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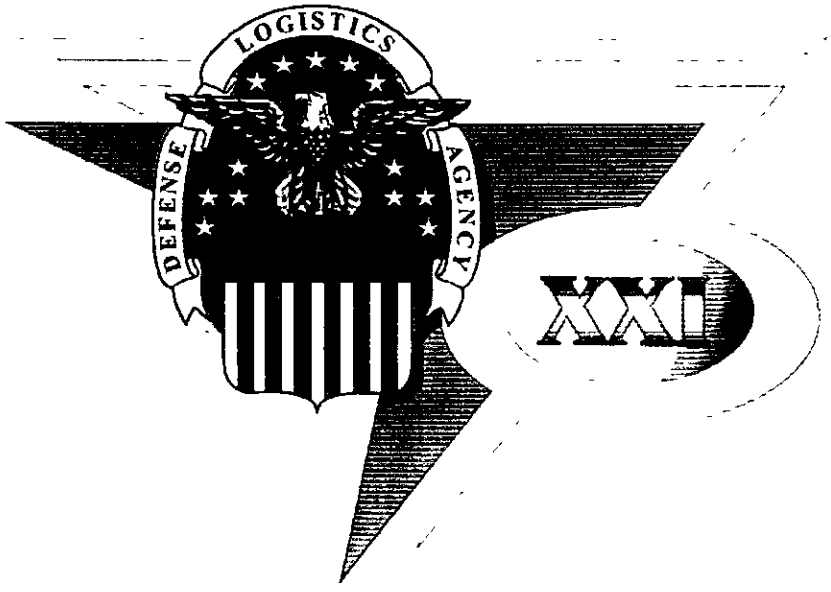
THE MEMPHIS DEPOT
TENNESSEE

ADMINISTRATIVE RECORD
COVER SHEET

AR File Number 510

Memphis Depot
Main Installation

Soils Feasibility Study Report



Memphis Depot Caretaker

July 2000

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CH2MHILL

U.S. Army Engineering and Support Center, Huntsville

U.S. Army Engineering and Support Center, Huntsville
Contract No. DACA87-94-D-0009
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August 4, 2000

Mr. Shawn Phillips, P.E.
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Memphis Depot Caretaker Division
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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 Pages
Final Groundwater FS, Set of Replacement Pages

Distribution: 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)

147543 FS 01 CH2M HILL Project File 147543

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 — Date

7/3/00

Stephen D. Offner, P.G.
CH2M HILL Project Manager — Date

FOR 7/3/00

Michael R. Harris, P.E.
CH2M HILL Senior Consultant — Date

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Acronyms and Abbreviations

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	Dichlorodiphenyldichloroethane
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
ft^2	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
IW	Inside worker
LDR	Land disposal restriction
LF	Linear feet
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
MCL	Maximum contaminant level

MCLG	Maximum contaminant level goal
MDL	Maximum detection limit
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MNA	Monitored natural attenuation
msl	Mean sea level
MW	Monitoring well
NAPL	Non-aqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	National Park Service
O&M	Operation and maintenance
OSHA	Occupational Safety and Health Administration
OU	Operable unit
OW	Outside worker
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethylene
PCP	Pentachlorophenol
ppm	Parts per million
RAO	Remedial action objective
RBC	Risk-based concentration
RBCA	Risk-based Corrective Action
RCRA	Resource Conservation and Recovery Act
RD	Remedial design
RE	Resident
RGO	Remedial goal option
RI/FS	Remedial investigation/feasibility study
ROD	Record of Decision
SDWA	Safe Drinking Water Act
SS	Surface soil
SVOC	Semivolatile organic compound
1,1,2,2-TCA	1,1,2,2-Tetrachloroethane
TCA	Tetracholorethane
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
TCE	Trichloroethene
TCLP	Toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TDS	Total dissolved solids
TM	Technical memorandum
TSCA	Toxic Substances Control Act
USC	United States Code
VOC	Volatile organic compound

TAB

Executive Summary

Executive Summary

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).

TAB

Section I

1.0 Introduction

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 Plan, 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 remedial 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 organic (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

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

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; rather, 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 (10^{-4}) 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:

  1) 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;

  2) 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 μg/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.

TABLE 1-1
Risk Assessment Summary for Each Functional Unit and Surrogate Sites at Main Installation
Memphis Depot Main Installation Soils FS - 7/31/00

			Risk Assessment Results[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	8×10^{-5}	0.09	1×10^{-3}	0.08	No	Yes	No
FU1 - Site 64	PAHs		7×10^{-5}	0.02	*NA*	NA	No	NA	
FU2	PAHs, Dieldrin, Arsenic	150[b]	3×10^{-5}	0.2	2×10^{-4}	2 7	No	Yes	No
FU2 - Site 59	Dieldrin		2×10^{-6}	0 008	*NA*	NA	No	NA	
FU3	PAHs, Arsenic, Lead	4150 (at RHA012)	9×10^{-6}	0.6	6×10^{-4}	0.6	No	Yes	Yes
FU3-Site 34	PAHs, Arsenic		4×10^{-5}	0.1	*NA*	NA	No	NA	
FU4	PAHs, PCB, Dieldrin, TCDD, Arsenic, Lead	2800 (SGA286)	4×10^{-5}	0.1	3×10^{-5}	0 01	No	No	Yes
FU4 - Site 36	Dieldrin, Arsenic		8×10^{-6}	0 06	*NA*	NA	No	NA	
FU5	PAHs, Dieldrin, Arsenic	109	3×10^{-5}	0.05	4×10^{-4}	NA	No	Yes	No
FU5 - Site77	PAHs, Arsenic		8×10^{-5}	0.05	*NA*	NA	No	NA	
FU6	PAHs, PCB, Dieldrin, Arsenic, Lead	3570 (A21, sumps in Bldgs Sump contents removed in 1999)	3×10^{-5}	0.5	1×10^{-4}	NA	No	Yes	No
FU6-Site 66	PAHs		2×10^{-5}	NA	*NA*	NA	No	NA	

ELCR Excess lifetime cancer risks
Note Target values estimated for lead are 1,536 mg/kg for industrial worker and 300 mg/kg for residential child health protection using blood-lead uptake models

[a] This table summarizes 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

Chemical	Industrial Worker		Residential	
	TR = 1E-06 (mg/kg)	THI =1 (mg/kg)	TR = 1E-06 (mg/kg)	THI =1 (mg/kg)
Metals				
Arsenic	3[b]	549	2[b]	197
Lead[a]	1536	1536	300	300
Pesticides	0.27	77	0 21	168
Dieldrin				
Semivolatiles	5	NC	4 3	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

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

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

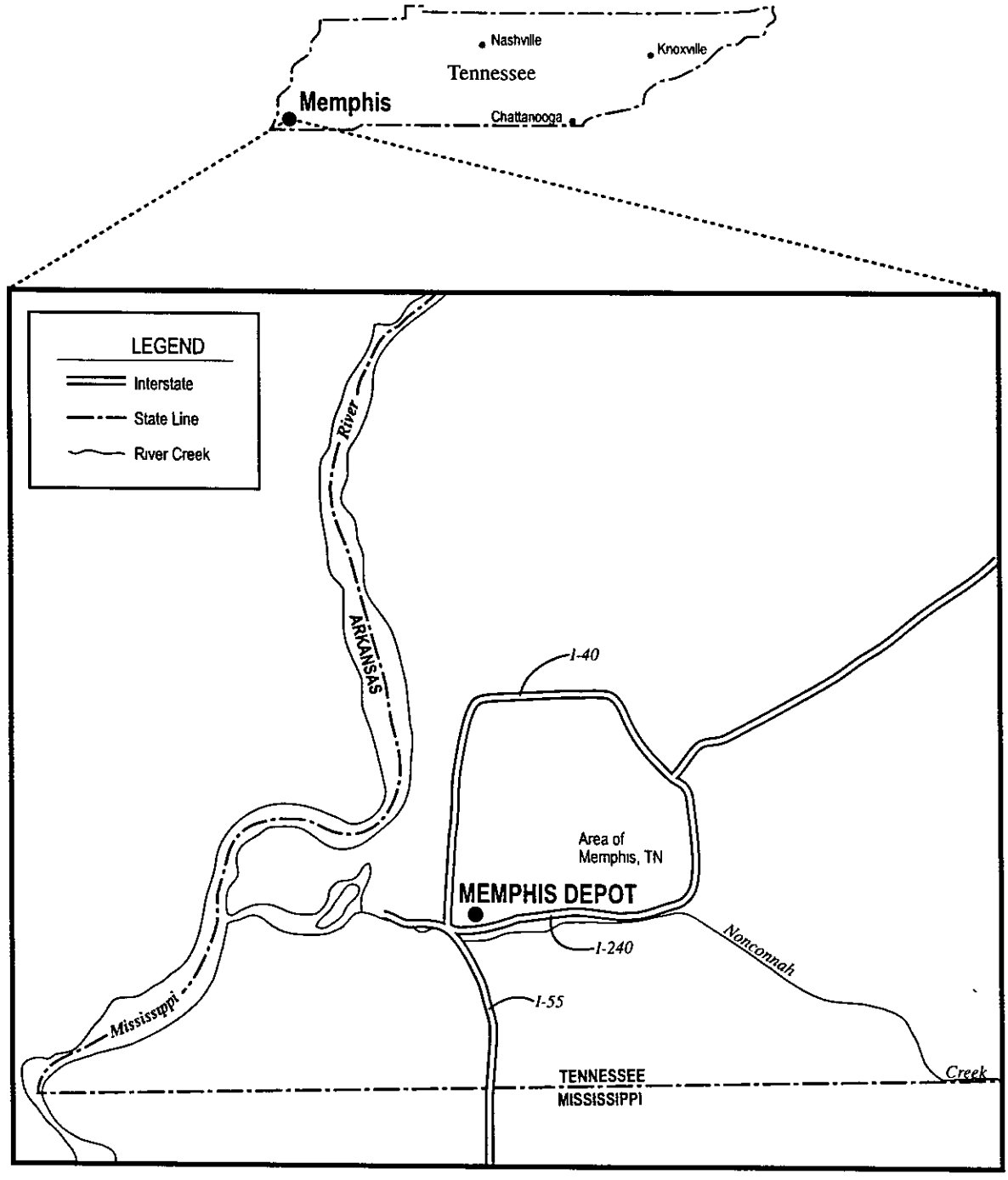
[b] Arsenic background value of 20 µg/kg is the target value (RGO) in Section 2.

NC A value not calculated
TR Target Risk
THI Target Hazard Index

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

Functional Unit	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 Ind. Target?	COCs[a] Industrial Scenario	Comment	COCsa Residential Scenario[b]	Comment
FU-1	PAHs, PCB, Dieldrin, Arsenic, and Lead	297	No	**Yes**	No	None	The cumulative risks were below 10-4 for industrial receptors, therefore, no COCs at FU-1	Arsenic, Dieldrin and PAHs[d]	Chemicals contributing to total risk at >1 x 10^{-4} levels for hypothetical residential receptors
FU-2	PAHs, Dieldrin, Arsenic	150[c]	No	**Yes**	No	None	No individual chemicals contributing to >10-4 risk level to an industrial worker	Arsenic, Dieldrin, PAHs[d]	Arsenic at 29 mg/kg, dieldrin 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^{-6} risk level to a future hypothetical resident
FU-3	PAHs, Arsenic, Lead	4150 (at RHA012)	No	**Yes**	**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 level to an industrial worker	Arsenic, Lead, PAHs[d]	Lead is above residential child health protective level of 300 mg/kg around the old paint shops PAHs from railroad tracks (sample location B[26 2]) present >10^{-4} cumulative risk level to a hypothetical resident
FU-4	PAHs, PCB, Dieldrin, TCDD, Arsenic, Lead	2800 (SGA286)	No	No	**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 below 10^{-4} level to a hypothetical resident TCDDs were below an ARAR of 1 ppb
FU-5	PAHs, Dieldrin, Arsenic	109	No	**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
FU-6	PAHs, PCB, Dieldrin, Arsenic, Lead	3570 (A21, sumps in Bldgs contents removed in 1999)	No	**Yes**	No	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} risk 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 Cafeteria

Yes Responses bolded, and italicized are above the target risk criteria
ELCR Excess lifetime 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
[a] COCs are chemicals contributing to risks at a cumulative risk of 10^{-4} with individual chemicals contributing to at least 10^{-6} risk levels or chemicals contributing to HI>1 0
[b] COPCs 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)
[c] 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
[d] PAHs across the main installation are associated with railroad tracks and asphalt paved roads and are not CERCLA releases Ongoing development at the site includes removal of the tracks



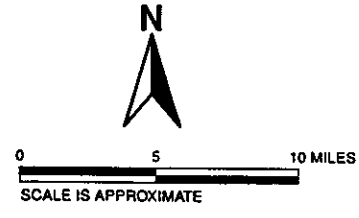


FIGURE 1-1
Memphis Depot Location in
Memphis Metropolitan Area
Memphis Depot Main Installation Soils FS

2901_02 (6/26/00)

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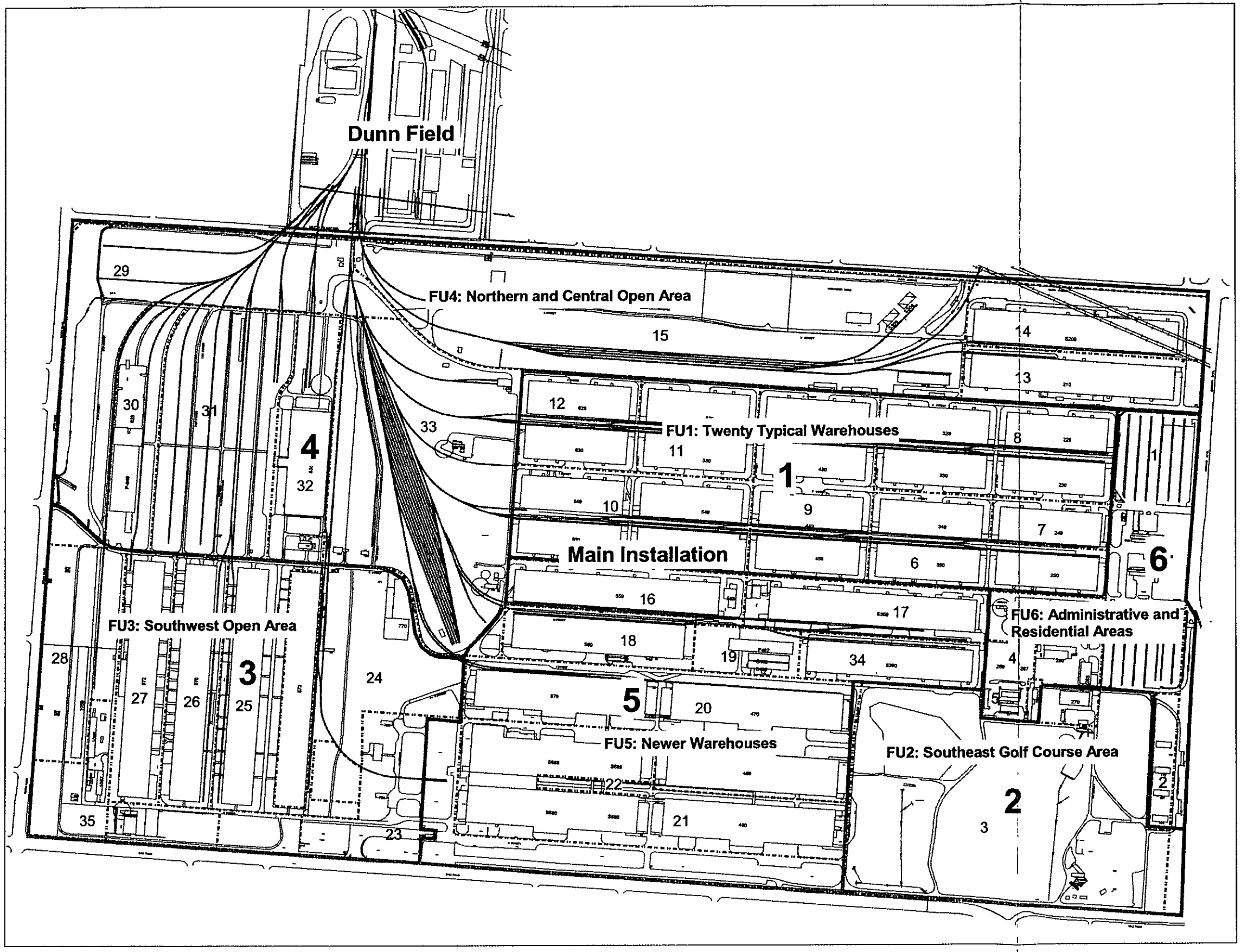

N

Legend

- 3 Functional Unit Number
- 26 BRAC Parcel Number
- BRAC Parcel Boundary
- Functional Unit Boundary

Note. Functional Unit 7 - Groundwater at the Main Installation

0 300 600 Feet

SCALE IS APPROXIMATE

FIGURE 1-2
Functional Units at Main Installation
Memphis Depot Main Installation Soils FS

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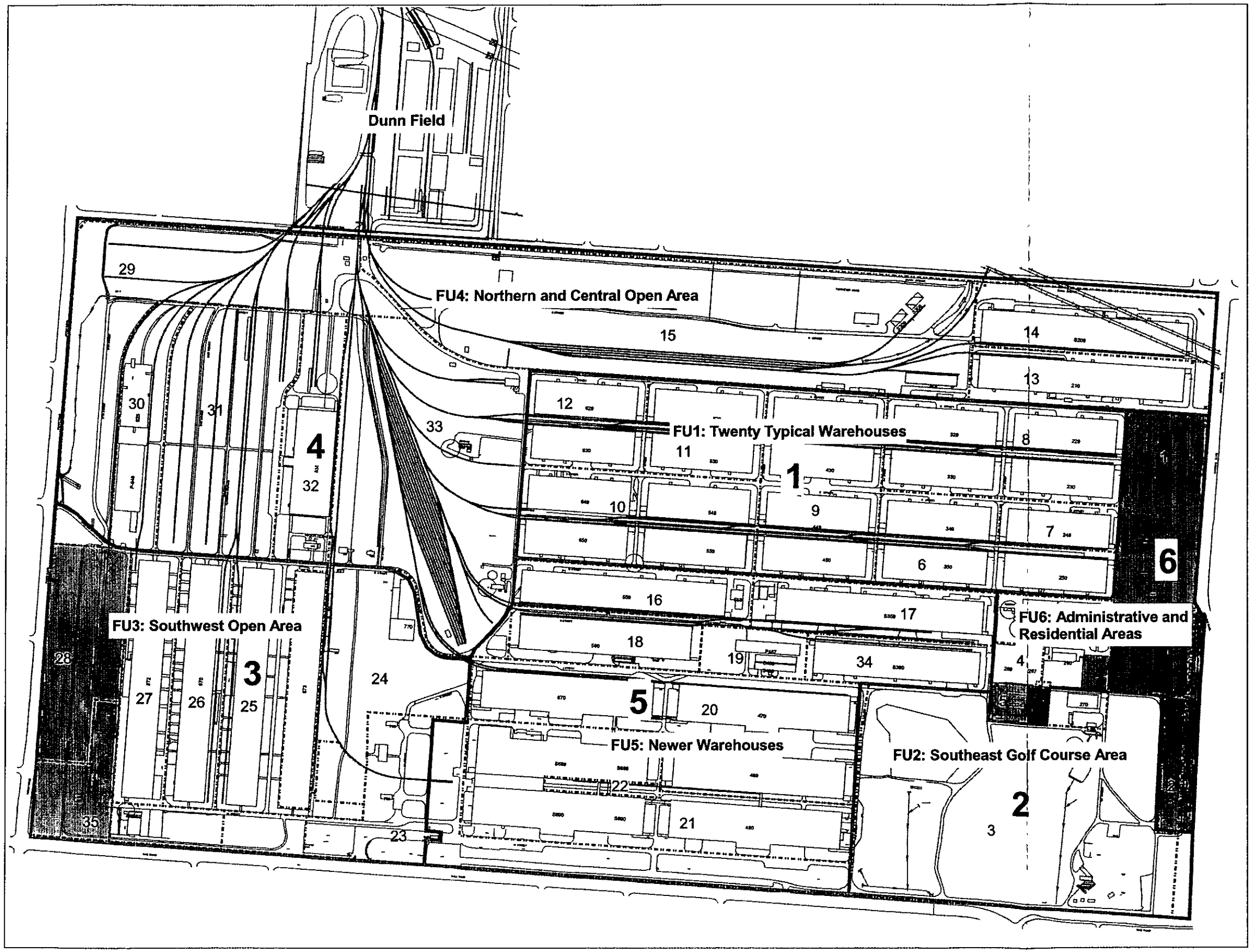

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Legend

- 3 Functional Unit Number
- 26 BRAC Parcel Number
- BRAC Parcel Boundary
- Functional Unit Boundary
- Eliminated Areas

0 300 600 Feet

SCALE IS APPROXIMATE

FIGURE 1-3
Main Installation Areas Eliminated From Feasibility Study
Memphis Depot Main Installation Soils FS

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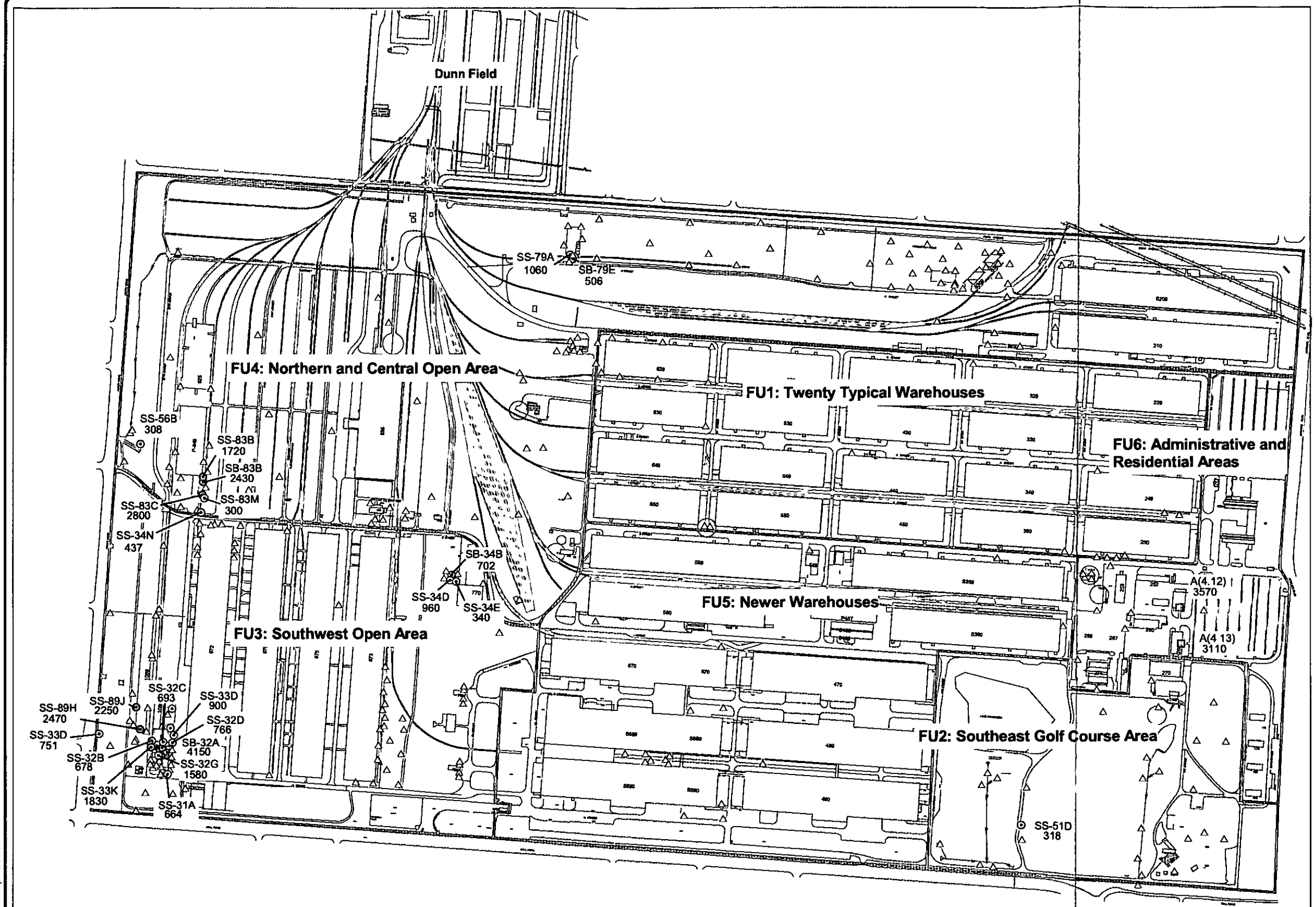

N

Legend

Lead Concentrations
- △ < 300 mg/kg
- ⊙ 300 - 1536 mg/kg
- ⊙ > = 1536 mg/kg
- Sump

Functional Unit Boundary
Depot Features

Note: 1) Lead concentrations < 300 mg/kg are not identified by sample number
2) A duplicate sample was taken at SS-51D with a lead value of 34 6 Therefore this sample point is not being used
3) Both Sumps have been cleaned

0 300 600 Feet
SCALE IS APPROXIMATE

FIGURE 1-4
Distribution of Surface Soil Lead Across the Main Installation
Memphis Depot Main Installation Soils FS

