Cost	\$0		\$1,200	\$1.750	O\$
Present Worth O&M Cost	\$0		\$18,000	\$3,000	09
Total Present Worth Cost	\$0		\$33,000	\$8,000	\$33,000
STATE ACCEPTANCE	This alternative would not likely be acceptable to state regulators. Although industrial use risks are acceptable without action, this alternative does not adequately prevent future residential use.	Institutional controls are likely to be acceptable to state regulators. Industrial use risks are acceptable without action and this alternative adequately prevents future residential use.	This alternative would not likely be acceptable to state regulators for future residential use since long-term effectiveness is marginal and ongoing monitoring of the covers and land use is required.	In-situ treatment would likely be acceptable to state régulators, allowing future residential use since all on-site soil would be treated to meet residential use criteria.	Excavation, transportation, and off-site disposal would likely be acceptable to state regulators, allowing future residential use since all on-site soil exceeding residential use criteria would be removed. The soil would be disposed of in a permitted off-site location.
COMMUNITY ACCEPTANCE	This alternative may not likely be acceptable to the community. Although industrial use risks are acceptable without action, this alternative does not adequately prevent future residential use on the site.	The community may be likely to accept this alternative for industrial use by preventing future residential use through institutional controls.	The community may be willing to accept this alternative for future residential use, but would likely insist on strong, ongoing institutional controls and monitoring of the covers and land use	In-situ treatment may be acceptable to the community, allowing future residential use since all on-site soil would be treated to meet residential use criteria.	Excavation, transportation, and off-site disposal may be acceptable to the community, allowing future residential use since all on-site soil exceeding residential use criteria would be removed. The soil would be disposed of in a permitted off-site location.
* The residential area in FU6 is not include ^a The cost to implement institutional contro Costs are expressed as order-of-magnitude The basis for the cost estimates is include For industrial use, there are no COCs for For residential use, arsenic is the only CC	led in this FS. A surface soil removal action was lis applies to all FUs combined. le estimates. d in Appendix B of this FS. FU6. DCs for FU6.	completed at this location.			
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Appendix A Risk Calculations

FIGURE A-1

Blood Level Distribution Probability Percent Plot for 655 μ g/g Lead Concentration in Soil (FU3 Child). Ages 0-12 Months Memphis Depot Main Installation Soils FS



FIGURE A-2

Blood Level Distribution Probability Percent Plot for 919 µg/g Lead Concentration in Soil (FU4 Child). Ages 0-12 Months Memphis Depot Main Installation Soils FS



FIGURE A-3

Blood Level Distribution Probability Percent Plot for 295 μ g/g Lead Concentration in Soil (Target Soil Lead Concentration): Ages 0-12 Months

Memphis Depot Main Installation Soils FS


						Health Risk	at UCL95%					
Exposure Scenario	FU	1	5	~	S-UF		5 E	4	5-UF			
	ELCR	Ŧ	ELCR	Ŧ	ELCR	Ŧ	FI CR	I	EI CB	Ξ		
Industrial Worker - Adult	8 OE-OS	10	3 0E-05	02	9 OE-06	06	4 0F-05	11	1 DE DE	Ē		Ē
Residential - Adult	2 6E-04	03	9 8E-05	90	2 9E-05	8	135-04		0 AF OF		3 UC-U3	0 1
Residential - Child	3 7E-04	90	1 4E-04	4.	4 2E-05	41	1 9F-04	2 6	1 46-04	4 6	8 OE-03	0 -
				•				;	\$ - -	2		4

TABLE 1 Relative Risk Summanes for Residential Receptors from FU-wide UCL95% Estimates

FU4- Arsenic, PAHs and TCDD equivalents are then risk drivers equivalents are then risk drivers Total TCDDs are below ATAR FU5- PAHs, arsenic and dieldrin FU3 - Risk drivers are Lead, value of 1 pb at the maximum PAHs and arsenic, while concentration of 0.47 pb), and EPC at 14.6 mg/kg, below i UCL95% for arsenic is 12.5 were similar to background in background, with a max of 29 mg/kg, which is well below distributions. Arsenic at mg/kg Thus arsenic is not background levels and Max is 49 UCL95% of 15.7 is below mg/kg Thus only PAHs and lead background, with a maximum of FS PAHs and dieldrin need need further FS.	FU4- Arsenic, PAHs and TCDD FU4- Arsenic, PAHs and TCDD equivalents are the risk drivers PAHs and dieldrim Maximum FU3 - Risk drivers are Lead, value of 1 pbb at the maximum are the risk drivers with arsenic arsenic is at 101 mg/kg. and PAHs and arsenic, while value of 1 pbb at the maximum are the risk drivers with arsenic dreldrim was at 100 mg/kg. PAHs UCL95% for arsenic is 12.5 were similar to background in background, with a max of 29 were low, with UCL95% being mg/kg, which is well below distributions Arsenic at 100 mg/kg. Thus arsenic is not s below the PQLs. Thus PAHs background levels and Max is 49 UCL95% of 15.7 is below and redidimended in mg/kg. Thus only PAHs and lead background, with a maximum of FS PAHs and diefinm need alternatives analysis for FU2.
FU4- Arsenic, PAHs and TCDD equivalents are the risk drivers equivalents are the risk drivers FU3 - Risk drivers are Lead, value of 1 ppb at the maximum PAHs and arsenic, while concentration of 0.47 pbb, and i UCL95% for arsenic is 12.5 were similar to background in mg/kg, which is well below background levels and Max is 49 UCL95% of 15.7 is below mg/kg. Trus only PAHs and lead background, with a maximum of need further FS 66 mo/kg	FU4- Arsenic, PAHs and TCDD FU4- Arsenic, PAHs and TCDD equivers Arsenic, PAHs and dieldrin Maximum FU3 - Risk drivers PAHs and dieldrin Maximum FU3 - Risk drivers are Lead, value of 1 ppb at the maximum arsenic is at 101 mg/kg, and PAHs and arsenic, while concentration of 0 47 ppb, and dieldrin was at 100 mg/kg. PAHs UCL95% for arsenic is 12 5 were similar to background in were low, with UCL95% being mg/kg, which is well below distributions Arsenic at should not be included in mg/kg. Thus only PAHs and Max is 49 UCL95% of 15 7 is below at element and visit and were low with a maximum of alternatives analysis for FU2.
FU3 - Risk drivers are Lead, PAHs and arsenic, while i UCL95% for arsenic is 12 5 mg/kg, which is well below background levels and Max is mg/kg Thus only PAHs and le meed turther FS	FU2- Risk Drivers are arsenic, PAHs and dieldrim Maximum FU3 - Risk drivers are Lead, arsenic is at 101 mg/kg, and PAHs and arsenic, while dreidrim was at 10 mg/kg, PAHs UCL95% for arsenic is 12 5 were low, with UCL95% being mg/kg, which is well below s below the POLs Thus PAHs background levels and Max is should not be included in mg/kg. Thus only PAHs and le alternatives analysis for FU2.
	FU2- Risk Drivers are arsenic, PAHs and dieldrin Maximum arsenic is at 101 mg/kg, and dreidrin was at 10 mg/kg PAHs were low, with UCL95% being s below the PCLs Thus PAHs s below the PCLs Thus PAHs atternatives analysis for FU2 alternatives analysis for FU2

Memphis Depot Main Installation FS Lead Uptake Model for Children

Dataulte		No	01	03	1, 2, 3, 4, 4, 4, hrs/day per each year	2, 3, 5, 5, 7, 7 m3/day per each year	03		25		4	0 2, 0 5, 0 52, 0 53, 0 55, 0 58, 0 59 L/day per each year	No		5 53, 5 78, 6 49, 6 24, 6 01, 6 34, 7 0 Pb/day per each year	No		0		FU-specific ²	Multiple Source Average (calculated by model)	0 45	0 085, 0 135, 0 135, 0 135, 0 1, 0 09, 0 085 g/day per each vear		07	100	PA No		vanahle		See attached Figure with 10 up/dL target blood-lead levels in lewer than 5% population (children), assuming multiple source contribution to total lead intake	
EU4 Child		ę	031	03	variable	variable	03		25		618	variable	٩		variable	ę		0	-	919	673	0 45	variable		07	<u>6</u>	QN		10.0		595	
FU3 Child		٩	031	03	vanable	vanable	03		25		618	vanable	°N N		vaпable	٩N		0		655	489	0 45	variable		07	100	ø		10.0		295	
Units			ng/m ³	%	hrs/day	m³/day			ng/dL		ug/L	L/day			Pb/day			ug Pb/day		5/6n	6/6n		g/day		conversion factor	conversion factor			ng/dL	,	6,6n	
Model Assumptions	AIR	Vary Air Concentration per year?	Outdoor Air Lead Concentration (background)	Indoor Air Lead Concentration (% of outdoor)	Time Outdoors	Ventilation Rates	Lung Absorption	MATERNAL DATA	Mother's Estimated Blood Lead Concentration at Birth	DRINKING WATER	Lead Concentration in Drinking Water	Drinking Water Intakes	Use Atternate Drinking Water Values?	DIET	Dietary Lead Intakes	Use Alternate Diet Values ²	OTHER	Change Other Lead Intake?	solubust	Lead Concentrations in Soif	Lead Concentrations in Dust	Soli/Dust Ingestion Weighting Factor	Daily Ingestion Levels	MULTIPLE SOURCE ANALYSIS (for Dust)	Contribution of Soil Pb to Indoor Household Dust Pb	Contribution of Outdoor Airborne Pb to Indoor Household Dust Pb	Consider Alternate Indoor Dust Pb Sources?	SETTINGS	Known Blood Lead Concentration	RESULTS	Target Soil Pb Concentration ³	

Adapted from the Uptake/Blokinetic Model for Lead, Version 0 99d Program development by USEPA, March 8, 1994 Model is used in accordance with the USEPA Guidance Manual for the Integrated Uptake Blokinetic Model for Lead in Children, January 1994 Note

Literature review (Air Quality Criteria for Lead, EPA 1996 & ATSDR for Lead, 1988)
 Site-specific UCL95% lead estimates for the FU
 s = value was rounded to 300 mg/kg as the target concentration protective eof children under residential land use for the FUs 3 and 4

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Lead Concentrations within FU3 Around Old Paint Shops

			-	-			_				
				•							
Unit	Matrix	StationID	SampleiD		linnerDenth	* I nwarDenth	DaramNama	• AnaValua	Broiffunt	Linte	Detrotod
3	SS	SB31A	SGA015	N	0	1	LEAD	51.4	=	MG/KG	TRUE
3	SS	SB31B	SGA020	N	0	1	LEAD	37 3	, =	MG/KG	TRUE
3	SS	SS31A	SGA011	N	0	1	ILEAD	664	=	MG/KG	TRUE
3	SS	SS31B	SGA012	N	0	0 83	LEAD	85 5	, ≅	MG/KG	TRUE
3	SS	SS31C	SGA013	N .	0	1	LEAD	84 6	+ =	MG/KG	TRUE
3	SS	SS31D	SGB058	N	05	1	LEAD	205	=	MG/KG	TRUE
Avera	ge soil c	oncentration	ns around Site	31			* er	188	•		
Maxin	um Soil	Concentrati	ons around Si	te 31				664		·'	
3	SS	SB32A	RHA012	N	0	1		4150			TRIF
3	SS	SS32B	RHA015	N	0	1		678		MG/KG	TRUE
3	SS	SS32C	RHA016	N	0	1		693	(<u> </u>	MG/KG	TRUE
3	SS	SS32D	RHA017	N	0	1	LEAD	766	=	MG/KG	
3	SS	SS32E	RHA018	N	0	1	LEAD	119		MG/KG	TRUE
3	SS	SS32F	RHA019	N	0	1	LEAD	105	_	MG/KG	TRUE
3	SS	SS32G	RHA020	N	0	1	LEAD	1580	=	MG/KG	TRUE
Avera	ge soil c	oncentration	ns around Site	32	*			1156	••••••••••••••••••••••••••••••••••••••		
Maxim	um Soil	Concentrati	ons around Si	te 32				4150			
3	SS	SB33A	SGA031	N	0	1	LEAD	46 9	=	MG/KG	TBUE
3	SS	SB33B	SGA036	N	0	1	LEAD	20 1	=	MG/KG	TRUE
3	SS	SB33C	SGA041	N	0	1	LEAD	16 1	=	MG/KG	TRUE
3	SS	SS33A	SGA025	N	0	1	LEAD	129	=	MG/KG	TRUE
3	SS	SS33B	SGB067	N	02	12	LEAD	321	=	MG/KG	TRUE
3	SS	SS33C	SGA027	N	Ö	1	LEAD	200	=	MG/KG	TRUE
3	SS	SS33D	SGA028	N	0	1	LEAD	751	=	MG/KG	TRUE
3	SS	SS33E	SGB068	N	0	1	LEAD	140	=	MG/KG	TRUE
3	SS	SS33F	SGA030	N	0	1	LEAD	79 3	=	MG/KG	TRUE
3	SS	SS33G	MIA333	N	0	1	LEAD	34 6	=	MG/KG	TRUE
3	SS	SS33H	MIA334	N	0	1	LEAD	900	=	MG/KG	TRUE
3	SS	SS33I	MIA335	N	0	1	LEAD	22 8	=	MG/KG	TRUE
3	SS	SS33J	MIA336	N	0	1	LEAD	10	=	MG/KG	TRUE
3	SS	SS33K	MIA325	N	0	1	LEAD	1830	=	MG/KG	TRUE
3	SS	SS33L	MIA326	N	0	1	LEAD	114	π	MG/KG	TRUE
3	SS	SS33M	MIA327	N	0	1	LEAD	332	=	MG/KG	TRUE
3	SS	SS33N	MIA330	N	0	1	LEAD	62 3	=	MG/KG	TRUE
Avera	ge soil ce	oncentration	is around Site	33				295			
Maxim	um Soil	Concentration	ons around Sil	te 33				1830			
3	ss 1	SS34D	RHA038	N T			FAD	080	=	MG/KG	
4	SS	SS34E	RHA039	N	,		LEAD	300	 =	MG/KG	TRUE
4	ss	SS34E	RHA180FD1	FD		'	LEAD	505	-	MG/KG	
3	ss i	SS34F	RHA040	N			L FAD	145		MG/KG	TRUE
Avera	e soil co	oncentration	s around Site	34				488			
Maxim	um Soll	Concentration	ons around Sit	e 34	· · · · · · · · · · · · · · · · · · ·			960		i	
	<u>ee</u>	200A	SCR014	N							
3	33	SS89A	SGB044	IN .	0	1	LEAD	24 6	=	MG/KG	TRUE
	<u></u>	00040	12/20/39	IN I	0	1	LEAD	139	=	MG/KG	TRUE
	33	00890	SGA250	N .		1	LEAD	227	=	MG/KG	TRUE
3	<u></u>	0088F	SGA253	N I	0	1		237	=	MG/KG	TRUE
3	<u></u>	0009H	SGA25/	IN I		1	LEAD	2470	=	MG/KG	TRUE
3	33	00001	SGA258	N	0	1		30 2	=	MG/KG	TRUE
	<u>33</u>	CCBOK	13GA259	IN	<u>0</u>	1	LEAU	2250	=	MG/KG	TRUE
- 3	<u></u>	2289K	MIA153	N .	0	1	LEAD		=	MG/KG	TRUE
3	33	0000H	MIA155			1	LEAD	64 7	⇒	MG/KG	TRUE
	33	228AW	MIA156	N		1	LEAD	256,	±	MG/KG	TRUE
3	<u> </u>	228AN	MIA15/	N	0,	1	LEAD	232,	=	MG/KG	TRUE
Averag	je soli co	oncentration	is around Site	89			<u> </u>	551		L	
Maxim	um Soil	Concentratio	ons around Sit	e 89				2470			

Overall average around Paint Shops

Unit Matrix	StationID	SampleID	SampleType	UpperDepth	LowerDepth	ParamName	AnaValue	ProjQual	Units	[/] Detected
4 SS	FS79A	MIA283AVG	;N	0	1	LEAD	360 45	=	MG/KG	- TRU
4'SS	'FS79B	MIA286AVG	N	0	1	LEAD	701 5	=	MG/KG	TAU
4 SS	FS79C	MIA289AVG	<u>i</u> N —	0	1	LEAD	88 9	,= .=	MG/KG	TRU
4 SS	ISB79A	ISGA441	1N	0	1	LEAD	32 9	=	MG/KG	TRU
4 <u>SS</u>	ISB79B	SGB137	N	0	1,	LEAD	208	=	MG/KG	TRL
<u>4'SS</u>	SB79C	SGA449	N	0	11	LEAD	27 1	1=	MG/KG	TRU
4,55	SS79A	ISGA314	N	0	1	LEAD	1060	.=	MG/KG	TRU
4 SS	SS79B	SGA315	N	0,	1	LEAD	105	,=	MG/KG	TAL
4,SS	SS79C	SGB097	<u>N</u>	0	1	LEAD	12 2	'=	MG/KG	TRU
4:55	SS79D	MIA277	N	0	1	LEAD	269	=	MG/KG	TRU
4'SS	SS79E	MIA280	N	0	1	LEAD	506		MG/KG	TRU
4'55	ISS79F	MIA281	IN	0	1	LEAD	83 9	*	MG/KG	TRU
verage Lead	Concentrati	on around Sit	e 79				288			
aximum Cor	centration a	round Site 79	······	·····			1060			
			↓		_					
4'55	FS830	MIA246AVG	N	0`	1	LEAD	320 2	=	MG/KG	TRI
4 55	FS83P	MIA249AVG	N	0	1	LEAD	362 9	=	MG/KG	TRU
4'55	FS83Q	MIA252AVG	N	0,	1	LEAD	87 05	J	MG/KG	TRU
4'85	FS83R	MIA255AVG	IN	<u>0</u>	1	LEAD	1495	J	MG/KG	TRL
4'55	FS83S	MIA258AVG	N	0	1	LEAD	410 6	J	MG/KG	TRU
4'55	FS83T	MIA261AVG	IN	0)	1	LEAD	1995	=	MG/KG	TRU
4 55	SB83A	SGA398	N	0`	1	LEAD	14 7	=	MG/KG	TRU
4 55	SB83B	SGA401	N	0,	1	LEAD	2430	=	MG/KG	TRU
4 55	SS83A	SGA284	N	0 7	1	LEAD	67 5	=	MG/KG	TRU
4 SS	SS83B	SGB075	N	0	1	LEAD	1720	=	MG/KG	TRU
4 55	SS83C	SGA286	N	0'	1	LÊAD	2800	=	MG/KG	TRU
4 55	SS83D	MIA234	N	0	1	LEAD	93 2	J	MG/KG	TRU
4 55	SS83E	MIA236	N	0;	1	LEAD	210	J	MG/KG	TRU
4 55	SS83F	MIA237	N	0`	1	LEAD	120	J	MG/KG	TRU
4 55	SS83G	MIA238	N	0	1	LEAD	24 9	J	MG/KG	TRU
4'85	SS83H	MIA239	N	0,	1)	LEAD	12 5	J	MG/KG	TRU
4'55	55831	MIA240	N	0	1	LEAD	22	J	MG/KG	TRU
4'SS	SS83J	MIA241	N	0	1	LEAD	21 8	= 1	MG/KG	TRL
4'SS	SS83K	MIA242	N	0	1	LEAD	80 2	=	MG/KG	TAL
4'SS	SS83L	MIA243	N	0	1	LEAD	188	j [MG/KG	TRL
4'SS	SS83M	MIA244	N	0	1	LEAD	300	= -	MG/KG	TRL
4'SS	SS83N	MIA245	N	0	1	LEAD	437	=	MG/KG	TRL
rerage Lead	Concentratio	on around Site	e 83				601			
aximum Con	centration as	round Site 83				·····	0000			

Unit Matrix	StationID	SampleID	SampleType	UpperDepth	LowerDepth	ParamName	AnaValue	ProjQual	Units	Detected
, 3 SB	SB31A	SGA016	Ň	4	6	LEAD	22.6	M	IG/KG	TRUE
3 SB	SB31A	SGA017	'N		10	LEAD	26.6	M	IG/KG	TRUE
<u>3 SB</u>	SB31A	SGA018	N	18	20	LEAD	11 1	:= M	IG/KG	TRUE
3 SB	SB31A	SGA019	N	38	40	LEAD	2	(́M	IG/KG	TRUE
. 3 SB	SB31B	.SGA021	N	4	6	LEAD	23	<u></u>	G/KG	TRUE
<u>3 SB</u>	SB31B	SGA022	<u>N</u>	8	10	LEAD	26 2	,= ¹ M	IG/KG	TRUE
<u>3 SB</u>	SB31B	ISGA024	'N	38	40	LEAD	7 5	[=}M	IG/KG	TRUE
3 SB	SB31B	SGB140	N	- 18	20	LEAD ·	63	= <u>iM</u>	IG/KG	TRUE
358	SB32A	HHA013	IN		5	LEAD	91	<u>;</u> =}M	IG/KG	TRUE
3 38	SB32A	HHAU14	N	8	10	LEAD	10 9	M	IG/KG	TRUE
300	SD33A	SGAU32	N	4	6	LEAD	30	.= /M	IG/KG	THUE
200	CD33A	ISGA033	IN N	8	10	LEAD	28 5	=M	IG/KG	
335	SB33A	SGA034	N	18	20		104	M	G/KG	TRUE
3 58	SB33B	SGA035	N	30	40		11		IG/KG	TRUE
3 SB	SB338	SGA038	N		10		20 4		GAG	TRUE
3'SB	SB33B	SGA039	N	18	20	LEAD	30 8	- M		
3 SB	SB33B	SGA040	N		40	IFAD	31	- M	IG/KG	TRUE
3.SB	SB33C	SGA042	N	3	5	LEAD	19.3	M	G/KG	TRUE
3.SB	SB33C	SGA043	N	8	10	LEAD	20		IG/KG	TRUE
3 SB	SB33C	SGA044	N	18	20	LEAD	12.3	= M	G/KG	TRUE
3 SB	SB33C	SGA045	N	38	40	LEAD	28.9	M	G/KG	
3 SB	SB34A	RHA022	N	3	5	LEAD	13	.= M	G/KG	TRUE
3 SB	SB34A	RHA023	N	8	10	LEAD	91	= M	G/KG	TRUE
3 SB	SB34A	RHA024	N	13	15	LEAD	73	= M	G/KG	TRUE
3 SB	SB34A	RHA025	N	18	20	LEAD	8	= M	G/KG	TRUE
3 SB	SB34B	RHA026	N	3	5	LEAD	13 7	i= ,W	IG/KG	TRUE
3 SB	SB34B	RHA027	N	8	10	LEAD	92	= M	IG/KG	TRUE
3 SB	SB34B	RHA028	N	13	15	LEAD	79	,= M	IG/KG	TRUE
3,SB	SB34B	RHA029	N	18	20	LEAD	9	_= M	G/KG	TRUE
3 SB	SB34C	RHA030	N	3	5	LEAD	13 5	= M	IG/KG	TRUE
3 SB	SB34C	RHA031	N	8	10	LEAD	10 4	= M	IG/KG	TRUE
3 SB	SB34C	RHA032	N	13	15	LEAD	68	= M	IG/KG	TRUE
3 SB	SB34C	RHA033	N	18	20	LEAD	79	= M	IG/KG	TRUE
3 SB	SB34C	RHA034FD1	FD	3)	5	LEAD	11 1	= M	IG/KG	TRUE
3'SB	SB89A	SGA374	N	3	5	LEAD	14 8	= M	IG/KG	TRUE
3'SB	SB89A	SGA375	N		10,	LEAD	14 2	=M	IG/KG	TRUE
3 SB	SB89B	SGA376	N	3	5	LEAD	17 6	=M	IG/KG	TRUE
3 SB	SB89B	SGA377	N	8	10	LEAD	20 3	=M	IG/KG	TRUE
3 SB	SB89B	SGA492FD1	FD	3	5	LEAD	25 1	= M	IG/KG	TRUE,
3 SB	SB89C	SGA378	N	3,		LEAD	17 2	= <u>M</u>	G/KG	TRUE
3,58	SB89C	SGA379	N	8	10	LEAD	24 7	=[M	IG/KG	TRUE
330	SB89D	SGA380	N	3	5		15.6	,'≕M	IG/KG	TRUE
3 30	SD09D	SGA381	N		10		20 7	=M	G/KG	
3 30	SBOAC		м со				84	N		
	SBROE	MIA147FD					11 0			TRUE
3.58	SREE	MIA149	N	18			110			
3 SB	SB89F	MIA151	N	10 20	20	IFAD			GIKC	TOILE
3.58	SB89F	MIA152	N	20		LEAD				
3 55	F\$33A	MIA337AVG	N	 	11	LEAD	1120	=	G/KG	TRUE
3'SS	FS33B	MIA340AVG	N	ñ		LEAD	211 15	= IM	G/KG	TAUE
3 55	FS33C	MIA343AVG	N	0		LEAD	1131	= M	G/KG	TRUF
3'55	FS33D	MIA346AVG	N	0,		LEAD	502 5	= _ M	IG/KG	TRUE
3 SS	FS33E	MIA349AVG	N	0	1	LEAD	21 85	= M	IG/KG	TRUE
3 55	FS33F	MIA352AVG	N	0	1	LEAD	138	= 1M	G/KG	TRUE
3,55	FS89P	MIA159AVG	N	0 [°]	1	LEAD	436 05	= M	IG/KG	TRUE
3 55	FS89Q	MIA164AVG	N	0	1	LEAD	484 05	= M	IG/KG	TRUE
3 SS	F\$89R	MIA167AVG	N	0	1	LEAD	36 6	= M	IG/KG	TRUE
3 55	FS89S	MIA170AVG	N	0	1	LEAD	61 25	= M	IG/KG	TRUE
3 55	SB31A	SGA015	N	0	1	LEAD	51 4	= M	ĪĠ/KĠ	TRUÉ
3,55	SB31A	SGA487FD1	FD T	0	1	LEAD	57 2	= M	IG/KG	TRUE
3 SS	SB31B	SGA020	N	0	1	LEAD	37 3	=M	IG/KG	TRUE
3 55	SB32A	RHA012	N	0	1	LEAD	4150	'= M	IG/KG	TRUE
3 55	SB33A	SGA031	N	0	1	LEAD	46 9	=iM	IG/KG	TRUE
3 SS	SB33B	SGA036	N	0	1	LEAD	20 1	i= [M	IG/KG	TRUE
<u>3,SS</u>	SB33B	SGA488FD1	FD	0	1	LEAD	119	= iM	IG/KG	TRUE
<u>3 SS</u>	SB33C	SGA041	N	0,	1	LEAD	16 1	=M	IG/KG	TRUE
3 SS	SB34A	RHA035	N	0	1	LEAD	94 1	= M	IG/KG	TRUE

