EPA/ROD/R04-04/089
2004

EPA Superfund
Record of Decision:

MEMPHIS DEFENSE DEPOT (DLA)
EPA ID: TN4210020570
OU 01
MEMPHIS, TN
04/12/2004

779 0 File: 541.460.000n
C.H.

THE MEMPHIS DEPOT
TENNESSEE

ADMINISTRATIVE RECORD COVER SHEET

AR File Number 779

File: 541.460.000e
779 1 C.H.
779

Memphis Depot
Dunn Field

Record of Decision

Defense Distribution Center (Memphis)

March 2004 — Final

CH2MHILL

U.S. Army Engineering and Support Center, Huntsville

U.S. Army Engineering and Support Center, Huntsville
Contract No. DACA87-94-D-0009
Task Order No. 10

E092002012ATL

Contents

Tables

Tables (con't)

Figures

Acronyms and Abbreviations

AEHA	Army Environmental Hygiene Agency
AFCEE	Air Force Center for Environmental Excellence
AOC	Area of Concern
ARAR	Applicable or relevant and appropriate requirement
AST	Aboveground storage tank
ATSDR	Agency for Toxic Substances and Disease Registry
BMP	Best management practice
BRA	Baseline Risk Assessment
BRAC	Base Realignment and Closure
BCT	BRAC Cleanup Team
CC-2	Impregnite
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	Chloroform
CFR	Code of Federal Regulations
COG	Chemical of concern
COPC	Chemical of potential concern
CSF	Cancer slope factor
CSM	Conceptual site model
CT	Carbon Tetrachloride
CVOC	Chlorinated volatile organic compound
CWA	Clean Water Act
CWM	Chemical Warfare Materiel
cy^3	Cubic yards
DANC	Decontaminanting Agent Non Corrosive
DDD	Dichlorodiphenyldichloroethane
DDE	1,1,1-Dichloro-2,2-bis(4-chlorophenyl) ethylene
DDT	Dichlorodiphenyltrichloroethane
DLA	Defense Logistics Agency
DNAPL	Dense non-aqueous phase liquid
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
DQE	Data quality evaluation
DRC	Depot Redevelopment Corporation
DSERTS	Defense Sites Environmental Restoration Tracking System
EE/CA	Engineering evaluation/cost analysis
ELCR	Excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological risk assessment
ESD	Explanation of Significant Differences
FDA	Food and Drug Administration
FFA	Federal Facilities Agreement
FS	Feasibility Study
FSP	Field sampling plan
FOD	Frequency of detection
ft	Feet

ft^2	Square feet
FU	Functional Unit
HHRA	Human Health Risk Assessment
HI	Hazard index
HQ	Hazard quotient
hr	hour
IA	Installation Assessment
ID	Identification number
IRA	Interim remedial action
IRP	Installation Restoration Program
LDR	Land disposal restriction LTM Long-term monitoring
LNAPL	Light non-aqueous phase liquid
LUC	Land use controls
LUCIP	Land Use Control Implementation Plan
m3	Cubic meters
MCL	Maximum contaminant level
MCLC	Maximum contaminant level goal
MDL	Minimum detection limit
MI	Main Installation
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
MLGW	Memphis Light Gas and Water
MNA	Monitored natural attenuation
MOA	Memorandum of Agreement
MSCHD	Memphis-Shelby County Health Department
msl	Mean sea level
MW	Monitoring well
NA	Natural attenuation
NAPL	Non-aqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No further action
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRDA	Natural Resources Damage Assessment
O&M	Operation and maintenance
OE	Explosive Ordnance
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste Emergency Response
OU	Operable unit
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCA	1,1,2,2-Tetrachloroethane
PCE	Tetrachloroethene
PCP	Pentachlorophenol
POTW	Publicly owned treatment works
ppm	Parts per million
PRB	Permeable Reactive Barrier

PRE	Preliminary risk evaluation
PW	Present worth
RA	Remedial action
RAB	Restoration Advisory Board
RAO	Remedial action objective
RBC	Risk-based concentration
RCRA	Resource Conservation and Recovery Act
RD	Remedial design
RFA	RCRA Facility Assessment
RfD	Reference dose
RFI	RCRA Facility Investigation
RGO	Remedial goal option
RI/FS	Remedial investigation/feasibility study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SMCL	Secondary maximum contaminant level
SVE	Soil vapor extraction
SVOC	Semi-volatile organic compound
STOP	SVE Termination or Optimization Process
STB	Super Topical Bleach
SWDA	Solid Waste Disposal Act
SWMU	Solid waste management unit
TBC	To be considered
TCA	1,1,2-Trichloroethane
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
TCE	Trichloroethene
TCL/TAL	Target compound list/target analyte list
TCLP	Toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TEC	Topographic Engineering Center
TMV	Toxicity, mobility, or volume
UCL	Upper confidence level
UIC	Underground injection control
USN	United States Navy
VOC	Volatile organic compound
XXCC-3	Stabilized impregnite
yr	Year
ZVI	Zero-valent iron

1.0 Declaration

1.1 Site Name and Location

Memphis Depot
Dunn Field, Operable Unit 1 (OU-1)
2163 Airways Boulevard
Memphis, Shelby County, Tennessee
U.S. Environmental Protection Agency (EPA) Identification Number (ID): TN4210020570

1.2 Statement of Basis and Purpose

This decision document presents the selected remedy for Dunn Field of the Memphis Depot, in Memphis, Tennessee. This action was chosen by the Defense Logistics Agency (DLA) in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and, to the extent practicable, the National Oil and Hazardous Pollution Contingency Plan (NCP, 40 CFR Part 300 et. seq.). This decision is based upon the Administrative Record file for Dunn Field, and EPA Policy including, *Land Use in the CERCLA Remedy Selection Process* (OSWER Directive No. 9355.7-04). This policy provides for consideration of the likely future land use of the Memphis Depot when selecting the remedy. The State of Tennessee Department of Environment and Conservation (TDEC) and EPA concur with and approve the selected remedy.

1.3 Assessment of the Site

The response action selected in this Record of Decision (ROD) is necessary to protect public health or welfare, or the environment, from actual or potential releases from the Dunn Field of pollutants, contaminants, or hazardous substances into the environment.

1.4 Description of the Selected Remedy

The selected remedy includes the remediation of disposal sites and associated subsurface soil, and groundwater contamination as well as volatile organic compound (VOC) contamination within subsurface soil that is outside of the disposal sites. The remedies will allow the transfer or lease of the Dunn Field property for its intended land use (industrial and recreational).

The major components of the selected remedy for Dunn Field include:

- Excavation, transport, and disposal of soil and material contained within disposal sites located in the western half of Dunn Field based upon results from a pre-design investigation into these sites.

- Use of soil vapor extraction (SVE) to reduce VOC concentrations in subsurface soils to levels that are protective of the intended land use and groundwater.

- Injection of zero-valent iron (ZVI) within Dunn Field to treat chlorinated volatile organic compounds (CVOCs) in the most contaminated part of the groundwater plume, and installation of a permeable reactive barrier (PRB) to remediate CVOCs within the off site areas of the groundwater plume.

- Monitored natural attenuation (MNA) and long-term groundwater monitoring (LTM) to document changes in plume concentrations, to detect potential plume migration to off-site areas or into deeper aquifers, and to track progress toward remediation goals.

- Implementation of land use controls, which consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; City of Memphis/Shelby County zoning restrictions and the Memphis and Shelby County Health Department groundwater well restrictions.

Subsurface soils, including the disposal sites, in the Disposal Area are considered to be principal threat wastes as defined by EPA guidance. The principal threat wastes have significantly degraded groundwater quality in the shallow fluvial aquifer. Based on the highest observed concentration of the detected solvents trichloroethene (TCE) and 1,1,2,2-tetrachloroethane (PCA) in groundwater, free-phase solvents may be present in Dunn Field groundwater and would be considered principal threat wastes. However, free-phase solvents have not been detected during the RI and subsequent groundwater sampling events.

1.5 Statutory Determinations

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. The selected remedy allows the entire Dunn Field to be available for the anticipated future land use.

The selected remedy for VOC contamination in groundwater and in subsurface soil outside of the disposal site locations at Dunn Field satisfies the statutory preference for treatment. The selected remedy for the disposal sites and associated subsurface soil non-VOC contamination at Dunn Field does not satisfy the statutory preference for treatment as a principal element of the remedy. However, the remedy for the disposal sites and associated subsurface soil was chosen for the following reasons:

- Excavation and off-site disposal provides permanent risk reduction through removal.

- The remedy will allow the Disposal Area/western portion of Dunn Field to be used for industrial land use, and does not preclude future response actions, if warranted.

- The remedy is cost-effective at achieving anticipated industrial land use criteria.

- Land use controls, which include institutional controls, can be implemented quickly and provide additional layers of protectiveness to the existing land use controls (zoning and groundwater well restrictions).

In-situ treatment is not selected primarily because of the homogeneity of disposed materials, which is incompatible with the technology. Ex-situ treatment calls for excavation and separation of pit contents, and return of residual mass to the pits. Either treatment alternative would leave residual concretized mass that could interfere with reuse options. As long as the disposal pit contents have to be excavated, it is prudent to dispose of them in a permitted landfill subject to all relevant regulations.

The remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unlimited exposure; therefore, in accordance with Section 121 (c) of CERCLA and NCP § 300.430(f)(5)(iii)(c), a statutory review will be conducted within 5 years of initiation of remedial action, and every 5 years there-after, to ensure that the remedy continues to be protective of human health and the environment.

Although active restoration is the remedial action objective for the contaminated groundwater, hazardous substances above health-based levels may remain in groundwater associated with Dunn Field after implementation of this remedy. Therefore, DLA, TDEC, and EPA recognize that Natural Resource Damage claims, in accordance with CERCLA, may be applicable. The remedy does address restoration or rehabilitation of groundwater, but does not determine the extent of any natural resource injuries that may have occurred. However, neither DLA nor TDEC waives any rights or defenses each may have under CERCLA, Sect. 107(a) 4(c).

1.6 ROD Data Certification Checklist

The following information is included in the *Decision Summary* section (Section 2) of this ROD. Additional information can be found in the Administrative Record for Dunn Field.

- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD (Section 2.6).
- Chemicals of concern (COCs) and their respective concentrations (Section 2.7.1.1 and Table 2-6).
- Baseline risk represented by the COCs (Section 2.7.1.5 and Tables 2-11 through 2-19).
- Remediation goals for soil and groundwater established for COCs, and the basis for these levels (Section 2.7.3 and Tables 2-21A through 2-12G).
- Source materials constituting principal threats on Dunn Field and how these threats are being addressed (Section 2.11).
- Key factor(s) that led to the selection of the remedy (Section 2.12.1).
- Estimated capital costs, annual operation and maintenance (O&M) costs, total present worth costs, discount rate, and number of years over which the remedial cost estimates are projected (Section 2 12.3).
- Potential land and groundwater use that will be available at Dunn Field as a result of the selected remedy (Section 2.12.4).

1.7 Authorizing Signatures

for Jeff McCausl
R.J. Ritchie
Captain, SC, USN
Commander

MAR 22, 2004
Date

Winston A. Smith
Winston A. Smith, Director
Waste Management Division
U.S. Environmental Protection Agency,
Region 4

April 12, 2004
Date

James W. Haynes
James W. Haynes, Director
Division of Superfund
Tennessee Department of Environment
and Conservation

April 6, 2004
Date

2.0 Decision Summary

2.1 Site Name, Location, and Description

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 2-1). 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). In 1995, the Depot was placed on the list of Department of Defense (DoD) facilities to be closed under Base Realignment and Closure (BRAC). 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 is located approximately 5 miles east of the Mississippi River and just northeast of Interstate 240. The property consists of approximately 642 acres and includes two components: the Main Installation (MI), which included open storage areas, warehouses, military family housing, and outdoor recreational areas, and Dunn Field, which includes former mineral storage and waste disposal areas.

Dunn Field, comprising approximately 64 acres of undeveloped land, is immediately adjacent, across Dunn Avenue, to the north-northwest portion of the MI. Dunn Field is bounded by the Illinois Central Gulf Railroad and Person Avenue to the north, Hays Road to the east, and Dunn Avenue to the south. Dunn Field is partially bounded to the west by: (1) Kyle Street; (2) a Memphis Light Gas and Water (MLGW) powerline corridor (which bisects Dunn Field); (3) undeveloped property; and (4) a light industrial/ warehouse facility (Figure 2-2). All of Dunn Field (and the Ml) is currently zoned as Light Industrial (I-L) (see Appendix A).

For purposes of completing the RI and FS, Dunn Field was divided into three separate areas: Northeast Open Area, Disposal Area, and Stockpile Area (Figure 2-3).

- **Northeast Open Area** - The Northeast Open Area (approximately 20 acres) consists of the grassy area with a number of interspersed mature trees in the northeast quadrant of Dunn Field. Table 2-1 describes seven sites listed under the Defense Sites Environmental Restoration Tracking System (DSERTS) that located with the Northeast Open Area (see Appendix C for the locations of the Sites). *The Memphis Depot Redevelopment Plan* (The Pathfinders, et al., 1997) identified this area as future public open space for recreational purposes.

- **Disposal Area** - The Disposal Area (approximately 14 acres) consists of the pits and trenches in the northwestern quadrant of Dunn Field. This area encompasses 25 Sites, described in Table 2-1 (see Appendix C for the locations of the Sites). Historical information concerning the location of the disposal sites is included in the Dunn Field RI and FS reports (CH2M HILL, July 2002 and May 2003). The anticipated land use within this area is light industrial (The Pathfinders, *et al.*, 1997).

- **Stockpile Area** - The Stockpile Area (approximately 30 acres) encompasses the former bauxite and fluorspar storage and burial areas in the eastern and southwestern portions of Dunn Field. Table 2-1 describes three identified sites located in this area, and two additional unidentified disposal sites (see Appendix C for the locations of the Sites). The anticipated land use within this area is also light industrial (The Pathfinders, *et al.*, 1997).

Approximately two-thirds of the area is grassed, and the remaining area is covered with crushed rock and paved surfaces. Dunn Field was used for bulk mineral storage (bauxite and fluorspar) and waste disposal.

The lead agency for site activities at the Depot is the Defense Logistics Agency (DLA). The regulatory oversight agencies are the Environmental Protection Agency (EPA), Region 4 and the Tennessee Department of Environment and Conservation (TDEC). OLA and the DoD will implement the selected response actions and will incur all associated costs. The Depot has an EPA Identification Number listed as TN4210020570.

2.2 Site History and Enforcement Activities

2.2.1 Site History

The Depot was officially activated on January 26, 1942, as the Memphis General Depot. Since that time, the Depot's mission and function has been to receive, store, and distribute various commodities to the Armed Forces and civilian agencies, when required. The U.S. Army operated the facility until 1963. The Defense Logistics Agency (DLA) took over in 1963 and operated the facility until it closed in September 1997 (U.S. Army Toxic and Hazardous Materials Agency [USATHAMA], 1982).

The Depot received, warehoused, and distributed supplies common to all U.S. military services and some civil agencies located primarily in the southeastern United States, Puerto Rico, and Panama. 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; total shipments amounted to about 107,000 tons of goods per year.

Disposal activities at Dunn Field began in July 1946 when 29 mustard-filled German bomb casings and all mustard-contaminated items (railcar wood, clothing, etc.) were decontaminated, destroyed (via burning) and buried (in Sites 24-A and 24-B). This activity included the use of Decontaminating Agent Non-Corrosive (DANC). DANC is an organic N-chloroamide compound in solution with 1,1,2,2-tetrachloroethane (PCA) (also known as acetylene tetrachloride). A mixture similar to DANC formulations (S-210 suspension formulation) contained tetrachloroethene (or perchloroethylene, PCE).

During the early to mid-1950s, Chemical Agent Identification Sets (CAIS) were allegedly disposed of and buried at Dunn Field at Site 1 in the Disposal Area portion of Dunn Field (USATHAMA, 1982). A search of the archived records also indicated that the remains of destroyed (burned or detonated) explosive ordnance (OE) consisting of military souvenirs, such as a 3.2-inch mortar round, smoke pots, chloroacetophenone (CN [also known as tear gas agent]) canisters, and smoke grenades, were occasionally buried in pits in the Disposal and Stockpile Areas. Based on completion of early response actions, the USACE issued a Statement of Clearance for Chemical Warfare Materiel (CWM) and OF at Dunn Field in August 2003 (included as Appendix B).

The CWM disposal pits were located in the Disposal Area section of Dunn Field and the Stockpile Area portions of Dunn Field (Sites 1, 24-A and 24-B). Section 1.3.4 of the Dunn Field RI (CH2M HILL, 2002) presents additional information on the history of CWM at Dunn Field.

In addition to that described above, other chemicals were buried in Dunn Field. Use and disposal of unknown quantities of chlorinated lime, super topical bleach (STB) and calcium hypochlorite (HTH) is documented at Dunn Field. Food stocks, paints/thinners, petroleum/oil/lubricants (POL), acids, herbicides, mixed chemicals, and medical waste were also reportedly destroyed or buried in pits and trenches at Dunn Field (USACE, 1995a, b). These are the sources for the chlorinated volatile organic compounds (CVOCs) (solvents and their degradation products) found in the soil and groundwater in and beneath Dunn Field. The most frequently detected CVOCs include 1,1,2,2-PCA, trichloroethane (TCA), PCE, trichloroethene (TCE), several dichlorothenes (DCE), vinyl chloride, carbon tetrachloride and chloroform. Table 2-1 lists the sites at Dunn Field (OU-1), including the disposal sites (see Appendix C for the locations of the Disposal Sites).

2.2.2 Enforcement Activities

Important dates for the Depot and Dunn Field in regards to environmental regulatory activities include:

- **In January 1990**, EPA Region 4 conducted a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) at the Memphis Depot through a contract with A. T. Kearney, Inc. (EPA, 1990). The RFA resulted in the identification of 49 SWMUs and 8 AOCs at the facility. Twenty-four (24) SWMUs and one AOC were identified on Dunn Field.

- **On September 28,1990**, the Depot was issued a RCRA Part B permit for the storage of hazardous waste (No. TN4 210-020-570) by EPA Region 4 and TDEC. The Hazardous and Solid Waste Amendments (HSWA) portion of the permit issued by EPA included requirements for the identification and, if necessary, corrective action of SWMUs and AOCs. Subsequent to issuing the permit, and in accordance with Section 120(d)(2) of CERCLA, and Title 42, Section 9620(d)(2) of the United States Code (USC), EPA prepared a final Hazard Ranking System (HRS) Scoring Package for the facility.

- **On October 14, 1992**, based on the final HRS score of 58.06, EPA added the Depot to the National Priorities List (NPL) (57 Federal Register 47180 No. 199).

- **On March 6, 1995**, a Federal Facilities Agreement (FFA) under CERCLA, Section 120, and RCRA, Sections 3008(h), and 3004(u) and (v), was entered into by EPA, TDEC, and DLA. Appendix C of the FFA (FY94 Site Management Plan) identified a list of the original sites for investigation. A BRAC Cleanup Plan (BCP) subsequently replaced the SMP and included the list of sites for further investigation under CERCLA. The FFA outlined the process for investigation and cleanup of the sites at the Depot under CERCLA. The parties agreed that investigation and cleanup of releases from the sites (including formerly identified SWMUs/AOCs) would satisfy any RCRA corrective action obligations under the EPA HSWA permit and T.C.A Section 68-212-101 et seq.

- **In July 1995**, the Depot was identified for closure under the BRAG process, which requires environmental restoration at the Depot to comply with requirements for property transfer under Public Law 101-510 of Title XXIX, Defense Base Closure and Realignment. Since then, environmental restoration activities have been funded under BRAG. After the Depot was placed on the BRAG closure list, the City of Memphis and County of Shelby established the Memphis Depot Redevelopment Agency, now the Depot Redevelopment Corporation (DRC), to plan and coordinate the reuse of the Depot. The DRC conducted several public meetings during the preparation of its *Memphis Depot Redevelopment Plan* to obtain community feedback on future land use plans. The *Memphis Depot Redevelopment Plan* was approved in 1997 (The Pathfinders, 1997).

2.3 Community Participation

The Depot has performed public participation activities in accordance with CERCLA and to the extent practicable the NCP throughout the CERCLA site clean-up process. This includes monthly Restoration Advisory Board (RAB) meetings since 1994, numerous Community Involvement Sessions and public meetings, production of a bi-monthly newsletter, and the establishment of information repositories and a Depot Community Outreach Room.

As part of the public participation activities for the Dunn Field remedy, the Depot placed the final Dunn Field RI report in the Depot's three Information Repositories in July 2002. Twenty (20) copies of Revision 1 (draft final) and 2 (final) of the Dunn Field RI report were sent to the members of the RAB in April 2002 and July 2002, respectively. The findings from the RI, including the baseline risk assessment (BRA), were presented to the public during the February and April 2002 RAB meetings. An overview and summary of the FS was presented by the Depot at the February 2003 RAB meeting.

Pursuant to CERCLA Sections 113(k)(2)(B)(i-v) and 117, and NCP Section 300.430(f)(3), the RI/FS reports and the Proposed Plan for the Dunn Field were released to the public for comment. These documents can be found at the following information repositories:

- Memphis Depot Community Outreach Room
- Memphis/Shelby County Health Department
- Cherokee Branch, Memphis/Shelby County Public Library System

The notice of the availability of these documents was published in the *Commercial Appeal*, *Tri-State Defender*, and *Silver Star News*. A public comment period was held from May 8, 2003, to June 6, 2002. In addition, a public meeting was held on May 14, 2003, to explain the Proposed Plan and all the alternatives presented in the FS. At this meeting, representatives from DLA accepted verbal and written comments about issues at Dunn Field and the remedial alternatives under consideration. The public comment period was extended by DLA for 39 days until July 15, 2003, at the request of persons interested in reviewing and forming comments on the Proposed Plan. The responses to the comments received during the 69-day review period are included in the Responsiveness Summary (see Section 3.1 of this ROD).

2.4 Scope and Role of Response Action

As with many NPL sites, the problems at the Depot are complex. As a result, the Depot was divided into two components for site characterization and response actions:

- Dunn Field (Operable Unit 1)
- MI (Operable Units 2, 3and 4)

The MI ROD was signed in September 2001. It called for institutional controls to prevent residential and day care use, and for restoration of contaminated ground water through enhanced bioremediation. The hydrogeology of the Depot and its environs is such that contamination at the MI does not affect the environment at Dunn Field, nor does Dunn Field affect the MI. Therefore, the management strategy for Dunn Field does not rely on actions taking place at the MI, except that data from remedial design activities for the MI groundwater remedy has been considered in development of alternatives in the Dunn Field FS.

This will be the final remedy for Dunn Field and the last planned CERCLA response action at the Depot. The selected remedy for Dunn Field will be performed in accordance with CERCLA and the NCP. The action is expected to satisfy any corrective action obligations that otherwise might be required under the RCRA HSWA permit for SWMUs and AOCs located at the site.

This ROD addresses the contamination found within the disposal sites and associated subsurface soil, subsurface soil outside of the disposal site locations, and groundwater contamination associated with Dunn Field.

2.4.1 Past Response Actions at Dunn Field

2.4.1.1 Interim Groundwater Remedial Action

An interim ROD was signed in April 1996, with the objectives of hydraulic containment to: (1) prevent further contaminant plume migration; and (2) reduce contaminant mass in groundwater. Contaminants of concern included VOCs and metals. A groundwater extraction system consisting of seven recovery wells began operation in November 1998. Four additional recovery wells were installed in late 1999 and early 2000 due to an increased understanding of the extent of groundwater contamination, which was gained during the remedial investigation.

From system startup in 1998 through October 31, 2003, the extraction system has pumped approximately 162,300,000 gallons of groundwater from the fluvial aquifer beneath Dunn Field and discharged to the City of Memphis publicly owned treatment works (POTW). Through October 31, 2003, an estimated total of 485 pounds of VOCs have been removed, which includes approximately 194 pounds of TCE removed (Jacobs, November 2003). As discussed in Section 14.5.3 of the Dunn Field RI report, groundwater capture zones between some recovery wells are not completely connected. Therefore, areas between these capture zones allow contaminates to pass through the hydraulic containment system.

The Five Year Review for Dunn Field (CH2M HILL, 2003), concluded that, while over 300 pounds of VOCs have been removed from groundwater by the IRA from 1998 to 2002, the extraction system does not provide adequate control over groundwater flow and the spread of contaminants of concern in the fluvial aquifer from the western perimeter of Dunn Field. As a result, contaminant levels have been increasing in a few monitoring wells downgradient and offsite (west) of Dunn Field. Section 2.14 of this ROD presents more detail on this issue.

2.4.1.2 CWM Removal Action at Sites 1, 24-A and 24-B

As discussed in Section 2.2.1 above, mustard agent and CAIS sets were reportedly disposed at Dunn Field. Following completion of an engineering evaluation and cost analysis (EE/CA), a non-time critical removal action was conducted to reduce or eliminate the potential risk posed by CWM wastes at Sites 1, 24-A, and 24-B. The action was completed in March 2001, and documented in the *Final Chemical Warfare Materiel Investigation/Removal Action Report*, December 2001. Approximately 914 cubic yards of soil contaminated with mustard degradation by-products and 19 cubic yards of mustard contaminated soil were excavated, transported and disposed offsite. Twenty-nine (29) bomb casings were recovered from Site 24-A. Appendix C of this ROD shows the locations of the three areas of excavation associated with Sites 1, 24-A, and 24-B.

2.4.1.3 Soil Removal Action at Site 60, Former Pistol Range

A non-time critical removal action to address lead contaminated surface soil at Site 60, a former pistol range in the Northeast Open Area, was completed in March 2003, pursuant to an EE/CA completed in July 2002. Approximately 930 cubic yards of lead impacted surface soil was excavated, transported and disposed offsite at an approved, permitted landfill. Appendix C shows the area of the Site 60 removal action.

2.4.2 Planned Response Actions at Dunn Field

Based on the results of the Dunn Field RI and BRA, and the response actions conducted to date on Dunn Field, a majority of the eastern half of Dunn Field is available for unrestricted reuse and no further action (NFA) is required. This area is depicted on Figure 2-4.

To achieve acceptable residual risk levels and allow for the planned land use for Dunn Field, the remedial actions listed below are planned for Dunn Field:

- Excavation, transport, and disposal of soil and material contained within disposal sites located in the western half of Dunn Field based upon results from a pre-design investigation into these sites.

- Use of soil vapor extraction (SVE) to remove volatile organic compounds (VOCs) from subsurface soils to levels that are protective of the intended land use and groundwater.

- Injection of zero-valent iron (ZVI) within Dunn Field to treat chlorinated volatile organic compounds (CVOCs) in the most contaminated part of the groundwater plume, and installation of a permeable reactive barrier (PRB) to remediate CVOCs within the off site areas of the groundwater plume.

- Monitored natural attenuation and long-term groundwater monitoring to document changes in plume concentrations and to detect potential plume migration to off-site areas or into deeper aquifers.

- Implement land use controls consisting of institutional controls, including deed restrictions, a Notice of Land Use Restrictions, zoning restrictions, and groundwater well restrictions. The inclusion of multiple land use controls (some of which already apply at the site) as part of the selected remedy, is designed to help ensure protectiveness.

2.4.3 RCRA-CERCLA Integration

As stated above in Section 2.2.2, on March 6,1995, an FFA under CERCLA, Section 120, and RCRA, Sections 3008(h), and 3004(u) and (v), was entered into by EPA, TDEC, and DLA. FFA Section IX outlined the process for investigation and cleanup of the sites at the Depot under CERCLA. The parties also agreed that investigation and cleanup of releases from the sites (including formerly identified SWMUs/AOCs) would satisfy any RCRA corrective action obligations under the EPA H-SWA permit and T.C.A Section 68-212-101 *et seq*. Table 2.2 lists the CERCLA response actions for all RCRA SWMUs and AOCs located within Dunn Field. For some of these sites, the parties of the FFA have determined "no further action" is needed under CERCLA or RCRA.

2.5 Site Characteristics

2.5.1 Overview of Site

The Depot covers 642 acres of land. Dunn Field comprises approximately 64 acres of the Depot. The MI, south of Dunn Field, comprises the majority and balance of the acreage.

2.5.1.1 Geology/Stratigraphy of Dunn Field

The four uppermost stratigraphic units underlying Dunn Field are (in descending order):

- loess, including surface soil;
- fluvial deposits;
- Jackson Formation/Upper Claiborne Group (the Jackson [if present], Cockfield, and Cook Mountain Formations); and
- Memphis Sand.

Loess. The Quaternary-aged loess consists of brown to reddish brown low-plasticity clayey silt (ML) or low-plasticity silty clay (CL) and is continuous throughout the entire Dunn Field area. The loess deposits range from 10 feet thick at MW-55 (southwest of Dunn Field) to 36 feet thick at MW-74 (western boundary of Dunn Field) and are on average about 20 to 30 feet thick.

Fluvial Deposits. The Quaternary- and possibly Pliocene-aged fluvial deposits, which underlies the loess, are composed of two generalized layers that can be identified throughout the subsurface of the Dunn Field area. The upper layer is a silty, sandy clay that transitions to a clayey sand. This layer ranges from about 10 feet thick at MW-55 (southwest of Dunn Field) to 36 feet thick at MW-74 (western boundary of Dunn Field). The second unit, composed of layers of sand, sandy gravel, and gravelly sand, has an average thickness of approximately 40 feet underneath Dunn Field and along the eastern and western boundaries. The fluvial deposits are commonly underlain by a thick clay unit of the Jackson Formation/Upper Claiborne Group.

Jackson Formation/Upper Claiborne Group. The Late Eocene-aged Jackson Formation/Upper Claiborne Group consists primarily of clays, silts and sands. The upper clay unit of the Jackson Formation/Upper Claiborne Group is continuous underneath the Dunn Field boundary except for a gap that appears between monitoring wells MW-56 and MW-34 (and extends to the south, into the MI) at the southwestern boundary of Dunn Field. Offsite there are gaps in the clay the west (at MW-43) and northwest (at MW-40) of Dunn Field. These gaps are windows to the intermediate aquifer underlying the fluvial deposits. Where present, the maximum known thickness of the confining unit directly underlying the fluvial deposits is 92 feet at MW-36.

Memphis Sand. According to Kingsbury and Parks (1993), the Early to Middle Eocene-aged Memphis Sand is composed primarily of thick-bedded, white to brown or gray, very fine-grained to gravelly, partly argillaceous and micaceous sand. Lignitic clay beds constitute only a small percentage of total thickness. The Memphis aquifer comprises the Memphis Sand. The Memphis Sand ranges from 500 to 890 feet in thickness and the depth to the top of the Memphis aquifer in the area ranges from approximately 120 feet to 300 feet bgs. The City of Memphis obtains its drinking water from this aquifer. Local stratigraphic data from the Allen Well Field, located approximately 1 to 2 miles west of Dunn Field (see Appendix 0), were evaluated to characterize the stratigraphy of the Memphis Sand (Kingsbury and Parks, 1993). At well Sh:J-104, the top of the Memphis Sand is at an elevation 46 feet msl. MW-67 is the only monitoring well completed in the Memphis Sand associated with Dunn Field. Soil boring logs indicate approximately 80 feet of alternating silt and clay layers from 21 to 101 feet msl. Below the alternating silt and clay layers, a fine to medium grained, gray, sand occurs to the borehole termination depth of 0.5 feet msl.

2.5.1.2 Hydrology and Hydrogeology of Dunn Field

There are no perennial flowing streams or creeks within the boundary of Dunn Field. Typically, surface drainage of Dunn Field occurs by overland flow via swales, ditches, concrete-lined channels, and a storm drainage system. Based on a generalized hydrogeologic cross section, groundwater elevations fall below local stream base elevations in the vicinity of the Depot, therefore, groundwater within the fluvial deposits does not appear to contribute to stream baseflow at this location.

There are three aquifers underlying Dunn Field and the local area, which correspond to the geologic units described previously. These aquifers are identified in descending order from ground surface to the Memphis Sand:

- Fluvial aquifer
- Intermediate aquifer
- Memphis aquifer

Fluvial Aquifer. The uppermost aquifer at Dunn Field is the unconfined fluvial aquifer, consisting of saturated sands and gravelly sands in the lower portion of the fluvial deposits. Recharge to this unit is primarily from the infiltration of rainfall (Graham and Parks, 1986). Discharge from the fluvial aquifer is generally directed toward underlying units in hydraulic communication with the fluvial deposits, or laterally into adjacent stream channels. The fluvial aquifer provides water for domestic and farm wells in rural areas (Kingsbury and Parks, 1993), but is not used as a drinking water source within the area surrounding the Depot.

The low-permeability uppermost clay of the Jackson Formation/Upper Claiborne Group serves as the base of the fluvial aquifer at most locations. This clay has very low permeability, with maximum, minimum, and average hydraulic conductivities of $2.5x10^{-7}$, $1.2x1l^{-8}$ and $6.4x10^{-8}$ cm/sec respectively, and constitutes a hydraulic barrier to downward migration of groundwater in the overlying fluvial aquifer.

Groundwater also exists in the vadose zone of the fluvial aquifer deposits usually above small clay lenses or laminae. These perched water zones are isolated, are probably ephemeral, and are not considered part of the regional water table of the fluvial aquifer.

Saturated thickness of the fluvial aquifer is variable across Dunn Field and is controlled by the configuration of the uppermost clay in the Jackson Formation/Upper Claiborne Group. Maximum saturated thickness ranges between 10 and 20 feet above the clay surface in Dunn Field. A potentiometric map displaying the water table surface of the fluvial aquifer (see Figure 2-5a) was developed for the Dunn Field RI report, based on November 2001 water levels. In general, the fluvial aquifer flows in a western direction, which follows the contours of the uppermost clay confining unit in the Jackson Formation/Upper Claiborne Group. Geologic cross-sections produced for the Dunn Field RI report suggest the clay confining unit, in vicinity of MW-43 to STB-14 to MW-55, ending around MW-34 (west to east), creates a groundwater limited-flow boundary or area of "no significant saturated thickness" (NSST) (see Figure 2-5a). An area of NSST is defined as an area where the surface of the upper clay confining unit intersects and exceeds the surface of the fluvial aquifer. These conditions " pinch out" the fluvial aquifer and create unsaturated conditions above the clay confining unit. Monitoring wells 41, 55 and 56 are located on the northern side of the NSST boundary and have fluvial aquifer thickness' of between 1- and 3-feet, as measured in November 2001. Like the NSST zones, fluvial deposits in the vicinity of MW-34, MW-40, and MW-43 are not saturated. In these areas, soil borings have confirmed the absence of a clay unit directly below the fluvial deposits; this absence allows recharge water to vertically percolate into the lower aquifer(s). Where the fluvial aquifer is present, the potentiometric surface surrounding MW-34, MW-40 and MW-43 indicates groundwater flow directed toward these areas. However, localized NSST zones around these areas where the upper confining clay is present likely impedes groundwater flow into lower aquifers.

The average hydraulic conductivities for the fluvial aquifer near Dunn Field are 6.1×10^{-3} (arithmetic mean) and 3.0×10^{-3} (geometric mean) cm/sec. Within the fluvial aquifer, groundwater flow velocities were calculated based upon data gathered from slug tests and aquifer pump tests. The range for groundwater velocity was estimated at 0.12 foot/day ($4.2 \text{ X } 10^{-5}$ cm/sec) to 1.69 feet/day (6.0×10^{-4} cm/sec).

In 1992, a pump test was conducted in the northwestern portion of Dunn Field (MW-3) to measure hydrogeologic parameters needed for design of the Dunn Field groundwater extraction system. The average hydraulic conductivity value obtained via pump testing of the fluvial aquifer, 3.5×10^{-2} cm/sec, is about an order of magnitude higher than the values obtained by slug testing.

Intermediate Aquifer. The intermediate aquifer underlying the Memphis Depot is locally developed in deposits of the Jackson Formation/Upper Claiborne Group, which also contain laterally extensive, thick deposits of clay, including a clay stratum separating the intermediate aquifer from the underlying Memphis Aquifer. However, limited contact between the two aquifers occurs in areas near MW-34, -40, and -43 where the clay confining unit is absent. Based on the lithologic log of MW-67, the intermediate aquifer is composed of interbedded sand, silt, and clay.

Aquifer tests conducted during August 1997 indicate the hydraulic conductivity for the intermediate aquifer is similar to the fluvial aquifer with conductivities of 1.3×10^{-3} (MW-34) and 5.4×10^{-4} (MW-40) cm/sec. Away from the influence of recharge from the fluvial aquifer through areas where the clay directly underlying the fluvial deposits is absent, water level elevations in the intermediate aquifer are approximately 150 feet msl with a general westward flow toward the Allen Well Field. Inferred groundwater flow directions with the intermediate aquifer are depicted on Figure 2-5b.

Memphis Aquifer. The Memphis aquifer contains groundwater under strong artesian (confined) conditions and is a regionally significant source of potable water in the Memphis area. The Memphis aquifer is confined by overlying clays and silts in the Cook Mountain Formation (part of the Jackson/Upper Claiborne Group). Clays and silts, which make up the Cook Mountain Formation, can be seen above the Memphis Sand in the log for MW-67. This hydrogeologic unit underlies Dunn Field at a depth of approximately 255 feet bgs (as defined in the log for MW-67), and receives most of its recharge from an outcrop area, several miles east of Memphis. Some recharge is derived from overlying or hydraulically communicating units. Locally, extensive pumping has lowered water levels considerably. The top of the Memphis aquifer potentiometric surface at MW-67, the only well at the Depot that intersects the Memphis aquifer, is 151.6 feet msl. Flow in the unit is generally westward, toward the Allen Well Field, a major local pumping zone (see Appendix D). VOC contamination within the fluvial aquifer at Dunn Field has not been detected within the Memphis aquifer at the Allen Well Field.

2.5.2 Groundwater Conceptual Model

The conceptual site model (CSM) for groundwater at Dunn Field has a hydrogeological framework of three water-bearing units: the fluvial aquifer, the intermediate aquifer, and the Memphis aquifer. Logs of multiple test borings indicate that the vadose zone consists of about 30 feet of loess (silt), 10 feet of sandy clay/clayey sand, and up to 45 feet of sand, gravelly sand, and sandy gravel. The fluvial aquifer is locally 10 to 12 feet thick and occurs within gravelly sand lithologies below the vadose zone. Beneath the fluvial aquifer is a confining clay unit (approximately 70 to 95 feet thick) followed by the intermediate aquifer comprised of up to 50 feet of alternating sand and clay layers (each layer up to 20 feet thick). Approximately 75 to 100 feet of alternating sand, silt, and clay layers (each layer averages 5 feet thick) separate this aquifer from the underlying Memphis aquifer.

Movement of COCs begins with infiltration of rain through contaminated soil. The rainwater dissolves the chemicals and carries them vertically through the vadose zone into the fluvial aquifer where the dissolved COCs migrate in the direction of groundwater flow (Figure 2-6). Although there is a pervasive downward gradient, the clay layer that separates the fluvial aquifer from the underlying intermediate aquifer greatly slows the downward migration of the COCs. Wherever the clay is absent (i.e., areas near MW-34, -40 and -43), COCs may migrate downward through the "window" into the intermediate aquifer, and may ultimately reach the Memphis aquifer (Figure 2-6). Within the fluvial aquifer, the groundwater flows predominantly to the west/northwest shifting more north/northwest near MW-54 and MW-76.

Below the intermediate aquifer is the Memphis aquifer. A "continuous" clay/silt unit in the area between Dunn Field and the Allen Well Field would be a substantial barrier to potential migration of dissolved COCS into the Memphis aquifer. However, where the unit may be discontinuous, there is a possibility that dissolved COCs within the intermediate aquifer could migrate into the Memphis aquifer and then into municipal wells at the Allen Well Field. There is currently no evidence that COCs in the fluvial aquifer at Dunn Field have entered the Memphis aquifer. A "worst case scenario" assumes that COCs will migrate from the fluvial aquifer through the intermediate aquifer into the Memphis aquifer. Section 16 of the Dunn Field RI report presents calculations of the potential transport of contaminants in the fluvial aquifer into the Memphis aquifer.

2.5.3 RI Summary

2.5.3.1 Previous Investigations

In conformance with DLA environmental programs, several technical studies have been conducted at the Depot prior to the RI that began in 1995.

Installation Assessment - In 1981, the DLA and the U.S. Army Toxic and Hazardous Materials Agency (USATHMA) conducted an Installation Assessment (IA) to identify previously used waste disposal areas and waste management practices pursuant to the Installation Restoration Program (IRP). The IA indicated that some past waste management practices were not compatible with waste management practices in use at the time of the inquiry. This study identified areas where hazardous materials might have been used, stored, treated, or disposed at the site. Based on this assessment's findings, USATHMA recommended that DLA conduct a field survey (USATHMA, July 1982).

Geohydrologic Study - In 1982, the Army Environmental Hygiene Agency (AEHA) conducted a geohydrologic study to characterize the geohydrologic setting and to identify and monitor sources of potential groundwater contamination. The study identified two areas as having the potential for groundwater contamination: Dunn Field and the PCP Dip Vat Area (AEHA, 1982).

RI/FS (1990) - In 1989 and 1990, the Depot initiated an RI/FS of several known and suspected sources of contamination. The study was performed in two phases, referred to as Phase I (primarily activities in 1989) and Phase II (primarily activities in 1990). The final 1990 RI report (Law Environmental, 1990a) was provided to EPA in August 1990 and the final FS report (Law Environmental, 1990b) was submitted in September 1990. The study indicated that the fluvial aquifer under Dunn Field was contaminated and that additional investigation was needed to fully identify contaminant source areas and to delineate the contaminant plume.

Groundwater Monitoring Study - In 1993, Environmental Science & Engineering, Inc. (ESE), performed a groundwater monitoring study using existing monitoring wells at the Depot (ESE, 1994). The study was conducted to assess changes in groundwater quality since the RI/FS was completed in 1990. Groundwater samples were collected from 35 existing monitoring wells on- and off-site. The results indicated that MCL exceedances were detected within the fluvial aquifer.

2.5.3.2 RI Sampling Strategy

Field investigations as part of the RI/FS were conducted to characterize the contamination in surface and subsurface soil, groundwater, surface water, and sediment Dunn Field in accordance with the existing work plans. Table 2-3A summarizes the RI field investigations and sampling events.