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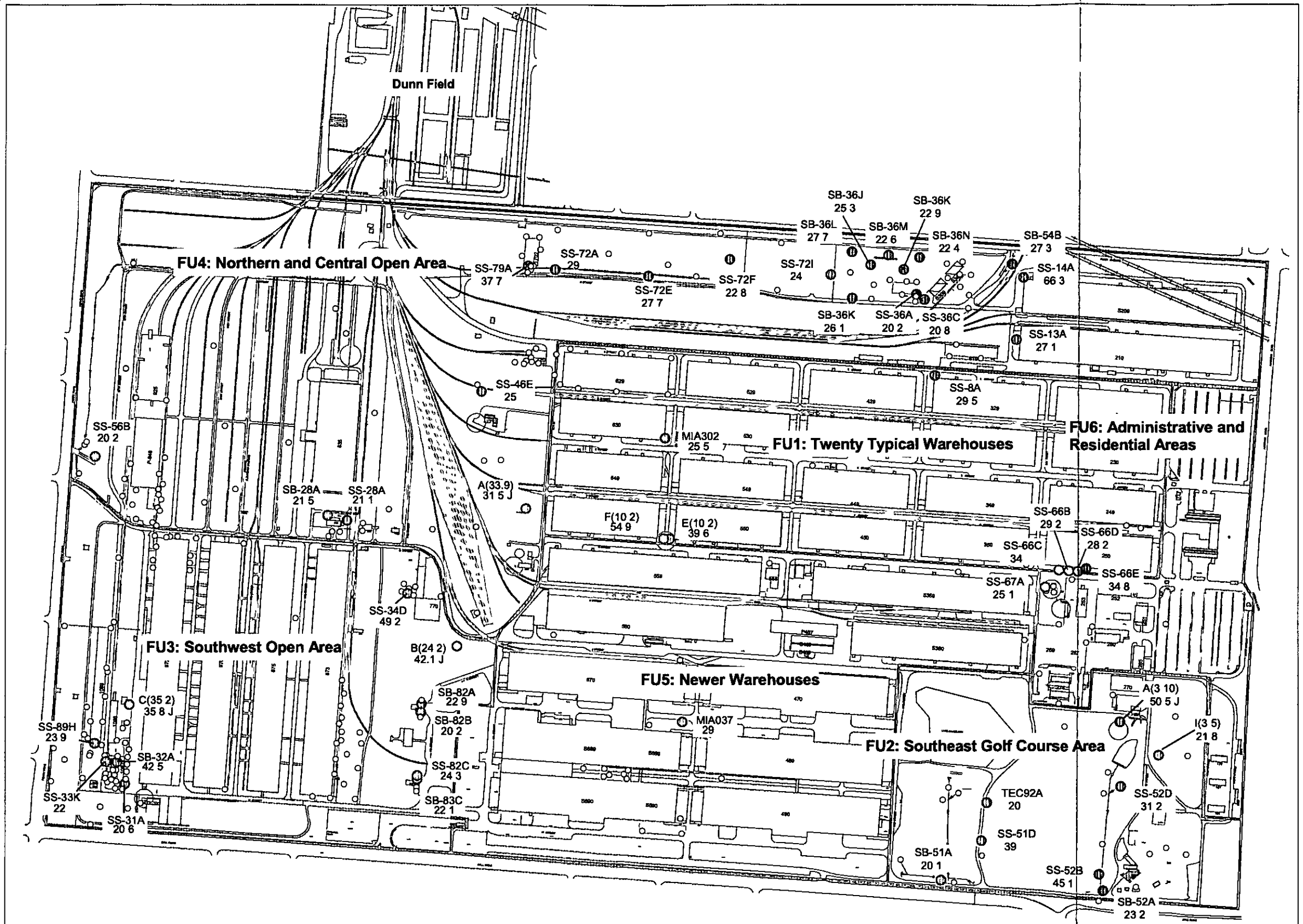

N

Legend

Arsenic Concentrations

- ○ < 20 mg/kg
- ○ > = 20 mg/kg

Functional Unit Boundary
Depot Features

Note: Arsenic concentrations < 20 mg/kg are not identified by sample number

0 300 600 Feet

SCALE IS APPROXIMATE

FIGURE 1-5
Distribution of Surface Soil Arsenic Across the Main Installation
Memphis Depot Main Installation Soils FS

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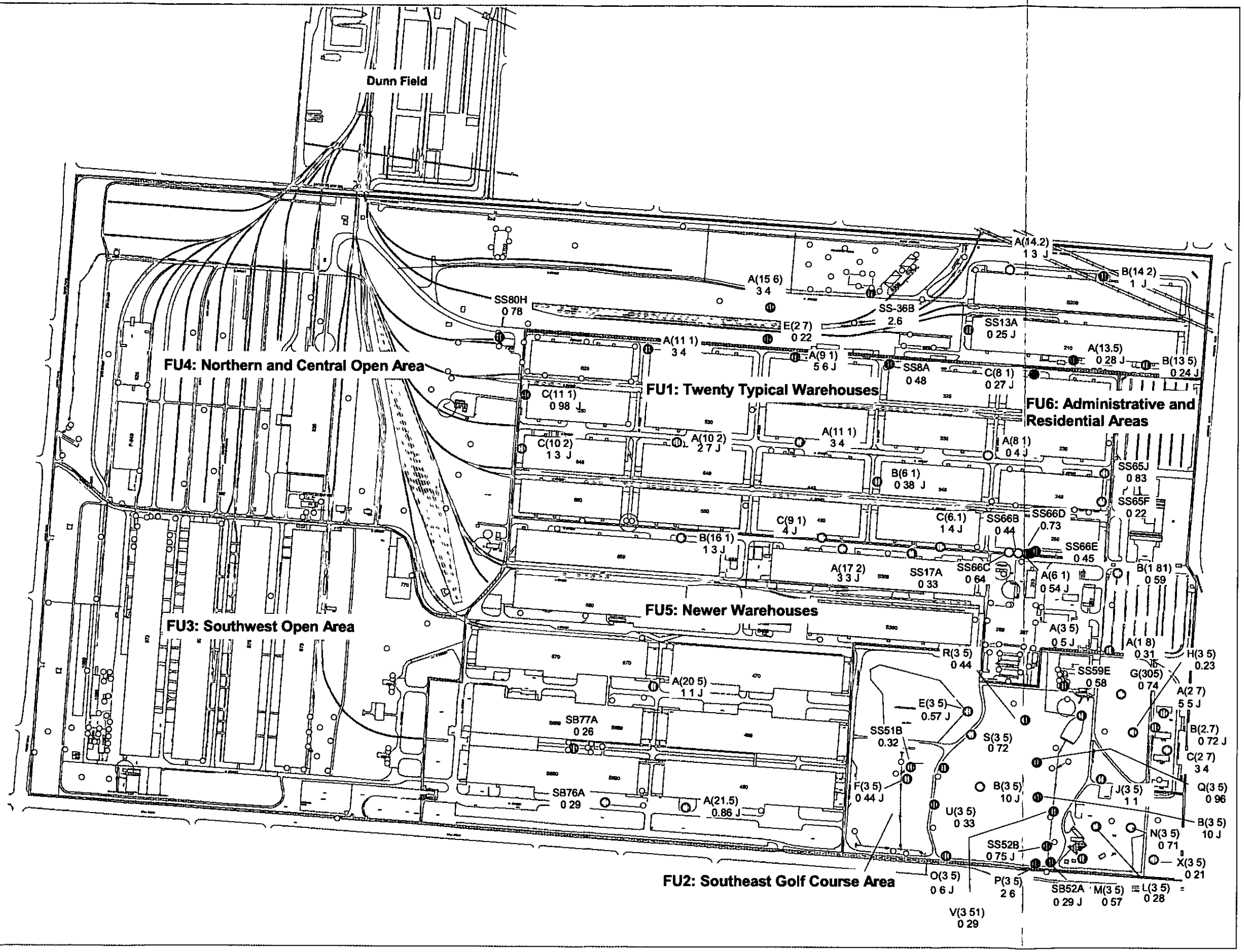

FIGURE 1-6
Distribution of Surface Soil Dieldrin Across the Main Installation
Memphis Depot Main Installation Soils FS

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TAB

Section 2

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 NPDES 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 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).

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 GRA. 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

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- 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.

TABLE 2-1
Remedial Action Objectives – Surface Soils
Memphis Depot Main Installation Soils FS - 7/3/00

Media/COC Group	COC	Exposure Route	Receptors	Remedial Goal Options[a]			
				Industrial Criteria[b]	Unlimited Recreational Criteria[b]	Residential Criteria[b]	Areas Affected[c]
Soil/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	[f]	[f]	20	Exceedance areas[e]
Soil/Pesticides	Dieldrin	Ingestion	Recreators and Residents	[f]	[f]	0.21	Exceedance areas, including entire golf course and recreational area

[a] ppm (mg/kg)

[b] Target concentrations developed based on risk assessment Lead target values were developed using blood-lead uptake models for adult workers and children (See Appendix A).

[c] Areas considered for alternatives analyses

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

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

[f] 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.

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 Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary 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 Depot 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 dieldrin, arsenic, and lead to prevent direct contact	Yes
		Clay Cap	Compacted clay placed over contaminated area. Clay should be covered by at least a foot of silty sand or sandy soil to maintain the integrity of the clay cap.	Native soil with erosion contol, applicable for dieldrin, arsenic, and lead to prevent direct contact.	Yes
		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	Native soil with erosion contol, applicable for dieldrin, arsenic, and lead to prevent direct contact	Yes
		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.	Light industrial with concrete or asphalt is compatible with existing use.	Yes
		Multilayered 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 properly designed, will meet RCRA requirements	Applicable to dieldrin, arsenic, and lead	Yes
		Chemical Sealant/Stabilizers	Water-dispersible emulsions and/or resins placed over contaminated areas to form a crust that reduces water and wind or dust erosion. Most are nontoxic to plants and animals. Temporary cover only.	Effects are temporary only.	No
	Vertical Barriers	Soil-Bentonite Slurry Wall	Trench around contaminated area excavated and filled with a bentonite slurry. Trench backfilled with a soil-bentonite mix.	Mobility not an issue.	No
		Cement-Bentonite Slurry Wall	Trench around contaminated area excavated and filled with a cement bentonite water slurry. Cement sets and forms the wall.	Mobility not an issue.	No
		Vibrating Beam Barrier Installation	Vibratory force used to advance steel beam into ground: injection of a relatively thin wall of cement or bentonite as beam is withdrawn.	Mobility not an issue.	No
		Sheet Piling	Steel sheet piling driven along contamination boundaries.	Mobility not an issue.	No
		Permeability Reduction Agents	Cement chemical grout or organic polymer injected into the soil matrix to reduce permeability. Experimental process option.	Mobility not an issue.	No
		Ground Freezing (CRYOCELL process)	Conventional ground freezing technology is used to form a flow-impervious, removable, and fully monitored ice barrier that circumscribes the contaminant source in-situ.	Mobility not an issue.	No
	Horizontal Barriers	Block Displacement	Controlled injection of slurry in notched injection holes produces a horizontal barrier beneath contamination. Experimental process option.	Mobility not an issue.	No
		Grout Injection	Grout pressure-injected at depth through closely spaced drilled holes.	Mobility not an issue.	No

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 Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Containment (continued)		Ground Freezing	Similar to vertical barriers by ground freezing. Experimental process option.	Mobility not an issue.	No
		Liners	Liners placed to restrict vertical flow can be constructed of the same materials considered for cap construction.	Mobility not an issue.	No
	Surface Controls	Grading	Reshaping of topography to manage surface water infiltration and runoff to control erosion.	Applicable to dieldrin, arsenic, and lead.	Yes
		Revegetatation	A systematic revegetation plan includes selection of a suitable plant species, seedbed preparation, seeding/planting, mulching and/or chemical stabilization, fertilization, and maintenance.	Cap maintenance option	Yes
		Erosion Control	Natural or man-made materials used to prevent erosion and subsequent exposure to /transport of contaminated soils	Cap maintenance option	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	Cap maintenance option	Yes
	Dust and Vapor Suppression	Water	Water sprayed over area of concern to prevent dust generation.	Not applicable, airborne particles not a problem.	No
		Organic Agents/Polymers/Foams	Organic agents/polymers/foams sprayed over area of concern to prevent dust/vapor generation.	Not applicable, airborne particles not a problem.	No
		Membranes/Tarps	Membranes or tarps are spread over area of concern to prevent dust/vapor generation.	Not applicable, airborne particles not a problem.	No
		Hygroscopic Agents	Hygroscopic salts absorb moisture into the soil in which they are mixed.	Not applicable, airborne particles not a problem.	No
Removal	Excavation	Excavation	Excavation of contaminated solids can use ordinary construction equipment backhoes, bulldozers, and front-end loaders(s).	Applicable to dieldrin, arsenic, and lead.	Yes
Treatment	In-situ Biological Treatment	Aerobic Cometabolic Bioremediation	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 (fortuitous cometabolism).	Not applicable to site contamination.	No
		Anaerobic Bioremediation	Subsurface delivery of electron donors within the target zone to stimulate anaerobic biodegradation of chlorinated compounds by reductive dechlorination.	Not applicable to site contamination.	No
		Phytoremediation	Use of plants and their associated rhizospheric mocroorganisms to remove, degrade, or contain chemical contaminants in soil.	Applicable for arsenic and lead.	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 (as shown in bench-scale treatability study)	Yes
		Bioventing	Oxygen is delivered to contaminated unsaturated soils by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation.	Not applicable to site contamination.	No
	In-situ Physical-Chemical Treatment	Pneumatic Fracturing	High-pressure injection of air to create self-propped subsurface fracture patterns that minimize contaminant travel time via diffusion. Complements vapor and fluid extraction technologies.	Not applicable to surface contamination.	No

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 Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Treatment (continued)	In-situ Physical-Chemical Treatment (continued)	Hydraulic Fracturing	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.	Not applicable to surface contamination.	No
		In-Situ Soil Mixing	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.	Not applicable to surface contamination.	No
		Electrokinetic Treatment	Creation 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.	Not applicable to surface contamination.	No
		Soil Vapor Extraction	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.	Not applicable to surface contamination.	No
		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, arsenic, and lead.	Yes
		LASAGNA™ Process	Electro-osmosis is used to mobilize contaminants to installed in-situ treatment zones, where contaminants are removed by adsorption, stabilization, or chemical degradation.	Not applicable to surface contamination.	No
		Surfactant/Cosolvent Flushing	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.	Not applicable for site contaminants.	No
		In-Situ Chemical Oxidation	Aqueous injection of an oxidizing agent (peroxide/iron, permanganate, or ozone) to promote abiotic in-situ oxidation of chlorinated organic compounds.	Not applicable for contaminants present.	No
	In-situ Thermal Treatment	Six-Phase Soil Heating	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.	Not applicable to subsurface contamination.	No
		Radio Frequency Heating	The introduction of radio frequency energy to heat the subsurface and vaporize target contaminants. Complements vapor extraction applications.	Not applicable to subsurface contamination.	No
		Electrical Resistance Heating	The introduction of electrical energy to heat the subsurface and vaporize target contaminants. Complements vapor extraction applications.	Not applicable to subsurface contamination.	No
		Steam Heating	The introduction of steam to heat the subsurface and vaporize target contaminants. Complements vapor and liquid extraction applications.	Not applicable to subsurface contamination.	No
		Dynamic Underground Stripping (DUS)	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.	Not applicable to subsurface contamination.	No
		Vitrification	Electrodes are used to melt contaminated soils at high temperature to form a glass and crystalline structure with very low leaching characteristics.	Applicable for dieldrin, arsenic, and lead	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 Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Treatment (continued)	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 Biological Treatment	**Aerobic Cometabolic Bioremediation**	**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).**	**Not applicable for contaminants present.**	**No**
		Anaerobic Bioremediation	**Bioreactor containing contaminants and electron donors to stimulate anaerobic biodegradation of chlorinated compounds by reductive dechlorination.**	**Not applicable for contaminants present.**	**No**
	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.	Applicable for dieldrin.	Yes
		Reductive Dehalogenation: Based-Catalyzed (BCD)	**Contaminated soil 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.**	**Halogenated compounds are not a COC for soils.**	**No**
		Reductive Dehalogenation: Glycolate	**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.**	**Halogenated compounds are not a COC for soils.**	**No**
		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 dieldrin, arsenic, and lead.	Yes
		Soil Vapor Extraction	**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.**	**Not applicable to site contamination.**	**No**
		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, and lead	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 for treatment and further use.	Applicable for dieldrin	Yes
	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.	Applicable for dieldrin	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.	Applicable for dieldrin	Yes
		Open Burn/Open Detonation	**Open burn: explosives/munitions are destroyed by self-sustained combustion, which is ignited by an external source. Open detonation: detonatable explosives/munitions are destroyed by a detonation.**	**Not applicable to site contamination.**	**No**

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 Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Treatment (continued)	Ex-situ Thermal Treatment (continued)	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	Applicable for dieldrin.	Yes
		Vitrification	Contaminated soils are melted at high temperature to form a glass and crystalline structure with very low leaching characteristics	Applicable for dieldrin, arsenic, and lead	Yes
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	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 2-4
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	Secondary Screening Comments	Pass Secondary 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 silty sand or sandy soil to maintain the integrity of the clay cap.**	**More expensive than native soil option.**	**No**
		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.**	**No**
		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
		Multilayered 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 properly designed, will meet RCRA requirements.**	**More expensive than native soil or clay.**	**No**
	Surface Controls	Grading	Reshaping of topography to manage surface water infiltration and runoff to control erosion.	Supports other technologies.	Yes
		Revegetatation	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

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	Secondary Screening Comments	Pass Secondary 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.**	**No**
		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 for treatment and further use.**	**Generates a second waste to have to manage onsite.**	**No**
	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.	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.**	**No**
		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.**	**No**
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 2-5
Final Remedial Technologies and Process Options for Soil Contaminants· PAH, 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
		Revegetatation	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, bulldozers, 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 (CONTINUED)
Final Remedial Technologies and Process Options for Soil Contaminants. PAH, Dieldrin, Arsenic, and Lead
Memphis Depot Main Installation Soils FS - 7/3/00

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 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
		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.
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
	Landfill	Hazardous Waste Landfill	Solid hazardous wastes are permanently disposed of in a RCRA-permitted landfill
		Non-Hazardous Waste Landfill	Solid nonhazardous wastes are permanently disposed of in a non-RCRA landfill

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
		Landfill	RCRA Landfill Non-RCRA Landfill

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.

3.1.4 Alternative 4 – In-situ Soil Treatment

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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	✔		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 is 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 is 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.

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 in-situ 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	✔		Keep per CERCLA
2	✔		Quick and inexpensive
3	✔		Cover could be an element of future infrastructure
4	✔		Proven by pilot tests
5		✔	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.

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

			Preliminary Alternatives						
			1	2	3	4	5	6	7
	General Response Action	Technology Type	No Action	Institutional Controls	Containment (Capping)	In-situ Soil Treatment	Soil Excavation and Biological Treatment	Soil Excavation and Thermal Treatment	Soil Excavation and Off-site Disposal
Medium									
Surface 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					•	•	
		Landfill							•

TAB

Section 4

4.0 Detailed Analysis of Alternatives

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

- 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-of-magnitude 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 (≥ 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.

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

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

[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;

- 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

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- 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 Recreational 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	X	1,960,200
3	NR	NR	---	---	X	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 ft^2 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 ft^2 [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 ft^2 [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 ft^2 = 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 difficult because 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 ft^2 [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 ft^2 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 ft^2 including the 7,200 ft^2 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.

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:

	Industrial Use			Residential Use		
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	X	56,600[b]	1,960,200[b]
3	NR	NR	NR	X	5,500	NR
4	X[c]	7,200	NR	X	274,700[d,e]	121,500[d]
5	NR	NR	NR	X	7,500	32,000
6	NR	NR	NR	X	400	NR

NR Not required

[a] 15,000 ft^2 of FU1 contains both arsenic and dieldrin; therefore, the 15,000-ft^2 area must receive both soil stabilization and remediation treatment Total area in FU1 = 206,300 ft^2

[b] The 56,600-ft^2 area contains arsenic and dieldrin, therefore the area must receive both soil stabilization and remediation treatment. Total area in FU2 = 1,960,200 ft^2

[c] Includes site controls (fencing and signage).

[d] 10,000 ft^2 of FU4 contains both arsenic and dieldrin; therefore, the 10,000-ft^2 area must receive both soil stabilization and remediation treatment. Total area in FU4 = 386,200 ft^2

[e] Includes the 7,200 ft^2 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 ft^2 [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 soil would 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 contamination to levels acceptable for future residential use. Both the arsenic- and lead-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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FU	Industrial Use			Residential Use		
	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	X	56,600[b]	1,960,200[b]
3	NR	NR	NR	X	5,500	NR
4	X[c]	7,200	NR	X	274,700[d, e]	121,500[d]
5	NR	NR	NR	X	7,500	32,000
6	NR	NR	NR	X	400	NR

NR Not required

[a] 15,000 ft^2 of FU1 contains both arsenic and dieldrin; therefore, the 15,000-ft^2 area must receive both soil stabilization and remediation treatment Total area in FU1 = 206,300 ft^2

[b] The 56,600-ft^2 area contains arsenic and dieldrin; therefore the area must receive both soil stabilization and remediation treatment. Total area in FU2 = 1,960,200 ft^2.

[c] Includes site controls (fencing and signage)

[d] 10,000 ft^2 of FU4 contains both arsenic and dieldrin; therefore, the 10,000-ft^2 area must receive both soil stabilization and remediation treatment. Total area in FU4 = 386,200 ft^2.

[e] Includes the 7,200 ft^2 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 ft^2 [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 ft^2 [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 ft^2 = 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 non-hazardous RCRA Subtitle D landfill.
- 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.

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

	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 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

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 is 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 Off-site 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	$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 4-1
COCs Associated with Alternate Land Uses for Each FU
Memphis Depot Main Installation Soils FS – 7/3/00

510 98

	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

TABLE 4-2
Areas Requiring Remediation
Memphis Depot Main Installation Soils FS – 7/3/00

Land Use Scenario	Number of Areas Requiring Remediation	Areas of Contaminated Surface Soil (ft^2)						
		Lead Only	Arsenic Only	Dieldrin Only	Lead and Arsenic	Lead and Dieldrin	Dieldrin and Arsenic	Total in FU
Industrial Use								
FU4	1	7,200	NA	NA	NA	NA	NA	7,200
Residential Use								
FU1	17	NA	30,300	161,000	NA	NA	15,000	206,300
FU2	1	NA	NA	1,903,600	NA	NA	56,600	1,960,200
FU3	4	1,700	2,900	NA	900	NA	NA	5,500
FU4	20	10,600[a]	251,500	111,500	2,600	NA	10,000	386,200[a]
FU5	8	NA	7,500	32,000	NA	NA	NA	39,500
FU6	1	NA	400	NA	NA	NA	NA	400

NA Not applicable

[a] Includes the 7,200 ft^2 exceeding Industrial Use criteria

TABLE 4-3
FU1-Twenty Typical Warehouses and FU5-Newer Warehouses: Summary of Individual Detailed Analysis of Surface Soil Alternatives
Memphis Depot Main Installation Soils FS – 7/3/00

510 100

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 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^2), 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 of 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 ft^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. This alternative does not provide additional institutional controls and other restrictions, and relies on existing land use controls to prevent future **residential** use.	Risk would be reduced because institutional controls can prevent future **residential** use, and exposure to dieldrin and arsenic in the surface soil Ongoing risks from **industrial** use of the site are acceptable.	This alternative does 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 Long-term institutional controls preventing disturbance of the cover are necessary to maintain protection of human health.	This alternative does protect human health for future **residential** use. Enhanced bioremediation of contaminated 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 arsenic to levels acceptable for future **residential** use. Institutional controls preventing future **residential** use of the site until the remedial action is complete are necessary to maintain protection for human health.	This alternative does 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.
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 **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 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 emissions 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.

TABLE 4-3
FU1-Twenty Typical Warehouses and FU5-Newer Warehouses: Summary of Individual Detailed Analysis of Surface Soil Alternatives
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
					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.
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 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 confirmed clean by laboratory testing prior to placement on-site.
LONG-TERM EFFECTIVENESS AND PERMANENCE					
Magnitude of Residual Risk **(Direct Contact/Soil Ingestion)**	The source has not been removed Unacceptable risk will remain for future **residential** use. Existing risk is acceptable for **industrial** use. Concentrations of dieldrin may decrease with time through natural biodegradation.	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. Concentrations of dieldrin may decrease with time through natural biodegradation.	Future **residential** risk at the site is acceptable as long as the protective 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 potentially disturb the cover would be difficult in a **residential** setting. Therefore, risk could increase over time.	Future **residential** use risk at the site from contaminated surface soil is reduced to acceptable levels by treatment that destroys dieldrin and stabilizes arsenic.	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.
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 future **residential** use. Long-term oversight by the lead agency would be required to maintain protective layers of institutional and land-use controls to prevent 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 prevent 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 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 the 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 covers are intact and provide adequate protection of human health for future **residential** use	Contaminated soil would be effectively bioremediated 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.

TABLE 4-3
FU1-Twenty Typical Warehouses and FU5-Newer Warehouses: Summary of Individual Detailed Analysis of Surface Soil Alternatives
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
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.	Enhanced 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: 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.	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.