Linit Matrix	StationID	Completin	1 0						1
1 out 1 manty	1 SUALIONID		Sample lype	UpperDepth	LowerDepth	ParamName	AnaValue	ProjQual Units	Detected
2000	68240	DUA007	N	0	1	LEAD	702	= ĮMG/KG	TRUE
3 99	6621 4	REAU37		0	1	LEAD	93 6	=/MG/KG	TRUE
3.55	5531B	SGA012	N			LEAD	664	= MG/KG	TRUE
3.55	SSIC	30A012	NI CARA	i	0.83	LEAD	855	= 'MG/KG	TRUE
3.55	188310	ISGA200ED1)en			LEAD	<u>84 6</u>	<u></u> MG/KG	TRUE
3.55	SS31D	SCB059		·	1	LEAD	712	= <u>MG/KG</u>	TRUE
3.55	SS32B	BHA015	N	r — — – – – ,		LEAD	205,	= MG/KG	TRUE
3.55	155320	BHADIE	FN	·0		LEAD	678	= img/kg	TRUE
3'55	SS32D	RHA017	114	f			693	=MG/KG	TRUE
3 55	SS32E	RHA018	IN IN		1	LEAD	766	= MG/KG	TRUE
3 SS	SS32F	BHA019	N	UU]	LEAD	119,	= MG/KG	TRUE
3'SS	SS32G	BHA020	N				105	= MG/KG	TRUE
3'55	SS32G	BHA021ED1	FD	- 1		LEAD	1580	= MG/KG	TRUE
3 SS	SS33A	SGA025	N	0,			563	= MG/KG	TRUE
3.55	SS33B	ISG8067	N	0.2	1.01		129	= MG/KG	TRUE
3.55	SS33C	SGA027	N			EAD		= MG/KG	TRUE
3 55	SS33D	SGA028	N			EAD	200	=MG/KG	TRUE
3 SS	SS33E	SGB068	N		11	EAD	/51	= MG/KG	TRUE
3 SS	SS33F	SGA030	N		11		140	= MG/KG	TRUE
3 55	SS33G	MIA333	N		······································	EAD	/93	MG/KG	TRUE
3 55	SS33H	MIA334	N	0 ⁺		EAD	34 6	MG/KG	
3 SS	SS33I	MIA335	N				900,:	MG/KG	TRUE
3'SS	SS33J	MIA336	N	Ň			22 8;	= MG/KG	
3 SS	SS33K	MIA325	N	<u>0</u>	11	EAD	10:	= MG/KG	
3 SS	SS33L	MIA326	N		11	EAD	114		IHUE
3¦SS	SS33M	MIA327	N	<u>0</u> ,		EAD	114,	MG/KG	TRUE
3,SS	SS33M	MIA328FD	FD	O	11	FAD	332	MG/KG	TRUE
3 SS	SS33N	MIA330	N		11	FAD	62.2		TRUE
3,SS	SS33O	MIA331	N		1	FAD	12 2		TRUE
3 SS	SS34D	RHA038	N	0		FAD	960 -		TOUE
3 SS	SS34F	RHA040	N	0		FAD	145 -		
3 SS	SS89A	SGB044	N	0	1	FAD	24.6		TRUE
3 SS	SS89B	SGB039	N	0	111	FAD	130	MG/KG	TRUE
3,55	SS89C	SGA250	N		1	FAD	109	MG/KG	
3'SS	SS89D	SGA251	N	0	111	FAD	14.0	MG/KG	TOUC
3 SS	SS89F	SGA253	N	0	11	FAD		MG/KG	TRUE
3'\$5	SS89H	SGA257	Ν	0	1it	EAD		MG/KG	
3 55	SS89I	SGA258	N	0	11	EAD	30 2 -	MG/KG	
3 SS	SSB9J	SGA259	N	0	1	EAD	2250 -	MG/KG	
3'SS	SS89J	SGA260FD1	FD	0		EAD	1310 -	MG/KG	
3,SS	SS89K	MIA153	N	0		EAD	39.0-	MG/KG	
3,SS	SS89L	MIA155	N	0	11	EAD	64 7	MG/KG	
3`SS[SS89M	MIA156	N	0	11	EAD	256 =	MG/KG	
3 55	SS89N	MIA157	N	0		ÉAD	232 =	MG/KG	
3,85	SS89O	MIA158	N	0		EAD		MG/KG	TRUE
								jwand	I NUE

Average Lead Concentraitons Across FU3 =

249

Unit	Matrix	StationID	SampleiD	SampleType	UpperDepth	LowerDepth	ParamName	AnaValue	ProjQual	Unsts	Detected
4	SB	SB79A	ISGA442	N	4	. 6	LEAD	31 9) =	MG/KG	TRUE
, 4	SB	SB79A	SGA443	N	8	- 10	LEAD	25 1	=	MG/KG	TRUE
4	SB	SB79A	SGA444	'N	18	20	LEAD	17 3	5 =	MG/KG	TRUE
4	SB	SB79B	ISGA447	N N	. 8	10	LEAD	21 5	j	MG/KG	TRUE
4	SB	SB79B	SGA448	N N	18	20	LEAD	148	i =	MG/KG	TRUE
4	SB	SB79B	SGB138	,N	, 4	55	LEAD	14 3	_ =	MG/KG	TRUE
4	SB	SB79C	1SGA450	, N	4	6	LEAD	38 4	l'=	MG/KG	TRUE
4	SB	SB79C	SGA451	'N	8	10	LEAD	19 6	δ =	MG/KG	TRUE
4	SB	SB79C	SGA452	ÎN	18	20	LEAD	17	, /;=	MG/KG	TRUE
4	SB .	SB79D	MIA125	IN	4	6	LEAD	12 1	. =	MG/KG	, TRUE
4	SB	SB79D	MIA126	N	8	10	LEAD	81	1=	MG/KG	TRUE
4	SB	SB79D	MIA127	IN	16	18	LEAD	65	, =	MG/KG	TRUE
4	SB	SB83A	SGA400	N	9	11	LEAD	22 2	•	MG/KG	TRUE
4	SB	SB83A	SGB121	N	4,	6	LEAD	88	 الا	MG/KG	TRUE
4	SB	SB83B	SGA402	N	4'	65	LEAD	36.3	; =	MG/KG	TRUE
4	SB	SB83B	SGA403	N	9	11	LEAD	26 2	!=	MG/KG	TRUE
4	SS	FS79A	MIA283AVG	Ň	0	1	LEAD	360 45)[=	MG/KG	TRUE
4	SS	FS79B	MIA286AVG	N	0	1	LEAD	701 5		MG/KG	TRUE
4	SS	FS79C	MIA289AVG	IN	0	1	LEAD	88 9	, 	MG/KG	TRUE
4	SS	FS830	MIA246AVG	N	0	1	LEAD	320 2	!=	MG/KG	TRUE
4	SS	FS83P	MIA249AVG	N	0	1	LEAD	362 9) =	MG/KG	TRUE
4	SS	FS83Q	MIA252AVG	N	0	1	LEAD	87 05	t	MG/KG	TRUE
4	SS	FS83R	MIA255AVG	N	0	1	LEAD	1495		MG/KG	TRUE
4	SS	FS83S	MIA258AVG	N	0.	1	LEAD	410.6	J	MG/KG	TRUE
4	SS	FS83T	MIA261AVG	N	0	1	LEAD	1995	,∮ ⁻	MG/KG	TRUE
4	SS	SB79A	SGA441	N	0	1	LEAD	32.9	∲	MG/KG	TRUE
4	SS	SB79B	SGB137	N	0	1	LEAD	208		MG/KG	TRUE
4	SS	SB79C	SGA449	N	0	1	LEAD	27 1	1=	MG/KG	TRUE
4	SS	SB83A	SGA398	N	0	1	LEAD	14 7	· ':=	MG/KG	TRUE
4	SS	SB83A	SGA482FD1	FD	0	1	LEAD	73	+	MG/KG	TRUE
4	SS	SB83B	SGA401	N	0	1	LEAD	2430	 ا:=	MG/KG	TRUE
4	SS	SS34E	RHA039	N	0	1	LEAD	340	<u>(</u>	MG/KG	TRUE
4	SS	SS34E	RHA180FD1	FD	0	1	LEAD	505	i =	MG/KG	TRUE
4	SS	SS79A	SGA314	N	0	1	LEAD	1060	+	MG/KG	TRUE
4	SS	SS79B	SGA315	N	0	1	LEAD	105	i =	MG/KG	TRUE
4	SS	SS79C	SGB097	N	0	1	LEAD	12.2	'=	MG/KG	TRUE
4	SS	SS79D	MIA277	N	0	1	LEAD	269	,	MG/KG	TRUE
4	SS	SS79D	MIA278FD	FD	0	1	LEAD	270	, =	MG/KG	TRUE
4	SS	SS79E	MIA280	N	0	1	LEAD	506	1	MG/KG	TRUE
4	SS	SS79F	MIA281	N	0	1	LEAD	83 9	+	MG/KG	TRUE
4	SS	SS79F	MIA282FD	FD	0	1	LEAD	80.8	• ••••• • • • • • •	MG/KG	TRUE
4	ss	SS83A	SGA284	Ň	07		LEAD	67.5	,	MG/KG	TRUE
4	s	SS83B	SGB075	N	0	1	LEAD	1720	/	MG/KG	TRUE
4	SS	SS83C	SGA286	N	0	1	LEAD	2800	∲	MG/KG	TRUE
4	SS	SS83D	MIA234	N	0		LEAD	93 2	;	MG/KG	TRUE
- 4	ss	SS83E	MIA236	N		1	LEAD		;	MG/KG	TRUE
4	SS i	SS83F	MIA237	,N	i 0'	1	LEAD	120	j <u>i</u>	MG/KG	TRUF
4	ss i	SS83G	MIA238	N		1	LEAD	24.9	J	MG/KG	TRUE
4	ss ¹ 1	SS83H	MIA239	N	0	1	LEAD	12 5	J	MG/KG	TRUE
4	ss i	SS831	MIA240	N	, <u> </u>	i	LEAD		، "J	MG/KG	TRUE
4	SS	SS83J	MIA241	N	0	1	LEAD	21 8	::	MG/KG	TRUF
4	SS	SS83K	MIA242	N	i 0'	1	LEAD	80 2	.=	MG/KG	TRUF
4	ssī	SS83L	MIA243	N	0	1	LEAD	188	J	MG/KG	TRUE
4	SS	SS83M	MIA244	N	0	1	LEAD	300	- + =	MG/KG	TRUE
4	SS	SS83N	MIA245	N	, of	1	I FAD	437	/ ': =	MG/KG	TRUE

Average Lead Across FU4 =

332

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Remedial Goal Options for Lead

Memphis Depot Main Installation Soils FS

$$RBRG = PbS = \frac{PbB_{adult, central, goal - PbB_{adult} * AT}}{(BKSF * IR_s * AF_s * EF_s)}$$

where,

$$PbB_{adult, central, goal} = \frac{PbB_{fetal, 0} 95, goal}{GSD_{i, adult}} * R_{fetal / maternal}$$

Exposure Parameter	Description	Adult Worker	Source ¹
RBRG	Risk-Based Remedial Goals (RBRGs) expressed in mg/kg; or PbS = Soil Lead Concentration (mg/kg)	1536	Calc.
PbBadult,central,goal	Goal for central estimate of Blood Lead Concentration expressed in ug/dl;	4 23	Calc.
PbBadult,0	Typical Blood Lead Concentration (ug/dL) in adults, (i.e., women of child-bearing age) in absence of exposures to the site	1.7	A
PbB _{fetal} ,0 95,goal	Goal for 95%blood lead concentration (ug/dL) in fetuses from exposures to women workers of childbearing age	10	A
BKSF	Biokinetic Slope Factor expressed in (ug/dL) per (ug/day) or day/dl,	0.4	A
IR _s	Intake rate for soil, including both indoor and outdoor soil-derived dust (g/day) (50 mg/day)	0.05	А
AFs	Absolute gastrointestinal absorption fraction for ingested lead in soil and lead in dust derived from soil (dimensionless)	0 12	A
EFs	Exposure Frequency for contact with assessed soils and/or dust derived part from site soils (days/year)	250	В
AT	Averaging time; 365 days/year	365	В
GSD ^{1 645} , _{adult}	Geometric standard deviation of the Reponses to lead exposure, on-site and offsite (unitless) 1 8-uniform population, 2 1 - heterogeneous population	2.63	A
R _{fetal/maternal}	Constant proportionality between fetal blood lead concentration at birth and maternal blood lead concentration (dimensionless)	09	A

¹Sources

A. USEPA 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. December 1996

B USEPA 1991 Human Health Evaluation Manual, Part B: "Development of Risk-based Preliminary Remedial Goals" Office of Solid Waste and Emergency Response OSWER Directive 9285 7-01B. December 13, 1991

TABLE 6-13

Calculation of a Soil Risk-Based Concentration for Lead Using the Bowers Adult Blood Lead Mode

$$C_{s/d} = \left[\underbrace{\frac{PbB - BPbB}{BSF} - (A_w \times I_w \times C_w) - (V_a \times A_a \times t_{res} \times C_{bg a})}{(I_{s/d} \times A_{s/d} \times t_{ing})} \right] + C_{bg s/d}$$

where,

PbB	_	PbB _{OSHA}
τυD	_	$\exp[Z_{0.05} \times \ln(\text{GSD})]$

Exposure		Construction	-
Parameter	Description	Values	Source ¹
C _{s/d}	Soil Risk-Based Concentration (RBC) expressed in mg/kg;	1087	Calc.
PbB	Target Blood Lead Concentration expressed in ug/dl;	8 85	Calc.
BPbB	Background Blood Lead Concentration expressed in ug/dL;	3.1	А
BSF	Blood-Lead Slope Factor expressed in (ug/dL) per (ug/day) or day/dl;	0 375	А
Aw	Water Absorption Factor (unitless),	0 08	A
l _w	Water Ingestion Rate expressed in L/day;	1	В
Cw	Water Lead Concentration expressed in ug/L,	15	С
Va	Ventilation Rate During Waking Hours expressed in m ³ /day,	20	В
Aa	Fraction for Lung Deposition and Absorption (unitless),	0.32	A
t _{res}	Fraction of Time Spent on Site for Respiration (unitless),	0.230	A
C _{bg a}	Background Air Lead Concentration expressed in ug/m ³ ;	0.2	A
l _{s/d}	Soil/Dust Ingestion Rate expressed in g/day,	0.48	В
A _{s/d}	Soil/Dust Absorption Factor (unitless),	0.08	А
t _{ing}	Fraction of Time Spent on Site for Ingestion (unitless);	0.340	Α
C _{bg s/d}	Background Soil or Dust Concentration expressed in mg/kg;	26.5	D
PbB _{OSHA}	Blood Lead Level recommended by OSHA for protection of workers of reproductive age expressed in ug/dl,	30	E
Z _{0.05}	95% confidence interval for Z, a normally distributed random variable (unitless); and,	1 6449	A
GSD	Geometric Standard Deviation for paired environmental concentration/blood lead data (unitless)	21	А

Adapted from Bowers et al (1994).

¹Sources

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			Carcinoge	nic Effects					Noncarcino	genic Effects			
	TR - 1F-06	dustrial worker TB - 1E-05	TD - 15 04	TD - 15 A6	Residential	40 F		fustrial worl	(er 	He I	sidential Ad	ntt	
Chemical					Ch-31 = 11		I.U= IN I		01=141	THI =0.1	TH =1	THI =10	
Metals	e	8	340		6 70	0000	1						
LEAD	1536	1536	1536	300	300	300	e A/N	erc V/A	ANA N	N/A	N/A	A/N	
Pesticides DieLDRIN	0.27	27	27.1	121	10	010	۲ د	4	ĥ	Ļ	007	1001	
Semivolatiles		I	i		•	,		2	2	2	001	1001	
BENZO(a)ANTHRACENE	S	25	516	43	43	428							
BENZO(a)PYRENE	05	47	47	04	ষ	41							
BENZO(b)FLUORANTHENE	S	52	516	43	43	428							
BENZO(k)FLUORANTHENE	52	516	5162	43	428	4281							
CHRYSENE	516	5162	51625	428	4281	42813							
	05	۰ ۱	52	0 43	4	43							
	n	25	516	4 28	43	428							
Age-adjusted Carcinogenic calculati RBC = (mg/kg)	ion (ADULT onl) • <u>TR x ATc</u> EF x (A+B+C)	0	-	Carcinogenic RBC = (mg/kg)	calculation (IN <u>TR x BW x ATr</u> ED x (A+B+C)	IDUSTRIAL W	ORKER only	•		Noncarcinog RBC = <u>1</u> (mg/kg)	jenic calcula <u>TH1 X BW x /</u> EF X ED x (A	tion (ALL RE <u>ATnc</u> +B+C)	ECEPTORS)
	Where				Where:								
Ac = Bc = Cc =	(SFo x IRing_a (SFd x SA_ad) (SFi x IRinh_ac	ld] x FI x CF) x AF x ABS x (1] x ((1/VF)+(1/P	CF)	Ac = Cc =	(SFo x IRing x (SFd x SA x AI (SFI x IRinh x (FI x CF) = x ABS x CF) (1/VF)+(1/PEF)	. 8		•	An = (Bn = (Cn = (((1/RfDo) × II ((1/RfDd) × S ((1/RfDi) × IF	Ring x Fl x Cl A x AF x AB A k ((1/VF))	F) S x CF) +(1/PEF)))
													4
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EXPOSURE EQUATION 5

Calculation of a Soil Risk-Based Concentration for Lead Using the Bowers Adult Blood Lead Model

$$C_{s/d} = \left[\underbrace{\frac{\left(\frac{PbB - BPbB}{BSF}\right) - \left(A_{w} \times I_{w} \times C_{w}\right) - \left(V_{a} \times A_{a} \times t_{res} \times C_{bg a}\right)}{\left(I_{s/d} \times A_{s/d} \times t_{ing}\right)} \right] + C_{bg s/d}$$

where,

$$PbB = \frac{PbB_{OSHA}}{exp[Z_{0.05} \times ln(GSD)]}$$

Exposure Parameter	Description	Construction Worker Values
C _{s/d}	Soil Risk-Based Concentration (RBC) expressed in mg/kg;	6,130
PbB	Target Blood Lead Concentration expressed in µg/dl;	13 164
BPbB	Background Blood Lead Concentration expressed in μ g/dL,	3.1
BSF	Blood-Lead Slope Factor expressed in (μ g/dL) per (μ g/day) or day/dl,	0 375
A _w	Water Absorption Factor (unitless),	0 08
l _w	Water Ingestion Rate expressed in L/day;	2
C,	Water Lead Concentration expressed in μ g/L;	15
Va	Ventilation Rate During Waking Hours expressed in m ³ /day;	20
A _a	Fraction for Lung Deposition and Absorption (unitless),	0 32
t _{res}	Fraction of Time Spent on Site for Respiration (unitless);	0 111
C _{bg a}	Background Air Lead Concentration expressed in µg/m3;	0 1
l _{s/d}	Soil/Dust Ingestion Rate expressed in g/day;	01
A _{s/d}	Soil/Dust Absorption Factor (unitless),	0 08
t _{ing}	Fraction of Time Spent on Site for Ingestion (unitless),	0.500
C _{bg s/d}	Background Soil or Dust Concentration expressed in mg/kg,	32 2
PbB _{OSHA}	Blood Lead Level recommended by OSHA for protection of workers of reproductive age expressed in μ g/dl,	30
Z _{0 05}	95% confidence interval for Z, a normally distributed random variable (unitless); and,	1 6449
GSD	Geometric Standard Deviation for paired environmental concentration/blood lead data (unitless)	1.65

Adapted from Bowers et al (1994)

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Exposure Scanarlo/parameter	Ingest Carcinogenic No	ion n earcinogenia Exposure Scenario/paremeter	Darma Carcinogenia N	l Tatal Ingestion on carcinogenic	+Dermel	Ľ	eletive riek at UC	¥96.							
Industrial Worker - Adult		industriai Worker - Aduit			FU-1		U-2	2	•	5	.	FU-5		FU - 8	
Us = concentration in soil (mg/kg)	-	 Ca = concentration in soil (mo/ka) 	-	•	Ceit	F		Ĩ	Ī	HIS	Ī	Risk	Ŧ	Risk	7
IH = Sort ingestion rate (mg/day)	8	50 SA = Skin Surface Area (cm2/avent)	2450												
FI = Fraction ingested from contaminated area (unitless)	•	1 AF = Soil Atheracce tactor (motern?)] -												
ET = Exposure Time (hours/24 hr workday)	24	24 ARS - Absorbing Exclarit Indiana)	-	_											
EF = Exposure frequency (days/30 years)	1 22		•												
ED = Exposure chratery (veace)	3 2		8	80											
CFE Conversion (antion (ventione)		23 EF = EXposure frequency (days/yr)	250	250											
Blv - Broth month Ant	1000000	u uuuuu EU = Exposure duralion (years)	22	53											
	2	70 CF= Conversion factor (unitless)	0 00001	0 00001											
AL = Averaging time(days/yr x years)	25550	9125 BW = Body weight (kg)	2	20											
lt)takto z	1756-07	4 89E-07 AT = Avaraging time(days/yr x years)	25550	9125											
		Intaka =	2 86E-06	241E-05 304E-06 24	CE.DS										
Percent Relative to Future Industinal Worker	100 1	100 Percent Relative to Future Industrial Y	100	100 100	100 B 0E-05	60.0	3 DOE-05	02	0E-06	0 £	05 OS	01 205 05	0.00	105.05	
Realdential - Aduit		Davidentis, Artista								, ,	2		200	50 20 %	20
Ca = concentration in and function)						œ	reidential Adult								
		¹ C4 = concentration in soil (mg/kg)	-	-											
	114 2	100 SA = Skin Surface Area (cm2/event)	1574	5419											
FI = Fraction ingested from contaminated area (unitless)	-	 AF = Soil Adherence (actor (mo/sm3) 	-	-											
ET = Exposure Time (hours/24 hr workday)	24	24 ARS = Absorbion Factor (Indiana)	-	-											
EF = Exposure frequency (days/30 years)	5	afo ET - European Tent Ann Mithe Ann	i	i											
ED = Exposure duration (veace)	3 5	Source = Expusive tame (nourses a n-oay)	54	24											
CFa Conversion factor (surface)	000000	Ju Er ± Exposure frequency (daysyr)	350	350											
BW - Rock watcht (La)		U UUUUUI EU $= Exposure duration (years)$	8	8											
	R	70 CF= Conversion factor (unitiess)	0 00001	0 000001											
E AVERQUIN UNDOLOGYSYY X YEARS	25550	10950 BW = Body weight (kg)	02	70											
	8 70E-07	1 37E-06 AT = Averaging Ime(daye/yr x vears)	25550	10950											
		Intaka =	9 24F-DR	7 495-04 0 01E.Ne 7 EP	e ne										
Percent Relative to Future Industrial Worker	198	280 Percent Relative to Future Industrial Y	323	806 854	306 2 6E-04	0.28	9 8E-05	0.6	61-05		UE-DA	0.0 0.05 05		201 00	;
								•	3		Ş			a ar-O	-
Residential - Child		Residential - Child				'									
Cs = concentration in soil (mo/kg)	-			•		æ	heldentlai Child								
IR = Sol ingestion rate (mo/day)	000	200 SA - Skin Sudan Ann Ann Ann Ann													
FI = Fraction moested (mm contaminated area (unitiase)	ŝ		No.	2384 P											
ET # Exposure Time (hours/24 hr workday)	3 7	1 W Per a Soli Achievance lactor (mg/cm/3)	8	- 00											
EF = Exposive (recurancy (dave)	5.02														
ED - Experime develop (using)	R '	300 E1 = Exposure Time (hours/24 hr-day)	24	24											
	8 0	6 EF = Exposure frequency (days/yr)	8	350											
CF= CONVERSION (ACTOR (UNITIESS)	000001	0 000001 ED = Exposure duration (years)	9	9											
BW = Gody weight (kg)	5	15 CF= Conversion factor (unitiess)	0.00001												
AT = Averaging time(days/yr x years)	25550	2190 BW = Body weight (kn)	ž	15											
intake =	1 10E-08	1 28E-05 AT = Averacenci Inne(davs/vr ir veare)	25550												
		brinks =													
Percent Relative to Future Industrial Worker	827	2513 Percent Rejetive to Future Industrial V	60-21 o	1 53E-UM 1 42E-US 7 50		1									
			ş		ers are-on	0.5 0	1 40E-04	14 42	E-02	15	5	07 140E-04	60	1 40E-04	34

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TAB



Appendix B Cost Estimates

FU1-6	5 with No Cleanup of FU4				
ltem	Activity/Component	Quantity	Cnit	Unit Cost	Capital Cost ^a Source/ Comments
-	Deed Restrictions				Deed restrictions include residential land use, industrial land use in lead-contaminated area, and day care restrictions.
	1.1 Attorney Fees	32	hr	\$200 /hr	\$6,400 CH2M HILL. American Scrap Metal Site, Panama City Order-of-Magnitude Cost Estimate for Alternative 2A
	1 2 Recording of the Deed	N	ea	\$500 /ea	\$1,000
2	Fence along Perimeter of Lead Hot Spot 2.1 Fencing	440	ŧ	α 4	
	р 1	, F	=	÷	out of the second of the second second were second of the
	2.2 Labor	20	hr	\$75 /hr	\$1,500 Assumes two field people will be on-site for 10 hours for 1 day
ო	Signs				Signs will be installed around lead hot spot to help prevent neonle from entering area
	3 1 Signs	2	63	\$22 /ea	\$50 Phone Quote from Sign-A-Rama Assume 2 12-inch by 18-inch signs on each side of the
	3 2 Posts	5	ea	\$25 /ea	\$50 Assumes 12-foot post.
	3.3 Labor	-	노	\$50 /hr	\$50 Assumes generally takes a half of an hour to install each sign
4	Plans for Implementation	88	노	\$75 /hr	\$6,600 Plans to develop include Site Safety and Health Plan and Environmental Protection Plan
					CH2M HILL ⁻ Draft EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999.
Total	Capital Costs				\$19,000
^a Estin typic plus (nates include remedial action, construction, and O& ally estimated to be a percentage of remedy cost ai 50 to minus 30 percent.	M costs that and nd therefore, do	e expecte o not fact	ed to differ betv or in comparati	veen alternatives. Planning and engineering costs are ve cost evaluations The estimate is typically accurate within