In 1995, CH2M HILL performed a background sampling program at the Depot (both Dunn Field and MI) to provide sufficient environmental data to establish statistically representative background concentrations for chemicals present in surface soil, subsurface soil, surface water, groundwater, and sediment (CH2M HILL, 1998). Background sampling (101 samples) was done in areas surrounding the Depot that were not affected by Depot operations. Chemical concentrations detected in various media as part of ongoing remedial activities at the Depot are compared with background data to evaluate whether the concentrations of these chemicals are attributable to Depot operations, are naturally occurring, or are caused by ambient effects from the urban environment surrounding the Depot.

Three activities at Dunn Field necessitated changing some of the sampling proposed in the OU1 FSP (CH2M HILL, 1995). First, in February 1998 Parsons Engineering Science (Parsons ES) conducted a geophysical survey at Dunn Field as part of EE/CA for CWM Sites 1 and 24-A/24-B. Geophysical anomalies were noted outside of the disposal areas identified, mapped and reported in the OU 1 FSP indicating that potential burial operations occurred outside of previously suspected areas. Second, in early 1998 OHM/IT Corp., performed waste characterization activities of excavated soil resulting from the installation of the below-grade conveyance system of the Dunn Field groundwater extraction system. VOC contamination was found along the western and northern perimeter of Dunn Field, outside of previously mapped disposal areas. This information required soil gas field screening to be conducted at Dunn Field to identify areas of contamination not previously identified.

A passive soil gas survey was conducted at Dunn Field in August (Phase 1) and October (Phase 2) of 1998. Phase 1 focused on the Disposal Area and Phase 2 expanded the soil gas sampling grid to the east and north to further delineate soil gas identified in Phase 1. The goal of this survey was to provide screening information on the potential sources of VOC contamination of groundwater at Dunn Field.

The primary objective of the 1999 RI effort was to provide data to characterize the nature and extent of contamination in surface and subsurface soils, groundwater, surface water, and sediments resulting from past waste handling and disposal operations. Data were collected to meet the following data quality objectives:

- Evaluate the presence of VOCs in surface soil and define horizontal and vertical extent;
- Characterize the nature of the materials contained in the Disposal Area;
- Support human health and ecological risk assessment of exposure to surface soil during intrusive activities; and
- Provide data for feasibility studies.

The objectives of the 2000/2001 expanded remedial investigation at Dunn Field were to assess (1) the presence or absence of a dense non-aqueous phase liquid (DNAPL) in the groundwater in the west-central portion of the Disposal Area; and (2) the source and areal extent of the subsurface DNAPL, if confirmed to be present.

Soil samples were collected from the CWM excavations at Sites 1, 24-A and 24-B to determine the presence of hazardous and toxic waste (HTW), including DNAPL and dissolved/sorbed phase chlorinated volatile organic compounds (CVOCs) in accordance with the Amended Sampling and Analysis Plan [III]: Soil Sampling from CWM Excavations 24-A, 24-B, and 1 for H-1W (CH2M HILL, March 2000). Because of the potential for CWM, these disposal areas were not investigated during the previous Dunn Field RI field efforts.

Table 2-3B presents the number of samples collected during the RI sampling events. Because of the wide variety of areas investigated, a complex array of analyses was conducted at a fixed-base laboratory. The analyses performed on the samples collected from Dunn Field included VOCs, SVOCs, pesticides, herbicides, and metals.

If, at any point, analytical results indicated either that contamination was not present or that the nature and extent of contamination had been defined based on comparison to the higher of either the background or risk-based concentration (RBC) of target compounds, no subsequent sampling was performed. However, if these criteria were not met, additional samples were collected and analyzed to more fully assess the nature and extent of contamination.

2.5.3.3 Known or Suspected Sources of Contamination

Types of past activities that led to the presence of hazardous materials in the environmental media at three Dunn Field Areas are as follows:

Northeast Open Area activities included firearms target practice and handling/disposal of military supplies and equipment. VOCs were found in surface and subsurface soil samples. In particular, PCE and TCE were detected at 3 to 5 feet below ground surface (bgs) and 8 to 1 0 feet bgs at multiple locations. The concentrations of these VOCs do not appear to be high enough to indicate a release from a definable source area. However, the VOCs results from the passive soil gas investigation suggest that incidental surface waste disposal of chlorinated solvents may have occurred in the Northeast Open Area during operations at Dunn Field. VOCs detected along the western boundary of the Northeast Open Area may be associated with waste disposal operations in the adjacent Disposal Area.

There is no indication that zinc or semi-volatile organic compounds (SVOCs) have migrated from the XXCC-3 (stabilized impregnite) burial site (Site 21) along the eastern boundary of the Northeast Open

Area. Lead concentrations ranged from 14 mg/kg to 2,100 mg/kg, with the maximum value recorded in samples from the former Pistol Range.

The distribution of pesticides across the Northeast Open Area is similar to that at the MI, indicating widespread surficial pesticide application on the ground surface rather than releases from the temporary pesticide storage area (Site 85).

Concentrations of compounds detected in samples of surface water and sediment in the drainage ditch (Site 50) are no different than background.

The frequency of detection for the COPCs in all media (except groundwater) in the Northeast Open Area is summarized in Table 2-4A.

The Disposal Area is a known burial area at the Depot, and the majority of burial sites are located on the northern half of the Disposal Area. Various chemicals, CWM, grease, paint thinner, methyl bromide, and nitric acid were buried in disposal sites. CVOCs were detected at elevated concentrations in subsurface soils in the Disposal Area. VOCs detected in soils via laboratory analysis of soil samples correlate well with the extent of VOCs detected during the passive soil gas survey. The apparent clustering of the higher VOC concentrations correlates well with the historical information indicating that the disposal pits and trenches were relatively small and separate. VOCs have been transported from near the base of the disposal trenches (8 to 10 feet bgs) to the fluvial aquifer (average 70 feet below ground surface).

Based on comparison of soil sample analytical results to environmental conditions in groundwater under Dunn Field, there appears to be a complete migration pathway from disposal area to subsurface soil and then to groundwater for CVOCs.

Chromium and lead detected in surface and subsurface soil consistently exceed background concentrations (see summary of the background sampling program in Section 2.5.3.2 [CH2M HILL, 1998]). It is expected that these levels result from waste management operations at the Disposal Area. Arsenic, antimony, aluminum, copper, and zinc also exceed background concentrations in soil. Metals in both surface and subsurface soil are widely distributed or random and do not correlate consistently with specific disposal locations or sites. Pesticides were also detected in surface and subsurface samples across the Disposal Area.

The frequency of detection of the COPCs for all media (except groundwater) in the Disposal Area is summarized in Table 2-4B.

The Stockpile Area was used for vehicle storage in the 1940s, for aboveground storage of fluorspar and bauxite beginning in the 1950s (Sites 62, 63, and 64), and also for the below ground storage of CWM. There is no indication that VOCs or SVOCs were disposed of at the Stockpile Area. The elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) detected in surface soil samples appear to be related to the incomplete combustion of the exhaust from trains and automobiles from the former/existing railroad tracks and asphalt roadways near or on this area of Dunn Field.

Detected metals are primarily associated with ore storage and in general are close to background levels, including arsenic. The distribution of pesticides across the Stockpile Area is similar to that at the MI, indicating widespread surficial pesticide application rather than releases.

The alleged CC-2 (impregnite) burial trench is suspected as being located adjacent/near to Site 24-B in the west-south portion of the Stockpile Area. Information indicates the possible burial of 86,100 pounds of containerized CC-2 material in a 40-foot long trench in the southwest quadrant of Dunn Field in 1947. Impregnite (unstablized [CC-2] and stabilized [XXCC-3, stabilized with zinc oxide]) was used for impregnating or permeating protective clothing after laundering to protect personnel against the action of vesicant-type chemical agents. In addition, Installation Assessment Site 31 (USATHAMA 1982) is identified as being located in the western portion of the Stockpile Area (see Table 2-1). This site was reportedly used for burning/disposal of smoke pots, CN (tear gas) grenades and souvenir ordnance, which included a 3.2 mortar round. This area was covered by the bauxite storage pile (Site 64). This area was not directly investigated during the RI field activities due to the CWM removal action, which was completed in 2001.

The frequency of detection for COPCs for all media (except groundwater) in the Stockpile Area is summarized in Table 2-4C.

Surface Soil

No COCs were identified at the Northeast Open Area in surface media. Lead-contaminated surface soils at Site 60 have been remediated as a non-time critical removal action, making a majority of the land acceptable for unrestricted use. No COCs were identified at the Stockpile Area in surface media. The maximum arsenic concentration is within the range of background levels of 4 to 28 mg/kg detected elsewhere in Shelby County as reported in the Background Sampling Program Report (CH2M HILL, May 1998). Arsenic was detected at an average concentration of 11 mg/kg in surface soil samples from across the entire exposure unit (a total of 26 samples). These results suggest that site arsenic levels are within background concentrations. EPA (CERCLA) guidance generally does not require clean up to concentrations below natural or anthropogenic background levels (EPA, 2002).

Subsurface Soil

VOCs were identified as COCs in subsurface soil in the Disposal Area for industrial land use during the RI.

Groundwater

The nature and extent of contamination in groundwater underlying Dunn Field and areas to the west were assessed based on an evaluation of chemical data obtained from groundwater samples collected during 16 sampling events from January 1996 through February 2001. Groundwater samples were collected and analyzed during this time period for seven major types of contaminant parameters, including explosives, herbicides, metals (total), pesticides, PCBs, SVOCs, and VOCs. Groundwater samples were also analyzed for CWM breakdown products, specifically thiodiglycol, 1,4-oxathiane, and 1,4-dithiane. In addition, groundwater samples were collected and analyzed for various geochemical and geotechnical parameters, including tritium and gases, such as oxygen and hydrogen. Of all these parameters, VOCs, SVOCs, and total metals were the most frequently detected analytical constituents in groundwater samples. Appendix A-7 of the Dunn Field Feasibility Study (FS) (CH2M HILL, May 2003) includes the figures from the Dunn Field RI report, which summarize the analytical results of groundwater samples for PCE, TCE, 1,2-DCE, 1,1-DCE, 1,1,2,2-PCA, 1, 1, 2-TCA, carbon tetrachloride and chloroform from 1996 through the beginning of 2001. The frequency of detection for organic COPCs in groundwater is summarized in Table 2-4D.

The Dunn Field FS evaluated the non-VOC chemicals, based on several criteria. Results of the evaluation indicate that it is not appropriate to carry the non-VOCs forward for remedial action.

Based on Figures 2-7a through 2-7h, there appear to be three major VOC plumes in the fluvial aquifer underlying Dunn Field, a northern, a west-northwest plume, and west-southwest plume, with much mixing and intermingling of the plumes, as expected from influence by the active groundwater extraction system, natural groundwater flow, and degradation processes. There are on-and offsite components of the plumes.

Nine persistent VOCs have been detected in groundwater during sampling events, including 1,1,1,2-PCA, CC14,1,1,2-TCA, chloroform, PCE, cis- and trans-1,2-DCE (total 1,2-DCE), and TCE. The plume along the northern boundary of the site appears to be composed of PCE, TCE, and 1,1-DCE. Since TCE and 1,1-DCE are both potential reductive dechlorination products of PCE, the contaminant plumes may be a result of the breakdown of PCE in the aquifer. However, since the TCE, and 1,1-DCE both appear in monitoring well MW-51 and piezometer PZ-02, which are upgradient to Dunn Field, there appears to be another source of these contaminants north to northeast of Dunn Field. A potential offsite source is discussed further in this section.

The west-northwest plume appears to be a mixture of PCE TCE, 1,2-DCE, 1.1-DCE, 1,1,2,2-PCA, 1,1,2-TCA, CC14, and chloroform. Portions of this plume underlying Dunn Field appear to have a source within the Disposal Area or possibly offsite as well. Offsite portions of this plume trend to the west and northwest. The west-southwest plume that underlies Dunn Field is a mixture of several different contaminants and the source of these plumes appears to be located at the southern end of the Disposal Area of Dunn Field. The west-southwest plume is principally composed of 1,1,2,2-PCA, CC14, 1,1,2-TCA, and chloroform, but there are also portions of the plume made up of TCE, PCE, and 1,2-DCE.

The nature and extent of VOCs in groundwater have been impacted by the groundwater extraction system at Dunn Field to some extent. PCE, TCE, and 1,1,2,2-PCA concentrations in offsite monitoring wells near the northwest corner of the extraction system have dropped by factors of 7 to 10 from pre-extraction concentrations. Although concentrations have decreased in the northwest portion, relatively high concentrations of TCE and 1,1,2,2-PCA were discovered in new wells installed near the west-central part of Dunn Field. These higher concentrations in downgradient monitoring wells indicate a significant portion of the west-central plumes are beyond the influence of the extraction system capture zone. Groundwater VOC monitoring data from April 2002 were included in the Dunn Field FS report for the first time. Figures 2-7a through 2-7h summarize the results of the April 2002 groundwater samples for PCE, TCE, 1,2-DCE, 1,1-DCE, 1,1,2,2-PCA, 1,1,2-TCA, carbon tetrachloride and chloroform.

From 1996 to 2002, 1,1-DCE has been detected in groundwater samples above the MCL of 7 µg/L in monitoring wells and piezometers along the northern perimeter of Dunn Field and offsite to the north, northwest and northeast of Dunn Field. 1,1-DCE was found in northern perimeter wells MW-03, MW-07, MW-08, MW-10, and MW-29 at concentrations as high as 25 µg/L in October 1998. In particular, this compound was detected in offsite well MW-51 (which is located 200-feet side-gradient to the northern boundary of Dunn Field) and piezometer PZ-02 (which is located 700-feet upgradient from the northern boundary of Dunn Field), with the highest offsite concentration being recorded in a sample from PZ-02 at 170 µg/L in October 1998. TCE has also been detected in these wells at concentrations that exceed the MCL of 5 µg/L with the highest value of 24.4 µg/L detected in PZ-02 in April 2002. MW-65 was also sampled in April 2002 and no VOCs were detected. This well is located approximately 1,100 feet north-northeast of PZ-02.

Three additional off-site monitoring wells were installed north and east of the northeastern corner of Dunn Field in June 2003. The analytical results of the groundwater samples collected from these up-gradient wells confirm the fact that an offsite plume, primarily containing PCE, TCE and 1,1-DCE, enters Dunn Field along the northeastern boundary of the site (Jacobs, August 2003).

PCE and TCE are frequently detected contaminants of concern found in the soils on the Dunn Field; however, 1,1-DCE is not. Since the PCE, TCE and 1,1-DCE both appear in offsite monitoring wells, which are upgradient to Dunn Field, respectively, there appears to be an offsite source of these contaminants north to northeast of Dunn Field, unrelated to the source areas on Dunn Field. This apparent source is creating an offsite plume that is migrating onsite and is further contributing to the VOC contamination in groundwater underlying the northeastern portion of Dunn Field. Consequently, any proposed remedial action for the groundwater underlying Dunn Field may need to consider this offsite plume as it enters the site unless otherwise addressed. This information is documented in the Technical Memorandum entitled *Potential Offsite Source of Groundwater Contamination, Northeast of Dunn Field* (CH2M HILL, November 2003).

2.5.4 Fate and Transport of the COCs

Figure 2-6 presents a conceptual site model (CSM) of contaminant transport beneath Dunn Field. Chemicals that are observed to occur frequently in the environmental media at Dunn Field (COCs) are addressed below by their chemical group (VOCs, metals, etc.). The fate and transport of each of these groups are briefly summarized from Section 6 of the RI report. Table 2-5 summarizes the physical and chemical properties of selected COPCs for Dunn Field.

Volatile Organic Compounds

VOCs are characterized by relatively high vapor pressures, Henry's Law constants, and generally low to moderate solubility in water. They have a tendency to partition to the vapor phase (air) from either the sorbed (soil) or dissolved (aqueous) phases. CVOCs detected at Dunn Field are mobile through soils and tend not to partition significantly from water to soil. These solvents may move through groundwater as DNAPLs because CVOCs are denser than water. The most consistently detected VOC group of chemicals at concentrations above comparison criteria in the site media are CVOCs, such as TCE, PCE, 1,1,2,2-PCA, carbon tetrachloride and chloroform.

Release and transport mechanisms include vertical migration through unsaturated soils toward the water table. The presence of VOC plumes emanating from Dunn Field supports the conclusion that VOCs are being transported through the soil column to the fluvial aquifer.

If CVOCs are present as NAPL in soil, they can be continuing potential sources of CVOCs to groundwater. As a general rule, the potential presence of NAPL is indicated if concentrations in groundwater exceed 1 percent of the chemical's solubility limits. Based on the highest observed concentration of the detected solvents TCE and 1,1,2,2-PCA in groundwater, free-phase solvents may be present in Dunn Field groundwater; however, DNAPL has not been detected during the RI and subsequent O&M groundwater sampling events.

Aerobic and anaerobic biodegradation are important transformation processes for chlorinated aliphatic compounds in natural water systems and soil. A full suite of parameters necessary to support evaluation of the biodegradation component of monitored natural attenuation (MNA) were collected at Dunn Field in March 2000. The results indicated that dissolved CVOCs in groundwater at Dunn Field are undergoing biologically facilitated reductive dechlorination; however, the occurrence of this process is limited and localized. Available information indicates that the TCE plume originating at Dunn Field is exhibiting mixed biodegradation rates. In MW-70, where the DO concentrations are relatively low, reductive dechlorination is proceeding. PCE, TCE, DCE, VC, and ethene/ethane concentrations in MW-70 suggest some degree of reductive dechlorination. There is inadequate to limited evidence of reductive dechlorination throughout the rest of the plume. In conclusion, monitoring wells within Dunn Field show some degradation of PCE to TCE to DCE to VC to ethane/ethene.

Semivolatile Organic Compounds

PAHs are common components of fuel oils and tar mixtures. PAHs have been detected extensively at the railroad operations across the Depot. Fuel use, vehicular and historical railroad traffic, asphalt roads, and pavement have contributed to non-point source releases of PAHS at the Depot. PAHs are relatively persistent 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, but are primarily low.

Metals

The potential release and migration of metals in the subsurface environment is a complex process. The migration of metals depends on factors such as the overall groundwater composition, pH, presence of dissolved organic matter that may complex with the metals, the valence state of the metal, and the cation-ion exchange capacity. Metals may be removed from the water phase through mechanisms such as precipitation and irreversible sorption (USEPA, December 1979). Because metals are not volatile, any emissions to ambient air would be in the form of particulate emissions.

Metals detected above background at Dunn Field include aluminum, antimony, arsenic, cadmium, chromium, and lead. Thallium has been detected as well; however, there is no background value. Metals that typically have very low solubilities or are highly absorbed in soils include lead and trivalent chromium. For example, lead has a tendency to form low-solubility compounds with the major anions of natural water. Hydroxide, carbonate, sulfide, and sulfate may act as solubility controls to precipitate lead from water. Another important factor is lead's strong tendency to sorb to soils. A significant fraction of lead is insoluble lead, which may be associated with colloidal particles. Arsenic is generally more mobile in groundwater than many other metals, but its behavior is complex. It can exist in multiple oxidation states that differ in solubility. The reduced form of arsenic (AS^{+3}) is more mobile than the oxidized form (As^{+5}).

Pesticides

Dieldrin is the pesticide most present at Dunn Field, with relatively infrequent detection of DDT, DDE, and DDD in soil and sediment. These pesticides are no longer used at the facility.

In general, these chlorinated pesticides have low Henry's Law constants and are not expected to volatilize significantly. All of the detected organo-chlorine pesticides have lower solubility and higher K_{oc} values, indicating that these pesticides are more likely to sorb to soil and are less mobile in aqueous phases. The most likely migration pathways for pesticides are transport in particulate emissions and transport of sorbed materials in surface runoff.

2.6 Current and Potential Future Land and Groundwater Uses

2.6.1 Land Use

The DEC board of directors, the City of Memphis, and Shelby County approved the *Memphis Depot Redevelopment Plan* in 1997. The intended land use is industrial for the Disposal and Stockpile Areas, and recreational for the Northeast Open Area. Dunn Field is currently zoned as Light Industrial (I-L) and is adjoined by residential areas to the northeast, east and west, and light industrial areas to the south, southwest, northwest and north (see Appendix A). Dunn Field is currently vacant with only occasional maintenance personnel onsite. It should be noted, that a small residential area exists to the west of Dunn Field in an area zoned I-L. This land use is considered non-conforming with respect to the current zoning designation (I-L); however, the City of Memphis allows the use based on the age of the housing units. Additional residential construction or expansion of the housing units is prohibited without a variance.

2.6.2 Groundwater Use

There are no public water supply wells within Dunn Field. A well survey conducted within a 2-mile radius of the Depot through the Environmental Data Resources, Inc. (EDR®) CeoCheck® report (dated March 2002 and included as Appendix A-3 of the Dunn Field RI report) determined that there are no private residential potable water wells within a 2-mile radius of Dunn Field. However there are several industrial production wells within 0.5 to 2 miles northwest, northeast and east of Dunn Field.

Approximately 1 mile west of Dunn Field is the Allen Well Field, where 26 water-supply wells pump from the Memphis aquifer (see Appendix D). This aquifer is the water source for the City of Memphis and most of Shelby County. Therefore, a factor in evaluating effectiveness of a remedial alternative is controlling migration of contaminants that might affect the quality of water produced by these public supply wells.

Groundwater from the aquifers beneath Dunn Field must meet the requirements of General Use Ground Water as defined by Rules of the TDEC Chapter 1200-4-3-.07(2)(b) (see Section 2.13.2). After remedial objectives have been met and the property transferred for re-use, it is possible that the new owner/lessee would want to use the groundwater for industrial water supply. It is important to note that the Ground Water Quality Control Board for Shelby County has established *Rules and Regulations of Wells in Shelby County* in accordance with the authority granted by the Code of Shelby County (Codified through Ord. No. 269, enacted Oct. 21, 2002, Chapter 29, Section 29-58). The Water Quality Branch is responsible for administering and enforcing these rules. Section 5.02(E) of the Well Construction Code prohibits installation of drinking water wells within a half-mile of the designated boundaries of a listed federal Superfund (i.e., CERCLA) site unless the well owner can demonstrate that the well will not enhance the movement of contaminated groundwater or materials into the shallow or deep aquifer.

2.7 Summary of Site Risks

The response action selected in this ROD is necessary to protect public health or welfare, or the environment, from actual or potential releases from the Dunn Field of pollutants, contaminants, or hazardous substances. The BRA estimates what risks Dunn Field poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the BRA for Dunn Field.

Details of the BRA are presented in the Dunn Field RI Report. The BRA focused on health effects for both children and adults, in industrial, recreational, and hypothetical residential settings that could result from contact with contaminated soil or groundwater. Examples include children ingesting soil while playing in the area or adults using groundwater for drinking water. A surrogate approach was used to conservatively assess potential human health risks. The selection of the surrogate site is based on the exposure unit concept and the high-end contamination areas. The surrogate site and Area-wide RAs are based on exposure units: the maintenance worker's exposure unit is the entire area within the boundaries of the study area, whereas an industrial worker/residential exposure is assumed to be a smaller exposure unit represented by a surrogate site. The surrogate site is assumed be a 1.0-acre lot, represented by an area around the highest preliminary risk evaluation (PRE) data point within the Area.

The risk assessment included the following receptor groups:

1. Current/future onsite maintenance worker;
2. Future onsite commercial/industrial worker;
3. Future onsite recreational adult, youth and child (Northeast Open Area only);
4. Future onsite utility worker (Disposal Area and Stockpile Area)
5. Future onsite resident (at the Surrogate Sites);
6. Offsite resident - inhalation exposure to VOCs in site soils; and
7. Offsite resident - adult and child (groundwater)

A future residential risk scenario was performed for comparison purposes only. Although the majority of the eastern half of Dunn Field is available for unrestricted use, it is unlikely that this property will be used for future residential purposes for several reasons. For example:

- Dunn Field is currently zoned light-industrial, which prohibits residential use.
- Depot redevelopment plans do not include future residential development.
- Light industrial uses offer the potential for employment.

Future residential health risks due to exposure to chemicals in soil were addressed to support remedial management decisions.

2.7.1 Summary of the Human Health Risk Assessment (HHRA)

2.7.1.1 Identification of COCs

The 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 population. The acceptable target HI for noncarcinogenic chemicals is 1.0. The chemicals that exceeded those criteria and require remedial action for the protection of human health are identified as COCs.

The summary of human health risk assessment is presented below by geographical area. Table 2-6 summarizes the COCs for the Northeast Open Area, Disposal Area, Stockpile Area and groundwater beneath Dunn Field.

- No COCs remain in the Northeast Open Area in surface media. Lead-contaminated surface soils at Site 60 have been remediated as a non-time critical removal action.

- No COCs were identified at the Stockpile Area in surface media. The maximum arsenic concentration of 25.5 mg/kg is within the range of background levels of 4 to 28 mg/kg detected elsewhere in Shelby County as reported in the Background Sampling Program Report (CH2M HILL, May 1998). EPA guidance generally does not require clean up to concentrations below natural or anthropogenic background levels (EPA, 2002).

- VOCs were identified as COCs in subsurface soil in the Disposal Area for industrial land use.

- COCs are identified as PAHs, arsenic, antimony and CVOCs to a hypothetical resident at the surrogate site in the Disposal Area.

- VOCs, dieldrin, arsenic, iron, and manganese were identified as COCs in onsite and offsite groundwater during the RI. Several rounds of additional monitoring data have been collected since the RI fieldwork. Most of the non-VOC organic and inorganic COCs chemicals detected previously were not detected at significant levels or do not have a high frequency of detection. Their detection is possibly associated with turbidity in samples which may have been introduced as a sampling artifact and biased the results high. Also based on the innate nature of these chemicals, they have low solubility, and subsurface soils above the aquifer do not have significant (above leachability based levels) levels of these chemicals. Thus metals and non-VOC chemicals are not selected as COCs. This is further supported by the following:

    > Groundwater samples were collected from the onsite recovery wells in November 1999 and 2000, and arsenic was not detected above the MDL of 0.003 mg/L in 17 of 18 samples. Arsenic was detected at a concentration of 0.003 mg/L in the sample from RW-01 in November 2000. In addition, arsenic was analyzed in 33 samples collected from the groundwater extraction system effluent between October 1998 and April 2002. Of the 33 samples analyzed, none had arsenic concentrations that exceeded the MDL of 0.003 mg/L. Therefore, arsenic does not appear to be a groundwater contaminant in the fluvial aquifer at Dunn Field.

    > Iron and manganese were analyzed in 33 samples collected from the groundwater extraction system effluent between October 1998 and April 2002. Of the 33 samples analyzed, none had iron or manganese concentrations that exceeded the background concentrations of 6.73 mg/L and 0.56 mg/L, respectively. The highest iron concentration was 0.7 mg/L and the highest manganese concentration was 0.175 mg/L. Therefore, iron and manganese do not appear to be a groundwater contaminant in the fluvial aquifer at Dunn Field.

    > Among the 37 groundwater samples collected during the RI and analyzed for organochlorine pesticides, dieldrin was detected in only 4 samples, ranging from 0.000036 to 0.000086 mg/L.

2.7.1.2 Exposure Point Concentrations

Chemical intakes were estimated, where possible, from direct chemical measurements in the soil, groundwater, surface water, and sediments. The upperbound estimate on the mean concentration was used for the exposure point concentration (EPC). For solid media, these EPCs were estimated as the upper confidence limit (UCL) at the 95th percentile on the mean (UCL 95 percent), and were calculated following EPA guidance. The UCL 95 percent calculation methodology is summarized in Appendix F of the Dunn

Field RI report. Individual EPCs calculated by this method are included in each of the Area descriptions and surrogate site RA sections in the Dunn Field RI.

For volatile organic COPCs in groundwater, instead of a statistical estimate as the EPC value, average concentrations from the wells within the center of a contaminant plume were selected as the EPCs. For constituents that do not typically exhibit plume behavior (e.g., inorganic chemicals) and are not identified with any site-related activities, but are detected throughout the site, the UCL 95 percent estimate of onsite Dunn Field monitoring wells was used as the EPC. Although groundwater is not currently used, future potential use was evaluated. The EPCs for groundwater are presented in Section 15 of the Dunn Field RI.

The EPC values for future industrial, recreational, and residential receptors are calculated for surrogate sites, which is a 1-acre circular area around the maximum PRE risk ratio sample. Samples from within the 1-acre circle were used to estimate the UJCL95 percent, which is the EPC.

2.7.1.3 Exposure Assessment

To identify potentially complete exposure pathways at Dunn Field, a conceptual exposure model was developed for each Area and the corresponding surrogate site. A conceptual site model (CSM) presents an overview of site conditions, potential contaminant migration pathways, and exposure pathways to potential receptors. The site conditions include both current and likely future conditions. These CSMs are described in detail in the RI (CH2M HILL, July 2002) and are presented as Figures 2-8a through 2-8d. Table 2-7 summarizes potentially exposed populations for each area of Dunn Field.

The groundwater at the site is found to have a CVOC plume, part of which has migrated to off site areas. A portion of the plume that extends beyond the property boundary of Dunn Field has migrated under some of the nearby residences. There are no direct exposures to these residents at the present time, as the residents are supplied with City of Memphis drinking water. However, indirect exposure to VOCs reaching the surface through the soil column at low levels could constitute a potentially complete exposure pathway. Potential off site resident's exposure through inhalation and ingestion is assessed as part of the off site contaminant plume risk evaluation (the results are included in Section 15 of the Dunn Field RI). Inhalation intake of VOCs in indoor air from subsurface vapor intrusion was also estimated for future onsite industrial workers, future onsite residents, and future offsite residents.

2.7.1.4 Toxicity Assessment

A toxicity assessment was performed to determine the relationship between the magnitude of exposure to a chemical at Dunn Field and the likelihood of adverse health effects to potentially exposed populations.

For cancer effects, EPA has developed a carcinogen classification system (USEPA, 1986b) using a weight-of-evidence (WoE) approach to classify the likelihood that a chemical is a human carcinogen. Information considered in developing the classification includes human studies of the association between cancer incidence and exposure, as well as long-term animal studies under controlled laboratory conditions. Other supporting evidence considered includes short-term tests for genotoxicity, metabolic and pharmacokinetics properties, toxicological effects other than cancer, structure-activity relationships, and physical and chemical properties of the chemical. Table 2-8 describes the EPA weight-of-evidence (WoE) classification system for carcinogenicity. The carcinogenicity grouping of the COCs identified is presented in Table 2-9.

For noncarcinogenic effects, toxicity values are derived based on the critical toxic endpoint (i.e., the most sensitive adverse effect following exposure). The toxicity value describing the dose-response relationship for noncancer effects is the reference dose (RfD). Table 2-10 provides noncarcinogenic risk information that is relevant to the COCs in both soil and groundwater.

Elevated lead concentrations were observed in the former pistol range area, where the lead could be from spent bullet casings strewn across the area around Sites 60/85. However, with the completion of the CERCLA removal action at Sites 60/85 in March 2003, the potential risk from elevated lead concentrations was removed from Dunn Field. Therefore, lead is no longer a COC for the site.

2.7.1.5 Risk Characterization

Tables 2-11 through Table 2-19 summarizes the risks and HIs for future industrial, residential, and recreational use, across Dunn Field for indoor and ambient air, surface and subsurface soil, sediment, surface water, and groundwater. Acceptable risk levels (risks) for Dunn Field range from 1 x 10^{-6} to 1 x 10^{-4} ELCRs. The acceptable target HI for noncarcinogenic chemicals is 1.0.

The risk characterization conclusions for human health protection for Dunn Field are summarized as follows:

Northeast Open Area

- None of these exposure scenarios resulted in risks above acceptable levels for this area.

Disposal Area

- The risk assessment indicated unacceptable risks in the Disposal Area for: (1) industrial worker exposed to indoor air; (2) the disposal sites in the Disposal Area are not suited for utility workers because of possible intrusive disturbance of buried wastes.

- The results of the risk assessment for Disposal Area - Site 61 Surrogate Study indicated unacceptable risks for the following: industrial worker (indoor) through exposure to soil-to-indoor air and groundwater (potable use); residential child (onsite) through exposure to surface soil, soil-to-indoor air and groundwater (potable use); and a residential adult (onsite) through exposure to surface soil, soil-to-indoor air and groundwater (potable use).

Stockpile Area

- None of these exposure scenarios resulted in risks above acceptable levels for this area. The total ELCR to future hypothetical onsite adult and child residents at Surrogate Site SSLFF was estimated at 6 x 10^{-5}, which is within the acceptable range of 10^{-6} to 10^{-4}. Total HI was estimated to be 0.2 for an adult and 2 for a child. The estimated risk and HI are also due to arsenic. The maximum arsenic level of 25.5 is within the range of background levels of 4 to 28 mg/kg detected elsewhere in Shelby County as reported in the Background Sampling Program Report (CH2M HILL, May 1998). The maximum arsenic concentration was used to calculate the risks and hazards for Surrogate Site SSLFF. Arsenic was detected at an average concentration of 11 mg/kg in surface soil samples from across the entire Stockpile Area (a total of 26 samples). These results suggest that site arsenic levels are within background, therefore, no action is proposed.

Groundwater

- The groundwater in the shallow fluvial aquifer under Dunn Field is not suitable for use as drinking water due to the concentrations of CVOCs detected during the RI.

- Overall, risks to a future industrial worker or hypothetical resident from exposure to onsite groundwater are not within the acceptable range of 1 to 100 in a million (ELCRs range from 1 x 10^{-4} to 1 x 10^{-2} and HIs range from 1.6 to 34). The affected groundwater plume under the site extends beyond the property boundary. The groundwater concentrations do not meet MCLs.

- There are houses in the offsite areas west of Dunn Field; however, all of the residents are supplied water via a municipal waterline. Groundwater impacts in the fluvial aquifer have been detected in selected offsite wells and indoor air exposures are the most pertinent exposure pathway. Risks through this pathway to the offsite residents are within the acceptable limits, presenting negligible risks (indoor air inhalation risks ranged from 2 X 10^{-7} to 5 x 10^{-10}) and hazards (HIs were all <0.01).

2.7.1.6 Uncertainty

Numerous sources of uncertainty are inherent in the risk assessment, due to the assumptions made. These generic uncertainty factors (and their relative effect on the risks and noncarcinogenic health hazards estimated for each site) are summarized in Table 2-20 and described qualitatively below. In the absence of measured data for exposures, risk calculations include conservative assumptions. Thus, when the actual situation is not known (uncertain), bias toward conservatism was used (e.g., future exposure scenarios and pathways, frequency of grass mowing, duration of time spent in a small area, exposure concentrations). The uncertainties associated with toxicity factors estimated by EPA include a bias to be conservative in RfD and CSF estimations.

2.7.2 Summary of Ecological Risk Assessment

The natural habitat in Dunn Field is very limited to non-existent. A screening level Ecological Risk Assessment (ERA) indicated little potential for significant ecological impacts or adverse effects to wildlife. The Screening Ecotoxicity Criteria for soil, sediment, surface water, and groundwater used in the ERA are listed in the Dunn Field RI (CH2M HILL, July 2002).

The Northeast Open Area is an entirely grassed section in which the landscape is routinely mowed or maintained, and this land maintenance is expected to continue into the future if the site is developed for recreational use. The onsite terrestrial habitat is of limited ecological value, and is generally supportive of maintained planted grasses, scattered hardwood trees, and some urbanized wildlife. Dieldrin and chromium were the only surface soil COPCs identified in the Northeast Open Area following the refinement step. Based on further refinement of the risk assumptions of dieldrin and chromium on the American robin as target receptor, along with the other site-specific characteristics and uncertainties, dieldrin and chromium will not be considered further as a COPCs for this area. Based on this evaluation, no further assessment of ecological risk associated with contaminants at the Northeast Open Area is warranted.

The Disposal Area is an entirely grassed section in which the landscape is routinely mowed or maintained, and this land maintenance is expected to continue into the future when the site is developed for light industrial use. The onsite terrestrial habitat is of poor ecological value and is generally supportive of maintained-planted grasses and some urbanized wildlife. Based on the lack of surface soil COPCs, ecological impacts are expected to be negligible and are not expected to change in the foreseeable future.

The Stockpile Area is an entirely grassed section in which the landscape is routinely mowed or maintained, and this land maintenance is expected to continue into the future if the site is developed for light industrial use. The onsite terrestrial habitat is of poor ecological value and is generally supportive of maintained-planted grasses and some urbanized wildlife.

Based on the lack of surface soil COPCs, ecological impacts are expected to be negligible and are not expected to change in the foreseeable future.

2.7.3 Remediation Goals for Soil and Groundwater

Based on the findings of the risk assessment and development of the COCs, the following remediation goals have been established for each medium on Dunn Field.

Surface Soil

Site 60 had lead as COC from past use as pistol range. The lead contaminated surface soil has been addressed under a CERCLA removal action as previously discussed in Section 2.4.1.3. There are no other COCS identified in surface soil for the Northeast Open Area and the Stockpile Area for unrestricted use, therefore no remediation goals were developed for surface soil in these areas. Surface soil in the Disposal Area is unacceptable for residential exposure (at Surrogate Site 61LE). The residential RGOs are the remediation goals for surface soil in the Disposal Area and are summarized in Table 2-21A. There are no remediation goals for surface soil in the Disposal Area under the industrial use scenario.

Subsurface Soil Impacted by VOCs

The subsurface soils, primarily within Disposal Area of Dunn Field, have residual CVOC levels well above the soil-to-groundwater migration based screening levels, and potential vapor intrusion to indoor air under altered land use conditions. The extent of the subsurface soil contamination, that extends vertically to the groundwater in the underlying fluvial aquifer due to leaching over time from the burial pit wastes, affords very little dilution attenuation to the soil CVOCs.

The Exposure Model for Soil-Organic Fate and Transport (EMSOFT) (EPA, 1997) was used to calculate site-specific values of soil concentration that would be protective of groundwater at Dunn Field. The one-dimensional screening model is based on the work described by Jury et at (1983, 1990) and incorporates volatilization, advective and diffusive transport, sorption, and decay. The model theory, verification, and validation are included in the EMSOFT User's Guide (EPA, 1997). As part of the model calculations, a site-specific dilution attenuation factor (OAF) of 6.1 was calculated for subsurface soil in the Disposal Area of Dunn Field. This DAF is based on the entire extent of VOC contamination in the Disposal Area (an area greater than 0.5 acres). Using this DAF and model results, Site-specific values were calculated for the loess and fluvial deposits and are summarized in Table 2-21B (*see Appendix C of the Dunn Field FS for the full discussion of the calculation of the site-specific soil remediation goals that would be protective of groundwater at Dunn Field*).

Subsurface Soil Associated with the Disposal Sites

Remediation goals have been calculated for the residual subsurface soils in the disposal sites based on potential or known chemicals associated with these sites. The selected remedy for Dunn Field includes remediation of approximately 17 disposal sites on the western half of Dunn Field. As discussed in the section above, site specific remediation goals have been established for VOCs that are COCs in the subsurface soil at Dunn Field that are protective of groundwater (see Table 2-21B). In addition to the identified COCs, based on records of past disposal practices at Dunn Field, several compounds may be located within and in soils beneath the burial pits and trenches in the Disposal Area; these chemicals include inorganic compounds (metals) and other organic compounds (including select VOCs, SVOCs, pesticides, and PCBs). Therefore, site specific remediation goals have been established for these chemicals also and are presented in Table 2-21C. As part of any active remedial action at the disposal sites, confirmation sampling and analyses will be required to verify that the remedial action objectives (RAOs) and remediation goals have been met.

The disposal sites are located in an area which is currently zoned light industrial. Future development of the Disposal Area/western portion of Dunn Field for industrial use is likely. Therefore the risk management scenario at the disposal pit sites is direct contact with workers under future industrial re-use. The EPA Region 9 Preliminary Remedial Goals (PRGs) and site background concentrations were used as a point of departure for industrial direct exposure and SSLs for groundwater protection.

A one in a hundred thousand cancer risk (1×10^{-5}) and an HI of 1 were selected for individual chemicals possibly contained in the disposal pits. This is appropriate because, under the risk management scenario, each individual pit or trench, by itself, would not be considered an individual exposure unit. With different residual chemicals potentially located in soil underneath different pits, the total exposure for a future worker in an appropriately sized industrial exposure unit would be a fraction of what the remediation goal would assume. To develop soil remediation goals for potential chemicals in the disposal sites, the chemicals were screened through a decision tree process. The decision tree is presented as Figure 2-17. In general, concentrations of chemicals which are protective of the migration to groundwater pathway are more stringent than industrial soil direct contact remedial levels. None of the potential chemicals identified in Table 2-21C are currently identified in the risk assessment as COCs for ground water. Any potential VOCs found in the disposal pits will be addressed by the SVE system, which will be used to remediate COG soil contamination; the footprint of the SVE system can be expanded to address any VOC contamination found in the disposal sites. Default remediation goals are presented in this document for potential VOCs in the disposal pits. Site-specific remediation goals will be developed for any new VOCs that are identified in the disposal pits during the SVE remedy using the same methodology presented in Appendix C of the Dunn Field ES. The site-specific soil and soil vapor concentrations which are protective of groundwater for these VOCs will be added to the closure criteria, or the indicators of remedy completion, for the SVE system.

Non-VOC compounds (metals, SVOCs, pesticides and PCBs) are, as a rule, significantly less mobile in subsurface soil than VOCs due to their physical-chemical properties, especially their soil/water partition coefficient (K_d), which is most likely the reason they have not been identified as COCs in groundwater. Mobility parameters for these compounds are presented as Table 2-21D. Organochlorine pesticides have only limited solubility in the chlorinated aliphatic VOCs found at Dunn Field. This greatly limits the possibility of facilitated transport by mixing with VOCs. Aromatic VOCs such as toluene, which were generally used as solvents for these pesticides, are occasionally present, but only at low micrograms per kilogram (µg/kg) concentrations. Based on the hydrogeology of the surficial aquifer system, it is highly unlikely that any soil contaminants, which do not preferentially partition into water, would leach into the surficial aquifer.