TABLE 4-3
FU1-Twenty Typical Warehouses and FU5-Newer Warehouses· Summary of Individual Detailed Analysis of Surface Soil Alternatives
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
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 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	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 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

TABLE 4-3
FU1-Twenty Typical Warehouses and FU5-Newer Warehouses: Summary of Individual Detailed Analysis of Surface Soil Alternatives
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	
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 future **residential** use.		Equipment and most materials are readily available for enhanced biodegradation of dieldrin-contaminated soil and stabilization of arsenic-contaminated soil. The bench-scale tested biological amendment is a proprietary product currently available from only one source. A number of stabilization amendments are 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	No technology is 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	**FU1 and FU5**	**All FUs[a]**	**FU1**	**FU5**	**FU1**	**FU5**	**FU1**	**FU5**
Industrial Use:			This alternative is not necessary for **industrial** use; therefore, there are no costs.		This alternative is not necessary for **industrial** use; therefore, there are no costs.		This alternative is not necessary for **industrial** use; therefore, there are no costs.	
Capital Cost	$0	$14,000						
First-Year Annual O&M Cost	$0	$3,800						
Present Worth O&M Cost	$0	$57,000						
Total Present Worth Cost	$0	$71,000						
Residential Use:		This alternative is designed to prevent **residential** use. Costs are included under the **Industrial** Use						
Capital Cost	$0		$305,000	$67,000	$146,000	$26,000	$608,000	$152,000
First-Year Annual O&M Cost	$0		$4,200	$1,200	$74,400	$13,600	$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	$70,000	$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 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, and soil would be disposed of in a permitted off-site location.	
COMMUNITY ACCEPTANCE	This alternative 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 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 likely be acceptable to the community, allowing future **residential** use since all on-site soil exceeding **residential** use criteria would be removed, and soil would be disposed of in a permitted off-site location	

[a] The cost to implement institutional controls applies to all FUs combined.

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, there are no COCs for FU1 or FU5

For **residential** use, dieldrin and arsenic are COCs for FU1 and FU5.

TABLE 4-4
FU2-Southeast Golf Course Area. Summary of Individual Detailed Analysis of Surface Soil Alternatives
Memphis Depot Main Installation Soils FS- 7/31/00

510 105

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-contaminated soil (a total of 45 acres), and institutional controls prohibiting residential use during 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 ingestion) to dieldrin and arsenic in the surface soil under this alternative Currently such risks are acceptable for **recreational** use but not for future **residential** use. This alternative does not provide additional institutional controls and other restrictions, and relies on existing land use controls to prevent future **residential** use.	There would be a reduction in risk because institutional controls can prevent future **residential** use, and exposure to dieldrin and arsenic in the surface soil. Ongoing risks from **recreational** use of the site are acceptable	This alternative does provide future **residential** use through the protection of human health 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** use. Long-term institutional controls preventing disturbance of the cover are necessary to maintain protection of human health.	This alternative does protect human health 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 decreases direct contact risk and soil ingestion risk of arsenic to levels acceptable for future **residential** use Institutional controls preventing future **residential** use of the site until the remedial action is complete are necessary to maintain protection of human health	This alternative does protect human health for future **residential** use. Excavation, transportation and off-site disposal of contaminated surface soil at a permitted, controlled landfill removes direct contact risk and soil ingestion risk of dieldrin- and arsenic-contaminated surface soil
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 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).

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

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 confirmed clean by laboratory testing prior to placement on-site.
LONG-TERM EFFECTIVENESS AND PERMANENCE					
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. Concentrations of dieldrin may decrease with time through natural biodegradation	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. Concentrations of dieldrin may decrease with time through natural biodegradation.	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 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. Since the majority of FU2 would be covered, **residential** development would be problematic	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
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 prevent 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 alternative is marginal because long-term oversight by the lead agency would be required to prevent 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.

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

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
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 Alternative 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 **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· 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.

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

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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
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.

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

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 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 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 **recreational** use; therefore, there are no costs.	This alternative is not necessary for **recreational** use; therefore, there are no costs	This alternative is not necessary for **recreational** use; therefore, there are no costs.
Capital Cost	$0	$14,000			
First-Year Annual O&M Cost	$0	$3,800			
Present Worth O&M Cost	$0	$57,000			
Total Present Worth Cost	$0	$71,000			
Residential Use:		This alternative is designed to prevent **residential** use. Costs are included under the **Industrial** Use.			
Capital Cost	$0		$2,799,000	$1,608,000	$5,097,000
First-Year Annual O&M Cost	$0		$38,100	$831,900	$0
Present Worth O&M Cost	$0		$576,000	$1,762,000	$0
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. Although **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 controls applies to all FUs combined
Costs are expressed as order-of-magnitude estimates.
The basis for the cost estimates is included in Appendix B of this FS
For **recreational** use, there are no COCs for FU2
For **residential** use, dieldrin and arsenic are COCs for FU2.

TABLE 4-5
FU3-Southwest Open Area· Summary of Individual Detailed Analysis of Surface Soil Alternatives
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 does not provide additional institutional controls and other restrictions, and relies on existing land use controls to prevent future **residential** use	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 does 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 maintain protection of human health.	This alternative does 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 protection of human health.	This alternative does 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.
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 Alternative 1.
Location-Specific ARARs	Currently, FU3 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 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.	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 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 backfilling operation would be required. Existing NPDES compliance of stormwater in contact with contaminated soil during construction activities would also be required

TABLE 4-5
FU3-Southwest Open Area: Summary of Individual Detailed Analysis of Surface Soil Alternatives
Memphis Depot Main Installation Soils FS – 7/3/00

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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
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 criteria 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 PERMANENCE					
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. 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.	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.
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 prevent 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 prevent 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.	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 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

TABLE 4-5
FU3-Southwest Open Area. Summary of Individual Detailed Analysis of Surface Soil Alternatives
Memphis Depot Main Installation Soils FS – 7/3/00

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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
Irreversible Treatment	There is no irreversible treatment under this alternative.	See Alternative 1.	See Alternative 1.	The treatment process is irreversible 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 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 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 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. 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 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 remedial areas, or add treatment.

TABLE 4-5
FU3-Southwest Open Area: Summary of Individual Detailed Analysis of Surface Soil Alternatives
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
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 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.	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 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	There are no services or capacities 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.
Availability of Necessary Equipment, Specialists, and Materials	There are no equipment, specialists, or materials required under this alternative.	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 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.
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	**FU3**	**All FUs[a]**	**FU3**	**FU3**	**FU3**
Industrial Use:			This alternative is not necessary for **industrial** use; therefore, there are no costs.	This alternative is not necessary for **industrial** use; therefore, there are no costs.	This alternative is not necessary for **industrial** use; therefore, there are no costs.
Capital Cost	$0	$14,000			
First-Year Annual O&M Cost	$0	$3,800			
Present Worth O&M Cost	$0	$57,000			
Total Present Worth Cost	$0	$71,000			
Residential Use:		This alternative is designed to prevent residential use. Costs are included under the **Industrial** Use.			
Capital Cost	$0		$18,000	$5,000	$106,000
First-Year Annual O&M Cost	$0		$1,200	$1,750	$0
Present Worth O&M Cost	$0		$18,000	$17,000	$0
Total Present Worth Cost	$0		$36,000	$22,000	$106,000

TABLE 4-5
FU3-Southwest Open Area: Summary of Individual Detailed Analysis of Surface Soil Alternatives
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
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 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. 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 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.

[a] The cost to implement institutional controls applies to all FUs combined. 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, there are no COCs for FU3

For **residential** use, lead and arsenic are COCs for FU3

TABLE 4-6A
FU4-Northern and Central Open Area. Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Industrial Land Use* Scenario
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 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 ft^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 are not acceptable for **industrial** use. This alternative does not 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 does 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 risk 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 does 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 does protect human health for **industrial** use Excavation, transportation, and off-site disposal at a permitted, controlled landfill 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 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 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

TABLE 4-6A
FU4-Northern and Central Open Area· Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Industrial Land Use* Scenario
Memphis Depot Main Installation Soils FS – 7/3/00

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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
					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	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** risk 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 lead-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 PERMANENCE					
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. Long-term control of activities that could potentially disturb the cover would be difficult in an **industrial** setting; therefore, risk could increase over time	**Industrial** use risk at the site from contaminated surface soil is reduced to acceptable levels by treatment that fixes lead.	**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.
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 prevent **industrial** use in the area of concern and prevent **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 prevent 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					
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 lead-contaminated surface soil	See Alternative 1

TABLE 4-6A
FU4-Northern and Central Open Area: Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Industrial Land Use* Scenario
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
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 **industrial** 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.

TABLE 4-6A
FU4-Northern and Central Open Area· Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Industrial Land Use* Scenario
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
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 controls 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**
Industrial Use:					
Capital Cost	$0	$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

TABLE 4-6A
FU4-Northern and Central Open Area: Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Industrial Land Use* Scenario
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
STATE ACCEPTANCE	This alternative would not likely be acceptable to state regulators. This alternative does not reduce the risk for **industrial** use.	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.
COMMUNITY ACCEPTANCE	This alternative would not likely be acceptable to the community. This alternative does not reduce the risk for **industrial** use across the 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.

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.

TABLE 4-6B
FU4-Northern and Central Open Areas: Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Residential Land Use* Scenario
Memphis Depot Main Installation Soils FS - 7/3/00

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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 FU4.	***This alternative does not apply 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 ft^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 are not acceptable **residential** use.	Alternative 2 does not apply to the **residential** use scenario.	This alternative does provide for the protection of human health for future **residential** use by covering dieldrin-, 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 does provide protection of human health for future **residential** use by treatment. Enhanced bioremediation of contaminated 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 protection of human health.	This alternative does 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 scenario	See Alternative 1.	See Alternative 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 Alternative 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 dieldrin- 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.

TABLE 4-6B
FU4-Northern and Central Open Areas· Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Residential Land Use* Scenario
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
					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.
Other Criteria and Guidance	Would not meet chemical-specific RAOs for future **residential** 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 soil RAOs for future **residential** use of FU4. Imported soil for backfill would be confirmed clean by laboratory testing prior to placement on-site.
LONG-TERM EFFECTIVENESS AND PERMANENCE					
Magnitude of Residual Risk **(Direct Contact/Soil Ingestion)**	The source has not been removed. Unacceptable risk will remain for future **residential** use. Concentrations of dieldrin may decrease with time through 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 potentially disturb the cover would be difficult in a **residential** setting; therefore, risk could increase over time.	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.
Adequacy and Reliability of Controls	There are no actions or controls; therefore, reliability is not applicable Surface soil would remain in place.	Alternative 2 does not apply to the **residential** use scenario.	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 prevent 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. Therefore, no management beyond the remedial implementation period is required.	Excavation, transportation, and off-site disposal effectively removes soil 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.
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.	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.	Contaminated soil would be effectively biotreated 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.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT					
Treatment Process Used	This alternative does not include active treatment of contaminated surface soil	Alternative 2 does not apply to the **residential** use scenario	See Alternative 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.

TABLE 4-6B
FU4-Northern and Central Open Areas· Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Residential Land Use* Scenario
Memphis Depot Main Installation Soils FS - 7/3/00

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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
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 **residential** use. 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.
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 Alternative 3	See Alternative 3.

TABLE 4-6B
FU4-Northern and Central Open Areas: Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Residential Land Use* Scenario
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
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 months after biological treatment for **residential** use.	Soil would be excavated and transported from the site within 1 year allowing **residential** use after implementation.
IMPLEMENTABILITY					
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 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 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 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.	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

TABLE 4-6B
FU4-Northern and Central Open Areas: Summary of Individual Detailed Analysis of Surface Soil Alternatives for *Residential Land Use* Scenario
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
Availability of Necessary Equipment, Specialists, and Materials	No equipment, specialists, or materials are required under this alternative.	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. 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.	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	$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-magnitude estimates.

The basis for the cost estimates is included in Appendix B of this FS

For **residential** use, dieldrin, lead, and arsenic are COCs for FU4.

TABLE 4-7
FU6-Administrative Area*: Summary of Individual Detailed Analysis of Surface Soil Alternatives
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 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^2), coupled with institutional controls preventing disturbance of the cover.***	***This alternative includes stabilization of arsenic-contaminated surface soil (a total area of 400 ft^2) and institutional controls prohibiting residential use during implementation of the remedial action at FU6.***	***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. This alternative does not 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 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 does 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 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 does 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 does 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 the soil ingestion risk of arsenic-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 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, 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 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.	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

TABLE 4-7
FU6-Administrative Area*: Summary of Individual Detailed Analysis of Surface Soil Alternatives
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
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 prevented 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 prior 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 PERMANENCE					
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. 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	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.
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 prevent future **residential** use	This alternative would contain contaminated surface soil and minimize the 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 prevent 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 alternative.	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.
Irreversible 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

TABLE 4-7
FU6-Administrative Area*. Summary of Individual Detailed Analysis of Surface Soil Alternatives
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
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 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 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 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 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.

TABLE 4-7
FU6-Administrative Area*: Summary of Individual Detailed Analysis of Surface Soil Alternatives
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
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 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.
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 is necessary to maintain existing long-term 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 maintain institutional controls to prevent disturbance of the covers	Existing land use controls would have to be lifted or altered to allow for 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 stabilization 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 future **residential** use	Equipment and most materials are readily available for 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	No technology is required under this alternative	See Alternative 1.	Soil cover technology is readily available, allowing future **residential** use.	The treatment technology is readily available, allowing future **residential** use.	The excavation, transportation, and disposal technologies are readily available, allowing future **residential** use.
COST	**FU6**	**All FUs[a]**	**FU6**	**FU6**	**FU6**
Industrial Use:			This alternative is not necessary for **industrial** use; therefore, there are no costs.	This alternative is not necessary for **industrial** use; therefore, there are no costs.	This alternative is not necessary for **industrial** use; therefore, there are no costs.
Capital Cost	$0	$14,000			
First Year Annual O&M Cost	$0	$3,800			
Present Worth O&M Cost	$0	$57,000			
Total Present Worth Cost	$0	$71,000			

TABLE 4-7
FU6-Administrative Area*: Summary of Individual Detailed Analysis of Surface Soil Alternatives
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
Residential Use:		This alternative is designed to prevent **residential** use Costs are included under the **Industrial** Use.			
Capital Cost	$0		$15,000	$5,000	$33,000
First Year Annual O&M Cost	$0		$1,200	$1,750	$0
Present Worth O&M Cost	$0		$18,000	$3,000	$0
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 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 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 included in this FS. A surface soil removal action was completed at this location.

[a] The cost to implement institutional controls applies to all FUs combined.

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, there are no COCs for FU6 .

For **residential** use, arsenic is the only COCs for FU6.

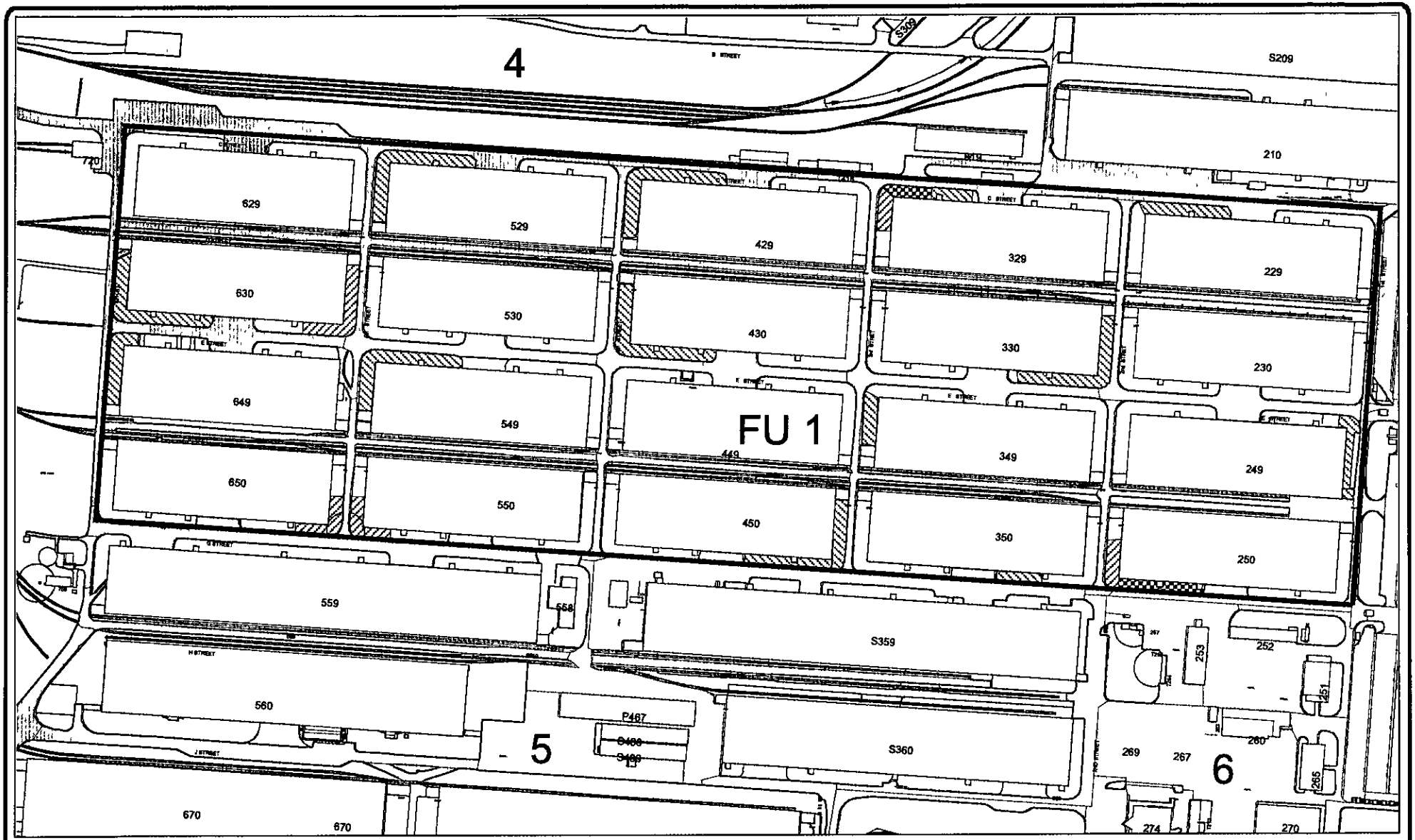

FIGURE 4-1
FU1: Candidate Areas for Surface Soil Remedial Actions
Memphis Depot Main Installation Soils FS

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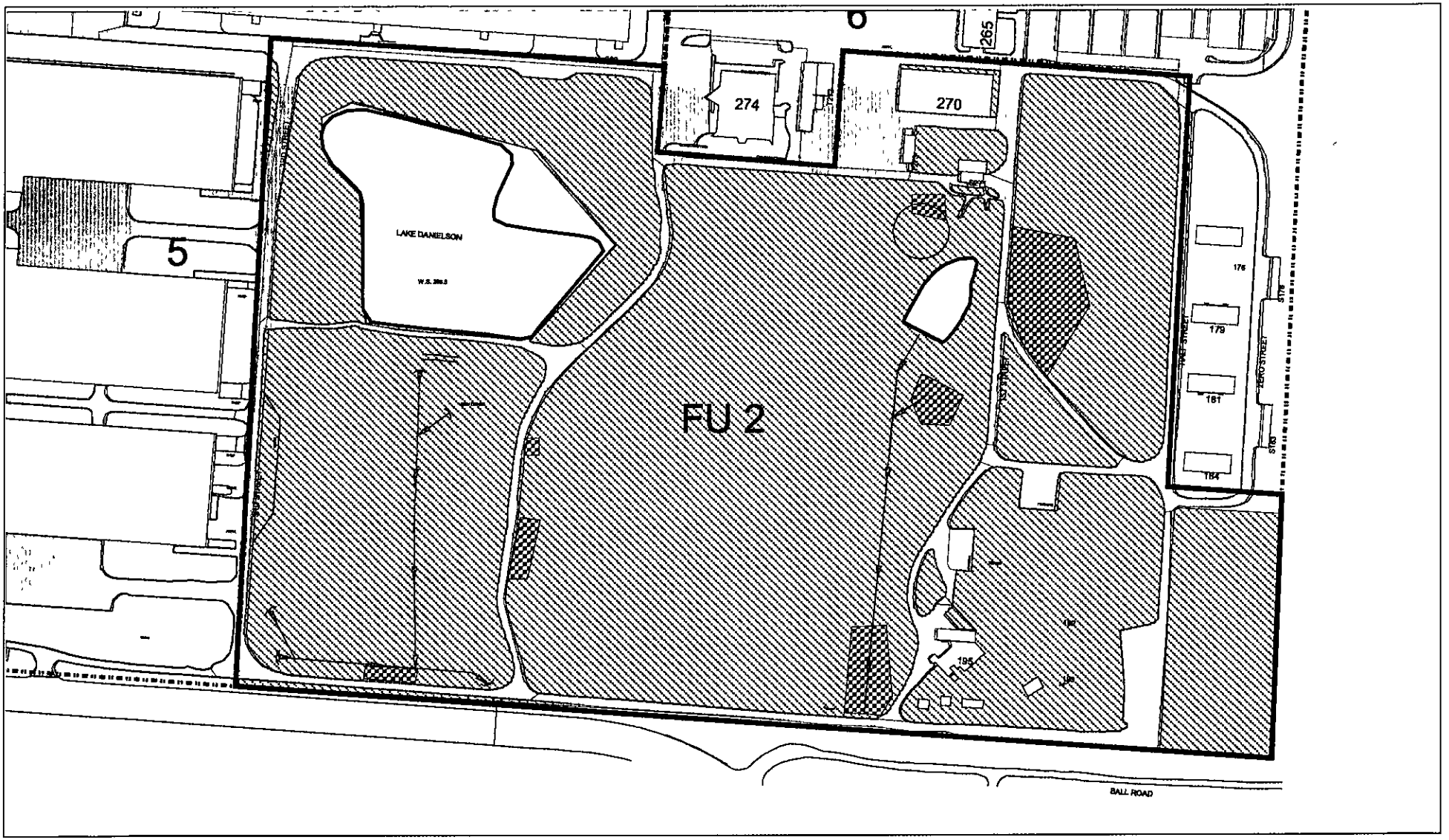
RDD \\Thor\Cart1\ddmt\fssoil_ddmt apr 6/26/00

510 130



Legend

- Arsenic (>/= 20 mg/kg) remediation area under future residential land use scenario
- Dieldrin (>/= 0 21 mg/kg) remediation area under future residential land use scenario
- Functional Unit Boundary
- Base Features
- Paved Area
- Buildings

N

0 200 400 Feet

SCALE IS APPROXIMATE

FIGURE 4-2
FU2· Candidate Areas for Surface Soil Remedial Actions
Memphis Depot Main Installation Soils FS

CH2MHILL

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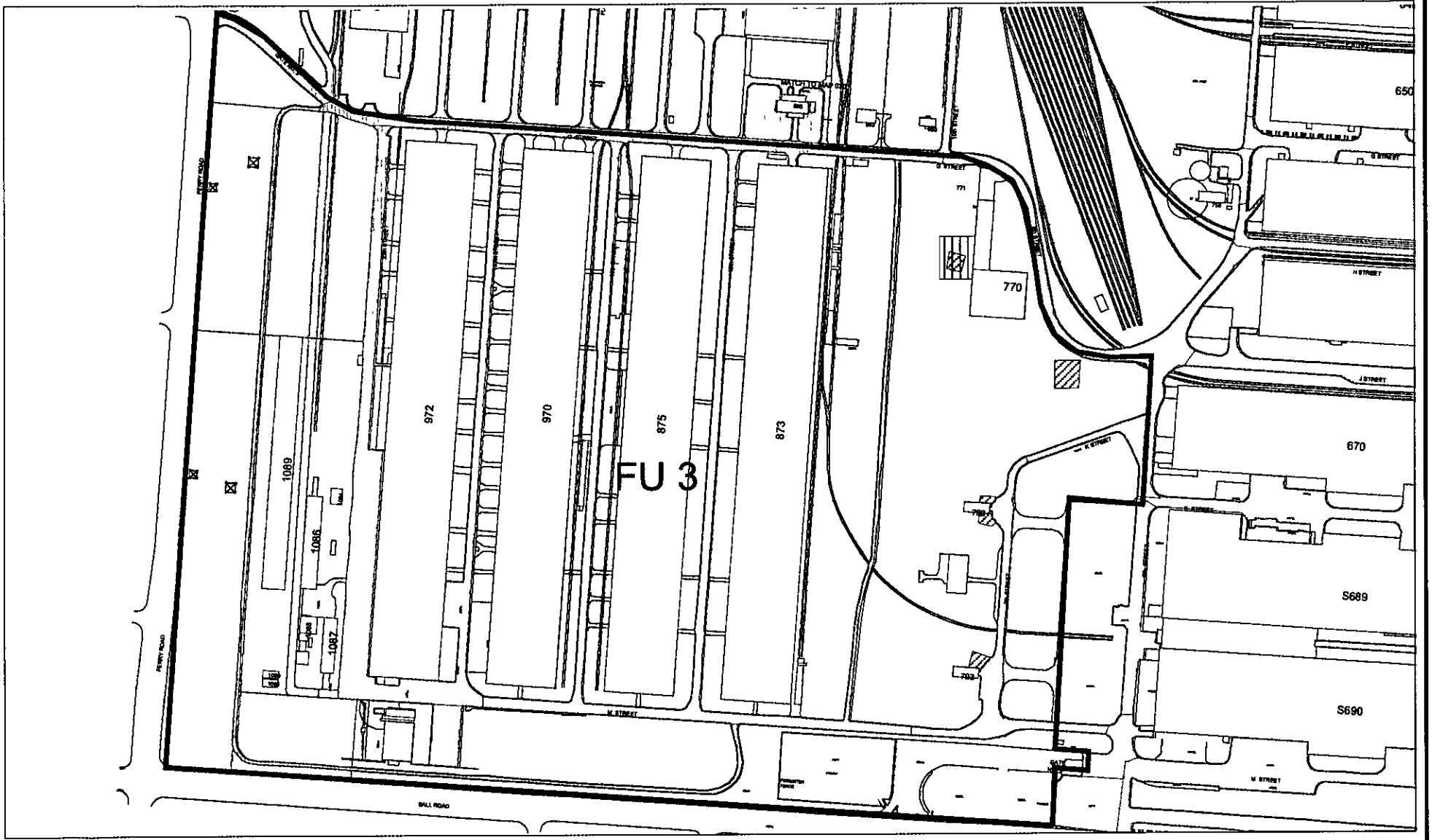
510 131