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SOILS

 TABLE B-1a

 Capital Cost Estimate: Alternative 2, Institutional Controls, Industrial Planned Use

 Memphis Depot Main Installation Soils FS

FU1-	6 with No Cleanup of FU4						
					Annual O&M	Present Worth	
Item	Activity/Component	Quantity	Unit	Unit Cost	Cost ^a	O&M Cost ^{a,b} Source/ Comments	
ъ	Maintenance of Site (Year 2-30)						
	5.1 Fencing (three over 30	years)				Assumes fencing will need to be replaced eve This indicates fence will be replaced three tim	ery 10 years
						years	
	5.1.1 Fencing	440	ft/yr	\$8 / I t	\$3500 (\$350 averaged over 10 years)	, \$4,600 CH2M HILL American Scrap Metal Site, Pan Order of Magnitude Cost Estimate for Alterna	ama Cıty tıve 5A
	5.12 Labor	50	hr/yr	\$75 /hr	\$1500 (\$150 averaged over 10 years)	\$2,000 Assumes two field people will be on-site for 1 day	0 hours for 1
	5.2 Signage (six over 30 ye	ars)				Assumes signs will be replaced every 5 years	This
	5.2 1 Signs	2	ea/yr	\$22 /еа	\$50 (\$10 averaged over 5 years)	\$200 Phone Quote from Sign-A-Rama	JU years.
						Assume 2 12-inch by 18-inch signs on each s area	ide of the
	5 2.2 Posts	N	ea/yr	\$25 /ea	\$50 (\$10 averaged over 5 years)	\$200 Assumes 12-foot post	
	5.2.3 Labor	~	hr/yr	\$50 /hr	\$50 (\$10 averaged over 5 years)	\$200 Assumes generally takes a half of an hour to i sign	nstall each
9	Annual Evaluation (Year 2-30)						
	6.1 Inspection	ω	hr/yr	\$75 /hr	\$600	\$9,100 Assumes site conditions and use will be inspe to determine if institutional controls are curren Evaluation would occur over 1 day.	cted annually tly acceptable

O&M Cost Estimate. Alternative 2, Institutional Controls, Industrial Planned Use Memphis Depot Main Installation Soils FS TABLE 8-1b

SOILS

B-2

TABLE B-1b O&M Cost Estimate: Alternative 2, Instituti Memphis Depot Main Installation Soils FS	tional Controls,	Industrial I	^o lanned Use			
FU1-6 with No Cleanup of FU4						
				Annual O&M	Present Worth	
Item Activity/Component	Quantity	Unit	Unit Cost	Cost ^a	O&M Cost ^{a,b}	Source/ Comments
6 2 Reporting	32	hr/yr	\$75 /hr	\$2,400	\$36,300 Assume r	eport will take 1 week to complete
7 5-Year Review (six over 30 years)	40	hr/yr	\$100 /hr	\$4000 (\$800 averaged over 5 years)	\$11,700 Remedial years to e adequate	alternative at site will need to be reviewed every 5 ensure that institutional controls are providing protection.
Total O&M Costs (Years 1-30) ^c				\$4,300	\$64,000	
^a Estimates include remedial action, co typically estimated to be a percentag plus 50 to minus 30 percent.	onstruction, ar je of remedy c	id O&M c sost and th	osts that are herefore, do i	expected to differ not factor in compi	between alternatives. Plan arative cost evaluations Tt	ining and engineering costs are he estimate is typically accurate within
^b Present worth cost calculated using a ^c The annual total O&M costs consist o	an interest rate of cost for ann	e of 5 per ual evalua	cent over 30	years. average of other c	osts over time period they c	occur. For example, the annual cost
for 5-year review is total \$4000 averagied O&M costs occur over a period of 30	jed over 5 yea years	Irs,				
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FU1-	5 with No Cleanup of FU4					
			:			
ltem	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost ⁶	
-	Deed Restrictions	\$7,400	NA	NA	\$7,400	
2	Fence along Perimeter of Lead Hot Spot	\$5,000	NA	NA	\$5,000	
ო	Signs	\$150	NA	NA	\$150	
4	Plans for Implementation	\$6,600	NA	NA	\$6,600	
2	Maintenance of Site (Year 2-30)	NA	\$530 ^d	\$7,200	\$7,200	
9	Annual Evaluation (Year 2-30)	NA	\$3,000	\$45,400	\$45,400	
2	5-Year Review	٩N	\$800 ^d	\$11,700	\$11,700	
Total	Cost for FU1-6 with No Cleanup of FU4°	\$19,000	\$4,300	\$64,000	\$83,000	
^a Estii typi b Pres c Tota d The for 5-) e This	mates include remedial action, construction, and O cally estimated to be a percentage of remedy cost 50 to minus 30 percent. sent worth cost calculated using an interest rate of all PW cost includes capital plus PW O&M costs over annual total O&M costs consist of cost for annual vear review is total \$4000 averaged over 5 years estimate applies to all FUs and includes industrial estimate applies to all FUs and includes industrial	X&M costs that are e and therefore, do n 5 percent over 30 y er 30 years. evaluation and an a evaluation and an a l site controls for lea	xpected to differ betwe of factor in comparative ears. verage of other costs o d hot spot in FU4 that i	en alternatives Planning and engine cost evaluations. The estimate is ty ver time period they occur For exar s not covered, treated, or removed	ering costs are pically accurate within ple, the annual cost	

Cost Estimate Summary: Alternative 2, Institutional Controls, Industrial Planned Use Memphis Depot Main Installation Soils FS

TABLE B-1c

SOILS

TABLE B-2a

Capital Cost Estimate: Alternative 2, Institutional Controls, Industrial Planned Use Memphis Depot Main Installation Soils FS

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Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/	Comments
	Deed Restrictions				Deed restrictions include lar	nd use and day care
	1.1 Attorney Fees	32	hr	\$200 /hr	restrictions. \$6,400 CH2M HILL. American Scra	ap Metal Site, Panama City
	1 2 Recording of the Deed	N	ea	\$500 /ea	Order-of-Magnitude Cost Es \$1,000	stimate for Alternative 2A
2	Plans for Implementation	88	ц	\$75 /hr	\$6,600 Plans to develop include Sit Environmental Protection Pl CH2M HILL. Draft EE/CA R Main Installation Defense Dr	te Safety and Health Plan and lan. Removal of Hot Spot Areas
					1999	
Total	Canital Costs					

olal Capital Costs

\$14,000

typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within ^a Estimates include remedial action, construction, and O&M costs that are expected to differ between alternatives. Planning and engineering costs are plus 50 to minus 30 percent. e,

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TABL	E B-2b					
O&M Memµ	Cost Estimate. Alternative 2, Institutio this Depot Main Installation Soils FS	nal Controls, Ir	ndustrial F	Planned Use		
FU1-	3, 5, and 6 with Cleanup of Lead	Hot Spot in	FU4 by .	Another Alte	rnative	
					Annual O&M	Present Worth
Item	Activity/Component	Quantity	Unit	Unit Cost	Cost ^a	O&M Cost ^{a,b} Source/ Comments
n	Annual Evaluation (Year 2-30) 3.1 Inspection	œ	hr/yr	\$75 /hr	\$600	\$9,100 Assumes site conditions and use will be inspected annually to determine if institutional controls are currently acceptable
	3 2 Reporting	32	hr/yr	\$75 /hr	\$2,400	\$36,300 Assume report will take 1 week to complete
4	5-Year Review (six over 30 years)	40	hr/yr	\$100 /hr	\$4000 (\$800 averaged over 5 years)	\$11,700 Remedial alternative at site will need to be reviewed every 5 years to ensure that institutional controls are providing adequate protection.
Total	O&M Costs (Years 1-30) ^c				\$3,800	\$57,000
^a Esti typi plus	mates include remedial action, con cally estimated to be a percentage 50 to minus 30 percent	struction, and of remedy co	d O&M c ost and t	osts that are the the the the the the the the the th	expected to differ I not factor in compa	between alternatives Planning and engineering costs are trative cost evaluations The estimate is typically accurate within
^b Pre: ° The	sent worth cost calculated using ar	n interest rate	of 5 per	cent over 30)	/ears	the strict from a strict of the second strict stric
for 5- d O&N	year review is total \$4000 average for costs occur over a period of 30 v	d over 5 year ears.	s.			uses over mine period mey occur. For example, me annual cost
	-					

Item	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost°	
-	Deed Restrictions	\$7,400	NA	NA	\$7,400	
2	Plans for Implementation	\$6,600	NA	NA	\$6,600	
e	Annual Evaluation (Year 2-30)	NA	\$3,000	\$45,400	\$45,400	
4	5-Year Review	NA	\$800 ^d	\$11,700	\$11,700	
Tota	l Cost for FU1-3, 5, and 6°	\$14,000	\$3,800	\$57,000	\$71,000	
^a Est typ plus	imates include remedial action, construction, and C ically estimated to be a percentage of remedy cost 50 to minus 30 percent	J&M costs that are e t and therefore, do no	xpected to differ betwe ot factor in comparative	en alternatives Planning and engine cost evaluations The estimate is ty	ering costs are pically accurate within	
^b Pre ° Tot	sent worth cost calculated using an interest rate of al PW cost includes capital plus PW O&M costs ow	f 5 percent over 30 ye /er 30 years.	ears.			
^a The for 5-	e annual total O&M costs consist of cost for annual year review is total \$4000 averaged over 5 years	evaluation and an av	verage of other costs o	ver time period they occur. For exam	ple, the annual cost	
^e It is is tl	assumed that institutional controls would require the same as the cost for the entire Depot. This estin	the same activity whe mate assumes that Ir	ether applied to one or a	all FUs Thus, the cost for each FU I include future use restrictions		
NA∮	entire FUs or Depot. This cost alternative is based (Not applicable	on the assumption th	iat FU4 will be remedia	ited by another alternative to industri	al land use criteria	
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FU1-3, 5, and 6 with Cleanup of Lead Hot Spot in FU4 by Another Alternative

Cost Estimate Summary⁻ Alternative 2, Institutional Controls, Industrial Planned Use Memphis Depot Main Installation Soils FS

TABLE B-2c

FU Control Control Control Control Source/Commonts 1 Deed Pretrotions Activity/Component Quantity Unit Unit Cort Source/Commonts 1 Deed Pretrotions Prediction Source/Commonts Source/Commonts Prediction of source and land use restrictions, prediction of source and land use restrictions, prediction 1 11 Attorney Fees 40 hr Source/Commonts Prediction of source and land use restrictions, prediction of land user restriction and land user restrestrestriction of land userered user	Memp	ohis Depot Main Installation Soils FS					
Item Activity/Component Quantity Unit Control Comparison Source/ Comment 1 Deed Pestinations 1 Deed Pestinations Deed Pestinations Deed Pestinations Peed Pestinations 1 Deed Pestinations 3 Peed Pestinations Peed Pestinations Peed Pestinations 1 1 Altiomary Fees 40 hr \$200 hr \$8.000 CH2M HLL American Strap Matal Stite, Parama 2 Pans for implementation 3 ea \$500 res \$1.500 3 Solid Cover (Over One Lead Hot Spot in FU4) 3 \$1.500 Pertor State Matal Fash. Parama 3 Solid Cover (Over One Lead Hot Spot in FU4) \$7.200 res \$1.500 Peero Bestor include Step Peanama 3 Solid Cover (Over One Lead Hot Spot in FU4) 7.200 res \$1.500 Peero Bestor include Step Peanama 3 Solid Cover (Over One Lead Hot Spot in FU4) 7.200 res \$1.700 res Peero Bestor include Step Peroval of Hot Spot 3 Solid Cover (Pest) 7.200 res \$0.11 r/rs \$5.000 res Peed Pestore Depot, Memihas	FU4						
1 Deed Fastrictions. Deed fastrictions. protection of soli cover, and land use restrictions. 1 11 Altomey Fees 40 hr \$200 /hr \$8,000 CH2M HILL American Scrap Matal Ste, Parama Carap Matal Ste, Parama Ste, Parama Carap Carap Matal Ste, Parama Carap Carap Matal Ste, Parama Carap Matal Ste,	ftem	Activity/Component	Quantity	Cuit	Unit Cost	Capital Cost ^a Source/ Comment	
11 Attorney Fees 40 hr \$200 /hr \$8,000 CH2M HILL American Scrap Metal Sile, Panama Cury Order of Magnutude Cost Estimate for Attending of the Deed 2 12 Recording of the Deed 3 ea \$500 /ea \$1,500 2 Plans for Implementation 96 hr \$7,200 Plans to develoy include Site Restoration Plan, Environmental Protection Plan, and Tests/Certificates tor Soil 3 Soil Cover (Over One Lead Hot Spot in FL4) 7,200 Plans to develoy include Site Restoration Plan, Environmental Protection Plan, and Tests/Certificates tor Soil 3 Soil Cover (Over One Lead Hot Spot in FL4) 7,200 Plans to develoy include Site Restoration Plan, Environmental Protection Plan, Environmental Plan, Plan	-	Deed Restrictions				Deed restrictions include day care protection of soil cover, and land u	restrictions, se restrictions
12 Peroving of the Deed 3 ea \$500 /ea \$1,500 2< Plans for Implementation		1 1 Attorney Fees	40	ц	\$200 /hr	\$8,000 CH2M HILL American Scrap Meta City: Order of Magnitude Cost Estir Alternation 2A	l Site, Panama nate for
2 Plans for Implementation 96 hr \$75. /hr \$7.200 Brins to develop include Site Restoration Plan, Envrommental Protection Plan, and Tests/Cenfficates for Soil 3 Soil Cover (Over One Lead Hot Spot in FU4) CH2M HILL. Draft: EE/CA Removal of Hot Spot include Site Restoration Defense Depot, Memphs. 3 Soil Cover (Over One Lead Hot Spot in FU4) Refer to Section 4 figures for isoge 3.1 Site Grading 7,200 R ² \$0.11 /fr ² 3.1 Site Grading 7,200 R ² \$0.11 /fr ² 3.2 Compacted Soil Cover (F&I) 400 yd ³ \$10 /yd ³ 3.2 Compacted Soil Cover (F&I) 400 yd ³ \$10 /yd ³		1.2 Recording of the Deed	ဗ	ea	\$500 /ea	\$1,500	
 3 Sol Cover (Over One Lead Hot Spot In FU4) 3 Sol Cover (Over One Lead Hot Spot In FU4) 3.1 Site Grading 7,200 Hr² 800 CH2M HILL. American Scrap Metal Site, Panama Ch7. 3.1 Site Grading 3.2 Compacted Sol Cover (F&l) 400 yd³ \$10 /yd³ <	N	Plans for Implementation	96	۲	\$75 /hr	\$7,200 Plans to develop include Site Rest Site Safety and Health Plan, Envirc Protection Plan, and Tests/Certifice	oration Plan, inmental ites for Soil
 3 Soil Cover (Over One Lead Hot Spot in FU4) 3.1 Site Grading 7,200 ft² 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 800 CH2M HILL. American Scrap Metal Site, Panama Ohy. 810 Jyd³ 810 Jyd³ 810 Jyd³ 810 Linckness In equired, Infentiose Soil cover was calculated using the 7,200 ff² area listed in Item 3 1 and assuming a the-inchenses for the (loose) soil cover 						CH2M HILL. Draft [.] EE/CA Remova Areas Maın Installation Defense D TN, March 1999	l of Hot Spot epot, Memphis,
3.1 Site Grading 7,200 H ² \$0 11 / H ² \$0 0 CH2M HILL. American Scrap Metal Site, Panama City. 3.1 Site Grading 7,200 H ² \$0 11 / H ² \$000 CH2M HILL. American Scrap Metal Site, Panama City. 3.2 Compacted Soil Cover (F&i) 400 yd ³ \$10 / yd ³ \$4,000 Soil cover will have a 12-inch compacted thickness is required, before compacted thickness is required to the (loose) soil cover was calculated using the 7,200 ft ² area listed in item 3 1 and assuming a 18-inch thickness for the (loose) soil cover was calculated using the tote is on cover	e	Soil Cover (Over One Lead Hot Spot in FU4)				Refer to Section 4 figures for locati	on of candidate
 3.2 Compacted Soil Cover (F&I) 400 yd³ \$10 /yd³ \$10 /yd³ 3.4,000 Soil cover will have a 12-inch compacted thickness is required, before compaction. The volume of soil cover was calculated using the 7,200 ft² area listed in Item 3 1 and assuming a 18-inch thickness for the (loose) soil cover 		3.1 Site Grading	7,200	łt ²	\$0 11 /ft ²	remediation area. \$800 CH2M HiLL. American Scrap Metal City. These costs includes labor, mobilization/demobilization, equipri material	Site, Panama lent, and
		3.2 Compacted Soil Cover (F&I)	400	۲d³	\$10 /yd ³	 \$4,000 Soil cover will have a 12-inch comp thickness To achieve this, an 18-in thickness is required, before comps The volume of soil cover was calcu 7,200 ft² area listed in Item 3 1 and 18-inch thickness for the (loose) so. 	acted ich loose soil iction. ated using the assuming a I cover

 TABLE B-3a
 Capital Cost Estimate. Alternative 3, Containment, Industrial Planned Use
 Memphis Depot Main Installation Soils FS

SOILS

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FU4						
Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a	Source/ Comments
						These costs includes labor, mobilization/demobilization, equipment, and material.
	3.3 Transportation of Imported soil Onsite	400	yd³	\$11.38 /yd ³	\$4,600	CH2M HILL. Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
	3.4 Laboratory Analysis on Clean Soil					This cost is associated with transport of 10-mile machine load haul of non-hazardous waste to BFI Special Waste Landfill from Depot. <u>Assuming</u> cost is approximately same for transport of clean soil on-site. Quote from Columbia Analytical Services, Berdimo CA
						TAL metals, TCL VOCs, Pesticides, and PCB analyses will be run for every 500 yd ³ of soil
	3 4.1 TCL Volatiles (8260) 3.4.2 TAL Metals (6010/700) 3 4 3 Pesticides (8081A) 3 4 4 PCBs (8082)	┯╸┯╴┿╴┯	6 6 6 6 6 6 6	\$198 /ea \$268 /ea \$141 /ea	\$200 \$270 \$150	
4	Surface Water Collection and Controls		69 63 6	\$10,000 /ea	\$10.000	CH2M HILL. Draft EE/CA Removal of Hot Sport
						Areas. Main Installation Defense Depot, Memphis, TN, March 1999. This cost includes sediment barners, straw bale dikes, and transport of contaminated water to treatment plant
ъ	Restoration of Site - Revegetation					CH2M HILL Draft: EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999.
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 TABLE B-3a
 Capital Cost Estimate: Alternative 3, Containment, Industrial Planned Use
 Memphis Depot Main Installation Soils FS

SOILS

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FU4						
ltem	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source	a/ Comments
	5.1 Soil Conditioning	017	acre	\$885 /acre	\$200 This cost includes the fertilizer.	application of lime and
	5.2 Seeding	0.17	acre	\$1,420 /acre	\$300 These costs includes I mobilization/demobiliz material.	labor, ation, equipment, and
9	Fence along Perimeter of Soil Cover 6.1 Fencing	440	Ħ	\$8 /ft	\$3,500 CH2M HILL [.] American City Order of Magnitu Alternative 5A	i Scrap Metal Site, Panama de Cost Estimate for
	62 Labor	20	노	\$75 /hr	\$3,000 Assumes two field peo hours for 1 day	pple will be on-site for 10
2	Signs along Soil Cover				Signs will be installed a prevent any disturbance	around soil cover to help se.
	7 1 Signs	2	ea	\$22 /ea	\$50 Phone Quote from Sig Assume 2 12-inch by 1 of the covered area	n-A-Rama 18-inch signs on each side
	7 2 Posts 7 3 Labor	0 -	ea hr	\$25 /ea \$50 /hr	\$50 Assumes 12-foot post\$50 Assumes generally takinstall each sign	es a half of an hour to
ω	Confirmation Sampling, 2 Events				Samples would be take confirm FU4 impacted One sample will be tak during each event	en at edges of soil cover to area has been contained ten per side of excavation
	8 1 Labor	40	ŗ	\$75 /hr	\$3,000 Assumes two field peo bours for 1 day for eac	ple will be on-site for 10 th event
	8 2 Laboratory Analysis - Lead	ω	ea	\$18 /ea	\$200 Cost estimated from pr Laboratories, PA	rice list from Lancaster

 TABLE 8-3a

 Capital Cost Estimate: Alternative 3, Containment, Industrial Planned Use

 Memphis Depot Main Installation Soils FS

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TABLE B-3a Capital Cost Estimate: Alternative 3, Containment, Industria Memphis Depot Main Installation Soils FS	al Planned Use				
FU4					
Item Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments	
8 3 Rental Equipment	N	event	\$360 /event	\$800 CH2M HILL Draft. EE/CA Removal of Hot Spot	1
. 8 4 Mobilization/Demobilization	32	h	\$75 /hr	Areas Main Installation Defense Depot, Memphis, TN, March 1999. \$2,400 Assumes it will take two field people 4 hours for mobilization and 4 hours for demobilization for	
8.5 Supplies	2	event	\$500 /event	 \$1,000 CH2M HILL. Reichold-Summary Invoice of Site Operations. 	
Total Capital Costs				\$51,000	
Estimates include remedial action, construction, and typically estimated to be a percentage of remedy cos plus 50 to minus 30 percent.	O&M costs that a st and therefore,	do not factor	I to differ between r in comparative co	alternatives Planning and engineering costs are ost evaluations. The estimate is typically accurate within	

SOILS

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TABL! 0&M C <i>Mempi</i>	E B-3b Cost Estimate Alternative 3, Containment, Ir his Depot Main Installation Soils FS	ıdustrıal Plann	ed Use			
FU4						
ltem	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b} Source/ Comments
Q	Maintenance of Site 9.1 Fencing (three over 30 year	() ()				Assumes fencing will need to be replaced every 10
	9 1.1 Fencing	440	ft/yr	\$8 /ft	\$3500 (\$350 averaged over 10 years)	years \$4,600 CH2M HILL American Scrap Metal Site, Panama City: Order of Magnitude Cost Estimate for Alternative 5A.
	912 Labor	20	hr/yr	\$75 /hr	\$1500 (\$150 averaged over 10 years)	\$2,000 Assumes two field people will be on-site for 10 hours for 1 day
	9 2 Signage (six over 30 years) 9.2.1 Signs	N	ea/yr	\$22 /ea	\$50 (\$10 averaged over 5 years)	Assumes signs will be replaced every 5 years \$200 Phone Quote from Sign-A-Rama
	9 2.2 Posts	N	ea/yr	\$25 /ea	\$50 (\$10 averaged over 5 vears)	Assume 2 12-inch by 18-inch signs on each side of the area \$200 Assumes 12-foot post
	923 Labor	←	hr/yr	\$50 /hr	\$50 (\$10 averaged over 5 years)	\$200 Assumes generally takes a half of an hour to install each sign.
	9.3 Soll Cover Maintenance	24	hr/yr	\$75 /hr	\$1,800	\$27,300 These costs assume local labor will be available Assumes a field operator will maintain soil cover an average of 2 hours per month for 30 years This includes repairs to soil cover due to erosion and intrusion

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			Annual O&M	Present Worth
	Quantity Unit	Unit Cost	Cost ^a	O&M Cost ^{a,b} Source/ Comments
	192 hríyr	\$75 /hr	\$14,400	\$218,000 Assumes a local field technician will perform landscaping an average of 16 hours (2 days) per month for 30 years This cost includes irrigation and mowing of site
	8 hr/yr	\$75 /hr	\$600	\$9,100 Assumes regulators would evaluate site annually to determine that soil covers were not disturbed
	32 hr/yr	\$75 /hr	\$2,400	Evaluation would occur over 1 day \$36,300 Assume report will take 1 week to complete.
ars)	40 hr/yr	\$100 /hr	\$4000 (\$800 averaged over 5 years)	\$11,700 Remedial alternative at site will need to be reviewed every 5 years to ensure that soil covers are intact and are providing adequate protection. Assume report will take 1 week to complete
	-		\$4,300	\$310,000
struction of reme i interest cost for a d over 5 ears.	, and O&M costs it dy cost and therefo rate of 5 percent or annual evaluation a years	iat are expecta ire, do not fact ver 30 years ind an average	ed to differ betweer or in comparative c e of other costs ove	in alternatives. Planning and engineering costs are cost evaluations. The estimate is typically accurate within er time period they occur. For example, the annual cost
			SOILS	B-13

ltem	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost ^c	
-	Deed Restrictions	\$9,500	NA	NA	\$9.500	
2	Plans for Implementation	\$7,200	NA	NA	\$7.200	
ო	Soil Cover	\$10,130	NA	NA	\$10.130	
4	Surface Water Collection and Controls	\$10,000	NA	NA	\$10.000	
5	Restoration of Site - Revegetation	\$500	NA	NA	\$500	
9	Fence along Perimeter of Soil Cover	\$6,500	NA	NA	\$6.500	
7	Signs along Soil Cover	\$150	NA	NA	\$150	
8	Confirmation Sampling	\$7,400	NA	NA	\$7,400	
ი	Maintenance of Site	NA	\$530 ^d	\$252.500	\$252,500	
₽	Annual Evaluation (Year 2-30)	AN	\$3,000	\$45,400	\$45,400	
=	5-Year Review	NA	\$800 ^d	\$11,700	\$11,700	
Total	Cost for Entire Depot	\$51,000	\$4,300	\$310,000	\$361.000	
Total	Costs for FU1	0	0	0	0	
Total	Costs for FU2	0	0	0	. 0	
Total	Costs for FU3	0	0	0	, 0	
Total	Costs for FU4 (100 Percent of Remedial Action)	51,000	4,300	310.000	361.000	
Total	Costs for FU5	0	0	0	0	
Total	Costs for FU6	0	0	0	0	
^a Estin tvnic	nates include remedial action, construction, and O&M ally estimated to be a necentate of remedy cost and	l costs that are ex t therefore do no	pected to differ betwee	en alternatives Planning and enginee	ring costs are	
plus	50 to minus 30 percent		>		ually accurate within	

^b Present worth cost calculated using an interest rate of 5 percent over 30 years

° Total PW cost includes capital plus PW O&M costs.