All potential chemicals for the disposal sites were screened in a two-part process. Chemicals were first screened to determine if they would preferentially migrate from soil to groundwater. The range of K_d values for the VOCs identified as COCs is 0.08 to 1.2 liters per kilogram (L/Kg), with a mean of 0.51 L/Kg. The range of water solubilities for these compounds is 200 to 13,000 milligrams per liter (mg/L), with a mean of 4,500 mg/L. For the potential chemicals in the disposal sites, a chemical was determined to have no or insignificant migration to groundwater if:

- the chemical's K_d was greater than 51 L/Kg (two orders of magnitude greater than the mean K_d for the CO~ s) or

- the chemical's K_d was greater than 5.1 L/Kg (one order of magnitude greater than the mean K_d for the COCs) and the chemical water solubility was less than 45 mg/L (two orders of magnitude less than the mean solubility for the COCs).

Mobility parameters for all potential chemicals are included in Table 2-21D. If a chemical was determined to have no potential to migrate, the industrial soil direct contact PRO was initially assigned as the soil remediation goal. If the chemical was determined to have a potential to migrate to groundwater from soil, the default SSL, with a DAF of 20, was initially assigned as the soil remediation goal. As stated in the Soil Screening Guidance (EPA, July 1996), a default DAF of 20 is selected as being protective of contaminated soil sources up to 0.5 acre in size. As shown in Appendix C, each disposal site at Dunn Field is less than 0.5 acre in area. Additionally, each disposal site contains different potential chemicals and thus is considered an individual source area. If a default SSL was not listed on the EPA 2002 PRO table (dated October 2002), a chemical-specific SSL was calculated for that compound using the tap water PRO as the target water concentration and default parameters and equations, as listed in the Soil Screening Guidance (EPA, July 1996).

In the second screening process, the direct contact exposure PRO or SSL for each chemical, whichever was applicable, was compared to the background soil concentration for that chemical established in the Dunn Field RI report. Background values for subsurface soils were used in this second screening process; however, if there was no value available, background values for surface soil were used. If the background value was determined to be greater than the default PRO or SSL, this value was re-assigned as the soil remediation goal for that compound. The final selected remediation goals for the potential chemicals are listed in Table 2-21C.

Groundwater

The groundwater in the fluvial aquifer underneath Dunn Field and to the west of Dunn Field has CVOCs above MCLs. In order to reduce the concentrations to levels that are protective of human health, both now and in the future, interim remedial actions have been implemented to date and additional remedial actions are planned for site groundwater. The planned actions aim to reduce the chlorinated solvent levels with time.

The groundwater at Dunn Field has been monitored for over 10 years and based on the data collected to date, most frequently detected chemicals are chlorinated solvents and their degradation products. The contaminant plumes are observed to have 4 to 5 parent solvents, likely from past use and subsurface disposal during the former operations at Dunn Field. One possible offsite source, not related to Depot operations, has also been previously identified during RI and subsequent investigations. The findings of the HHRA for the chlorinated solvents detected in the groundwater in the fluvial aquifer indicate that concentrations are high enough to make the water unfit for drinking either by industrial workers or residential receptors. The chemicals responsible for this predicted excess risk are mostly CVOCs. Though some organochlorine pesticides and metals were initially identified as COCs due to the relatively high toxicity, subsequent monitoring indicated a low frequency of detection of these chemicals in groundwater. Inorganic chemicals are likely associated with the turbidity in groundwater as discussed above. Thus the target groundwater remediation goals are developed only for CVOCs which are the primary COCs, as these are the most frequently detected in widespread areas at relatively higher concentrations above maximum contaminant levels (MCLs).

Currently there is no exposure to the contaminated groundwater in the fluvial aquifer at Dunn Field. Thus the focus of this ROD is to protect human health from potential future exposures as well as complying with the NCP program management principal of restoring ground water to its beneficial uses in a reasonable timeframe.

For this ROD, the Safe Drinking Water Act (SDWA) MCLs under TDEC Rule 1200-4-3-.08(2) Criteria for General Use Ground Water are relevant and appropriate requirements for groundwater at Dunn Field (see Section 2.13.2). Where there is no MCL, a PRG/RBC has been used as the target remediation goal. Since multiple chlorinated solvents were detected in groundwater at the site and in the immediate downgradient area, targeting to meet the MCLs may not be adequately protective of a potentially exposed receptor due to the possibility of cumulative toxicity at the MCLs exceeding the upper-bound limit of the acceptable risk or HI. However, the cumulative risks are dependent on the total number of chemicals present and their individual concentration levels in the groundwater. Depending on the location within the contaminant plume underneath Dunn Field, the number and concentration of multiple COCs will vary with location and time. Therefore, in order to ensure protectiveness and provide a measure of flexibility in achieving the remedial objectives, the primary means of demonstrating cleanup will be by indicating, at each point where compliance is measured, that the residual risk is within the risk range established in the NCP. As a secondary measure, MCLs must be achieved at every such point of compliance.

Therefore, following the EPA guidance for Superfund sites (EPA, 1991 Full reference: *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, OSWER Directive 9355.0-30, April 1991*) an upper-bound limit on target cumulative risk level of 1 in 10,000 (1×10^{-4}) and an HI of 1.0 are selected as the target remedial goals for the individual plumes within and immediately downgradient of Dunn Field. Thus upon completion of the remedial actions, the residual risks will not exceed these target levels at the points of compliance throughout the plume(s). The individual concentration of each COC within these plumes will be different from contaminated area to area; however, they will not exceed MCL or non-zero MCLG levels and combined concentration levels will not exceed a cumulative upper-bound target risk of 1 in 10,000 (1×10^{-4}) and HI of 1.0 within the plumes.

A preliminary list of quantitative target risk based concentration levels were developed using the COCs, which are the CVOCs most frequently (>10% in 70+ samples) detected in all the rounds of sampling, including the latest RI data (see Table 2-21E). These calculated target concentrations assume that all the chemicals are present in each of the Plumes, thus represents a conservative assumption for setting a target remediation goal. However, these levels will be revisited during the evaluation of remedial action groundwater monitoring to ensure target risk levels are met. Some of the individual chemical concentrations can be higher or lower depending on proportion of the cumulative risk each COC presents in that particular plume at that time, while meeting target risk level.

Table 2-21F presents the COCs in groundwater and their respective target remediation goals based on cumulative target risk level of 1 in a million (10^{-6}) and 1 in 10,000 (10^{-4}). The proposed concentration levels in the remediation goal table are likely to change based on the number of COCs that are carcinogens at any one sampling location, although target risk levels will remain the primary goal during ground water remediation. Any newer chemicals not identified as a COC in these tables will be added to the list if they are detected at a future time. These target remediation goals (see Table 2-21F) are calculated as follows:

Target Concentration Level = MCL X Target Risk/Risk at MCL

Or

Target risk = Target MCL* 10^{-6} (TG for PRG)/PRG

Risks from individual target concentrations are added to obtain cumulative risk as included in Table 2-21F. As stated earlier, these individual chemical concentration levels will likely change with the number of chemicals present in a plume, while target risk level (e.g. 1 X 10^{-4}) will remain fixed. A summary of the VOC soil and groundwater remediation goals is presented in Table 2-21G.

2.8 Remedial Action Objectives

Remedial action objectives (RAOs) are medium-specific goals that the remedial actions are expected to accomplish to protect human health and the environment. They guide the formulation and evaluation of remedial alternatives. RAOs have been developed to reflect the anticipated future land use for the Disposal Area of Dunn Field in accordance with EPA Policy, *Land Use in the CERCLA Remedy Selection Process (OSWER Directive No. 9355.7-04).*

The following RAOs have been developed for surface soil at the Disposal Area of Dunn Field:

- Limit use of the surface soil in the Disposal Area to activities consistent with Light Industrial use and prevent residential use through land use controls.

The following RAOs have been developed for the disposal sites in the Disposal Area and the Stockpile Area of Dunn Field:

- Prevent groundwater impacts from a release of buried containerized hazardous liquids and the leaching of contaminants from buried hazardous solids;

- Prevent unacceptable risk of direct contact with buried hazardous liquid and/or solids due to intrusive activities during future land use or site development.

The following RAOs have been developed for subsurface soil impacted with VOCs at the Disposal Area of Dunn Field:

- Prevent direct inhalation of indoor air vapors from subsurface soils in excess of industrial worker criteria.

- Reduce or eliminate further impacts to the shallow fluvial aquifer from the VOCs in the subsurface soil.

The Dunn Field RI also identified contaminants in groundwater that could pose unacceptable risk to possible receptors (CH2M HILL, July 2002). Currently there are no users of the groundwater in the fluvial aquifer beneath Dunn Field. Contaminants in the fluvial aquifer may migrate further offsite to the west or into deeper aquifers, posing a threat to potable water supplies (i.e., the underlying Memphis aquifer). Based on analyses of the contaminants present, both onsite and offsite potential receptors, and permissible exposure levels, the following RAOs have been developed for groundwater at Dunn Field:

- Prevent human exposure to contaminated groundwater (i.e., exceeding protective target levels);
- Prevent further offsite migration of VOCs in groundwater in excess of protective target levels; and
- Remediate fluvial aquifer groundwater to drinking water quality to be protective of the deeper Memphis aquifer (see Section 2.7.3 for groundwater remediation goals).

2.9 Description of Alternatives

The remedial alternatives for Dunn Field that are presented in the following text are numbered as shown below to correspond to the numbers in the Dunn Field FS report and Proposed Plan (CH2M HILL, May 2003).

Medium	FS Alternative	Description
All	DS1, S13 and GW1	No Action
Disposal Sites & Associated Subsurface Soil	DS3	Soil Containment with Institutional Controls
	DS5	Ex-situ Soil Treatment with Institutional Controls
	DS6	Excavation, Transportation and Offsite Disposal with Institutional Controls
Subsurface Soil	SB2	Presumptive Remedy (Soil Vapor Extraction [SVE]) with Institutional Controls
Groundwater	GW2	Zero-Valent Iron (ZVI) Injection, Enhanced Bioremediation and Enhanced Groundwater Extraction, and Monitored Natural Attenuation (MNA) with Institutional Controls
	GW3	ZVI Injection. Permeable Reactive Barrier (PRB), and MNA with Institutional Controls
	GW4	Air Sparging with SVE, PRB, and MNA with Institutional Controls
DS - Disposal Sites	*SB - Subsurface Soil*	*GW- Groundwater*

2.9.1 Description of Remedy Components

No Action Alternative

The 'No Action' alternative was evaluated for Dunn Field as a whole in accordance with the CERCLA statute. Based on the results of the baseline risk assessment (BRA) in the Dunn Field RI, unacceptable risks exist at portions of Dunn Field. Therefore the 'No Action' alternative is not protective and does not meet the threshold criteria for remedy selection. It is not a medium-specific alternative and it will not be evaluated against each set of alternatives for each medium (Disposal Sites, Subsurface Soil and Groundwater).

2.9.1.1 Disposal Sites and Associated Subsurface Soil

Based on information presented in the Dunn Field RI and FS reports, approximately 15 disposal sites are known to exist in the Disposal Area and two disposal sites (a CC-2 impregnite disposal trench and former burn/disposal area) are known to exist in the southwestern portion of Dunn Field (see Figure 2-9). These sites have been identified by the BCT as having a priority ranking for remedial action (Priority A and B sites - see Appendix C for the locations of these sites on Dunn Field, including the Priority C sites [no remedial action required]). The anticipated land use for these areas is industrial. While the alternatives discussed in this section may be effective at REMEDIATION contaminants contained within the disposal sites and associated subsurface soils to industrial use standards, remedial action for subsurface soils contaminated with VOCs will be required prior to the Disposal Area being acceptable for industrial use, and to be protective of the underlying groundwater of the fluvial aquifer.

EPA policy on land use allows reasonably likely future land uses to be considered in making risk management decisions, if properly documented. Through the BRAC process, the local redevelopment authority (Depot Redevelopment Corporation) produced the Memphis Depot Redevelopment Plan. This plan, in conjunction with current zoning for Dunn Field (i.e., light industrial use [I-L]), presents a compelling case that future residential use is unlikely for the Disposal Area/western portion of Dunn Field of Dunn Field. The only RAO required to address residential risk is, therefore, prevention of residential use.

Each of the alternatives described in this section would result in contaminants remaining at the site above levels that would typically allow for unlimited and unrestricted exposure. Therefore, as required by CERCLA and the NCP, a review of the selected remedial action will be necessary no less often than each 5 years after initiation of the remedial action to assure that human health and the environment are being protected.

Alternative DS3: Soil Containment with Institutional Controls

The soil containment alternative involves the placement of a protective cover or cap over contaminated soil and residual waste to act as a physical barrier against direct contact to workers and water percolation. Natural clean soil consisting of low-permeability (clay) and high-permeability (sand) soil, asphalt, concrete or other material such as flexible geomembrane liner from offsite will be placed over contaminated areas. Surface controls such as stormwater control and vegetative cover will be necessary to prevent erosion damage to a soil cover. This alternative also includes land use controls, which include institutional controls, that will restrict the use of the property, maintenance of access barriers to limit entry into contaminated areas, signage to warn visitors to the site that these areas exist, and periodic inspection for cover disturbance.

Containment will be applied to individual soil areas within the Disposal Area that require remedial action to obtain the RAOs. The time to achieve RAOs would be approximately less than 1 year. Present worth costs use 30 years as a costing period, although the remedy may require monitoring, maintenance and enforcement beyond this 30-year period.

Containment Component of Remedy

- Approximately 760 cubic yards of low permeability soil cover will be required for placement covering the 10,215 square feet of land surface over the disposal sites with two feet of cover.

Land Use Controls

- The land use controls would consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; and zoning restrictions. Intrusive activities (e.g., digging, drilling, excavation, etc.) will be restricted and residential use will be prohibited. In addition, access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented both during the remedial activities and as part of the long-term remedy.

O&M and Monitoring Activities

- Maintenance of access barriers and signage.

- Periodic evaluation of the site including visual inspection of the cover to verify that it remains intact.

Alternative DS5: Ex-situ Soil Treatment with Institutional Controls

This alternative includes excavation of each disposal site and associated contaminated subsurface soils, treatment of contaminated subsurface soils through solidification, and institutional controls that restrict use of the Disposal Area. This alternative will immobilize contaminants in associated subsurface soils and remove any potential source in the buried receptacles. The excavated containers/receptacles will be disposed of in an appropriate disposal facility. Implementation of this alternative will be fully protective for industrial use by eliminating risk of exposure to subsurface soil areas with contaminants exceeding levels acceptable for industrial workers.

Treatment will be applied to individual soil areas within the Disposal Area that require remedial action to obtain the RAOS. The time to achieve RAOs would be approximately less than 1 year. Present worth costs use 30 years as a costing period (due to ongoing land use controls), although the remedy may require monitoring, maintenance and enforcement beyond this 30-year period.

Treatment Component of the Remedy

- Approximately 3,900 cubic yards of contaminated subsurface soil will be treated with chemical process (emulsified asphalt, pozzolan/Portland cement, or vitrification/molten glass) to solidify soils. Treated soil will be placed back in the disposal site excavations after post-treatment verification analytical results indicate that treatment standards have been met. Depending upon the results of field characterization sampling, some excavated containers/waste may be considered RCRA hazardous waste and would require special handling, treatment and disposal at an offsite RCRA hazardous waste facility. Non-hazardous solid waste would be disposed of in an offsite, RCRA Subtitle 0 landfill.

Land Use Controls

- The land use controls would consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; and zoning restrictions. Intrusive activities (e.g., digging, drilling, excavation, etc.) will be restricted and residential use will be prohibited. In addition, temporary access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented during the remedial activities.

O&M and Monitoring Activities

- Periodic evaluation of the site to verify that the remedy remains intact and protective.

Alternative D56: Excavation, Transportation and Off-site Disposal with Institutional Controls

This alternative includes the excavation, transportation, and offsite disposal of contaminated buried receptacles and associated contaminated subsurface soil, and institutional controls that restricts use of the Disposal Area. Implementation of this alternative will be fully protective for industrial use by eliminating risk of exposure to areas with concentrations exceeding industrial levels.

This remedial technology will be applied to individual soil areas within the Disposal Area that require remedial action to obtain the RAOS. The time to achieve RAOs would be approximately less than 1 year. Present worth costs use 30 years as a costing period (due to ongoing land use controls), although the remedy may require monitoring, maintenance and enforcement beyond this 30-year period.

Buried receptacles and associated contaminated soil will be excavated at each disposal site (approximately 3,900 cubic yards of buried material and contaminated subsurface soil). This varies with each disposal site, but is 10-feet below land surface on average. Confirmation sampling and analyses will be required to verify that remediation goals have been met. Depending upon the results of field characterization sampling, some excavated subsurface soil and containers/waste holding chemicals may be considered RCRA hazardous waste and would require special handling, treatment and disposal at an offsite RCRA hazardous waste facility. Non-hazardous solid waste would be disposed of in an offsite, RCRA Subtitle D landfill.

Land Use Controls

- The land use controls would consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; and zoning restrictions. Residential use will be prohibited. In addition, temporary access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented during the remedial activities.

O&M and Monitoring Activities

- Periodic evaluation of the site to verify that the remedy remains protective.

2.9.1.2 Subsurface Soil

VOC-contaminated subsurface soils are located within the Disposal Area of Dunn Field. The intended land use for this area is industrial. While the alternative discussed here in may be effective at REMEDIATION VOC-contaminated soils and soil-to-indoor air to industrial use standards, remedial action for disposal sites and associated soils (see above) and groundwater (see below) contaminated with VOCs will be required for the Disposal Area to be acceptable for industrial land use.

The proposed alternative for soils contaminated with VOCs and soil-to-indoor air is the presumptive remedy, SVE.

Alternative SB2: Soil Vapor Extraction

As part of this presumptive remedy, air flow will be induced through contaminated soil by applying a vacuum, using soil vapor extraction wells, to create a pressure gradient in the vapor phase within the unsaturated (vadose) zone of the targeted soil. As the soil vapor migrates though the soil pores toward the extraction vents, VOCs will be volatilized, transported out of subsurface soil, and collected aboveground. Two preliminary SVE remediation systems for Dunn Field have been conceptually designed: Alternative SB2a refers to a vertical SVE system and Alternative SB2b refers to a horizontal and vertical SVE system. Both designs are based on contaminant mass calculations from soil analytical data and the December 2001/January 2002 Dunn Field SVE pilot test data (Appendix C of the Dunn Field FS). This alternative also includes land use controls, which include institutional controls, that will restrict the use of the property.

The remedy will require up 4 years to achieve rernediation goals. This estimated cleanup time is based on the results of the SVE pilot test (see Appendix C of the Dunn Field FS) and the average mass removal rate for the individual CVOCs that was obtained from the pilot test for the loess and fluvial deposits.

Treatment Component of the Remedy

- The vertical and/or horizontal SVE system will include soil vapor extraction wells installed in the loess to a depth of approximately 25 ft bls and in the fluvial deposits to a depth of approximately 70 ft bls. A soil vacuum and vapor monitoring system will be installed within the network of SVE wells to monitor full-scale soil vapor extraction. The SVE treatment areas will be covered by a 360,000-ft^2 temporary cap of 20-mm liner covered with gravel. The site will be graded to direct stormwater runoff to the existing stormwater system on the western half of Dunn Field. Figure 2-10 includes a conceptual layout of the SVE system on Dunn Field.

- An aboveground vapor treatment system will be set up with electrical controls, vacuum pumps, and off-gas collection and treatment units. Off-gasses (extracted volatile organic compounds) and hydrochloric acid (HCL) (produced through the oxidation of chlorinated hydrocarbons) emissions released to the atmosphere will be treated (e.g., by a chlorinated catalytic oxidizer and a scrubber, with sodium hydroxide [NaOH]).

Land Use Controls

- The land use controls would consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; and zoning restrictions. Residential use will be prohibited. In addition, temporary access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented during the remedial activities.

O&M and Monitoring Activities

- Off-gas monitoring, SVE performance air monitoring, and system O&M will be performed regularly throughout the duration of the remedial action.

- Wastewater effluent from the remediation system will be collected and analyzed monthly in accordance with the POTW pre-treatment requirements in order to monitor industrial discharge levels and system performance.

- Annual summaries of monitoring data will be produced to document the site conditions and progress of the remedy. After remediation goals are met, the system will be decommissioned and all wells will be 'closed' or 'plugged and abandoned' in accordance with TDEC and Shelby County regulations. Site restoration will be required to restore the site to conditions suitable for the land use.

- Periodic evaluation of the site to verify that the remedy remains protective.

2.9.1.3 Groundwater

The Dunn Field RI identified contaminants in the groundwater of the fluvial aquifer, both on- and offsite that could pose unacceptable risk to possible receptors (CH2M HILL, July 2002). In addition, contaminants in the fluvial aquifer may migrate further offsite or into deeper aquifers, posing a threat to the potable water supplies of the Memphis aquifer. The RAOs developed for the onsite/offsite groundwater states the site shall be cleaned up until the sampling program indicates with reasonable confidence that the concentrations of the contaminants at the entire site are less than the protective target levels. Figure 2-11 includes a composite of the VOCs plumes in the fluvial aquifer on and west of Dunn Field.

For each of the alternatives for groundwater, contaminated groundwater will remain at the site until remediation goals are met. Consequently, as required by CERCLA and the NCP, a review of the selected remedial action will be necessary no less often than each 5 years after initiation of the remedial action to assure that human health and the environment are being protected.

Alternative GW2: Zero-Valent Iron (ZVI) Injection for Source Areas, Groundwater Extraction Enhancement, and Enhanced Bioremediation with Monitored Natural Attenuation [MNA] and Institutional Controls

The principal active groundwater treatment methods within this alternative include onsite ZVI injection, enhancement of the existing groundwater extraction and discharge system, and enhancement of bioremediation processes within the fluvial aquifer downgradient of Dunn Field (see Figure 2-12). The ZVI injection will be used to treat source areas in the aquifer underlying Dunn Field. The existing groundwater extraction system will be used to control further migration of contaminant plumes offsite, but will be supplemented with 10 additional extraction wells. Since the extraction system will be introducing additional contaminant levels into the current system, the water may exceed pre-treatment permit limits currently allowed by the City of Memphis. For this reason, an in-line pre-treatment system may need to be introduced prior to release into the municipal lines. This is considered a contingency action.

Enhanced bioremediation will be used to treat portions of the plume away from the perimeter of the other methods in this alternative. Monitored natural attenuation will be implemented as a polishing step to the active groundwater treatment methods. Groundwater monitoring will occur throughout this alternative and will take place to document changes in plume concentrations, and to detect any potential plume migration into deeper aquifers. The sampling program will continue until it indicates with reasonable confidence that the concentrations of the contaminants at the entire site are less than the remediation goals.

The cleanup time is estimated to be approximately 15 years after remedial action implementation, with the operation of the enhanced groundwater extraction system for 10 of the 15 years after expansion. This cleanup time is based on the active groundwater source area remediation within Dunn Field (injection of ZVI in the source areas for a 90% mass removal rate for the VOCs) and along the west side of Dunn Field (groundwater extraction), and a downgradient enhancement of bioremediation with MNA as a polishing step, an assumption was made that the alternatives will greatly increase the contaminant reduction/ degradation rate within the fluvial aquifer. This also takes into account that subsurface soil remediation is occurring concurrently and the mass transfer from soil to groundwater has been abated on Dunn Field (as described above for the remedial alternatives).

This alternative will require land use controls, which include institutional controls that will prohibit installation of production and consumptive-use wells on portions of Dunn Field, and drilling into aquifers below the fluvial aquifer. An additional institutional control includes existing groundwater well restrictions established by the MSCHD, Water Quality Branch.

The principal uncertainties of this alternative include: (1) the ability to deliver the ZVI evenly into the source areas through injection; (2) the capture zone of the groundwater extraction wells; (3) the degradation rate of the VOCs through in situ chemical reduction, enhanced bioremediation and natural attenuation; and (4) the potential movement of the plume and the length of time required for cleanup. More active remedial measures may be needed to control the plume during the life of the action. The scope and cost of more active measures cannot be predicted.

Treatment Component of the Remedy

- ZVI will be injected into the fluvial aquifer underlying Dunn Field suspected of acting as a source for continued downgradient groundwater contamination. In situ chemical reduction is the primary treatment (degradation) process. The degradation process is an abiotic reductive dehalogenation process occurring on the surface of the granular iron, with the iron acting as an electron source. During the dehalogenation process, the halides on the compound (i.e., chloride) are replaced by hydrogen resulting in the transformation of halogenated VOCs to ethene, ethane, methane and halide ions (Cl-).

- An enhanced bioremediation treatment zone will be established via nutrient (e.g., sodium lactate) injection in a downgradient position in the fluvial aquifer across the plume to capture and reduce contaminants at those portions not effected by the other treatment methods in this alternative. Nutrient re-injection will occur at temporal intervals determined by monitoring results.

Land Use Controls

- The land use controls would consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; and groundwater well restrictions that collectively restrict production/consumptive use of groundwater and prohibit drilling groundwater wells within the contaminated groundwater associated with Dunn Field. In addition, temporary access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented during the remedial activities.

O&M and Monitoring Activities

- Monitoring of groundwater wells for establishing the effectiveness of the groundwater remedy and natural attenuation processes will be conducted in a manner to be specified in the Remedial Design report. Groundwater monitoring will continue until concentrations of the COCS meet remediation goats throughout the plume(s). The sampling schedule may therefore be subject to change due to observed trends and variability.

  > Wells inside the plumes to measure the effectiveness of the active treatment measures and MNA.

  > Boundary wells to detect potential migration of the plume further offsite to the west-northwest, upgradient or downgradient.

  > Sentinel wells to detect potential migration of the plume into the deeper intermediate aquifer or the Memphis aquifer.

- Monitoring of groundwater extraction system effluent prior to discharge to the City of Memphis sanitary sewer system.

- Extraction, injection and monitoring well maintenance (cleaning, wellhead repairs, plugging, and abandonment) as needed. All monitoring and extraction wells will be plugged and abandoned at the completion of the remedy.

- The progress of the remedy will be evaluated periodically through a groundwater monitoring program established in the remedial design, and will be reported on annual basis. The annual report will be prepared documenting the effectiveness of the groundwater remedies until the remediation goals are met. The annual reports will be submitted for regulatory concurrence. This annual effectiveness report will indicate whether there are consumptive use wells present within the groundwater plume(s) associated with Dunn Field.

- Periodic evaluation of the site to verify that the remedy remains protective.

Alternative GW3: ZVI Injection for Source Areas, Installation of a Permeable Reactive Barrier (PRB) with MNA and Institutional Controls

The principal, active groundwater treatment methods within this alternative include onsite ZVI injection and installation of an offsite PRB containing ZVI. The ZVI injection will be used to treat source areas in the fluvial aquifer underlying Dunn Field and the area west of Dunn Field. The offsite granular iron PRB will be placed across the flow path of the VOC plume, as the plume flows through the PRB under natural gradients, the VOCs are destroyed to non-toxic end products (see Figure 2-13). Untreated parts of the plume will degrade under natural attenuation processes (as described in Alternative GW2). This alternative includes the decommissioning of the existing groundwater extraction system upon implementation of the remedy.

The cleanup time is estimated to be approximately 15 years after remedial action implementation. This cleanup time is based on the active groundwater source area remediation within Dunn Field (injection of ZVI in the source areas for a 90% degradation rate for the VOCs), and a downgradient iron PRB (with a 95% VOC degradation rate) with MNA as a polishing step, an assumption was made that the alternatives will greatly increase the contaminant reduction/degradation rate within the fluvial aquifer. This also takes into account that subsurface soil remediation is occurring concurrently and the mass transfer from soil to groundwater has been abated on Dunn Field (as described above for the remedial alternatives).

This alternative will require land use controls, which includes institutional controls that will prohibit installation of production and consumptive-use wells on portions of Dunn Field, and drilling into aquifers below the fluvial aquifer. These institutional controls include existing groundwater well restrictions established by the MSCHD, Water Quality Branch.

The principal uncertainties of this alternative include: (1) the ability to deliver the ZVI evenly into the source areas through injection; (2) the vertical installation of the offsite PRB to depths of 100' below land surface; (3) the degradation rate of the VOCS through in situ chemical reduction and natural attenuation; and (4) the potential movement of the plume and the length of time required for cleanup. More active remedial measures may be needed to control the plume during the life of the action. The scope and cost of more active measures cannot be predicted.

Treatment Components of the Remedy

- ZVI will be injected into the fluvial aquifer underlying Dunn Field suspected of acting as a source for continued downgradient groundwater contamination. In situ chemical reduction is the primary treatment (degradation) process. The degradation process is an abiotic reductive dehalogenation process occurring on the surface of the granular iron, with the iron acting as an electron source. During the dehalogenation process, the halides on the compound (i.e., chloride) are replaced by hydrogen resulting in the transformation of halogenated VOCs to ethene, ethane, methane and halide ions (Cl-).

- A granular iron PRB will be installed offsite and downgradient of Dunn Field across the flow path of the VOC plume. As the plume flows through the PRB under natural gradients, the VOCs are destroyed to non-toxic end products via in situ chemical reduction as described above.

Land Use Controls

- The land use controls would consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; and groundwater well restrictions that collectively restrict production/consumptive use of groundwater and prohibit drilling groundwater wells within the contaminated groundwater associated with Dunn Field. In addition, temporary access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented during the remedial activities.

O&M and Monitoring Activities

- Monitoring of groundwater wells for establishing the effectiveness of the groundwater remedy and natural attenuation processes will be conducted in a manner to be specified in the Remedial Design report. Groundwater monitoring will continue until concentrations of the COCs meet remediation goals throughout the plume(s). The sampling schedule may therefore be subject to change due to observed trends and variability.

    > Wells inside the plumes to measure the effectiveness of the active treatment measures and MNA.

> Boundary wells to detect potential migration of the plume further offsite to the west-northwest, upgradient or downgradient.

> Sentinel wells to detect potential migration of the plume into the deeper intermediate aquifer or the Memphis aquifer.

- Injection and monitoring well maintenance (cleaning, wellhead repairs, plugging, and abandonment) as needed. All monitoring and extraction wells will be plugged and abandoned at the completion of the remedy.

- The existing groundwater extraction system will be "moth-balled" during the life of the remedies in this alternative and will be dismantled at the end of the remedy. The system will not be dismantled immediately because of potential use in the future to assist with the aquifer remediation.

- The progress of the remedy will be evaluated periodically through a groundwater monitoring program established in the remedial design, and will be reported on annual basis. The annual report will be prepared documenting the effectiveness of the groundwater remedies until the remediation goals are met. The annual reports will be submitted for regulatory concurrence. This annual effectiveness report will indicate whether there are consumptive use wells present within the groundwater plume(s) associated with Dunn Field.

- Periodic evaluation of the site to verify that the remedy remains protective.

Alternative GW4: Air Sparging with SVE for Source Areas Installation of a Permeable Reactive Barrier (PRB) with MNA and Institutional Controls

This alternative treats groundwater through volatilization in the most contaminated parts of the plume both on- and offsite by injecting air into the fluvial aquifer. Volatilized contaminants will be recovered by the SVE system, installed as part of the presumptive remedy for subsurface soils. Additional extraction wells and lines for the SVE will be installed in the offsite portions of the plume. The remedy is expected to remove contaminants from the most contaminated parts of the plume. In addition to the air sparging activities, an offsite granular PRB will be constructed downgradient of Dunn Field, across the flow path of the contaminant plumes (same as Alternative GW3) (see Figure 2-14). Untreated parts of the plume will degrade under natural attenuation processes. Therefore, this alternative includes institutional controls and groundwater monitoring similar to Alternative GW3.

The cleanup time is estimated to be approximately 15 years after remedial action implementation, with the operation of the air sparging system for 5 years. This cleanup time is based on the active groundwater source area remediation via sparging within Dunn Field (90% to 95% mass removal rates for the VOCs), and a downgradient iron PRB (with a 95% VOC degradation rate) with MNA as a polishing step. This also takes into account that subsurface soil remediation is occurring concurrently and the mass transfer from soil to groundwater has been abated on Dunn Field (as described above for the remedial alternatives).

This alternative will require land use controls, which includes institutional controls that will prohibit installation of production and consumptive-use wells on portions of Dunn Field, and drilling into aquifers below the fluvial aquifer. These institutional controls include existing groundwater well restrictions established by the MSCH-D, Water Quality Branch.

The principal uncertainties of this alternative include: (1) the effective zone of influence of the air sparging array; (2) the vertical installation of the offsite PRB to depths of 100' below land surface; (3) the volatilization rate of the VOCs through sparging, and the in situ chemical reduction and natural attenuation rate of the VOCs; and (4) the potential movement of the plume and the length of time required for cleanup. More active remedial measures may be needed to control the plume during the life of the action. The scope and cost of more active measures cannot be predicted.

Treatment Components of the Remedy

- Air sparging is an in situ technology in which air is injected through a contaminated aquifer. Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes contaminants by volatilization. This injected air helps to flush (bubble) the contaminants up into the unsaturated zone where an SVE system is implemented in conjunction with air sparging to remove the generated vapor phase contamination. This technology is designed to operate at high flow rates to maintain increased contact between ground water and soil and strip more ground water by sparging. Air sparging of the fluvial aquifer will be conducted via a network of hundreds of sparge wells. Treatment or sparging zones will be established in the most contaminated parts of the plume on- and offsite of Dunn Field. A pilot test will be required to determine air injection rates, well spacing, and zone of influence in the fluvial aquifer. SVE will be used to capture the VOCS volatized from the groundwater (see Alternative SB2 above for SVE details).

- A granular iron PRB will be installed offsite and downgradient of Dunn Field across the flow path of the VOC plume. As the plume flows through the PRB under natural gradients, the VOCs are destroyed to non-toxic end products via in situ chemical reduction. The degradation process is an abiotic reductive dehalogenation process occurring on the surface of the granular iron, with the iron acting as an electron source. During the dehalogenation process, the halides on the compound (i.e., chloride) are replaced by hydrogen resulting in the transformation of halogenated VOCs to ethene, ethane, methane and halide ions (Cl-).

Land Use Controls

- The land use controls would consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; and groundwater well restrictions that collectively restrict production/consumptive use of groundwater and prohibit drilling groundwater wells within the contaminated groundwater associated with Dunn Field. In addition, temporary access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented during the remedial activities.

O&M and Monitoring Activities

- Monitoring of groundwater wells for establishing the effectiveness of the groundwater remedy and natural attenuation processes will be conducted in a manner to be specified in the Remedial Design report. Groundwater monitoring will continue until concentrations of the COCs meet remediation goals throughout the plume(s). The sampling schedule may therefore be subject to change due to observed trends and variability.

    - Wells inside the plumes to measure the effectiveness of the active treatment measures and MNA.

  - > Boundary wells to detect potential migration of the plume further offsite to the west-northwest, upgradient or downgradient.

  - > Sentinel wells to detect potential migration of the plume into the deeper intermediate aquifer or the Memphis aquifer.

- Injection, extraction (SVE) and monitoring well maintenance (cleaning, wellhead repairs, plugging, and abandonment) as needed. All monitoring and extraction wells will be plugged and abandoned at the completion of the remedy.

- The existing groundwater extraction system will be "moth-balled" during the life of the remedies in this alternative and will be dismantled at the end of the remedy. The system will not be dismantled immediately because of potential use in the future to assist with the aquifer remediation.

- The progress of the remedy will be evaluated periodically through a groundwater monitoring program established in the remedial design, and will be reported on annual basis. The annual report will be prepared documenting the effectiveness of the groundwater remedies until the remediation goals are met. The annual reports will be submitted for regulatory concurrence. This annual effectiveness report will indicate whether there are consumptive use wells present within the groundwater plume(s) associated with Dunn Field.

- Periodic evaluation of the site to verify that the remedy remains protective.

2.9.2 Common Elements and Distinguishing Features

Consistent with CERCLA, all of the alternatives utilize active components to the maximum extent practicable and institutional controls to supplement the active measures or engineering controls. Many of the alternatives have common components.

Land use controls, including institutional controls, are a common element to all of the active alternatives for all media (soil and groundwater). Land use controls in general include the following: deed and/or lease restrictions; Notice of Land Use Restrictions; zoning restrictions; and groundwater well restrictions. In addition, temporary access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented during the remedial activities. Alternatives DS3 and DS5 would require long-term access barriers and signage. For all of alternatives for disposal sites and subsurface soil areas, residential use is prohibited for the Disposal Area/western portion of Dunn Field. For the groundwater alternatives, institutional controls will prohibit installation of production and consumptive-use wells within the contaminated groundwater associated with Dunn Field, and drilling into aquifers below the fluvial aquifer. These institutional controls include existing groundwater well restrictions established by the MSCHD, Water Quality Branch. Monitoring to ensure the effectiveness of the remedy, including institutional controls, is part of each alternative. In addition, MNA is part of each groundwater alternative.

Each alternative for the disposal sites includes a pre-design investigation for selected sites. This field effort is designed to:

- define the location and dimensions of each disposal site as compared to existing information on each site,

- evaluate the chemical and physical characteristics of materials present within the former disposal sites along with the surrounding soil media, and

- develop estimates of the physical condition and quantity of waste to be generated from the disposal sites.

Although the Dunn Field RI and FS evaluated potential residential reuse, alternatives that would clean up to a level that would allow this use were not carried forward because it is not part of the planned reuse of Dunn Field. All active soil and groundwater alternatives are expected to attain the RAOs.

2.9.3 Expected Outcomes of Each Alternative

All soil (surface soil, subsurface soil and disposal sites) alternatives would enable the future intended land use for Dunn Field. All groundwater alternatives would reduce the VOCS to concentrations that are protective to potential future users and potable water supplies of the Memphis aquifer.

2.10 Summary of Comparative Analysis of Alternatives

2.10.1 Evaluation Criteria

The various remediation alternatives were evaluated individually against nine evaluation criteria in order to select a preferred remedy for Dunn Field. The nine criteria, divided into threshold, balancing, and modifying criteria, are defined below.

Threshold Criteria

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

1. Overall Protection of Human Health and the Environment
Addresses whether a remedy provides adequate protection of human health and the environment, and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

2. Compliance with ARARs
Addresses whether or not a remedy is expected to meet any identified 'applicable' or 'relevant and appropriate' federal or more stringent state environmental law or regulations (i.e., ARARs) under CERCLA Section 121(d). Alternatively, addresses whether a waiver of an ARAR can be invoked under CERCLA Section 121 (d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable (40 CFR Part 300.5). Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate (40 CFR Part 300.5).

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for invoking a waiver.

Balancing Criteria

Balancing criteria are the five primary criteria on which analyses of remedial actions are based. These criteria provide decision-makers with a means to determine which alternative best achieves the RAOs.

3. Long-Term Effectiveness and Permanence
Refers to the expected magnitude of residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up goals have been met.

4. Reduction of Toxicity, Mobility, or Volume through Treatment
Refers to the anticipated performance of the treatment technologies that may be employed in a remedy.

5. Short-Term Effectiveness
Addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until clean-up goals are achieved.

6. Implementability
Refers to the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

7. Cost
Includes estimated capital and O&M costs, also expressed as net present worth costs. Per EPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, present worth costs do not exceed 30 years. Costs are based on conceptual design and professional experience and are estimated to an accuracy of +50% to -30%, per the EPA guidance.

Modifying Criteria

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

8. State Acceptance
Indicates whether, based on its review of the FS and Proposed Plan, the State concurs with, opposes, or has no comment on the preferred alternative.

9. Community Acceptance
Summarizes the general response to the alternative described in the FS and Proposed Plan on public comments received. Community acceptance is to be assessed in this ROD following a review of the public comments received on the FS and Proposed Plan.

Each of the alternatives is evaluated by the nine criteria in the following subsections.

2.10.2 Disposal Sites and Associated Subsurface Soil

The alternatives are compared to each other using the nine EPA criteria. A description of this comparison is included in the following paragraphs. This section concludes with a summary of the comparative analysis.

Overall Protection of Human Health and the Environment

All alternatives are considered protective of human health and the environment.

Compliance with ARARs

All alternatives (DS3, DS5 and D56) are expected to meet ARARs at the completion of implementation. Alternative 053 (Soil Containment) will comply with ARARs, in particular the relevant portions of RCRA Subtitle C landfill closure and post-closure requirements at 40 CFR 264 and TDEC Rule 1200-1-11.06 (7)(g) and (j). Alternative DS5 (Ex-situ Soil Treatment) also complies with ARARs, in particular fugitive dust and stormwater controls, and RCRA hazardous waste and land disposal restrictions. Finally, Alternative DS6 (Excavation, Transportation and Offsite Disposal) complies with ARARs, in particular fugitive dust, vapor, and stormwater controls and RCRA hazardous waste and land disposal restrictions.

Long-term Effectiveness and Permanence

Alternatives DS5 and DS6 are expected to be effective and permanent at the completion of implementation through treatment or removal for offsite disposal. Although Alternative DS3 (Soil Containment) is effective through the covering of the disposal sites with a low permeability cap, it does not provide long-term effectiveness and permanence against the potential future release of containerized liquids that may be currently buried to the underlying groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative DS5 (Ex-situ Soil Treatment) is the only action that satisfies the statutory preference for treatment as a principal element. Ex-situ solidification of subsurface soils/waste is used to reduce the mobility of contaminants to residual levels acceptable to industrial land use. Although Alternatives DS3 (Soil Containment) and DS6 (Excavation, Transportation and Offsite Disposal) reduces the mobility of chemicals, the reduction is not achieved through treatment. Treatment may be required at the disposal facility prior to the final disposition of the waste materials.

Short-term Effectiveness

Alternative DS3 (Soil Containment) has the greatest short-term effectiveness because it presents the least risk to workers, community, and the environment, and is the quickest way to short-term protection (6 months). This alternative does require some engineering controls during placement of the cap material.

Alternatives DS5 (Ex-situ Soil Treatment) and 6 (Excavation, Transportation and Off-site Disposal) require significant engineering controls during remedial activities to minimize impacts from fugitive dust and vapor emissions, and stormwater runoff. These alternatives pose greater risk to workers and the community through the excavation of buried waste materials than Alternative DS3 (Soil Containment), but these risks can be managed through application of widely accepted safety and engineering practices. The alternatives should take less than 1 year to implement. Alternatives DS5 (to a lesser degree) and DS6 may also cause traffic impacts due to offsite hauling of excavated material and the hauling of backfill material onsite.