Legend

- Arsenic (>/= 20 mg/kg) remediation area under future residential land use scenario
- Lead (300 to < 1536 mg/kg) remediation area under future residential land use scenario
- Area addressed as part of the Parcel 35 and 28 EE/CA, and is not part of this FS
- Functional Unit Boundary
- Base Features
- Paved Area
- Buildings

N

0 200 400 Feet

SCALE IS APPROXIMATE

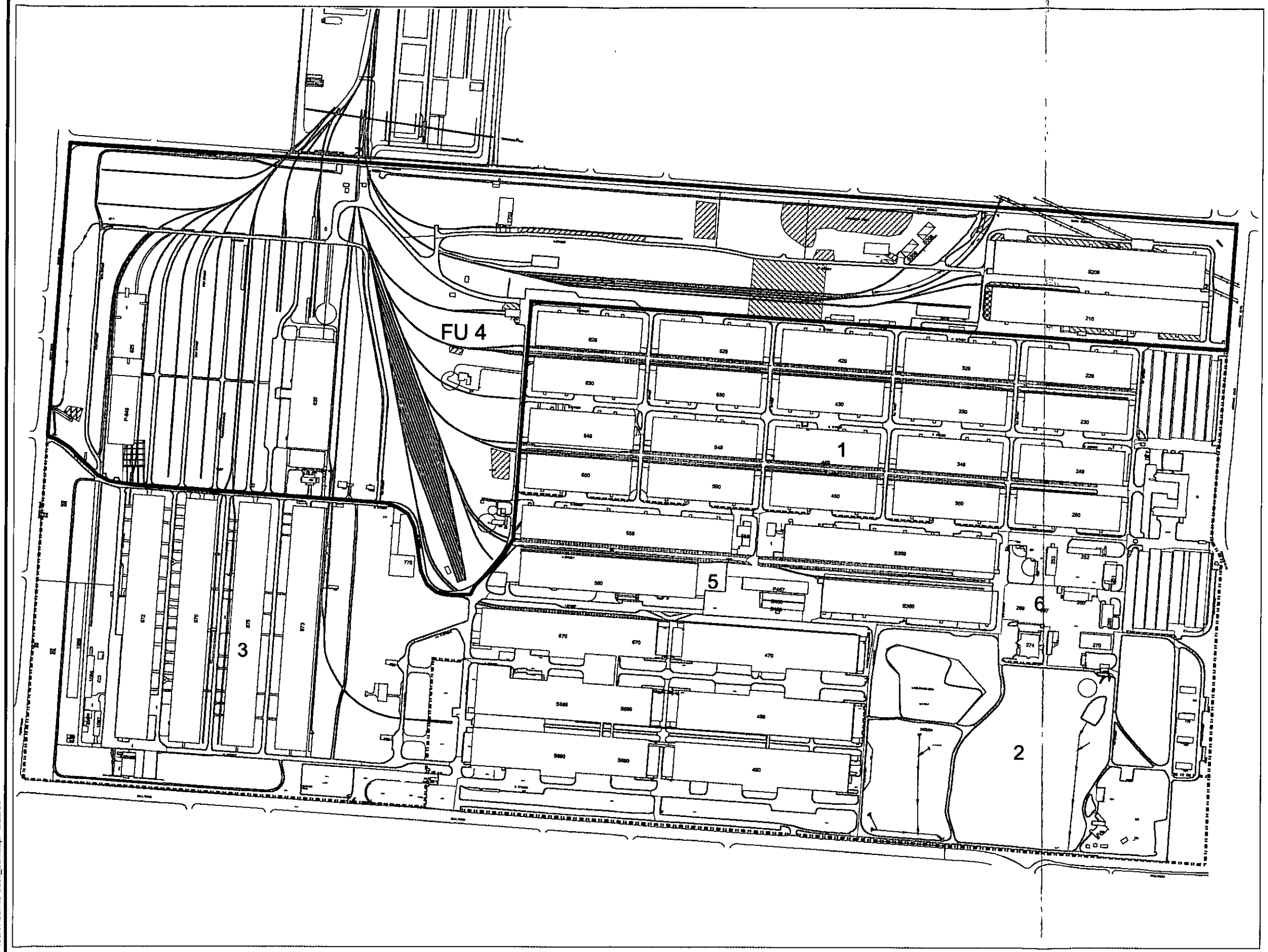
FIGURE 4-3
FU3: Candidate Areas for Surface Soil Remedial Actions
Memphis Depot Main Installation Soils FS

CH2MHILL

RDD \\Thor\Cart1\ddmt\fssoil_ddmt apr 6/26/00

510 132

510 133



RDD \\Thor\Carr1\ddmf\FSsoil_ddmf.apr 6/26/00

FIGURE 4-4
FU4: Candidate Areas for Surface Soil Remedial Actions
Memphis Depot Main Installation Soils FS

CH2MHILL

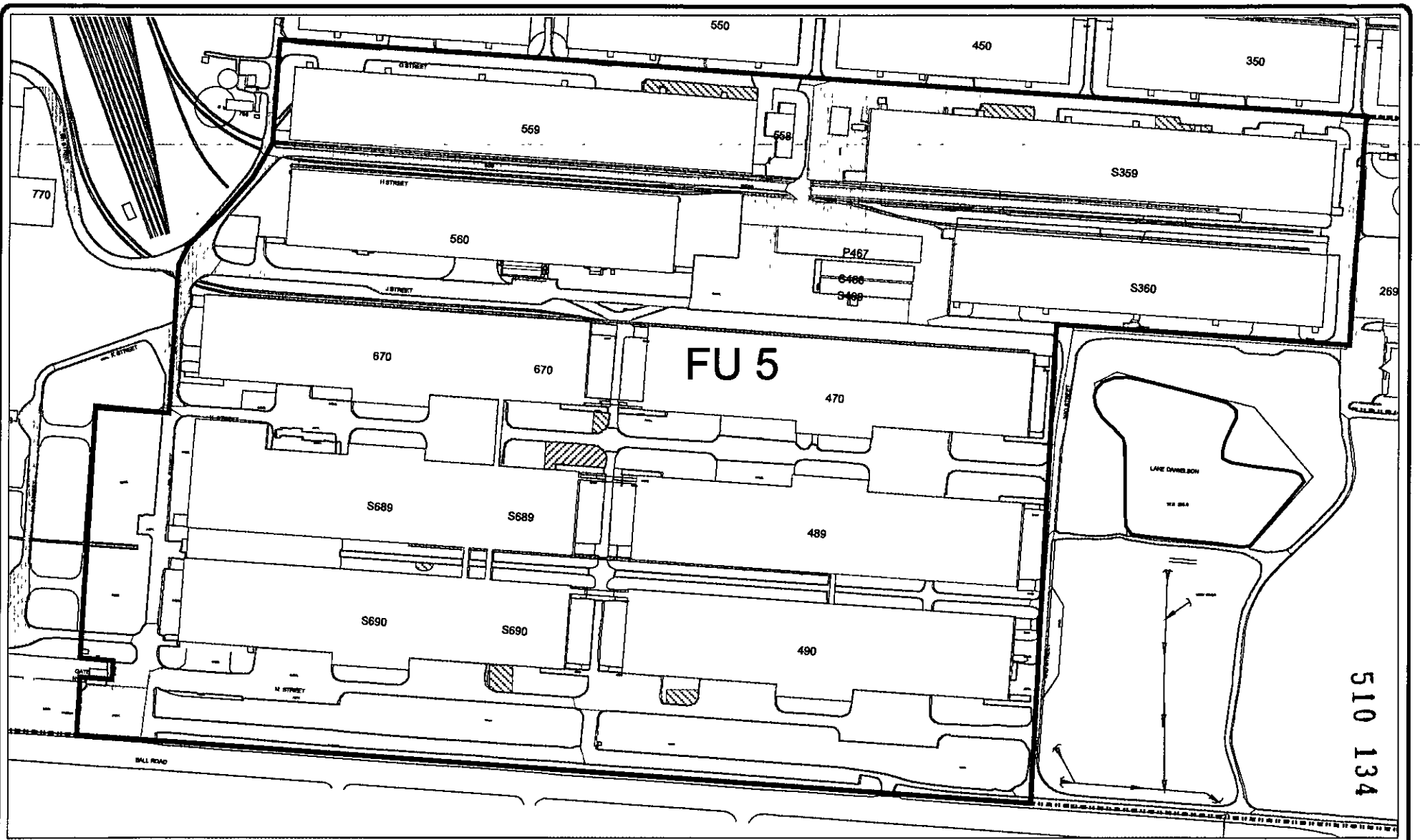


FIGURE 4-5
FU5· Candidate Areas for Surface Soil Remedial Actions
Memphis Depot Main Installation Soils FS

CH2MHILL

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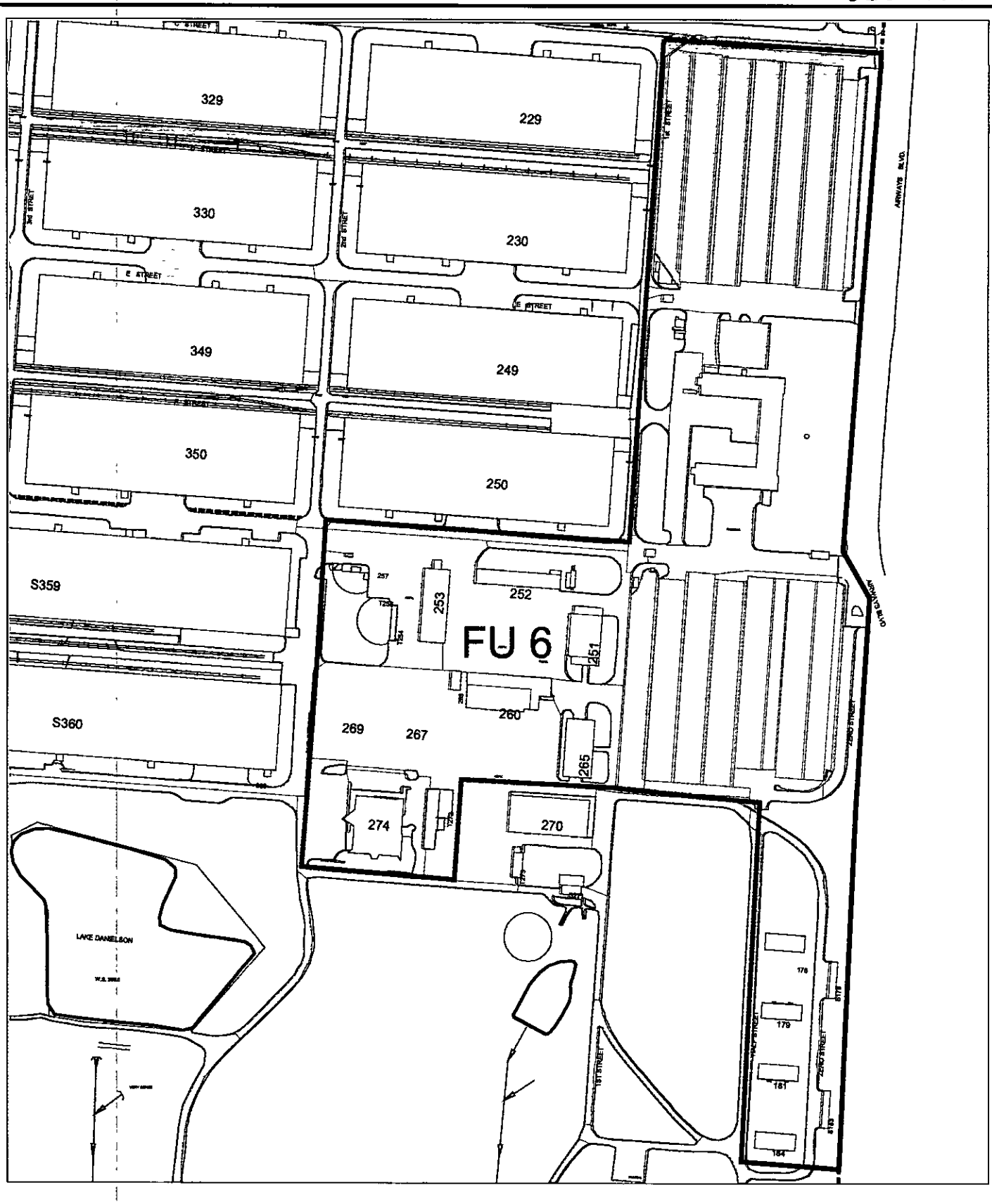

Legend

- Arsenic (>/= 20 mg/kg) remediation area under future residential land use scenario
- Functional Unit Boundary
- Base Features
- Paved Area
- Buildings

N

0 150 300 Feet

SCALE IS APPROXIMATE

FIGURE 4-6

FU6 Candidate Areas for Surface Soil Remedial Actions

Memphis Depot Main Installation Soils FS

CH2MHILL

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TAB

Section 5

5.0 References

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TAB

Appendix A

Appendix A
Risk Calculations

FIGURE A-1
Blood Level Distribution Probability Percent Plot for 655 μg/g Lead Concentration in Soil (FU3 Child). Ages 0-12 Months
Memphis Depot Main Installation Soils FS

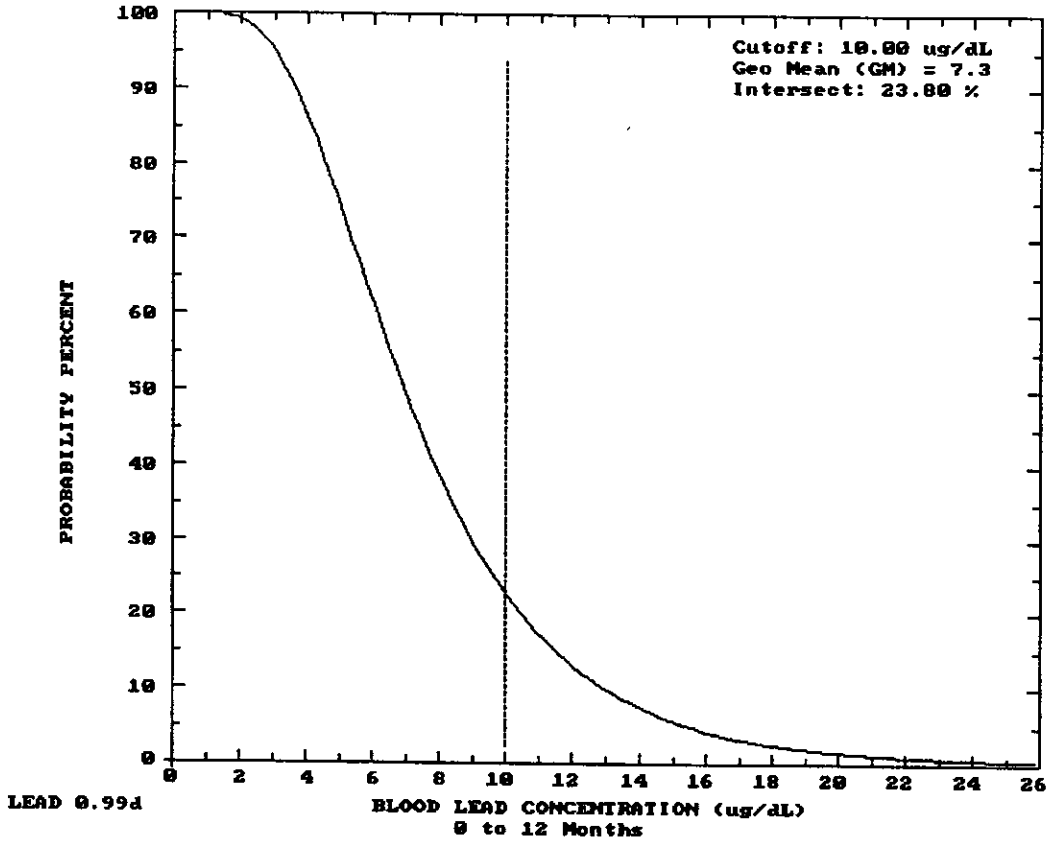

FIGURE A-2
Blood Level Distribution Probability Percent Plot for 919 μg/g Lead Concentration in Soil (FU4 Child). Ages 0-12 Months
Memphis Depot Main Installation Soils FS

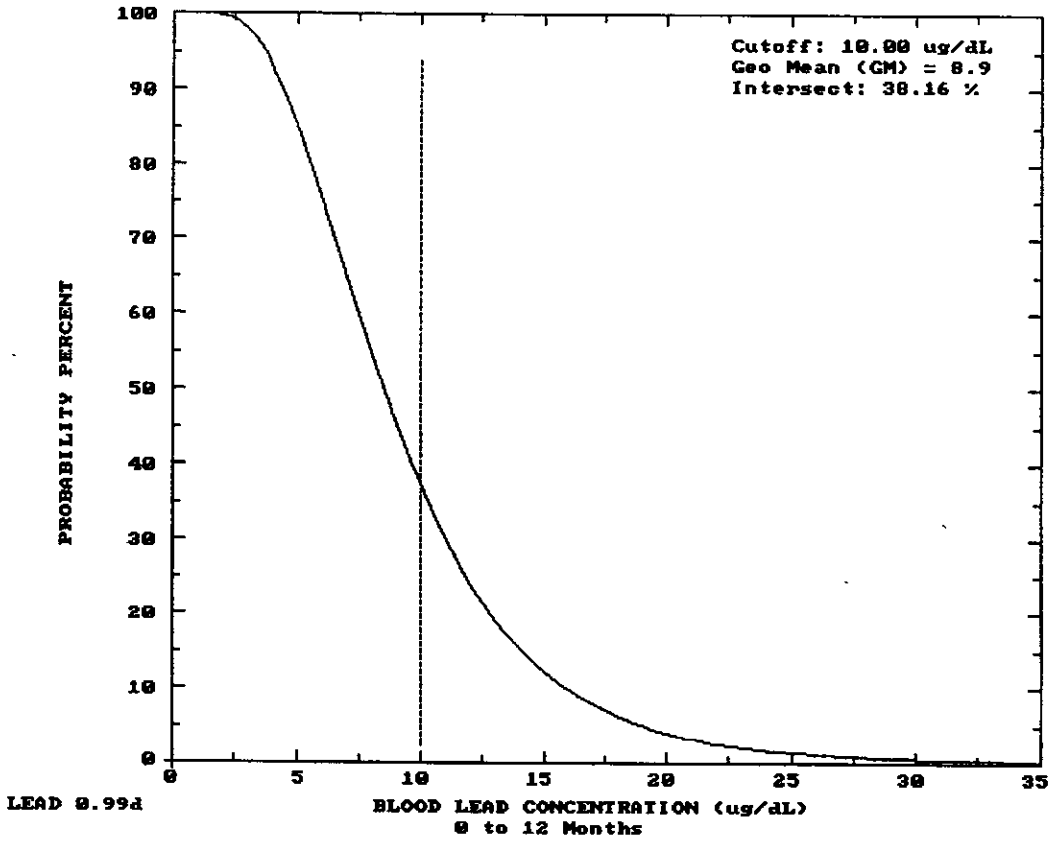

FIGURE A-3
Blood Level Distribution Probability Percent Plot for 295 μg/g Lead Concentration in Soil (Target Soil Lead Concentration): Ages 0-12 Months
Memphis Depot Main Installation Soils FS

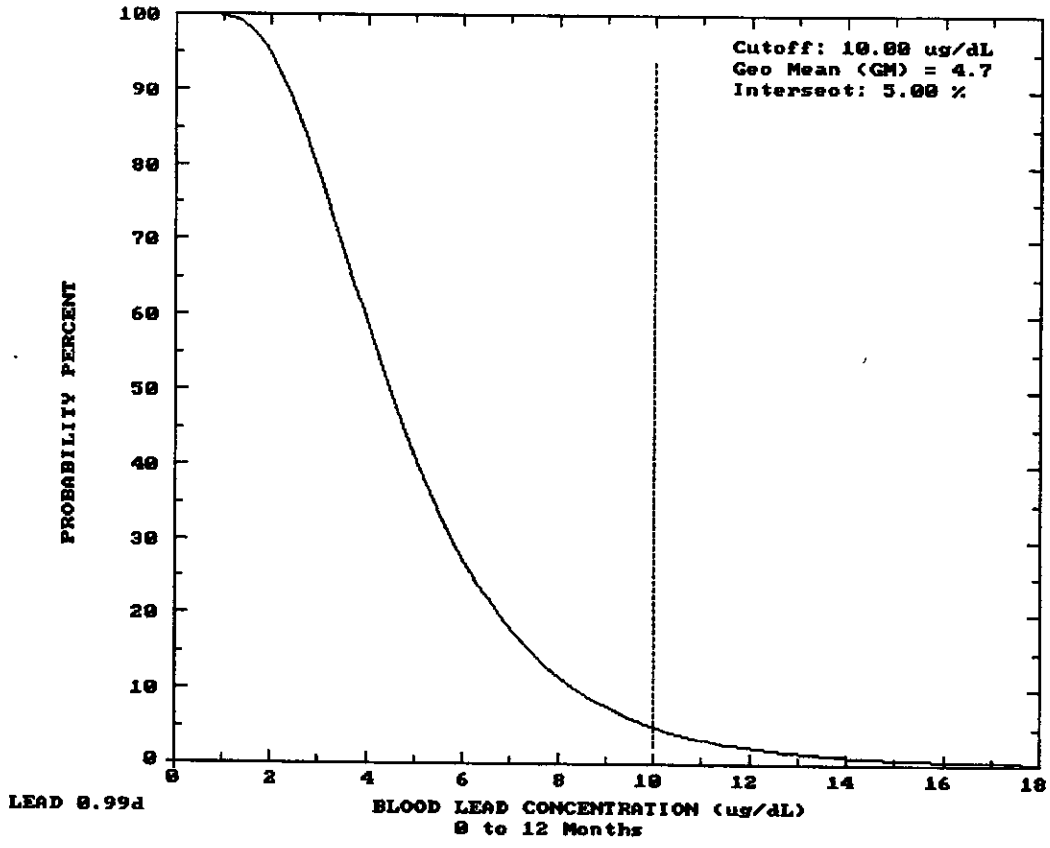

TABLE 1

Relative Risk Summaries for Residential Receptors from FU-wide UCL95% Estimates

Exposure Scenario	Health Risk at UCL95%											
	FU-1		FU-2		FU-3		FU-4		FU-5		FU-6	
	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI
Industrial Worker - Adult	8 0E-05	0 1	3 0E-05	0 2	9 0E-06	0 6	4 0E-05	0 1	3 0E-05	0 1	3 0E-05	0 5
Residential - Adult	2 6E-04	0 3	9 8E-05	0 6	2 9E-05	1 8	1 3E-04	0 3	9 8E-05	0 2	9 8E-05	1 5
Residential - Child	3 7E-04	0 6	1 4E-04	1.4	4 2E-05	4 1	1 9E-04	0 7	1 4E-04	0 3	1 4E-04	3 4

FU1-Risk drivers are dieldrin, PAHs and arsenic Arsenic at UCL95% in surface soil is at 26 3 mg/kg, near background, where as the maximum is 55 mg/kg Max B(a)P is at 67 mg/kg

FU2- Risk Drivers are arsenic, PAHs and dieldrin Maximum arsenic is at 101 mg/kg, and dieldrin was at 10 mg/kg PAHs were low, with UCL95% being below the PQLs Thus PAHs should not be included in alternatives analysis for FU2

FU3 - Risk drivers are Lead, PAHs and arsenic, while UCL95% for arsenic is 12 5 mg/kg, which is well below background levels and Max is 49 mg/kg Thus only PAHs and lead need further FS

FU4- Arsenic, PAHs and TCDD equivalents are the risk drivers Total TCDDs are below ARAR value of 1 ppb at the maximum concentration of 0 47 ppb, and were similar to background in distributions Arsenic at UCL95% of 15 7 is below background, with a maximum of 66 mg/kg

FU5- PAHs, arsenic and dieldrin are the risk drivers with arsenic EPC at 14 6 mg/kg, below background, with a max of 29 mg/kg Thus arsenic is not recommended for inclusion in FS PAHs and dieldrin need further FS evaluation