^d The annual total O&M costs consist of cost for annual evaluation and an average of other costs over time period they occur For example, the annual cost for 5-year review is total \$4000 averaged over 5 years NA Not applicable

Cost Estimate Summary: Alternative 3, Containment, Industrial Planned Use Memphis Depot Main Installation Soils FS

TABLE B-3c

FU4

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FU1.	FUG					
Item	Activity/Component	Quantity	Cnit	Unit Cost	Capital Cost ^a	Source/ Comments
-	Deed Restrictions				Deec	d restrictions include protection of soil cover
	1 1 Attorney Fees	24	μ	\$200 /hr	\$4,800 CH2 City.	M HILL American Scrap Metal Site, Panama Order of Magnitude Cost Estimate for
	1 2 Recording of the Deed	÷	еа	\$500 /ea	Allen \$500	nalive zA.
N	Plans for implementation	96	Ē	\$75 /hr	\$7,200 Plan Safel Plan CH21 Area: TN, M	s to develop include Site Restoration Plan, Site by and Health Plan, Environmental Protection , and Tests/Certificates for Soil. M HILL: Draft EE/CA Removal of Hot Spot & Main Installation Defense Depot, Memphis, March 1999
ო	Soil Cover (over Lead, Arsenic, and Dieldrin area: 31 Site Grading				CH2 Assu Assu Peca	M HiLL ⁻ American Scrap Metal Site, Panama mes this includes labor, lization/demobilization, and equipment djusted \$0 11/ ft ² unit cost to \$0.07/ft ² use of the greater volume of soil use of the greater volume of soil
	3 1 FU1	206,300	⁴¹ 2	\$0.07 /ft ²	reme \$14,500 This hot s spots conta	diation areas. area corresponds to 12 dieldrin-contaminated pots (161,000 ft ²), 3 arsenic-contaminated hot- (30,300 ft ²), and 2 arsenic- and dieldrin- iminated hot spot (15,000 ft ²).

 TABLE B-4a

 Capital Cost Estimate
 Alternative 3, Containment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

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SOILS

ten fi	- FU6 Activity/Comnonent	Ouantity	- This	I Init Cost	Panital Panita Causad Pananata
	3 1 2 FU2	1,960,200	²	\$0 07 /ft ²	\$137,300 This area corresponds to the entire area of FU2, not including Lake Danielson and the Golf Course Pond (45 acres) There are 7 arsenic- contaminated hot spots (56,601 ft ²) included within this 45-acre area
	3.1 3 FU3	5,500	2 =	\$0 07 /ft²	\$400 This area corresponds to 1 lead-contaminated hot spot (2,600 ft ²), and 4 arsenic-contaminated hot- spots (3,800 ft ²) One of the arsenic-contaminated hot spots (900 ft ²) is contained within the area of the lead hot spot. Therefore, the total area for site remediation is 5500 ft ² .
	3.1 4 FU4	386,200	II ²	\$0 07 /ft²	\$27,100 This area corresponds to 1 lead-contaminated hot spot (10,600 ft ²), 10 arsenic-contaminated hot spots (251,500 ft ²), 5 dieldrin-contaminated hot spots (111,500 ft ²), 2 arsenic and lead- contaminated hot spots (2,600 ft ²), and 2 arsenic and dieldrin-contaminated hot spots (10,000 ft ²).
	3.1 5 FU5	39,500	ft²	\$0 07 /ft²	\$2,800 This area corresponds to 7 dieldrin-contaminated hot spots (32,000 ft ²) and 1 arsenic-contaminated hot-spot (7,500 ft ²)
	316FU6	400	ft²	\$0.07 /ft ²	\$30 This area corresponds to 1 arsenic-contaminated hot spot (400 ft ²).

 TABLE B-4a
 Capital Cost Estimate
 Alternative 3, Containment, Residential Planned Use
 Memphis Depot Main Installation Soils FS
 Memphis Depot Main Installation

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SOILS

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 TABLE B-4a

 Capital Cost Estimate: Alternative 3, Containment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

FU1	. FUG					
Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a	Source/ Comments
	3.2 Compacted Soil Cover (F&I) 3.2 1 FU1	11,500	یں ۲	\$10 \\\\d3	\$115,000	Soil cover will have a 12-inch compacted thickness. To achieve this, an 18-inch loose soil thickness is required, before compaction. Volumes for soil cover were calculated using the areas listed in Item 3 1 and assuming a 18-inch thickness for the (loose) soil cover These costs includes labor, mobilization/demobilization, equipment, and material
	3 2 2 FU2 3 2.3 FU3 3.2 4 FU4 3.2 5 FU5 3 2 6 FU6	108,900 300 21,500 2,200 20	۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲	\$10 /yd ³ \$10 /yd ³ \$10 /yd ³ \$10 /yd ³	\$1,089,000 \$3,000 \$215,000 \$22,000 \$22,000	
	3.3 Transportation of Imported soil Onsite					CH2M HILL: Draft: EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999. This cost is associated with transport of 10-mile machine load haul of non-hazardous waste to BFI Special Waste Landfill from Depot. <u>Assuming</u> cost s approximately same for transport of clean soil on- site.
	321FU1 322FU2 323FU3 324FU4 325FU5 3.26FU6	11,500 108,900 300 21,500 2,200 20	v v v d ³ v d ³ d ³ d ³	\$11 38 /yd ³ \$11.38 /yd ³ \$11.38 /yd ³ \$11.38 /yd ³ \$11.38 /yd ³ \$11.38 /yd ³	\$130,900 \$1,239,300 \$3,500 \$244,700 \$25,100 \$25,100	

FU1-	FU6	;				
Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments	
	3.4 Laboratory Analysis - TAL/TLC on Clean Soil				Quote from Columbia Analytical Services, Redding, CA	
					TAL metals, TCL VOCs, Pesticides, and PCB analyses will be run for every 500 yd ³ of soil transported on-site. Total volume of imported soil is approximately	
	3 4 1 TCL Volatiles (8260)	289	ea	\$198 /ea	\$57,200	
	3.4.2 TAL Metals (6010/700)	289	ea	\$268 /ea	\$77,400	
	3 4 3 Pesticides (8081A)	289	ea	\$141 /ea	\$40,700	
	3.4.4 PCBs (8082)	289	ea	\$110 /ea	\$31,800	
4	Surface Water Collection and Controls					
	4.1 FU1	-	63	\$10,000 /ea	\$10,000 CH2M HILL Draft EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999.	
	42 FU2	-	ea	\$10,000 /ea	\$10,000 This cost includes sediment barriers, straw bale dikes, and transport of contaminated water to treatment plant	
	43 FU3	-	ea	\$10,000 /ea	\$10,000	
	44 FU4	-	ea	\$10,000 /ea	\$10,000	
	4.5 FU5	-	ea	\$10,000 /ea	\$10,000	
	4 6 FU6	-	ea	\$10,000 /ea	\$10,000	
5	Restoration of Site - Revegetation				CH2M HILL · Draft: EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis,	
	5 2 Soil Conditioning				I N, March 1999. This cost includes the application of lime and fertilizer	

 TABLE B-4a

 Capital Cost Estimate: Alternative 3, Containment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

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FU1	- FUG						
Item	n Activity/Component	Quantity	Cnit	Unit Cost	Capital Cost ^a	Source/ Comments	
	5.1.1 FU1	S	acre	\$885 /acre	\$4,200 Areas a	are equivalent acres per areas listed in Item	
	5.1.2 FU2	45	acre	\$885 /acre	3.1.		
	5 1.3 FU3	0 13	acre	\$885 /acre	\$200 \$200		
	5.1.4 FU4	თ	acre	\$885 /acre	\$7.900		
	5 1 5 FU5	-	acre	\$885 /acre	006\$		
	516FU6	0.01	acre	\$885 /acre	\$10		
	5 2 Seeding				These c mobilize materia	costs include labor, ation/demobilization, equipment, and	
	5 2 1 FU1	5	acre	\$1,420 /acre	\$6.800		
	5.2.2 FU2	45	acre	\$1,420 /acre	\$63,900		
	523FU3	013	acre	\$1,420 /acre	\$200		
	5.2.4 FU4	б	acre	\$1,420 /acre	\$12,600		
	5.2.5 FU5	-	acre	\$1,420 /acre	\$1,300		
	5 2 6 FU6	0.01	acre	\$1,420 /acre	\$20		
9	Confirmation Sampling, 2 Events				Sample	s would be taken at edges of soil cover to	
					connirm each ev	impacted area has been contained during tent	
					Assume hot spot samples	ss 4 samples will be taken at each <u>dieldrin</u> t area for each FU, except FU4, where 10 s will be taken.	
					Assume hot spot	es 4 samples will be taken at each <u>arsenic</u> t area for each FU	
					Assume spot are	ss 4 samples will be taken at each <u>lead</u> hot sa for each FU.	
	6.1 Labor	480	۲	\$75 /hr	\$36,000 Assume hours fo	ss two field people will be on-site for 10 C or 12 days for each event.	510
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 TABLE B-4a

 Capital Cost Estimate. Alternative 3, Containment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

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Capital Cost Estimate. Alternative 3, Containment, Residential Planned Use Memphis Depot Main Installation Soils FS

FU1 - FU6

Item

Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
6.2 Laboratory Analysis - Dieldrin	244	ea	\$100 /ea	\$24,400 Quote from Columbia Analytical Services, Redding, CA
6 3 Laboratory Analysis - Arsenic	256	63	\$18 /ea	\$4,700 Cost estimated from price list from Lancaster Laboratories, PA
6 4 Laboratory Analysis - Lead	32	ea	\$18 /ea	\$600 Cost estimated from price list from Lancaster Laboratories, PA
6 5 Rental Equipment	N	event	\$360 /event	\$800 CH2M HILL. Draft: EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999.
6.6 Mobilization/Demobilization	64	Ъ	\$75 /hr	\$4,800 Assumes it will take two field people 8 hours for mobilization and 8 hours for demobilization for each event
6 7 Supplies	N	event	\$500 /event	\$1,000 CH2M HILL Reichold-Summary Invoice of Site Operations

Total Capital Costs

typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations The estimate is typically accurate within ^a Estimates include remedial action, construction, and O&M costs that are expected to differ between alternatives Planning and engineering costs are plus 50 to minus 30 percent.

\$3,760,000

 TABLE 8-4b
 O&M Cost Estimate
 Alternative 3, Containment, Residential Planned Use

 Memphis Depot Main Installation Soils FS
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FU1-FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b} Source/ Comn	ments
7	Annual Evaluation (Year 2-30)						
	7.1 Inspection	Ø	hr/yr	\$75 /hr	\$600	\$9,100 Assumes regulators would eval	aluate site annually to
						cetermine mat soil covers were Evaluation would occur over 1.	e not disturbed day
	7.2 Reporting	32	hr/yr	\$75 /hr	\$2,400	\$36,300 Assume report will take 1 week	k to complete
ω	Maintenance of Site						
	8.1 Soil Cover Maintenance	240	hr/yr	\$75 /hr	\$18,000	\$272,500 These costs assume local labo	or will be available
						Assumes a field operator wili m average of 20 hours per month	naintain soil cover an h for 30 years This
						includes repairs to soil cover du intrusion.	lue to erosion and
	8 2 Landscaping	384	hr/yr	\$75 /hr	\$28,800	\$436,100 Assumes a local field technicial landscaping an average of 32 h month for a year	an will perform hours (4 days) per
						This cost includes irrigation and	d mowing of site.

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TABLE B-4b O&M Cost Estimate: Alternative 3, Containm Memphis Depot Main Installation Soils FS	ent, Residential P	lanned Us	Φ			
FU1-FU6						
Item Activity/Component	Ouantitv	Unit	linit Cost	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Coursed Comments
9 5-Year Review (six over 30 years)	40	hır/yr	\$100 /hr	\$4000 (\$800 averaged over 5 years)	\$11,700 F	Remedial alternative at site will need to be reviewed every 5 years to ensure that soil covers are intact and are providing adequate protection. Assume eport will take 1 week to complete.
Total O&M Costs (Years 1-30) ^c			-	\$50,600	\$766,000	
^a Estimates include remedial action, cons typically estimated to be a percentage of plus 50 to minus 30 percent.	truction, and Of of remedy cost a	kM costs i and theref	that are expeo ore, do not fac	ted to differ between	n alternatives Pla cost evaluations 1	nning and engineering costs are The estimate is typically accurate within
^b Present worth cost calculated using an i ^c The annual total O&M costs consist of c for 5-year review is total \$4000 averaged ^d O&M costs occur over a period of 30 ye.	interest rate of 5 cost for annual e over 5 years ars.	percent valuation	over 30 years and an averaç	ge of other costs ove	sr time period they	occur For example, the annual cost
٤ĺ	Activity/Component	Capital Cost"	Annual O&M Cost ^a	Present Worth O&M Cost"	Total PW Cost ^c	
----	--	---------------	------------------------------	-------------------------	----------------------------	
	Deed Restrictions	\$5,300	NA	NA	\$5,300	
	Plans for Implementation	\$7,200	NA	NA	\$7,200	
	Soil Cover				\$3,477,300	
	FU1	\$260,400	NA	NA		
	FU2	\$2,465,600	NA	NA		
	FU3	\$6,900	NA	NA		
	FU4	\$486,800	NA	NA		
	FUS	\$49,900	NA	NA		
	FUG	\$530	NA	NA		
	Laboratory Analysis - TAL/TLC on Clean Soil	\$207,100	NA	NA		
	Surface Water Collection and Controls (\$10,000/FU)	\$60,000	NA	NA	\$60,000	
	Restoration of Site - Revegetation				\$137.900	
	FU1	\$11,000	NA	NA	- - -	
	FU2	\$103,800	NA	NA		
	FU3	\$400	NA	AN		
	FU4	\$20,500	NA	NA		
	FUS	\$2,200	NA	NA		
	FU6	\$30	NA	NA		
	Confirmation Sampling	\$72,300	NA	AA	\$72.300	
	Annual Evaluation (Year 2-30)	NA	\$3,000	\$45,400	\$45.400	
	Maintenance of Site	NA	\$46,800	\$708,600	\$708,600	
	5-Year Review	NA	\$800 9	\$11,700	\$11,700	
S	ost to Remediate all FUs at One Time				1	
Ľ	<u>te Items)</u>	\$3,760,000	\$50,600	\$766,000	\$4,526,000	

 TABLE B-4c

 Cost Estimate Summary: Alternative 3, Containment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

FU1-FU6

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	Individual FI	U Costs (Based	on Line Items an	d Percentage				
		of Ren	iediation) ^d			Adjusted	FU Costs ^h	
	Capital	Annual O&M	Present Worth	Total PW		Annual O&M	Present Worth	Total PW
	Cost ^ª	Cost ^a	O&M Cost ^{a,b}	Cost ^c	Capital Cost ^a	Cost ^ª	O&M Cost ^{a,b}	Cost
Fotal Cost for Entire Depot	\$3,760,000	\$50,600	\$766,000	\$4,526,000	\$3,764,000	\$53,300	\$805,000	\$4,569,000
Fotal Costs for FU1 (contains 8 3 Dercent of soil to be remediated)	305,000	4,200	63,000	368,000	305,000	4,200	63,000	368,000
Total Costs for FU2 (contains 75 2 bercent of soil to be remediated)	2,799,000	38,100	576,000	3,375,000	2,799,000	38,100	576,000	3,375,000
Total Costs for FU3 (contains 0 24 ercent of soil to be remediated)	18,000	100	2,000	20,000	18,000	1,200 *	18,000	36,000
otal Costs for FU4 (contains 14 8 iercent of soil to be remediated)	560,000	7,400	112,000	672,000	560,000	7,400	112,000	672,000
⁻ otal Costs for FU5 (contains 1 5 lercent of soil to be remediated)	67,000	700	11,000	78,000	67,000	1,200 ^e	18,000	85,000
otal Costs for FU6 (contains 0.01 ercent of soil to be remediated)	11,000	100	2,000	13,000	15,000 f	1,200 ^e	18,000	33,000
Estimates include remedial action, co	pnstruction, and	O&M costs that	are expected to dif	fer between alt	ernatives Plann	ing and engineeri	ing costs are	

typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within plus 50 to minus 30 percent.

3,375,000 ^b Present worth cost calculated using an interest rate of 5 percent over 30 years.

^c Total PW cost includes capital plus PW O&M costs.

^a These costs apply if all FUs are remediated together. Individual FU costs were determined by adding FU-specific activity costs where broken down in tables above to the total costs for remaining grouped activities multiplied by a proportion of assumed FU soil area to be remediated to the total (all FU) amount of soil to be remediated

^e Because of the small remedial area within this FU, O&M cost based on 16 hrs labor per year (\$1,200) for site inspections and reporting

Because of the small remedial area within this FU, capital costs includes a \$4,000 mobilization cost (based on best professional estimate).

⁹ The annual total O&M costs consist of cost for annual evaluation and an average of other costs over time period they occur For example, the annual cost for 5-year review is total \$4000 averaged over 5 years

^h Adjusted costs are individual FU costs which have been adjusted up for small scale activity. These costs apply if FU is remediated alone.

NA Not applicable

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Cost Estimate Summary: Alternative 3, Containment, Residential Planned Use

Memphis Depot Main Installation Soils FS

TABLE B-4c

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FU4					
Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
4	Surface Water Collection and Controls	~~	60 60	\$10,000 /ea	\$10,000 CH2M HILL Draft: EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999 This cost includes sediment barriers, straw bale dikes, and transport of contaminated water to treatment plant
2	Confirmation Sampling, 2 Events				Samples would be taken at edges of solidified soil to confirm FU4 impacted area has been contained
	51 Labor	40	hr	\$75 /hr	\$3,000 Assumes two field people will be on-site for 10 hours for 1 day for each event
	5 2 Laboratory Analysis - Lead	ω	ea	\$18 /ea	\$200 Cost estimated from price list from Lancaster Laboratories. PA
	5.3 Rental Equipment	N	event	\$360 /event	\$800 CH2M HILL Draft EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999
	5 4 Mobilization/Demobilization	32	hr	\$75 /hr	\$2,400 Assumes it will take two field people 4 hours for mobilization and 4 hours for demobilization for each event.
	5 5 Supplies	0	event	\$500 /event	\$1,000 CH2M HILL Reichold-Summary Invoice of Site Operations.
G	Restoration of Site - Revegetation				CH2M HILL. Draft [•] EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999 Assumes site restoration will occur in year one since there is no biotreatment under this land use option
	6.1 Soil Conditioning	0 17	acre	\$885 /acre	\$200 This cost includes the application of time and fertilizer

 TABLE B-5a
 Capital Cost Estimate: Alternative 4, In-situ Soil Treatment, Industrial Planned Use

 Memphis Depot Main Installation Soils FS

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FU4						
Item Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a	Source/ Comments	1
6.2 Seeding	017	acre	\$1,420 /acre	\$300 The	ese costs includes labor, bilization/demobilization, equipment, and materia	al.
Total Capital Costs				\$51.000		
^a Estimates include remedial action, construction, and O, typically estimated to be a percentage of remedy cost plus 50 to minus 30 percent. ^b Assumes soil bulk density of 1 4 tons/yd ³ based on his	XM costs that and therefore, storical surface	are expec do not fac solf remov	ted to differ betwe stor in comparative val actions conduc	en alternatives. Plai e cost evaluations. T	nning and engineering costs are The estimate is typically accurate within	1
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 TABLE B-5a

 Capital Cost Estimate: Alternative 4, In-situ Soil Treatment, Industrial Planned Use

 Memphis Depot Main Installation Soils FS

TAB O&N Mem	LE B-5b A Cost Estimate: Alternative 4, In-situ phis Depot Main Installation Soils FS	u Soil Treatn	rent, Ind	ustrial Plan	ned Use	
FU4						
Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b} Source/ Comments
7	Maintenance of Site- Landscaping	192	hr/yr	\$75 /hr	\$14,400	\$14,400 Assumes a field technician will perform landscaping an average of 16 hours (2 days) per month for a year This cost includes irrigation and mowing of site
ß	Annual Evaluation (Year 2-30) 8.1 Inspection	œ	hr/yr	\$75 /hr	\$600	\$9,100 Assumes site conditions and use will be inspected annually to determine if institutional controis are currently acceptable Evaluation would occur over 1 dov
	8.2 Reporting	32	hr/yr	\$75 /hr	\$2,400	\$36,300 Assume report will take 1 week to complete
თ	5-Year Review (sıx over 30 years)	40	hr/yr	\$100 /hr	\$4000 (\$800 averaged over 5 years)	\$11,700 Remedial alternative at site will need to be reviewed every 5 years to ensure that institutional controls are providing adequate protection.
Tota	l O&M Costs (Years 1-30) ^c				\$18,200	\$72,000
a Est typ plus	imates include remedial action, construct ically estimated to be a percentage of rei 50 to minus 30 percent.	ion, and O&A medy cost an	d costs th d therefor	at are expect e, do not fac	led to differ betweer tor in comparative o	n alternatives Planning and engineering costs are cost evaluations The estimate is typically accurate within
The for 5- O&I	sent worrn cost calculated using an Inter- e annual total O&M costs consist of cost f year review is total \$4000 averaged over y costs occur over a period of 30 years	est rate of 5 p or annual eve r 5 years	ercent ov iluation al	rer 30 years nd an averag	ie of other costs ove	er time period they occur For example, the annual cost

FU4					
Item	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost ^c
-	Deed Restrictions	\$7,400	NA	NA	\$7 400
2	Plans for Implementation	\$7.200	NA	NA NA	
ო	Stabilization of Lead	\$18.800	NA	NA	¢18 800
4	Surface Water Collection and Controls	\$10,000	NA	AN AN	¢10,000
ŝ	Confirmation Samuling	\$7 AND			000'01¢
0				AN	\$1,400
0	Hestoration of Site - Hevegetation	\$500	NA	NA	\$500
~	Maintenance of Site- Landscaping	NA	\$14,400	\$14,400	\$14.400
œ	Annual Evaluation (Year 2-30)	NA	\$3.000	\$45,400	\$45,400
თ	5-Year Review (six over 30 years)	NA		\$11 700	
Tota	I Cost for Entire Depot	\$51,000	\$18,200	\$72,000	\$123.000
Tota	I Costs for FU1	0	0	NA	C
Tota	I Costs for FU2	0	. 0	NA	
Tota	I Costs for FU3	0	, c	AN AN	
Tota	I Costs for FU4 (100 Percent of Remedial Action)	51,000	18.200	72,000	123 000
Tota	I Costs for FU5	Ō	C	NA	000/071
Tota	I Costs for FU6	0		AN	 -
^a Esti	imates include remedial action, construction, and O&M	costs that are expecte	ed to differ between altern	atives Planning and engineering co	bete are
typ	ically estimated to be a percentage of remedy cost and	therefore. do not facto	or in comparative cost eve	thations The estimate is typically a	accurate within
plus	50 to minus 30 percent			n funcid fr at continues and a strategy	

Cost Estimate Summary Alternative 4, In-situ Soil Treatment, Industrial Planned Use Memphis Depot Main Installation Soils FS

TABLE B-5c

^b Present worth cost calculated using an interest rate of 5 percent.

^c Total PW cost includes capital plus PW O&M costs.

^d The annual total O&M costs consist of cost for annual evaluation and an average of other costs over time period they occur. For example, the annual cost for 5-year review is total \$4000 averaged over 5 years NA Not applicable

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 TABLE B-6a

 Capital Cost Estimate
 Alternative 4, In-situ Soil Treatment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

FUI	- FUG					
ltem	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a	Source/ Comments
-	Deed Restrictions					Deed restrictionswould be temporary land use restrictions during implementation
	1 1 Attorney Fees	24	ŗ	\$200 /hr	\$4,800	CH2M HILL American Scrap Metal Site, Panama City: Order of Magnitude Cost Estimate for Alternative 2A.
	1 2 Recording of the Deed	÷	ea	\$500 /ea	\$500	
2	Plans for Implementation	96	ž	\$75 /hr	\$7,200	Plans to develop include Site Restoration Plan, Site Safety and Health Plan, Environmental Protection Plan, and Tests/Certificates for Soil
						CH2M HILL: Draft: EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
e	Enhanced Biological Treatment					Based on Venture Capital Estimate Refer to Table B-14 for detailed assumptions
	3.1 Amendments/Application/Sampling					This cost includes treatment solution (mineral saits, carbon, fertilizer) and application to soil, equipment, soil sampling, and approximately 300 analytical samples for dieldrin per year. Soil will be treated to a protective depth of 1 foot. Assumes that will need to re-apply biological treatment media twice a year (growing season and summer), will need to aerate (with tractor) every 2 weeks, and need to re-apply fertilizer every month.

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Capital Cost Estimate: Alternative 4, In-situ Soil Treatment, Residential Planned Use Memphis Depot Main Installation Soils FS

FU1 - FU6 Item Activ

Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments	
3.1.1 FU1	176,000	ft²	\$0 77 /ft²	Assumes that local labor will be av aeration, landscaping, and fertilize applications \$135,600 This area corresponds to an area dieldrin-contaminated hot spots (1 and a depth of 1 foot	vallable for er with 14 76,000 ft ²)
3 1 2 FU2	1,960,200	H ²	\$0 77 /ft²	\$1,509,400 This area corresponds to the entire FU2, not including Lake Danielson Golf Course Pond (45 acres) and a foot	e area of ì and the a depth of 1
3.1 3 FU3	0	ft²	\$0 77 /ft²	\$0 There are no soils in this FU above criteria for dieldrin	e the
3.1 4 FU4	121,500	₩ ²	\$0.77 /ft²	\$93,600 This area corresponds to an area v dieldrin-contaminated hot spots (1 with a depth of 1 foot.	with 7 21,500 ft ²)
3 1.5 FU5	32,000	41 ₂	\$0 77 /ft²	\$24,700 This area corresponds to an area v dieldrin-contaminated hot spots (3 and a depth of 1 foot	with 7 2,000 ft ²)
3 1.6 FU6	0	ft²	\$0 77 /ft²	\$0 There are no soils in this FU above critena for dieldrin.	e the
3.2 Lab Studies	N	ea	\$30,000 /ea	\$60,000 Assumes lab studies will be perforn determine if treatment solution nee modified for better performance	med to eds to be
Surface Water Collection and Controls					1.