Implementability

All alternatives are considered technically feasible and can be implemented with available labor, materials, and equipment. Alternative DS3 (Soil Containment) is considered the simplest to implement, however, long-term monitoring and maintenance will be required for the capped areas. Alternative DS5 (Ex-situ Soil Treatment) is most difficult to implement because of the treatment processes and time required. Care will need to be taken to avoid damage/release from excavated buried containers during implementation of Alternatives DS5 (Ex-situ Soil Treatment) and DS6 (Excavation, Transportation and Off-site Disposal).

Cost

Present worth costs are summarized in the following list.

Alternative	Capital Cost	O&M Cost	Present Worth
DS1-No Action	$0	$0	$0
DS3-Soil Containment	$304,000	$312,000	$616,000
DS5-Ex-situ Treatment	$2,069,000	$60,000	$2,129,000
DS6-Excavation, Transport, and Offsite Disposal	$1,715,000	$57,000	$1,772,000

There are no costs associated with Alternative DS1 (No Action). With present worth cost of $616,000, Alternative DS3 (Soil Containment), is the least expensive of the active alternatives. Alternative DS6 (Excavation, Transportation, and Offsite Disposal) with a present worth cost of $1,772,000 is more expensive than Alternative DS3, but less expensive that Alternative DS5 (Ex-situ Treatment) at $2,129,000.

State Acceptance

State acceptance is likely for all alternatives except no action and soil containment (Alternative DS3), since waste materials are left in-place and there is a potential long-term threat to groundwater quality and future workers.

Community Acceptance

No substantive comments were received during the public comment period for the proposed plan for the disposal sites and associated subsurface soil. However, the community is not likely to accept the soil containment with institutional controls alternative because the contaminants and contents of the disposal sites are left in place and untreated. The community is likely to accept the ex-situ treatment and excavation, transportation, and offsite disposal alternatives. Ongoing community involvement activities will be an important element of remedy implementation.

Summary

The comparative analysis of alternatives is summarized as follows.

Evaluation Criteria	DS1 No Action	DS3 Soil Containment with ICs	DS5 Ex-Situ Treatment with ICs	DS6 Excavation, Transport, and Off-site Disposal with ICs
Protective of Human Hearth and Environ.	No	Low	High	High
Complies with ARARs	N/A	Yes	Yes	Yes
Effective and Permanent	N/A	Low	Medium	High
Reduces Toxicity, Mobility or Volume through Treatment	N/A	No	Yes	No
Short-term Effectiveness	N/A	High	Medium	Medium
Implementable	N/A	Yes	Yes	Yes
Cost				
Capital Cost	$0	$304,000	$2,069,000	$1,715,000
Present Worth O&M	$0	$312,000	$60,000	$57,000
Total Present Worth Cost	$0	$616,000	$2,129,000	$1,772,000
State Acceptance	Unlikely	Unlikely	Likely	Likely
Community Acceptance	Unlikely	Unlikely	Likely	Likely

2.10.3 Subsurface Soil Impacted by VOCs

A detailed analyses of the SVE alternative to the EPA criteria is presented in Presumptive Remedies: Site Characterization and Technology Selection For CERCLA Sites with Volatile Organic Compounds in Soils - Appendix B Criteria Evaluation for Technologies Used to Treat VOC-Contaminated Soil (EPA, 1993) (included in Appendix B of Dunn Field FS). The following site-specific analysis of the costs, and state and community acceptance is presented below.

Cost

Present worth costs are summarized in the following list:

Alternative	Capital Cost	Present Worth O&M Cost	Total Present Worth
1 - No Action	$0	$0	$0
2 - SVE System	$3,183.000	$1,228.000	$4,411,000

State Acceptance

State acceptance is unlikely for no action because it will not reduce the risks to groundwater and industrial workers. State acceptance of the presumptive remedy, SVE, is likely.

Community Acceptance

Community acceptance is unlikely for no action because it will leave contaminated soils in place without treatment, and because it will not reduce the risks to groundwater and human health. Community acceptance of SVE is likely because the life of the remedy is relatively short (5 years), involves treatment and has been deemed as a presumptive remedy by EPA.

Summary

All comparative analyses necessary to support SVE were done by EPA through the presumptive remedy guidance process.

2.10.4 Groundwater

The alternatives are compared to each other using the nine EPA criteria. A description of this comparison is included in the following paragraphs. This section concludes with a summary of the comparative analysis.

Overall Protection of Human Health and the Environment

All alternatives are considered protective of human health and the environment. Alternatives GW2 (ZVI/Enhanced Groundwater Extraction/Enhanced Bioremediation/MNA/ICs), GW3 (ZVI/PRB/MNA/ICs) and GW4 (Air Sparging and SVE/PRB/MNA/ICs) provide protection through active remediation of the groundwater to remediation goals in the fluvial aquifer, both on and off Dunn Field, and provide protection for the deeper, underlying Memphis aquifer. All three alternatives also include institutional controls to prevent the use of the groundwater in the fluvial aquifer during remediation.

Compliance with ARARs

All alternatives are expected to meet ARARs at the completion of implementation. The groundwater underneath Dunn Field would be considered "General Use Ground Water" based upon the yield and Total Dissolved Solids levels. The Criteria specified in the TDEC Rule 1200-4-3-.08(2) for General Use Ground Water are considered an ARAR. The Criteria consist of SDWA MCLs, MCLGs, SMCLs and Action-levels for organic and inorganic constituents. Accordingly, the MCLs and non-zero MCLGs are considered relevant and appropriate remediation goals for the Dunn Field groundwater including the offsite plume.

Each of the three active alternatives employ active remediation of the source areas on and off of Dunn Field, and provide treatment of the offsite plume through installation of a PRB (using ZVI) (Alternatives GW3 and GW4) or through enhanced bioremediation (Alternative GW2). MNA is used in all three active alternatives as a 'polishing' step for the diffuse contaminants beyond the areas of active in situ remediation. Based on known groundwater flow velocities and attenuation data, all three active alternatives are expected to be in compliance with ARARs within 15 years.

Long-term Effectiveness and Permanence

All alternatives are expected to be effective and permanent at the completion of implementation. The enhanced bioremediation portion of Alternative 2 may require additional injection of chemicals/nutrients, as they are consumed in the biodegradation process. The ZVI injected into the source areas or as part of the PRB has been shown to last for up to two decades without replacement.

Reduction of Toxicity, Mobility, or Volume (TMV) through Treatment

All alternatives are expected to reduce the toxicity, mobility and volume for the CVOCs through treatment at the completion of implementation. Alternative GW2 relies on in-situ chemical reduction (using ZVI) and enhanced bioremediation for treatment. The groundwater extraction component of the remedy does not use treatment, but does reduce volume of contaminants. Alternative GW3 relies primarily on in-situ chemical reduction (using ZVI injection for the source area and a PRB for the downgradient, offsite plumes) for treatment. Alternative GW4 uses volatilization (through air sparging) and in-situ chemical reduction (using a PRB for the downgradient, offsite plumes) for treatment. Vapors generated from air sparge system and collected through the SVE system are treated aboveground prior to release to the atmosphere.

Short-term Effectiveness

Alternatives GW2 through GW4 require some engineering controls during installation of treatment to protect the environment and safety controls to protect workers. Air sparging will require engineering controls (including an associated SVE system) for fugitive VOC emissions during treatment. Alternative GW1 has no short-term impacts because nothing is implemented.

Implementability

All alternatives are considered technically feasible and can be implemented with available labor, materials, and equipment. All of the active remedies require offsite access for remedial actions, which can pose implementability concerns. The depth to groundwater creates delivery obstacles for installation of a granular iron PRB (GW3 and GW4) and for ZVI source area injection (GW2 and GW3). Depth to water and limited saturated thickness presents technical implementability issues concerning radius of influence for air sparging (GW4), enhancing bioremediation through injection of chemicals/nutrients (GW2) and groundwater extraction (GW2). With respect to the use of ZVI source area treatment (GW2 and GW3) and ZVI in a PRB (GW3 and GW4), the degree to which complete dechlorination can be achieved is important for understanding the viability and implementability of the alternatives which rely on in-situ chemical reduction. In-situ delivery of the ZVI to the subsurface and the resultant contact time between the CVOC and the ZVI are important implementability issues for all the active groundwater alternatives. Alternatives GW2 through GW4 will all require pilot testing to determine an effective design for implementation.

Cost

Present worth costs are summarized in the following list.

Alternative	Capital Cost	Present Worth O&M Cost	Total Present Worth
GW1 - No Action	$0	$0	$0
GW2 - ZVI/Enhanced GE/Enhanced Bio/MNA/ICs	$10,506,000	$4,322,000	$14,828,000
GW3 - ZVI/PRB/MNA/ICs	$7,827,000	$981,000	$8,808,000
GW4 - Air Sparging/PRB/MNA/ICs	$7,195,000	$1,949,000	$9,144,000

ICs Institutional controls
ZVI Zero-Valent Iron (as a source area treatment)
GE Groundwater extraction
PRB Permeable reactive barrier (using ZVI [granular iron])
MNA Monitored Natural Attenuation

There are no costs associated with Alternative GW1 (No Action). Alternatives GW3 and GW4 are the least expensive of the treatment alternatives at approximately $9 million each. Alternative GW2 is the most expensive at $14.8 million.

State Acceptance

State acceptance is likely for all active alternatives.

Community Acceptance

Comments received during the public comment period of the Dunn Field Proposed Plan expressed concern about the air sparging alternative spreading contamination further in the environment. Also, comments were received pertaining to the costs of the groundwater alternatives, and the timeframe associated with the costs and cleanup. However, community acceptance of the active remedial alternatives, such as the alternatives presented herein, is likely. Ongoing community involvement activities will be an important element of remedy implementation.

Summary

The comparative analysis of alternatives is summarized as follows.

Evaluation Criteria	**GW1 No Action**	**GW12 ZVI/Enhanced Groundwater Extraction / Enhanced Bioremediation / MNA / ICs**	**GW3 ZVI / PRB / MNA/ ICs**	**GW4 Air Sparging/ PRB/ MNA / ICs**
Protective of Human Hearth and Environ.	No	Medium	High	High
Complies with ARARs	N/A	Yes	Yes	Yes
Effective and Permanent	N/A	Medium	High	High
Reduces Toxicity, Mobility or Volume through Treatment	N/A	Yes	Yes	Yes
Short-term Effectiveness	N/A	Medium	High	Medium
Implementable	N/A	Yes	Yes	Yes
Cost				
Capital Cost	$0	$10,506,000	$7,827,000	$7,195,000
Present Worth O&M	$0	$4,322,000	$981,000	$1,949,000
Total Present Worth Cost	$0	$14,828,000	$8,807,000	$9,144,000
State Acceptance	Unlikely	Likely	Likely	Likely
Community Acceptance	Unlikely	Likely	Likely	Likely

2.11 Principal Threat Wastes

The NCP establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practicable (NCP § 300.430(a)(1)(iii)(A)). In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Conversely, non-principal threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of exposure.

Subsurface soils (greater that 1000 pounds of VOCS present in the subsurface soils), including the disposal sites (approximately 3,900 cubic yards of contaminated media), in the Disposal Area are considered to be principal threat wastes as defined by EPA guidance (see the definition above). The principal threat wastes have significantly degraded groundwater quality in the shallow fluvial aquifer along the western portion of Dunn Field. Based on the highest observed concentration of the detected solvents TCE and 1,1,2,2-PCA in groundwater, free-phase solvents may be present in Dunn Field groundwater and would be considered principal threat wastes. However, free-phase solvents were not been detected during the RI and subsequent operations and maintenance (O&M) groundwater sampling events through 2002.

The subsurface soils and disposal sites that are considered principal threat wastes will be addressed by the selected remedy through treatment (SVE) and through excavation and offsite disposal. These components and the statutory determinations of the selected remedy are discussed below.

2.12 Selected Remedy

Based on a detailed analysis of all the feasible clean-up alternatives using the criteria described in the previous sections, the following clean-up plan to address surface soil in the Disposal Area, disposal sites and associated subsurface soil, subsurface soil impacted by VOCs, and groundwater contamination associated with the Dunn Field (OU-1) portion of the Depot is selected.

The selected remedy includes the following components:

1. Excavation, transportation, and offsite disposal of the disposal site contents and associated contaminated soil (see Figure 2-9);

2. SVE of the VOC contaminated subsurface soil (see Figure 2-10);

3. ZVI source area injection, installation of an offsite PRB and MNA for contaminated groundwater associated with Dunn Field (see Figure 2-13); and

4. Land use controls consisting of deed and/or lease restriction, Notice of Land Use restrictions, City of Memphis/Shelby County zoning restrictions and MSCHD groundwater well restrictions (see Figures 2-15 and 2-16).

It is EPA's expectation that institutional controls (such as water use and deed restrictions) will be used to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances [40 CFR 300.430(a)(1)(iii)(D)]. Per TDEC Rule 1200-1-13-.08(10), institutional controls are required whenever a remedial action does not fully address concentrations of hazardous substances, which pose or may pose an unreasonable threat to human health or the environment.

2.12.1 Summary of the Rationale for the Selected Remedy

Disposal Sites and Associated Subsurface Soil

The DRC board of directors, the City of Memphis, and Shelby County approved the *Memphis Depot Redevelopment Plan* in 1997. The intended land use is light industrial for the Disposal Area and the western portion of Dunn Field. The selected remedy was chosen on the basis of anticipated industrial land use for this area.

The risk assessment in the Dunn Field RI determined that the majority of the Northeast Open Area and the eastern half of the Stockpile Area of the Dunn Field were available for unrestricted land use. Groundwater contamination in small portions of the Northeast Open Area and the Stockpile Area, and two disposal sites identified in the western portion of the Stockpile Area subsequent to the risk assessment are the only risk factors preventing unrestricted use of these portions of the respective areas. Land use controls will be used to prevent residential use in the Disposal Area/western portion of Dunn Field.

Alternative DS6 was chosen as the preferred alternative for remediation of the disposal sites due to its expediency, permanency, and moderate cost. DS6 provides permanent reduction through removal verses containment as described in DS2 and treatment as described in DS5. This alternative is expected to allow the property to be used for the anticipated industrial land use, and does not preclude future removal actions if warranted. Some of the soil and disposed materials that are excavated (i.e., generated) may exhibit a RCRA hazardous characteristic because it contains elevated concentrations of constituents. Since contaminants will remain on-site above levels that would allow for unrestricted and exposure criteria, the soil remedial action will be reviewed on a 5-year basis to ensure that the protectiveness is still effective.

VOCs in Subsurface Soil

Alternative SB32 (SVE) is the presumptive remedy to treat soil containing VOCs to levels that are protective of human health and acceptable for industrial land use, and that are protective of groundwater. There is greater than 1000 pounds of VOCs present in the soils in the Disposal Area, which require treatment. Presumptive remedies are "preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation" (EPA, 1993). SVE has been selected as the preferred remedy based on data analyses of similar types of sites conducted by EPA. Through this evaluation, it has been determined that certain remedies have been consistently selected as the appropriate remedy and other alternatives are typically screened out based on effectiveness, implementability, excessive costs, and the nine detailed criteria. The use of presumptive remedies are recommended by EPA because they allow the FS process to be streamlined by bypassing the technology identification and screening steps, potentially saving time and money.

The Remedial Design shall develop specific measures to ensure that the active components of the remedy and its monitoring systems are not inadvertently damaged or otherwise compromised before the relevant remedial action objectives are achieved.

Groundwater

The preferred groundwater alternative (GW3 was selected over the other alternatives because it is expected to achieve risk reduction through the reductive destruction of VOCs via the injection of ZVI into the four source areas of the groundwater plumes on and near Dunn Field (total areas of approximately 312,000 square feet). The offsite, downgradient VOC plume will be passively treated through an iron PRB that will be installed as a permanent unit across the flow path of the offsite contaminant plume (approximately 1000 linear feet in length). This alternative also relies on MNA (dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials) to reduce groundwater COC concentrations in the untreated portions of the groundwater plumes.

The selected remedy utilizes land use controls which consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; and groundwater well restrictions (established by the MSCH-D, Water Quality Branch), that collectively restrict production/consumptive use of groundwater and prohibit drilling groundwater wells within the contaminated groundwater associated with Dunn Field. In addition, temporary access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented during the remedial activities.

Groundwater monitoring shall occur to document changes in plume concentrations, and to detect potential further plume migration to offsite areas or into deeper aquifers. The groundwater monitoring will also indicate whether there are consumptive use wells present within the groundwater plume(s) associated with Dunn Field.

The combination of Alternatives DS6 (Excavation, Transportation, and Offsite Disposal with Institutional Controls), SB32 (SVE), and GW3 (ZVI Injection for Source Areas, Installation of a PRB with MNA and Institutional Controls), hereafter referred to as the "selected remedy", reduces the risk within a reasonable time frame and provides for long-term reliability of the remedy. The net present worth cost for the selected remedy is $14,991,000. A contingency plan shall be developed and implemented if an unacceptable risk were indicated during the monitoring of the effectiveness of this remedy (i.e., concentrations of VOCs migrating deeper into underlying aquifers greater than the protective target levels). The progress of the remedy will be evaluated periodically through a groundwater monitoring program established in the remedial design, and will be reported on annual basis. DLA, EPA, and TDEC believe that the contamination in the northeast upgradient plume will be adequately addressed by ground water treatment components of the selected remedy. In the meantime, TDEC has initiated the process of locating the source(s) of the upgradient contamination in light of identifying the responsible party. A contingency plan may be implemented to further address remediation of the offsite VOC groundwater plume entering the northeast portion of Dunn Field in the event the parties determine the on-site remedy is inadequate and poses unacceptable risk to human health and the environment.

If a significant or fundamental change to remedy is warranted, then an Explanation of Significant Differences (ESD) or a ROD amendment shall be required in accordance with CERLA § 117(c) and NCP § 300.435(c)(2)(i) and (ii). Because the Preferred Alternative leaves waste in place at levels that do not allow for unrestricted future use at the site, CERCLA requires that the protectiveness of the remedy be reviewed at least every 5 years.

2.12.2 Description of the Selected Remedy

Excavation, Transportation and Offsite Disposal

This alternative includes the excavation, transportation, and offsite disposal of contaminated buried receptacles and associated contaminated subsurface soil. Implementation of this alternative will be fully protective for industrial use by eliminating risk of exposure to areas with concentrations exceeding industrial levels.

Excavation, transport, and offsite disposal of soil and material contained within approximately 17 disposal sites located in the western half of Dunn Field will be based upon results from a pre-design investigation into these sites. This alternative is protective of human health and the environment by removing buried receptacles and associated contaminated subsurface soil to meet remediation goals (see Table 2-21C). Removing contaminants reduces industrial worker exposure to levels that are acceptable.

This remedy will comply with the ARARs detailed in Section 2.13.2 below, in particular the characterization, generation, management and disposal of RCRA wastes (including remediation wastes).

This alternative remains effective after completion because contaminated soil is removed. Removal is reliable and permanent. No monitoring or management beyond the implementation period will be required. A 5-year review will be required, as some waste will remain onsite. This alternative provides no reduction in TMV of the contaminated soil through treatment, although, treatment may be applied offsite at the disposal facility. Disposal in an offsite landfill reduces the mobility of contaminants by physical containment.

For the short-term, site engineering controls will be required to minimize fugitive dust and stormwater releases during site preparation, excavation activities, and transport of soil and containers. Adequate precautionary safety measures will be undertaken to protect workers and the nearby public community. These controls include perimeter air sampling for particulate (dust) and organic vapors, and establishment of exclusion area work zones. This alternative is easily implemented and monitored. No special techniques, materials, equipment, or skills are required. Native soil is available locally for backfill. Offsite transportation may require special controls on trucking operations. The remedy could be enhanced by enlarging the excavated area if more contamination were discovered.

Soil Vapor Extraction

The presumptive remedy for VOCs in subsurface soil is SVE. The SVE alternative is protective of human health and the environment by treating VOC-contaminated soil to the remediation goals (see Table 2-21G) that are acceptable for industrial land use and that are protective of groundwater. This alternative complies with ARARs detailed in Section 2.13.2. This alternative remains effective after completion because the treatment removes VOCs from the subsurface soil to site specific remediation goals. Treatment is reliable and permanent. No monitoring or management beyond completion will be required.

This alternative meets the statutory preference for using treatment as a principal element and few waste streams are produced. In the short-term, site engineering controls will be required to minimize fugitive dust and stormwater releases during installation of treatment system. Site workers might be required to wear dermal and respiratory protection to minimize the likelihood of exposure during intrusive activities in the VOC-contaminated areas. Temporary access barriers will be required to prevent exposure or disturbance to contaminated soil during the treatment period. SVE treatment is expected to take <5 years to meet RAOs. SVE is reasonably easy to implement and a proven technology. Equipment is readily available.

Implementation of this alternative will be fully protective for the Disposal Area for industrial use by eliminating risk of exposure to soil-to-indoor air VOCs and the risk to the underlying groundwater. This alternative will remain effective after completion because contaminated soil will have been treated via SVE. Removal is reliable and permanent.

Zero-Valent Iron (ZVI) Injection for Source Areas, Installation of a Permeable Reactive Barrier (PRB) with MNA and Institutional Controls

The principal active groundwater treatment methods within this alternative include onsite ZVI injection and installation of an offsite PRB containing ZVI. The ZVI injection will be used to treat source areas in the fluvial aquifer underlying Dunn Field and the area west of Dunn Field. The offsite granular iron PRB will be placed across the flow path of the VOC plume. The length of the PRI3 shall be determined during the RD phase based on the furthest northeast and southwest 50 µg/L isoconcentration contour for any COC (see Figure 2-14 for the conceptual layout of the offsite PRB). As the plume flows through the PRB3 under natural gradients, the VOCs are destroyed to non-toxic end products. Untreated parts of the plume will degrade under natural attenuation processes. This alternative includes the decommissioning of the existing groundwater extraction system upon implementation of the remedy.

This alternative reduces the risk to human health and the environment because groundwater will be treated to remediation goals (see Table 2-21G) using in situ chemical reduction via the injection of ZVI into the fluvial aquifer. Contaminated groundwater migrating offsite will be treated by the granular iron PRB. In addition, portions of the contaminant plume outside of the influence of the ZVI injection and the PRB will be treated via natural attenuation. This alternative also includes production/consumptive use groundwater controls for the fluvial aquifer on the western half and along the northern boundary of the eastern half of Dunn Field, and prevention of drilling into aquifers below the fluvial aquifer until aquifer restoration is achieved (as detailed above). Groundwater monitoring will be conducted for providing information on the plume degradation via mechanical and natural means, and until the sampling program indicates with reasonable confidence that the concentrations of the contaminants at the entire site are less than the remediation goals. This remedy will comply with ARARs, and is considered effective and permanent. A review of the alternative will be conducted every 5 years.

The alternative employs ZVI injection as a treatment technology of the most contaminated parts of the plume, and treatment of the remaining areas of contaminated groundwater through installation of a PRB3 and natural attenuation. Reduction in the total mass and concentration of the plume will be acceptable through this alternative. The expected duration of this alternative, approximately 15 years, is also acceptable, with no risk to workers, the community, or the environment during the remedy lifetime. The alternative is technically feasible although pilot tests are needed to determine specifications. The alternative can be implemented with commercially available labor, materials, and equipment. There are some proprietary technologies associated with the delivery of the ZVI and installation of the PRB.

The principal uncertainties of this alternative include: (1) the ability to deliver the ZVI evenly into the source areas through injection; (2) the vertical installation of the offsite PRB to depths of 100, below land surface; (3) the degradation rate of the VOCS through in situ chemical reduction and natural attenuation; and (4) the potential movement of the plume and the length of time required for cleanup. More active remedial measures may be needed to control the plume during the life of the action. The scope and cost of more active measures cannot be predicted.

Land Use Controls

The selected remedy leaves contaminated surface soil in place that does not allow for unrestricted use. Although active restoration is the remedy for contaminated groundwater, it will remain unusable until the remediation goals are achieved.

LUC Objectives

The LUC objectives, based upon the considerations above and the RAOs [see Section 2.8], are as follows:

1. Prevention of direct contact/ingestion of contaminated surface soils in the Disposal Area of Dunn Field in excess of human health risk assessment criteria for residents.

2. Prevent ingestion of water contaminated with VOCs in excess of MCLs from potential future onsite and offsite wells.

Land Use Restrictions

The following land use restrictions for Dunn Field are required to meet the LUC objectives:

1. Prohibit residential use or other child-occupied facilities (including daycare) in the Disposal Area/western portion of Dunn Field (see Figure 2-15).

2. Restrict installation of production/consumptive use groundwater wells or drilling groundwater wells in contaminated groundwater associated with Dunn Field (see Figure 2-16).

Description of LUCs
Accordingly, land use controls (including institutional controls) are included in the selected remedy to prevent unacceptable exposure to residual contamination and to ensure adherence to the aforementioned land use restrictions in the future.

The land use controls included in the selected remedy consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; City of Memphis/Shelby County zoning restrictions and the MSCHD, Water Quality Branch groundwater well restrictions. In addition, temporary access barriers (i.e., fence) and signage preventing unauthorized entry will be implemented during the remedial construction activities.

A brief description of each of the LUCs is as follows:

Deed and/or Lease Restrictions
Any transfer (i.e., sale or lease) of Dunn Field parcels will include restrictive covenants in the deed or lease that specifically: (1) prohibit residential use or other child-occupied facilities (including daycare) in the Disposal Area/western portion of Dunn Field; and (2) restrict installation of production/consumptive use groundwater wells or drilling groundwater wells in contaminated groundwater associated with Dunn Field. Although not considered part of the selected remedy, transfer documents will include provisions to prevent transferees from interfering with any component of the remedial actions.

It should be noted, a portion of the Northeast Open Area of Dunn Field is slated for transfer from the DoD (Army) through the DOT/NPS 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 at its discretion. The majority of this area was determined in this ROD as requiring "No Further Action" and is designated as "unrestricted use". However, due to groundwater contamination from an upgradient offsite source, the northern-most portion of this area will be subject to groundwater use restrictions until remediation goals are achieved.

Notice of Land Use Restriction

Tennessee law requires that a "Notice of Land Use Restrictions" be prepared and recorded by a property owner wherein land use restrictions are part of the remedial action on such property. The Army's property disposal agent will include or incorporate by reference the "Notice of Land Use Restrictions" into the deeds or other instruments used in transferring the Dunn Field property. This Notice of Land Use Restrictions shall be prepared and recorded at the Shelby County Register of Deeds office in accordance with Tennessee Code Annotated Section 68-212-225.

Zoning Restrictions
The Memphis and Shelby County Land Use Control Board has zoned the area where the Memphis Depot, including Dunn Field, is located as Light Industrial (I-L). The principal uses permitted in the I-L district are

manufacturing, wholesaling, and warehousing. The boundaries of the zoning districts are shown on "City of Memphis and Shelby County Zoning District Maps" (see Appendix A).

Unless the zoning classification changes, residential development is not allowed on this site by the zoning ordinance. The Memphis and Shelby County Land Use Control Board (and not the Army) is responsible for administering and enforcing the zoning regulations. The zoning regulations are an existing governmental control that provides an additional layer of protection to the deed/lease restrictions in preventing residential use.

Groundwater Well Restrictions
Section 5.02(E) of the MSCHD Well Construction Code prohibits installation of drinking water wells within a half-mile of the designated boundaries of a listed federal Superfund (i.e., CERCLA) site unless the well owner can demonstrate that the well will not enhance the movement of contaminated groundwater or materials into the shallow or deep aquifer. The Water Quality Branch is aware that the Memphis Depot is a federal CERCLA site with contaminated groundwater both on and off site. According to the Water Quality Branch Manager, in the case of offsite groundwater contamination from a CERCLA site, the half-mile boundary limit means no wells would be permitted on or within half-mile of the "facility" (as defined in CERCLA Section 101-9) including all areas with ground water contamination (see Figure 2-16).

The groundwater well regulations are an existing governmental control that are being referenced as a LUC and provide an additional layer of protection to the deed/lease restrictions in preventing consumptive use of groundwater or drilling groundwater wells on Dunn Field. The Water Quality Branch is responsible for administering and enforcing these rules.

There is no increase in risk to the community or to workers due to implementation of land use controls because there are no site activities that will affect exposure. Controls and restrictions will take an estimated 6 months to implement. The action could be enhanced by extending the areas of control and related temporary access barriers.

Remedy Performance

The progress of the active portions of the remedy will be evaluated periodically through a monitoring program established in the remedial design, and will be reported on annual basis. The projection of time to achieve remediation goals, originally estimated in the Dunn Field FS at 4 years for subsurface soil via SVE and 15 years for groundwater, shall be refined based on data collected during the RD phase. The RD shall also include methods and metrics for evaluating the effectiveness of all aspects of the remedy including:

- Developing decision/logic trees for soil and groundwater cleanup to determine effectiveness and whether enhancements or changes to the selected remedy are required
- Tracking concentration trends of COCs in soil and groundwater over time in order to assess progress towards achieving RAOs
- Establishing locations for monitoring progress toward achieving soil and groundwater remediation goals, in consultation with the parties to the FFA
- Meeting soil and groundwater remediation goals at points of compliance

2.12.3 Summary of Estimated Remedy Costs

Disposal Sites

The estimated costs for the selected soil remedy, Excavation Transportation and Off-site Disposal with Institutional Controls, are as follows:

Capital Costs:	$1,715,000
PW O&M Costs:	$57,000
Total PW Costs:	$1,772,000

Table 2-22A presents a detailed description of the costs associated with this remedy. The assumptions used in developing the cost estimate for this alternative were as follows:

- The remedy will require less than 1 year to achieve remedial goals.
- Institutional controls will be implemented to prevent residential land use in the Disposal Area/western portion of Dunn Field.
- Areas identified with buried receptacles and subsurface soils contaminated with concentrations exceeding the RGOs will be excavated for offsite disposal. The extent of the disposal sites and associated subsurface soils as well as the contaminant concentration will be refined within the Dunn Field Remedial Design. Additional field investigation will be conducted which will include geophysical surveys of the disposal sites, exploratory excavations, documentation of the contents of the disposal sites, and sample collection and analyses.
- Approximately 3,900 cubic yards of contaminated subsurface soil and debris will require excavation and offsite disposal.
- Contaminated soils will be excavated to 1 foot below depth of each disposal site, on average 10 feet, and replaced with compacted, clean (as determined by analytical testing) backfill, obtained from offsite.
- Some remediation waste is likely going to be considered RCRA hazardous waste and it will be treated, if necessary, and disposed off-site in a RCRA Subtitle C landfill.
- Trucks will be required to transport clean backfill onsite and transport excavated remediation wastes, which will consist of contaminated soil, debris, containers and waste materials, offsite. Some excavated remediation waste may have to be overpacked.
- Engineering controls will be used to abate any air emissions (e.g., fugitive dust) and stormwater run-off during remedial activities.
- Excavation confirmation sampling and analyses will be required to confirm that RGOs were met.
- Site restoration will be required following remediation to restore the site to acceptable conditions.
- Periodic 5-year reviews performed by the DoD, with approval by the regulators, will also be required.

Subsurface Soils

The estimated costs for the selected subsurface soil remedy, SVE, are as follows:

Capital Costs: $3,183,000
PW O&M Costs: $1,228,000
Total PW Costs: $4,411,000

Table 2-22B presents a detailed description of the costs associated with this remedy. The assumptions used in developing the cost estimate for this alternative were as follows:

- For a vertical SVE system, 81 SVE wells will be installed using rotosonic-drilling methods. Ten thousand feet of 4-inch, SDR 11, HDPE piping will be used. Three 25-horsepower (HP) multiphase extraction (MPE) systems for wells constructed in the loess and one 15-HP regenerative system for wells constructed in the fluvial deposits will be utilized. For a horizontal SVE system, 5 SVE wells will be installed using a horizontal drilling methods and 34 SVE wells will be installed using rotosonic-drilling methods. Four thousand five hundred (4,500) feet of 4-inch, SDR 11, HOPE piping will be used. One 75-HP MPE system for wells constructed in the loess and one 15-HP regenerative system for wells constructed in the fluvial deposits will be utilized.

- One chlorinated catalytic oxidizer, one scrubber, and 66,600 gallons of sodium hydroxide will be used to treat-off gasses and hydrochloric acid emissions released to the atmosphere from the SVE system.

- The remedy will require up to 4 years to achieve remedial goals. This estimated cleanup time is based on the results of the SVE pilot test (see Appendix C of the Dunn Field FS) and the average mass removal rate for the individual CVOCs that was obtained from the pilot test for the loess and fluvial deposits. Total contaminant mass calculations for VOCs (PCE, TCE and 1,1,2,2-PCA) in the sorbed-phase in the soils (excluding the disposal sites) indicate that approximately 1,200 pounds of VOCs are present. The total contaminant mass in the disposal sites is not known at this time; however, the SVE system will be installed and operated following the implementation of the selected remedial approach for the disposal sites.

- The development of measures to signal completion of the SVE remedy, which will be implemented as part of the SVE design process, includes calculated soil screening levels (SSLs) protective of groundwater in the fluvial aquifer for VOC contamination in the loess and the unsaturated fluvial deposits. Soil vapor concentrations in equilibrium with both SSLs (loess and fluvial) were developed for each COC (see Table 2-21E for these site-specific remediation goals for the loess and fluvial deposits). The measures also include use of the SVE Termination or Optimization Process (STOP) protocol referenced in the Air Force Center for Environmental Excellence (AFCEE) June 2001 *Final Guidance on Soil Vapor Extraction Optimization*. An example of the STOP decision tree that will be included into the design of the SVE remedy for Dunn Field is included as Figure 2-18. Ultimate cleanup for purposes of determining that the remedy is complete must be demonstrated by direct measurements of subsurface soil. Soil vapor may be used as a surrogate for the purpose of optimizing the system operations and indicating when confirmation soil sampling should be initiated.

- Areas identified with subsurface soils with VOC concentrations exceeding the RGOs will be treated. Eighty (80) additional soil samples will be collected during soil monitoring point installation (4 samples from 20 borings) to confirm the extent of vadose VOCs identified in the RI, or allow adjustments to be made as necessary.

- The pilot test has already been performed, which has adequately defined design parameters for the treatment system.

- A network of soil monitoring points will be installed to various depths as part of the SVE monitoring system.

- The SVE treatment areas will be covered by a 360,000-ft^2 cap of 20-mm liner (or equal) covered with gravel. The cap will be keyed into the existing wells at the site and will be turned-down and keyed into trenches along the edge of the treatment zones. The site will be graded to direct stormwater runoff to the existing stormwater system on the western half of Dunn Field.

- System startup will last for up to 14 days.

- Off-gas monitoring, SVE performance air monitoring, and system O&M will be performed regularly. Air samples, collected from the scrubber, for VOCs and HCI will be collected daily for three days and then weekly for 4 weeks during the system startup. Afterwards, samples will be collected monthly till completion of treatment. O&M of the SVE system and air monitoring will be conducted during air sampling events.

- Wastewater effluent from the remediation system will be collected and analyzed monthly in accordance with the POTW pre-treatment requirements in order to monitor industrial discharge levels and system performance.

- Soil vapor confirmation sampling will be conducted to determine the end of treatment. Actual soil confirmation samples will be collected when the treatment endpoint has been reached. Vapor-phase concentrations represent screening level indicators that will serve as a benchmark of site-specific remediation goals for COCs in soil at Dunn Field, and for initiating a phased approach of remedy optimization and determination of the point in which the SVE system at the site could be: (1) temporarily shut down to perform equilibrium/rebound tests; or (2) permanently shutdown. Final cleanup confirmation will be determined through direct measurement of the soils through standard soil sample collection and analyses.

- An annual evaluation of remedy effectiveness and progress of the SVE system will be performed until RGOs for subsurface soil are achieved. Annual response action performance monitoring reports to EPA and TDEC will document the evaluation.

- Upon completion of the remedy, the system will be decommissioned and all wells will be abandoned. Site restoration will be required to restore the site to acceptable conditions.

- 5-year reviews by regulators will be required for Dunn Field (OU-1) until RAOs are achieved.

Groundwater

The estimated costs for the selected groundwater remedy, ZVI Injection for Source Areas, Installation of a PRB with MNA and Institutional Controls, are as follows.

Capital Costs: $7,827,000
PW O&M Costs: $981,000
Total PW Costs: $8,808,000

Table 2-22C presents a detailed description of the costs associated with this remedy. The assumptions used in developing the cost estimate for this alternative were as follows:

- The active treatment portion of the remedy will occur over the first 15 years.

- ZVI injection will occur into the four source areas of the groundwater plumes on and near Dunn Field (total areas of approximately 312,000 square feet) in the fluvial aquifer underlying the western portion of Dunn Field. Each injection zone will include injection points to the bottom of the fluvial aquifer.

- A pilot study will be completed to determine design parameters of the ZVI injection, such as injection amounts, depth, and zone of influence. The pilot study will include installation of injection borings and new monitoring wells.

- Approximately 1050 feet of injection points will be installed as part of the PRB construction.

- A bench-scale study will be completed to determine design parameters of the PRB injection lines, such as amount of ZVI needed, depth, thickness and zone of influence.

- Drafting and filing of the Notice of land use (groundwater) restrictions are the only costs for institutional controls that need to be estimated.

- Clearing and grubbing of the areas surrounding the areas of the planned PRB and offsite ZVI injections will be necessary. Property access agreements will also be required.

- An estimated 15 new monitoring wells will be installed and a total of 43 wells will be included in the groundwater monitoring program. The wells will used to monitor progress toward RGOs and guard against vertical and horizontal contaminant migration.

- Groundwater monitoring will occur quarterly for the first year, semiannually for 9 years and once every year for 5 years. Water samples will be analyzed for VOCs and degradation parameters. Field parameters will be measured during sample collection. Monitoring may be discontinued once the remediation goals have been achieved and maintained for three consecutive sampling periods.

- The existing groundwater extraction system will be "moth-balled" during the life of the remedies in this alternative and will be dismantled at the end of the remedy. The system will not be dismantled immediately because of potential use in the future to assist with the aquifer remediation.

- All monitoring and extraction wells and injection borings will be plugged and abandoned at the completion of the remedy.

- Annual monitoring reports will document the site status. These reports will include a potentiometric surface map, a plume map, summary tables of detected parameters, use new and existing data to document cumulative trends toward achieving RGOs, and an appendix that contains the laboratory data and field forms.

The principal uncertainties of this alternative include: (1) the ability to deliver the ZVI evenly into the source areas through injection; (2) the vertical installation of the offsite PRB to depths of 100, below land surface; (3) the degradation rate of the VOCs through in situ treatment; and (4) the potential movement of the plume and the length of time required for cleanup. Bench-scale and field pilot tests will reduce these uncertainties. The preliminary design and cost estimate assume application amounts and frequencies based on the experience of the queried vendor(s) and subcontractors.

The information used to create these cost estimate summaries for the selected remedy was based on the best available data regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the selected remedy. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences (ESD), or a ROD amendment. The order-of-magnitude engineering cost estimates presented are expected to be within +50 to -30 percent of the actual project cost.

2.12.4 Expected Outcomes of the Selected Remedy

Based on the information available at this time, DLA, EPA, and TDEC believe the selected remedy will be protective of human health and the environment, will comply with ARARs, will be cost-effective, and will utilize permanent solutions and alternative treatment technologies to the maximum extent practicable.

Implementation of the selected remedy will facilitate the transfer of this closed redevelopment and reuse as light industrial and recreational facilities, providing a strong economic base to anchor the low-income and disadvantaged neighborhoods of southeast Memphis.

Groundwater from the fluvial aquifer in the Dunn Field area is not currently used for drinking water and will not be used for this purpose in the future. Groundwater concentrations of VOCs above the remediation goals are expected to be reduced so as not to pose an unacceptable risk to potential future users or the deeper potable water supply of the Memphis aquifer. Remediation of the disposal sites and subsurface soil will also reduce the migration of COCs from the soil to the groundwater of the fluvial aquifer.

The DLA as operator, and/or the U.S. Army as property owner, are responsible for implementing, maintaining, reporting on and enforcing the remedy, including land use controls. As part of the Remedial Design, a LUCIP will be developed. This portion of the Remedial Design will detail how the land use controls in the selected remedy will be implemented, maintained, enforced and monitored over time. Although DLA and/or the Army may later transfer the monitoring responsibilities to another party, DLA and/or the Army shall retain ultimate responsibility for protectiveness and integrity of the remedy. As a planning document pursuant to a ROD, the LUCIP will be enforceable by any party under CERCLA.

2.13 Statutory Determinations

Under CERCLA and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes.

2.13.1 Protection of Human Health and the Environment

Source control and groundwater restoration, coupled with land use controls, are protective of human health and environment since exposure to contamination is controlled.

Excavation, transportation, and off-site disposal are protective of human health and the environment by removing contaminated soil and material. SVE is protective of human health and the environment by treating contaminated soil. Removing and treating soil contaminants reduces industrial worker exposure to levels that are acceptable for the intended land use; however, unacceptable levels for the residential scenario will remain at areas where no removal will occur.

In situ chemical reduction of groundwater is considered protective of human health and the environment because groundwater will be treated in order to lower contamination levels to protective target levels. During implementation, monitoring will warn if the plumes begin to migrate off-site or into deeper aquifers. The remedy will be reviewed on a 5-year basis to ensure that the remedy is still protective. If a groundwater data review indicates that VOCs are migrating further off-site or into an underlying aquifer at levels greater than the remediation goals, a contingency plan will be developed for remediation of those constituents. The progress of the remedy will be evaluated periodically through a groundwater monitoring program established in the remedial design, and will be reported on annual basis.

Land use controls included in the selected remedy prevent unacceptable exposure to residual contamination. In particular, deed/lease restrictions and the Notice of Land Use Restrictions will prohibit the installation of production/consumptive-use groundwater wells and residential use or other child-occupied facilities (including daycare) in the Disposal Area/western portion of Dunn Field. In addition, both the zoning and groundwater well regulations are existing governmental controls that provide additional layers of protection to the deed and/or lease restrictions and Notice of Land Use Restrictions.