FU6 - PAHs, arsenic and PCB (Arochlor 1260)are the risk drivers Arsenic had an EPC of 28 5 mg/kg with a max concentration of 35 mg/kg PCBs were detected in 1 of 22 samples at a concentration of 6 3 mg/kg These soils may have been removed (Cafeteria area soil removals)

Lead Uptake Model for Children

Memphis Depot Main Installation FS

Model Assumptions	Units	FU3 Child	FU4 Child	Defaults
AIR				
Vary Air Concentration per year?		No	No	No
Outdoor Air Lead Concentration (background)	ug/m^3	0 3 [1]	0 3 [1]	0 1
Indoor Air Lead Concentration (% of outdoor)	%	0 3	0 3	0 3
Time Outdoors	hrs/day	variable	variable	1, 2 ,3, 4, 4, 4, 4 hrs/day per each year
Ventilation Rates	m^3/day	variable	variable	2, 3, 5, 5, 5, 7, 7 m3/day per each year
Lung Absorption		0 3	0 3	0 3
MATERNAL DATA				
Mother's Estimated Blood Lead Concentration at Birth	ug/dL	2 5	2 5	2 5
DRINKING WATER				
Lead Concentration in Drinking Water	ug/L	6 18	6 18	4
Drinking Water Intakes	L/day	variable	variable	0 2, 0 5, 0 52, 0 53, 0 55, 0 58, 0 59 L/day per each year
Use Alternate Drinking Water Values?		No	No	No
DIET				
Dietary Lead Intakes	Pb/day	variable	variable	5 53, 5 78, 6 49, 6 24, 6 01, 6 34, 7 0 Pb/day per each year
Use Alternate Diet Values?		No	No	No
OTHER				
Change Other Lead Intake?	ug Pb/day	0	0	0
SOIL/DUST				
Lead Concentrations in Soil [2]	ug/g	655	919	FU-specific [2]
Lead Concentrations in Dust	ug/g	489	673	Multiple Source Average (calculated by model)
Soil/Dust Ingestion Weighting Factor		0 45	0 45	0 45
Daily Ingestion Levels	g/day	variable	variable	0 085, 0 135, 0 135, 0 135, 0 1, 0 09, 0 085 g/day per each year
MULTIPLE SOURCE ANALYSIS (for Dust)				
Contribution of Soil Pb to Indoor Household Dust Pb	conversion factor	0 7	0 7	0 7
Contribution of Outdoor Airborne Pb to Indoor Household Dust Pb	conversion factor	100	100	100
Consider Alternate Indoor Dust Pb Sources?		No	No	No
SETTINGS				
Known Blood Lead Concentration	ug/dL	10 0	10 0	variable
RESULTS				
Target Soil Pb Concentration [3]	ug/g	**295**	**295**	See attached Figure with 10 ug/dL target blood-lead levels in fewer than 5% population (children), assuming multiple source contribution to total lead intake

Adapted from the Uptake/Biokinetic 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 Biokinetic Model for Lead in Children, January 1994

Note

1 = Literature review (Air Quality Criteria for Lead, EPA 1996 & ATSDR for Lead, 1988)

2 = Site-specific UCL95% lead estimates for the FU

3 = value was rounded to 300 mg/kg as the target concentration protective eof children under residential land use for the FUs 3 and 4

Lead Concentrations within FU3 Around Old Paint Shops

Unit	Matrix	StationID	SampleID	SampleType	UpperDepth	LowerDepth	ParamName	AnaValue	ProjQual	Units	Detected
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	LEAD	664	=	MG/KG	TRUE
3	SS	SS31B	SGA012	N	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	0 5	1	LEAD	205	=	MG/KG	TRUE
Average soil concentrations around Site 31								**188**			
Maximum Soil Concentrations around Site 31								**664**			
3	SS	SB32A	RHA012	N	0	1	LEAD	4150	=	MG/KG	TRUE
3	SS	SS32B	RHA015	N	0	1	LEAD	678	=	MG/KG	TRUE
3	SS	SS32C	RHA016	N	0	1	LEAD	693	=	MG/KG	TRUE
3	SS	SS32D	RHA017	N	0	1	LEAD	766	=	MG/KG	TRUE
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
Average soil concentrations around Site 32								**1156**			
Maximum Soil Concentrations around Site 32								**4150**			
3	SS	SB33A	SGA031	N	0	1	LEAD	46 9	=	MG/KG	TRUE
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	0 2	1 2	LEAD	321	=	MG/KG	TRUE
3	SS	SS33C	SGA027	N	0	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	=	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
Average soil concentrations around Site 33								**295**			
Maximum Soil Concentrations around Site 33								**1830**			
3	SS	SS34D	RHA038	N	0	1	LEAD	960	=	MG/KG	TRUE
4	SS	SS34E	RHA039	N	0	1	LEAD	340	=	MG/KG	TRUE
4	SS	SS34E	RHA180FD1	FD	0	1	LEAD	505	=	MG/KG	TRUE
3	SS	SS34F	RHA040	N	0	1	LEAD	145	=	MG/KG	TRUE
Average soil concentrations around Site 34								**488**			
Maximum Soil Concentrations around Site 34								**960**			
3	SS	SS89A	SGB044	N	0	1	LEAD	24 6	=	MG/KG	TRUE
3	SS	SS89B	SGB039	N	0	1	LEAD	139	=	MG/KG	TRUE
3	SS	SS89C	SGA250	N	0	1	LEAD	227	=	MG/KG	TRUE
3	SS	SS89F	SGA253	N	0	1	LEAD	237	=	MG/KG	TRUE
3	SS	SS89H	SGA257	N	0	1	LEAD	2470	=	MG/KG	TRUE
3	SS	SS89I	SGA258	N	0	1	LEAD	30 2	=	MG/KG	TRUE
3	SS	SS89J	SGA259	N	0	1	LEAD	2250	=	MG/KG	TRUE
3	SS	SS89K	MIA153	N	0	1	LEAD	39 9	=	MG/KG	TRUE
3	SS	SS89L	MIA155	N	0	1	LEAD	64 7	=	MG/KG	TRUE
3	SS	SS89M	MIA156	N	0	1	LEAD	256	=	MG/KG	TRUE
3	SS	SS89N	MIA157	N	0	1	LEAD	232	=	MG/KG	TRUE
Average soil concentrations around Site 89								**551**			
Maximum Soil Concentrations around Site 89								**2470**			

Overall average around Paint Shops **492**

Lead Concentrations within FU4 Around Building 949 (Site 83) and Building 702 (Site 79)

Unit	Matrix	StationID	SampleID	SampleType	UpperDepth	LowerDepth	ParamName	AnaValue	ProjQual	Units	Detected
4	SS	FS79A	MIA283AVG	N	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	N	0	1	LEAD	88 9	=	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	=	MG/KG	TRUE
4	SS	SS79A	SGA314	N	0	1	LEAD	1060	=	MG/KG	TRUE
4	SS	SS79B	SGA315	N	0	1	LEAD	105	=	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	SS79E	MIA280	N	0	1	LEAD	506	=	MG/KG	TRUE
4	SS	SS79F	MIA281	N	0	1	LEAD	83 9	=	MG/KG	TRUE
Average Lead Concentration around Site 79								**288**			
Maximum Concentration around Site 79								**1060**			
4	SS	FS83O	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	J	MG/KG	TRUE
4	SS	FS83R	MIA255AVG	N	0	1	LEAD	1495	J	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	SB83A	SGA398	N	0	1	LEAD	14 7	=	MG/KG	TRUE
4	SS	SB83B	SGA401	N	0	1	LEAD	2430	=	MG/KG	TRUE
4	SS	SS83A	SGA284	N	0 7	1	LEAD	67 5	=	MG/KG	TRUE
4	SS	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	1	LEAD	93 2	J	MG/KG	TRUE
4	SS	SS83E	MIA236	N	0	1	LEAD	210	J	MG/KG	TRUE
4	SS	SS83F	MIA237	N	0	1	LEAD	120	J	MG/KG	TRUE
4	SS	SS83G	MIA238	N	0	1	LEAD	24 9	J	MG/KG	TRUE
4	SS	SS83H	MIA239	N	0	1	LEAD	12 5	J	MG/KG	TRUE
4	SS	SS83I	MIA240	N	0	1	LEAD	22	J	MG/KG	TRUE
4	SS	SS83J	MIA241	N	0	1	LEAD	21 8	=	MG/KG	TRUE
4	SS	SS83K	MIA242	N	0	1	LEAD	80 2	=	MG/KG	TRUE
4	SS	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	0	1	LEAD	437	=	MG/KG	TRUE
Average Lead Concentration around Site 83								**601**			
Maximum Concentration around Site 83								**2800**			

Unit	Matrix	StationID	SampleID	SampleType	UpperDepth	LowerDepth	ParamName	AnaValue	ProjQual	Units	Detected
3	SB	SB31A	SGA016	N	4	6	LEAD	22 6	=	MG/KG	TRUE
3	SB	SB31A	SGA017	N	8	10	LEAD	26 6	=	MG/KG	TRUE
3	SB	SB31A	SGA018	N	18	20	LEAD	11 1	=	MG/KG	TRUE
3	SB	SB31A	SGA019	N	38	40	LEAD	2	=	MG/KG	TRUE
3	SB	SB31B	SGA021	N	4	6	LEAD	23	=	MG/KG	TRUE
3	SB	SB31B	SGA022	N	8	10	LEAD	26 2	=	MG/KG	TRUE
3	SB	SB31B	SGA024	N	38	40	LEAD	7 5	=	MG/KG	TRUE
3	SB	SB31B	SGB140	N	18	20	LEAD	6 3	=	MG/KG	TRUE
3	SB	SB32A	RHA013	N	3	5	LEAD	9 1	=	MG/KG	TRUE
3	SB	SB32A	RHA014	N	8	10	LEAD	10 9	=	MG/KG	TRUE
3	SB	SB33A	SGA032	N	4	6	LEAD	30	=	MG/KG	TRUE
3	SB	SB33A	SGA033	N	8	10	LEAD	28 5	=	MG/KG	TRUE
3	SB	SB33A	SGA034	N	18	20	LEAD	10 4	=	MG/KG	TRUE
3	SB	SB33A	SGA035	N	38	40	LEAD	1 1	=	MG/KG	TRUE
3	SB	SB33B	SGA037	N	4	6	LEAD	20 4	=	MG/KG	TRUE
3	SB	SB33B	SGA038	N	8	10	LEAD	30 8	=	MG/KG	TRUE
3	SB	SB33B	SGA039	N	18	20	LEAD	7 7	=	MG/KG	TRUE
3	SB	SB33B	SGA040	N	38	40	LEAD	3 1	=	MG/KG	TRUE
3	SB	SB33C	SGA042	N	3	5	LEAD	19 3	=	MG/KG	TRUE
3	SB	SB33C	SGA043	N	8	10	LEAD	20	=	MG/KG	TRUE
3	SB	SB33C	SGA044	N	18	20	LEAD	12 3	=	MG/KG	TRUE
3	SB	SB33C	SGA045	N	38	40	LEAD	28 9	=	MG/KG	TRUE
3	SB	SB34A	RHA022	N	3	5	LEAD	13	=	MG/KG	TRUE
3	SB	SB34A	RHA023	N	8	10	LEAD	9 1	=	MG/KG	TRUE
3	SB	SB34A	RHA024	N	13	15	LEAD	7 3	=	MG/KG	TRUE
3	SB	SB34A	RHA025	N	18	20	LEAD	8	=	MG/KG	TRUE
3	SB	SB34B	RHA026	N	3	5	LEAD	13 7	=	MG/KG	TRUE
3	SB	SB34B	RHA027	N	8	10	LEAD	9 2	=	MG/KG	TRUE
3	SB	SB34B	RHA028	N	13	15	LEAD	7 9	=	MG/KG	TRUE
3	SB	SB34B	RHA029	N	18	20	LEAD	9	=	MG/KG	TRUE
3	SB	SB34C	RHA030	N	3	5	LEAD	13 5	=	MG/KG	TRUE
3	SB	SB34C	RHA031	N	8	10	LEAD	10 4	=	MG/KG	TRUE
3	SB	SB34C	RHA032	N	13	15	LEAD	6 8	=	MG/KG	TRUE
3	SB	SB34C	RHA033	N	18	20	LEAD	7 9	=	MG/KG	TRUE
3	SB	SB34C	RHA034FD1	FD	3	5	LEAD	11 1	=	MG/KG	TRUE
3	SB	SB89A	SGA374	N	3	5	LEAD	14 8	=	MG/KG	TRUE
3	SB	SB89A	SGA375	N	8	10	LEAD	14 2	=	MG/KG	TRUE
3	SB	SB89B	SGA376	N	3	5	LEAD	17 6	=	MG/KG	TRUE
3	SB	SB89B	SGA377	N	8	10	LEAD	20 3	=	MG/KG	TRUE
3	SB	SB89B	SGA492FD1	FD	3	5	LEAD	25 1	=	MG/KG	TRUE
3	SB	SB89C	SGA378	N	3	5	LEAD	17 2	=	MG/KG	TRUE
3	SB	SB89C	SGA379	N	8	10	LEAD	24 7	=	MG/KG	TRUE
3	SB	SB89D	SGA380	N	3	5	LEAD	15 6	=	MG/KG	TRUE
3	SB	SB89D	SGA381	N	8	10	LEAD	20 7	=	MG/KG	TRUE
3	SB	SB89E	MIA146	N	3	5	LEAD	8 4	=	MG/KG	TRUE
3	SB	SB89E	MIA147FD	FD	3	5	LEAD	7 5	=	MG/KG	TRUE
3	SB	SB89E	MIA149	N	8	10	LEAD	11 6	=	MG/KG	TRUE
3	SB	SB89E	MIA150	N	18	20	LEAD	4 6	=	MG/KG	TRUE
3	SB	SB89E	MIA151	N	28	30	LEAD	3 1	=	MG/KG	TRUE
3	SB	SB89E	MIA152	N	36	38	LEAD	1 7	=	MG/KG	TRUE
3	SS	FS33A	MIA337AVG	N	0	1	LEAD	113 9	=	MG/KG	TRUE
3	SS	FS33B	MIA340AVG	N	0	1	LEAD	211 15	=	MG/KG	TRUE
3	SS	FS33C	MIA343AVG	N	0	1	LEAD	1131	=	MG/KG	TRUE
3	SS	FS33D	MIA346AVG	N	0	1	LEAD	502 5	=	MG/KG	TRUE
3	SS	FS33E	MIA349AVG	N	0	1	LEAD	21 85	=	MG/KG	TRUE
3	SS	FS33F	MIA352AVG	N	0	1	LEAD	138	=	MG/KG	TRUE
3	SS	FS89P	MIA159AVG	N	0	1	LEAD	436 05	=	MG/KG	TRUE
3	SS	FS89Q	MIA164AVG	N	0	1	LEAD	484 05	=	MG/KG	TRUE
3	SS	FS89R	MIA167AVG	N	0	1	LEAD	36 6	=	MG/KG	TRUE
3	SS	FS89S	MIA170AVG	N	0	1	LEAD	61 25	=	MG/KG	TRUE
3	SS	SB31A	SGA015	N	0	1	LEAD	51 4	=	MG/KG	TRUE
3	SS	SB31A	SGA487FD1	FD	0	1	LEAD	57 2	=	MG/KG	TRUE
3	SS	SB31B	SGA020	N	0	1	LEAD	37 3	=	MG/KG	TRUE
3	SS	SB32A	RHA012	N	0	1	LEAD	4150	=	MG/KG	TRUE
3	SS	SB33A	SGA031	N	0	1	LEAD	46 9	=	MG/KG	TRUE
3	SS	SB33B	SGA036	N	0	1	LEAD	20 1	=	MG/KG	TRUE
3	SS	SB33B	SGA488FD1	FD	0	1	LEAD	119	=	MG/KG	TRUE
3	SS	SB33C	SGA041	N	0	1	LEAD	16 1	=	MG/KG	TRUE
3	SS	SB34A	RHA035	N	0	1	LEAD	94 1	=	MG/KG	TRUE

Unit	Matrix	StationID	SampleID	SampleType	UpperDepth	LowerDepth	ParamName	AnaValue	ProjQual	Units	Detected
3	SS	SB34B	RHA036	N	0	1	LEAD	702	=	MG/KG	TRUE
3	SS	SB34C	RHA037	N	0	1	LEAD	93 6	=	MG/KG	TRUE
3	SS	SS31A	SGA011	N	0	1	LEAD	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	SS31C	SGA300FD1	FD	0	1	LEAD	71 2	=	MG/KG	TRUE
3	SS	SS31D	SGB058	N	0 5	1	LEAD	205	=	MG/KG	TRUE
3	SS	SS32B	RHA015	N	0	1	LEAD	678	=	MG/KG	TRUE
3	SS	SS32C	RHA016	N	0	1	LEAD	693	=	MG/KG	TRUE
3	SS	SS32D	RHA017	N	0	1	LEAD	766	=	MG/KG	TRUE
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
3	SS	SS32G	RHA021FD1	FD	0	1	LEAD	563	=	MG/KG	TRUE
3	SS	SS33A	SGA025	N	0	1	LEAD	129	=	MG/KG	TRUE
3	SS	SS33B	SGB067	N	0 2	1 2	LEAD	321	=	MG/KG	TRUE
3	SS	SS33C	SGA027	N	0	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	=	MG/KG	TRUE
3	SS	SS33M	MIA327	N	0	1	LEAD	332	=	MG/KG	TRUE
3	SS	SS33M	MIA328FD	FD	0	1	LEAD	373	=	MG/KG	TRUE
3	SS	SS33N	MIA330	N	0	1	LEAD	62 3	=	MG/KG	TRUE
3	SS	SS33O	MIA331	N	0	1	LEAD	13 2	=	MG/KG	TRUE
3	SS	SS34D	RHA038	N	0	1	LEAD	960	=	MG/KG	TRUE
3	SS	SS34F	RHA040	N	0	1	LEAD	145	=	MG/KG	TRUE
3	SS	SS89A	SGB044	N	0	1	LEAD	24 6	=	MG/KG	TRUE
3	SS	SS89B	SGB039	N	0	1	LEAD	139	=	MG/KG	TRUE
3	SS	SS89C	SGA250	N	0	1	LEAD	227	=	MG/KG	TRUE
3	SS	SS89D	SGA251	N	0	1	LEAD	14 9	=	MG/KG	TRUE
3	SS	SS89F	SGA253	N	0	1	LEAD	237	=	MG/KG	TRUE
3	SS	SS89H	SGA257	N	0	1	LEAD	2470	=	MG/KG	TRUE
3	SS	SS89I	SGA258	N	0	1	LEAD	30 2	=	MG/KG	TRUE
3	SS	SS89J	SGA259	N	0	1	LEAD	2250	=	MG/KG	TRUE
3	SS	SS89J	SGA260FD1	FD	0	1	LEAD	1310	=	MG/KG	TRUE
3	SS	SS89K	MIA153	N	0	1	LEAD	39 9	=	MG/KG	TRUE
3	SS	SS89L	MIA155	N	0	1	LEAD	64 7	=	MG/KG	TRUE
3	SS	SS89M	MIA156	N	0	1	LEAD	256	=	MG/KG	TRUE
3	SS	SS89N	MIA157	N	0	1	LEAD	232	=	MG/KG	TRUE
3	SS	SS89O	MIA158	N	0	1	LEAD	53	=	MG/KG	TRUE

Average Lead Concentraitons Across FU3 = 249

Unit	Matrix	StationID	SampleID	SampleType	UpperDepth	LowerDepth	ParamName	AnaValue	ProjQual	Units	Detected
4	SB	SB79A	SGA442	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	=	MG/KG	TRUE
4	SB	SB79B	SGA447	N	8	10	LEAD	21 5	=	MG/KG	TRUE
4	SB	SB79B	SGA448	N	18	20	LEAD	14 8	=	MG/KG	TRUE
4	SB	SB79B	SGB138	N	4	5 5	LEAD	14 3	=	MG/KG	TRUE
4	SB	SB79C	SGA450	N	4	6	LEAD	38 4	=	MG/KG	TRUE
4	SB	SB79C	SGA451	N	8	10	LEAD	19 6	=	MG/KG	TRUE
4	SB	SB79C	SGA452	N	18	20	LEAD	17	=	MG/KG	TRUE
4	SB	SB79D	MIA125	N	4	6	LEAD	12 1	=	MG/KG	TRUE
4	SB	SB79D	MIA126	N	8	10	LEAD	8 1	=	MG/KG	TRUE
4	SB	SB79D	MIA127	N	16	18	LEAD	6 5	=	MG/KG	TRUE
4	SB	SB83A	SGA400	N	9	11	LEAD	22 2	=	MG/KG	TRUE
4	SB	SB83A	SGB121	N	4	6	LEAD	8 8	=	MG/KG	TRUE
4	SB	SB83B	SGA402	N	4	6 5	LEAD	36 3	=	MG/KG	TRUE
4	SB	SB83B	SGA403	N	9	11	LEAD	26 2	=	MG/KG	TRUE
4	SS	FS79A	MIA283AVG	N	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	N	0	1	LEAD	88 9	=	MG/KG	TRUE
4	SS	FS83O	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	J	MG/KG	TRUE
4	SS	FS83R	MIA255AVG	N	0	1	LEAD	1495	J	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	=	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	=	MG/KG	TRUE
4	SS	SS34E	RHA039	N	0	1	LEAD	340	=	MG/KG	TRUE
4	SS	SS34E	RHA180FD1	FD	0	1	LEAD	505	=	MG/KG	TRUE
4	SS	SS79A	SGA314	N	0	1	LEAD	1060	=	MG/KG	TRUE
4	SS	SS79B	SGA315	N	0	1	LEAD	105	=	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	=	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	N	0 7	1	LEAD	67 5	=	MG/KG	TRUE
4	SS	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	1	LEAD	93 2	J	MG/KG	TRUE
4	SS	SS83E	MIA236	N	0	1	LEAD	210	J	MG/KG	TRUE
4	SS	SS83F	MIA237	N	0	1	LEAD	120	J	MG/KG	TRUE
4	SS	SS83G	MIA238	N	0	1	LEAD	24 9	J	MG/KG	TRUE
4	SS	SS83H	MIA239	N	0	1	LEAD	12 5	J	MG/KG	TRUE
4	SS	SS83I	MIA240	N	0	1	LEAD	22	J	MG/KG	TRUE
4	SS	SS83J	MIA241	N	0	1	LEAD	21 8	=	MG/KG	TRUE
4	SS	SS83K	MIA242	N	0	1	LEAD	80 2	=	MG/KG	TRUE
4	SS	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	0	1	LEAD	437	=	MG/KG	TRUE

Average Lead Across FU4 = **332**

Remedial Goal Options for Lead
Memphis Depot Main Installation Soils FS

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

where,

$$PbB_{adult,\,central,\,goal} = \frac{\mathrm{PbB}_{fetal,0\ 95,\,goal}}{\mathrm{GSD}_{i,adult}^{1.645} * R_{fetal\,/\,maternal}}$$

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.**
$PbB_{adult,central,goal}$	Goal for central estimate of Blood Lead Concentration expressed in ug/dl;	4 23	Calc.
$PbB_{adult,0}$	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	A
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	B
AT	Averaging time; 365 days/year	365	B
$GSD^{1\,645}_{i,adult}$	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)	0 9	A

[1]Sources

A. USEPA 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach tc 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'

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

where,

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

Exposure Parameter	Description	Construction Worker 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	A
BSF	Blood-Lead Slope Factor expressed in (ug/dL) per (ug/day) or day/dl;	0 375	A
A_w	Water Absorption Factor (unitless),	0 08	A
I_w	Water Ingestion Rate expressed in L/day;	1	B
C_w	Water Lead Concentration expressed in ug/L,	15	C
V_a	Ventilation Rate During Waking Hours expressed in m^3/day,	20	B
A_a	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
$I_{s/d}$	Soil/Dust Ingestion Rate expressed in g/day,	0.48	B
$A_{s/d}$	Soil/Dust Absorption Factor (unitless),	0.08	A
t_{ing}	Fraction of Time Spent on Site for Ingestion (unitless);	0.340	A
$C_{bg\,s/d}$	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)	2 1	A

Adapted from Bowers et al (1994).