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ttem	Activi	ity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
-	4	FUT	-	ea	\$10,000 /ea	\$10,000 CH2M HILL Draft EE/CA Removal of Hot
						Spot Areas Main installation Defense Depot,
						Memphis, IN, March 1999.
-	4 2	FU2	•	ea	\$10,000 /ea	\$10,000 This cost includes sediment barriers, straw
						bale dikes, and transport of contaminated
						water to treatment plant
•	43	FU3	-	ea	\$10,000 /ea	\$10,000
-	4.4	FU4	-	63	\$10.000 /ea	\$10,000
-	5	FUS	-	Q	\$10,000 /ee	¢10,000
)	22	-	d D	4-0,000 /CA	
,	46	FUG	-	ea	\$10,000 /ea	\$10,000
Total (Capita	Il Costs				\$1,896.000

typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within **Total Capital Costs** ^a Estimates include remedial action, construction, and O&M costs that are expected to differ between alternatives. Planning and engineering costs are plus 50 to minus 30 percent. ^b Assumes soil bulk density of 1.4 tons/yd³ based on historical surface soil removal actions conducted at the Depot

Capital Cost Estimate: Alternative 4, In-situ Soil Treatment, Residential Planned Use Memphis Depot Main Installation Soils FS

TABLE B-6a

FU1 · FU6

 TABLE B-6b
 O&M Cost Estimate: Alternative 4, In-situ Soll Treatment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

FU1 - FU6

Its	oerform ours (4 days) mowing of	iate Refer to ution (mineral lication to soil, pproximately in per year	e depth of 1 treatment ison and very 2 weeks, every month	available for zer a with 14 `` (176,000 ft ²)	tire area of on and the d a depth of 1
Source/ Commer	Assumes a field technician will plandscaping an average of 32 h per month per year This cost includes irrigation and site	Based on Venture Capital Estim Table B-14 for full assumptions This cost includes treatment sol salts, carbon, fertilizer) and appl salts, carbon, soil sampling, and a equipment, soil samples for dield	Soil will be treated to a protectiv foot. Assumes re-applying biological media twice a year (growing sec summer), aerating with tractor e and possibly reapplying fertilizer	Assumes that local labor will be aeration, landscaping, and fertili applications This area corresponds to an are dieldrin-contaminated hot spots and a depth of 1 foot	This area corresponds to the en FU2, not including Lake Daniels Golf Course Pond (45 acres) an oot
Present Worth O&M Cost ^{a,b}	\$53,600			\$124,400	\$1,385,100 ⁻
Annual O&M Cost ^a	\$28,800			\$66,900	\$744,900
Unit Cost	\$75 /hr			\$0 38 /ft²	\$0 38 /ft²
Unit	hr/yr			ft²/yr	ft²/yr
Quantity	384	2 and 3)		176,000	1,960,200
Activity/Component	Maintenance of Site- Landscaping (Year 1-3)	Continued Brological Treatment (Year 6.1 Amendments/Application/ Sampling		611FU1	6 1.2 FU2
Item	ъ	Q			

SOILS

FU1.	- FU6						
ltem	Activity/Component	Quantity	Unit	Unit Cost	Annuai O&M Cost ^a	Present Worth O&M Cost ^{a,b} Source/ Comme	ents
	6.1.3 FU3	0	ft²/yr	\$0.38 /ft²	0\$	\$0 There are no soils in this FU a for dieldrin	bove the criteria
	6 1.4 FU4	121,500	ft²/yr	\$0 38 /ft²	\$46,200	\$85,900 This area corresponds to an a dieldrin-contaminated hot spot with a depth of 1 foot	rea with 7 ts (121,500 ft ²)
	6 1.5 FU5	32,000	ft²/yr	\$0.38 /ft ²	\$12,200	\$22,700 This area corresponds to an a dieldrin-contaminated hot spot and a depth of 1 foot.	rea with 7 ts (32,000 ft²)
	6 1 6 FU6	0	ft²/yr	\$0.38 /ft ²	\$0 \$	\$0 There are no soils in this FU a for dieldrin	bove the criteria
	6.2 Lab Studies	N	ea/yr	\$30,000 /ea	\$60,000	\$111,600 Assumes lab studies will be pe determine if treatment solution modified for better performanc	erformed to i needs to be e
~	Stabilization of Lead and Arsenic (Year 3 7.1 Bench-Scale Study	-	ea/yr	\$2,000 /ea	\$2,000	Phone quote from SOLUCORF All stabilization of contaminate occur in year 3 \$1,900 A bench-scale study will be pe determine the best treatment s conditions.	rd soils would informed to solution for site

 TABLE B-6b

 O&M Cost Estimate: Alternative 4, In-situ Soil Treatment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

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 TABLE B-6b
 O&M Cost Estimate: Alternative 4, In-situ Soil Treatment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

FU1 - FU6

					Annual O&M	Present Worth	
ltem	Activity/Component	Quantity	Unit	Unit Cost	Cost ^a	O&M Cost ^{a,b}	Source/ Comments
	7.2 Treatment						his cost includes the stabilizing compound nd a technical administrator to be on-site for pplication of the compound Assumes cost lso includes equipment and nobilization/demobilization Assumes
	7 2 1 FU1 (Arsenic)	2,349 b	tons/yr	\$45 /ton	\$105,700	\$95,900 T	ompound can be tilled in as dry chemical. This weight corresponds to an area with 5 rsenic-contaminated hot spots (45,300 ft²), a epth of 1 foot. and a bulk density of 1 4
	7 2 2 FU2 (Arsenic)	2,935 b	tons/yr	\$45 /ton	\$132,100	\$119,800 T	$r_{\rm r}$ ms/yd ³ his weight corresponds to an area with 7 rsenic-contaminated hot spots (56,600 ft ²), a
	7.2.3 FU3 (Arsenic and Lead)	285 b	tons/yr	\$45 /ton	\$12,900	\$11,700 T	openation 1 and a pair openation of 1 a pair of 1 a pair of 1 and 2 and 4 and
						®U ♡£	rsenic-contarninated hot-spots (3,800 ft ²) one of the arsenic-contarninated hot spots 300 ft ²) is contained within the area of the lead of spot. Therefore, the total area for site
						2 @ O	smediation is 5,500 ft ² A depth of 1 foot and bulk density of 1 4 tons/yd ³ are used in the alculation

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FU1-	- FUG					
ltem	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b} Source/ Comments
	7.2.4 FU4 (Arsenic and Lead)	14,249 b	tons/yr	\$45 /ton	\$641,200	\$581,600 This weight corresponds to an area with 1 lead- contaminated hot spot (10,600 ft ²), 10 arsenic- contaminated hot spots (251500 ft ²), 2 arsenic and lead-contaminated hot spots (2,600 ft ²), and 2 arsenic and dieldrin-contaminated hot spots (10,000 ft ²), a depth of 1 foot, and a bulk
	7 2.5 FU5 (Arsenic)	389 b	tons/yr	\$45 /ton	\$17,500	\$15,900 This weight corresponds to an area with 1 arsenic-contaminated hot-spot (7,500 ft ²), a depth of 1 foot, and a bulk density of 1 4
	7 2.6 FU6 (Arsenic)	21 b	tons/yr	\$45 /ton	\$1,000	tons/yd ³ \$900 This weight corresponds to an area with 1 arsenic-contarninated hot spot (400 ft ²), a depth of 1 foot, and a bulk density of 1 4 tons/yd ³
ω	Confirmation Sampling - Lead and Arseni	ic Areas, 2 Ev	vents (Year 3)	0		Samples would be taken at edges of solidified solf to confirm impacted area has been contained Sampling of soils undergoing biological treatment is included in the unit cost for Items 3 and 6.
	8.1 Labor	480	hưyr	\$75 /hr	\$36,000	Assumes 4 samples will be taken at each <u>arsenic</u> hot spot area for each FU Assumes 4 samples wilt be taken at each <u>lead</u> hot spot area for each FU \$32,700 Assumes two field people will be on-site for 10 hours for 12 days for each event

O&M Cost Estimate: Alternative 4, In-situ Soil Treatment, Residential Planned Use Memphis Depot Main Installation Soils FS TABLE B-6b

TAB O&N Mem	L E B-6b A Cost Estimate: Alternative 4, In-situ So phis Depot Main Installation Soils FS	oil Treatmen	ıt, Resident	ial Planned U	ŝ	
5	- FU6					
					Annual O&M	Present Worth
Item	Activity/Component	Quantity	Unit	Unit Cost	Cost ^a	O&M Cost ^{a,b} Source/ Comments
	8 2 Laboratory Analysis - Arsenic	256	ea/yr	\$18 /ea	\$4,700	\$4,200 Cost estimated from price list from Lancaster
	8 3 Laboratory Analysis - Lead	32	ea/yr	\$18 /ea	\$600	\$600 Cost estimated from price list from Lancaster
	8 4 Rental Equipment	5	event/yr	\$360 /event	\$800	Laboratories, PA. \$700 CH2M HILL: Draft: EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Membhis. TN, March 1999
	8 5 Mobilization/Demobilization	64	hr/yr	\$75 /hr	\$4,800	\$4,400 Assumes it will take two field people 8 hours for mobilization and 8 hours for demobilization for each event
	8 6 Supplies	2	event/yr	\$500 /event	\$1,000	\$1,000 CH2M HILL: Reichold-Summary Invoice of Site Operations
თ	Restoration of Site (Year 3)					CH2M HILL. Draft EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memobis TN March 1999
	9 2 Soil Conditioning 9 1.1 FU1	ы	acre/vr	\$885 /acre	AA	\$3.900 This area corresponds to 12 cheldrin-
						contaminated hot spots (161,000 ft ²), 3 arsenic- contaminated hot-spots (30,300 ft ²), and 2 arsenic- and dieldrin-contaminated hot spot (15,000 ft ²).
	9.1 2 FU2	45	acre/yr	\$885 /acre	NA	\$36,200 This area corresponds to the entire area of FU2, not including Lake Danielson and the Golf Course Pond (45 acres)
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TABLE B-6b O&M Cost Estimate: Alternative 4, In-situ Soil Treatment, Residential Planned Use Memphis Depot Main Installation Soils FS

FU1 - FU6

ltem	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost ^a	Present worth O&M Cost ^{a,b} Source/ Comments
	9.1.3 FU3	0 13	acre/yr	\$885 /acre	NA	\$200 This area corresponds to 1 lead-contaminated
						hot spot (2,600 ft ⁺), and 4 arsenic- contaminated hot-spots (3,800 ft ²). One of the
						arsenic-contaminated hot spots (900 ft^2) is
						contained within the area of the lead hot spot. Therefore the total area for any considents of
						5,500 ft ²
	9.1.4 FU4	თ	acre/yr	\$885 /acre	NA	\$7,200 This area corresponds to 1 lead-contaminated
						hot spot (10,600 ft ²), 10 arsenic-contaminated
						hot spots (251,500 ft^2), 5 dieldrin-contaminated
						hot spots (111,500 ft^2), 2 arsenic and lead-
						contaminated hot spots (2,600 ft ²), and 2
						arsenic and dieldrin-contaminated hot spots
						(10,000 Tr).
	GD4 G.L B	-	acre/yr	\$885 /acre	NA	\$900 This area corresponds to 7 dieldrin-
						contaminated hot spots (32,000 ${ m ft}^2$) and 1
						arsenic-contaminated hot-spot (7,500ft ²)
	9 1 6 FU6	0.01	acre/yr	\$885 /acre	NA	\$10 This area corresponds to 1 arsenic-
						contaminated hot spot (400 ft ²)
	9 2 Seeding					These costs includes labor,
						mobilization/demobilization, equipment, and
						material
	921FU1	ß	acre/yr	\$1,420 /acre	NA	\$6,100 Areas are the same as those listed for Item
	9 2 2 FU2	45	acre/yr	\$1,420 /acre	NA	\$58.000
	9.2.3 FU3	013	acre/vr	\$1.420 /acre	NA	S200
	9 2.4 FU4	თ	acre/vr	\$1.420 /acre	NA	\$11 500
	0 2 5 FI 15	÷		#1 400 /sere		
	0 - 0 - 0	-	acreryr	¢1,4∠∪ /acre	NA	\$1,300

TABLE B-6b

O&M Cost Estimate: Alternative 4, In-situ Soil Treatment, Residential Planned Use Memphis Depot Main Installation Soils FS

FU1 - FU6

:					Annual O&M	Present Worth	
tem	Activity/Component	Quantity	Unit	Unit Cost	Cost ^a	O&M Cost ^{a,b}	Source/ Comments
	9.2.6 FU6	0 01	acre/yr	\$1,420 /acre	NA	\$20	
10	Annual Evaluation (Year 2 and 3) 10 1 Inspection	ω	hr/yr	\$75 /hr	\$600	\$1,100 Assumes determine acceptable	site will be inspected annually to tif remedial alternative is currently e. Inspection will occur over 1 day
	10.2 Reporting	32	hr/yr	\$75 /hr	\$2,400	\$4,500 Assume re	eport will take 1 week to complete.
Total ^a Estin tvpic	O&M Costs (Years 1-3) ates include remedial action, constructior ally estimated to be a percentage of reme), and O&M co dv cost and th	osts that are	e expected to dif	\$1,922,300 Ifer between alter	\$2,786,000 Tatives Planning and engir	neering costs are

interetore, up not lactor in comparative cost evaluations. The estimate is typically accurate within blue 50 to minus 30 percent. ^b Present worth cost calculated using an interest rate of 5 percent

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^c O&M costs occur over a period of 3 years.

NA Not applicable

FU1-FU6					
Item	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost ^c
 c	Deed Restrictions	\$5,300	AN N	NA	\$5,300
Nm	Plans for Implementation Enhanced Biological Treatment	\$7,200	AN	NA	\$7,200 \$1,823,300
	FU1	\$135,600	NA	NA	
	FU2	\$1,509,400	NA	NA	
	FU3	\$0	NA	NA	
	FU4	\$93,600	NA	NA	
	FU5	\$24,700	NA	NA	
	FUG	\$0	NA	NA	
~	Lab Studies Surface Motor Collection and Controls	\$60,000	NA	NA	
r	Conace water conection and controls (\$10,000/FU)	\$60,000	NA	NA	\$60,000
ы С	Maintenance of Site- Landscaping	٩N	\$28,800	\$53,600	\$53,600
,		, NIA			\$1,729,700
	FU2	NA	\$744 900	\$124,400 \$1385100	
	FU3	AN	\$0	\$0 \$0	
	FU4	NA	\$46,200	\$85,900	
	FUS	NA	\$12,200	\$22,700	
	FUG	NA	\$0	\$0	
I	Lab Studies	NA	\$60,000	\$111,600	
~	Stabilization of Lead and Arsenic				\$215,700
	FUI	NA	NA	\$95,900	
	FU2	NA	AN	\$119,800	

 TABLE B-6c

 Cost Estimate Summary: Alternative 4, In-situ Soil Treatment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

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SOILS

 TABLE B-6c

 Cost Estimate Summary: Alternative 4, In-situ Soil Treatment, Residential Planned Use

 Memphis Depot Main Installation Soils FS

FU1-FU6

Item	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost ^c
	FU3	AN	NA	\$11,700	
	FU4	NA	NA	\$581,600	
	FU5	AN	NA	\$15,900	
	FUG	AN	NA	006\$	
	Bench-Scale Study	NA	AN	\$1,900	
o	Confirmation Sampling	:			
œ		NA	AN	\$43,600	\$43,600
თ	Restoration of Site (Year 3)				\$125,530
	FU1	NA	NA	\$10,000	
	FU2	NA	NA	\$94,200	
	FU3	AN	AN	\$400	
	FU4	NA	NA	\$18.700	
	FU5	AN	NA	\$2,200	
	FUG	NA	NA	\$30	
10	Annual Evaluation (Year 2 and 3)	AN	\$3,000	\$5,600	\$5,600
(Per Line I	ttems)	\$1,896,000	\$959,000	\$1,999,000	\$3,895,000

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FU1-FU6								
	Individual FU	Costs (Based	on Line Items an	d Percentage				
		of Rem	ediation) ^d			Adjuste	d FU Costs ^g	
	Capital	Annual O&M	Present Worth	Total PW		Annual O&M	Present Worth	Total PW
	Cost ^a	Cost ^a	O&M Cost ^{a,b}	Cost°	Capital Cost ^a	Cost ^a	O&M Cost ^{a,b}	Cost
Total Cost for Entire Depot	\$1,896,000	\$959,000	\$1,999,000	\$3,895,000	\$1,903,000	\$965,200	\$2,793,000	\$4,696,000
Total Costs for FU1 (contains 8 3 percent of soil to be remediated)	146,000	74,400	249,000	395,000	146,000	74,400	249,000	395,000
Total Costs for FU2 (contains 75.2 percent of soil to be remediated)	1,608,000	813,900	1,762,000	3,370,000	1,608,000	813,900	1,762,000	3,370,000
Total Costs for FU3 (contains 0 24 percent of soil to be remediated)	1,000	200	13,000	14,000	5,000 1	1,750 °	17,000	22,000
Total Costs for FU4 (contains 14 8 percent of soil to be remediated)	113,000	59,800	718,000	831,000	113,000	59,800	718,000	831,000
Total Costs for FU5 (contains 1 5 percent of soil to be remediated)	26,000	13,600	44,000	70,000	26,000	13,600	44,000	70,000
Total Costs for FU6 (contains 0.01 percent of soil to be remediated)	1,000	100	1,000	2,000	5,000 f	1,750 °	3,000	8,000
^a Estimates include remedial action, or typically estimated to be a percentaç minus 30 percent.	onstruction, and (ge of remedy cos	D&M costs that t and therefore,	are expected to di do not factor in co	ffer between alt mparative cost	ernatives Planr evaluations. Th	ing and engine e estimate is tyr	ering costs are bically accurate with	in plus 50 to
^b Present worth cost calculated using ⁱ ^c Total PW cost includes capital plus P	an interest rate of W O&M costs.	f 5 percent						
^d These costs apply if all FUs are reme above to the total costs for remainin soil to be remediated.	ediated together ng grouped activi	Individual FU c ties multiplied b	osts were determi y a proportion of a	ned by adding F ssumed FU soi	⁻ U-specific activ I area to be rem	ity costs where ediated to the to	broken down in tab ital (all FU) amount	of

^e Because of the small remedial area within F3 and FU6, O&M cost is based on \$500 to mobilize and vegetation of 5 acre (\$1,250) for a total O&M cost of \$1,750

⁴ Because of the small remedial area within FU6, capital costs includes a \$4,000 mobilization cost (based on best professional estimate)

Thus, the capital cost for FU6 is equal to \$4,000 plus \$1000 (percentage of total cost for Depot based on amount of contaminated soil in FU) ^a Adjusted costs are individual FU costs which have been adjusted up for small scale activity. These costs apply if FU is remediated alone NA Not applicable

Cost Estimate Summary: Alternative 4, In-situ Soil Treatment, Residential Planned Use

Memphis Depot Main Installation Soils FS

TABLE B-6c

TA Caj Me	BLE B-7a pital Cost Estimate: Alternative 7, Excavation and Off-site mphis Depot Main Installation Soils FS	e Disposal, Indu	strial Pla	nned Use		
Ę	4					
Iter	m Activity/Component	Quantity	Cnit	Unit Cost	Capital Cost ^a Source/ Comments	
-	Deed Restrictions				Deed restrictions include day care restriction	s and land
	1.1 Attorney Fees	32	hr	\$200 /hr	\$6,400 CH2M HILL: American Scrap Metal Site, Par	ama City
	1 2 Recording of the Deed	N	ea	\$500 /ea	Urder of Magnitude Cost Estimate for Altern \$1,000	ative 2A.
2	Plans for implementation	96	2	\$75 /hr	\$7,200 Plans to develop include Site Restoration Pland Health Plan, Environmental Protection F Tests/Certificates for Soil. CH2M HILL· Draft EE/CA Removal of Hot S Main Installation Defense Depot, Memphis, 1 1999	an, Site Safety Ian, and pot Areas N, March
ი	Excavation of Soils (One Lead Hot Spot in FU4)	267	yd³	\$3 69 /yd ³	\$1,000 CH2M HILL. Draft EE/CA Removal of Hot S Main Installation Defense Depot, Memphis, 1999. Includes excavation and loading of contamin soil, equipment, labor, mobilization/demobiliz The volume of soil is based on a 7,200 ft ² ar spot and an excavation depth of 1 foot.	oot Areas. N, March ated surface ation sa for one hot
4	Surface Water Collection and Controis	-	6	\$10,000 /ea	\$10,000 CH2M HILL. Draft [•] EE/CA Removal of Hot S Main Installation Defense Depot, Memphis, 1 1999. This cost includes sediment barriers, straw b transport of contaminated water to treatment	ot Areas. N, March ale dikes, and plant
വ	Disposal of Contaminated Soils (One Lead Hot S 5 1 Laboratory Analysis - TCLP	spot in FU4) 1	6	\$1,500 /ea	\$1,500 Cost estimated from price list from Lancaster PA	Laboratories,
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Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
5 2 Transportation-Emille, Al	373 b	tons	\$33 /ton	TCLP analyses will be run for every 500 yd ³ of soil transported off-site \$12.200 Phone quote from Waste Manadement
5.3 Disposal Fee and Taxes- Haz Waste Landfill	373 b	tons	\$308 /ton	\$115,000 Assumes contaminated soil will be transported to RCRA
5 4 Application Fees-Haz Waste Landfill	÷	ea	\$250 /ea	nazaruous waste Landnii in Emile, Alabama. \$250
Confirmation Sampling, 2 Events				Samples would be taken at edges of excavated soil to confirm FU4 contamination has been removed
6 1 Labor for Both Events	40	ħr	\$75 /hr	\$3,000 Assumes two field people will be on-site for 10 hours for 1 day for each event
6.2 Laboratory Analysis - Lead	ω	ea	\$18 /ea	\$200 Cost estimated from price list from Lancaster Laboratories PA
6.3 Rental Equipment	N	event	\$360 /event	\$800 CH2M HILL: Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999.
6.4 Mobilization/Demobilization	32	hr	\$75 /hr	\$2,400 Assumes it will take two field people 8 hours for mobilization and 8 hours for demobilization for each event
6.5 Supplies	2	event	\$500 /event	\$1,000 CH2M HILL Reichold-Summary Invoice of Site Operations.
Restoration of Site				
7.1 Imported Backfill (material)	267	yd³	\$10 /yd³	\$2,600 CH2M HILL Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
7 2 Transportation of Backfill On-site	267	yd ³	\$11 38 /yd ³	This cost includes material and placement \$3,100 Assumes backfill is imported and will need to be transported on-site Cost is assumed to be the same as for non-hazardous waste transportation

TABLE B-7a Capital Cost Estimate⁻ Alternative 7, Excavation and Off-site Disposal, Industrial Planned Use *Memphis Depot Main Installation Soils FS*

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 TABLE B-7a

 Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Industrial Planned Use

 Memphis Depot Main Installation Soils FS

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Item	n Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a	Source/ Comments
	7.3 Laboratory Analysis on Clean Soil				Quote from C	olumbia Analytical Services, Redding, CA
					TAL metals, be run for eve	ICL VOCs, Pesticides, and PCB analyses will sry 500 yd ³ of soil transported on-site
	 7.3.1 TCL Volatiles (8260) 7.3.2 TAL Metals (6010/700) 7.3.3 Pesticides (8081A) 7.3.4 PCBs (8082) 		6 6 6 6 6 6 6 6	\$198 /ea \$268 /ea \$111 /ea \$110 /ea	\$200 \$270 \$150 \$110	
	7.4 Soil Conditioning	0.17	acre	\$885 /acre	\$200 This cost inclu	udes the application of lime and fertilizer
	7 5 Seeding	0.17	acre	\$1,420 /acre	\$300 These costs II equipment, ar	nclude labor, mobilization/demobilization, id material.
ø	Maintenance of Site- Landscaping	192	노	\$75 /hr	\$14,400 Assumes a fic average of 16 This cost inclu	ild technician will perform landscaping an hours (2 days) per month for a year ides irrigation and mowing of site
Tota	il Capital Costs				\$183,000	
typ typ plus Ass	timates include remedial action, construction, and O bically estimated to be a percentage of remedy cost s 50 to minus 30 percent. sumes soil bulk density of 1.4 tons/yd ³ based on his	0&M costs tha and therefore storical surfac	t are exp e, do not f e soll ren	ected to differ bei factor in compara ioval actions con	ween alternatives. Planning a ive cost evaluations The esti lucted at the Depot.	ind engineering costs are mate is typically accurate within

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TABL O&M Memp	E B-7b I Cost Estimate: Alternative 7, Excav this Depot Main Installation Soils FS	/ation and O	ff-site D	Isposal, Ind	ustrial Planned I	Jse	
FU4							
:					Annual O&M	Present Worth	
ltem	Activity/Component	Quantity	Unit	Unit Cost	Cost ^a	O&M Cost ^{a,b} Source/ Comments	5
თ	Annual Evaluation (Year 2-30) 9 1 Inspection	ω	hr/yr	\$75 /hr	\$600	\$9,100 Assumes site conditions and use will annually to determine if institutional c currently acceptable. Evaluation wou	l be inspected controls are
	9 2 Reporting	32	hr/yr	\$75 /hr	\$2,400	day. \$36,300 Assume report will take 1 week to co	omplete
10	5-Year Review (six over 30 years)	40	hr/yr	\$100 /hr	\$4000 (\$800 averaged over 5 years)	\$11,700 Remedial alternative at site will need every 5 years to ensure that institutio providing adequate protection	l to be reviewed onal controls are
Total	O&M Costs				\$3,800	\$57,000	
^a Estir typic plus b Pres c The d for 5-y	nates include remedial action, construct cally estimated to be a percentage of rer 50 to minus 30 percent. ent worth cost calculated using an inter- annual total O&M costs consist of cost fi fear review is total \$4000 averaged over least soccur over a period of 30 years	ion, and O&N medy cost and sst rate of 5 p or annual eva r 5 years	l costs th d therefor ercent ov luation al	at are expect e, do not fac er 30 years nd an averag	ed to differ betwe tor in comparative e of other costs o	en alternatives. Planning and engineering costs are cost evaluations The estimate is typically accurate w ver time period they occur For example, the annual c	vithin ost