2.13.2 Compliance with ARARs

CERCLA Section 121(d), specifies in part, that remedial actions for cleanup of hazardous substances must comply with requirements and standards under federal or more stringent state environmental laws and regulations that are applicable or relevant and appropriate (i.e., ARARs) to the hazardous substances or particular circumstances at a site or obtain a waiver [see also 40 CFR 300.430(f)(1)(ii)(B3)]. Applicable or relevant and appropriate requirement (ARARs) include only federal and state environmental or facility siting laws/regulations and do not include occupational safety or worker protection requirements. In addition, per 40 CFR 300.405(g)(3), other advisories, criteria, or guidance may be considered in determining remedies (so-called To-Be-Considered [TBC] guidance category).

In accordance with 40 CFR 300.400(g), the DLA, TDEC, and EPA have identified the specific ARARs and TBC for the selected remedy. The selected remedy complies with all ARARs/TBCs directly related to implementing the selected actions. Tables 2-23 and 2-24 list respectively the Chemical-specific and Action-specific ARARs for remedial actions in the selected remedy. A brief summary of the remedial actions and associated ARARs/TBC guidance follows.

Chemical-Specific ARARs/TBC Guidance

Chemical-specific ARARs provide health- or risk-based concentration limits or discharge limitations in various environmental media (i.e., surface water, groundwater, soil, and air) for specific hazardous substances, pollutants, or contaminants. The chemical specific ARARs for groundwater are listed in Table 2-23 and discussed below. There are no chemical-specific ARARs/TBC guidance for soil. Remediation levels for soils will be based upon risk-based concentrations and/or in consideration of reducing releases into ground water (see Section 2.7.3).

One of EPA's Superfund Program goals under its ground water policy is to return usable ground waters to their beneficial uses within a timeframe that is reasonable given the particular circumstances of the site. The first consideration at a CERCLA site is determining whether the contaminated ground water is classified as a drinking water or is a potential source of drinking water. According to the final NCP preamble, EPA will make use of state classifications and consider their applicability in the selection of a remedy for ground water [55 Fed Reg. 8732-33, March 8, 1990].

Per 40 CFR 300.430 of the NCP, MCLGs (established under the Safe Drinking Water Act of 1974, as amended [SDWA] at 40 CFR Part 141 et. seq.) that are set at levels above zero, shall be attained by remedial actions for ground waters that are current or potential sources of drinking water, where relevant and appropriate to the circumstances of the release. Where the MCLG for a contaminant has been set at zero, or it is determined not to be relevant and appropriate, the corresponding MCL for that contaminant shall be attained [40 CFR 430(g)(2)(i)(B) and (c)].

The fluvial aquifer beneath Dunn Field is not used as a drinking water source at the Depot; however, the underlying Memphis aquifer is a source of potable water for the City of Memphis. The Allen well field, which is located approximately 1-mile west of the Depot, pumps groundwater from the Memphis aquifer. There is no default classification for ground water in the State of Tennessee and it is classified as it is encountered according to the TDEC groundwater classification regulations at 1200-4-3-.07. The groundwater underneath Dunn Field would be considered "General Use Ground Water" based upon the yield and Total Dissolved Solids levels. The Criteria specified in the TDEC Rule 1200-4-3-.08(2) for General Use Ground Water are considered an ARAR. The Criteria consist of SDWA MCLs, MCLGs, SMCLs and Action-levels for organic and inorganic constituents. Accordingly, the MCLs and non-zero MCLGs are considered relevant and appropriate remediation goals for the Dunn Field groundwater including the offsite plume. TDEC's Public Water System regulations at 1200-5-1-.06 list the MCLGs and MCLs, which are identical to the federal SDWA MCLGs and MCLs found at 40 CFR 141 et seq.

Location-Specific ARARs/TBC Guidance

Location-specific requirements establish restrictions on permissible concentrations of hazardous substances or establish requirements for how activities will be conducted because they are in special locations (e.g., wetlands, floodplains, critical habitats, and streams). There are no Location-specific ARARs/TBC guidance for the Dunn Field remedial actions.

Action-Specific ARARs/TBC Guidance

Action-specific ARARs include operation, performance, and design requirements or limitations based on the waste types, media, and remedial activities. Component actions include limited removal of contaminated surface soils and disposal pit wastes, in situ treatment of contaminated soils and ground water, groundwater treatment and monitoring, institutional controls, waste management (characterization, staging) and transportation of remediation wastes for off-site treatment and disposal. ARARs for each component action are listed in Table 2-24 and briefly discussed below.

Requirements for the control of fugitive dust at TDEC Rule 1200-3-8-.01(1) and storm water runoff potentially provide ARARs for all construction, excavation, trenching and site preparation activities. On-site remedial actions that involve land-disturbing activities include excavation of contaminated soils/disposal pit wastes, construction of the surface seal for the SVE system and placement of ZVI for in-situ groundwater treatment. For purposes of CERCLA Section 121(e) (l), placement of ZVI injection boreholes and the PRB outside of the Depot property boundary for treatment of the contaminated groundwater associated with Dunn Field is considered 'on-site' as defined in 40 CFR Part 300.5 and 300.400(e)(1). Reasonable precautions must be taken and include the use of best management practices for erosion control to prevent runoff, and application of water on exposed soil/debris surfaces to prevent particulate matter from becoming airborne. Activities that disturb greater than one acre of land are required to comply only with the substantive requirements of the NPDES stormwater permit program as implemented by TDEC under its General Permit (Stormwater Discharge from Construction Activities, No. TNR10-0000). Per CERCLA Section 121(e) on-site response actions are not required to obtain permits or adhere to other administrative requirements (e.g., submittal of a Notice of Intent, a Storm Water Pollution Prevention Plan, and Notice of Termination).

The excavation of contaminated soil/disposal pit wastes material may result in the generation of remediation wastes that are considered RCRA characteristic hazardous waste due to elevated concentrations of hazardous constituents. Also, some secondary waste streams such as spent treatment media (i.e., activated carbon filters, etc.) and extracted wastewater from the SVE system for disposal may be considered RCRA waste. The toxicity characteristic leaching procedure (TCLP) test, along with tests for reactivity, corrosivity and ignitability, will be conducted on representative remediation/secondary waste samples to determine whether it is considered RCRA characteristic hazardous waste. Based upon the limited and inconclusive documentation related to historic disposal activities that occurred in Dunn Field, generation of RCRA listed waste is not anticipated. However, it is possible containers with residual chemicals (e.g., methyl bromide) that could be considered P or U listed RCRA hazardous waste under 40 CFR 261.33, may be discovered during excavation actions.

All RCRA hazardous waste will be managed in accordance with all applicable TDEC hazardous waste management regulations identified on Table 2-24, including those related to temporary storage of waste in containers and transportation off-site. Movement of hazardous remediation waste that contains RCRA-restricted waste off-site for treatment and disposal will trigger the RCRA land disposal restrictions (LDRs). These wastes must meet the specified treatment standards at 40 CFR 268 et. seq. and must be disposed of in an RCRA Subtitle C hazardous waste landfill or other approved disposal facility.

Any remediation wastes that are transferred off-site or transported in commerce along public right-of-ways must meet the requirements summarized in Table 2-24. These include packaging, labeling, marking, manifesting, and placarding requirements for hazardous materials. In addition, CERCLA Section 121(d)(3) provides that the off-site transfer of any hazardous substance, pollutant, or contaminant generated during CERCLA response actions be sent to a treatment, storage, or disposal facility that is in compliance with applicable federal and state laws and has been approved by EPA for acceptance of CERCLA waste [see also the 'Off-Site Rule' at 40 CFR 300.440 et. seq.]. Accordingly, DLA will verify with the appropriate EPA regional contact that any needed off-site facility is acceptable for receipt of CERCLA wastes before transfer.

Operation of the SVE system to treat volatile organic compounds (VOCs) in subsurface soils will create emissions of air pollutants that are captured in a hood for filtration/treatment. This on-site treatment must comply with the substantive requirements of the Tennessee Air Quality Act and TDEC Rule 1200-3-9. These requirements include the monitoring and control of the release of volatile organics to the atmosphere, the control of fugitive dust emissions, and compliance with ambient air quality standards.

In addition, the SVE system will generate wastewater due to extraction of moisture from the soils. Also, installation of groundwater monitoring and injection wells, as well as decontamination activities, may result in relatively small quantities of contaminated water that are considered wastewaters. All of these wastewaters will sent off-site to an NPDES permitted Wastewater Treatment Facility. One alternative is discharging these wastewaters via the on-site outfall to the POTW operated by the City of Memphis. Discharged wastewaters must meet the POTW industrial discharge standards that limit contaminant levels and therefore may require pre-treatment. Wastewaters that are hazardous only because they exhibit a RCRA hazardous characteristic, and which are otherwise restricted from land disposal, are not prohibited if such wastes are managed in a treatment system that subsequently discharges to waters of the United States pursuant to a permit issued under Sect. 402 of the CWA (i.e., NPDES permitted) [40 CFR 268.1(c)(4)(i); TDEC Rule 1200-1-11-.10(1)(a)(30(iv)(I)].

The Ground Water Quality Control Board for Shelby County, Tennessee, has promulgated *Rules and Regulations of Wells in Shelby County*. These regulations govern the location, design, installation, use, modification, repair, and abandonment of all types of wells and soil borings; for example, monitoring, injection, recovery, and vapor extraction wells. These requirements are more stringent than corresponding federal and state rules. The substantive requirements of these regulations are considered ARARs. According to Tennessee Rule 1200-4-6, monitoring and injection wells at Dunn Field would be classified as Class V (shallow, non-hazardous) wells. Substantive requirements of an underground injection control (UIC) Class V permit application for injection wells will be adhered to, although no permit is required.

Other Criteria and Guidance

There are no identified TBCs; however, the EPA Region 9 PRGs were used as a part of the process for establishing soil remediation goals for the disposal sites soils (see Section 2.7.3).

2.13.3 Cost-Effectiveness

The selected remedies are cost-effective and represent a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." (NCP 300.430(f)(1)(ii)(D)). This was accomplished by evaluating the overall effectiveness of those alternatives that satisfied the threshold criteria. Overall effectiveness was evaluated by assessing three of the five balancing criteria (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of these remedial alternatives was determined to be proportional to its costs; hence, this selected remedy represents a reasonable value for the money to be spent.

The estimated present worth costs of the selected soil remedies are $1,772,000 for the disposal sites and $4,411,000 for the subsurface soil impacted by VOCs. The estimated present worth cost of the selected groundwater remedy is $8,808,000. Excavation and offsite disposal was chosen due to its expediency, permanency, and moderate cost. It provides permanent reduction through removal verses containment and onsite treatment. This alternative is expected to allow the property to be used for the anticipated industrial land use, and does not preclude future removal actions if warranted. SVE is a proven, presumptive remedy for VOCs in soil. Groundwater Alternative GW3 was chosen over Alternative GW2 and GW4 because it is expected to achieve RAOs in about the same timeframe, but for less cost, less O& M required and satisfies the statutory preference for treatment.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Possible

Of those alternatives that are protective of human health and the environment and comply with ARARs, the selected remedies proved the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against off-site treatment and disposal and considering State and community acceptance.

The remedy will satisfy the criteria for long-term effectiveness by permanently removing the disposal sites and treating the subsurface soil that exceed the industrial-use criteria and reduce the threat to the underlying groundwater. In situ chemical reductions will reduce the volume and toxicity of contaminated groundwater through treatment. The selected remedies will not present short-term risks different from the other treatment alternatives.

2.13.5 Preference for Treatment as a Principal Element

By treating the contaminated subsurface soil and groundwater through the treatment technologies of SVE and in situ chemical reduction via the use of ZVI, the selected subsurface soil and groundwater alternatives addresses potential exposure pathways posed by Dunn Field. By utilizing treatment as a significant portion of the remedy, the statutory preference for remedies that employ treatment as a principal element is satisfied.

The selected remedy for the disposal sites and associated subsurface soil contamination at Dunn Field does not satisfy the statutory preference for treatment as a principal element of the remedy. However, the remedy for the disposal sites and associated subsurface soil was chosen for the following reasons:

- Land use controls, which include institutional controls, can be implemented quickly and provide additional layers of protectiveness to the existing land use controls (City of Memphis/Shelby County zoning and MSCHD groundwater well restrictions)

- Excavation and off-site disposal provides permanent risk reduction through removal.

- The remedy will allow the Disposal Area of Dunn Field to be used for industrial land use, and does not preclude future response actions, if warranted.

- The remedy is cost-effective at achieving anticipated industrial land use criteria.

In-situ treatment is not selected primarily because of the homogeneity of disposed materials, which is incompatible with the technology. Ex-situ treatment calls for excavation and separation of pit contents, and return of residual mass to the pits. Either treatment alternative would leave residual concretized mass that could interfere with reuse options. As long as the disposal pit contents have to be excavated, it is prudent to dispose of them in a permitted landfill subject to all relevant regulations.

2.13.6 Five-Year Review Requirements

Both selected soil and groundwater remedies will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure. Therefore, as required by Section 121(c) of CERCLA and NCP § 300.430(f)(5)(iii)(c), a statutory review will be conducted every 5 years from initiation of remedial action to ensure that the remedy continues to be protective of human health and the environment. Statutory five-year reviews may be discontinued when no hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure.

2.13.7 Natural Resource Damages

Although active restoration is the remedial action objective for the contaminated groundwater, hazardous substances above health-based levels may remain in groundwater associated with Dunn Field after implementation of this remedy. Therefore, DLA, TDEC, and EPA recognize that Natural Resource Damage claims, in accordance with CERCLA, may be applicable. The remedy does address restoration or rehabilitation of groundwater, but does not determine the extent of any natural resource injuries that may have occurred. However, neither OLA nor TDEC waives any rights or defenses each may have under CERCLA, Sect. 107(a) 4(c).

2.14 Documentation of Significant Changes

CERCLA Section 117(b) requires an explanation of significant change from the selected remedy presented in the Proposed Plan that was published for public comment. Although, there are no significant changes to the selected remedy included in the Proposed Plan (CH2M HILL, May 2003), there was a change to the interim remedy presented in the Record of Decision for Interim Remedial Action (IRA) of the Groundwater at Dunn Field (OU-1) (CH2M HILL, 1996). Accordingly, the following paragraphs present a change in the interim remedy for OU-1.

The ROD for the IRA of the Groundwater at Dunn Field (OU-1) was signed by DLA in April 1996. As stated in the document, the interim remedy for groundwater was developed because contaminated groundwater in the "Fluvial aquifer [underlying Dunn Field] poses a potential threat to the deeper Memphis Sand Aquifer, [and as a result] it is considered as a potential threat to human health and the environment". The IRA was intended to provide hydraulic control of the contaminant plume in groundwater. The major components of the selected IRA include the following:

- Evaluation of aquifer characteristics which may include installation of a pump test well.
- Installation of additional monitoring wells to locate the western edge of the groundwater plume.
- Installation of recovery wells along the leading edge of the plume.
- Obtaining discharge permit for disposal of recovered groundwater to the POTW or municipal sewer system.
- Operation of the system of recovery wells until the risk associated with the contaminants is reduced to acceptable levels or until the final remedy is in place.

- Chemical analysis will be conducted to monitor the quality of the discharge in accordance with the city discharge permit requirements; the permit will include parameters to be monitored and frequency.

The interim groundwater extraction system was to be installed in three phases: (1) installation of the initial seven recovery wells on Dunn Field; (2) installation of remaining recovery wells on Dunn Field; and (3) installation of offsite wells west of Dunn Field. The initial plan in 1997 identified that at the end of the first two phases, monitoring data would be reviewed and any changes would be made to the implementation of the Phase III. The concept of a phased approach grew out of two concerns: (1) the Depot's desire at the time (circa 1996-1997) to keep the initial wells onsite; and (2) a dearth of data on the variability of the offsite hydrogeologic parameters and extent of groundwater contamination in the fluvial aquifer. The first two phases were modeled; onsite wells only, and offsite wells to capture the residual downgradient plume. System capture from the onsite wells would be used to model placement of the downgradient, offsite wells. In the initial design documentation, CH2M HILL discussed a Phase II (additional onsite wells along the perimeter of Dunn Field) and Phase III - offsite wells.

Phase I and II of the interim groundwater remedy were implemented at Dunn Field from 1998 through 2001. The remedial investigation was completed in 2001 and the RI report was finalized in July 2002. Delineation of the western extent of the groundwater contamination in the fluvial aquifer was completed in 2001. Data gathered during phases l and II of the interim remedy, and during the RI, strongly suggested that aquifer restoration could be accomplished more effectively by means other than expanding the interim groundwater extraction system as a final remedy. Phase III of the interim remedy (offsite recovery wells) was not implemented. Based on the new information developed subsequent to the 1996 ROD and implementation of Phases I and II, DLA, EPA, and TDEC agreed that the offsite groundwater plume in the fluvial aquifer would be addressed in the final remedy for Dunn Field, as presented in the Proposed Plan and Record of Decision. The existing groundwater extraction system (Phase I and II) will continue to operate until the final remedy is implemented.

Tables for Section 2, Rev2 Dunn Field ROD

TABLE 2-1
List of Dunn Field (OU 1) Sites
Rev 1 Dunn Field Record of Decision

INSTALLATION RESTORATION SITES NUMBER	DSERTS SITE NUMBER(a)	PRIORITY LEVEL(b)	SITE TYPE	SITE DESCRIPTION
Northeast Open Area				
19	19	C	SS	Former Tear Gas Canister Burn Site (c)
20	20	C	SS	Probable Asphalt Burial Site
21	21	C	SS	XXCC-3 Impregnite Burial Site (300,000 Pounds)
50	50	C	SS	Dunn Field Northeastern Quadrant Drainage Ditch
60	60	Remediated[1]	SS	Pistol Range Impact Area/Bullet Stop
62	62	C	SS	Bauxite Storage
85	85	Remediated[1]	RI	Old Pistol Range Building 1184/Temporary Pesticide Storage
Disposal Area				
1	1	Remediated[2]	CWM	Mustard and Lewisite Training Sets Burial Site (1955)
2	2	C	RI	Ammonia Hydroxide (7 Pounds) and Acetic Acid (1-Gallon) Burial Site (1955)
3	3	B	RI	Mixed Chemical Burial Site (Orthotouldine Dihydrochloride) (1955)
4	4	A	RI	POL Burial Site (13, 55-Gallon Drums of Oil, Grease and Paint)
4.1	90	A	RI	POL Burial Site (32, 55-Gallon Drums of Oil, Grease and Thinner)
5	5	C	RI	Methyl Bromide Burial Site A (3 Cubic Feet) (1955)
6	6	C	RI	40,037 Units of Eye Ointment Burial Site (1955)
7	7	A	RI	Nitric Acid Burial Site (1,700 Quart Bottles) (1954)
8	8	A	RI	Methyl Bromide Burial Site B (3,768 1-gallon cans) (1954)
9	9	C	RI	Ashes and Metal Burial Site (Burning Pit Refuse) (1955)
10	10	B	RI	Solid Waste Burial Site (Near MW-10) (Metal, Glass, Trash, etc.)
11	11	B	RI	Trichloroacetic Acid Burial Site (1,433, 1-ounce Bottles) (1965)
12 & 12.1	12	B	RI	Sulfuric Acid and Hydrochloric Acid Burial (1967)
13	13	A	RI	Mixed Chemical Burial (Acid, 900 Pounds; Unnamed Solids, 8,100 Pounds)
14	14	C	RI	Municipal Waste Burial Site B (Near MW-12) (Food, Paper Products)
15	15	B	RI	Sodium Burial Sites (1968)
15.1	91	B	RI	Sodium Phosphate Burial (1968)
15.2	92	B	RI	14 Burial Pits: Na2PO4, Sodium, Acid, Medical Supplies, and Chlorinated Lime
16	16	B	RI	Unknown Acid Burial Site (1969)
16.1	93	B	RI	Acid Burial Site
17	17	B	RI	Mixed Chemical Burial Site C (1969)
18	18	C	Proposed NFA	Plane Crash Residue
22	22	C	Proposed NFA	Hardware Burial Site (Nuts and Bolts)
23	23	C	Proposed NFA	Construction Debris and Food Burial Site
24-A	24	Remediated[2]	CWM	Bomb Casing Burial Site (29 Bomb Casings used to Transport Mustard Agent)
61	61	C	SS	Buried Drain Pipe
63	63	C	Proposed NFA	Aboveground Fluorspar Storage
64	64	C	Proposed NFA	Aboveground Bauxite Storage (1942 to 1972)
86	86	C	RI	Food Supplies
Stockpile Area (d)				
24-B	24	Remediated[2]	CWM	Neutralization Pit for the Contents of the 29 Bomb Casing used to Transport Mustard Agent
62	62	C	SS	Aboveground Bauxite Storage
63	63	C	Proposed NFA	Aboveground Fluorspar Storage
64	64	C	SS	Aboveground Bauxite Storage (1949 to 1972)
--	64(e)	B	–	CC-2 Impregnite Burial Site (86,100 Pounds in 1947)
--	64(e)	B	–	Installation Assessment Site 31, Burning and Disposal Site

Notes.

[1] Remedial action for Sites 60/85 (CH2M HILL, 2002) was completed in early 2003 following the EE/CA and Action Memorandum.

[2] CWM remedial actions at sites are documented in the Final Chemical Warfare Materiel Investigation/Removal Action Report, dated December 2001 (UXB International, Inc).

SS	Screening Site
RI.	Remedial Investigation
RA.	Remedial Action
NFA:	No Further Action
CWM.	Chemical Warfare Materiel
Na2PO4.	Sodium Phosphate
POL	Petroleum, Oil, and Lubricants
XXCC-3/CC-2:	Stabilized/Unstabilized Impregnite for Impregnating Clothing Used to Protect Personnel against the Action of Vesicant-Type Chemical Agents

(a) Defense Site Environmental Restoration Tracking System (DoD Database)

(b) Priority levels were established for Installation Restoration Sites Number/DSERT Site Number Areas where remedial action will be required with some investigatory effort to determine extent of area Levels are as follows: A - Highest Priority; B - Medium Priority; C - Lowest Priority (no RA likely) Designation is based on described quantity of material, potential hazard to human health and the environment, and form of material (solid or liquid) A pre-design investigation will be conducted at Priority Sites A and B. These sites are shaded in this table

(c) According to the available information, burning in this area dated back to the 1940s and included chloroacetophenone (CN) canisters, fuses, and smokes, in addition to sanitary wastes. Operations were conducted in pits and incorporated the weekly cleanup of residue and garbage in addition to material. The ash was then allegedly buried in the north end of Dunn Field.

(d) According to available information, USATHAMA (1982) Installation Assessment Site 31 is located in the southwest portion of Dunn Field This site was reportedly used for burning/disposal of smoke pots, CN (tear gas) grenades and souvenir ordnance, which included a 3.2 mortar round This area was covered by the bauxite storage pile (Site 64) Installation Site 31 was not designated as an IRP site or given a DSERTS site number However, the site is now included in DSERTS Site 64

(e) According to an April 15, 2003 email from the Defense Logistics Agency - DDC (New Cumberland) to DDC (Memphis) and CEHNC, DSERTS Site 64 will include the CC-2 Impregnite Burial Site and Installation Assessment Site 31 as a result of the proximity of all three sites and because Site 64 encompasses both of the other two sites.

TABLE 2-2
Summary of Response Actions for Dunn Field (OU-1) Sites
Rev 2 Memphis Depot Dunn Field Record of Decision

INSTALLATION RESTORATION (RCRA) SITES NUMBER	DSERTS SITE NUMBER[1]	SITE NAME	SITE DESCRIPTION	PROPOSED RESPONSE ACTION
Northeast Open Area				
19	19	Former Tear Gas Canister Burn Site	This site is located at the southern boundary of the Northeast Open Area, approximately 525 feet from the eastern boundary and 825 feet from the northern boundary of Dunn Field. The aerial photo review indicated evidence of ground disturbance suggesting past burial activity Historical disposal records suggest a maximum burial depth of 10 feet below ground surface (bgs). According to the available information, burning in this area was from 1955 to 1960 and included chloroacetophenone (CN) canisters, fuses, and smokes, in addition to sanitary wastes. Operations were conducted in pits and incorporated the weekly cleanup of residue and garbage in addition to material. The ash was then allegedly buried in the north end of Dunn Field Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 19 as part of the Northeast Open exposure unit, and the area is available for unrestricted use.	No Further Action
20	20	Probable Asphalt Burial Site	According to Depot records, Site 20 is a former asphalt burial site located approximately 570 feet from the eastern boundary and 360 feet from the northern boundary of Dunn Field. According to the Installation Assessment (USATHMA, 1982) both asphalt and roofing gravel were dumped in surface fill at this location. The maximum burial depth as stated in historical records is 10 feet bgs. The Base Cleanup Plan indicates that debris was removed in 1981 Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 20 as part of the Northeast Open exposure unit, and the area is available for unrestricted use	No Further Action
21	21	XXCC-3 Stabilized Impregnite Burial Site	Site 21 is approximately 350 feet from the northern boundary of Dunn Field, adjacent to the eastern boundary The boundary of Site 21 was estimated using the Installation Assessment (USATHMA, 1982). This site includes two trenches, each 260 feet by 25 feet. The depth of burial is not indicated; however, it is believed to be less than 10 feet because the deepest documented burial site is 8 feet for Site 12. The impregnite (XXCC-3), a wax-covered textile, is also believed to have been buried here XXCC-3 was produced by mixing CC-2 with zinc oxide (ZnO). CC-2 was a chemical produced by E. I DuPont de Nemours during the 1940s and 1950s. Impregnite (unstabilized, CC-2 and stabilized, XXCC-3 [stabilized with zinc oxide]) was used for impregnating or permeating protective clothing after laundering to protect personnel against the action of vesicant-type chemical agents. CC-2, (sym. dichlor-bis(2,4,6 trichlorphenyl)urea) a labile (unstable) organic compound, is difficult to detect because of its instability The results of SVOC analysis are used to evaluate whether refractory organics are present that could have resulted from the breakdown of the structure of the urea. In particular, semivolatile chlorinated phenyl compounds and chlorinated aromatics probably would be present if the substance has undergone degradation Additional information from the South Research Institute in Birmingham, Alabama, indicates the impregnite (CC-2) is finely ground N-bis(2,4,6-trichlorophenyl)dichlorourea It appeared as a fine white granular crystal with a chlorine-like odor It deteriorates upon exposure to moisture Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 21 as part of the Northeast Open exposure unit, and the area is available for unrestricted use.	No Further Action
50	50	Dunn Field Northeastern Quadrant Drainage Ditch	This site is a concrete-lined drainage ditch that carries storm water runoff from the eastern part of Dunn Field and from the adjoining property on the east to the storm water discharge point at the northern boundary of Dunn Field The ditch is primarily located in the rolling grassy area of Dunn Field and collects storm water runoff from Sites 19, 20, 21, 60, 62, and 85. Pesticides and other constituents from these sites may have been transmitted to receiving waters through Site 50.Site 50 is approximately 1,000 feet long (about 3 feet wide) and is located in the northeastern corner of Dunn Field The concrete channel was constructed in the 1940s and has been used since then for storm water runoff. Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 50 as part of the Northeast Open exposure unit, and the area is available for unrestricted use.	No Further Action
60 [2]	60	Pistol Range Impact Area/Bullet Stop	According to Depot records, Site 60 is a former pistol range used for marksmanship training. The aerial photograph review indicated that the range was constructed between 1953 and 1958. The time period that Site 60 was used for target practice is unknown, but the Installation Assessment report (USATHMA, 1982) states that the "area was abandoned in the late 1970s and the building [1184] is currently being used for pesticide storage." There is no documented evidence that this site was used for storage or handling of hazardous materials A removal action for lead in surface soil was conducted in 2003, and the area is available for unrestricted use.	No Further Action[4]
62	62	Bauxite Storage	Site 62 was comprised of three bauxite stockpiles covering approximately 4 acres located in the eastern half of Dunn Field These storage areas contained only bauxite, a nonhazardous commodity Bauxite is a naturally occurring mixture of hydrous aluminum oxides (diaspra, gibbsite, and boehmite) that contains iron The primary use of bauxite is aluminum ore production. Bauxite was stored continuously from June 14, 1950, until 1999, when it (the stockpiled material) was removed from the Depot. Based on the findings from the Dunn Field RI and BRA, there no RAOs for Site 62 as part of the Northeast Open exposure unit, and the area is available for unrestricted use	No Further Action
85 [2]	85	Old Pistol Range Building 1184/Temporary Pesticide Storage	From historical documents, Site 85 appears to be the location of a former pistol range that preceded the range now designated as Site 60, and Building 1184 was part of the range. After the range was abandoned in the late 1970s and the building was used for temporary pesticide storage The building at Site 85 was razed in 2003 as part of the removal action (see Site 60) The area is available for unrestricted use	No Further Action[4]
Disposal Area				
1[3]	1	Mustard and Lewisite Training Sets Burial Site (1955)	This site was suspected of containing Chemical Agent Identification Sets (CAIS) containing small quantities of diluted agent and is located in the Disposal Area of Dunn Field. Historical documents suggested the CAIS might have been placed in PIGS (metal containment vessels exclusively used for CWM) Beginning in May 2000, the entire target area was excavated, but neither CAIS nor PIGS were recovered However, 24 jars labeled as "HS" (sulfur mustard) were recovered, but they were tested to be free of CWM. No CWM or CWM contaminated soil was found within the investigation area of Site 1 In August 2000, the removal action was complete at Site 1	No Further Action (per CWM Removal Action)[4]
2	2	Ammonia Hydroxide Burial Site	This site is believed to be a small excavation into which 1 gallon of ammonia hydroxide and 1 gallon of acetic acid were buried in 1955 These materials are considered to have low toxicity and a local influence because of their small volume Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 2 as part of the Disposal Area exposure unit.	No Further Action[4]
3	3	Mixed Chemical Burial Site (Orthotoluidine Dihydrochloride)	This site is estimated to be approximately 30 feet long and 10 feet wide. It reportedly contains about 3,000 quarts of various chemicals, plus 5 cubic feet of orthotoluidine dihydrochloride buried in 1955. As a result, toxicity potential is unknown based on the description of "various chemicals"	Remedial Action Planned
4	4	POL Burial Site (13, 55-Gallon Drums of Oil, Grease and Paint)	This site is a trench containing approximately 13 drums of oil, grease, and paint thinner that were disposed of in the mid-1950's These materials are considered to be both potentially toxic and highly mobile Since the drums were placed 50 years ago, they may have corroded and may no longer be intact.	Remedial Action Planned
4 1	90	POL Burial Site (32, 55-Gallon Drums of Oil, Grease and Thinner)	This site is similar to Site 4, except that it contains approximately 32 drums of oil, grease, or thinners that were disposed of in the mid-1950's. These materials are considered to be both potentially toxic and highly mobile. Since the drums were placed 50 years ago, they may have corroded and may no longer be intact	Remedial Action Planned
5	5	Methyl Bromide Burial Site A	This site reportedly contains a single container of methyl bromide (bromomethane) approximately 3 cubic feet in volume from 1995 If the container is broken, local/limited contamination by this material may have resulted Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 5 as part of the Disposal Area exposure unit.	No Further Action[4]
6	6	40,037 Units of Eye Ointment Burial Site	This site contains approximately 40,037 units of eye ointment, estimated to be buried in boxes at a maximum depth of 6 feet in 1955. This material is non-hazardous and does not pose a known environmental hazard. Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 6 as part of the Disposal Site exposure unit	No Further Action[4]

TABLE 2-2
Summary of Response Actions for Dunn Field (OU-1) Sites
Rev 2 Memphis Depot Dunn Field Record of Decision

INSTALLATION RESTORATION (RCRA) SITES NUMBER	OSERTS SITE NUMBER[1]	SITE NAME	SITE DESCRIPTION	PROPOSED RESPONSE ACTION
7	7	Nitric Acid Burial Site	This site is a trench containing approximately 1,700 quart bottles of nitric acid from 1954. Nitric acid is considered to have low toxicity, but could cause a low pH in the area, or mobilize metals, or both	Remedial Action Planned
8	8	Methyl Bromide Burial Site B	This site is an excavation containing approximately 3,768 cans of methyl bromide (bromomethane) from 1954 Burial depth is estimated to be 7 feet. The hazard is similar to that of Site 5, but the quantity is significantly greater and that makes this a higher priority site *(During the Dunn Field RI, bromomethane was not detected in the surface soil or subsurface soil on Dunn Field where tested during the RI [>250 samples]. Bromomethane was detected in 5 monitoring wells [MW-13, -69. -70, -76 & -77] in 2001 at low estimated concentrations ranging from 0.2J ug/L to 0 6J ug/L. No bromomethane was detected in the recovery wells. Bromomethane was not detected in groundwater samples prior to 2001 [a total of >500 groundwater samples] There is no federal or state drinking water standard for bromomethane in groundwater.)*	Remedial Action Planned
9	9	Ashes and Metal Burial Site	Ashes and metal refuse from the Former Miscellaneous Burn Site (Site 24) was buried to an unknown depth in this site Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 9 as part of the Disposal Area exposure unit.	No Further Action[4]
10	10	Solid Waste Burial Site (Near MW-10)	This a solid waste burial site approximately 100 feet long and 50 feet wide containing metal, cans, ash, broken glass, and other similar material last used in 1955. Information indicates the waste was located in a zone from 3.5 to 10 feet below the ground surface Material descriptions suggest that the burial site contains little organic matter The site is not expected to contain hazardous materials, but the actual contents of the buried material are unknown	Remedial Action Planned
11	11	Trichloroacetic Acid Burial Site	This site is an excavation containing 11 gallons of the herbicide trichloroacetic acid in 1,433 1-ounce bottles buried in 1965 to a depth of 6 feet. This is a reportedly unstable chemical, with a transient influence on pH and with low toxicity	Remedial Action Planned
12 & 12 1	12	Sulfuric Acid and Hydrochloric Acid Burial Site	These sites (12 and 12.1) consist of 3 trenches containing a total of 30 pallets of sulfuric and hydrochloric acid buried in 1967 These below-grade materials are not expected to be extremely toxic, but could affect the pH in the local area and cause metals to become more mobile	Remedial Action Planned
13	13	Mixed Chemical Burial Site	This site contains approximately 32 cubic yards of mixed chemicals, acid and detergents, plus approximately 8,100 pounds of unknown solids. The area is estimated at approximately 35 feet wide by 50 feet long, approximately 8 feet deep.	Remedial Action Planned
14	14	Municipal Waste Burial Site B (Near MW-12)	This is a solid waste burial site reported to contain paper, food, and other similar sanitary landfill materials. The trench reportedly has horizontal dimensions of 40 feet by 80 feet and waste depths ranging from 6 to 10 feet. Based on the known contents, this is a low priority site. Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 14 as part of the Disposal Area exposure unit.	No Further Action[4]
15	15	Sodium Burial Sites	These sites (15, 15.1 and 15.2) comprise an area approximately 100 feet long and 20 feet wide containing 14 discrete trenches with sodium salt, sodium phosphate, chlorinated lime, acid wastes, and various medical supplies buried in 1968 The disposal area is estimated at approximately 8 feet deep. Sodium salts and lime materials are typically not considered to be hazardous materials: however, the contents are not clearly identified.	Remedial Action Planned
15 1	91	Sodium Phosphate Burial		Remedial Action Planned
15 2	92	14 Burial Pits Na2PO4, Sodium, Acid, Medical Supplies, and Chlorinated Lime		Remedial Action Planned
16	16	Unknown Acid Burial Site	These sites (16 and 16 1) are disposal areas containing unknown acid materials. Records indicate disposal of one pallet of an unknown acid Depending upon the quantity, this acid could adversely affect the local pH and groundwater	Remedial Action Planned
16 1	93	Acid Burial Site		Remedial Action Planned
17	17	Mixed Chemical Burial Site C	This site is a 20-foot by 30-foot disposal area containing an unknown quantity of herbicides, medical supplies, and cleaning compounds. The depth of the disposal trench is estimated at 8 feet	Remedial Action Planned
18	18	Plane Crash Residue	Sites 18, 22, 23, and 86 contain plane crash residue, hardware (nuts and bolts), and construction/food debris, and food supplies, respectively Based on the findings from the Dunn Field RI and BRA, there are RAOs for Sites 18, 22, 23 and 86 as part of the Disposal Area exposure unit.	No Further Action[4]
22	22	Hardware Burial Site	See description for Site 18.	No Further Action[4]
23	23	Construction Debris and Food Burial Site	See description for Site 18.	No Further Action[4]
24-A[3]	24	Bomb Casing Burial Site	This site is the confirmed burial location for 29 bomb casings that were used to transport mustard agent from Germany to the U.S after World War II and is located in the Disposal Area of Dunn Field The bomb casings were buried at this location after being drained into a neutralization pit. Beginning in August 2000, all 29 bomb casings were recovered at this site No mustard or other CWM was discovered at this site, however, 900 cubic yards of soil contaminated with mustard degradation by-products were transported and disposed offsite In November 2000, the removal action was complete at this site	No Further Action (per CWM Removal Action)[4]
61	61	Buried Drain Pipe	Site 61 is a buried pipe that drains surface runoff from the southwestern portion of the Northeast Open Area and extends across the subsurface northern portion of the Disposal Area Based on the findings from the Dunn Field RI and BRA, no RAOs were required for Site 61 as part of the Disposal Area exposure unit.	No Further Action[4]
63	63	Aboveground Fluorspar Storage	Site 63 was comprised of seven fluorspar stockpiles covering approximately 6 acres located in the eastern half of Dunn Field. These storage areas contained only fluorspar, a non-hazardous commodity Fluorspar, the commercial name for fluorite, is a naturally occurring mineral composed of calcium and fluorine. The primary use of fluorspar is in glass and enamel production, as well as the manufacture of hydrofluoric acid. Fluorspar was stored continuously from June 14, 1950, until 1999, when it (the stockpiled material) was removed from the Depot. Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 63 as part of the Disposal Area exposure unit	No Further Action[4]
64	64	Aboveground Bauxite Storage	Site 64 was comprised of one, relatively large bauxite stockpile covering most of the southwestern portion of Dunn Field Site 64 was located in the southwestern quadrant of Dunn Field extending from the Stockpile Area into the southern portion of the Disposal Area to the north. Historical information indicates that Site 64 was placed over Site 24-B This storage area contained only bauxite Bauxite was stored continuously from June 14, 1950, until 1972, when it (the stockpiled material) was removed from the Depot. Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 64 as part of the Disposal Area exposure unit.	No Further Action for the Portion of Site 64 in the Disposal Area[4] *(see the Site 64 description below in the Stockpile Area)*
86	86	Food Supplies Burial Site	See description for Site 18	No Further Action[4]

TABLE 2-2
Summary of Response Actions for Dunn Field (OU-1) Sites
Rev 2 Memphis Depot Dunn Field Record of Decision

INSTALLATION RESTORATION (RCRA) SITES NUMBER	DSERTS SITE NUMBER[1]	SITE NAME	SITE DESCRIPTION	PROPOSED RESPONSE ACTION
Stockpile Area				
24-B[3]	24	Neutralization Pit for the Contents of the 29 Bomb Casing used to Transport Mustard Agent	This site is the confirmed location of the neutralization pit for the contents of the 29 bomb casings and is located in the Stockpile Area of Dunn Field. Beginning in November 2000, 19 cubic yards of mustard contaminated soil and 14 cubic yards of soil contaminated with mustard degradation by-products were transported and disposed offsite In March 2001, the removal action was complete at this site.	No Further Action (per CWM Removal Action)[4]
62	62	Aboveground Bauxite Storage	Site 62 was comprised of three bauxite stockpiles covering approximately 4 acres located in the eastern half of Dunn Field. The northern-most former stockpile is located in the Northeast Open Area. These storage areas contained only bauxite, a non-hazardous commodity Bauxite is a naturally occurring mixture of hydrous aluminum oxides (diaspra, gibbsite, and boehmite) that contains iron The primary use of bauxite is aluminum ore production Bauxite was stored continuously from June 14, 1950, until 1999, when it (the stockpiled material) was removed from the Depot. Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 62 as part of the Stockpile exposure unit	No Further Action
63	63	Aboveground Fluorspar Storage	Site 63 was comprised of seven fluorspar stockpiles covering approximately 6 acres located in the eastern half of Dunn Field. These storage areas contained only fluorspar, a non-hazardous commodity Fluorspar, the commercial name for fluorite, is a naturally occurring mineral composed of calcium and fluorine The primary use of fluorspar is in glass and enamel production, as well as the manufacture of hydrofluoric acid. Fluorspar was stored continuously from June 14, 1950, until 1999, when it (the stockpiled area) was removed from the Depot. Based on the findings from the Dunn Field RI and BRA, there are no RAOs for Site 63 as part of the Stockpile exposure unit.	No Further Action
64	64	Aboveground Bauxite Storage (1949 to 1972)	Site 64 was comprised of one, relatively large bauxite stockpile covering most of the southwestern portion of Dunn Field (Figure 12-2). Site 64 was located in the southwestern quadrant of Dunn Field extending from the Stockpile Area into the southern portion of the Disposal Area to the north. Historical information indicates that Site 64 was placed over Site 24-B. This storage area contained only bauxite. Bauxite was stored continuously from June 14, 1950, until 1972, when it (the stockpiled area) was removed from the Depot.	No Further Action[4]
--	64[a]	CC-2 Impregnite Burial Site (86,100 Pounds in 1947) and Installation Assessment Site 31	The alleged CC-2 burial trench, as documented in the ASR, is suspected as being located adjacent/near to Site 24-B and was not directly investigated during the RI field activities due to the pending CWM removal action (that was completed in 2001). As stated in Section 8 of the Dunn Field RI, XXCC-3 was produced by mixing CC-2 with zinc oxide (ZnO). CC-2 was a chemical produced by E I DuPont de Nemours during the 1940s and 1950s CC-2, (sym. dichlor-bis(2,4,6 trichlorphenyl)urea) a labile (unstable) organic compound, is difficult to detect because of its instability Additional information from the South Research Institute in Birmingham, Alabama, indicates the impregnite (CC-2) is finely ground N-bis(2,4,6-trichlorophenyl)dichlorourea. It appeared as a fine white granular crystal with a chlorine-like odor It deteriorates upon exposure to moisture However, the findings of the investigation at Site 21 (XXCC-3 [stabilized impregnite] Burial Site) in the Northeast Open Area did not indicate an unacceptable risk to the groundwater or human health. USATHAMA (1982) Installation Assessment Site 31 is located in the southwest portion of Dunn Field, adjacent to the CC-2 burial site. This area was reportedly used for burning/disposal of smoke pots, CN (tear gas) grenades and souvenir ordnance, which included a 3 2 mortar round This area was Installation Site 31 was not designated as an IRP site or given a DSERTS site number However, the site is now included in DSERTS Site 64 The CC-2 and Installation Site 31 area was covered by the bauxite storage pile (Site 64). The site is now included in DSERTS Site 64 Additional pre-design investigation is planed for this location during the RD/RA process to determine if these former burial sites pose an unacceptable threat to groundwater or human health.	Remedial Action Planned

Notes

[1] Defense Site Environmental Restoration Tracking System (DoD Database)

[2] Removal action for Sites 60/85 (CH2M HILL, 2002) was completed in early 2003 following EE/CA and Action Memorandum.