[1]Sources

A. Bowers, T.S , B.D Beck, and H S Karam. 1994. "Assessing the Relationship Between Environmental Lead Concentrations and Adult Blood Lead Levels " *Risk Analysis* , Vol 14, No 2, 1994.
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.
C. Safe Drinking Water Act
D Ciolkosz, E J , M K Amistadie, and N.C Thurman June 1993. Metals in Pennsylvania Soils. Agronomy Series Number 128. Agronomy Department, The Pennsylvania State University, University Park, Pennsylvania.
E. Occupational Safety and Health Administration

Remedial Goal Options - Soil

Memphis Depot Main Installation Soils FS

Chemical	Carcinogenic Effects						Noncarcinogenic Effects					
	Industrial worker			Residential			Industrial worker			Residential Adult		
	TR = 1E-06	TR = 1E-05	TR = 1E-04	TR = 1E-06	TR = 1E-05	TR = 1E-04	THI =0.1	THI =1	THI =10	THI =0.1	THI =1	THI =10
Metals												
ARSENIC	3	34	340	2	24 3	242 8	55	549	5487	20	197	1971
LEAD	1536	1536	1536	300	300	300	N/A	N/A	N/A	N/A	N/A	N/A
Pesticides												
DIELDRIN	0 27	2 7	27 1	0 21	2 1	21 0	7 7	77	773	17	168	1681
Semivolatiles												
BENZO(a)ANTHRACENE	5	52	516	4 3	43	428						
BENZO(a)PYRENE	0 5	4 7	47	0 4	4	41						
BENZO(b)FLUORANTHENE	5	52	516	4 3	43	428						
BENZO(k)FLUORANTHENE	52	516	5162	43	428	4281						
CHRYSENE	516	5162	51625	428	4281	42813						
DIBENZ(a,h)ANTHRACENE	0 5	5	52	0 43	4	43						
INDENO(1,2,3-c,d)PYRENE	5	52	516	4 28	43	428						

Note: All units are mg/kg

Lead target concentrations are calculated using blood-lead uptake model

Formulas:

Age-adjusted Carcinogenic calculation (ADULT only)

$$RBC = \frac{TR \times ATc}{(mg/kg)\ EF \times (A+B+C)}$$

Where

Ac = (SFo x IRing_adj x FI x CF)

Bc = (SFd x SA_adj x AF x ABS x CF)

Cc = (SFI x IRinh_adj x ((1/VF)+(1/PEF)))

Carcinogenic calculation (INDUSTRIAL WORKER only)

$$RBC = \frac{TR \times BW \times ATc}{(mg/kg)\ ED \times (A+B+C)}$$

Where:

Ac = (SFo x IRing x FI x CF)

Bc = (SFd x SA x AF x ABS x CF)

Cc = (SFI x IRinh x ((1/VF)+(1/PEF)))

Noncarcinogenic calculation (ALL RECEPTORS)

$$RBC = \frac{THI \times BW \times ATnc}{(mg/kg)\ EF \times ED \times (A+B+C)}$$

An = ((1/RfDo) x IRing x FI x CF)

Bn = ((1/RfDd) x SA x AF x ABS x CF)

Cn = ((1/RfDi) x IRinh x ((1/VF)+(1/PEF)))

EXPOSURE EQUATION 5

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

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

where,

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

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 μg/dL,	3.1
BSF	Blood-Lead Slope Factor expressed in (μg/dL) per (μg/day) or day/dl,	0 375
A_w	Water Absorption Factor (unitless),	0 08
I_w	Water Ingestion Rate expressed in L/day;	2
C_w	Water Lead Concentration expressed in μg/L;	15
V_a	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
$I_{s/d}$	Soil/Dust Ingestion Rate expressed in g/day;	0 1
$A_{s/d}$	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 μg/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)

Attachment A Exposure Scenario Specific Parameters for Recreational Users
Intake Estimation formulas

$$\text{Intake} = \frac{Cs * IR * FI * EF * ED * CF}{BW * AT}$$

Exposure Scenario/parameter	Ingestion Carcinogenic	Ingestion Non carcinogenic	Exposure Scenario/parameter	Dermal Carcinogenic	Dermal Non carcinogenic	Total Ingestion+Dermal Carcinogenic	Total Ingestion+Dermal Non carcinogenic	Relative risk at UCL95% FU - 1 Risk	FU - 1 HI	FU - 2 Risk	FU - 2 HI	FU - 3 Risk	FU - 3 HI	FU - 4 Risk	FU - 4 HI	FU - 5 Risk	FU - 5 HI	FU - 6 Risk	FU - 6 HI
Industrial Worker - Adult			***Industrial Worker - Adult***																
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1														
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	1														
ET = Exposure Time (hours/24 hr workday)	24	24	ABS = Absorption Factor (Unitless)																
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	70														
Intake =	1 75E-07	4 89E-07	AT = Averaging time(days/yr x years)	25550	9125														
			Intake =	2 86E-06	2 41E-05	3 04E-06	2 45E-05												
Percent Relative to Future Industrial Worker	**100**	**100**	**Percent Relative to Future Industrial V**	**100**	**100**	**100**	**100**	8 0E-05	0 09	3 00E-05	0 2	9 0E-06	0 6	4 0E 05	0 1	3 0E 05	0 05	3 0E 05	0 5
Residential - Adult			***Residential - Adult***							***Residential Adult***									
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1														
IR = Soil ingestion rate (mg/day)	114 2	100	SA = Skin Surface Area (cm2/event)	1574	5419														
FI = Fraction ingested from contaminated area (unitless)	1	1	AF = Soil Adherence factor (mg/cm3)	1	1														
ET = Exposure Time (hours/24 hr workday)	24	24	ABS = Absorption Factor (Unitless)																
EF = Exposure frequency (days/30 years)	350	350	ET = Exposure Time (hours/24 hr-day)	24	24														
ED = Exposure duration (years)	30	30	EF = Exposure frequency (days/yr)	350	350														
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	30	30														
BW = Body weight (kg)	70	70	CF= Conversion factor (unitless)	0 000001	0 000001														
AT = Averaging time(days/yr x years)	25550	10950	BW = Body weight (kg)	70	70														
Intake =	8 70E-07	1 37E-06	AT = Averaging time(days/yr x years)	25550	10950														
			Intake =	9 24E-06	7 42E-05	9 91E-06	7 58E-05												
Percent Relative to Future Industrial Worker	**384**	**280**	**Percent Relative to Future Industrial V**	**323**	**309**	**326**	**308**	2 6E-04	0 28	9 8E-05	0.6	2 9E-05	1 8	1 3E-04	0 3	9 8E-05	0 2	9 8E-05	1 5
Residential - Child			***Residential - Child***							***Residential Child***									
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1														
IR = Soil ingestion rate (mg/day)	200	200	SA = Skin Surface Area (cm2/event)	2394	2394														
FI = Fraction ingested from contaminated area (unitless)	1 00	1 00	AF = Soil Adherence factor (mg/cm3)	1 00	1 00														
ET = Exposure Time (hours/24 hr workday)	24	24	ABS = Absorption Factor (Unitless)																
EF = Exposure frequency (days)	350	350	ET = Exposure Time (hours/24 hr-day)	24	24														
ED = Exposure duration (years)	6	6	EF = Exposure frequency (days/yr)	350	350														
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	6	6														
BW = Body weight (kg)	15	15	CF= Conversion factor (unitless)	0 000001	0 000001														
AT = Averaging time(days/yr x years)	25550	2190	BW = Body weight (kg)	15	15														
Intake =	1 10E-06	1 28E-05	AT = Averaging time(days/yr x years)	25550	2190														
			Intake =	1 31E-05	1 53E-04	1 42E-05	1 66E-04												
Percent Relative to Future Industrial Worker	**827**	**2613**	**Percent Relative to Future Industrial V**	**458**	**638**	**468**	**678**	3.7E-04	0.8	1 40E-04	1 4	4 21E-05	4 1	1 9E-04	0 7	1 40E-04	0 3	1 40E-04	3 4

TAB

Appendix B

Appendix B
Cost Estimates

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

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	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	2	ea	$500 /ea	$1,000	
2	Fence along Perimeter of Lead Hot Spot					
	2 1 Fencing	440	ft	$8 /ft	$3,500	CH2M HILL. American Scrap Metal Site, Panama City Order of Magnitude Cost Estimate for Alternative 5A
	2 2 Labor	20	hr	$75 /hr	$1,500	Assumes two field people will be on-site for 10 hours for 1 day
3	Signs					Signs will be installed around lead hot spot to help prevent people from entering area.
	3 1 Signs	2	ea	$22 /ea	$50	Phone Quote from Sign-A-Rama Assume 2 12-inch by 18-inch signs on each side of the area
	3 2 Posts	2	ea	$25 /ea	$50	Assumes 12-foot post.
	3.3 Labor	1	hr	$50 /hr	$50	Assumes generally takes a half of an hour to install each sign
4	Plans for Implementation	88	hr	$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] 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.

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

FU1-6 with No Cleanup of FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
5	Maintenance of Site (Year 2-30)						
	5.1 Fencing (three over 30 years)						Assumes fencing will need to be replaced every 10 years This indicates fence will be replaced three times over 30 years
	5.1.1 Fencing	440	ft/yr	$8 /ft	$3500 ($350 averaged over 10 years)	$4,600	CH2M HILL American Scrap Metal Site, Panama City Order of Magnitude Cost Estimate for Alternative 5A
	5.1 2 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
	5.2 Signage (six over 30 years)						Assumes signs will be replaced every 5 years This indicates signs will be replaced six times over 30 years.
	5.2 1 Signs	2	ea/yr	$22 /ea	$50 ($10 averaged over 5 years)	$200	Phone Quote from Sign-A-Rama
	5 2.2 Posts	2	ea/yr	$25 /ea	$50 ($10 averaged over 5 years)	$200	Assume 2 12-inch by 18-inch signs on each side of the area Assumes 12-foot post
	5.2.3 Labor	1	hr/yr	$50 /hr	$50 ($10 averaged over 5 years)	$200	Assumes generally takes a half of an hour to install each sign
6	Annual Evaluation (Year 2-30)						
	6.1 Inspection	8	hr/yr	$75 /hr	$600	$9,100	Assumes site conditions and use will be inspected annually to determine if institutional controls are currently acceptable Evaluation would occur over 1 day.

TABLE B-1b

O&M Cost Estimate: Alternative 2, Institutional Controls, Industrial Planned Use

Memphis Depot Main Installation Soils FS

FU1-6 with No Cleanup of FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
	6 2 Reporting	32	hr/yr	$75 /hr	$2,400	$36,300	Assume report 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 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]					**$4,300**	**$64,000**	

[a] 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 over 30 years.

[c] 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.

[d] O&M costs occur over a period of 30 years

TABLE B-1c

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

Memphis Depot Main Installation Soils FS

FU1-6 with No Cleanup of FU4

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Deed Restrictions	$7,400	NA	NA	$7,400
2	Fence along Perimeter of Lead Hot Spot	$5,000	NA	NA	$5,000
3	Signs	$150	NA	NA	$150
4	Plans for Implementation	$6,600	NA	NA	$6,600
5	Maintenance of Site (Year 2-30)	NA	$530 [d]	$7,200	$7,200
6	Annual Evaluation (Year 2-30)	NA	$3,000	$45,400	$45,400
7	5-Year Review	NA	$800 [d]	$11,700	$11,700
Total Cost for FU1-6 with No Cleanup of FU4[e]		**$19,000**	**$4,300**	**$64,000**	**$83,000**

[a] 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 over 30 years.

[c] Total PW cost includes capital plus PW O&M costs over 30 years.

[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

[e] This estimate applies to all FUs and includes industrial site controls for lead hot spot in FU4 that is not covered, treated, or removed

TABLE B-2a

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

Memphis Depot Main Installation Soils FS

FU1-3, 5, and 6 with Cleanup of Lead Hot Spot in FU4 by Another Alternative

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Deed Restrictions					Deed restrictions include land use 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	2	ea	$500 /ea	$1,000	
2	Plans for Implementation	88	hr	$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					**$14,000**	

[a] 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.

TABLE B-2b

O&M Cost Estimate. Alternative 2, Institutional Controls, Industrial Planned Use

Memphis Depot Main Installation Soils FS

FU1-3, 5, and 6 with Cleanup of Lead Hot Spot in FU4 by Another Alternative

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
3	Annual Evaluation (Year 2-30)						
	3.1 Inspection	8	hr/yr	$75 /hr	$600	$9,100	Assumes site conditions and use will be inspected annually to determine if institutional controls are currently acceptable Evaluation would occur over 1 day
	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] 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 over 30 years

[c] 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.

[d] O&M costs occur over a period of 30 years.

TABLE B-2c

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

FU1-3, 5, and 6 with Cleanup of Lead Hot Spot in FU4 by Another Alternative

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Deed Restrictions	$7,400	NA	NA	$7,400
2	Plans for Implementation	$6,600	NA	NA	$6,600
3	Annual Evaluation (Year 2-30)	NA	$3,000	$45,400	$45,400
4	5-Year Review	NA	$800 [d]	$11,700	$11,700
Total Cost for FU1-3, 5, and 6[e]		**$14,000**	**$3,800**	**$57,000**	**$71,000**

[a] 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 over 30 years.

[c] Total PW cost includes capital plus PW O&M costs over 30 years.

[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

[e] It is assumed that institutional controls would require the same activity whether applied to one or all FUs Thus, the cost for each FU is the same as the cost for the entire Depot. This estimate assumes that Institutional Controls will include future use restrictions of entire FUs or Depot. This cost alternative is based on the assumption that FU4 will be remediated by another alternative to industrial land use criteria

NA Not applicable

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

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Deed Restrictions					Deed restrictions include day care restrictions, protection of soil cover, and land use restrictions
	1 1 Attorney Fees	40	hr	$200 /hr	$8,000	CH2M HILL American Scrap Metal Site, Panama City· Order of Magnitude Cost Estimate for Alternative 2A.
	1.2 Recording of the Deed	3	ea	$500 /ea	$1,500	
2	Plans for Implementation	96	hr	$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
3	Soil Cover (Over One Lead Hot Spot in FU4)					Refer to Section 4 figures for location of candidate remediation area.
	3.1 Site Grading	7,200	ft^2	$0 11 /$ft^2$	$800	CH2M HILL. American Scrap Metal Site, Panama City. These costs includes labor, mobilization/demobilization, equipment, and material
	3.2 Compacted Soil Cover (F&I)	400	yd^3	$10 /$yd^3$	$4,000	Soil cover will have a 12-inch compacted thickness To achieve this, an 18-inch loose soil thickness is required, before compaction. The volume of 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

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

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	yd^3	$11.38 /$yd^3$	$4,600	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. Assuming cost is approximately same for transport of clean soil on-site.
	3.4 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
	3 4.1 TCL Volatiles (8260)	1	ea	$198 /ea	$200	
	3.4.2 TAL Metals (6010/700)	1	ea	$268 /ea	$270	
	3 4 3 Pesticides (8081A)	1	ea	$141 /ea	$150	
	3.4.4 PCBs (8082)	1	ea	$110 /ea	$110	
4	Surface Water Collection and Controls	1	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
5	Restoration of Site - Revegetation					CH2M HILL Draft: EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999.

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

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	5.1 Soil Conditioning	0 17	acre	$885 /acre	$200	This cost includes the application of lime and fertilizer.
	5 2 Seeding	0.17	acre	$1,420 /acre	$300	These costs includes labor, mobilization/demobilization, equipment, and material.
6	Fence along Perimeter of Soil Cover					
	6.1 Fencing	440	ft	$8 /ft	$3,500	CH2M HILL· American Scrap Metal Site, Panama City Order of Magnitude Cost Estimate for Alternative 5A
	6 2 Labor	20	hr	$75 /hr	$3,000	Assumes two field people will be on-site for 10 hours for 1 day
7	Signs along Soil Cover					Signs will be installed around soil cover to help prevent any disturbance.
	7 1 Signs	2	ea	$22 /ea	$50	Phone Quote from Sign-A-Rama Assume 2 12-inch by 18-inch signs on each side of the covered area
	7 2 Posts	2	ea	$25 /ea	$50	Assumes 12-foot post
	7 3 Labor	1	hr	$50 /hr	$50	Assumes generally takes a half of an hour to install each sign
8	Confirmation Sampling, 2 Events					Samples would be taken at edges of soil cover to confirm FU4 impacted area has been contained One sample will be taken per side of excavation during each event.
	8 1 Labor	40	hr	$75 /hr	$3,000	Assumes two field people will be on-site for 10 hours for 1 day for each event.
	8 2 Laboratory Analysis - Lead	8	ea	$18 /ea	$200	Cost estimated from price list from Lancaster Laboratories, PA

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

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	8 3 Rental Equipment	2	event	$360 /event	$800	CH2M HILL· Draft. EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999.
	8 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.
	8.5 Supplies	2	event	$500 /event	$1,000	CH2M HILL. Reichold-Summary Invoice of Site Operations.
Total Capital Costs					**$51,000**	

[a] 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.

TABLE B-3b
O&M Cost Estimate Alternative 3, Containment, Industrial Planned Use
Memphis Depot Main Installation Soils FS

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
9	Maintenance of Site						
	9.1 Fencing (three over 30 years)						Assumes fencing will need to be replaced every 10 years
	9 1.1 Fencing	440	ft/yr	$8 /ft	$3500 ($350 averaged over 10 years)	$4,600	CH2M HILL American Scrap Metal Site, Panama City: Order of Magnitude Cost Estimate for Alternative 5A.
	9 1 2 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)						Assumes signs will be replaced every 5 years
	9.2.1 Signs	2	ea/yr	$22 /ea	$50 ($10 averaged over 5 years)	$200	Phone Quote from Sign-A-Rama
							Assume 2 12-inch by 18-inch signs on each side of the area
	9 2.2 Posts	2	ea/yr	$25 /ea	$50 ($10 averaged over 5 years)	$200	Assumes 12-foot post
	9 2 3 Labor	1	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 Soil 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

TABLE B-3b

O&M Cost Estimate. Alternative 3, Containment, Industrial Planned Use

Memphis Depot Main Installation Soils FS

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
	9.4 Landscaping	192	hr/yr	$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
10	Annual Evaluation (Year 2-30)						
	10.1 Inspection	8	hr/yr	$75 /hr	$600	$9,100	Assumes regulators would evaluate site annually to determine that soil covers were not disturbed Evaluation would occur over 1 day
	10.2 Reporting	32	hr/yr	$75 /hr	$2,400	$36,300	Assume report will take 1 week to complete.
11	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 soil covers are intact and are providing adequate protection. Assume report will take 1 week to complete
Total O&M Costs (Years 1-30)[c]					**$4,300**	**$310,000**	

[a] 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 over 30 years

[c] 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

[d] O&M costs occur over a period of 30 years.

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

FU4

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Deed Restrictions	$9,500	NA	NA	$9,500
2	Plans for Implementation	$7,200	NA	NA	$7,200
3	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
6	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
9	Maintenance of Site	NA	$530 [d]	$252,500	$252,500
10	Annual Evaluation (Year 2-30)	NA	$3,000	$45,400	$45,400
11	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] 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 over 30 years

[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

TABLE B-4a
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
1	Deed Restrictions					Deed restrictions include protection of soil cover
	1 1 Attorney Fees	24	hr	$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	1	ea	$500 /ea	$500	
2	Plans for Implementation	96	hr	$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
3	Soil Cover (over Lead, Arsenic, and Dieldrin areas)					
	3 1 Site Grading					CH2M HILL· American Scrap Metal Site, Panama City. Assumes this includes labor, mobilization/demobilization, and equipment Re-adjusted $0 11/ ft^2 unit cost to $0.07/$ft^2$ because of the greater volume of soil Refer to Section 4 figures for location of candidate remediation areas.
	3 1 1 FU1	206,300	ft^2	$0.07 /$ft^2$	$14,500	This area corresponds to 12 dieldrin-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).

TABLE B-4a
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
	3 1 2 FU2	1,960,200	ft^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	ft^2	$0 07 /$ft^2$	$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	ft^2	$0 07 /$ft^2$	$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	ft^2	$0 07 /$ft^2$	$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)
	3 1 6 FU6	400	ft^2	$0.07 /$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

FU1 - FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	3.2 Compacted Soil Cover (F&I)					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 1 FU1	11,500	yd^3	$10 /$yd^3$	$115,000	
	3 2 2 FU2	108,900	yd^3	$10 /$yd^3$	$1,089,000	
	3 2.3 FU3	300	yd^3	$10 /$yd^3$	$3,000	
	3.2.4 FU4	21,500	yd^3	$10 /$yd^3$	$215,000	
	3.2 5 FU5	2,200	yd^3	$10 /$yd^3$	$22,000	
	3 2 6 FU6	20	yd^3	$10 /$yd^3$	$200	
	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. Assuming cost is approximately same for transport of clean soil on-site.
	3 2 1 FU1	11,500	yd^3	$11 38 /$yd^3$	$130,900	
	3 2.2 FU2	108,900	yd^3	$11.38 /$yd^3$	$1,239,300	
	3.2 3 FU3	300	yd^3	$11.38 /$yd^3$	$3,500	
	3 2 4 FU4	21,500	yd^3	$11 38 /$yd^3$	$244,700	
	3.2.5 FU5	2,200	yd^3	$11.38 /$yd^3$	$25,100	
	3.2 6 FU6	20	yd^3	$11 38 /$yd^3$	$300	

TABLE B-4a
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
	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 144,420 yd^3
	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	1	ea	$10,000 /ea	$10,000	CH2M HILL Draft EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999.
	4 2 FU2	1	ea	$10,000 /ea	$10,000	This cost includes sediment barriers, straw bale dikes, and transport of contaminated water to treatment plant
	4 3 FU3	1	ea	$10,000 /ea	$10,000	
	4 4 FU4	1	ea	$10,000 /ea	$10,000	
	4.5 FU5	1	ea	$10,000 /ea	$10,000	
	4 6 FU6	1	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, TN, March 1999.
	5 2 Soil Conditioning					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

FU1 - FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	5.1.1 FU1	5	acre	$885 /acre	$4,200	Areas are equivalent acres per areas listed in Item 3.1.
	5.1.2 FU2	45	acre	$885 /acre	$39,900	
	5 1.3 FU3	0 13	acre	$885 /acre	$200	
	5.1.4 FU4	9	acre	$885 /acre	$7,900	
	5 1 5 FU5	1	acre	$885 /acre	$900	
	5 1 6 FU6	0 01	acre	$885 /acre	$10	
	5 2 Seeding					These costs include labor, mobilization/demobilization, equipment, and material.
	5 2 1 FU1	5	acre	$1,420 /acre	$6,800	
	5.2.2 FU2	45	acre	$1,420 /acre	$63,900	
	5 2 3 FU3	0 13	acre	$1,420 /acre	$200	
	5.2.4 FU4	9	acre	$1,420 /acre	$12,600	
	5.2.5 FU5	1	acre	$1,420 /acre	$1,300	
	5 2 6 FU6	0.01	acre	$1,420 /acre	$20	
6	Confirmation Sampling, 2 Events					Samples would be taken at edges of soil cover to confirm impacted area has been contained during each event Assumes 4 samples will be taken at each dieldrin hot spot area for each FU, except FU4, where 10 samples will be taken. Assumes 4 samples will be taken at each arsenic hot spot area for each FU Assumes 4 samples will be taken at each lead hot spot area for each FU.
	6.1 Labor	480	hr	$75 /hr	$36,000	Assumes two field people will be on-site for 10 hours for 12 days for each event.

TABLE B-4a
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	ea	$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	2	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	hr	$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	2	event	$500 /event	$1,000	CH2M HILL Reichold-Summary Invoice of Site Operations
Total Capital Costs					**$3,760,000**	

[a] 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.

TABLE B-4b
O&M Cost Estimate Alternative 3, Containment, Residential Planned Use
Memphis Depot Main Installation Soils FS

FU1-FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
7	Annual Evaluation (Year 2-30)						
	7.1 Inspection	8	hr/yr	$75 /hr	$600	$9,100	Assumes regulators would evaluate site annually to determine that soil covers were not disturbed Evaluation would occur over 1 day
	7.2 Reporting	32	hr/yr	$75 /hr	$2,400	$36,300	Assume report will take 1 week to complete
8	Maintenance of Site						
	8.1 Soil Cover Maintenance	240	hr/yr	$75 /hr	$18,000	$272,500	These costs assume local labor will be available Assumes a field operator will maintain soil cover an average of 20 hours per month for 30 years This includes repairs to soil cover due to erosion and intrusion.
	8 2 Landscaping	384	hr/yr	$75 /hr	$28,800	$436,100	Assumes a local 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.

TABLE B-4b
O&M Cost Estimate: Alternative 3, Containment, Residential Planned Use
Memphis Depot Main Installation Soils FS

FU1-FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
9	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 soil covers are intact and are providing adequate protection. Assume report will take 1 week to complete.
Total O&M Costs (Years 1-30)[c]					**$50,600**	**$766,000**	

[a] 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 over 30 years

[c] 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

[d] O&M costs occur over a period of 30 years.