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Cost Estimate Summary Alternative 7, Excavation and Off-site Disposal, Industrial Planned Use Memphis Depot Main Installation Soils FS

FU4

ltem	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost ^c
-	Deed Restrictions	\$7,400	NA	NA	\$7 400
2	Plans for Implementation	\$7,200	NA	NA	\$7.200
ო	Excavation of Soils	\$1,000	NA N	AN	\$1 000
4	Surface Water Collection and Controls	\$10,000	NA	NA	\$10,000
ŝ	Disposal of Contaminated Soils	\$128,950	NA	NA	\$128.950
9	Confirmation Sampling	\$7,400	NA	NA	\$7.400
~	Restoration of Site	\$6,930	NA	NA	\$6.930
æ	Maintenance of Site- Landscaping	\$14,400	NA	NA	\$14.400
ი	Annual Evaluation (Year 2-30)	NA	\$3,000	\$45.400	\$45,400
10	5-Year Review (six over 30 years)	NA	\$800 d	\$11,700	\$11,700
Total	Cost for Entire Depot	\$183,000	\$3,800	\$57,000	\$240.000
Total	Costs for FU1	0	NA	N	C
Total	Costs for FU2	0	NA	AN	
Total	Costs for FU3	0	NA	AN AN) C
Tota	Costs for FU4 (100 Percent of Remedial Action)	183,000	3,800	57.000	240.000
Total	Costs for FU5	0	AN	NA	0
Total	Costs for FU6	0	NA	NA	• c
^a Esti. tvpi	mates include remedial action, construction, and O&M cally estimated to be a percentage of remedy cost and	costs that are expe	scted to differ between a	Iternatives. Planning and engineeri	ng costs are
					any accurate within

plus 50 to minus 30 percent. ^b Present worth cost calculated using an interest rate of 5 percent

^c Totał PW cost includes capitał plus PW O&M costs

^d The annual total O&M costs consist of cost for annual evaluation and an average of other costs over time period they occur. For example, the annual cost for 5-year review is total \$4000 averaged over 5 years NA Not applicable

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ltem	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Com	Iments
-	Plans for Implementation	96	È	\$75 /hr	\$7,200 Plans to develop include Site Re Safety and Health Plan, Environr and Tests/Certificates for Soil CH2M HILL Draft EE/CA Remo Main Installation Defense Depot, 1999	storation Plan, Site mental Protection Plan, val of Hot Spot Areas , Memphis, TN, March
2	Excavation of Contaminated Soils				CH2M HILL ⁻ Draft EE/CA Remo Main Installation Defense Depot, 1999.	val of Hot Spot Areas Memphis, TN, March
	Arsenic- and Dieldrin-Contaminated Soils	7,641	yd ³	\$3.69 /yd ³	\$28,200 Includes excavation and loading soil, equipment, labor, mobilizatio	of contaminated surface on/demobilization
					This volume corresponds to 13 di spots (176,000 ft²), 4 arsenic-con (30,300 ft²), 1 arsenic- and dieldr (15,000 ft²), and an excavation de	leidrin-contaminated hot ntaminated hot-spots in-contaminated hot spot epth of 1 foot.
ი	Surface Water Collection and Controls	-	G	\$10,000 /ea	\$10,000 CH2M HILL Draft EE/CA Remov Main Installation Defense Depot, 1999. This cost includes sediment barrie and transport of contaminated wa	val of Hot Spot Areas Memphis, TN, March ers, straw bale dikes, ater to treatment plant
4	Disposal of Contaminated Soils				Assumes all excavated material is RCRA Subtitle D landfill will acce TCLP value)	s non-hazardous and pt (if below required

TABLE B-8a Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use *Memphis Depot Main installation Soils FS*

SOILS

TABLE B-8a Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use *Memphis Depot Main Installation Soils FS*

FU1 Item

n Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
4.1 Laboratory Analysis - TCLP	9	69	\$1,500 /ea	\$24,000 Cost estimated from price list from Lancaster Laboratories, PA TCLP analyses will be run for every 500 yd ³ of soil transported off-site
4.2 Transportation - Local Landfill	7,641	yd³	\$11.38 /yd ³	\$87,000 CH2M HILL Draft. EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999. Assumes a 10-mile machine load haul to BFI Special Waste Landfill (RCRA Subtitle D Landfill) from Depot
4.3 Disposal Fee - Nonhazardous	10,697 b	tons	\$19 /ton	\$203,300 Phone quote from Shana Smiley - BFi Special Waste Landfill in Memphis
Confirmation Sampling, 2 Events				Assumes 4 samples will be taken at each arsenic and
5.1 Labor for Both Events	280	h	\$75 /hr	dieldrin excavated hot spot area for each event \$21,000 Assumes two field people for will be on-site for 10 hours
5 2 Laboratory Analysis - Dieldrin	112	ea	\$100 /ea	tor 7 days for each event. \$11,200 Quote from Columbia Analytical Services, Redding, CA
5 3 Laboratory Analysis - Arsenic	40	ea	\$18 /ea	\$800 Cost estimated from price list from Lancaster
5.4 Rental Equipment	N	event	\$360 /event	Laboratories, PA \$800 CH2M HILL. Draft: EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999.
5 5 Mobilization/Demobilization	32	ŗ	\$75 /hr	\$2,400 Assumes it will take two field people 8 hours for mobilization and 8 hours for demobilization for each
5 6 Supplies	N	event	\$500 /event	\$1,000 CH2M HILL: Reichold-Summary Invoice of Site Operations

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Men	nphis Depot Main Installation Soils FS				
FUI					
Iten	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
Q	Restoration of Site 6 1 Imported Backfill (material)	7,641	yd ³	\$10 /yd ³	\$76,500 CH2M HILL: Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
	6 2 Transportation of Backfill On-site	7,641	yd ³	\$11.38 /yd ³	This cost includes material and placement \$87,000 Assumes backfill is imported and will need to be transported on-site Cost is assumed to be the same as for non-hazardous waste transportation.
	6 3 Laboratory Analysis on Clean Soil				Quote from Columbia Analytical Services, Redding, CA
					TAL metals, TCL VOCs, Pesticides, and PCB analyses will be run for every 500 yd ³ of soil transported on-site
	6.3.1 TCL Volatiles (8260)	16	ea	\$198 /ea	\$3,170
	6 3 2 TAL Metals (6010/700)	16	ea	\$268 /ea	\$4,290
	6 3.3 Pesticides (8081A) 6 3 4 PCBs (8082)	16 16	68 68	\$141 /ea \$110 /ea	\$2,260 \$1,760
	6 4 Soil Conditioning	ŋ	acre	\$885 /acre	\$4,200 This cost includes the application of lime and fertilizer
	6.5 Seeding	۵	acre	\$1,420 /acre	\$6,800 These costs includes labor, mobilization/demobilization, equipment, and material
~	Maintenance of Site- Landscaping	288	ų	\$75 /hr	\$21,600 Assumes a field technician will perform landscaping an average of 24 hours (3 days) per month for a year This cost includes irrigation and mowing of site

TABLE B-8a Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use Memphis Depot Main Installation Soils FS

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FU1					
Item Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comn	nents
8 Final Evaluation	40	눋	\$100 /hr	\$4,000 Remedial aftermative at site will ne upon completion to ensure that ac been provided Assume report will complete	ed to be evaluated lequate protection has I take 1 week to
Total Capital Costs					
^a Estimates include remedial action, construction, and O typically estimated to be a percentage of remedy cost plus 50 to minus 30 percent. ^b Assumes soit built density of 1.4 tone/of ³ hased on his	and therefore	t are expec	ted to differ betw stor in comparati	een alternatives. Planning and engineering costs /e cost evaluations. The estimate is typically accu	are trate within
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 TABLE B-8a

 Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use

 Memphis Depot Main Installation Soils FS

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SOILS

ltem	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost ^c
-	Plans for Implementation	\$7,200	NA	NA	\$7.200
2	Excavation of Soils	\$28,200	NA	NA	\$28.200
с С	Surface Water Collection and Controls	· \$10,000	NA	NA	\$10,000
4	Disposal of Contaminated Soils	\$314,300	NA	NA	\$314.300
5	Confirmation Sampling	\$37,200	NA	NA	\$37.200
9	Restoration of Site	\$185,980	NA	NA	\$185.980
7	Maintenance of Site- Landscaping	\$21,600	AN	NA	\$21.600
ω	Final Evaluation	\$4,000	NA	NA	\$4,000
Total Cos	its for FU1	\$608,000	NA	NA	\$608.000
^a Estimate	s include remedial action, construction, and C	8M costs that are ex	pected to differ between al	ternatives. Planning and engineering	j costs are
tvoically	estimated to be a percentage of remedy cost	and therefore do not	factor in comparative ros	t evaluatione The actimate is twined	in accurate within

Cost Estimate Summary: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use Memphis Depot Main Installation Soils FS

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TABLE B-8b

typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within plus 50 to minus 30 percent

^b Present worth cost calculated using an interest rate of 5 percent

^c Total PW cost includes capital plus PW O&M costs

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Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use Memphis Depot Main Installation Soils FS

FU2

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments	
-	Plans for Implementation	8	<u>ع</u>	\$75 /hr	\$7,200 Plans to develop include Site Restoratio Safety and Health Plan, Environmental i and Tests/Certificates for Soil CH2M HILL ⁻ Draft EE/CA Removal of F Main Installation Defense Depot, Mempi 1999	n Plan, Site Protection Plan, lot Spot Areas his, TN, March
2	Excavation of Contaminated Soils				CH2M HILL: Draft: EE/CA Removal of H Main Installation Defense Depot, Mempl 1999.	lot Spot Areas nis, TN, March
	Arsenic- and Dieldrin-Contaminated Soils	72,600	yd ³	\$3 69 /yd ³	\$267,900 Includes excavation and loading of contisent, soil, equipment, labor, mobilization/demi This volume corresponds to the entire ar including Lake Danielson and the Golf C acres) and an excavation depth of 1 foot	aminated surface bblization ea of FU 2, not ourse Pond (45
ო	Surface Water Collection and Controls	-	ea	\$10,000 /ea	\$10,000 CH2M HILL [.] Draft. EE/CA Removal of H Main Installation Defense Depot, Memph 1999 This cost includes sediment barriers, stra and transport of contaminated water to t	ot Spot Areas iis, TN, March aw bale dikes, reatment plant.
4	Disposal of Contarninated Soils				Assumes all excavated material is non-h RCBA Subtitle D landfill will accept (if be TCI P value)	azardous and Iow required
	4.1 Laboratory Analysis - TCLP	146	e	\$1,500 /ea	\$219,000 Cost estimated from price list from Lance Laboratories, PA TCLP analyses will be run for every 500 transported off-site.	aster yd ³ of soul

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SOILS

2				
n Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
4.2 Transportation - Local Landfill	72,600	yd³	\$11.38 /yd ³	\$826,200 CH2M HILL. Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
4.3 Disposal Fee - Nonhazardous	101,640 ^b	tons	\$19 /ton	Assumes a 10-mile machine load haul to BFI Special Waste Landfill (RCRA Subtitle D Landfill) from Depot \$1,931,200 Phone quote from Shana Smiley - BFI Special Waste Landfill in Memphis
Confirmation Sampling, 2 Events				Assumes 4 samples will be taken at each arsenic excavated hot spot area for FU4 for each event One dieldrin sample will be taken for each acre excavated for each event
5.1 Labor for Both Events	280	μ	\$75 /hr	\$21,000 Assumes two field people for will be on-site for 10 hours for 7 days for each event.
5 2 Laboratory Analysis - Dieldrin	06	ea	\$100 /ea	\$9,000 Quote from Columbia Analytical Services, Redding, CA
5 3 Laboratory Analysis - Arsenic	56	ea	\$18 /ea	\$1,100 Cost estimated from price list from Lancaster Laboratories, PA.
5.4 Rental Equipment	N	event	\$360 /event	\$800 CH2M HILL. Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
5.5 Mobilization/Demobilization	32	Ъг	\$75 /hr	\$2,400 Assumes it will take two field people 8 hours for mobilization and 8 hours for demobilization for each event
5.6 Supplies	5	event	\$500 /event	\$1,000 CH2M HILL. Reichold-Summary Invoice of Site Operations.
Restoration of Site		1		
6 1 Imported Backfill (material)	72,600	yd ³	\$10 /yd³	\$726,000 CH2M HILL [.] Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
				This cost includes material and placement

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TABLE B-9a Capital Cost Estimate. Alternative 7, Excavation and Off-site Disposal, Residential Planned Use *Memphis Depot Main installation Soits FS*

FU2 Item A

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SOILS

EID						
tem	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments	I
	6 2 Transportation of Backfill On-site	72,600	yd ³	\$11 38 /yd ³	\$826,200 Assumes backfill is imported and will need to be transported on-site. Cost is assumed to be the same as for non-hazardous waste transportation.	1
	6.3 Laboratory Analysis on Clean Soil				Quote from Columbia Analytical Services, Redding, CA	
					TAL metals, TCL VOCs, Pesticides, and PCB analyses will be run for every 500 yd ³ of soil transported on-site	
	6 3 1 TCL Volatiles (8260) 6 3 2 TAL Module (6010/700)	146	69	\$198 /ea	\$28,910	
	6.3.3 Pesticides (8081A)	146 146	ea ea	\$268 /ea \$141 /ea	\$39,130 \$20,590	
	6 3 4 PCBs (8082)	146	ea	\$110 /ea	\$16,060	
	6 4 Soil Conditioning	45	acre	\$885 /acre	\$39,900 This cost includes the application of lime and fertilizer	
	6.5 Seeding	45	acre	\$1,420 /acre	\$63,900 These costs include labor, mobilization/demobilization, equipment, and material.	
~	Maintenance of Site- Landscaping	480	노	\$75 /hr	\$36,000 Assumes a field technician will perform landscaping an average of 40 hours (5 days) per month for a year This cost includes irrigation and mowing of site	

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FU2 Item

TABLE B-9a					
Capital Cost Estimate: Alternative 7, Excavation and Off-site Memphis Depot Main Installation Soils FS	Disposal, Resid	dential Plann	ed Use		
FU2					
Item Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a	Source/ Comments
8 Final Evaluation	40	Ъ	\$100 /hr	\$4,000 Remed upon cc been pr complet	al alternative at site will need to be evaluated ompletion to ensure that adequate protection has ovided Assume report will take 1 week to
Total Capital Costs				\$5,097,000	
^a Estimates include remedial action, construction, and (typically estimated to be a percentage of remedy cos plus 50 to minus 30 percent.)&M costs tha : and therefore	t are expect 9, do not fac	ted to differ betw tor in comparativ	een atternatives Plani e cost evaluations Th	ning and engineering costs are te estimate is typically accurate within
^b Assumes soil bulk density of 1 4 tons/yd ³ based on hi	storical surfac	e soil remov	/al actions cond	icted at the Depot.	

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Cost Estimate Summary Alternative 7, Excavation and Off-site Disposal, Residential Planned Use Memphis Depot Main Installation Soils FS

FU2 Ham

ltem	Activity/Component	Canital Cost ^a	Annial O&M Coet ^a	Drecont Month Celli Contain	Totel Ditt Coote
					I OLAI PW COSL
-	Plans for Implementation	\$7,200	NA	NA	\$7,200
2	Excavation of Soils	\$267,900	AN	NA	\$267 QUD
e	Surface Water Collection and Controls	\$10,000	NA	NA	\$10 000 \$10 000
4	Disnosal of Contaminated Soile	\$2 076 AND			
• 1		00+1010'20		NA	\$2,9/6,400
ъ	Confirmation Sampling	\$35,300	AN	NA	\$35,300
9	Restoration of Site	\$1.760.690	NA	NA	¢1 760 600
1					000,000 1,1 4
•	Maintenance of Site- Landscaping	\$36,000	AN	NA	\$36,000
80	Final Evaluation	\$4,000	NA	NA	
				-	
Total Cos	ts for FU2	\$5,097,000	NA	AN	\$5.097.000
Fistimate	s include remedial action construction and O	12.hd occess that are over	acated to differ hotizan	Discrete and a second se	•

Estimates include remedial action, construction, and O&M costs that are expected to differ between alternatives. Planning and engineering costs are typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within plus 50 to minus 30 percent.

^b Present worth cost calculated using an interest rate of 5 percent

^c Total PW cost includes capital plus PW O&M costs

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FU3						
Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a	Source/ Comments
-	Plans for Implementation	96	<u>ب</u>	\$75 /hr	\$7,200 F	Plans to develop include Site Restoration Plan, Site Safety and Health Plan, Environmental Protection Plan, and Tests/Certificates for Soil. CH2M HILL Draft. EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 999
2	Excavation of Contaminated Soils				024	CH2M HILL [.] Draft [.] EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 999.
	Arsenic- and Lead-Contaminated Soils	204	yd ³	\$3.69 /yd ³	\$800 I	nciudes excavation and loading of contaminated urface soil, equipment, labor, nobilization/demobilization
						his volume corresponds to an area containing 1 lead- ontaminated hot spot (2,600 ft ²), and 4 arsenic- ontaminated hot-spots (3,800 ft ²). One of the arsenic- ontaminated hot spots (900 ft ²) is contained within he area of the lead hot spot. Therefore, the total area or site remediation is 5,500 ft ² An excavation depth f 1 foot is used
σ	Surface Water Collection and Controls	~	e e	\$10,000 /ea	\$10,000 C	HZM HiLL. Draft EE/CA Removal of Hot Spot Areas fain Installation Defense Depot, Memphis, TN, March 999 his cost includes sediment barriers, straw bale dikes, nd transport of contaminated water to treatment lant.

TABLE B-10a Capital Cost Estimate⁻ Alternative 7, Excavation and Off-site Disposal, Residential Planned Use *Memphis Depot Main Installation Soils FS* SOILS
Iter	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Commants	1
			5	200 mb		1
4	Disposal of Contaminated Soils				Assumes excavated material containing arsenic contamination is non-hazardous and RCRA Subtitle landfill will accept (if below required TCLP value).	٥
					Assumes excavated soil containing lead contamination is hazardous and will be disposed of RCRA landfitl in Emitle, AL	Ē
	4 1 Laboratory Analysis - TCLP	-	e	\$1,500 /ea	\$1,500 Cost estimated from price list from Lancaster Laboratories, PA. TCLP analyses will be run for every 500 yd ³ of soil transported off-site.	
	4.2 Transportation - Local Landfill	106	yd ³	\$11 38 /yd³	\$1,300 CH2M HILL: Draft EE/CA Removal of Hot Spot Are Main Installation Defense Depot, Memphis, TN, Mai 1999 Assumes a 10-mile machine load haul to BFI Specia Waste Landfill (RCRA Subtitle D Landfill) from Dep	tr⊒ chas
	4 3 Disposal Fee - Nonhazardous	149 b	tons	\$19 /ton	\$2,900 Phone quote from Shana Smiley - BFI Special Was Landfill in Memphis.	Q
	4 4 Transportation-Emille, AL 4 5 Disposal Fee and Taxes- Haz Waste Landfill	137 b 137 b	tons tons	\$33 /ton \$308 /ton	\$4,500 Phone quote from Waste Management \$42,200 Assumes contaminated soil will be transported to PCDA Hoscordan Mastel Loodelling Al	
	4 6 Application Fees-Haz. Waste Landfill	+	ea	\$250 /ea	\$250	
2J	Confirmation Sampling, 2 Events 5 1 Labor for Both Events	80	ŗ	\$75 /hr	Assumes 4 samples will be taken at each arsenic at lead excavated hot spot area for each event. \$6,000 Assumes two field people for will be on-site for 10	ý ,
					riours for 2 day for each event.	

 TABLE B-10a

 Capital Cost Estimate Alternative 7, Excavation and Off-site Disposal, Residential Planned Use

 Memphis Depot Main Installation Soils FS

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SOILS

Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
5 2 Laboratory Analysis - Lead	œ	ea	\$18 /ea	\$200 Quantitative Estimate - Chemist (Herb Kelly/CH2M HILL)
5.3 Laboratory Analysis - Arsenic	32	ea	\$18 /ea	\$600 Cost estimated from price list from Lancaster Laboratories. PA
5.4 Rental Equipment	N	event	\$360 /event	\$800 CH2M HILL Draft: EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999.
5.5 Mobilization/Demobilization	32	ł	\$75 /hr	\$2,400 Assumes it will take two field people 8 hours for mobilization and 8 hours for demobilization for each event.
5.6 Supplies	N	event	\$500 /event	\$1,000 CH2M HILL Reichold-Summary Invoice of Site Operations.
Restoration of Site				
6 1 Imported Backfill (materral)	204	yd ³	\$10 /yd ³	\$2,100 CH2M HILL. Draft' EE/CA Removal of Hot Spot Areas Main installation Defense Depot, Memphis, TN, March 1999 This cost includes material and algorithms.
6.2 Transportation of Backfill On-site	204	yd ³	\$11 38 /yd ³	\$2,400 Assumes backfill is imported and will need to be transported on-site. Cost is assumed to be the same as for non-hazardous waste transportation.
6.3 Laboratory Analysis on Clean Soi				Quote from Columbia Analytical Services, Redding, CA
				TAL metals, TCL VOCs, Pesticides, and PCB analyses will be run for every 500 yd ³ of soil transported on-site.
6.3.1 TCL Volatiles (8260)	.	ea	\$198 /ea	\$200
0.3.2 Pesticides (8081A)		ea ea	ъ∠оо /еа \$141 /еа	\$2/0 \$150
6.3 4 PCBs (8082)	-	68	\$110 /ea	\$110

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TABLE B-10a Capital Cost Estimate. Alternative 7, Excavation and Off-site Disposal, Residential Planned Use *Memphis Depot Main Installation Soils FS*

FU3 Item

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FU3					
ten	n Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
	6.4 Soil Conditioning	0.13	acre	\$885 /acre	\$200 This cost includes the application of lime and fertilize
	6.5 Seeding	0 13	acre	\$1,420 /acre	\$200 These costs includes labor, mobilization/demobilization, equipment, and material
~	Maintenance of Site- Landscaping	192	노	\$75 /hr	\$14,400 Assumes a field technician will perform landscaping an average of 16 hours (2 days) per month for a year
					This cost includes irrigation and mowing of site
ω	Final Evaluation	40	hr	\$100 /hr	\$4,000 Remedial alternative at site will need to be evaluated upon completion to ensure that adequate protection has been provided Assume report will take 1 week to complete
Tota	il Capital Costs				\$106,000
a Est typ	irmates include remedial action, construction, and O8 incally estimated to be a percentage of remedy cost a	&M costs that and therefore,	are expe , do not fa	icted to differ betv actor in comparati	veen alternatives Planning and engineering costs are ve cost evaluations The estimate is typically accurate within

 TABLE B-10a

 Capital Cost Estimate. Alternative 7, Excavation and Off-site Disposal, Residential Planned Use

 Memphis Depot Main installation Soils FS

2 plus 50 to minus 30 percent ^b Assumes soil bulk density of 1.4 tons/yd³ based on historical surface soil removal actions conducted at the Depot

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SOILS

ltem	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost
1	Plans for Implementation	\$7,200	NA	NA	\$7,200
0	Excavation of Soils	\$800	NA	NA	\$800
e e	Surface Water Collection and Controls	\$10,000	NA	٨A	\$10,000
4	Disposal of Contaminated Soils	\$52,650	NA	AN	\$52,650
ы С	Confirmation Sampling	\$11,000	NA	NA	\$11,000
6	Restoration of Site	\$5,630	NA	NA	\$5,630
•	Maintenance of Site- Landscaping	\$14,400	NA	NA	\$14,400
m	Finat Evaluation	\$4,000	NA	NA	\$4,000
Total Cos	ts for FU3	\$106,000	NA	NA	\$106.000

typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within plus 50 to minus 30 percent ^b Present worth cost calculated using an interest rate of 5 percent ^c Total PW cost includes capital plus PW O&M costs

Cost Estimate Summary Alternative 7, Excavation and Off-site Disposal, Residential Planned Use Memphis Depot Main Installation Soils FS

TABLE B-10b

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SOILS

TAE Cap Men	SLE B-11a ital Cost Estimate: Alternative 7, Excavation and Off-sitinphis Depot Main Installation Soils FS	e Disposal, Resid	lential Plar	ned Use	
FU4	t 1. Activity/Component				
		quantity	Cuit	Unit Cost	Capital Cost ^a Source/ Comments
~	Plans for Implementation	96	ž	\$75 /hr	\$7,200 Plans to develop include Site Restoration Plan, Site Safety and Health Plan, Environmental Protection Plan, and Tests/Certificates for Soll. CH2M HILL. Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
2	Excavation of Contaminated Soils				CH2M HILL: Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March
	Arsenic-, Lead-, and Dieldrin- Contaminated Soils	14,400	yd ³	\$3.69 /yd ³	\$53,200 Includes excavation and loading of contaminated surface soil, equipment, labor, mobilization/demobilization.
					This volume corresponds to 1 lead-contaminated hot spot (10,600 ft ²), 11 arsenic-contaminated hot spots (251,500 ft ²), 6 dieldrin-contaminated hot spots (111,500 ft ²), 1 arsenic- and lead-contaminated hot spot (2,600 ft ²), 2 arsenic- and dieldrin-contaminated hot spots (10,000 ft ²), and an excavation depth of 1 foot
n	Surface Water Collection and Controls	-	6 3	\$10,000 /ea	\$10,000 CH2M HILL [·] Draft. EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999. This cost includes sediment barriers, straw bale dikes, and transport of contaminated water to treatment plant
					ŕ
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Mem	ohis Depot Main Installation Soils FS				
FU4					
tem	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
4	Disposal of Contaminated Soils				Assumes excavated material containing arsenic contamination is non-hazardous and RCRA Subtitle D landfill will accept (if below required TCLP value)
					Assumes excavated soil containing lead contamination is hazardous and will be disposed of in RCRA landfill in Emilte, AL
	4 1 Laboratory Analysis - TCLP	5	ea	\$1,500 /ea	\$43,200 Cost estimated from price list from Lancaster Laboratories, PA. TCLP analyses will be run for every 500 yd ³ of soil transported off-site
	4.2 Transportation - Local Landfill	13,818	yd ³	\$11.38 /yd ³	\$157,300 CH2M HILL Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999. Assumes a 10-mile machine load haul to BFI Special Waste Landfill (RCRA Subtitle D Landfill) from Depot
	4.3 Disposal Fee - Nonhazardous	19,346 ^b	tons	\$19 /ton	\$367,600 Phone quote from Shana Smiley - BFI Special Waste Landfill in Memphis
	4.4 Transportation-Emille, AL	684 b	tons	\$33 /ton	\$22,300 Phone quote from Waste Management
	4 5 Disposal Fee and Taxes- Haz Waste Landfill	684 ^b	tons	\$308 /ton	\$210,900 Assumes contaminated soil will be transported to RCRA Hazardous Waste Landfill in Emille. AL
	4 6 Application Fees-Haz. Waste Landfill		ea	\$250 /ea	\$250
വ	Confirmation Sampling, 2 Events				Assumes 4 samples will be taken at each arsenic, lead, and dieldrin excavated hot spot area for each event.
	5.1 Labor for Both Events	360	Ч	\$75 /hr	\$27,000 Assumes two field people will be on-site for 10 hours for 9 days for each event