[3] CWM removal actions at sites are documented in the Final Chemical Warfare Materiel Investigation/Removal Action Report, dated December 2001 (UXB International, Inc).

[4] This Site does not require remedial action, however, it is coincidentally located in the Disposal Area where Land Use Controls apply to the entire area.

SS:	Screening Site
RI	Remedial Investigation
RA.	Remedial Action
NFA.	No Further Action
CWM.	Chemical Warfare Materiel
Na2PO4	Sodium Phosphate
POL	Petroleum, Oil, and Lubricants
XXCC-3/CC-2:	Stabilized/Unstabilized Impregnite for Impregnating Clothing Used to Protect Personnel against the Action of Vesicant-Type Chemical Agents

[a] According to an April 15, 2003 email from the Defense Logistics Agency - DDC (New Cumberland) to DDC (Memphis) and CEHNC, DSERTS Site 64 will include the CC-2 Impregnite Burial Site and Installation Assessment Site 31 as a result of the proximity of all three sites and because Site 64 encompasses both of the other two sites

TABLE 2-3A
Summary of the Field Investigations for the Dunn Field RI
Rev. 1 Memphis Depot Dunn Field Record of Decision

Field Investigation	Event	Date	Comments
Passive Soil Gas Survey (CH2M HILL)	Phase I	Aug-1998	Disposal Area only
	Phase II	Oct-1998	Expanded to Northeast Open Area & Stockpile Area
EE/CA Investigation of the CWM Sites (Parsons ES)	Geophysical Investigation	Feb through Jul-1998	Investigating the CWM sites (1, 24-A & 24-B) in the Disposal Area & Stockpile Area. 6 soil borings & 6 monitoring wells installed & sampled.
	Soil Borings & Sampling	Aug-1998	
	Monitoring Well Installation & Sampling	Aug-1998	
RI Sampling (CH2M HILL)	Initial Soil, Sediment and Surface Water Sampling	Mar & Apr-1999	Northeast Open Area & Disposal Area
	Supplemental Soil Sampling	Oct-1999	Stockpile Area
Expanded RI Sampling (CH2M HILL)	Soil Borings & Sampling	Oct & Nov-2000	Disposal Area & off-site to the West of Dunn Field
	Monitoring Well Installation	Oct, Nov & Dec-2000	Installed 5 well on-site in the Disposal Area & 6 well off-site to the west & northwest of Dunn Field.
Dunn Field Groundwater Sampling (CH2M HILL)	1st Quarter	Jan & Feb-1996	33 Dunn Field wells sampled
	2nd Quarter	Jun-1997	33 Dunn Field wells sampled
	3rd Quarter	Sep-1997	33 Dunn Field wells sampled
	4th Quarter	Mar-1998	39 Dunn Field wells sampled
	5th Quarter	Oct & Nov-1998	34 Dunn Field wells sampled
	MNA Study	Mar-2000	8 Dunn Field wells sampled
	Expanded RI	Jan & Feb-2001	9 wells initially sampled in Jan-2001 & additional 3 wells were sampled in Feb-2001 with diffusion bag samplers

TABLE 2-3A
Summary of the Field Investigations for the Dunn Field RI
Rev. 1 Memphis Depot Dunn Field Record of Decision

Field Investigation	Event	Date	Comments
Groundwater Extraction System Performance Monitoring (OHM/IT Corp. [Year 1] & Jacobs Engineering [Years 2 through 5])	Year 1 of Operation – Quarters 1, 2, 3 & 4	Feb, May, Aug & Nov-1999	Quarterly sampled 10 monitoring wells & 7 recovery wells
	Year 2 of Operation – Quarters 1, 2, 3 & 4	Feb, May, Aug & Nov-2000	Quarterly sampled 20 monitoring wells & 11 recovery wells
	Year 3 of Operation – Semi-Annual*	April, October - 2001	Semi-annually sampled 20 monitoring wells & 11 recovery wells
	Year 4 of Operation – Semi-Annual*	April, October - 2002	Semi-annually sampled 26 monitoring wells & 11 recovery wells
	Year 5 of Operation – Semi-Annual*	April-2003	Semi-annually sampled 23 monitoring wells & 11 recovery wells
CWM Site Excavation Sampling (UXB & CH2M HILL)	Site 1	Jun-2000	2 excavation floor samples were collected for TAL/TCL analyses (Disposal Area)
	Site 24-A	Oct & Nov-2000	1 excavation floor & 2 sidewall samples were collected for TAL/TCL analyses (Disposal Area)
	Site 24-B	Mar-2001	2 excavation floor & 1 sidewall samples were collected for TAL/TCL analyses (Stockpile Area)

CWM = chemical warfare materiel
EE/CA = Engineering Evaluation/Cost Analysis
TAL/TCL = target analyte list/target compound list
* Years 3, 4, and 5 of the operation and maintenance of the extraction system were conducted after submission of the Dunn Field RI but are part of the continued sampling and data collection program at Dunn Field.

TABLE 2-3B
Number of Samples Collected during the Dunn Field RI
Rev 0 Memphis Depot Dunn Field ROD

Media Type	Sample Event	Sample Start Date	Sample End Date	Dioxins	Explosives	Gases	General Chemistry	Geotechnical	Herbicides	Ignitability	Metals	Miscellaneous Organics	Organophosphorus Pesticides	Pesticide/PCB	Reactive CN/H2S	Semivolatile Orgainics	Thiodiglycol	TPH	Tritium	Volatile Organics
Soil/Sediment	Background Sampling*	Oct-95	Oct-95	67					67		67			67		67				67
Soil/Sediment	Dunn Field Initial Sampling	Sep-98	Oct-99	4	29		8	6	58		134			105		109	5			217
Soil/Sediment	Periodic Groundwater Sampling*	Jan-96	Nov-98				4	5	9		9			9		8				9
Soil/Sediment	MNA Treatability Study*	Feb-00	Feb-00				1													
Soil/Sediment	Supplemental Dunn Field RI Sampling	Jun-00	Mar-01				24		3	3	11			11	3	11				56
Soil/Sediment	Parsons EE/CA	Aug-98	Aug-98		45						45	45					45			
Soil/Sediment	Supplemental Dunn Field Well Installation and Sampling	Sep-01	Oct-01				20									12				27
			Total :	*71*	*74*	*0*	*57*	*11*	*137*	*3*	*266*	*45*	*0*	*192*	*3*	*207*	*50*	*0*	*0*	*376*
Water	Background Sampling*	Oct-95	Oct-95	23					23		45			23		23				23
Water	Dunn Field Initial Sampling	Mar-99	Oct-99	1			1		1		11			11		11	1			9
Water	Periodic Groundwater Sampling*	Jan-96	Nov-98			30	89		35		264			35		181			2	277
Water	MNA Treatability Study*	Mar-00	Mar-00				17													18
Water	Supplemental Dunn Field RI Sampling	Dec-00	Mar-01																	37
Water	Groundwater O&M Sampling	Feb-99	Dec-00				37		8		58			16		66				218
Water	Parsons EE/CA	Aug-98	Aug-98		8						8	8					8			
Water	Supplemental Dunn Field Well Installation and Sampling	Sep-01	Dec-01													1				116
			Total :	*24*	*8*	*30*	*144*	*0*	*67*	*0*	*386*	*8*	*0*	*85*	*0*	*282*	*9*	*0*	*2*	*698*

** = Samples were collected from Dunn Field and Main Installation*
Water = Groundwater and Surface Water

779 94

Table 2-4A

Frequency of Detection for COPCs in All Media (except Groundwater) Sampled in the Northeast Open Area

Rev. 2 Memphis Depot Dunn Field ROD

Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration
Metals							
Surface Soils							
MG/KG	ANTIMONY	16	2	5	24	15	7.0
MG/KG	CHROMIUM, TOTAL	16	16	9	239	33	24.8
MG/KG	LEAD	16	16	14	2100	175	30.0
MG/KG	THALLIUM	16	9	0.2	0.6	0.5	--
OC Pesticides							
Sediments							
MG/KG	DIELDRIN	2	2	0.08	0.2	0.1	0.011
Surface Soils							
MG/KG	DIELDRIN	15	13	0.002	5	1	0.086
Surface Water							
MG/L	DIELDRIN	2	1	0.00007	0.00007	0.00007	--
Surface Water							
MG/L	PHENANTHRENE	2	1	0.0005	0.0005	0.0005	--
Volatile Organics							
Subsurface Soils							
MG/KG	1,1,2,2-TETRACHLOROETHANE	20	1	0.01	0.01	0.01	--
MG/KG	METHYLENE CHLORIDE	20	1	0.07	0.07	0.07	--
MG/KG	TOTAL 1,2-DICHLOROETHENE	20	1	0.02	0.02	0.02	--
MG/KG	Total Xylenes	20	1	1	1	1	0.002
MG/KG	TRICHLOROETHYLENE (TCE)	20	5	0.0004	0.1	0.04	--
Surface Soils							
MG/KG	1,1,2,2-TETRACHLOROETHANE	9	2	0.001	0.005	0.003	--
MG/KG	TRICHLOROETHYLENE (TCE)	9	2	0.004	0.7	0.4	--

Note. Data evaluated includes field duplicates and normal samples (2 feet and below).

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

TABLE 2-4B

Frequency of Detection for COPCs in All Media (except Groundwater) in the Disposal Area

Rev. 2 Memphis Depot Dunn Field ROD

Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration
Metals							
Subsurface Soils							
MG/KG	ANTIMONY	53	16	1.1	5.9	2.9	--
MG/KG	ARSENIC	53	49	2.2	35.6	9.13	17
MG/KG	CHROMIUM, TOTAL	53	53	1.6	74.6	19.2	26.4
MG/KG	THALLIUM	53	8	0.31	0.64	0.4	--
MG/KG	ZINC	53	25	2.2	2650	155	114
Sediments							
MG/KG	ARSENIC	2	2	4.8	14.1	9.45	12
Surface Soils							
MG/KG	ALUMINUM	48	48	6070	31100	13764	23810
MG/KG	ARSENIC	48	48	1.9	43.7	11	20
MG/KG	CHROMIUM, TOTAL	47	47	9.5	212	30.2	24.8
MG/KG	LEAD	48	48	7.4	1020	108	30
MG/KG	ANTIMONY	48	22	1.5	355	22.2	7
MG/KG	THALLIUM	48	20	0.22	0.68	0.46	--
OC Pesticides							
Sediments							
MG/KG	DIELDRIN	2	1	0.0617	0.0617	0.062	0.011
Surface Soils							
MG/KG	DIELDRIN	28	20	0.00054	0.964	0.1	0.086
Polynuclear Aromatic Hydrocarbons							
Subsurface Soils							
MG/KG	BENZO(a)ANTHRACENE	28	10	0.0041	0.74	0.16	--
MG/KG	BENZO(b)FLUORANTHENE	28	7	0.02	1.2	0.31	--
Sediments							
MG/KG	BENZO(a)ANTHRACENE	2	2	1.4	5.4	3.4	2.9
MG/KG	BENZO(a)PYRENE	2	2	1.6	5.9	3.75	2.5
MG/KG	BENZO(b)FLUORANTHENE	2	2	1.6	7.4	4.5	2.2
MG/KG	BENZO(k)FLUORANTHENE	2	2	1.6	5	3.3	2.3
MG/KG	CHRYSENE	2	2	1.6	5.8	3.7	3.2
MG/KG	DIBENZ(a,h)ANTHRACENE	2	2	0.3	1.8	1.05	0.7
MG/KG	INDENO(1,2,3-c,d)PYRENE	2	2	1.3	5.1	3.2	1.7
Surface Soils							
MG/KG	BENZO(a)ANTHRACENE	29	19	0.0093	5.8	0.82	0.71
MG/KG	BENZO(a)PYRENE	29	19	0.057	6.7	0.89	0.96
MG/KG	BENZO(b)FLUORANTHENE	29	17	0.074	8.2	1.17	0.9
MG/KG	CHRYSENE	29	19	0.068	6.3	0.9	0.94
MG/KG	DIBENZ(a,h)ANTHRACENE	29	15	0.02	1.6	0.27	0.26
Surface Water							
MG/L	BENZO(b)FLUORANTHENE	2	2	0.00028	0.00035	0.00032	--
MG/L	CHRYSENE	2	2	0.00032	0.00046	0.00039	--
MG/L	INDENO(1,2,3-c,d)PYRENE	2	1	0.00027	0.00027	0.00027	--
MG/L	PHENANTHRENE	2	2	0.0003	0.00034	0.00032	--
Semivolatile Organics							
Subsurface Soils							
MG/KG	2,4,6-TRICHLOROPHENOL	28	1	0.27	0.27	0.27	--
MG/KG	PENTACHLOROPHENOL	28	1	0.22	0.22	0.22	--
Sediments							
MG/KG	CARBAZOLE	2	2	0.37	1.6	0.99	1.1
Surface Soils							
MG/KG	CARBAZOLE	29	8	0.049	2	0.51	0.067
Volatile Organics							
Subsurface Soils							
MG/KG	1,1,2,2-TETRACHLOROETHANE	155	56	0.003	160	6.18	--
MG/KG	1,1,2-TRICHLOROETHANE	155	25	0.0003	2.2	0.18	--
MG/KG	1,2-DICHLOROETHANE	155	5	0.001	0.046	0.016	--
MG/KG	CARBON TETRACHLORIDE	155	16	0.0005	6.8	0.52	--
MG/KG	CHLOROFORM	154	37	0.0008	14	0.94	--
MG/KG	METHYLENE CHLORIDE	155	20	0.0005	0.039	0.0071	--
MG/KG	TETRACHLOROETHYLENE(PCE)	155	56	0.0004	4.4	0.16	--
MG/KG	TOTAL 1,2-DICHLOROETHENE	105	42	0.0006	190	7.93	--
MG/KG	TRICHLOROETHYLENE (TCE)	155	92	0.0005	460	7.89	--
MG/KG	VINYL CHLORIDE	155	15	0.002	7	0.64	--
Surface Soils							
MG/KG	TOTAL 1,2-DICHLOROETHENE	45	7	0.0009	0.87	0.16	--
MG/KG	1,1,2,2-TETRACHLOROETHANE	45	2	0.007	0.083	0.045	--
MG/KG	TRICHLOROETHYLENE (TCE)	45	11	0.0009	0.85	0.16	--
MG/KG	VINYL CHLORIDE	45	1	0.11	0.11	0.11	--

Note: Data evaluated includes field duplicates and normal samples

MG/KG = milligram per kilogram

Background concentrations per the Background Sampling Program Report (May 1998)

-- = no background concentration value established for that constituent

TABLE 2-4C
Frequency of Detection for COPCs in All Media (except Groundwater) in the Stockpile Area
Rev 2 Memphis Depot Dunn Field ROD

Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration
Metals							
Subsurface Soils							
MG/KG	ARSENIC	25	24	0 83	19	8 17	17
MG/KG	CHROMIUM, TOTAL	25	25	7 2	35.8	16 2	26 4
MG/KG	VANADIUM	25	25	7 3	51.3	29 6	51 3
Surface Soils							
MG/KG	ALUMINUM	30	30	2460	52600	19179	23810
MG/KG	ARSENIC	30	30	1.4	25.5	11.2	20
MG/KG	BARIUM	30	30	22 4	297	117 2	234
MG/KG	CADMIUM	30	27	0 16	0.53	0 29	1 4
MG/KG	CHROMIUM, TOTAL	32	32	7.3	55.7	19 4	24 8
MG/KG	COBALT	30	30	1 5	20 3	7 09	18 3
MG/KG	LEAD	30	30	2 8	107	29 4	30
MG/KG	VANADIUM	30	30	8 7	96 6	31.5	48 4
OC Pesticides							
Surface Soils							
MG/KG	DIELDRIN	30	15	0 00081	0 13	0.026	0 086
Polyaromatic Hydrocarbons							
Surface Soils							
MG/KG	BENZO(a)ANTHRACENE	30	5	0.86	3	1 83	0 71
MG/KG	BENZO(a)PYRENE	30	5	0 9	3.8	2 22	0 96
MG/KG	BENZO(b)FLUORANTHENE	30	6	0 98	5.8	2.93	0 9
MG/KG	BENZO(g,h,i)PERYLENE	30	4	0 92	3.1	1 96	0 82
MG/KG	BENZO(k)FLUORANTHENE	30	2	1 8	2 3	2 05	0 78
MG/KG	CHRYSENE	30	5	1.1	5	2 82	0 94
MG/KG	DIBENZ(a,h)ANTHRACENE	30	3	0 78	1 1	0 9	0 26
MG/KG	FLUORANTHENE	30	7	1 1	6 2	3 37	1 6
MG/KG	INDENO(1,2,3-c,d)PYRENE	30	5	0 81	3 6	2	0 7
MG/KG	PHENANTHRENE	30	6	0 99	2 6	1 85	0 61
MG/KG	PYRENE	30	7	0 89	6	3 04	1 5
Volatile Organics							
Surface Soils							
MG/KG	CARBON DISULFIDE	30	1	0 003	0 003	0 003	0 002
MG/KG	METHYL ETHYL KETONE (2-BUTANONE	30	10	0 007	0 043	0 016	0.002
MG/KG	TOLUENE	30	2	0 0009	0.012	0 0065	0 002
MG/KG	XYLENES, TOTAL	30	5	0 003	0 015	0 0084	0 009

Note· Data evaluated includes field duplicates and normal samples (2 feet and below)
mg/kg = milligrams per kilogram
Background concentrations per the Background Sampling Program Report (May 1998)
-- = no background concentration value established for that constituent

Table 2-4D

Frequency of Detection of COPCs (Organics) for Dunn Field Groundwater*

Rev 2 Memphis Depot Dunn Field ROD

Parameter Name	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Units	Background Values	Number Background Exceedances
OC Pesticides									
HEPTACHLOR EPOXIDE	37	4	0.0000086	J	0 000014	J	MG/L	–	
Semivolatile Organics									
bis(2-ETHYLHEXYL) PHTHALATE	166	6	0.001	J	0.003	J	MG/L	–	
Volatile Organics									
1,1,2,2-TETRACHLOROETHANE	444	155	0.0006	J	33	J	MG/L	–	
1,1,2-TRICHLOROETHANE	444	96	0.00032	J	0.0394	=	MG/L	–	
1,1-DICHLOROETHANE	444	44	0.0001	J	0.0189	=	MG/L	–	
1,1-DICHLOROETHENE	444	87	0.0002	J	0.17	=	MG/L	2.00E-03	74
1,2-DICHLOROETHANE	444	24	0.0002	J	0 0278	=	MG/L	–	
1,2-DICHLOROPROPANE	444	1	0.0002	J	0 0002	J	MG/L	–	
BENZENE	444	13	0.0001	J	0 0043	=	MG/L	–	
BROMODICHLOROMETHANE	444	10	0.00047	J	0 0198	=	MG/L	–	
CARBON TETRACHLORIDE	444	160	0.000099	J	0 0796	=	MG/L	–	
CHLOROFORM	444	229	0 0001	J	1 61	=	MG/L	–	
cis-1,2-DICHLOROETHYLENE	246	167	0 0002	J	0 522	=	MG/L	–	
DIBROMOCHLOROMETHANE	444	3	0 0002	J	0 001	J	MG/L	–	
METHYLENE CHLORIDE	437	4	0 00012	J	0 28	J	MG/L	–	
TETRACHLOROETHYLENE(PCE)	444	261	0 0002	J	0 18	=	MG/L	1 00E-03	225
TOTAL 1,2-DICHLOROETHENE	198	61	0 001	J	0 76	=	MG/L	–	
trans-1,2-DICHLOROETHENE	246	156	0 0002	J	0.149	=	MG/L	–	
TRICHLOROETHYLENE (TCE)	444	306	0.00064	J	11 7	=	MG/L	–	
VINYL CHLORIDE	444	14	0.0001	J	0.008	=	MG/L	–	

Note Data evaluated includes field duplicates and normal samples

J = Estimated detection, Contaminant detected at or below laboratory detection limit

(=) Contaminant detected

MG/L = milligrams per liter

*Metals are not included in this table

Background concentrations per the Background Sampling Program Report (May 1998)

– = no background concentration value established for that constituent

TABLE 2-5

Physical and Chemical Properties of Selected COCs

Rev. 2 Memphis Depot Dunn Field ROD

Chemical Name	CAS Registry Number	Molecular Weight	Henry's Law Constant (dimensionless)		HENRY'S_LAW CONSTANT (atm*m³/mol)		Koc (cm³/gm)		Log Kow		Kd (L/kg) (pH = 7)		Water Solubility (mg\L)		Air Diffusivity (cm²/sec)		Water Diffusivity (cm²/sec)		BCF L/kg	BCF Species		Vapor Pressure mm Hg at 20C	
Metals																							
Antimony	7440-36-0	122									4.50E+01	q		c	6.20E-01	jj			<1	bluegill, whole body	e	1.00E+00	o
Arsenic	7440-38-2	75									2.90E+01	q			6.50E-01	jj			4.00E+00	bluegill (wb)	e	1.00E+00	o
Lead	7439-92-1	207									4.50E+00	g							4.50E+01	bluegill sunfish		1.00E+00	o
Thallium	7440-28-0	204									7.40E+01	q			5.90E-01	jj			3.40E+01	bluegill	c	1.00E+00	o
Pesticides/PCBs																							
Dieldrin	60-57-1	381	6.19E-04	q	1.51E-05	q	2.14E+04	q	5.37E+00	q			1.95E-01	q	1.25E-02	q	4.74E-06	q	5.80E+03	kk	y	1.78E-07	z
Semi-volatile Organics																							
Acenaphthene	83-32-9	154	6.36E-03	q	1.84E-04	p	7.08E+03	q	3.92E+00	o			4.24E+00	q	4.21E-02	q	7.69E-06	q	3.87E+02	bluegill (wb)	e	1.00E+01	o
Benzo(a)anthracene	56-55-3	228	1.37E-04	q	3.61E-06	p	3.98E+05	q	5.61E+00	n			9.40E-03	q	5.10E-02	q	9.00E-06	q	3.00E+01	kk	e	5.00E-09	o
Benzo(a)pyrene	50-32-8	252	4.63E-05	q	8.36E-07	p	1.02E+06	q	5.98E+00	n			1.62E-03	q	4.30E-02	q	9.00E-06	q	1.20E+01	bluegill (wb)	i	5.00E-09	o
Benzo(b)fluoranthene	205-99-2	252	4.55E-03	q	6.17E-06	p	1.23E+06	q	6.57E+00	o			1.50E-03	q	2.26E-02	q	5.56E-06	q				5.00E-07	o
Benzo(k)fluoranthene	207-08-9	252	3.40E-05	q	3.87E-05	c	1.23E+06	q	6.84E+00	o			8.00E-04	q	2.26E-02	q	5.56E-06	q				9.59E-11	o
Carbazole	86-74-8	167	6.26E-07	q			3.39E+03	q	3.23E+00	kk			7.48E+00	q	3.90E-02	q	7.03E-06	q					
Chrysene	218-01-9	228	3.88E-03	q	1.21E-06	p	3.98E+05	q	5.61E+00	n			1.60E-03	p	2.48E-02	q	6.21E-06	q				6.30E-09	o
Dibenz(a,h)anthracene	53-70-3	278	6.03E-07	q	1.12E-08	p	3.80E+06	q	5.97E+00	n			2.49E-03	q	2.02E-02	q	5.18E-06	q	1.35E+03	fathead minnow (wb)	gg	1.00E-10	o
Fluoranthene	206-44-0	202	6.60E-04	q	9.33E-06	p	1.07E+05	q	5.33E+00	n			2.06E-01	q	3.02E-02	q	6.35E-06	q	2.90E+03	kk	e	5.00E-06	o
Fluorene	86-73-7	166	2.61E-03	q	7.29E-05	p	1.38E+04	q	4.18E+00	o			1.98E+00	q	3.63E-02	q	7.88E-06	q	1.80E+03	bluegill (wb)	i	1.00E+01	o
Indeno(1,2,3-cd)pyrene	193-39-5	276	6.56E-05	q	4.85E-09	p	3.47E+06	q	6.58E+00	n			2.20E-05	q	1.90E-02	q	5.66E-06	q	3.00E+01	kk	e	1.00E-10	o
Methylnaphthalene, 2-	91-57-6	142	2.08E-02	v	4.99E-04	v	2.46E+03	v	3.86E+00	o			2.60E+01	q	6.80E-02	jj	7.20E-06	jj	3.10E+02	bluegill (wb)	oo	1.00E+01	o
Naphthalene	91-20-3	128	1.98E-02	q	4.82E-04	p	2.00E+03	q	3.30E+00	n			3.10E+01	q	5.90E-02	q	7.50E-06	q	3.10E+02	bluegill (wb)	i	8.20E-02	o
Pentachlorophenol	87-86-5	266	1.00E-06	q	1.42E-05	p	5.92E+02	q	5.01E+00	n			1.95E+03	q	5.60E-02	q	6.10E-06	q	1.30E+01	sheephead minnow	nn	1.10E-04	o
Phenanthrene	85-01-8	178	9.41E-03	c	2.26E-04	c	1.40E+04	c	4.46E+00	n			8.16E-01	o	6.20E-02	jj	7.47E-06	jj	2.63E+03	fathead minnow (wb)	gg	1.00E+00	o
Pyrene	129-00-0	202	4.54E-04	q	8.27E-06	p	1.05E+05	q	5.18E+00	o			1.35E-01	q	2.72E-02	q	7.24E-06	q	6.90E+01	rainbow trout (liver)	i	2.50E+00	o
Volatile Organics																							
1,2-Dichloroethene (trans)	156-60-5	97	3.85E-01	q	9.38E-03	q	5.25E+01	q	2.07E+00	q			6.30E+03	q	7.07E-02	q	1.19E-05	q	2.20E+01	kk	t	3.24E+02	k
Benzene	71-43-2	78	2.28E-01	q	5.00E-03	p	5.89E+01	q	2.13E+00	n			1.75E+03	q	8.80E-02	q	9.80E-06	q	1.32E+01	kk	e	9.50E+01	o
Carbon Tetrachloride	56-23-5	154	1.25E+00	q	3.04E-02	q	1.74E+02	q	2.73E+00	q			7.93E+02	q	7.80E-02	q	8.80E-06	q	3.02E+01	bluegill	t	1.10E+02	r
Chlorobenzene	108-90-7	113	1.52E-01	q	3.70E-03	q	2.19E+02	q	2.86E+00	q			4.72E+02	q	7.30E-02	q	8.70E-06	q	4.47E+02	fathead minnow	s	1.17E+01	j
Chloroethane	75-00-3	65	3.60E-01	jj	8.80E-03	u	8.80E+01	u	1.43E+00	x			5.74E+03	hh	1.15E-01	y	1.19E-05	f				7.60E+02	h
Chloromethane	74-87-3	50	3.67E-01	o	8.82E-03	o	6.02E+00	q	9.10E-01	n			6.36E+03	o	1.26E-01	p	6.50E-06	mm				3.80E+03	o
Methylene chloride	75-09-2	85	8.98E-02	q	2.00E-03	p	1.17E+01	q	1.25E+00	n			1.30E+04	q	1.01E-01	q	1.17E-05	q	5.00E+00	kk	t	4.29E+02	o
Tetrachloroethane, 1,1,2,2-	79-34-5	168	1.41E-02	q			9.33E+01	q	2.39E+00	n			2.97E+03	q	7.10E-02	q	7.90E-06	q	7.90E+00	bluegill	t	4.00E+00	o
Tetrachloroethene	127-18-4	166	7.54E-01	q	1.70E-02	p	1.55E+02	q	2.53E+00	n			2.00E+02	q	7.20E-02	q	8.20E-06	q	4.90E+01	bluegill	w	1.90E+01	o
Trichloroethene	79-01-6	131	4.22E-01	q	1.10E-02	p	1.66E+02	q	2.53E+00	n			1.10E+03	q	7.90E-02	q	9.10E-06	q	1.70E+01	bluegill	w	7.70E+01	o

Notes.

a Adams, W.J., Blaine, K.M. 1985 Geometric mean water solubility at 25oC from values reported in A Water Solubility of 2,3,7,8-TCDD Monsanto Company, St. Louis, Missouri, Dioxin 85 - 5th International Symposium on Chlorinated Dioxins and Related Compounds

b ATSDR 1990 Toxicological profile for copper U.S. Dept. of Health & Human Services, Public Health Service, ATSDR, Atlanta, GA

c ATSDR 1992 Toxicological profiles for benzo(g,h,i)perylene, benzo(k)fluoranthene, cyanide, manganese, phenanthrene U.S. Dept. of Health & Human Services, Public Health Service, ATSDR, Atlanta, GA

d ATSDR 1993 Toxicological profiles for chromium, mercury U.S. Dept. of Health & Human Services, Public Health Service, ATSDR, Atlanta, GA

e Ambient Water Quality Criteria Documents for [chemical specific], EPA (Note estimated steady-state BCFs from AWQC are based on 7.6 percent lipids)

f Center for Human and Environmental Toxicology Technical Report Development of Soil Cleanup Target Levels (SCTLs) for Chapter 62-785, F.A.C., April 1998.

g Dragun, J 1988 The Fate of Hazardous Materials in Soil HMC, May/June (observed ranges in agricultural soils/clays at pH 4.5 - 9.0)

h Electronic Handbook of Risk Assessment Values database 1998 Although vapor pressure in a closed system may be greater than 760 mmHg, under environmental conditions, the vapor pressure will be the same as ambient barometric pressure

i Eisler, R 1987. Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates A Synoptic Review

j EPA 1984 Health Effects Assessment for Chlorobenzene. Environmental Criteria and Assessment Office, Cincinnati, Ohio September 1984 EPA 540/1-86-040. PB86-134517

k EPA 1984 Health Effects Assessment for cis-1,2-Dichloroethylene Environmental Criteria and Assessment Office, Cincinnati, Ohio September 1984 NTIS PB86-134269

l EPA 1986 Superfund Public Health Evaluation Manual EPA 540 1-86 060 EPA, Washington, DC

m EPA 1987. Geometric mean log Kow 4 values reported in Review and Development of Methodologies for Estimating Exposure to Dioxin Environmental Protection Agency The Exposure Assessment Group Office of Health and Environmental January, 1987.

n EPA 1992a Dermal Exposure Assessment Principles and Applications, Interim Report EPA/600/8-91/011B, January 1992, EPA, Washington, DC

o EPA 1992b Handbook of RCRA Groundwater Monitoring Constituents Chemical and Physical Properties (40 CFR Part 264, Appendix IX) September 1992, EPA, Washington, DC

p EPA 1994 Technical Background Document for Soil Screening Guidance Draft 1994 Office of Solid Waste and Emergency Response, EPA, Washington, DC

q EPA 1996 Technical Background Document for Soil Screening Guidance EPA/540/R-95/128 May 1996 Office of Solid Waste and Emergency Response, EPA, Washington, DC

r Hine, J., Mookerjee, P.K. 1975 The Intrinsic Hydrophilic Character of Organic Compounds Correlations in Terms of Structural Contributions J Org Chem 40 292-8

s Howard, P.H., ed 1989 Handbook of Environmental Fate and Exposure Data for Organic Chemicals Vol 1 Large Production and Priority. Lewis Publishers, Inc., Chelsa, MI

t Howard, P.H., ed 1990 Handbook of Environmental Fate and Exposure Data for Organic Chemicals Vol 2 Solvents Lewis Publishers, Inc., Chelsa, MI.

u Hazardous Substance Data Bank cited in Center for Human and Environmental Toxicology Technical Report Development of Soil Cleanup Target Levels (SCTLs) for Chapter 62-785, F.A.C., April 1998

v HSDB 1994 *Hazardous Substance Data Bank* Online search for specified chemicals

w The Installation Restoration Program (IRP) Toxicology Guide, Volume I, Dept. of the Air Force, October, 1985, Arthur D. Little, Inc. Cambridge, MA

x Jow, P and Hansch, C Pomona College Unpublished Results

y Lyman, W.J., Reehl, W.F., and Rosenblatt, D.H. 1982. Chemical Property Estimation Methods McGraw-Hill, Inc., New York

z Mabey, W.R., Smith, J.H., Podoll, R.T., Johnson, H.L., Mill, T., Chou, T.W., Gates, J., Patridge, I.W., Jaber, H., and Vandenberg, D. 1982 Aquatic Fate Process Data for Organic Priority Pollutants. Prepared by SRI International Prepared for Monitoring and Data Support Division, Office of Water Regulations and Standards Washington, D.C. EPA Nos 68-01-3867 and 68-03-2981.

aa Mackay, D and Shiu, W.Y 1981 A Critical Review of Henry's Law Constants for Chemicals of Environmental Interest J Phys Chem Ref Data 10 1175-1199

bb Pomona College of Medicinal Chemistry Project. Hardcopy of 1983 version Data extracted from the Log P Parameter Data base Geometric means were calculated for those chemicals with ranges of values listed

cc Podoll, R.T., Jaber, H.M., Mill, T 1986 Tetra-chlorodibenzodioxin Rates of Volatilization and Photolysis in the Environment Environ Sci Technol 20 490-492 (Value is geometric mean of two values)

dd	Superfund Chemical Database Matrix 1993
ee	Superfund Chemical Database Matrix cited in Center for Human and Environmental Toxicology Technical Report. Development of Soil Cleanup Target Levels (SCTLs) for Chapter 62-785, F.A C , April 1998
ff	Suntio, L R , Shiu W.Y , and Mackay, D. 1988 A review of the nature properties of chemicals present in pulp mill effluents. Chemosphere 17.1249-1290
gg	Veith, G D., D L DeFoe, and B V. Bergstedt 1979 Measuring and estimating the bioconcentration factor of chemicals in fish. J. Fish Res Board Can 36 1040-1048
hh	Verschueren, K 1983 Handbook of Environmental Data for Organic Chemicals, Second Edition. Van Nostrand Reinhold Co., New York
ii	Walters, R W., Ostazeski, S A.,Guiseppi-Elie, A 1989 Sorption of 2,3,7,8-Tetrachlorodibenzo-p-dioxin from Water by Surface Soils Sci. Technol 23 480-484
jj	calculated
kk	estimated
ll	ATSDR 1997. Toxicological profile for chlorinated dibenzo-*p*-dioxins U S. Dept of Health & Human Services, Public Health Service, ATSDR, Atlanta, GA
mm	EPA 1995 Hazardous Waste Identification Rule (HWIR)
nn	The Installation Restoration Program (IRP) Toxicology Guide, Volume II, Dept. of the Air Force, May 1987, Arthur D Little, Inc. Cambridge, MA
oo	adapted from BCF of Naphthalene

(atm*m3/mol) = atmospheric pressure times cubic meters per molar

(cm3/gm) = centimeters cubed per gram

Koc = organic carbon partitioning coefficient

Kow = octanol water coefficient

Kd = distribution coefficient

(L/kg) = liter per kilogram

(mg/L) = milligram per liter

(cm2/sec) = centimeters squared per second

mm Hg at 20C = millimeters of mercury at 20 degrees Celcius

Table 2-6
Selection of COCs from COPCs Identified During Risk Assessment for Various Functional Units and Surrogate Sites at Dunn Field
Rev. 1 Memphis Depot Dunn Field ROD

Functional Unit	COPCs	Max. Lead (Pb) Conc. (mg/kg)	Above target >10^{-4}, >1.0 - Maintenance	Above target >10^{-4}, >1.0 - Industrial	Above target >10^{-4}, >1.0 - Onsite Residential	Above target >10^{-4}, >1.0- Offsite Residential	Above target >10^{-4}, >1.0 - Recreational	COCs* Industrial Worker	Comment	COCs Residential Scenario	Comment
Surface and Subsurface Soil											
Northeast Open Area	Dieldrin, Lead	2100	NO	NO	NA	NO	NO	None	Lead in surface soil was excavated for offsite disposal via a removal action in 2003.	NA	NA
Surrogate Site 6085	Dieldrin, Lead	2100	NA	NO	NO	NA	NA	None		None	Lead in surface soil was excavated for offsite disposal via a removal action in 2003.
Disposal Area	Arsenic, CVOCs, Dieldrin, PAHs	1020	NO	YES	NA	NO	NA	CVOCs	Subsurface CVOCs would be an unacceptable risk if site is built over with new industrial buildings.	NA	NA
Surrogate Site 61LE	Antimony, Arsenic, CVOCs, Dieldrin, PAHs	211	NA	YES	YES	NO	NA	CVOCs		PAHs, Antimony, Arsenic, CVOCs	The cumulative risks were greater than 10^{-4} and 1.0 levels to a hypothetical resident at the surrogate site. Therefore, residential COCs are identified.
Stockpile Area	Arsenic, Benzo(a)pyrene (a PAH)	Below background	NO	NO	NA	NA	NA	None	None of the chemicals exceeded the acceptable risk criteria for workers	NA	NA
Surrogate Site SSLFF	Arsenic	Below background	NA	NO	YES	NA	NA	None		Arsenic	The cumulative risks were greater than 1.0 levels to a hypothetical resident at the surrogate site due to arsenic. The arsenic levels within this surrogate sites are similar to those detected elsewhere within Shelby County, as reported in the Background Sampling Program Report (Ch2M HILL, May 1998). Thus, the observed risks are similar to those from background
Groundwater Plumes (Average Concentration) - Onsite & Offsite											
North Plume (Onsite)	Arsenic, Dieldrin, CVOCs, Manganese	--	NA	NO	YES	NA	NA	None	None of the chemicals exceeded the acceptable risk criteria for workers	Arsenic, Dieldrin, CVOCs, Manganese	The risks are from the ingestion, dermal contact and inhalation of groundwater from the fluvial aquifer. Currently, there are no residential users of the groundwater from the fluvial aquifer.
Northwest Plume (Onsite)	Arsenic, Benzene, CVOCs	--	NA	YES	YES	NA	NA	Arsenic, Benzene, CVOCs	The risk are from the ingestion, dermal contact and inhalation of groundwater from the fluvial aquifer. Currently, there are no residential users of the groundwater from the fluvial aquifer.	Arsenic, Benzene, CVOCs	
Southwest Plume (Onsite)	Arsenic, CVOCs	--	NA	YES	YES	NA	NA	Arsenic, CVOCs		Arsenic, CVOCs	
Offsite Plume	Arsenic, CVOCs, Iron	--	NA	NA	NA	YES	NA	NA	NA	Arsenic, CVOCs, Iron	The risks are from the ingestion, dermal contact and inhalation of groundwater from the fluvial aquifer Currently, there are no residential users of the groundwater from the fluvial aquifer. The risks from groundwater to indoor air are acceptable.