TABLE B-4c
Cost Estimate Summary: Alternative 3, Containment, 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]
1	Deed Restrictions	$5,300	NA	NA	$5,300
2	Plans for Implementation	$7,200	NA	NA	$7,200
3	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	
	FU5	$49,900	NA	NA	
	FU6	$530	NA	NA	
	Laboratory Analysis - TAL/TLC on Clean Soil	$207,100	NA	NA	
4	Surface Water Collection and Controls ($10,000/FU)	$60,000	NA	NA	$60,000
5	Restoration of Site - Revegetation				$137,900
	FU1	$11,000	NA	NA	
	FU2	$103,800	NA	NA	
	FU3	$400	NA	NA	
	FU4	$20,500	NA	NA	
	FU5	$2,200	NA	NA	
	FU6	$30	NA	NA	
6	Confirmation Sampling	$72,300	NA	NA	$72,300
7	Annual Evaluation (Year 2-30)	NA	$3,000	$45,400	$45,400
8	Maintenance of Site	NA	$46,800	$708,600	$708,600
9	5-Year Review	NA	$800 [g]	$11,700	$11,700
Total Cost to Remediate all FUs at One Time (Per Line Items)		**$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

	Individual FU Costs (Based on Line Items and Percentage of Remediation)[d]				Adjusted FU Costs[h]			
	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
Total Cost for Entire Depot	**$3,760,000**	**$50,600**	**$766,000**	**$4,526,000**	**$3,764,000**	**$53,300**	**$805,000**	**$4,569,000**
Total Costs for **FU1** (contains 8 3 percent 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 percent 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 percent of soil to be remediated)	**18,000**	**100**	**2,000**	**20,000**	**18,000**	**1,200** [e]	**18,000**	**36,000**
Total Costs for **FU4** (contains 14 8 percent of soil to be remediated)	**560,000**	**7,400**	**112,000**	**672,000**	**560,000**	**7,400**	**112,000**	**672,000**
Total Costs for **FU5** (contains 1 5 percent of soil to be remediated)	**67,000**	**700**	**11,000**	**78,000**	**67,000**	**1,200** [e]	**18,000**	**85,000**
Total Costs for **FU6** (contains 0.01 percent of soil to be remediated)	**11,000**	**100**	**2,000**	**13,000**	**15,000** [f]	**1,200** [e]	**18,000**	**33,000**

[a] 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 over 30 years. 3,375,000

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

[d] 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

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

[g] 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

TABLE B-5a
Capital Cost Estimate: Alternative 4, In-situ Soil Treatment, Industrial Planned Use
Memphis Depot Main Installation Soils FS

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Deed Restrictions					Deed restrictions include day care restrictions and land use restrictions during and after implementation
	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	2	ea	$500 /ea	$1,000	
2	Plans for Implementation	96	hr	$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
3	Stabilization (One Lead Hot Spot in FU4)					Phone quote from SOLUCORP
	3 1 Bench-Scale Study	1	ea	$2,000 /ea	$2,000	A bench-scale study will be performed to determine the best treatment solution for site conditions.
	3.2 Treatment	373 [b]	tons	$45 /ton	$16,800	This cost includes the stabilizing compound and a technical administrator to be on-site for application of the compound Assume cost also includes equipment and mobilization/demobilization Assumes compound can be tilled in as dry chemical. This weight corresponds to an area with one lead-contaminated hot spots (7,200 ft^2), a depth of 1 foot, and a bulk density of 1.4 $tons/yd^3$

TABLE B-5a
Capital Cost Estimate: Alternative 4, In-situ Soil Treatment, Industrial Planned Use
Memphis Depot Main Installation Soils FS

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
4	Surface Water Collection and Controls	1	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
5	Confirmation Sampling, 2 Events					Samples would be taken at edges of solidified soil to confirm FU4 impacted area has been contained
	5 1 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	8	ea	$18 /ea	$200	Cost estimated from price list from Lancaster Laboratories, PA
	5 3 Rental Equipment	2	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	2	event	$500 /event	$1,000	CH2M HILL· Reichold-Summary Invoice of Site Operations.
6	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 lime and fertilizer

TABLE B-5a

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

Memphis Depot Main Installation Soils FS

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	6.2 Seeding	0 17	acre	$1,420 /acre	$300	These costs includes labor, mobilization/demobilization, equipment, and material.
Total Capital Costs					**$51,000**	

[a] 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] Assumes soil bulk density of 1 4 tons/yd^3 based on historical surface soil removal actions conducted at the Depot

TABLE B-5b
O&M Cost Estimate: Alternative 4, In-situ Soil Treatment, Industrial Planned Use
Memphis Depot Main Installation Soils FS

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
8	Annual Evaluation (Year 2-30)						
	8.1 Inspection	8	hr/yr	$75 /hr	$600	$9,100	Assumes site conditions and use will be inspected annually to determine if institutional controls are currently acceptable Evaluation would occur over 1 day.
	8.2 Reporting	32	hr/yr	$75 /hr	$2,400	$36,300	Assume report will take 1 week to complete
9	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]					**$18,200**	**$72,000**	

[a] 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 over 30 years

[c] 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

[d] O&M costs occur over a period of 30 years

TABLE B-5c
Cost Estimate Summary· Alternative 4, In-situ Soil Treatment, Industrial Planned Use
Memphis Depot Main Installation Soils FS

FU4

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Deed Restrictions	$7,400	NA	NA	$7,400
2	Plans for Implementation	$7,200	NA	NA	$7,200
3	Stabilization of Lead	$18,800	NA	NA	$18,800
4	Surface Water Collection and Controls	$10,000	NA	NA	$10,000
5	Confirmation Sampling	$7,400	NA	NA	$7,400
6	Restoration of Site - Revegetation	$500	NA	NA	$500
7	Maintenance of Site- Landscaping	NA	$14,400	$14,400	$14,400
8	Annual Evaluation (Year 2-30)	NA	$3,000	$45,400	$45,400
9	5-Year Review (six over 30 years)	NA	$800 [d]	$11,700	$11,700
Total Cost for Entire Depot		**$51,000**	**$18,200**	**$72,000**	**$123,000**
Total Costs for FU1		0	0	NA	0
Total Costs for FU2		0	0	NA	0
Total Costs for FU3		0	0	NA	0
Total Costs for FU4 (100 Percent of Remedial Action)		**51,000**	**18,200**	**72,000**	**123,000**
Total Costs for FU5		0	0	NA	0
Total Costs for FU6		0	0	NA	0

[a] 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.

[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

TABLE B-6a
Capital Cost Estimate· Alternative 4, In-situ Soil Treatment, Residential Planned Use
Memphis Depot Main Installation Soils FS

FU1 - FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Deed Restrictions					Deed restrictionswould be temporary land use restrictions during implementation
	1 1 Attorney Fees	24	hr	$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	1	ea	$500 /ea	$500	
2	Plans for Implementation	96	hr	$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
3	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 salts, 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.

TABLE B-6a
Capital Cost Estimate: Alternative 4, In-situ Soil Treatment, Residential Planned Use
Memphis Depot Main Installation Soils FS

FU1 - FU6

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

TABLE B-6a

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

Memphis Depot Main Installation Soils FS

FU1 - FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
4 1	FU1	1	ea	$10,000 /ea	$10,000	CH2M HILL Draft EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999.
4.2	FU2	1	ea	$10,000 /ea	$10,000	This cost includes sediment barriers, straw bale dikes, and transport of contaminated water to treatment plant
43	FU3	1	ea	$10,000 /ea	$10,000	
4.4	FU4	1	ea	$10,000 /ea	$10,000	
4.5	FU5	1	ea	$10,000 /ea	$10,000	
4 6	FU6	1	ea	$10,000 /ea	$10,000	
Total Capital Costs					**$1,896,000**	

[a] 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] Assumes soil bulk density of 1.4 tons/yd^3 based on historical surface soil removal actions conducted at the Depot

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

FU1 - FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
5	Maintenance of Site- Landscaping (Year 1-3)	384	hr/yr	$75 /hr	$28,800	$53,600	Assumes a field technician will perform landscaping an average of 32 hours (4 days) per month per year This cost includes irrigation and mowing of site
6	Continued Biological Treatment (Year 2 and 3)						Based on Venture Capital Estimate Refer to Table B-14 for full assumptions
	6.1 Amendments/Application/ Sampling						This cost includes treatment solution (mineral salts, 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 re-applying biological treatment media twice a year (growing season and summer), aerating with tractor every 2 weeks, and possibly reapplying fertilizer every month Assumes that local labor will be available for aeration, landscaping, and fertilizer applications
	6 1 1 FU1	176,000	ft^2/yr	$0 38 /$ft^2$	$66,900	$124,400	This area corresponds to an area with 14 dieldrin-contaminated hot spots (176,000 ft^2) and a depth of 1 foot
	6 1.2 FU2	1,960,200	ft^2/yr	$0 38 /$ft^2$	$744,900	$1,385,100	This area corresponds to the entire area of FU2, not including Lake Danielson and the Golf Course Pond (45 acres) and a depth of 1 foot

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

FU1 - FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
	6.1.3 FU3	0	ft^2/yr	$0.38 /$ft^2$	$0	$0	There are no soils in this FU above the criteria for dieldrin
	6 1.4 FU4	121,500	ft^2/yr	$0 38 /$ft^2$	$46,200	$85,900	This area corresponds to an area with 7 dieldrin-contaminated hot spots (121,500 ft^2) with a depth of 1 foot
	6 1.5 FU5	32,000	ft^2/yr	$0.38 /$ft^2$	$12,200	$22,700	This area corresponds to an area with 7 dieldrin-contaminated hot spots (32,000 ft^2) and a depth of 1 foot.
	6 1 6 FU6	0	ft^2/yr	$0.38 /$ft^2$	$0	$0	There are no soils in this FU above the criteria for dieldrin
	6 2 Lab Studies	2	ea/yr	$30,000 /ea	$60,000	$111,600	Assumes lab studies will be performed to determine if treatment solution needs to be modified for better performance
7	Stabilization of Lead and Arsenic (Year 3)						Phone quote from SOLUCORP All stabilization of contaminated soils would occur in year 3
	7.1 Bench-Scale Study	1	ea/yr	$2,000 /ea	$2,000	$1,900	A bench-scale study will be performed to determine the best treatment solution for site conditions.

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

FU1 - FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
	7 2 Treatment						This cost includes the stabilizing compound and a technical administrator to be on-site for application of the compound Assumes cost also includes equipment and mobilization/demobilization Assumes compound can be tilled in as dry chemical.
	7 2 1 FU1 (Arsenic)	2,349 [b]	tons/yr	$45 /ton	$105,700	$95,900	This weight corresponds to an area with 5 arsenic-contaminated hot spots (45,300 ft^2), a depth of 1 foot, and a bulk density of 1 4 tons/yd^3
	7 2 2 FU2 (Arsenic)	2,935 [b]	tons/yr	$45 /ton	$132,100	$119,800	This weight corresponds to an area with 7 arsenic-contaminated hot spots (56,600 ft^2), a depth of 1 foot, and a bulk density of 1 4 tons/yd^3
	7.2.3 FU3 (Arsenic and Lead)	285 [b]	tons/yr	$45 /ton	$12,900	$11,700	This weight corresponds to an area with 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 5,500 ft^2 A depth of 1 foot and a bulk density of 1 4 tons/yd^3 are used in the calculation

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

FU1 - FU6

Item	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 density of 1.4 $tons/yd^3$
	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 $tons/yd^3$
	7 2.6 FU6 (Arsenic)	21 [b]	tons/yr	$45 /ton	$1,000	$900	This weight corresponds to an area with 1 arsenic-contaminated hot spot (400 ft^2), a depth of 1 foot, and a bulk density of 1 4 $tons/yd^3$
8	Confirmation Sampling - Lead and Arsenic Areas, 2 Events (Year 3)						Samples would be taken at edges of solidified soil to confirm impacted area has been contained Sampling of soils undergoing biological treatment is included in the unit cost for Items 3 and 6. Assumes 4 samples will be taken at each arsenic hot spot area for each FU Assumes 4 samples will be taken at each lead hot spot area for each FU
	8.1 Labor	480	hr/yr	$75 /hr	$36,000	$32,700	Assumes two field people will be on-site for 10 hours for 12 days for each event

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

FU1 - FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth 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 Laboratories, PA.
	8 3 Laboratory Analysis - Lead	32	ea/yr	$18 /ea	$600	$600	Cost estimated from price list from Lancaster Laboratories, PA.
	8 4 Rental Equipment	2	event/yr	$360 /event	$800	$700	CH2M HILL: Draft· EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, 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
9	Restoration of Site (Year 3)						CH2M HILL. Draft· EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999.
	9 2 Soil Conditioning						
	9 1.1 FU1	5	acre/yr	$885 /acre	NA	$3,900	This area corresponds to 12 dieldrin-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)

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

FU1 - FU6

Item	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^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 5,500 ft^2
	9.1.4 FU4	9	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 ft^2).
	9 1.5 FU5	1	acre/yr	$885 /acre	NA	$900	This area corresponds to 7 dieldrin-contaminated hot spots (32,000 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
	9 2 1 FU1	5	acre/yr	$1,420 /acre	NA	$6,100	Areas are the same as those listed for Item 8 1
	9 2 2 FU2	45	acre/yr	$1,420 /acre	NA	$58,000	
	9.2.3 FU3	0 13	acre/yr	$1,420 /acre	NA	$200	
	9 2.4 FU4	9	acre/yr	$1,420 /acre	NA	$11,500	
	9 2 5 FU5	1	acre/yr	$1,420 /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

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth 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	8	hr/yr	$75 /hr	$600	$1,100	Assumes site will be inspected annually to determine if remedial alternative is currently acceptable. Inspection will occur over 1 day
	10.2 Reporting	32	hr/yr	$75 /hr	$2,400	$4,500	Assume report will take 1 week to complete.
Total O&M Costs (Years 1-3)					**$1,922,300**	**$2,786,000**	

[a] 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] O&M costs occur over a period of 3 years.

NA Not applicable

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]
1	Deed Restrictions	$5,300	NA	NA	$5,300
2	Plans for Implementation	$7,200	NA	NA	$7,200
3	Enhanced Biological Treatment				$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	
	FU6	$0	NA	NA	
	Lab Studies	$60,000	NA	NA	
4	Surface Water Collection and Controls ($10,000/FU)	$60,000	NA	NA	$60,000
5	Maintenance of Site- Landscaping	NA	$28,800	$53,600	$53,600
6	Continued Biological Treatment (Year 2 and 3)				$1,729,700
	FU1	NA	$66,900	$124,400	
	FU2	NA	$744,900	$1,385,100	
	FU3	NA	$0	$0	
	FU4	NA	$46,200	$85,900	
	FU5	NA	$12,200	$22,700	
	FU6	NA	$0	$0	
	Lab Studies	NA	$60,000	$111,600	
7	Stabilization of Lead and Arsenic				$215,700
	FU1	NA	NA	$95,900	
	FU2	NA	NA	$119,800	

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	NA	NA	$11,700	
	FU4	NA	NA	$581,600	
	FU5	NA	NA	$15,900	
	FU6	NA	NA	$900	
	Bench-Scale Study	NA	NA	$1,900	
	Confirmation Sampling				
8		NA	NA	$43,600	$43,600
9	Restoration of Site (Year 3)				$125,530
	FU1	NA	NA	$10,000	
	FU2	NA	NA	$94,200	
	FU3	NA	NA	$400	
	FU4	NA	NA	$18,700	
	FU5	NA	NA	$2,200	
	FU6	NA	NA	$30	
10	Annual Evaluation (Year 2 and 3)	NA	$3,000	$5,600	$5,600
(Per Line Items)		**$1,896,000**	**$959,000**	**$1,999,000**	**$3,895,000**

TABLE B-6c
Cost Estimate Summary: Alternative 4, In-situ Soil Treatment, Residential Planned Use
Memphis Depot Main Installation Soils FS

FU1-FU6

	Individual FU Costs (Based on Line Items and Percentage of Remediation)[d]				Adjusted FU Costs[g]			
	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
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 [f]	1,750 [e]	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 [e]	3,000	8,000

[a] 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.

[d] 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 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

[f] 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)

[g] 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

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

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Deed Restrictions					Deed restrictions include day care restrictions and land use 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	2	ea	$500 /ea	$1,000	
2	Plans for Implementation	96	hr	$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
3	Excavation of Soils (One Lead Hot Spot in FU4)	267	yd^3	$3 69 /$yd^3$	$1,000	CH2M HILL. Draft· EE/CA Removal of Hot Spot Areas. Main Installation Defense Depot, Memphis, TN, March 1999. Includes excavation and loading of contaminated surface soil, equipment, labor, mobilization/demobilization The volume of soil is based on a 7,200 ft^2 area for one hot spot and an excavation depth of 1 foot.
4	Surface Water Collection and Controls	1	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
5	Disposal of Contaminated Soils (One Lead Hot Spot in FU4)					
	5 1 Laboratory Analysis - TCLP	1	ea	$1,500 /ea	$1,500	Cost estimated from price list from Lancaster Laboratories, PA

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

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
						TCLP analyses will be run for every 500 yd^3 of soil transported off-site
	5 2 Transportation-Emille, Al	373 [b]	tons	$33 /ton	$12,200	Phone quote from Waste Management.
	5.3 Disposal Fee and Taxes- Haz Waste Landfill	373 [b]	tons	$308 /ton	$115,000	Assumes contaminated soil will be transported to RCRA Hazardous Waste Landfill in Emille, Alabama.
	5 4 Application Fees-Haz Waste Landfill	1	ea	$250 /ea	$250	
6	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	hr	$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	8	ea	$18 /ea	$200	Cost estimated from price list from Lancaster Laboratories, PA
	6.3 Rental Equipment	2	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.
7	Restoration of Site					
	7.1 Imported Backfill (material)	267	yd^3	$10 /$yd^3$	$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$	$3,100	This cost includes material and placement 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

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	7.3 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
	7.3.1 TCL Volatiles (8260)	1	ea	$198 /ea	$200	
	7 3 2 TAL Metals (6010/700)	1	ea	$268 /ea	$270	
	7 3 3 Pesticides (8081A)	1	ea	$141 /ea	$150	
	7.3.4 PCBs (8082)	1	ea	$110 /ea	$110	
	7.4 Soil Conditioning	0.17	acre	$885 /acre	$200	This cost includes the application of lime and fertilizer
	7 5 Seeding	0.17	acre	$1,420 /acre	$300	These costs include labor, mobilization/demobilization, equipment, and material.
8	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
Total Capital Costs					**$183,000**	

[a] 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] Assumes soil bulk density of 1.4 tons/yd^3 based on historical surface soil removal actions conducted at the Depot.

TABLE B-7b
O&M Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Industrial Planned Use
Memphis Depot Main Installation Soils FS

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Source/ Comments
9	Annual Evaluation (Year 2-30)						
	9 1 Inspection	8	hr/yr	$75 /hr	$600	$9,100	Assumes site conditions and use will be inspected annually to determine if institutional controls are currently acceptable. Evaluation would occur over 1 day.
	9 2 Reporting	32	hr/yr	$75 /hr	$2,400	$36,300	Assume report will take 1 week to complete
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 to be reviewed every 5 years to ensure that institutional controls are providing adequate protection
Total O&M Costs					**$3,800**	**$57,000**	

[a] 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 over 30 years

[c] 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

[d] O&M costs occur over a period of 30 years

TABLE B-7c

Cost Estimate Summary· Alternative 7, Excavation and Off-site Disposal, Industrial Planned Use

Memphis Depot Main Installation Soils FS

FU4

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Deed Restrictions	$7,400	NA	NA	$7,400
2	Plans for Implementation	$7,200	NA	NA	$7,200
3	Excavation of Soils	$1,000	NA	NA	$1,000
4	Surface Water Collection and Controls	$10,000	NA	NA	$10,000
5	Disposal of Contaminated Soils	$128,950	NA	NA	$128,950
6	Confirmation Sampling	$7,400	NA	NA	$7,400
7	Restoration of Site	$6,930	NA	NA	$6,930
8	Maintenance of Site- Landscaping	$14,400	NA	NA	$14,400
9	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	NA	0
Total Costs for FU2		0	NA	NA	0
Total Costs for FU3		0	NA	NA	0
Total Costs for FU4 (100 Percent of Remedial Action)		**183,000**	**3,800**	**57,000**	**240,000**
Total Costs for FU5		0	NA	NA	0
Total Costs for FU6		0	NA	NA	0

[a] 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

[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

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

FU1

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Plans for Implementation	96	hr	$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 1999.
	Arsenic- and Dieldrin-Contaminated Soils	7,641	yd^3	$3.69 /$yd^3$	$28,200	Includes excavation and loading of contaminated surface soil, equipment, labor, mobilization/demobilization This volume corresponds to 13 dieldrin-contaminated hot spots (176,000 ft^2), 4 arsenic-contaminated hot-spots (30,300 ft^2), 1 arsenic- and dieldrin-contaminated hot spot (15,000 ft^2), and an excavation depth of 1 foot.
3	Surface Water Collection and Controls	1	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)

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

FU1

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	4.1 Laboratory Analysis - TCLP	16	ea	$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	yd^3	$11.38 /$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
5	Confirmation Sampling, 2 Events					Assumes 4 samples will be taken at each arsenic and dieldrin excavated hot spot area for each event
	5.1 Labor for Both Events	280	hr	$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	112	ea	$100 /ea	$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 Laboratories, PA
	5 4 Rental Equipment	2	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	2	event	$500 /event	$1,000	CH2M HILL· Reichold-Summary Invoice of Site Operations

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

FU1

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
6	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$	$87,000	This cost includes material and placement 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)	16	ea	$141 /ea	$2,260	
	6 3 4 PCBs (8082)	16	ea	$110 /ea	$1,760	
	6 4 Soil Conditioning	5	acre	$885 /acre	$4,200	This cost includes the application of lime and fertilizer
	6 5 Seeding	5	acre	$1,420 /acre	$6,800	These costs includes labor, mobilization/demobilization, equipment, and material
7	Maintenance of Site- Landscaping	288	hr	$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

FU1

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
8	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
Total Capital Costs					**$608,000**	

[a] 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] Assumes soil bulk density of 1.4 tons/yd^3 based on historical surface soil removal actions conducted at the Depot

TABLE B-8b

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

Memphis Depot Main Installation Soils FS

FU1

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Plans for Implementation	$7,200	NA	NA	$7,200
2	Excavation of Soils	$28,200	NA	NA	$28,200
3	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
6	Restoration of Site	$185,980	NA	NA	$185,980
7	Maintenance of Site- Landscaping	$21,600	NA	NA	$21,600
8	Final Evaluation	$4,000	NA	NA	$4,000
Total Costs for FU1		**$608,000**	**NA**	**NA**	**$608,000**

[a] 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

TABLE B-9a
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
1	Plans for Implementation	96	hr	$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 1999.
	Arsenic- and Dieldrin-Contaminated Soils	72,600	yd^3	$3 69 /$yd^3$	$267,900	Includes excavation and loading of contaminated surface soil, equipment, labor, mobilization/demobilization This volume corresponds to the entire area of FU 2, not including Lake Danielson and the Golf Course Pond (45 acres) and an excavation depth of 1 foot
3	Surface Water Collection and Controls	1	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	146	ea	$1,500 /ea	$219,000	Cost estimated from price list from Lancaster Laboratories, PA TCLP analyses will be run for every 500 yd^3 of soil transported off-site.

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TABLE B-9a
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
	4.2 Transportation - Local Landfill	72,600	yd^3	$11.38 /$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	$1,931,200	Assumes a 10-mile machine load haul to BFI Special Waste Landfill (RCRA Subtitle D Landfill) from Depot Phone quote from Shana Smiley - BFI Special Waste Landfill in Memphis
5	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	hr	$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	90	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	2	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	2	event	$500 /event	$1,000	CH2M HILL. Reichold-Summary Invoice of Site Operations.
6	Restoration of Site					
	6 1 Imported Backfill (material)	72,600	yd^3	$10 /$yd^3$	$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

TABLE B-9a
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
	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.
	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)	146	ea	$198 /ea	$28,910	
	6 3.2 TAL Metals (6010/700)	146	ea	$268 /ea	$39,130	
	6.3.3 Pesticides (8081A)	146	ea	$141 /ea	$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.
7	Maintenance of Site- Landscaping	480	hr	$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

TABLE B-9a
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
8	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
Total Capital Costs					**$5,097,000**	

[a] 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] Assumes soil bulk density of 1 4 tons/yd^3 based on historical surface soil removal actions conducted at the Depot.

TABLE B-9b

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

Memphis Depot Main Installation Soils FS

FU2

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Plans for Implementation	$7,200	NA	NA	$7,200
2	Excavation of Soils	$267,900	NA	NA	$267,900
3	Surface Water Collection and Controls	$10,000	NA	NA	$10,000
4	Disposal of Contaminated Soils	$2,976,400	NA	NA	$2,976,400
5	Confirmation Sampling	$35,300	NA	NA	$35,300
6	Restoration of Site	$1,760,690	NA	NA	$1,760,690
7	Maintenance of Site- Landscaping	$36,000	NA	NA	$36,000
8	Final Evaluation	$4,000	NA	NA	$4,000
Total Costs for FU2		**$5,097,000**	**NA**	**NA**	**$5,097,000**

[a] 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

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

FU3

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Plans for Implementation	96	hr	$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 1999.
	Arsenic- and Lead-Contaminated Soils	204	yd^3	$3.69 /$yd^3$	$800	Includes excavation and loading of contaminated surface soil, equipment, labor, mobilization/demobilization. This volume corresponds to an area containing 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 5,500 ft^2 An excavation depth of 1 foot is used
3	Surface Water Collection and Controls	1	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.