TABLE B-11a Capital Cost Estimate. Alternative 7, Excavation and Off-site Disposal, Residential Planned Use *Memphis Depot Main Installation Soils FS*

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TABLE B-11a Capital Cost Estimate Alternative 7, Excavation and Off-site Disposal, Residential Planned Use *Memphis Depot Main Installation Soils FS*

FU4 Item

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	QUANTITY	I	Unit Cost	Capital Cost ^a Source/ Comments
5 2 Laboratory Analysis - Diełdrin	56	ea	\$100 /ea.	\$5,600 Quote from Columbia Analytical Services, Redding, CA
5 3 Laboratory Analysis - Arsenic	112	ea	\$18 /ea	\$2,100 Cost estimated from price list from Lancaster
5 4 Laboratory Analysis - Lead	24	ea	\$18 /ea	\$500 Cost estimated from price list from Lancaster
55 Rental Equipment	0	event	\$360 /event	Laboratories, PA \$800 CH2M HILL. Draft: EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
5 6 Mobilization/Demobilization	32	È	\$75 /hr	\$2,400 Assumes it will take two field people 8 hours for mobilization and 8 hours for demobilization for each event
5.7 Supplies	N	event	\$500 /event	\$1,000 CH2M HILL. Reichold-Summary Invoice of Site Operations.
Restoration of Site 6 1 Imported Backfill (material)	14,400	yd³	\$10 /yd ³	\$144,000 CH2M HILL: Draft EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999
6.2 Transportation of Backfill On-site	14,400	yd ³	\$11 38 /yd ³	This cost includes material and placement \$163,900 Assumes backfill is imported and will need to be transported on-site Cost is assumed to be the same as for non-hazardous waste transportation.
6 3 Laboratory Analysis on Clean Soil				Quote from Columbia Analytical Services, Redding, CA
				TAL metals, TCL VOCs, Pesticides, and PCB analyses will be run for every 500 yd ³ of soil transported on-site
6 3.1 TCL Volatiles (8260) 6.3.2 TAL Metals (6010/700) 6.3.3 Pesticides (8081A)	56 56 56	63 63 63	\$198 /ea \$268 /ea \$141 /ea	\$5,750 \$7,780 \$4,090

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SOILS

TAB Capit Mem	LE B-11a tal Cost Estimate: Alternative 7, Excavation and Off-site D phis Depot Main Installation Soils FS	Disposal, Reside	ential Planr	ed Use		
FU4						
ltem	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a	Source/ Comments
	6.3 4 PCBs (8082)	29	ea	\$110 /ea	\$3,190	
	6 4 Soil Conditioning	თ	acre	\$885 /acre	\$7,900	This cost includes the application of lime and fertilizer
	6.5 Seeding	თ	acre	\$1,420 /acre	\$12,700	These costs include labor, mobilization/demobilization, equipment, and material
~	Maintenance of Site- Landscaping	384	Ъг	\$75 /hr	\$28,800	Assumes a field technician will perform landscaping an average of 32 hours (4 days) per month for a year
						This cost includes irrigation and mowing of site.
ω	Final Evaluation	40	μ	\$100 /hr	\$4,000	Remedial alternative at site will need to be evaluated upon completion to ensure that adequate protection has been provided Assume report will take 1 week to complete.
Tota	l Capital Costs				\$1,293,000	
a Est typ plus	imates include remedial action, construction, and O& ically estimated to be a percentage of remedy cost <i>a</i> \$50 to minus 30 percent.	&M costs that and therefore,	are expec do not fac	ted to differ betw stor in comparativ	een alternatives. e cost evaluatior	Planning and engineering costs are is. The estimate is typically accurate within
^b Asé	umes soil bulk density of 1 4 tons/yd ³ based on hist	storical surface	soil remo	val actions condu	icted at the Depo	÷

SOILS

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Cost Estimate Summary. Alternative 7, Excavation and Off-site Disposal, Residential Planned Use Memphis Depot Main Installation Soils FS

ltem FU4

Horn					
	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total DW Coet ^c
•	Plans for Implementation	\$7.200	NA	NA NA	1000 H 1000
c				AN AN	\$7,20U
v	EXCAVATION OF SOIIS	\$53,200	NA	NA	\$53 200
ო	Surface Water Collection and Controls	\$10 000	NA		
•				NA	\$10,000
•		\$801,550	NA	NA	\$801 550
D	Confirmation Sampling	\$39.400	NA	QN	CO 100
ŝ	Bastoration of Cito				\$28'\$OO
> 1		\$349,310	NA	NA	\$349.310
-	Maintenance of Site- Landscaning	\$28 B∩0	NIA		
0		000°0	EN	NA	\$28,800
0	FINAL EVALUATION	\$4,000	NA	NA	\$4 000
				-	
Total Cost	s for FU4	\$1,293.000	NA	N	¢1 702 000
^a Cotimotoo	and the second				91,233,UUU
Califiates	include remedial action, construction, and O	&M costs that are expec	ted to differ between alterr	atives Planning and engineering	toete aro

typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within plus 50 to minus 30 percent ^b Present worth cost calculated using an interest rate of 5 percent.

^c Total PW cost includes capital plus PW O&M costs.

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Mem	ohis Depot Main Installation Soils FS				
FU5					
Item	Activity/Component	Quantity	Cnit	Unit Cost	Capital Cost ^a Source/ Comments
-	Plans for Implementation	96	ž	\$75 /hr	\$7,200 Plans to develop include Site Restoration Plan, Site Safety and Health Plan, Environmental Protection Plan, and Tests/Certificates for Soil CH2M HILL: Draft. EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
2	Excavation of Contaminated Soils				CH2M HILL. Draft. EE/CA Removal of Hot Spot Areas Main Installation Defense Depot. Memphis. TN. March
	Arsenic- and Dieldrin-Contaminated Soils	1,463	yd ³	\$3 69 /yd ³	\$5,400 Includes excavation and loading of contaminated surface soil, equipment, labor, mobilization/demobilization. This volume corresponds to 7 dieldrin-contaminated hot spots (32,000 ft ²) 1 arsenic-contaminated hot-spot (7,500 ft ²) and an excavation depth of 1 foot.
ო	Surface Water Collection and Controls	-	ea	\$10,000 /ea	\$10,000 CH2M HILL: Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999 This cost includes sediment barriers, straw bale dikes, and transport of contaminated water to treatment plant.
4	Disposal of Contaminated Soils				Assumes all excavated material is non-hazardous and RCRA Subtitle D landfill will accept (if below required TCLP value)
	4.1 Laboratory Analysis - TCLP	ო	69	\$1,500 /ea	\$4,400 Cost estimated from price list from Lancaster Laboratories, PA TCLP analyses will be run for every 500 yd ³ of soil transported off-site
	4 2 Transportation - Local Landfill	1,463	yd ³	\$11 38 /yd ³	\$16,700 CH2M HILL: Draft: EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999

 TABLE B-12a

 Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use

 Memphis Depot Main Installation Solis FS

SOILS

TAE Cap Mer	ILE B-12a Ital Cost Estimate ⁻ Alternative 7, Excavation and Off-s inphis Depot Main Installation Soils FS	ilte Disposal, Res	idential Pla	nned Use	
Ρ̈́Ξ					
Iten	n Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
					Assumes a 10-mile machine load haul to BFI Special Waste Landfill (RCRA Subtitle D Landfill) from Depot.
	4 3 Disposal Fee - Nonhazardous	2,048 b	tons	\$19 /ton	\$39,000 Phone quote from Shana Smiley - BFI Special Waste Landfill in Memphis.
ഹ	Confirmation Sampling, 2 Events				Assumes 4 samples will be taken at each arsenic and
	51 Labor for Both Events	120	hr	\$75 /hr	dieldrin excavated not spot area for each event \$9,000 Assumes two field people for will be on-site for 10 hours for 3 days for each event
	5.2 Laboratory Analysis - Dieldrin	8	63	\$100 /ea	\$800 Quote from Columbia Analytical Services, Redding, CA
	5 3 Laboratory Analysis - Arsenic	56	ea	\$18 /ea	\$1,100 Cost estimated from price list from Lancaster
	5.4 Rental Equipment	7	event	\$360 /event	\$800 CH2M HILL Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
	5.5 Mobilization/Demobilization	32	hr	\$75 /hr	\$2,400 Assumes it will take two field people 8 hours for mobilization and 8 hours for demobilization for each event
	5.6 Supplies	0	event	\$500 /event	\$1,000 CH2M HILL Reichold-Summary Invoice of Site Operations.
9	Restoration of Site 6.1 Imported Backfill (material)	1,463	yd ³	\$10 /yd ³	\$14,700 CH2M HILL. Draft [.] EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March
	6.2 Transportation of Backfill Onsite	1,463	yd ³	\$11 38 /yd³	\$16,700 Assumes backfill is imported and will need to be transported on-site Cost is assumed to be the same as for non-hazardous waste transportation.
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FUS				
Item Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
6 3 Laboratory Analysis on Clean Soil				Quote from Columbia Analytical Services, Redding, CA
				TAL metals, TCL VOCs, Pesticides, and PCB analyses will be run for every 500 yd ³ of soil transported on-site
 6 3 1 TCL Volatifies (8260) 6 3 2 TAL Metals (6010/700) 6.3.3 Pesticides (8081A) 6 3.4 PCBs (8082) 	8 8 9 8 9 8 9 8 9 8 9 8 9 8 9 8 9 8 9	8 8 8 8 6 6 6 6	\$198 /ea \$268 /ea \$141 /ea \$110 /ea	\$600 \$810 \$430 \$330
6 4 Soil Conditioning	-	acre	\$885 /acre	\$900 This cost includes the application of lime and fertilizer
6 5 Seeding	-	acre	\$1,420 /acre	\$1,300 These costs include labor, mobilization/demobilization, equipment, and material
7 Maintenance of Site- Landscaping	192	hr	\$75 /hr	\$14,400 Assumes a field technician will perform landscaping an average of 16 hours (2 days) per month for a year This cost includes irrigation and mowing of site
8 Final Evaluation	40	ž	\$100 /hr	\$4,000 Remedial alternative at site will need to be evaluated upon completion to ensure that adequate protection has been provided Assume report will take 1 week to complete
Total Capital Costs ^a Estimates include remodel action prostruction	and OPM controller		فعط تمكلكم مالقفم	\$152,000
typically estimated to be a percentage of remed plus 50 to minus 30 percent ^b Assumes soil bulk density of 1.4 tons/yd ³ based	y cost and therefor on historical surface	e, do not se soil ren	factor in compara factor in compara noval actions con	ween airernatives. Planning and engineering costs are ive cost evaluations The estimate is typically accurate within fucted at the Depot.

TABLE B-12a Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use *Memphis Depot Main Installation Soits FS*

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SOILS

TABLE B-12b

Cost Estimate Summary: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use Memphis Depot Main Installation Soils FS

FU5 Item

100m					
	Activity/Component	Capital Cost [*]	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total DW Coetc
•	Plans for Implementation	0.7 0.00			
•		007'/¢	NA	NA	\$7 200
2	Excavation of Soils	66 400			
		40,400	NA	NA	\$5.400
'n	Surface Water Collection and Controls	\$10,000	NA	NIA	010 000
V	Disposal of Centeminated Control				\$10,000
t	Uspusal of Colligninated Solls	\$60,100	NA	NA	\$60 100
S	Confirmation Sampling	\$15 100	NIA		
ç			AN	NA	\$15,100
ø	Hestoration of Site	\$35.770	NA	NA	00C 770
Ļ	Mointenance of Cite 1 Jac failed				01/1000
-	IVIAIIIITEITATICE OF SILE- LANDSCAPING	\$14,400	NA	NA	C14 400
α	Einel Evoluation				001119
>		\$4,000	NA	NA	\$4 000
Total Cost	te for EllE				
		\$152,000	NA	NA	\$152.000
^a Estimates	s include remedial action, construction, and O	& M costs that are evic	acted to differ between alter	motion Discuss and security	

typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within a non-second percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within the second percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within the second percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within the second percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within the second percentage of remedy accurate within the second percentage of the second percentage of

plus 50 to minus 30 percent ^b Present worth cost calculated using an interest rate of 5 percent. ^c Total PW cost includes capital plus PW O&M costs.

TABI Capit <i>Mem</i> j	.E B-13a al Cost Estimate: Alternative 7, Excavation and Off-sit <i>his Depot Main Installation Soils FS</i>	le Disposal, Resi	dential Ple	anned Use	
FUG					
Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
~	Plans for Implementation	1	ř	\$75 /hr	\$1,000 Plans to develop include Site Restoration Plan, Site Safety and Health Plan, Environmental Protection Plan, and Tests/Certificates for Soil Number of hours have been adjusted to account for small area of excavation required in FU6 CH2M HILL. Draft: EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March
N	Excavation of Contaminated Soils				CH2M HILL Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
	Arsenic-Contaminated Soils	Ċ.	yd ³	\$3.69 /yd ³	\$100 Includes excavation and loading of contaminated surface soil, equipment, labor, mobilization/demobilization This volume corresponds to 1 arsenic-contaminated hot spot (400 ft ²) and an excavation depth of 1 foot.
ო	Surface Water Collection and Controls	-	6 6	\$10,000 /ea	\$10,000 CH2M HILL. Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999 This cost includes sediment barriers, straw bale dikes, and transport of contaminated water to treatment plant.
4	Disposal of Contaminated Soils				Assumes all excavated material is non-hazardous and RCRA Subtitle D landfill will accept (if below required TCLP value)

SOILS

 TABLE B-13a
 Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use
 Memphys Depot Main Installation Soils FS
 Memphys Depot Main Installation Soils FS
 Memphysel Statement
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FU6 Item

Activity/Component	Onantity	tinit	Init Coot	
				Capital Cost Source/ Comments
4 1 Laboratory Analysis - TCLP	÷	ea	\$1,500 /ea	\$1,500 Cost estimated from price list from Lancaster Laboratories, PA
				TCLP analyses will be run for every 500 yd ³ of soil transported off-site
4.2 Transportation - Local Landfill	15	yd ³	\$11 38 /yd ³	\$200 CH2M HILL. Draft. EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
4 3 Disposal Fee - Nonhazardous	21 b	tons	\$19 /ton	Assumes a 10-mile machine load haul to BFI Special Waste Landfill (RCRA Subtitle D Landfill) from Depot \$400 Phone quote from Shana Smiley - BFI Special Waste Landfill in Memphis
Confirmation Sampling, 2 Events				Assumes 4 samples will be taken at each arsenic
5.1 Labor for Both Events	40	hr	\$75 /hr	excavated hot spot area for each event. \$3,000 Assumes two field people will be on-site for 10 hours for 1
5 2 Laboratory Analysis - Arsenic	ω	ea	\$18 /ea	day for each event. \$200 Cost estimated from price list from Lancaster
5 3 Rental Equipment	2	event	\$360 /event	Laboratories, P.A. \$800 CH2M HiLL Draft [.] EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
5.4 Mobilization/Demobilization	32	hr	\$75 /hr	\$2,400 Assumes it will take two field people 8 hours for mobilization and 8 hours for demobilization for each
5 5 Supplies	2	event	\$500 /event	\$1,000 CH2M HILL' Reichold-Summary Invoice of Site Operations.

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Men	npnis Lepot Main Installation Solis FS				
FU6					
Iten	1 Activity/Component	Quantity	Unit	Unit Cost	Capital Cost ^a Source/ Comments
G	Restoration of Site 6 1 Imported Backfill (material)	15	yd ³	\$10 /yd ³	\$200 CH2M HILL ⁻ Draft. EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
	6.2 Transportation of Backfill On-site	15	yd ³	\$11 38 /yd ³	This cost includes material and placement \$200 Assumes backfill is imported and will need to be transported on-site. Cost is assumed to be the same as for non-hazardous waste transportation.
	6 3 Laboratory Analysis on Clean Soil				Quote from Columbia Analytical Services, Redding, CA
					TAL metals, TCL VOCs, Pesticides, and PCB analyses will be run for every 500 yd ³ of soil transported on-site
	 6 3 1 TCL Volatiles (8260) 6.3.2 TAL Metals (6010/700) 6.3.3 Pesticides (8081A) 6 3.4 PCBs (8082) 		8 8 8 8 8 8 8 8 8 8 8 8	\$198 /ea \$268 /ea \$141 /ea \$110 /ea	\$200 \$270 \$150 \$110
	6 4 Soil Conditioning	0.01	acre	\$885 /acre	\$100 This cost includes the application of lime and fertilizer
	6.5 Seeding	0 01	acre	\$1,420 /acre	\$100 These costs includes labor, mobilization/demobilization, equipment, and material
~	Maintenance of Site- Landscaping	96	μ	\$75 /hr	\$7,200 Assumes a field technician will perform landscaping an average of 8 hours (1 day) per month for a year This cost includes irrigation and mowing of site

TABLE B-13a Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use *Memphis Depot Main Installation Soits FS*

		1		' J	1-75
Source/ Comments	liternative at site will need to be evaluated letion to ensure that adequate protection has ted. Assume report will take 1 week to	j and engineering costs are	estimate is typically accurate within		
Capital Cost ^a	\$4,000 Remedial a upon comp been provic complete	\$33,000 Ween alternatives. Plannin	irve cost evaluations. The ∈ ducted at the Depot		
Unit Cost	\$100 /hr	cted to differ bet	actor in compara oval actions con		SOILS
Unit	Ĭ	t are expe	e soil rem		
Quantity	40	I O&M costs tha	ber and merenore historical surface		
Item Activity/Component	8 Final Evaluation	Total Capital Costs ^a Estimates include remedial action, construction, and truncally estimated to be a proceeding of comody of	b Assumes soil bulk density of 1.4 tons/yd ³ based on		GNV/003673674-Sth2057 xls

 TABLE B-13a
 Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use
 Memphis Depot Main Installation Soils FS
 Memphis Planned Use
 Memphis Pl

ltern	Activity/Component	Capital Cost ^a	Annual O&M Cost ^a	Present Worth O&M Cost ^{a,b}	Total PW Cost ^c
	Plans for Implementation	\$1,000	NA	NA	\$1,000
2	Excavation of Soils	\$100	NA	NA	\$100
e	Surface Water Collection and Controls	\$10,000	NA	NA	\$10,000
4	Disposal of Contaminated Soils	\$2,100	NA	NA	\$2,100
ъ	Confirmation Sampling	\$7,400	NA	NA	\$7,400
9	Restoration of Site	\$1,330	NA	NA	\$1,330
7	Maintenance of Site- Landscaping	\$7,200	NA	NA	\$7,200
ω	Final Evaluation	\$4,000	NA	NA	\$4,000
Total Cos	ts for FU6	\$33,000	NA	NA	\$33,000
^a Estimate	s include remedial action, construction, and Ot	M costs that are expec	sted to differ between alterna	tives Planning and engineering costs	are
tvoically	estimated to be a nercentage of remedy cost :	and therefore do not far	ntor in comparative nost avai	The estimate is the settimate is the set of	and a subsection of the section of t

typically estimated to be a percentage of remedy cost and therefore, do not factor in comparative cost evaluations. The estimate is typically accurate within plus 50 to minus 30 percent ^b Present worth cost calculated using an interest rate of 5 percent.

° Total PW cost includes capital plus PW O&M costs

Cost Estimate Summary⁻ Alternative 7, Excavation and Off-site Disposal, Residential Planned Use Memphis Depot Main Installation Soils FS

TABLE B-13b

FU6

		Total Numl	ber of Samples a	nd Analyses		
	Lead	Dieldrin	Arsenic	TAL/ TCL/ Pest / PCB	TCLP ¹	
Alternative 3 [.] Containment, Industrial Planned Use (For 2 Events) ^a						
FU4	ω	NA	ΝA	۲	NA	
Alternative 3. Containment, Residential Planned Use (For 2 Events) ^a						
FUI	AN	112	40	23	NA	
FU2	NA	20	56	217	AN	
FU3	œ	AN	32	-	AN	
FU4	24	56	112	43	AN	
FUS	NA	56	æ	4	NA	
FUG	AN	NA	œ	-	NA	
Alternative 4: In-situ Soil Treatment, Industrial Planned Use (For 2 Even	nts) ^b					
FU4	8	NA	NA	NA	NA	
Alternative 4: In-situ Soif Treatment, Residential Planned Use						
FU1 (8% Dieldrin Contaminated Soil)	NA	72	NA	NA	NA	
FU2 (86% Dieldrin Contaminated Soil)	AN	774	NA	NA	NA	
FU3	NA	NA	NA	NA	NA	
FU4 (5% Dieldrin Contaminated Soil)	NA	45	NA	NA	NA	
FU5 (1% Dieldrin Contaminated Soil)	NA	б	NA	NA	AN	
FUG	NA	NA	AN	NA	NA	
Solidification Lead/Arsenic(For 2 Events) ^b						
FU1	NA	112	40	NA	NA	
FU2	NA	20	56	NA	AN	
FU3	8	NA	32	NA	AN	
FU4	24	56	112	NA	AN	م.
FUS	NA	56	8	NA	NA	
FUG	NA	NA	ω	NA	AN	

TABLE B-14 Summary of Soil Sampling and Analyses Memphis Depot Main Installation Soils FS

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SOILS

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TABLE B-14 Summary of Soil Sampling and Analyses Memphis Depot Main Installation Soils FS					
		Total Num	per of Samples a	nd Analyses	
	Lead	Dieldrin	Arsenic	TAL/ TCL/ Pest / PCB	TCLP
			-		i
Alternative 7 Excavation and Off-site Disposal, Industrial Planned Use (For 2 Events) ^d					
FU4	8	٩N	ΝA	-	
Alternative 7: Excavation and Off-site Disposal, Residential					
Planned Use (For 2 Events)					
FU1	NA	112	40	16	16
FU2	NA	06	56	146	146
FU3	ω	NA	32	-	
FU4	24	56	112	29	29
FU5	NA	56	8	ო	° M
FUG	NA	NA	8		,
^a The Containment alternative assume that 4 soil samples will be colle except FU4, where 10 samples will be taken per event A group of an for soil cover.	ected at each dieldr alyses (TCL/TAL/p	in, lead, and arser esticides/PCBs) wi	lic hot spot for eac	th event within each FU 500 cy of soil imported	
^b The In-situ alternative assume that 4 soil samples will be collected at	t each lead and ars	tenic hot spot unde	rgoing stabilizatio	n for each event within	
except FU4, where 10 samples will be taken per event	•				
Assumes 300 dieldrin samples will be collected per year under treatr	nent scheme for er	hanced bioremed	ation of		
entire Depot Number of samples per FU were calculated by multiplyin	ing the total 300 sai	mples by a proport	ion of		
assumed dieldin contaminated FU soil to the total amount of dieldrin c	contaminated soil				
¹ The Excavtation and offsite disposal alternative assume that 4 soil sa within each FU, except FU4, where 1 sample will be taken per acre pe transported offsite. A group of analyses (TCL/TAL/pesticides/PCBs) w NA Not analyzed	umples will be collever ar event TCLP ana will be run on every	cted at each dieldr lyses will be run or 500 cy of soil impo	n, lead, and arser n every 500 cy of s orted	nc hot spot for each ev soil excavated and	ent

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SOILS

TABLE B-15 Enhanced Bioremediation Unit Cost Calculation Memphis Depot Main Installation Soils FS		
Objective: Calculate a unit cost for enhanced bioremediation of dieldrin based on Venture Capital's Treatability Study and future cost estimates This value will be used in cost estimate of Alternative 4 for Soils FS for the Memphis Depot Main Installation		
 Given: 1) Venture estimated that the initial year of treatment would cost approximately \$600,000 to \$1,500,000 This range in cost is primal due to the size of area used (between 12 and 16 acres) and the number of samples analyzed for (between 80, determined from a 10-pt grid, and 1,200, determined from a 150-pt grid) 2) Venture's cost estimate also includes a consulting fee to Venture of approximately \$200,000 3) Lab studies on biological treatment cost approximately \$30,000 and are performed by a University in California 	ţţ.	
 Assumptions: Based on 12-acre area, 1 ft depth. Life of treatment will be 3 years Excert treatment cost includes Treatment cost includes Treatment solution (mineral salts, carbon, fertilizer) and application to soil equipment Local labor for aeration, landscaping, and fertilizer applications - cost will be minimal 80 samples (8 samples per 10 point grid over 12-acre area) twice per year Will need to re-apply biological treatment media twice a year (growing season and summer) May need to re-apply fertilizer every month Will need to aerate (with tractor) every 2 weeks May need additional landscaping; e g., cut grass more often. 		
 Calculations: 1) The smaller cost value (\$600,000) was chosen to estimate a unit cost. 2) The \$200,000 Venture consulting fee was subtracted from this \$600,000 since engineering planning fees are not included at this time. 3) The cost for lab studies is NOT included in the \$600,000 and will not be used in determining a unit cost. 4) The following 2 years would cost approximately \$400,000 if using an initial cost of \$600,000. 		
Thus, for biological treatment of dieldrin-contaminated soils, not including lab studies: 1st Year Unit Cost = (\$600,000 - \$200,000) / (12 acre * 43,560 ft ² /acre *1 ft depth) = 2nd and 3rd Year Unit Cost = (\$400,000 - \$200,000) / (12 acre * 43,560 ft ² /acre * 1 ft depth) =	\$0.77 /ft ³ (or sf of area treated) \$0.38 /ft ³ /yr (or sf of area treated)	JI 0
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Venture Biological C	cost Estimate - Based on 12	acres in FU2						
ltem	Activity/Component	Ouantity	Unit	t Init Cost	Canital Cost	Annual O&M	PW O&M Cost for Period ^a	Total DW Cast
						1000		
Biological Treatment	(including sampling and testing)							\$430,000
(First Year)	5	522,720	ď	\$0 77 /cf	\$400,000	\$0	\$0	
	Treatment Lab Studies	-	ea	\$30,000 /ea	\$30,000	\$0	0\$	
Biological Treatment	(including sampling and testing)							\$217,746
(Second Year)	5	522,720	បី	\$0 38 /cf	\$0	\$200,000	\$189,175	
	Treatment Lab Studies	-	ea	\$30,000 /ea	\$0	\$30,000	\$28,571	
Biological Treatment	(including sampling and testing)							\$207,377
(Third Year)	5	522,720	ď	\$0 38 /cf	\$0	\$200,000	\$180,167	
	Treatment Lab Studies	•	63	\$30,000 /ea	\$0	\$30,000	\$27.211	
Total Costs				•	\$430,000	\$460,000	\$425,124	\$855.124
^a PW calculated using	an interest rate of 5 percent				, .			