Note
Target Values estimated for lead are 1,536 mg/kg for industrial worker, and 400 mg/kg for a residential child health protection
CVOCs = chlorinated volatile organic compounds
NA = not analyzed

Table 2-7
Potential Receptors
Rev. 0 Memphis Depot Dunn Field Record of Decision

Area/(Surrogate Site)	Current/Immediate Future Land Use	Future Land Use				
	Maintenance Worker	Utility Worker	Landscaper	Industrial	Recreational	Residential
Northeast Open Area	**X**	X	**X**	X	**X**	
(Sites 60/85)	X	**X**	**X**	X		**X**
Disposal Area	**X**	X	**X**	X		
(Site 61 and associated sites)	X	**X**	**X**	X		**X**
Stockpile Area	**X**	X	**X**	X		
(Site SSLFF)	X	**X**	**X**	X		**X**

X Boldface indicates pathways quantified as conservative representatives of the other similar receptor populations

Table 2-8
EPA Weight-of-Evidence (WoE) Classification System for Carcinogenicity
Rev. 1 Memphis Depot Dunn Field Record of Decision

Group	Description
A	Human carcinogen, based on evidence from epidemiological studies
B1 or B2	Probable human carcinogen B1 indicates that limited human data are available B2 indicates sufficient evidence in animals and inadequate or no evidence in humans
C	Possible human carcinogen, based on limited evidence in animals
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity for humans

Note.
Source. EPA, 1986

Table 2-9
Carcinogenic Toxicity Factors
Rev. 2 Memphis Depot Dunn Field ROD

Parameter Name	Class	CAS Number	Oral SF kg-day/mg	Oral Slope Factor Source	Inhal SF kg-day/mg	Inhal SF Source	Weight-of-Evidence Basis	Weight-of-Evidence Class	Weight-of-Evidence Source
1,1,2,2-Tetrachloroethane	VOC	79-34-5	2.00E-01	IRIS, 1999	2.03E-01	IRIS, 1999 (calculated from unit risk)	Increased incidence of hepatocellualr carcinomas in mice	C	IRIS, 1999
1,1,2-Trichloroethane	VOC	79-00-5	5 70E-02	IRIS, 1999	5.60E-02	IRIS, 1999 (calculated from unit risk)	Hepatocellular carcinomas and pheochromocytomas in one strain of mice. Carcinogenicity was not shown in rats 1,1,2-Trichloroethane is structurally related 1,2-dichloroethane, a probable human carcinogen.	C	IRIS, 1999
1,1-Dichloroethene	VOC	75-35-4	6 00E-01	IRIS, 1999	1.75E-01	IRIS, 1999 (calculated from unit risk)	Tumors observed in one mouse strain after inhalation exposure Other studies were of inadequate design. Vinylidene chloride is mutagenic, and a metabolite is known to alkylate and to bind covalently to DNA. It is structurally related to the known human	C	IRIS, 1999
1,2-Dichloroethane	VOC	107-06-2	9 10E-02	IRIS, 1999	9 10E-02	IRIS, 1999 (calculated from unit risk)	Induction of several tumor types in rats and mice treated by gavage and lung pappillomas in mice after topical application	B2	IRIS, 1999
Arsenic	Inorganic	7440-38-2	1.50E+00	IRIS, 1999	1.51E+01	IRIS, 1999 (calculated from unit risk)	Based on observation of increased lung cancer mortality in populations exposed primarily through inhalation and on increased skin cancer incidence in several populations consuming drinking water with high arsenic concentrations	A	IRIS, 1999
Benzo(a)anthracene	SVOC	56-55-3	7.30E-01	USEPA Region IV, November 1995	3 10E-01	USEPA Region IV, November 1995; TEF of Benzo(a)pyrene	No human data from animal bioassays. B(a)A produced tumors in mice exposed by gavage, i p., subcutaneous, or intramuscular injection & topical application. B(a)A produced mutations in bacteria and mammalian cells, & transformed mammalian cells in cultur	B2	IRIS, 1999
Benzo(a)pyrene	SVOC	50-32-8	7.30E+00	IRIS, 1999	3 10E+00	USEPA Region IV, November 1995	Human data specifically linking BAP to a carcinogenic effect are lacking There are, however, multiple animal studies in many species demonstrating BAP to be carcinogenic following administration by numerous routes. BAP has produced positive results in	B2	IRIS, 1999
Benzo(b)fluoranthene	SVOC	205-99-2	7.30E-01	USEPA Region IV, November 1995	3 10E-01	USEPA Region IV, November 1995; TEF of Benzo(a)pyrene	No human and sufficient data from animal bioassays. B(b)F produced tumors in mice after lung implantation, i.p or subcutaneous injection and skin painting.	B2	IRIS, 1999
Benzo(k)fluoranthene	SVOC	207-08-9	7.30E-02	USEPA Region IV, November 1995	3.10E-02	USEPA Region IV, November 1995; TEF of Benzo(a)pyrene	No human data & sufficient data from animal bioassays B(k)F produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Equivocal results have been found in a lung adenoma assay in mice Benzo[	B2	IRIS, 1999
Carbon tetrachloride	VOC	56-23-5	1 30E-01	IRIS, 1999	5 25E-02	IRIS, 1999 (calculated from unit risk)	Carcinogenicity in rats, mice, and hamsters.	B2	IRIS, 1999
Chloroethane	VOC	75-00-3	2 90E-03	Choudhury, STSC-NCEA to Ted Simon, Region 4 EPA,			Uncommon carcinomas of the uterus and liver tumors	B2	STSC-NCEA, 1999
Chloromethane	VOC	74-87-3	1.30E-02	HEAST, 1997	6 00E-03	HEAST, 1997		C	HEAST, 1997
Chrysene	SVOC	218-01-9	7.30E-03	USEPA Region IV, November 1995	3.10E-03	USEPA Region IV, November 1995; TEF of Benzo(a)pyrene	No human data and sufficient data from animal bioassays. Produced carcinomas and malignant lymphoma in mice after intraperitoneal injection and skin carcinomas in mice following dermal exposure. Produced chromosomal abnormalities in hamsters and mice.	B2	IRIS, 1999

Table 2-9 (cont'd)
Carcinogenic Toxicity Factors
Rev 2 Memphis Depot Dunn Field ROD

Parameter Name	Class	CAS Number	Oral SF kg-day/mg	Oral Slope Factor Source	Inhal SF kg-day/mg	Inhal SF Source	Weight-of-Evidence Basis	Weight-of-Evidence Class	Weight-of-Evidence Source
Dibenz(a,h)anthracene	SVOC	53-70-3	7 30E+00	USEPA Region IV, November 1995	3.10E+00	USEPA Region IV, November 1995; TEF of Benzo(a)pyrene	No human data & sufficient data from animal bioassays. Produced carcinomas in mice following oral or dermal exposure & injection site tumors in several species following subcutaneous or intramuscular administration Has induced DNA damage and gene mutat	B2	IRIS, 1999
Dieldrin	Pesticide	60-57-1	1.60E+01	IRIS, 1999	1 60E+01	IRIS, 1999 (calculated from unit risk)	Carcinogenic in seven strains of mice when administered orally. Structurally related to compounds (aldrin, chlordane, heptachlor, heptachlor epoxide, and chorendic acid) which produce tumors in rodents	B2	IRIS, 1999
Indeno(1,2,3-c,d)pyrene	SVOC	193-39-5	7.30E-01	USEPA Region IV, November 1995	3 10E-01	USEPA Region IV, November 1995; TEF of Benzo(a)pyrene	No human data and sufficient data from animal bioassays. Produced tumors in mice following lung implants, subcutaneous injection and dermal exposure Tested positive in bacterial gene mutation assays.	B2	IRIS, 1999
Methylene chloride	VOC	75-09-2	7 50E-03	IRIS, 1999	1 65E-03	IRIS, 1999 (calculated from unit risk)	Inadequate human data and sufficient evidence of carcinogenicity in animals increased incidence of hepatocellular neoplasms and alveolar/bronchiolar neoplasms in male and female mice, and increased incidence of benign mammary tumors in both sexes.	B2	IRIS, 1999
Tetrachloroethene	VOC	127-18-4	5.20E-02	Provisional SF Memo from H. Choudhury, STSC-NCEA to Ted Simon, Region 4 EPA, Feb 23, 1999	2 00E-03	Provisional SF Memo from H Choudhury, STSC-NCEA to Ted Simon, Region 4 EPA, Feb 23, 1999		C-B2	Withdrawn from IRIS. Value listed in HEAST 1991 is used
Trichloroethene	VOC	79-01-6	1.10E-02	Provisional SF Memo from H Choudhury, STSC-NCEA to Ted Simon, Region 4 EPA, Feb 23, 1999	6.00E-03	Provisional SF Memo from H. Choudhury, STSC-NCEA to Ted Simon, Region 4 EPA, Feb 23, 1999		B2	Withdrawn from IRIS Value listed in HEAST 1991 is used.
Vinyl chloride	Voa	75-01-4	1 90E+00	HEAST, 1997	3.00E-01	IRIS, 1999 (calculated from unit risk)		A	HEAST, 1997

CAS	Chemical Abstract System number	Kg-day/mg	kilogram per day per milligram
EPA	Environmental Protection Agency	NC	No Comment
HEAST	Health Effects Assessment Summary Table	NCEA	National Center for Environmental Assessment
Inhal	Inhalation	PCB	polychlorinated biphenyl
IRIS	Integrated Risk Information System	RBC	risk-based concentration
Kg-day/mg	kilogram per day per milligram	SF	Slope Factor
		STSC	Superfund Technical Support Center
		SVOC	semivolatile organic compound
		TEF	toxicity equivalent factor
		VOC	volatile organic compound

Table 2-10
Noncarcinogenic Toxicity Factors
Rev 2 Memphis Depot Dunn Field Record of Decision

Parameter Name	Class	CAS Number	C Oral RfD mg/kg-day	C Oral RfD Critical Effect	C Oral RfD Uncert Factor	C Oral RfD Modify Factor	C Oral RfD Source	C Oral RfD Confidence	C Oral RfD Comment	C Inhal RfD mg/kg-day	C Inhal RfD Critical Effect	C Inhal RfD Uncert Factor	C Inhal RfD Modify Factor	C Inhal RfD Source	C Inhal RfC Comment	C Inhal RfC Uncert Factor	C Inhal RfC Source	C Inhal RfC Modify Factor	C Inhal RfC mg/m3	C Inhal RfC Confidence	C Inhal RfD Confidence	Weight-of-Evidence Basis	Weight-of-Evidence Class	Weight-of-Evidence Source
1,1,2-Trichloroethane	Voa	79-00-5	4 00E-03	Clinical serum chemistry	1000	1	IRIS, 1999	medium	NC													Hepatocellular carcinomas and pheochromocytomas in one strain of mice Carcinogenicity was not shown in rats 1,1,2-Trichloroethane is structurally related 1,2-dichloroethane, a probable human carcinogen	C	IRIS, 1999
1,1-Dichloroethene	Voa	75-35-4	9 00E-03	Hepatic lesions	1000	1	IRIS, 1999	medium	NC													Tumors observed in one mouse strain after inhalation exposure Other studies were of inadequate design Vinylidene chloride is mutagenic, and a metabolite is known to alkylate and to bind covalently to DNA It is structurally related to the known human carcinogen, vinyl chloride	C	IRIS, 1999
1,2-Dichloroethane	Voa	107-06-2	3 00E-02				Provisional RfD Memo from H Choudhury, STSC-NCEA to Ted Simon, Region 4 EPA, Aug 20, 1999			1 40E-03				Provisional RfD Memo from H. Choudhury, STSC-NCEA to Ted Simon, Region 4 EPA, Aug 20, 1999					5 00E-03			Induction of several tumor types in rats and mice treated by gavage and lung pappilomas in mice after topical application	B2	IRIS, 1999
1,2-Dichloroethene (total)	Voa	540-59-0	9.00E-03	Liver lesions	1000	1	HEAST, 1997																	
Antimony	Inorganic	7440-36-0	4 00E-04	Longevity, blood glucose, and cholesterol	1000	1	IRIS, 1999	low	NC		Pulmonary toxicity, chronic interstitial inflammation												D	DWHA, 1992
Arsenic	Inorganic	7440-38-2	3 00E-04	Hyperpigmentation, keratosis and possible vascular complications	3	1	IRIS, 1999	medium	NC													Based on observation of increased lung cancer mortality in populations exposed primarily through inhalation and on increased skin cancer incidence in several populations consuming drinking water with high arsenic concentrations	A	IRIS, 1999
Carbon tetrachloride	Voa	56-23-5	7 00E-04	Liver lesions	1000	1	IRIS, 1999	medium	NC	5 71E-04				EPA-NCEA provisional value from USEPA Region III Risk Based Concentrations Table, October 1998; not								Carcinogenicity in rats, mice, and hamsters	B2	IRIS, 1999
Chloroethane	Voa	75-00-3	4 00E-01		3000		Provisional RfD Memo from H Choudhury, STSC-NCEA to Ted Simon, Region 4 EPA, Feb 23, 1999	low		2 90E+00	Delayed fetal ossification			IRIS, 1999 (calculated from RfC)		300	IRIS, 1999	1	1 00E+01	medium	medium		B2	STSC-NCEA, 1999
Dieldrin	Pest/PCB	60-57-1	5.00E-05	Liver lesions	100	1	IRIS, 1999	medium	NC													Carcinogenic in seven strains of mice when administered orally. Structurally related to compounds (aldrin, chlordane, heptachlor, heptachlor epoxide, and chorendic acid) which produce tumors in rodents	B2	IRIS, 1999
Lead	Inorganic	7439-92-1																				Sufficient animal evidence Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short term studies show that lead affects gene expression. Human evidence is inadequate	B2	IRIS, 1999
Methylene chloride	Voa	75-09-2	6 00E-02	Liver toxicity	100	1	IRIS, 1999	medium	NC	8.57E-01	Liver toxicity	100	1	HEAST, 1997		100	HEAST, 1997	1	3			Inadequate human data and sufficient evidence of carcinogenicity in animals increased incidence of hepatocellular neoplasms and alveolar/bronchiolar neoplasms in male and female mice, and increased incidence of benign mammary tumors in both sexes.	B2	IRIS, 1999
Phenanthrene	Semi-Voa	85-01-8																				No human data and inadequate data from a single gavage study in rats and skin painting and injection studies in mice	D	IRIS, 1999
Tetrachloroethene	Voa	127-18-4	1 00E-02	Hepatotoxicity in mice, weight gain in rats	1000	1	IRIS, 1999	medium	NC	1 71E-01				Provisional RfD Memo from H. Choudhury, STSC-NCEA to Ted Simon, Region 4 EPA, Feb 23, 1999			Ted Simon		6 00E-01				C-B2	Withdrawn from IRIS. Value listed in HEAST 1991 is used
Thallium	Inorganic	7440-28-0	8 00E-05				Value for Thallium chloride adapted from IRIS, 1999																D	DWHA (4/1992)
Trichloroethene	Voa	79-01-6	6.00E-03	Liver - Toxicity	1000	3	EPA-NCEA provisional value from USEPA Region III Risk Based Concentrations Table, October 1998; not verified by Region IV yet	low	NC														B2	Withdrawn from IRIS. Value listed in HEAST 1991 is used.

Note:

C	Chronic	ESOD	erthrocyte superoxide dismutase	NC	No Comment	RfD	Reference Dose
CAS	Chemical Abstract System number	HEAST	Health Effects Assessment Summary Table	NCEA	National Center for Environmental Assessment	STSC	Superfund Technical Support Center
DDT	dichlorodiphynyltrichloroethene	Inhal	Inhalation	NOAEL	no observed adverse effects level	SVOC	semivolatile organic compound
DWHA	Drinking Water Health Advisory	IRIS	Integrated Risk Information System	RBC	risk-based concentration	TEF	toxicity equivalent factor
ECAO	Environmental Criteria and Assessment Office	Mg/kg-day	milligrams per kilograms per day	RFC	reference concentration	Uncert	uncertainty
EPA	Environmental Protection Agency					VOC	volatile organic compound

Table 2-11

Summary of Risks and Hazards at Northeast Open Area

Rev 1 Memphis Depot Dunn Field Record of Decision

Exposure Receptors	Carcinogenic Risks				Noncarcinogenic Hazard Index				COPCs
	Ingestion	Dermal	Inhalation	Total ELCR	Ingestion	Dermal	Inhalation	Total HI	
Maintenance Worker									
Surface Soil	3 E-07	2 E-07	4 E-08	6E-07	0.003	0.001	0.00006	0.004	N/A
Surface Water	3 E-09	3 E-08	N/A	3E-08	0.00001	0.0001	N/A	0.0001	N/A
Sediment	2 E-08	5 E-09	N/A	3E-08	0.00007	0.00002	N/A	0.00009	N/A
Total Risks & Hazards (combined from all pathways)				***6E-07***				***0.004***	N/A
Industrial Worker									
Surface Soil	3 E-06	1 E-06	2 E-07	5E-06	0.03	0.005	0.0003	0.04	dieldrin
Surface Water	1 E-08	1 E-07	N/A	1E-07	0.00005	0.0004	N/A	0.0005	N/A
Sediment	8 E-08	2 E-08	N/A	1E-07	0.0003	0.00008	N/A	0.0004	N/A
Soil Column	3 E-06	1 E-06	1 E-07	4E-06	0.03	0.005	0.0003	0.04	dieldrin
Soil Column - Ambient Air	N/A	N/A	1 E-07	1E-07	N/A	N/A	0.0001	0.0001	N/A
Total Risks/Hazards (combined for surface media)[1]				***5E-06***				***0.04***	*dieldrin*
Groundwater (Ave -Table15-7)	7 E-06	4 E-08	3 E-05	4E-05	0.1	0.011	0.001	0.11	
Total Risks & Hazards (combined for all media)[1]				***5E-05***				***0.04***	*As, dieldrin, 1,1,2,2-PCA, 1,1-DCE, 1,2-DCA, chloroform, CCl4, PCE, TCE*
Soil Column - Indoor Air	N/A	N/A	1 E-05	1E-05	N/A	N/A	0.009	0.009	1,1,2,2-PCA
Utility Worker									
Soil Column	3 E-07	3 E-07	1 E-08	7E-07	0.003	0.002	0.00003	0.005	N/A
Soil Column - Ambient Air	N/A	N/A	5 E-10	5E-10	N/A	N/A	0.0000004	0.0000004	N/A
Total Risks & Hazards (combined from all pathways)				***7E-07***				***0.005***	*N/A*
Recreational Adult									
Surface Soil	1 E-06	7 E-08	7 E-09	1E-06	0.01	0.0003	0.000009	0.01	dieldrin
Surface Water	2 E-08	3 E-07	N/A	3E-07	0.00005	0.0008	N/A	0.0009	N/A
Sediment	2 E-07	2 E-08	N/A	2E-07	0.0005	0.00005	N/A	0.0006	N/A
Total Risks & Hazards (combined from all pathways)				***2E-06***				***0.01***	*dieldrin*
Recreational Child									
Surface Soil	2 E-06	1 E-07	5 E-09	2E-06	0.1	0.003	0.00003	0.1	dieldrin
Surface Water	1 E-08	9 E-08	N/A	1E-07	0.0002	0.001	N/A	0.001	N/A
Sediment	3 E-07	5 E-09	N/A	3E-07	0.005	0.00008	N/A	0.005	N/A
Total Risks & Hazards (combined from all pathways)				***2E-06***				***0.1***	*dieldrin*
Recreational Youth									
Surface Soil	7 E-07	2 E-07	4 E-09	9E-07	0.02	0.002	0.00001	0.02	N/A
Surface Water	8 E-09	1 E-07	N/A	1E-07	0.00007	0.001	N/A	0.001	N/A
Sediment	1 E-07	8 E-09	N/A	1E-07	0.0008	0.00007	N/A	0.0009	N/A
Total Risks & Hazards (combined from all pathways)				***1E-06***				***0.02***	*N/A*
Offsite Residential									
Soil Column - Ambient Air	N/A	N/A	3 E-08	3E-08	N/A	N/A	0.00002	0.00002	N/A
Total Risks & Hazards (combined from all pathways)				**3E-08**				**0.00002**	*N/A*

Note

1 = Industrial Worker Soil Column risks (4E-06) were not included in Total Risks & Hazards because they were less than Surface Soil risks (5E-06)

Since a worker is assumed to be exposed to ambient air during work, Indoor Air is also not combined with other media

COPCs are the chemicals contributing to risks at or above 1 in a million, and/or to HI at or above 1.0.

Where:

- As: Arsenic
- CCl4: Carbon tetrachloride
- PAHs: Polyaromatic hydrocarbons
- PCE: Tetrachloroethane
- TCE: Trichloroethane
- 1,1-DCE: 1,1-Dichloroethene
- 1,2-DCA: 1,2-Dichloroethane
- 1,1,2,2-PCA: 1,1,2,2-Tetrachloroethane

779 107

Table 2-12
Summary of Risks and Hazards at Surrogate Site 60/85
Rev 1 Memphis Depot Dunn Field Record of Decision

Exposure Route/Receptors	Carcinogenic Risks				Noncarcinogenic Hazard Index				COPCs
	Ingestion	Dermal	Inhalation	Total ELCR	Ingestion	Dermal	Inhalation	Total HI	
<u>**Industrial Worker**</u>									
Surface Soil	7.E-06	2 E-06	2 E-09	**9E-06**	0.02	0.008	N/A	0 03	dieldnn
Northeast Plume (Ave VOCs)*	2.E-03	6 E-07	2 E-03	**3.E-03**	5	0.007	1	**5**	As, dieldrin, 1,1,2,2-PCA, 1,1-DCE, chloroform, CCl4, PCE, TCE
Combined risks and hazards for all media				**3E-03**				**5**	
<u>**Residential Adult**</u>									
Surface Soil	6.E-05	1 E-06	9 E-10	**7E-05**	0 07	0.004	N/A	0 07	dieldnn
Northeast Plume (Ave VOCs)*	8.E-03	8 E-06	7.E-03	**1E-02**	13.0	0 1	1.8	**14.8**	As, dieldrin, heptachlor epoxide, 1,1,2,2-PCA, 1,1-DCE, 1,2-DCA, chloroform, CCl4, PCE, TCE
Combined risks and hazards for all media				**1E-02**				**15**	
<u>**Residential Child**</u>									
Surface Soil	NA	NA	NA	**NA**	0 6	0.04	N/A	0.7	dieldrin
Northeast Plume (Ave VOCs)*	NA	NA	NA	**NA**	30.2	0 11	4.09	**34**	As, dieldnn, 1,1,2,2-PCA, 1,1-DCE, 1,2-DCA, chloroform, CCl4, PCE, TCE
Combined risks and hazards for all media				**NA**				**35.1**	

Note= *Groundwater nsks and HIs are from Table 15-7 of the Dunn Field RI
COPCs are the chemicals contributing to nsks at or above 1 in a million, and/or to HI at or above 1 0.

Where		
	As	Arsenic
	CCl4	Carbon tetrachloride
	PAHs	Polyaromatic hydrocarbons
	PCE	Tetrachloroethane
	TCE	Tnchloroethane
	1,1-DCE	1,1-Dichloroethene
	1,2-DCA	1,2-Dichloroethane
	1,1,2,2-PCA	1,1,2,2-Tetrachloroethane

Table 2-13
Summary of Risks and Hazards at Disposal Area
Rev. 1 Memphis Depot Dunn Field Record of Decision

Exposure Route/Receptors	Ingestion	Dermal	Inhalation	Total ELCR	Ingestion	Dermal	Inhalation	Total HI	COPCs
Industrial Worker									
Surface Water	6 E-09	8 E-06	N/A	**8E-06**	0.0007	0 0004	N/A	**0.001**	PAHs
Sediment	3 E-06	1.E-06	N/A	**5E-06**	0.005	0.0005	N/A	**0.005**	BaP
Surface Soil	7 E-06	2.E-06	2 E-07	**9E-06**	0.05	0 006	0 0002	**0.06**	Arsenic, BaP, dieldrin
Soil Column - Ambient Air	N/A	N/A	3 E-05	**4E-05**	N/A	N/A	0 2	**0.3**	1,1,2,2-Tetrachloroethane, Vinyl chloride, TCE
Total Risks & Hazards (combined from all pathways) [1]				***6E-05***				***0.3***	***As, PAHs, dieldrin, 1,1,2,2-Tetrachloroethane, VCl, TCE***
Soil Column - Indoor Air	N/A	N/A	8 E-04	**8E-04**	N/A	N/A	4	**4**	1,1,2,2-Tetrachloroethane,1,1,2-TCA, TCE, VCl, CCl4
Maintenance Worker									
Surface Water	2.E-09	2.E-06	N/A	**2E-06**	0.0002	0 00009	N/A	**0.0003**	PAHs
Sediment	8.E-07	3.E-07	N/A	**1E-06**	0 001	0 0001	N/A	**0.001**	N/A
Surface Soil	7.E-07	4.E-07	2 E-08	**1E-06**	0 005	0 001	0.00003	**0.006**	N/A
Total Risks & Hazards (combined from all pathways)				***4E-06***				***0.008***	***PAHs***
Utility Worker									
Soil Column	4.E-07	3.E-07	5 E-08	**8E-07**	0 004	0 001	0 002	**0.007**	N/A
Soil Column - Ambient Air	N/A	N/A	3.E-08	**8E-07**	N/A	N/A	0 0002	**0.005**	N/A
Total Risks & Hazards (combined from all pathways)				***8E-07***				***0.002***	***N/A***
Offsite Residential									
Soil Column - Ambient Air	N/A	N/A	4.E-06	**4E-06**	N/A	N/A	0 02	**0.02**	1,1,2,2-Tetrachloroethane
Total Risks & Hazards (combined from all pathways)				***4E-06***				***0.02***	***1,1,2,2-Tetrachloroethane***

Note:

1 = Industrial Worker Soil Column risks (6E-06) were not included in Total Risks & Hazards because they were less than Surface Soil risks (9E-06)

Indoor Air is also not included in this summary.

Where:

As	Arsenic
BaP	Benzo(a)pyrene
CCl4	Carbon tetrachloride
PAHs	Polyaromatic hydrocarbons
1,1,2-TCA	1,1,2-Trichloroethane
TCE	Trichloroethane
VCl	Vinyl chloride

Table 2-14

Summary of Risks and Hazards from all Media at Surrogate Site 61LE1

Rev. 1 Memphis Depot Dunn Field Record of Decision

Exposure Route/Receptors	Carcinogenic Risks				Noncarcinogenic Hazard Index				COPCs
	Ingestion	Dermal	Inhalation	Total ELCR	Ingestion	Dermal	Inhalation	Total HI	
Industrial Worker (Outdoor) [2]									
Surface Media									
Surface Soil	2 E-05	9 E-06	4 E-08	3E-05	0 5	0.04	NA	0 6	PAH, AS, SB
Groundwater									
North Plume (Avg VOCs)	8 E-05	3 E-08	3 E-05	1E-04	0 84	7 01E-04	0.040	0 88	AS, PCA, DCA12, DCE11, CTCL, PCE, TCLME, TCE
Total Risks & Hazards (all media & with ambient air)				***1E-04***				***1.4***	*AS, SB, PAH, PCA, TCE, DCA12, DCE11, CTCL, PCE, TCLME*
Industrial Worker (Indoor) [2]									
Indoor Air									
Soil-to-Indoor Air			7 E-05	7.E-05			5 0	5 0	PCA, TCE, VC, TOT12DCE
Groundwater (Potable Use)									
North Plume (Avg VOCs)	8 E-05	3 E-08	3 E-05	1E-04	0 84	7.01E-04	0 040	0 88	AS, PCA, DCA12, DCE11, CTCL, PCE, TCLME, TCE
Total Risks & Hazards (combined from all pathways)				***2E-04***				***6***	*AS, PCA, DCA12, DCE11, CTCL, PCE, TCLME, TCE, VC, TOT12DCE*
Utility Worker									
Surface Media									
Surface Soil	2 E-06	3 E-06	4 E-09	5E-06	0 05	0 01	0	0 06	AS, BaP
Total Risks & Hazards (all media & with ambient air)				***2E-06***				***0.01***	*AS, BaP*
Residential Child (Onsite)									
Surface Media									
Surface Soil	N/A	N/A	N/A	NA	13	0 2	NA	14	PAH, AS, SB
Groundwater									
North Plume (Avg VOCs)	NA	NA	N/A	NA	5 5	0 011	0 26	5.7	
Indoor Air									
Soil-to-Indoor Air	NA	NA	N/A	NA			75	75	TOT12DCE
Total Risks & Hazards (combined from all pathways)				***NA***				***94***	*PAH, AS, SB, TOT12DCE*
Residential Adult (Onsite)									
Surface Media									
Surface Soil	2 E-04	6 E-06	2 E-08	2E-04	1	0 02	NA	1	PAH, AS, SB
Groundwater									
North Plume (Ave VOCs)	4 E-04	4 E-07	1 E-04	5E-04	2 3	0.0073	0 11	2 5	AS, PCA, DCA12, DCE11, CTCL, PCE, TCLME, TCE
Indoor Air									
Soil-to-Indoor Air			5 E-04	5E-04			21	21	PCA, 112TCA, PCE, TCE, VC, TOT12DCE
Total Risks & Hazards (with average ambient air)				***1E-03***				***25***	*PAH, AS, SB, PCA, TCE, DCA12, DCE11, CTCL, PCE, TCLME, TOT12DCE, 112TCA, VC*

Note:
1 = Indoor air risks from subsurface volatilization from soils is found in Table 11-18A of the Dunn Field RI Report
2 = Worker is assumed to spend all time outdoors
COPCs are the chemicals contributing to risks at or above 1 in a million, and/or to HI at or above 1 0

Where:

As	Arsenic	TCLME	Chloroform
BaP	Benzo(a)pyrene	TOT12DCE	Total-1,2-Dichloroethene
CTCL	Carbon tetrachloride	VC	Vinyl Chloride
12DCA	1,2-Dichloroethane	11DCE	1,1-Dichloroethene
PAH	Polyaromatic hydrocarbons	PCE	Tetrachloroethene
SB	Antimony		
112TCA	1,1,2-Trichloroethane		
TCE	Trichloroethane		

Table 2-15

Summary of Risks and Hazards - Stockpile Area

Rev. 1 Memphis Depot Dunn Field Record of Decision

Exposure Receptors	Ingestion	Dermal	Inhalation	Total ELCR	Ingestion	Dermal	Inhalation	Total HI	COPCs
Maintenance Worker									
Surface Soil	1.1E-06	3.4E-07	1.2E-08	**1E-06**	0.008	0.0007	0.00002	**0.009**	
Total Risks & Hazards				***1E-06***				***0.009***	***Arsenic*, benzo(a)pyrene****
Industrial Worker									
Surface Soil	5.6E-06	1.7E-06	6.0E-08	**7E-06**	0.04	0.004	0.0001	**0.04**	
Subsurface Soil	3.2E-06	3.8E-07	5.4E-08	**4E-06**	0.04	0.003	0.006	**0.05**	
Total Risks & Hazards				***7E-06***				***0.05***	***Arsenic, benzo(a)pyrene***
Utility Worker									
Subsurface Soil	3.1E-07	1.2E-07	5.2E-09	**4E-07**	0.004	0.001	0.0006	**0.005**	
Total Risks & Hazards				***4E-07***				***0.005***	***N/A***

* = individually these constituents do not exceed 1E-06, but accumulatively they contribute to this risk total.

ELCR = Estimated Lifetime Cancer Risk

HI = Hazard Indices

COPCs = Chemicals of Potential Concern

Table 2-16
Summary of Risks and Hazards at SSLFF Soil
Rev. 1 Memphis Depot Dunn Field Record of Decision

Exposure Route/Receptors	Ingestion	Dermal	Inhalation	Total ELCR	Ingestion	Dermal	Inhalation	Total HI	COPCs
Industrial Worker									
Surface Soil	6.7E-06	7.9E-07	2.0E-08	**8E-06**	0.06	0.005	0.00001	**0.06**	***Arsenic***
Residential Adult									
Surface Soil	6.4E-05	5.1E-07	8.6E-09	**6E-05**	0.1	0.0002	0.000001	**0.2**	***Arsenic***
Residential Child									
Surface Soil	N/A	N/A	N/A	**N/A**	1	0.02	0.000004	**2**	***Arsenic***

ELCR = Estimated Lifetime Cancer Risk
HI = Hazard Indices
COPCs= Chemicals of Potential Concern

Table 2-17

Summary of Risks and Hazards at Onsite Plumes

Rev 1 Memphis Depot Dunn Field ROD

Exposure Route/Receptors	Groundwater				Indoor Air	Total ELCR	Groundwater				Indoor Air	Total HI	COPCs of Concern
	Ingestion	Dermal	Inhalation	Total	Inhalation		Ingestion	Dermal	Inhalation	Total	Inhalation		
North Plume:													
Industrial Worker	8.E-05	3 E-08	3.E-05	1 E-04	7 E-08	**1E-04**	0 84	7.01E-04	0 040	0 88	4.76E-05	**0.88**	As, dieldrin, PCA1122, DCA12, DCE11, CCl4, PCE, Chloroform, TCE
Residential Adult	4.E-04	4 E-07	1 E-04	5.E-04	2 E-07	**5E-04**	2 3	0.0073	0 11	2.5	6.66E-05	**2.5**	As, dieldrin, PCA1122, TCA112, DCE11, DCA12, Bromodichloromethane, CCl4, Chloroform, PCE, TCE
Residential Child							5 5	0 011	0.26	5 7	2 33E-04	**5.7**	TCE, Manganese
Northwest Plume:													
Industrial Worker	2.E-03	6 E-07	2 E-03	3.E-03	8.E-08	**3E-03**	4.6	0.0067	0.63	5 3	2.04E-04	**5.3**	As, PCA1122, TCA112, DCE11, DCA12, DCP12, Benzene, CCl4, Chloroform, PCE, TCE, VC
Residential Adult	8.E-03	8.E-06	7 E-03	1 E-02	2.E-07	**1E-02**	13	0.070	1.8	15	2.86E-04	**15**	As, PCA1122, TCA112, DCE11, DCA12, DCP12, Benzene, CCl4, Chloroform, PCE, TCE, VC
Residential Child							30	0.11	4 1	34	0.0010	**34**	TCE
Southwest Plume:													
Industrial Worker	1 E-04	5.E-08	2.E-04	3 E-04	2.E-08	**3E-04**	1 6	0.0014	0 0099	1.6	2.02E-05	**1.6**	As, PCA1122, TCA112, CCl4, Chloroform, PCE, TCE
Residential Adult	6.E-04	7 E-07	8.E-04	1 E-03	4.E-08	**1E-03**	4 5	0 014	0.028	4.6	2.82E-05	**4.6**	As, PCA1122, TCA112, Bromodichloromethane, CCl4, Chloroform, PCE, TCE
Residential Child							11	0.022	0.065	11	9 87E-05	**11**	CCl4, Chloroform, TCE

HI = Hazard indices

ELCR = Exposure

Table 2-18
Summary of Risks and Hazards at Offsite Groundwater A2Plumes
Rev 1 Memphis Depot Dunn Field ROD

Exposure Route/Receptors	Groundwater				Indoor Air	Total ELCR	Groundwater				Indoor Air	Total HI	COPCs of Concern
	Ingestion	Dermal	Inhalation	Total	Inhalation		Ingestion	Dermal	Inhalation	Total	Inhalation		
MW30:													
Residential Adult	5.E-05	1.E-09		5.E-05		**5E-05**	0 81	0.0027		0.81		**0.81**	As
Residential Child							1.9	0 0041		1 9		**1.9**	As
MW31:													
Residential Adult	5 E-04	7 E-07	3 E-04	8 E-04	1.E-07	**8E-04**	3 0	0 014	0 076	3 1	5 29E-05	**3.1**	Chlorinated solvents
Residential Child							7.0	0.021	0 18	7 2	1.85E-04	**7.2**	Chlorinated solvents
MW32:													
Residential Adult	3 E-04	3 E-07	2 E-03	2 E-03	4 E-08	**2E-03**	5 0	0.013	0.029	5 0	1 52E-05	**5.0**	Chlorinated solvents
Residential Child							12	0 020	0 067	12	5 31E-05	**12**	Chlorinated solvents
MW33:													
Residential Adult	1 E-04	9 E-09	7 E-06	2 E-04	5 E-10	**2E-04**	1 4	0 0028	0	1 4	0	**1.4**	Chlorinated solvents
Residential Child							3 2	0 0043	0	3.2	0	**3.2**	Chlorinated solvents
MW37:													
Residential Adult	*No carcinogenic COPCs*						0 36	0 0010	0	0.36		**0.36**	
Residential Child							0.83	0.0016	0	0 84		**0.84**	
MW40:													
Residential Adult	2 E-05	2 E-08	6 E-06	3 E-05	6 E-08	**3E-05**	0 35	8 83E-05	0	0 35	0	**0.35**	1,1-Dichloroethene
Residential Child							0.83	1 35E-04	0	0.83	0	**0.83**	
MW42													
Residential Adult	0 E+00	0 E+00	0 E+00	0 E+00		**0E+00**	0.19	8 23E-04	0	0 19		**0.19**	
Residential Child							0.44	0 0013	0	0 44		**0.44**	
MW44.													
Residential Adult	2 E-04	3 E-08	6 E-06	2 E-04	4 E-08	**2E-04**	2.2	0 0011	0	2 2	3 09E-06	**2.2**	As, Chlorinated solvents
Residential Child							5 2	0 0017	0	5 2	1 08E-05	**5.2**	As, Fe, Chlorinated solvents

Table 2-18

Summary of Risks and Hazards at Offsite Groundwater A2Plumes

Rev. 1 Memphis Depot Dunn Field ROD

Exposure Route/Receptors	Groundwater				Indoor Air	Total ELCR	Groundwater				Indoor Air	Total HI	COPCs of Concern
	Ingestion	Dermal	Inhalation	Total	Inhalation		Ingestion	Dermal	Inhalation	Total	Inhalation		
MW54:													
Residential Adult	5 E-05	1 E-07	5 E-05	1 E-04	5 E-08	**1E-04**	1.1	0 0028	0 077	1.2	1 30E-04	**1.2**	Chlorinated solvents
Residential Child							2.6	0.0044	0.18	2 8	4 54E-04	**2.8**	Chlorinated solvents
MW51:													
Residential Adult	2 E-04	2 E-07	4 E-05	2 E-04	2 E-07	**2E-04**	0 42	3 34E-04	2 76E-04	0 42	4.22E-06	**0.42**	Chlorinated solvents
Residential Child							0.97	5.10E-04	6.43E-04	0 97	1.48E-05	**0.97**	As
MW71.													
Residential Adult	6 E-04	9 E-07	2 E-03	2 E-03	5 E-08	**2E-03**	5 0	0.018	0 026	5.0	1.91E-05	**5.0**	Chlorinated solvents
Residential Child							12	0 028	0 061	12	6 68E-05	**12**	Chlorinated solvents
MW76/77:													
Residential Adult	7 E-03	7 E-06	7 E-03	1 E-02	5 E-08	**1E-02**	8.9	0 056	0 35	9 3	0 0016	**9.3**	Chlorinated solvents
Residential Child							21	0.086	0 61	22	5.26E-04	**22**	Chlorinated solvents
MW79:													
Residential Adult	4 E-04	4 E-07	1 E-04	5 E-04	1 E-07	**5E-04**	0 31	0 0011	0.043	0 36	1.37E-04	**0.36**	Chlorinated solvents
Residential Child							0 73	0.0017	0.10	0 83	4.80E-04	**0.83**	Chlorinated solvents

HI = Hazard Indices

ELCR = Excess Lifetime Cancer Risk

COPC = Chemicals of Potential Concern

Table 2-19
Risk Assessment Summary for Dunn Field
Rev. 2 Memphis Depot Dunn Field ROD

Exposure Receptors	Total ELCR	Total HI	Above Target ELCR 1x10^{-4} or HI 1	COCs[a]
Northeast Open Area				
Maintenance Worker	6E-07	0.004	No	N/A
Industrial Worker[b]	5E-05	0.04	No	As, dieldrin, 1,1,2,2-PCA, 1,1-DCE, 1,2-DCA, chloroform, CCl4, PCE, TCE
Utility Worker	7E-07	0.005	No	N/A
Recreational Adult	2E-06	0.01	No	dieldrin
Recreational Child	2E-06	0.1	No	dieldrin
Recreational Youth	1E-06	0.02	No	N/A
Offsite Residential	3E-08	0.00002	No	N/A
Northeast Open Area - Surrogate Site 60/85				
Industrial Worker[b]	3E-03	5	**Yes**	As, dieldrin, 1,1,2,2-PCA, 1,1-DCE, chloroform, CCl4, PCE, TCE
Residential Adult[b]	1E-02	15	**Yes**	As, dieldrin, heptachlor epoxide, 1,1,2,2-PCA, 1,1-DCE, 1,2-DCA, chloroform, CCl4, PCE, TCE
Residential Child[b]	N/A	35.1	**Yes**	As, dieldrin, 1,1,2,2-PCA, 1,1-DCE, 1,2-DCA, chloroform, CCl4, PCE, TCE
Disposal Area				
Maintenance Worker	4E-06	0.008	No	PAHs
Industrial Worker	6E-05	0.3	No	As, PAHs, dieldrin, 1,1,2,2-Tetrachloroethane, VCl, TCE
Utility Worker	8E-07	0.002	No	N/A
Offsite Residential	4E-06	0.02	No	1,1,2,2-Tetrachloroethane
Disposal Area - Surrogate Site 61LE				
Industrial Worker	8E-05	0.3	No	As, BaP, TCE, 1,1,2,2-Tetrachloroethane,VCl
Utility Worker	6E-06	0.01	No	TCE, 1,1,2,2-Tetrachloroethane,VCl
Residential Adult	3E-04	2	**Yes**	PAHs, As, Sb, TCE, 1,1,2,2-Tetrachloroethane,VCl
Residential Child	N/A	14	**Yes**	PAHS, Antimony, Arsenic
Offsite Residential	9E-07	0.005	No	N/A
Stockpile Area				
Maintenance Worker	1E-06	0.009	No	Arsenic*, benzo(a)pyrene*
Industrial Worker	7E-06	0.05	No	Arsenic, benzo(a)pyrene
Utility Worker	4E-07	0.005	No	N/A
Stockpile Area - Surrogate SSLFF Soil				
Industrial Worker	8.E-06	0.06	No	Arsenic
Residential Adult	6 E-05	0.2	No	Arsenic
Residential Child	N/A	2	**Yes**	Arsenic
Groundwater - Onsite Plumes				
North Plume				
Industrial Worker	1.E-04	0.88	No	As, dieldrin, PCA1122, DCA12, DCE11, CCl4, PCE, Chloroform, TCE
Residential Adult	5.E-04	2.5	**Yes**	As, dieldrin, PCA1122, TCA112, DCE11, DCA12, Bromodichloromethane, CCl4, Chloroform, PCE, TCE
Residential Child	N/A	5.7	**Yes**	TCE, Manganese

Table 2-19
Risk Assessment Summary for Dunn Field
Rev. 2 Memphis Depot Dunn Field ROD

Exposure Receptors	Total ELCR	Total HI	Above Target ELCR $1x10^{-4}$ or HI 1	COCs[a]
Northwest Plume				
Industrial Worker	3.E-03	5.3	**Yes**	As, PCA1122, TCA112, DCE11, DCA12, DCP12, Benzene, CCl4, Chloroform, PCE, TCE, VC
Residential Adult	1.E-02	15	**Yes**	As, PCA1122, TCA112, DCE11, DCA12, DCP12, Benzene, CCl4, Chloroform, PCE, TCE, VC
Residential Child	N/A	34	**Yes**	TCE
Southwest Plume				
Industrial Worker	3.E-04	1.6	**Yes**	As, PCA1122, TCA112, CCl4, Chloroform, PCE, TCE
Residential Adult	1 E-03	4 6	**Yes**	As, PCA1122, TCA112, Bromodichloromethane, CCl4, Chloroform, PCE, TCE
Residential Child	N/A	11	**Yes**	CCl4, Chloroform, TCE
Groundwater - Offsite Plumes				
MW30				
Residential Adult	5.E-05	0.81	No	As
Residential Child	N/A	1.9	**Yes**	As
MW31				
Residential Adult	8.E-04	3 1	**Yes**	Chlorinated solvents
Residential Child	N/A	7.2	**Yes**	Chlorinated solvents
MW32				
Residential Adult	2.E-03	5	**Yes**	Chlorinated solvents
Residential Child	N/A	12	**Yes**	Chlorinated solvents
MW33				
Residential Adult	2.E-04	1.4	**Yes**	Chlorinated solvents
Residential Child	N/A	3.2	**Yes**	Chlorinated solvents
MW40				
Residential Adult	3.E-05	0.35	No	1,1-Dichloroethene
Residential Child	N/A	0.83	No	
MW44				
Residential Adult	2.E-04	2.2	**Yes**	As, Chlorinated solvents
Residential Child	N/A	5.2	**Yes**	As, Fe, Chlorinated solvents
MW54				
Residential Adult	1 E-04	1.2	**Yes**	Chlorinated solvents
Residential Child	N/A	2.8	**Yes**	Chlorinated solvents
MW51				
Residential Adult	2 E-04	0.42	**Yes**	Chlorinated solvents
Residential Child	N/A	0.97	No	As, Chlorinated solvents
MW71				
Residential Adult	2.E-03	5	**Yes**	Chlorinated solvents
Residential Child	N/A	12	**Yes**	Chlorinated solvents
MW76/77				
Residential Adult	1.E-02	9.3	**Yes**	Chlorinated solvents
Residential Child	N/A	22	**Yes**	Chlorinated solvents
MW79				
Residential Adult	5.E-04	0 36	**Yes**	Chlorinated solvents
Residential Child	N/A	0.83	No	Chlorinated solvents

Table 2-19
Risk Assessment Summary for Dunn Field
Rev. 2 Memphis Depot Dunn Field ROD

Exposure Receptors	Total ELCR	Total HI	Above Target ELCR $1x10^{-4}$ or HI 1	COCs[a]

[a] COCs are the chemicals contributing to risks at or above 1 in a million, and/or to HI at or above 1 0.