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

FU3

Item	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 Emille, AL
	4 1 Laboratory Analysis - TCLP	1	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	106	yd^3	$11 38 /$yd^3$	$1,300	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	149 [b]	tons	$19 /ton	$2,900	Phone quote from Shana Smiley - BFI Special Waste Landfill in Memphis.
	4 4 Transportation-Emille, AL	137 [b]	tons	$33 /ton	$4,500	Phone quote from Waste Management
	4 5 Disposal Fee and Taxes- Haz Waste Landfill	137 [b]	tons	$308 /ton	$42,200	Assumes contaminated soil will be transported to RCRA Hazardous Waste Landfill in Emille, AL
	4 6 Application Fees-Haz. Waste Landfill	1	ea	$250 /ea	$250	
5	Confirmation Sampling, 2 Events					Assumes 4 samples will be taken at each arsenic and lead excavated hot spot area for each event.
	5 1 Labor for Both Events	80	hr	$75 /hr	$6,000	Assumes two field people for will be on-site for 10 hours 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

FU3

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	5 2 Laboratory Analysis - Lead	8	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	2	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	2	event	$500 /event	$1,000	CH2M HILL Reichold-Summary Invoice of Site Operations.
6	Restoration of Site					
	6 1 Imported Backfill (material)	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
	6.2 Transportation of Backfill On-site	204	yd^3	$11 38 /$yd^3$	$2,400	This cost includes material and placement 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)	1	ea	$198 /ea	$200	
	6 3 2 TAL Metals (6010/700)	1	ea	$268 /ea	$270	
	6.3.3 Pesticides (8081A)	1	ea	$141 /ea	$150	
	6.3 4 PCBs (8082)	1	ea	$110 /ea	$110	

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

FU3

Item	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 fertilizer
	6.5 Seeding	0 13	acre	$1,420 /acre	$200	These costs includes 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	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
Total Capital Costs					**$106,000**	

[a] 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] Assumes soil bulk density of 1.4 tons/yd^3 based on historical surface soil removal actions conducted at the Depot

TABLE B-10b

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

Memphis Depot Main Installation Soils FS

FU3

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Plans for Implementation	$7,200	NA	NA	$7,200
2	Excavation of Soils	$800	NA	NA	$800
3	Surface Water Collection and Controls	$10,000	NA	NA	$10,000
4	Disposal of Contaminated Soils	$52,650	NA	NA	$52,650
5	Confirmation Sampling	$11,000	NA	NA	$11,000
6	Restoration of Site	$5,630	NA	NA	$5,630
7	Maintenance of Site- Landscaping	$14,400	NA	NA	$14,400
8	Final Evaluation	$4,000	NA	NA	$4,000
Total Costs for FU3		**$106,000**	**NA**	**NA**	**$106,000**

[a] 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

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

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Plans for Implementation	96	hr	$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 1999
	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
3	Surface Water Collection and Controls	1	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

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

FU4

Item	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 Emille, AL
	4 1 Laboratory Analysis - TCLP	29	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	1	ea	$250 /ea	$250	
5	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	hr	$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

FU4

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	5 2 Laboratory Analysis - Dieldrin	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 Laboratories, PA
	5 4 Laboratory Analysis - Lead	24	ea	$18 /ea	$500	Cost estimated from price list from Lancaster Laboratories, PA
	5 5 Rental Equipment	2	event	$360 /event	$800	CH2M HILL. Draft: EE/CA Removal of Hot Spot Areas Main Installation Defense Depot, Memphis, TN, March 1999
	5 6 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
	5.7 Supplies	2	event	$500 /event	$1,000	CH2M HILL. Reichold-Summary Invoice of Site Operations.
6	Restoration of Site					
	6 1 Imported Backfill (material)	14,400	yd^3	$10 /$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$	$163,900	This cost includes material and placement 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)	29	ea	$198 /ea	$5,750	
	6.3.2 TAL Metals (6010/700)	29	ea	$268 /ea	$7,780	
	6.3.3 Pesticides (8081A)	29	ea	$141 /ea	$4,090	

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

FU4

Item	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	9	acre	$885 /acre	$7,900	This cost includes the application of lime and fertilizer
	6 5 Seeding	9	acre	$1,420 /acre	$12,700	These costs include labor, mobilization/demobilization, equipment, and material
7	Maintenance of Site- Landscaping	384	hr	$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.
8	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.
Total Capital Costs					**$1,293,000**	

[a] 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] Assumes soil bulk density of 1 4 tons/yd^3 based on historical surface soil removal actions conducted at the Depot.

TABLE B-11b

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

Memphis Depot Main Installation Soils FS

FU4

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Plans for Implementation	$7,200	NA	NA	$7,200
2	Excavation of Soils	$53,200	NA	NA	$53,200
3	Surface Water Collection and Controls	$10,000	NA	NA	$10,000
4	Disposal of Contaminated Soils	$801,550	NA	NA	$801,550
5	Confirmation Sampling	$39,400	NA	NA	$39,400
6	Restoration of Site	$349,310	NA	NA	$349,310
7	Maintenance of Site- Landscaping	$28,800	NA	NA	$28,800
8	Final Evaluation	$4,000	NA	NA	$4,000
Total Costs for FU4		**$1,293,000**	**NA**	**NA**	**$1,293,000**

[a] 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.

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

FU5

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Plans for Implementation	96	hr	$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.
3	Surface Water Collection and Controls	1	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	3	ea	$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 Soils FS

FU5

Item	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.
5	Confirmation Sampling, 2 Events					Assumes 4 samples will be taken at each arsenic and dieldrin excavated hot spot area for each event
	5 1 Labor for Both Events	120	hr	$75 /hr	$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	ea	$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 Laboratories, PA.
	5.4 Rental Equipment	2	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	2	event	$500 /event	$1,000	CH2M HILL Reichold-Summary Invoice of Site Operations.
6	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 1999
	6 2 Transportation of Backfill Onsite	1,463	yd^3	$11 38 /$yd^3$	$16,700	This cost includes material and placement 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-12a
Capital Cost Estimate: Alternative 7, Excavation and Off-site Disposal, Residential Planned Use
Memphis Depot Main Installation Soils FS

FU5

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 Volatiles (8260)	3	ea	$198 /ea	$600	
	6 3 2 TAL Metals (6010/700)	3	ea	$268 /ea	$810	
	6.3.3 Pesticides (8081A)	3	ea	$141 /ea	$430	
	6 3.4 PCBs (8082)	3	ea	$110 /ea	$330	
	6 4 Soil Conditioning	1	acre	$885 /acre	$900	This cost includes the application of lime and fertilizer
	6 5 Seeding	1	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	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
Total Capital Costs					**$152,000**	

[a] 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] Assumes soil bulk density of 1.4 tons/yd^3 based on historical surface soil removal actions conducted at the Depot.

TABLE B-12b

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

Memphis Depot Main Installation Soils FS

FU5

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Plans for Implementation	$7,200	NA	NA	$7,200
2	Excavation of Soils	$5,400	NA	NA	$5,400
3	Surface Water Collection and Controls	$10,000	NA	NA	$10,000
4	Disposal of Contaminated Soils	$60,100	NA	NA	$60,100
5	Confirmation Sampling	$15,100	NA	NA	$15,100
6	Restoration of Site	$35,770	NA	NA	$35,770
7	Maintenance of Site- Landscaping	$14,400	NA	NA	$14,400
8	Final Evaluation	$4,000	NA	NA	$4,000
Total Costs for FU5		**$152,000**	**NA**	**NA**	**$152,000**

[a] 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.

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

FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Plans for Implementation	13	hr	$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
2	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	15	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.
3	Surface Water Collection and Controls	1	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)

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

FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	4 1 Laboratory Analysis - TCLP	1	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 Assumes a 10-mile machine load haul to BFI Special Waste Landfill (RCRA Subtitle D Landfill) from Depot
	4 3 Disposal Fee - Nonhazardous	21 [b]	tons	$19 /ton	$400	Phone quote from Shana Smiley - BFI Special Waste Landfill in Memphis
5	Confirmation Sampling, 2 Events					Assumes 4 samples will be taken at each arsenic excavated hot spot area for each event.
	5.1 Labor for Both Events	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 - Arsenic	8	ea	$18 /ea	$200	Cost estimated from price list from Lancaster Laboratories, PA.
	5 3 Rental Equipment	2	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 8 hours for mobilization and 8 hours for demobilization for each event.
	5 5 Supplies	2	event	$500 /event	$1,000	CH2M HILL· Reichold-Summary Invoice of Site Operations.

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

FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
6	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 This cost includes material and placement
	6.2 Transportation of Backfill On-site	15	yd^3	$11 38 /$yd^3$	$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)	1	ea	$198 /ea	$200	
	6.3.2 TAL Metals (6010/700)	1	ea	$268 /ea	$270	
	6.3.3 Pesticides (8081A)	1	ea	$141 /ea	$150	
	6 3.4 PCBs (8082)	1	ea	$110 /ea	$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
7	Maintenance of Site- Landscaping	96	hr	$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 Soils FS

FU6

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
8	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
Total Capital Costs					**$33,000**	

[a] 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] Assumes soil bulk density of 1.4 tons/yd^3 based on historical surface soil removal actions conducted at the Depot

TABLE B-13b

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

Memphis Depot Main Installation Soils FS

FU6

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Plans for Implementation	$1,000	NA	NA	$1,000
2	Excavation of Soils	$100	NA	NA	$100
3	Surface Water Collection and Controls	$10,000	NA	NA	$10,000
4	Disposal of Contaminated Soils	$2,100	NA	NA	$2,100
5	Confirmation Sampling	$7,400	NA	NA	$7,400
6	Restoration of Site	$1,330	NA	NA	$1,330
7	Maintenance of Site- Landscaping	$7,200	NA	NA	$7,200
8	Final Evaluation	$4,000	NA	NA	$4,000
Total Costs for FU6		**$33,000**	**NA**	**NA**	**$33,000**

[a] 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

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

	Total Number of Samples and Analyses				
	Lead	Dieldrin	Arsenic	TAL/ TCL/ Pest / PCB	TCLP[f]
Alternative 3· Containment, Industrial Planned Use (For 2 Events)[a]					
FU4	8	NA	NA	1	NA
Alternative 3. Containment, Residential Planned Use (For 2 Events)[a]					
FU1	NA	112	40	23	NA
FU2	NA	20	56	217	NA
FU3	8	NA	32	1	NA
FU4	24	56	112	43	NA
FU5	NA	56	8	4	NA
FU6	NA	NA	8	1	NA
Alternative 4· In-situ Soil Treatment, Industrial Planned Use (For 2 Events)[b]					
FU4	8	NA	NA	NA	NA
Alternative 4: In-situ Soil Treatment, Residential Planned Use Enhanced Bioremediation (For 3 Events)[c]					
FU1 (8% Dieldrin Contaminated Soil)	NA	72	NA	NA	NA
FU2 (86% Dieldrin Contaminated Soil)	NA	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	9	NA	NA	NA
FU6	NA	NA	NA	NA	NA
Solidification Lead/Arsenic (For 2 Events)[b]					
FU1	NA	112	40	NA	NA
FU2	NA	20	56	NA	NA
FU3	8	NA	32	NA	NA
FU4	24	56	112	NA	NA
FU5	NA	56	8	NA	NA
FU6	NA	NA	8	NA	NA

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

	Total Number of Samples and Analyses				
	Lead	Dieldrin	Arsenic	TAL/ TCL/ Pest / PCB	TCLP[f]
Alternative 7 Excavation and Off-site Disposal, Industrial Planned Use (For 2 Events)[d]					
FU4	8	NA	NA	1	1
Alternative 7: Excavation and Off-site Disposal, Residential Planned Use (For 2 Events)[d]					
FU1	NA	112	40	16	16
FU2	NA	90	56	146	146
FU3	8	NA	32	1	1
FU4	24	56	112	29	29
FU5	NA	56	8	3	3
FU6	NA	NA	8	1	1

[a] The Containment alternative assume that 4 soil samples will be collected at each dieldrin, lead, and arsenic hot spot for each event within each FU, except FU4, where 10 samples will be taken per event A group of analyses (TCL/TAL/pesticides/PCBs) will be run on every 500 cy of soil imported for soil cover.

[b] The In-situ alternative assume that 4 soil samples will be collected at each lead and arsenic hot spot undergoing stabilization for each event within except FU4, where 10 samples will be taken per event

[c] Assumes 300 dieldrin samples will be collected per year under treatment scheme for enhanced bioremediation of entire Depot Number of samples per FU were calculated by multiplying the total 300 samples by a proportion of assumed dieldin contaminated FU soil to the total amount of dieldrin contaminated soil

[d] The Excavtaion and offsite disposal alternative assume that 4 soil samples will be collected at each dieldrin, lead, and arsenic hot spot for each event within each FU, except FU4, where 1 sample will be taken per acre per event TCLP analyses will be run on every 500 cy of soil excavated and transported offsite. A group of analyses (TCL/TAL/pesticides/PCBs) will be run on every 500 cy of soil imported

NA Not analyzed

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 primarily 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

Assumptions:
1) Based on 12-acre area, 1 ft depth.
2) Life of treatment will be 3 years
3) Biological 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
4) Will need to re-apply biological treatment media twice a year (growing season and summer)
5) May need to re-apply fertilizer every month
6) Will need to aerate (with tractor) every 2 weeks
7) May need additional landscaping; e g., cut grass more often.
8) Lab studies will be required each year to asses treatment effectiveness and modify if needed.

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) = **$0.77 /$ft^3$** (or sf of area treated)
2nd and 3rd Year Unit Cost = ($400,000 - $200,000) / (12 acre * 43,560 ft^2/acre * 1 ft depth) = **$0.38 /$ft^3$/yr** (or sf of area treated)

TABLE B-15
Enhanced Bioremediation Unit Cost Calculation
Memphis Depot Main Installation Soils FS

Venture Biological Cost Estimate - Based on 12 acres in FU2

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost	Annual O&M Cost	PW O&M Cost for Period [a]	Total PW Cost
Biological Treatment	(including sampling and testing)							**$430,000**
(First Year)		522,720	cf	$0 77 /cf	$400,000	$0	$0	
	Treatment Lab Studies	1	ea	$30,000 /ea	$30,000	$0	$0	
Biological Treatment	(including sampling and testing)							**$217,746**
(Second Year)		522,720	cf	$0 38 /cf	$0	$200,000	$189,175	
	Treatment Lab Studies	1	ea	$30,000 /ea	$0	$30,000	$28,571	
Biological Treatment	(including sampling and testing)							**$207,377**
(Third Year)		522,720	cf	$0 38 /cf	$0	$200,000	$180,167	
	Treatment Lab Studies	1	ea	$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

TABLE B-15
Enhanced Bioremediation Unit Cost Calculation
Memphis Depot Main Installation Soils FS

Biological Cost Estimate: Residential Land Use - Entire Main Installation

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost	Annual O&M Cost	PW O&M Cost for Period [a]	Total PW Cost [b,c]
Biological Treatment	(including sampling and testing)							**$1,792,926**
(First Year)		2,289,514	cf	$0 77 /cf	$1,762,926	$0	$0	
	Treatment Lab Studies	1	ea	$30,000 /ea	$30,000	$0	$0	
Biological Treatment	(including sampling and testing)							**$857,157**
(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)							**$816,340**
(Third Year)		2,289,514	cf	$0.38 /cf	$0	$870,015	$789,129	
	Treatment Lab Studies	1	ea	$30,000 /ea	$0	$30,000	$27,211	
Total Costs					**$1,792,926**	**$1,800,030**	**$1,673,498**	**$3,466,424**

[a] PW calculated using an interest rate of 5 percent.

[b] Based on 52.6 acres.

[c] Cost includes 300 dieldrin samples to be taken twice per year

TAB

Appendix C

Appendix C

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

TECHNICAL MEMORANDUM CH2MHILL

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 Remedial 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 [cm^2]) 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/cm^2) 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 cm^2 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 cm^2 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 cm^2).

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 cm^2/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.

TABLE C-1
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)	(mg/kg)
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	1 4	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					
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

Exposure Scenario	Health Risk at UCL95 Percent	
	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

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

Exposure Scenario/Parameter	Ingestion		Exposure Scenario/Parameter	Dermal		Total Ingestion+Dermal		Relative Risk at UCL95%	
	Carcin-ogenic	Non Carcin-ogenic		Carcin-ogenic	Non carcin-ogenic				
			Jogger/Runner - Adult - 30 years						
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1	Carc-Intake	Noncarc	Risk	HI
IR = Soil ingestion rate (mg/day)	100	100	SA = Skin Surface Area (cm2/event)	5419	5419				
FI = Fraction ingested from contaminated area (unitless)	0 5	0 5	AF = Soil Adherence factor (mg/cm3)	1	1				
ET = Exposure Time (hours/24 hr-day)	1	1	ABS = Absorption Factor (Unitless)	Chem Specific	Chem Specific				
EF = Exposure frequency (days/yr)	150	150	ET = Exposure Time (hours/24 hr-day)	1	1				
ED = Exposure duration (years)	30	30	EF = Exposure frequency (days/yr)	150	150				
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	30	30				
BW = Body weight (kg)	70	70	CF= Conversion factor (unitless)	0 000001	0 000001				
AT = Averaging time(days/yr x years)	25550	10950	BW = Body weight (kg)	70	70				
			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**	**0 02**
			Jogger/Runner - Adult - 14 years						
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1	Carc-Intake	Noncarc	Risk	HI
IR = Soil ingestion rate (mg/day)	100	100	SA = Skin Surface Area (cm2/event)	5419	5419				
FI = Fraction ingested from contaminated area (unitless)	0 5	0 5	AF = Soil Adherence factor (mg/cm3)	1	1				
ET = Exposure Time (hours/24 hr-day)	1	1	ABS = Absorption Factor (Unitless)	Chem Specific	Chem Specific				
EF = Exposure frequency (days/yr)	150	150	ET = Exposure Time (hours/24 hr-day)	1	1				
ED = Exposure duration (years)	14	14	EF = Exposure frequency (days/yr)	150	150				
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	14	14				
BW = Body weight (kg)	70	70	CF= Conversion factor (unitless)	0 000001	0 000001				
AT = Averaging time(days/yr x years)	25550	5110	BW = Body weight (kg)	70	70				
			AT = Averaging time(days/yr x years)	25550	5110				
Intake =	**5 87E-08**	**2 94E-07**	**Intake =**	**2.65E-07**	**1.33E-06**	**3 24E-07**	**1 62E-06**		
Percent Relative to a Future Industrial Worker (%)	**33 6**	**60 0**	**Percent Relative to a Future Industrial Worker (%)**	**9**	**17**	**11**	**19**	**3 20E-06**	**0 019**
			Child - Playground						
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1				
IR = Soil ingestion rate (mg/day)	200	200	SA = Skin Surface Area (cm2/event)	2394	2394				
FI = Fraction ingested from contaminated area (unitless)	1	1	AF = Soil Adherence factor (mg/cm3)	1	1				
ET = Exposure Time (hours/24 hr workday)	N/A	N/A	ABS = Absorption Factor (Unitless)	Chem Specific	Chem Specific				
EF = Exposure frequency (days/yr)	64	64	ET = Exposure Time (hours/24 hr-day)	4	4				
ED = Exposure duration (years)	6	6	EF = Exposure frequency (days/yr)	64	64				
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	6	6				
BW = Body weight (kg)	15	15	CF= Conversion factor (unitless)	0 000001	0 000001				
AT = Averaging time(days/yr x years)	25550	2190	BW = Body weight (kg)	15	15				
			AT = Averaging time(days/yr x years)	25550	2190				
Intake =	**2.00E-07**	**2.34E-06**	**Intake =**	**4 00E-07**	**4 66E-06**	6 00E-07	7 00E-06		
Percent Relative to Onsite Golfer	**115**	**478**	**Percent Relative to Onsite Golfer**	**14**	**58**	**20**	**82**	**5 93E-06**	**0 08**

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

Exposure Scenario/Parameter	Ingestion		Exposure Scenario/Parameter	Dermal		Total Ingestion+Dermal		Relative Risk at UCL95%	
	Carcin-ogenic	Non Carcin-ogenic		Carcin-ogenic	Non carcin-ogenic				
			Child/Youth - Baseball Player						
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1				
IR = Soil ingestion rate (mg/day)	200	200	SA = Skin Surface Area (cm2/event)	2080	2080				
FI = Fraction ingested from contaminated area (unitless)	1	1	AF = Soil Adherence factor (mg/cm3)	1	1				
ET = Exposure Time (hours/24 hr workday)	2	2	ABS = Absorption Factor (Unitless)	Chem Specific	Chem Specific				
EF = Exposure frequency (days/yr)	20	20	ET = Exposure Time (hours/24 hr-day)	2	2				
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)	8	8				
BW = Body weight (kg)	30	30	CF= Conversion factor (unitless)	0 000001	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				
Intake =	**4 17E-08**	**3 65E-07**	**Intake =**	**3 62E-08**	**3 17E-07**	7 79E-08	6 82E-07		
Percent Relative to a Future Industrial Worker (%)	**24**	**75**	**Percent Relative to a Future Industrial Worker (%)**	**1**	**4**	**3**	**8**	**7 70E-07**	**0 008**
			Child/Youth - Soccer Player (6-16 years)						
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1				
IR = Soil ingestion rate (mg/day)	150	150	SA = Skin Surface Area (cm2/event)	4371	4371				
FI = Fraction ingested from contaminated area (unitless)	1	1	AF = Soil Adherence factor (mg/cm3)	1	1				
ET = Exposure Time (hours/24 hr workday)	4	4	ABS = Absorption Factor (Unitless)	Chem 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)	80	80				
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**	6 11E-07	4 28E-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 05**
			Industrial Worker - Adult						
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1				
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	1				
ET = Exposure Time (hours/24 hr workday)	N/A	N/A	ABS = Absorption Factor (Unitless)	Chem 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	70				
			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 51E-06		
Percent Relative to a Future Industrial Worker (%)	**100**	**100**	**Percent Relative to a Future Industrial Worker (%)**	**100**	**100**	**100**	**100**	**3 00E-05**	**0 1**

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

Exposure Scenario/Parameter	Ingestion		Exposure Scenario/Parameter	Dermal		Total Ingestion+Dermal		Relative Risk at UCL95%	
	Carcin-ogenic	Non Carcin-ogenic		Carcin-ogenic	Non carcin-ogenic				
			Residential - Adult						
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1				
IR = Soil ingestion rate (mg/day)	114 2	100	SA = Skin Surface Area (cm2/event)	1574	1574				
FI = Fraction ingested from contaminated area (unitless)	1	1	AF = Soil Adherence factor (mg/cm3)	1	1				
ET = Exposure Time (hours/24 hr workday)	N/A	N/A	ABS = Absorption Factor (Unitless)	Chem Specific	Chem Specific				
EF = Exposure frequency (days/30 years)	350	350	ET = Exposure Time (hours/24 hr-day)	N/A	N/A				
ED = Exposure duration (years)		30	EF = Exposure frequency (days/yr)	350	350				
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	30	30				
BW = Body weight (kg)		70	CF= Conversion factor (unitless)	0 000001	0 000001				
AT = Averaging time(days/yr x years)	25550	10950	BW = Body weight (kg)		70				
			AT = Averaging time(days/yr x years)	25550	10950				
Intake =	**1 56E-06**	**1 37E-06**	**Intake =**	**2 16E-05**	**2 16E-05**	2 31E-05	2 29E-05		
Percent Relative to a Future Industrial Worker (%)	**895**	**280**	**Percent Relative to a Future Industrial Worker (%)**	**753**	**269**	**761**	**270**	**2 28E-04**	**0 3**
			Residential - Child						
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1				
IR = Soil ingestion rate (mg/day)	200	200	SA = Skin Surface Area (cm2/event)	2394	2394				
FI = Fraction ingested from contaminated area (unitless)	1	1	AF = Soil Adherence factor (mg/cm3)	1	1				
ET = Exposure Time (hours/24 hr workday)	N/A	N/A	ABS = Absorption Factor (Unitless)	Chem Specific	Chem Specific				
EF = Exposure frequency (days)	350	350	ET = Exposure Time (24 hours/24 hr-day)	1	1				
ED = Exposure duration (years)	6	6	EF = Exposure frequency (days/yr)	350	350				
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	6	6				
BW = Body weight (kg)	15	15	CF= Conversion factor (unitless)	0 000001	0 000001				
AT = Averaging time(days/yr x years)	25550	2190	BW = Body weight (kg)	15	15				
			AT = Averaging time(days/yr x years)	25550	2190				
Intake =	**1.10E-06**	**1 28E-05**	**Intake =**	**1 31E-05**	**1.53E-04**	1 42E-05	1 66E-04		
Percent Relative to a Future Industrial Worker (%)	**627**	**2613**	**Percent Relative to a Future Industrial Worker (%)**	**458**	**1909**	**468**	**1949**	**1 40E-04**	**1 9**
			Golfer						
Cs = concentration in soil (mg/kg)	1	1	Cs = concentration in soil (mg/kg)	1	1				
IR = Soil ingestion rate (mg/day)	50	50	SA = Skin Surface Area (cm2/event)	4371	4371				
FI = Fraction ingested from contaminated area (unitless)	1	1	AF = Soil Adherence factor (mg/cm3)	1	1				
ET = Exposure Time (hours/24 hr workday)	2	2	ABS = Absorption Factor (Unitless)	Chem Specific	Chem Specific				
EFadj = Exposure frequency (days/30 years)	4680	4680	ET = Exposure Time (hours/24 hr-day)	2	2				
ED = Exposure duration (years)	30	30	EF = Exposure frequency (days/yr)	4680	4680				
CF= Conversion factor (unitless)	0 000001	0 000001	ED = Exposure duration (years)	30	30				
BW = Body weight (kg)	70	70	CF= Conversion factor (unitless)	0 000001	0 000001				
AT = Averaging time(days/yr x years)	25550	10950	BW = Body weight (kg)	70	70				
			AT = Averaging time(days/yr x years)	25550	10950				
Intake =	**1.31E-07**	**3 05E-07**	**Intake =**	**9 53E-07**	**2 22E-06**	1 08E-06	2 53E-06		
Percent Relative to a Future Industrial Worker (%)	**75**	**62**	**Percent Relative to a Future Industrial Worker (%)**	**33**	**28**	**36**	**30**	**1 07E-05**	**0 03**

Intake Estimation formulas

$$\text{Intake} = \frac{Cs * IR * FI * EF * ED * CF}{BW * AT}$$

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ADMINISTRATIVE RECORD

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