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 TABLE B-15

 Enhanced Bioremediation Unit Cost Calculation

 Memphis Depot Main Installation Soils FS

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Enhanced Bioremediation Unit Cost Calculation	Memphis Depot Main Installation Soils FS
	Enhanced Bioremediation Unit Cost Calculation

Installation
Entire Main
Land Use -
Residential
st Estimate:
iological Cos

Item Activity/Component Quantity Unit Cost Capital Cost for Period ^a Total Biological Treatment (including sampling and testing) (including sampling and testing) 2,289,514 cf \$0.77 /cf \$1,762,926 \$0 \$0 \$0 \$1,762,926 \$0 \$							Annual O&M	PW O&M Cost	
Biological Treatment (including sampling and testing) (First Year) (including sampling and testing) (incl	Item	Activity/Component	Quantity	Chit	Unit Cost	Capital Cost	Cost	for Period ^a	Total PW Cost ^{b.}
(First Year) 2,289,514 cf \$0.77 /cf \$1,762,926 \$0	Biological Treatment	(including sampling and testing)							\$1,792,926
Biological Treatment testing) (including sampling and testing) 2,289,514 cf \$0.38 /cf \$0 \$870,015 \$828,586 \$5 (Second Year) Treatment Lab Studies 1 ea \$30,000 /ea \$0 \$30,000 \$28,571 \$5 Biological Treatment Lab Studies 1 ea \$30,000 /ea \$0 \$30,000 \$28,571 \$5 Biological Treatment (including sampling and testing) (Intrd Year) 2,289,514 cf \$0.38 /cf \$0 \$30,000 \$28,571 \$5 Treatment Lab Studies 1 ea \$30,000 /ea \$0 \$30,000 \$28,70,015 \$789,129 \$5 Third Year) Treatment Lab Studies 1 ea \$30,000 /ea \$0 \$30,000 \$27,211 \$5 Total Costs 51.792.926 \$1.800.030 \$1.53 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.532.96 \$1.572.	(First Year)	Treatment Lab Studies	2,289,514 1	ea ea	\$0 77 /cf \$30,000 /ea	\$1,762,926 \$30,000	\$0 \$0	\$0 \$0	
(Second Year) 2,289,514 cf \$0.38 /cf \$0 \$870,015 \$828,586 Treatment Lab Studies 1 ea \$30,000 /ea \$0 \$30,000 \$28,571 Biological Treatment (including sampling and testing) (including sampling and testing) 2,289,514 cf \$0.38 /cf \$0 \$30,000 \$28,571 \$8 Rological Treatment (including sampling and testing) (Third Year) 2,289,514 cf \$0.38 /cf \$0 \$70,015 \$789,129 \$8 Third Year) Treatment Lab Studies 1 ea \$30,000 /ea \$0 \$30,000 \$27,211 \$16,73,408 \$36,688,129 \$36,688 \$36,688 \$36,688 \$36,688 \$36,7216 \$36,688 \$36,688 \$36,688 \$36,688 \$36,688 \$36,688 \$36,688 \$36,688 \$36,688 \$36,688 \$36,688 \$36,688 \$36,688 \$36,	Biological Treatment	(including sampling and testing)							\$857,157
Treatment Lab Studies 1 ea \$30,000 /ea \$0 \$30,000 \$28,571 Biological Treatment (including sampling and testing) (including sampling and testing) \$6 \$7 \$6 \$7 \$6 \$6 \$7 \$6	(Second Year)	i	2,289,514	ď	\$0 38 /cf	\$0	\$870,015	\$828,586	
Biological Treatment (including sampling and testing) 2,289,514 cf \$0.38 \$0 \$870,015 \$789,129 (Third Year) 7,reatment Lab Studies 1 ea \$30,000 6a \$30,000 \$2,72,11 Total Costs 51.792.926 51.800 30 53 53 53		Treatment Lab Studies	-	ea	\$30,000 /ea	\$0	\$30,000	\$28,571	
(Third Year) 2,289,514 cf \$0.38 \$0 \$870,015 \$789,129 Treatment Lab Studies 1 ea \$30,000 \$30,000 \$27,211 Total Costs 51.792.926 \$1.800.030 \$1.673.408 \$33	Biological Treatment	(including sampling and testing)							\$816,340
Treatment Lab Studies 1 ea \$30,000 /ea \$0 \$30,000 \$27,211 Total Costs 51,673,498 53	(Thırd Year)		2,289,514	σ	\$0.38 /cf	\$0	\$870,015	\$789,129	
Total Costs 51.673.498 53.600.030 51.673.498 53		Treatment Lab Studies	~~	ea	\$30,000 /ea	\$0	\$30,000	\$27,211	
	Total Costs					\$1,792,926	\$1,800,030	\$1,673,498	\$3.466.424

^b Based on 52.6 acres. ^c Cost includes 300 dieldrin samples to be taken <u>twice</u> per year

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Appendix C

Revised Evaluation of Recreational Land Use Scenarios at FU2, Memphis Depot

Revised Evaluation of Recreational Land Use Scenarios at FU2, Memphis Depot

PREPARED FOR:	Defense Logistics Agency, Memphis Environmental Protection Agency Region IV Tennessee Department of Environment and Conservation Corps of Engineers, Huntsville
PREPARED BY:	CH2M HILL
DATE:	June 2, 2000

Introduction

This technical memorandum (TM) evaluates the potential human health risks of using Functional Unit 2 (FU2) at Memphis Depot as a general recreational area such as a public park. Future use as a golf course has been evaluated, as well as use for a jogging trail, soccer field, and playground. Based on the assumptions described herein, FU2 may be used without unacceptable risks to human health for a golf course, baseball field, playground, and soccer field, but may not be used as a residential area.

In an earlier assessment (CH2M HILL, *Streamlined Risk Assessment for Parcel 3*, January 1999), FU2 was evaluated for a golfer playing at the golf course, for a baseball player at the baseball diamond area, and for a child at a playground. The entire FU2 area was also evaluated for future industrial and residential use scenarios. These assessments provided a foundation for the risk assessments described in this TM. In addition, a nature and extent evaluation, and a risk assessment extracted from the Parcel 3 risk assessment was provided in the *Final Main Installation Remedual Investigation Report* (CH2M HILL, 2000).

For the evaluation in this TM, several exposure scenarios were evaluated for FU2 using the upper confidence limit at 95 percent above the mean value (UCL 95 percent) as exposure point concentrations (EPCs). *Table 1* lists the constituents of potential concern (COPCs) and exposure point concentrations (EPCs) from the combined data set used for industrial worker risk estimations in the *Streamlined Risk Assessment* (CH2M HILL, 1999). *Table 2* summarizes the risks and Hazardous Indexes (HIs) for each scenario. *Table 3* includes the assumptions used for each scenario and the estimated intakes and risks. The intakes estimated for a unit concentration in soil for the new recreational scenarios were compared with a golfer intake from the Streamlined Risk Assessment (CH2M HILL, 1999) (*Tables 2 and 3*).

Exposure Scenarios

As part of ongoing property transfer at the Depot, many areas of the Main Installation (MI) are being considered for future altered land uses. The exposure scenarios evaluated in this TM are associated with the public using the entire area of FU2 as a golf course, baseball

diamond, soccer field, and/or a public jogging trail. FU2 was also evaluated as a future industrial facility and as a residential area.

Golfer

The golfer exposure assumptions were previously presented in the *Streamlined Risk Assessment* (CH2M HILL, 1999). The previous EPCs to the golfer were based on data collected from the golf course only. Therefore this scenario was reevaluated in this TM to compare risks from exposure to the entire FU2.

Exposure assumptions are based on the typical behavior of a golfer while golfing. Golfers have been reported to place golf tees into their mouths, to lick golf balls, or to touch their mouths, food, or drinks with unwashed hands. These actions potentially increase soil consumption rates from that of dust or sand that they may ingest incidentally. A soil ingestion rate of 50 milligrams per day (mg/day) is assumed for a golfer, and 100 percent of this ingested soil is assumed to be contaminated soil.

Golfers are also assumed to wear shorts, short-sleeved shirts, socks, shoes, and hats. The assumed surface area (4,680 square centimeters [cm²]) available for contact with soils includes hands, half of the arms, and half of the legs. An adherence factor of 1 milligram per square centimeters (mg/cm²) is assumed (CH2M HILL, 1999). The factors used are included in Table 3.

Adult Jogger

A jogger is assumed to use the jogging trails three times a week for 50 weeks per year, resulting in an exposure frequency of 150 days per year. The soil ingestion rate is conservatively assumed to be 100 mg/day, with 50 percent originating from contaminated areas of the golf course. The jogger is assumed to be a local resident who is assumed to live in the same area for 30 years. Most of the skin surface area of hands and legs, and half of the arms (half-sleeved T-shirt) is assumed for exposure to soil adherence.

Child Playground User

Exposure of a child in the playground was evaluated using the exposure assumptions listed in the previously conducted Streamlined Risk Assessment (CH2M HILL, 1999). The child is assumed to visit the park two days per week, during warmer months of the year for 8 months of the year (64 days per year), and is assumed to have a soil ingestion rate of 200 mg/day. Each visit is assumed to last for 4 hours. The child visiting the park is assumed to be up to 6 years of age. A skin surface area of 2,394 cm² is assumed to be available for soil contact and includes the surface area of hands, feet, and half of both arms and legs. The default ingestion rates are conservative. Exposure factors are listed in detail in Table 3.

Child Baseball Player

Children are assumed to play baseball during the season once a week for 20 weeks (20 days per year) for 8 years. The soil ingestion rate during the ball game is assumed to be 200 mg/day. The assumed clothing is a typical baseball uniform consisting of long pants, short-sleeved shirt, socks, shoes, and a cap. A skin surface area of 2,080 cm² is assumed to be available for soil contact and includes the surface area of hands, feet, and half of both arms

and legs. The default ingestion rates are conservative. Exposure factors are listed in detail in Table 3.

Cumulative Recreational Adult

The total exposures to a child at the playground, and to a youth baseball player and a jogger using trails for 16 years are assumed to be cumulative. Therefore risks and HIs for these scenarios were summed to estimate potential risks to a receptor growing up in this area for a total of 30 years

Youth Soccer Player

A soccer player scenario was developed using best professional judgement and conservative assumptions. Soccer players are assumed to be children between 6 and 16 years of age with a youth body weight of 45 kilograms. Their exposure duration is assumed to be 10 years. The soccer season lasts for 4 months at 20 days per month for a total of 80 days per yearly season with youths playing soccer more frequently and for longer durations than younger children.

The soil ingestion rate is assumed to be 150 mg/day, which is between the adult and child ingestion rates. The skin surface area available for contact is similar to an adult with a surface area of half of the arms and hands available for soil adherence (4,371 cm²).

Industrial Worker Scenario

A future industrial worker is assumed to have a soil ingestion rate of 50 mg/day for 250 days per year, with an exposure duration of 25 years. Dermal contact with soils was estimated for the exposed skin area of hands, half of the arms, and the head (2,458 cm²/event), for 8 hrs per day. The exposures and risks from this scenario were selected for comparison with other exposure scenarios in this TM.

Residential Adult and Child Scenarios

Default assumptions are used for residential adults and children. Adults are assumed to have an ingestion rate of 100 mg/day, and children are assumed to have an ingestion rate of 200 mg/day. Exposure frequencies for both adults and children are assumed at 350 days per year. The exposure duration for adults is 30 years and for children is 6 years. Table 3 includes the assumptions used in calculating the intake factors.

Exposure Point Concentrations (EPCs)

The reasonable maximum exposure (RME) risks and hazards were estimated using the UCL 95 percent EPCs estimated for a golfer in the streamlined risk assessment (Table 1). Results of the exposure estimates and the risks/HIs for each exposure scenario are presented in Tables 2 and 3.

Risk Evaluation Results

In this risk evaluation, an acceptable risk range is 1 to 100 in a million (10⁻⁶ to 10⁻⁴), and an acceptable HI is equal to or less than 1.0. Based on these assumptions, the following observations can be made for FU2 future alternative land use (including golf course, playground and baseball diamond), based on the COPCs and EPCs listed in Table 1.

- 1 Risks to a future **jogger** using the golf course as a jogging trail area are within the U.S. Environmental Protection Agency's (EPA's) acceptable risk criteria Thus the potential risks from such future use are negligible.
- 2. Risks to a child using the FU2 for a playground are within acceptable limits.
- 3. Any area of the golf course may be used as a **baseball field or soccer field** under current conditions, as the risks and HIs to both of these receptors is within the acceptable risk criteria.
- 4. Risks and HIs to a **cumulative recreational adult** are within acceptable limits, under the conservative assumptions.
- 5. Risks and HIs to future **industrial worker** from converting FU2 to industrial area are within acceptable limits.
- 6. Without remediating the surface soil concentrations, the golf course is not suitable for future **residential** use in which residents may spend an entire workday outdoors in contact with soil.

Conclusion

In conclusion, FU2 may be used as a public park with playground, golf course, baseball field, and soccer field without unacceptable risks to human health. FU2 may not be used as a residential area under the assumed exposure conditions evaluated in this risk assessment. The exposure assumptions used are generally conservative.

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TABLE C-1

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COPCs and EPCs Used for Industrial Worker Risk Estimations at FU2

Chemical Name	No. of Analyses	No. of Detects	Mean	Maximum	RME (EPC)
Metals and Pesticides			(mg/kg)	(mg/kg)	(ma/ka)
Arsenic	27	27	22	101	29 3
Chromium	27	27	19	40.3	21 5
Copper	27	27	25	55 4	30 9
Manganese	13	13	770	1860	983
Nickel	27	27	21	57 6	25 9
Lead	27	27	47	167	75 9
Alpha-chlordane	32	1	0 10	14	0 23
Gamma-chlordane	39	2	0.11	1.4	0.27
Dieldrin	42	40	0 71	10	2.21
DDE	41	26	0.28	2	0.80
DDT	41	24	0.42	- 6.7	0.96
Semivolatiles					0.00
Benzo(a)anthracene	30	13	0 17	0.92	0.25
Benzo(a)pyrene	30	11	0.16	0.93	0.26
Benzo(b)fluoranthene	30	11	0 18	1.1	0.28

RME Reasonable maximum exposure concentration (UCL95 percent estimation)

EPC Exposure point concentration

TABLE C-2

Relative Risk Summaries for Recreational/Alternative Uses for the Depot Golf Course

	Health Risk at	t UCL95 Percent
Exposure Scenario	ELCR	HI
Adult Jogger (30 years)	6.9E-06	0 02
Adult Jogger (16 years)	3 7E-06	0.019
Child at Playground	5.9E-06	0 08
Baseball Player - Child (6-14 years)	7.7E-07	0.008
Cumulative Recreational ^a	1.0E-05	0.11
Youth Soccer Player (6-16 years)	6 0E-06	0 05
Industrial Worker – Adult	3.0E-05	0.1
Residential – Adult	2.3E-04	0.27
Residential – Child	1.4E-04	1.9
Golfer – Adult	1.1E-05	0 03

ELCR Excess lifetime cancer risk

HI Hazard index

UCL Upper confidence limit

^a Cumulative recreational includes exposures as a child at playground, youth-baseball player, and adult jogger (14 years)

Bold values exceed ELCR of 10⁻⁴ or HI of 1

Exposure Scenarlo/Parameter 0 CS = concentration in soil (mg/kg)	ŀ	10010		ē	rmai				
CS = concentration in soil (mg/kg)	arcin- genic	Non Carcin- ogenic	Exposite Scensto/Daramotor	Carcin-odenie	Non carcin-	Tota		Relative	Risk at
Cs = concentration in soil (mg/kg)			Jogger/Runner - Adult - 30 vears			Ingestion+	Dermal	nor	95%
	F	F	Cs = concentration in soil (mn/kn)						
in = oui ingestion rate (mg/day)	100	100	SA = Skin Surface Area (cm2/event)	5410	2410	Carc-Intake	Noncarc	Hisk	Ŧ
FI = Fraction ingested from contaminated area (unitless)	05	05	AF = Soil Adherence factor (mo/cm3)						
ET = Exposure Time (hours/24 hr-day)	+	-	ABS = Absorption Factor (Unitless)	Chem Specific	Chem Snertin				
EF = Exposure frequency (days/yr)	150	150	ET = Exposure Time (hours/24 hr-dav)	1					
ED = Exposure duration (years)	30	30	EF = Exposure frequency (days/yr)	150	150				
CF= Conversion factor (unitiess) 01	000001	0 000001	ED = Exposure duration (vears)	30	86				
BW = Body weight (kg)	70	20	CF= Conversion factor (unitless)	0 00001					
AT = Averaging time(days/yr x years)	25550	10950	BW = Body weight (kg)	20	100000		t		
			AT = Averaging time(days/yr x years)	25550	10950				
Intake = 1.	26E-07	2.94E-07	Intake	= 5 68E-07	1.33E-06	6 94E-07	1 62E.06		
Percent Relative to a Future Industrial Worker (%)	72.0	60.0	Percent Relative to a Future Industrial Worker (%	() 20	17	23	19	6.85E-06	00
			Jogger/Runner - Adult - 14 years						
Cs = concentration in soil (mg/kg)	٣	1	Cs = concentration in soil (mg/kg)	-	1	Care-Intake	Nonoro	1400	
IR = Soil ingestion rate (mg/day)	100	100	SA = Skin Surface Area (cm2/event)	5419	E410				Ē
FI = Fraction ingested from contaminated area (unitless)	05	05	AF = Soil Adherence factor (mo/cm3)		5				
ET = Exposure Time (hours/24 hr-day)	*	-	ABS = Absorption Factor (Unitless)	Chem Snectic	Chem Snecific				
EF = Exposure frequency (days/yr)	150	150	ET = Exposure Time (hours/24 hr-day)	-					
ED = Exposure duration (years)	14	14	EF = Exposure frequency (davs/vr.)	150	150				
CF= Conversion factor (unitiess) 0.0	00001	0 000001	ED = Exposure duration (years)	14	44				
3W = Body weight (kg)	70	20 (CF= Conversion factor (unitless)	0.00001	1000000			+	
AT = Averaging time(days/yr x years)	25550	5110	BW = Body weight (kg)	20	02				
			AT = Averaging time(davs/vr_x vears)	05KED	5110				
Intake = 5 6	87E-08	2 94E-07	Intake -	- 9 66E-07	1 225 76	2 747 07			
Percent Relative to a Future Industrial Worker (%)	33.6	60.0	Percent Relative to a Future Industrial Worker (%		1.335-00	3 24E-U/ 11	1 62E-U6	2000	0 010
			Child - Playaround			•			
Ss = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)		+				
R = Soil ingestion rate (mg/day)	200	200	SA = Skin Surface Area (cm2/event)	2394	2394				
I = Fraction ingested from contaminated area (unitless)		11	AF = Soil Adherence factor (mg/cm3)						
ET = Exposure Time (hours/24 hr workday) NVA	Ż	1 V	ABS = Absorption Factor (Unitless)	Chem Specific (Chem Snectic				
<pre>Exposure frequency (days/yr)</pre>	64	64 E	ET = Exposure Time (hours/24 hr-day)	4	4				
<pre>CD = Exposure duration (years)</pre>	9	6 6	EF = Exposure frequency (days/yr)	64	64				
2F= Conversion factor (unitless) 0.0	00001	0 000001 E	ED = Exposure duration (years)	g					
3W = Body weight (kg)	15	15 0	CF= Conversion factor (unitless)	0.00001	0.00001				
VT = Averaging time(days/yr x years)	25550	2190 E	3W = Body weight (kg)	15	15				
		4	VT = Averaging time(days/yr x years)	25550	2190		╁╼		
11ake = 2.0	0E-07	2.34E-06 II	ntake =	4 00E-07	4 66E-06	6 00F-07	7 00E-06		
	115	478 F	Percent Relative to Onsite Golfer	14	58	20	82 5	93E-06	0 08

TABLE C-3 FU 2 Recreational Users Risk Calculations

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Exposure Scenario/Parameter	Carcin- ogenic	Non Carcin- ogenic	Exposure Scenario/Parameter	Carcin-ogenic	Non carcin- ogenic	Total Ingestion+Dern	al Relativ	re Risk at 1 95%
	-,		¹ . Child/Youth - Baseball Player					
Cs = concentration in soil (mg/kg)	ŀ	1	Cs = concentration in soil (mg/kg)					
IR = Soit ingestion rate (mg/day)	200	200	SA = Skin Surface Area (cm2/event)	2080	2080			
FI = Fraction ingested from contaminated area (unitless)	F	-	AF = Soil Adherence factor (mg/cm3)		-			
ET = Exposure Time (hours/24 hr workday)	2	2	ABS = Absorption Factor (Unitless)	Chem Specific	Chem Specific			
EF = Exposure frequency (days/yr)	50	20	ET = Exposure Time (hours/24 hr-day)	N	24			
ED = Exposure duration (years)	8	8	EF = Exposure frequency (days/yr)	20	20			
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	60	80			
BW = Body weight (kg)	30	30	CF= Conversion factor (unitless)	0 00001	0 000001			
AT = Averaging time(days/yr x years)	25550	2920	BW = Body weight (kg)	30	30			
			AT = Averaging time(days/yr x years)	25550	2920			
tntake =	4 17E-08	3 65E-07	Intake =	= 3 62E-08	3 17E-07	7 79E-08 6 82	E-07	
Percent Relative to a Future Industrial Worker (%)	24	75	Percent Relative to a Future Industrial Worker (%) 1	4	e	8 7 70E-07	0 0 0
		۰, ۰	Child/Youth - Soccer Player (6-16 years)					
Cs = concentration in soil (mg/kg)	-	1	Cs = concentration in soil (mg/kg)	1	L .			
IR = Soil ingestion rate (mg/day)	150	150	SA = Skin Surface Area (cm2/event)	4371	4371			
FI = Fraction ingested from contaminated area (unitless)	+	1	AF = Soil Adherence factor (mg/cm3)	1	I.			
ET = Exposure Time (hours/24 hr workday)	4	4	ABS = Absorption Factor (Unitless)	Chern Specific	Chem Specific			
EF = Exposure frequency (days/yr)	80	80	ET = Exposure Time (hours/24 hr-day)	4	4			
ED = Exposure duration (years)	10	10	EF = Exposure frequency (days/yr)	90	08			
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	10	10			
BW ≈ Body weight (kg)	45	45	CF= Conversion factor (unitless)	0 000001	0 000001			
AT = Averaging time(days/yr x years)	25550	3650	BW = Body weight (kg)	45	45			
			AT = Averaging time(days/yr x years)	25550	3650			
intake =	1 04E-07	7.31E-07	Intake =	= 5.07E-07	3 55E-06	611E-07 428	E-06	
Percent Relative to a Future Industrial Worker (%)	60	149	Percent Relative to a Future Industrial Worker (%	18	44	20	50 6 04E-06	0 02
5		ţ	Industrial Worker - Adult					
Cs = concentration in soil (mg/kg)	+	1	Cs = concentration in soil (mg/kg)	1	J +			
IR = Soil ingestion rate (mg/day)	50	50	SA = Skin Surface Area (cm2/event)	2458	2458			
Fi = Fraction ingested from contaminated area (unitless)	1	1	AF = Soil Adherence factor (mg/cm3)		1			
ET = Exposure Time (hours/24 hr workday)	NVA	N/A	ABS = Absorption Factor (Unitless)	Chern Specific	Chem Specific			
EF = Exposure frequency (days/30 years)	250	250	ET = Exposure Time (hours/24 hr-day)	8	8			
ED = Exposure duration (years)	25	25	EF = Exposure frequency (days/yr)	250	250			
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	25	25			
BW = Body weight (kg)	70	70	CF= Conversion factor (unitless)	0 000001	0 000001			
AT = Averaging time(days/yr x years)	25550	9125	BW = Body weight (kg)	70	20			
			AT = Averaging time(days/yr x years)	25550	9125			
Intake =	1.75E-07	4.89E-07	Intake =	2.86E-06	8 02E-06	3 04E-06 8 51	E-06	
Percent Relative to a Future Industrial Worker (%)	9	- <u>1</u> 0	Percent Relative to a Future Industrial Worker (%)	100	100	100	100 3 00E-05	0

TABLE C-3 FU 2 Recreational Users Risk Calculations

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TABLE C-3 FU 2 Recreational Users Risk Calculations

FUNCTIONAL UNIT 2 RECREATIONAL LAND USE RISK CALCULATIONS - RELATIVE EXPOSURES COMPARED TO A FUTURE INDUSTRIAL WORKER

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