[b] Risk calculations include risk from groundwater media through ingestion, dermal, and inhalation exposure routes.

ELCR = Estimated Lifetime Cancer Risk
HI = Hazard Indices
COCs= Chemicals of Concern
As = Arsenic
CCl4 = Carbon Tetrachloride
PAHs = Polyaromatic hydrocarbons
PCE = Tetrachloroethane
TCE = Trichloroethene
1,1-DCE = 1,1-Dichloroethene
1,2-DCE = 1,2-Dichloroethane
1,1,2,2-PCA = 1,1,2,2-Tetrachloroethane

TABLE 2-20
Sources of Uncertainty and their Contribution to Conservatism in Risk Assessment
Rev. 1 Memphis Depot Dunn Field Record of Decision

Sources of Uncertainty in Risk Assessment	Degree to which Factor May Result in Overestimated Risk	Degree to which Factor May Result in Underestimated Risk	Degree to which Factor May Result in Overestimated or Underestimated Risk
Hazard Identification			
Field sampling location bias	Moderate-High		
Inclusion of soil data from depths outside realistic exposure intervals			Low-Moderate
Use of one-half reporting limit for non-detects	Moderate-High		
Determination of background conditions			Moderate
Comparison criteria used in selecting COPCs			Moderate
Exposure Assessment			
Selection of site-specific exposure pathways			Low-moderate
Estimation of exposure to multiple substances			Moderate
Assumption that exposure scenarios and contact with affected media will occur	High		
Assumption of frequent, routine exposure over prolonged durations	High		
Assumption of equivalency of physicochemical characteristics of soil and sediment	Moderate-High		
Selection of UCL 95% or maximum concentration for EPC	Moderate-High		
Use of default exposure values for physiologic parameters:			Low-high
- Skin surface area exposed	Moderate-High		
- Inhalation rates	Moderate		
- Sediment ingestion rates	High		
- Soil ingestion rates	Moderate		
Toxicity Assessment			
Factors used in derivation of toxicity values (e.g., inner-species extrapolation)	Moderate-High		
Weight of evidence for human carcinogenicity	Moderate-High		
Extrapolation of less than lifetime exposure to lifetime cancer risks	High		
Interaction of multiple chemical substances		Moderate	
Use of published RfDs and SFs derived by standard EPA methods	Moderate-High		
Derivation of dermal SFs and RfDs using GI absorption factors			Moderate
Derivation of inhalation RfDs from published RfC values			Uncertain
Lack of toxicity values for some chemicals or exposure routes		Low-Moderate	

TABLE 2-20
Sources of Uncertainty and their Contribution to Conservatism in Risk Assessment
Rev. 1 Memphis Depot Dunn Field Record of Decision

Sources of Uncertainty in Risk Assessment	Degree to which Factor May Result in Overestimated Risk	Degree to which Factor May Result in Underestimated Risk	Degree to which Factor May Result in Overestimated or Underestimated Risk
Assumption of additivity of toxicological effects	Moderate-High		
Use of default PEFs			Low-Moderate
Risk Characterization			
Addition of risks across multiple exposure pathways	Moderate -High		
Addition of risks from multiple chemical substances			Low-High
Lack of consideration of source depletion, natural degradation, or attenuation of COPCs over time	Moderate		

Notes:

95UCL	95% of the upper confidence limit	PEF	particulate emission factor
COPC	contaminant of potential concern	RfC	reference concentration
EPC	exposure point concentration	RfD	reference dose
GI	gastrointestinal	SF	slope factor

Table 2-21A
Remedial Goal Options for Disposal Area (Residential Use)
Rev. 1 Memphis Depot Dunn Field ROD

Chemical	Carcinogenic Effects			Noncarcinogenic Effects
	Residential Adult			Residential Adult
	TR = 1E-06	TR = 1E-05	TR = 1E-04	THI =1
Pesticides				
Dieldrin	0.035	0.35	3.50	28
Metals				
Arsenic	0.405	4.05	40.47	197
Semivolatiles				
Benzo(a)anthracene	0.714	7.14	71.36	
Benzo(a)pyrene	0.068	0.68	6.76	
Benzo(b)fluoranthene	0.714	7.14	71.36	
Carbazole	29.03	290.29	2902.93	
Chrysene	71.36	713.56	7135.57	
Dibenz(a,h)anthracene	0.071	0.71	7.14	
Indeno(1,2,3-c,d)pyrene	0.714	7.14	71.36	

Note: All units are mg/kg

779 121

TABLE 2-21B
Summary of Site Specific SSLs to be Protective of Groundwater
Rev 2 Memphis Depot Dunn Field ROD

							Generic SSL Calculated from EPA Guidance[c,e]		EMSOFT Calculated SSL		Protective Soil Vapor Concentration[d]	
Parameter	Protective Groundwater Criteria[a] (mg/L)	Target Soil Leachate Concentration[b] (mg/L)	Disposal Area Concentrations (mg/kg) Max.	Mean	Detects	% Detects	Loess Specific Values (mg/kg)	Fluvial Deposit Specific Values (mg/kg)	Loess Specific Values (mg/kg)	Fluvial Deposit Specific Values (mg/kg)	Loess Specific Values (ppbv)	Fluvial Deposit Specific Values (ppbv)
Benzene	0 005	0.0305	0 003	0 0013	4/155	3%	0 01842	0.00440	0 0775	0 0406	9 25	4 85
Carbon Tetrachloride	0 0050	0 0305	6 8	0 52	16/155	10%	0 04759	0.01636	0 2150	0 1086	28.14	14 22
Chloroform	0 0790	0 4819	14	0 94	37/154	24%	0 22668	0 06032	0.9170	0 4860	61 57	32 63
Dichloroethane, 1,2-	0.0050	0 0305	0 046	0 016	5/155	3%	0 00911	0.00229	0 0329	0 0189	1 12	0 64
Dichloroethene, 1,1	0.0070	0 0427	0 06	0 014	8/155	5%	0 03118	0 01605	0 1500	0 0764	57 00	29 03
Dichloroethene, cis-1,2-	0.0700	0 4270	0 132	0 013	40/49	82%	0 18899	0 05344	0 7550	0 4040	73 86	39 52
Dichloroethene,1,2-trans-	0.1000	0 6100	0 044	0 0054	22/49	45%	0 36080	0 12018	1 5200	0 7910	256.53	133 50
Methylene chloride	0 0050	0 0305	0 039	0 0071	20/155	13%	0 00810	0 00250	0 0305	0 0169	5.14	2 85
Tetrachloroethane, 1,1,2,2-	0 0005	0.0031	160	6.18	56/155	36%	0 00252	0 00044	0 0112	0 0066	0 03	0 55
Tetrachloroethene	0 0050	0 0305	4 4	0.16	56/155	36%	0 04147	0 01197	0 1806	0 0920	15 18	0 99
Trichloroethane, 1,1,2-	0 0050	0 0305	2 2	0 18	25/155	16%	0 01608	0.00327	0 0627	0 0355	0 84	2 03
Trichloroethene	0.0050	0 0305	460	7 89	92/155	59%	0 04243	0 00976	0.1820	0 0932	10 56	2 06
Vinyl chloride	0 0020	0.0122	7 0	0 64	15/155	10%	0 00553	0 00422	0 0294	0 0150	28.94	14 77

[a] Protective groundwater criteria assumed to be MCL for all compounds except 1,1,2,2-Tetrachloroethane, in which the laboratory reporting limit was used The MCL for Chloroform is 99% of the MCL for Total Trihalomethanes, which is 0 08 mg/L, based on Dunn Field groundwater concentration

[b] Target Soil Leachate Concentration = protective groundwater criteria times a DAF of 6 1

[c] SSL Calculated from Equation 10 in SSL Guidance (EPA, 1996)

[d] Soil Vapor concentration is in equilibrium with EMSOFT calculated SSL

[e] Does not account for thickness of layers or that Loess exists on top of fluvial deposits

SSL = Soil Screening Level
MCL = Maximum Contaminant Level
DAF = Dilution Attenuation Factor

Table 2-21C
Disposal Sites Subsurface Soil Remediation Goals
Rev. 2 Memphis Depot Dunn Field ROD

Potential Chemicals in the Disposal Sites[1]	Chemical Class	Soil Remediation Goal (mg/kg)	Basis for Remediation Goal[2, 6]	Basis of Risk[3]
Acetone	VOC	16	SSL	gw
Aluminum	Inorganic	100,000	DE	max
Antimony	Inorganic	7	BKND	---
Arsenic	Inorganic	29	SSL	gw
Barium	Inorganic	1,600	SSL	gw
Beryllium	Inorganic	19,000	DE	ca
Bis(2-ethylhexyl)phthalate (DEHP)	SVOC	1,231	DE	ca
Bromomethane (Methyl bromide)	VOC	0.2	SSL	gw
Butyl benzyl phthalate	SVOC	100,000	DE	max
Cadmium	Inorganic	451	DE	gw
Carbazole	SVOC	862	DE	ca
Chlordane	Pesticide	64.6	DE	ca
Chlorobenzene	VOC	1	SSL	gw
Chloromethane	VOC	0.082	SSL*	gw
Chromium	Inorganic	4,483	DE	ca
Cobalt	Inorganic	661	SSL*	gw
Copper	Inorganic	669	SSL*	gw
DDD	Pesticide	99.5	DE	ca
DDE	Pesticide	70.2	DE	ca
DDT	Pesticide	70.2	DE	ca
Dibutyl phthalate	SVOC	61,561	DE	nc
1,2-Dichlorobenzene	VOC	17	SSL	gw
1,3-Dichlorobenzene	VOC	0.36	SSL*	gw
1,4-Dichlorobenzene	VOC	2	SSL	gw
1,1-Dichloroethane	VOC	23	SSL	gw
2,4-Dichlorophenol	SVOC	1	SSL	gw
Dieldrin	Pesticide	1.08	DE	ca
Diethyl phthalate	SVOC	1,285	SSL*	gw
Dimethyl phthalate	SVOC	3,309	SSL*	gw
di-n-Octyl phthalate	SVOC	24,624	DE	nc
Endosulfan	Pesticide	3,694	DE	nc
Endrin	Pesticide	185	DE	nc
Ethylbenzene	VOC	13	SSL	gw
HCH (alpha)	Pesticide	3.59	DE	ca
HCH (beta)	Pesticide	12.6	DE	ca
HCH (gamma) Lindane	Pesticide	17.4	DE	ca
Heptachlor	Pesticide	3.83	DE	ca
Heptachlor epoxide	Pesticide	8	DE	ca
Hexachlorobenzene	SVOC/Pesticide	10.7	DE	ca
Lead[4]	Inorganic	1,536	DE	nc
Manganese	Inorganic	1,540	BKND	---
Mercury	Inorganic	307	DE	nc
Methoxychlor	Pesticide	3,078	DE	nc
2-Methylaniline (o-toluidine)	SVOC	0.04	SSL*	gw

Table 2-21C
Disposal Sites Subsurface Soil Remediation Goals
Rev. 2 Memphis Depot Dunn Field ROD

Potential Chemicals in the Disposal Sites[1]	Chemical Class	Soil Remediation Goal (mg/kg)	Basis for Remediation Goal[2, 6]	Basis of Risk[3]
Methyl Ethyl Ketone	VOC	8.55	SSL*	gw
Nickel	Inorganic	20,439	DE	nc
Pentachlorophenol	SVOC/Pesticide	27[(7)]	Site Specific[(7)]	gw
Phenol	SVOC	100	SSL	gw
Polychlorinated Biphenyls (PCBs)				
Aroclor 1016	PCB	37.2	DE	nc
Aroclor 1221	PCB	7.44	DE	ca
Aroclor 1232	PCB	7.44	DE	ca
Aroclor 1242	PCB	7.44	DE	ca
Aroclor 1248	PCB	7.44	DE	ca
Aroclor 1254	PCB	7.44	DE	ca
Aroclor 1260	PCB	7.44	DE	ca
Polynuclear Aromatic Hydrocarbons (PAHs)				
Acenaphthene	PAH	29,219	DE	ca
Anthracene	PAH	100,000	DE	max
Benz[a]anthracene	PAH	21.1	DE	ca
Benzo[b]fluoranthene	PAH	21.1	DE	ca
Benzo[k]fluoranthene	PAH	211	DE	ca
Benzo[a]pyrene	PAH	2.11	DE	ca
Chrysene	PAH	2,110	DE	ca
Dibenz[ah]anthracene	PAH	2.11	DE	ca
Fluoranthene	PAH	22,000	DE	nc
Fluorene	PAH	26,281	DE	nc
Indeno[1,2,3-cd]pyrene	PAH	21.1	DE	ca
Naphthalene	PAH	188	DE	nc
Pyrene	PAH	29,126	DE	nc
Selenium	Inorganic	5	SSL	gw
Silver	Inorganic	34	SSL	gw
Styrene	VOC	4	SSL	gw
2,3,4,6-Tetrachlorophenol	SVOC	18,468	DE	nc
Thallium	Inorganic	67.5	DE	nc
Toluene	VOC	12	SSL	gw
Toxaphene	Pesticide	15.7	DE	ca
Trichloroacetic Acid[5]	VOC/Pesticide	1 2	SSL	gw
1,1,1-Trichloroethane	VOC	2	SSL	gw
2,4,5-Trichlorophenol	SVOC	270	SSL	gw
2,4,6-Trichlorophenol	SVOC	0.2	SSL	gw
1,2,3-Trimethylbenzene[5]	VOC	0.3	SSL	gw
1,2,4-Trimethybenzene	VOC	1.26	SSL*	gw
1,3,5-Trimethylbenzene	VOC	1.24	SSL*	gw
Vanadium	Inorganic	7,154	DE	nc
Xylenes	VOC	210	SSL	gw
Zinc	Inorganic	100,000	DE	max

Table 2-21C
Disposal Sites Subsurface Soil Remediation Goals
Rev. 2 Memphis Depot Dunn Field ROD

Potential Chemicals in the Disposal Sites[1]	Chemical Class	Soil Remediation Goal (mg/kg)	Basis for Remediation Goal[2, 6]	Basis of Risk[3]

Notes:

1. See Table 2-21A for Site-Specific Cleanup Goals for specific VOCs in subsurface soil.

2. Soil Remediation Goals were determined by screening potential chemicals through a decision tree process This process is described in Figure 2-15 and Table 2-21D of this ROD. The Basis for the Remediation Goals are listed as follows:

BKND = Background Value in Soil as Listed in Tables 3-8 and 3-9 of the Dunn Field RI, Rev 2 (CH2M HILL, July 2002)

DE = Industrial Soil Direct Contact Exposure Pathway PRG; Assumes a risk of 1 x 10-5 and HI of 1 (EPA Region 9 PRGs Table, October 2002)

SSL = Default Soil Screening Level for the Migration to Groundwater Pathway; Assumes a default dilution attenuation factor of 20 for source area up to 0.5 acre (EPA Region 9 PRGs Table, October 2002)

SSL* = Soil Screening Level calculated using default values and Equation 10 of the Soil Screening Guidance. User's Guide (EPA, July 1996). The chemical-specific target soil leachate concentration is based on the Tap Water PRG (EPA Region 9 PRGs Table, October 2002) and a DAF of 20 for source area up to 0.5 acre

3 Basis of Risk References are as follows:

ca = carcinogen (Target Cancer Risk of 1 x 10^{-5})

max = non-risk based ceiling limit concentration of 10^{+5} mg/kg for inorganic or semivolatile chemicals

nc = noncarcinogen (Target Hazard Index of 1)

sat = soil saturation limit for volatiles

4. Established Dunn Field Industrial Cleanup Goal for Lead

5. No EPA Region 9 PRG Established Remediation Cleanup Goal referenced per Chapter 62-777, State of Florida Administrative Code

6. Solubility values for inorganics assume that compounds are in a soluble ionic form, such as Al(+3), to be conservative.

7 Based on the January 2004 BCT meeting, fate and transport (F&T) modeling was performed to determine if potential PCP contamination in disposal sites pose a threat to groundwater The objectives for the F&T modeling were to determine the PCP source concentration which would leach into the water table below the MCL of 1 ug/L for PCP Based on the MULTIMED model results, with limited biodegradation, PCP in soil leachate should attenuate below the MCL of 1 ug/L before reaching the water table at source concentrations much greater than the default SSL for PCP (0.03 mg/Kg). An alternative remediation goal (RG) of 27 mg/Kg is recommended for PCP in subsurface soil for disposal sites located at Dunn Field. Based on the MULTIMED model results, a PCP concentration of 27 mg/Kg will be protective of groundwater if detected at the disposal sites. These results are founded on a realistic maximum exposure scenario with slow biodegradation and conservative recharge The alternative RG is lower than the industrial direct contact risk PRG for PCP of 90 mg/Kg (ELCR of 1x10E-5)

- References. Results of a Fate and Transport Model for PCP Contamination at Dunn Field Disposal Sites (CH2MHILL, Feb 2004); Results of a Soil Investigation at the Former PCP Dip Vat and Underground PCP Storage Tank Sites, Main Installation, Memphis Depot (CH2MHILL, Jan 2004)

MCL = maximum contaminant level

mg/kg = milligrams per kilogram

PAH = polynuclear aromatic hydrocarbons

PCB = polychlorinated biphenyls

PCP = pentachlorophenol

PRG = preliminary remedial goal

VOC = volatile organic compound

SVOC = semi-volatile organic compound

Table 2-21D
Summary of Mobility Parameters for Potential Chemicals in Disposal Sites
Rev. 2 Memphis Depot Dunn Field ROD

Potential Chemicals in the Disposal Sites	Mobility Parameters[1,2,3]						
	Chemical Class	***Organic Carbon/Water Partition Coefficient (Koc) (L/Kg)***		***Soil /Water Partition Coefficient (Kd) (L/Kg)***		***Water Solubility (mg/L)***	
Acetone	VOC	5.75E-01	a	4.03E-03		1.00E+06	a
Aluminum	Inorganic	---		3.55E+02	e	2.32E+03	f
Antimony	Inorganic	---		4.50E+01	a	2.81E+04	f
Arsenic	Inorganic	---		2.90E+01	a	4.41E+04	f
Barium	Inorganic	---		4.10E+01	a	1.24E+02	f
Beryllium	Inorganic	---		7.90E+02	a	1.45E+03	f
Bis(2-ethylhexyl)phthalate (DEHP)	SVOC	1.51E+07	a	1.06E+05		1.72E+04	a
Bromomethane (Methyl bromide)	VOC	1.05E+01	a	7.35E-02		3.40E-01	a
Butyl benzyl phthalate	SVOC	5.75E+04	a	4.03E+02		2.69E+00	a
Cadmium	Inorganic	---		7.50E+01	a	3 87E+03	f
Carbazole	SVOC	3.39E+03	a	2.37E+01		7.48E+00	a
Chlordane	Pesticide	1.20E+05	a	8.40E+02		5.60E-02	a
Chlorobenzene	VOC	2.19E+02	a	1.53E+00		4.72E+02	a
Chloromethane	VOC	6.00E+00	d	1.00E-01		4.80E+03	f
Chromium	Inorganic	---		5.85E+03	a	1.98E+03	c
Cobalt	Inorganic	---		4.50E+01	g	3.98E+03	f
Copper	Inorganic	---		2.20E+01	g	5.69E+03	f
DDD	Pesticide	1.00E+06	a	7.00E+03		9 00E-02	a
DDE	Pesticide	4.47E+06	a	3.13E+04		1.20E-01	a
DDT	Pesticide	2.63E+06	a	1.84E+04		2.50E-02	a
Dibutyl phthalate	SVOC	3.39E+04	a	2.37E+02		1.12E+01	a
1,2-Dichlorobenzene	VOC	6.17E+02	a	4.32E+00		1.56E+02	a
1,3-Dichlorobenzene	VOC	4.34E+02	b	3.04E+00		1.25E+02	b
1,4-Dichlorobenzene	VOC	6.17E+02	a	4.32E+00		7.38E+01	a
1,1-Dichloroethane	VOC	3.16E+01	a	2.21E-01		5.06E+03	a
2,4-Dichlorophenol	SVOC	1 47E+02	a	1.03E+00		4.50E+03	a
Dieldrin	Pesticide	2.14E+04	a	1.50E+02		1.95E-01	a
Diethyl phthalate	SVOC	2.88E+02	a	2.02E+00		1.08E+03	a
Dimethyl phthalate	SVOC	3 71E+01	b	2 60E-01		4.00E+03	b
di-n-Octyl phthalate	SVOC	8.32E+07	a	5.82E+05		2.00E-02	a
Endosulfan	Pesticide	2.14E+03	a	1.50E+01		5.10E-01	a
Endrin	Pesticide	1.23E+04	a	8.61E+01		2.50E-01	a
Ethylbenzene	VOC	3.63E+02	a	2 54E+00		1.69E+02	a
HCH (alpha)	Pesticide	1.23E+03	a	8.61E+00		2 00E+00	a
HCH (beta)	Pesticide	1.26E+03	a	8.82E+00		2.40E-01	a
HCH (gamma) Lindane	Pesticide	1.07E+03	a	7.49E+00		6.80E+00	a
Heptachlor	Pesticide	1.41E+06	a	9.87E+03		1 80E-01	a
Heptachlor epoxide	Pesticide	8.32E+04	a	5.82E+02		2.00E-01	a
Hexachlorobenzene	SVOC/Pesticide	5.50E+04	a	3.85E+02		6.20E+00	a
Lead[4]	Inorganic	---		9.00E+02	b	3.98E+03	f
Manganese	Inorganic	---		5.01E+01	h	5.03E+03	f

Table 2-21D
Summary of Mobility Parameters for Potential Chemicals in Disposal Sites
Rev. 2 Memphis Depot Dunn Field ROD

Potential Chemicals in the Disposal Sites	Mobility Parameters[1,2,3]						
	Chemical Class	*Organic Carbon/Water Partition Coefficient (Koc) (L/Kg)*		*Soil /Water Partition Coefficient (Kd) (L/Kg)*		*Water Solubility (mg/L)*	
Mercury	Inorganic	---		5.20E+01	a	4.93E+03	f
Methoxychlor	Pesticide	9.77E+04	a	6.84E+02		4.50E-02	a
2-Methylaniline (o-toluidine)	SVOC	7 40E+01	b	5.18E-01		1.66E+04	b
Methyl Ethyl Ketone	VOC	3.55E+00	f	2.48E-02		1.36E+05	f
Nickel	Inorganic	---		6.50E+01	a	1.13E+00	f
Pentachlorophenol	SVOC/Pesticide	5.92E+02	a	4.14E+00		1.95E+03	a
Phenol	SVOC	2 88E+01	a	2.02E-01		8.28E+04	a
Polychlorinated Biphenyls (PCBs)		3.09E+05	a	2.16E+03		7.00E-01	a
Aroclor 1016	PCB	---				---	
Aroclor 1221	PCB	---				---	
Aroclor 1232	PCB	---				---	
Aroclor 1242	PCB	---				---	
Aroclor 1248	PCB	---				---	
Aroclor 1254	PCB	---				---	
Aroclor 1260	PCB	---				---	
Polynuclear Aromatic Hydrocarbons (PAHs)							
Acenaphthene	PAH	7.08E+03	a	4.96E+01		4.24E+00	a
Anthracene	PAH	2.95E+04	a	2.07E+02		4.34E-02	a
Benz[a]anthracene	PAH	3.98E+05	a	2.79E+03		9.40E-03	a
Benzo[b]fluoranthene	PAH	1.23E+06	a	8.61E+03		1.50E-03	a
Benzo[k]fluoranthene	PAH	1.23E+06	a	8.61E+03		8.00E-04	a
Benzo[a]pyrene	PAH	1.02E+06	a	7.14E+03		1.62E-03	a
Chrysene	PAH	3.98E+05	a	2.79E+03		1.60E-03	a
Dibenz[ah]anthracene	PAH	3.80E+06	a	2.66E+04		2.49E-03	a
Fluoranthene	PAH	1.07E+05	a	7.49E+02		2.06E-01	a
Fluorene	PAH	1.38E+04	a	9.66E+01		1.98E+00	a
Indeno[1,2,3-cd]pyrene	PAH	3.47E+06	a	2.43E+04		2.20E-05	a
Naphthalene	PAH	2.00E+03	a	1.40E+01		3.10E+01	a
Pyrene	PAH	1.05E+05	a	7.35E+02		1.35E-01	a
Selenium	Inorganic	---		5.00E+00	a	1.04E+04	f
Silver	Inorganic	---		8.30E+00	a	5.15E+03	f
Styrene	VOC	7.76E+02	a	5.43E+00		3.10E+02	a
2,3,4,6-Tetrachlorophenol	SVOC	2.00E+03	b	1.40E+01		2.30E+01	b
Thallium	Inorganic	---		7.10E+01	a	3 75E+03	f
Toluene	VOC	1.82E+02	a	1.27E+00		5.26E+02	a
Toxaphene	Pesticide	2.57E+05	a	1.80E+03		7.40E-01	a
Trichloroacetic Acid	VOC/Pesticide	2.74E+00	b	1 92E-02		4.40E+04	b
1,1,1-Trichloroethane	VOC	1.10E+02	a	7.70E-01		1 33E+03	a
2,4,5-Trichlorophenol	SVOC	1.60E+03	a	1.12E+01		1 20E+03	a
2,4,6-Trichlorophenol	SVOC	3.81E+02	a	2.67E+00		8.00E+02	a
1,2,3-Trimethylbenzene	VOC	6.31E+02	d	4.42E+00		6.55E+01	d
1,2,4-Trimethybenzene	VOC	7.18E+02	b	5 02E+00		5.70E+01	b
1,3,5-Trimethylbenzene	VOC	7.03E+02	b	4.92E+00		4.82E+01	b

Table 2-21D
Summary of Mobility Parameters for Potential Chemicals in Disposal Sites
Rev. 2 Memphis Depot Dunn Field ROD

Potential Chemicals in the Disposal Sites	Mobility Parameters[1,2,3]						
	Chemical Class	*Organic Carbon/Water Partition Coefficient (Koc) (L/Kg)*		*Soil /Water Partition Coefficient (Kd) (L/Kg)*		*Water Solubility (mg/L)*	
Vanadium	Inorganic	---		1.00E+03	a	3.06E+03	f
Xylenes	VOC	3.86E+02	a	2.70E+00		1.75E+02	a
Zinc	Inorganic	---		6.20E+01	a	4.22E+03	f
Chemicals of Concern Identified in Dunn Field Groundwater (for reference)							
Carbon Tetrachloride	VOC	1.74E+02	a	1.22E+00		7.93E+02	a
Chloroform	VOC	3.98E+01	a	2.79E-01		7.92E+03	a
1,2-Dichlorethane	VOC	1.74E+01	a	1.22E-01		8.52E+03	a
1,1-Dichloroethene	VOC	5.89E+01	a	4.12E-01		2.25E+03	a
cis-1,2-Dichloroethene	VOC	3.55E+01	a	2.49E-01		3.50E+03	a
trans-1,2-Dichloroethene	VOC	5.25E+01	a	3.68E-01		6.30E+03	a
Methylene Chloride	VOC	1.17E+01	a	8.19E-02		1.30E+04	a
1,1,2,2-Tetrachloroethane	VOC	9.33E+01	a	6.53E-01		2.97E+03	a
Tetrachloroethene	VOC	1.55E+02	a	1.09E+00		2.00E+02	a
1,1,2-Trichloroethane	VOC	5.01E+01	a	3.51E-01		4.42E+03	a
Trichloroethene	VOC	1.66E+02	a	1.16E+00		1.10E+03	a
Vinyl Chloride	VOC	1.86E+01	a	1.30E-01		2.76E+03	a
Benzene (non-COC)	*VOC*	*5.89E+01*	*a*	*4.12E-01*		*1.75E+03*	*a*
Average		*72.7*		*5.09E-01*		*4.48E+03*	
Min		*11.7*		*8.19E-02*		*2.00E+02*	
Max		*174*		*1.22E+00*		*1.30E+04*	

Notes.

1. K_d values for metals from Table C-4, Soil Screening Guidance Assumes a typical subsurface pH value.
2. Mobility References are as follows:
   a U S EPA. July 1996. Soil Screening Guidance: User's Guide, Attachment C: Chemical Properties for SSL
   b. Values were taken from http://www.epa.gov/oppt/exposure/docs/episuitedl htm Values were estimated using programs, PCKOCWIN, HENRYWIN, and WSKOWWIN.
   c. Weast RC *CRC handbook of chemistry and physics.* Boca Raton, FL: CRC Press
   d Mackay, D., W. Shiu, and K. Ma. 2000 *Physical-Chemical Propoerties and Environmental Fate Handbook.* Chapman &Hall
   e. State of Texas Comission on Environmental Quality (TECQ) Rules. Chapter 350 (Texas Risk Reduction Program) Subchapter D. Section 73. Figure 30
   f. Chemical-specific ASTDR Toxicological Profile Sheets http://www.atsdr cdc gov/toxpro2 html
   g. HydroGeoLogic, Inc. June 1999. *Draft Partition Coefficient for Metals in Surface Water, Soil, and Waste*. Prepared for U.S. EPA.
   h. Dunn Field RI (CH2M HILL, July 2002)
3. Solubility values for inorganics assume that compounds are in a soluble ionic form, such as Al(+3), to be conservative.

L/kg = liters per kilogram
mg/L = milligrams per liter
PAH = polynuclear aromatic hydrocarbons
PCB = polychlorinated biphenyls
VOC = volatile organic compound
SVOC = semi-volatile organic compound

Table 2-21E
Selection of COCs for Groundwater at Dunn Field - Most Frequently Detected Chemicals and Exceedence of MCLs/PRGs
Rev. 2 Memphis Depot Dunn Field ROD

Chemical of Concern	Units	Maximum Contaminant Level (MCL)-Primary Drinking Water Standard	Risk/HI at MCL	USEPA Region 9 PRGs-Tap Water (October 1, 2002)	Risk/HI at RBCs	Average Conc	All-time Max Conc.	Frequency of Detections	Risk/HI at Average	Risk/HI at Max
Carbon Tetrachloride	ug/L	5	2.9E-05	0 17	1.0E-06	17 7	44 4	21%	1 0E-04	2.6E-04
Chloroform	ug/L	80	1 3E-05	6 2	1.0E-06	117	857	33%	1 9E-05	1.4E-04
1,1-Dichloroethene*	ug/L	7	0 02	340	NC, HI=1 0	23.3	39 5	15%	0 07	0.1
Trans 1,2-Dichloroethene	ug/L	100	0 83	120	NC, HI=1 0	8.2	54 0	26%	0 07	0.5
Cis 1,2-Dichloroethene	ug/L	70	1.1	61	NC, HI=1 0	28.8	250	25%	0.47	4.1
1,1,2,2-Tetrachloroethane	ug/L	NA	NA	0 055	1 0E-06	2000	33000	26%	3.6E-02	6.0E-01
Tetrachloroethene	ug/L	5	7 6E-06	0.66	1 0E-06	19.5	120	29%	3.0E-05	1 8E-04
1,1,2-Trichloroethane	ug/L	5	2 6E-05	0.19	1 0E-06	4 2	9.5	8%	2.2E-05	5 0E-05
Trichloroethene**	ug/L	5	8 9E-06	0.56	1.0E-06	254	3170	55%	4.5E-04	5.7E-03
Total Risk/HI			**8.5E-05**		**6.0E-06**				**3.7E-02**	**6.1E-01**

Only compounds detected are listed
ug/L = micrograms per liter
DL = Detection Limit
TCL = Target Compound List
BDL = Below Detection Limit
MCL = Maximum Contaminant Level - Primary Drinking Water Standards
RBCs = Risk Based Contaminants
NS = no standard NP = not performed
NA = not available
* - 1,1-dichlorethene has recently been reclassified by EPA as a non-carcinogen, however existing MCL is based on previous assumption that it is a carcinogen.
** - For Trichloroethene, a slope factor of 0.02 (mg/kg-day) [1] from the range of 0.02 to 0.4 (mg/kg-day) [1]

779 129

Table 2-21F

Target Risk Based Concentration Levels for COCs Detected in Groundwater at Dunn Field

Rev. 2 Memphis Depot Dunn Field ROD

Chemical of Concern	Units	Maximum Contaminant Level (MCL)-Primary Drinking Water Standard	Risk/HI at MCL	USEPA Region 9 PRGs-Tap Water (October 1, 2002)	Risk/HI at RBCs	Target Concentrations at 10^{-6} target risk levels and Target HI=1.0: Target MCL	Risk at Target	HI at Target	Target Concentrations at 10^{-4} target risk levels and Target HI=1.0: Target MCL	Risk at Target	HI at Target	Target Organ
Carbon Tetrachloride	ug/L	5	2.9E-05	0.17	1 0E-06	**0.03**	2.0E-07	NA	**3.0**	1.8E-05	NA	
Chloroform	ug/L	80	1.3E-05	6.2	1 0E-06	**0.62**	1.0E-07	NA	**12**	2 0E-06	NA	
1,1-Dichloroethene**	ug/L	7	0 02	340	NC, HI=1.0	**112.2**	NA	0.33	**7/340****	NA	**1.00**	Liver
Trans 1,2-Dichloroethene	ug/L	100	0 83	120	NC, HI=1 0	**39.6**	NA	0.33	**50**	NA	**0 42**	Blood
Cis 1,2-Dichloroethene	ug/L	70	1.1	61	NC, HI=1 0	**20.1**	NA	0.33	**35**	NA	**0.57**	Blood
1,1,2,2-Tetrachloroethane	ug/L	NA	NA	0 055	1.0E-06	**0.011**	2 0E-07	NA	**2.20**	4 0E-05	NA	
Tetrachloroethene	ug/L	5	7 6E-06	0 66	1.0E-06	**0.132**	2.0E-07	NA	**2.5**	3 8E-06	NA	
1,1,2-Trichloroethane	ug/L	5	2.6E-05	0 19	1.0E-06	**0.019**	1.0E-07	NA	**1.9**	1 0E-05	NA	
Trichloroethene***	ug/L	5	8.9E-06	0.56	1.0E-06	**0.1120**	2 0E-07	NA	**5.0**	8.9E-06	NA	
Total Risk/HI			**8.5E-05**		**6.0E-06**		**1.0E-06**	**0.99**		**8.2E-05**	**</= 1**	

Only compounds detected are listed

ug/L = micrograms per liter

DL = Detection Limit

TCL = Target Compound List

BDL = Below Detection Limit

MCL = Maximum Contaminant Level - Primary Drinking Water Standards

RBCs = Risk Based Contaminants

NS = no standard NP = not performed

NA = not available

** - 1,1-dichlorethene has recently been reclassified by EPA as a non-carcinogen; however, existing MCL is based on previous assumption that it is a carcinogen

*** - For Trichloroethene, a slope factor of 0 02 $(mg/kg\text{-}day)^{-1}$ from the range of 0 02 to 0.4 $(mg/kg\text{-}day)^{-1}$

779 130

Table 2-21G

Summary of Remediation Goals for VOCs in Soil, Soil Vapor, and Groundwater at Dunn Field

Rev. 2 Memphis Depot Dunn Field Record of Decision

Parameter	Remedial Goal Objectives				
	Site-Specific Soil Screening Levels to be Protective of Groundwater		Protective Soil Vapor Concentration		Groundwater Target Concentrations at 10E-04 Target Risk Levels and Target HI=1.0
	Loess Specific Values (mg/kg)	Fluvial Deposit Specific Values (mg/kg)	Loess Specific Values (ppbv)	Fluvial Deposit Specific Values (ppbv)	Protective Target Level (ug/L)
Carbon Tetrachloride	0.2150	0.1086	28.14	14.22	3.0
Chloroform	0.9170	0.4860	61.57	32.63	12.0
Dichloroethane, 1,2-	0.0329	0.0189	1.12	0.64	--
Dichloroethene, 1,1-*	0.1500	0.0764	57.00	29.03	7/340**
Dichloroethene, cis-1,2-	0.7550	0.4040	73.86	39.52	35.0
Dichloroethene, trans-1,2-	1.5200	0.7910	256.53	133.50	50.0
Methylene chloride	0.0305	0.0169	5.14	2.85	--
Tetrachloroethane, 1,1,2,2-	0.0112	0.0066	0.03	0.55	2.2
Tetrachloroethene	0.1806	0.0920	15.18	0.99	2.5
Trichloroethane, 1,1,2	0.0627	0.0355	0.84	2.03	1.9
Trichloroethene**	0.1820	0.0932	10.56	2.06	5.0
Vinyl chloride	0.0294	0.0150	28.94	14.77	--

Notes

mg/kg = milligrams per kilogram

ppbv = parts per billion per volume

ug/L = micrograms per liter

MCL = Maximum Contaminant Level

HI = Hazard Indices

-- = Not available for groundwater cleanup goals because of low number of detections or detected values consistently less than MCLs.

* 1,1-dichloroethene has recently been reclassified by EPA as a non-carcinogen; however, existing MCL is based on previous assumption that it is a carcinogen

** For Trichloroethene, a slope factor of 0 02 (mg/kg-day)E-01 from the range of 0.02 to 0 4 (mg/kg-day)E-01

779 131

Table 2-22a
Capital Cost Estimate: Excavation, Transportation, and Off-site Disposal
Disposal Sites and Associated Subsurface Soil
Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Institutional Controls (Deed Restrictions)					Deed restrictions would prohibit redevelopment of property to residential standards.
	1.1 Attorney Fees	32	hr	$200 /hr	$6,400	CH2M HILL: American Scrap Metal Site, Panama City: Order of Magnitude Cost Estimate
	1 2 Recording of the Deed	2	ea	$500 /ea	$1,000	
2	Plans for Implementation	120	hr	$85 /hr	$10,200	Based on CH2M HILL's professional judgement.
						Plans to develop include Site Safety and Health Plan and Environmental Protection Plan.
3	Pre-Design Engineering/Investigation					
	5.1 Pre-Design Planning	120	hr	$85 /hr	$10,200	Assume it will include RA Workplan development with engineering design, bidding, permitting, and as-built drawings.
	5.2 Geophysical Locating of Sites	1	ea	$12,000 /ea	$12,000	Reichhold Kensington,GA site. $3270 per day, plus $1500 mobilization and $500 per report.
	5.3 Test-Pitting of Disposal Sites	1	ea	$42,550 /ea	$42,550	Use of excavator to conduct test pits in Level B.
	5 4 Field Oversight of Test Pitting	1	ea	$23,500 /ea	$23,500	Assumes 1 person in field for 6 days at 10 hrs per day, plus field equipment (meters, sample. kits.) expenses.
	5.5 Analytical Costs for Analysis of Disposal Site Soils and Waste	1	ea	$64,560 /ea	$64,560	Assumes comprehensive soil samples (plus QA/QC samples) from test pits in each disposal site. 54 samples analyzed for TCL/TAL and 16 samples analyzed for disposal characterization.
	5.6 Misc. Field Costs	1	LS	$7,500 /each	$7,500	Estimated.

779 132

Table 2-22a
Capital Cost Estimate: Excavation, Transportation, and Off-site Disposal
Disposal Sites and Associated Subsurface Soil
Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
4	Excavation					The total volume for the 16 disposal sites is 13,620 cubic feet (approx. 5100 cubic yards). Assume that 75% of the disposal sites will require excavation and 25% of the soil will characterized as nonhazardous. Assuming that this action is run with rolloff boxes in Level B
	4.1 Mobilization/Demobilization	1	ea	$10,000 /ea	$10,000	Estimated.
	4.2 On site Management by Subcontractor	1	ea	$25,000 /ea	$25,000	Management on site during remedial action. CH2M HILL Professional estimate
	4.3 Control Bldgs	1	ea	$5,000 /ea	$5,000	Estimate from RS Means *2001 Environmental Remediation Cost Data - Unit Price* for temporary offices
	4 4 Heavy Equipment Rental - Loader, Excavator, Forklift incl operators personnel	1	mo	$150,000 /mo	$150,000	Estimate from RS Means *2001 Environmental Remediation Cost Data - Unit Price* for equipment rental in Level B
5	Transportation and Disposal					Transport of materials from site. 12 sites with 25% of the total cubic yards characterized as non-hazardous
	5 1 Chemical Oxidation Treatment for Pesticide contaminated hazardous waste					
	5.1.1 Transport and Disposal	1974	tn	$240 tn	$473,800	1223 cy to dispose. Estimate $240 per ton
	5 2 Incineration of Hazardous Waste Soils					
	5.2.1 Transport and Disposal	389	tn	$700 tn	$272,300	91 cy to dispose. Estimated $700 per ton
	5.3 "C" Listed Hazardous Waste Soils					
	5.3.1 Transported and Disposal	2226	tn	$157 tn	$349,500	1403 cy to dispose. Estimated $157 per ton
	5.4 Non-hazardous Soils					
	5.4 1 Transport and Disposal	1814	tn	$32 tn	$58,000	1109 cy to dispose. Estimated $32 per ton
	5.5 Clean Backfill for Each Pit	3,900	cy	$25 /cy	$97,500	Placed and compacted clean backfill

779 133

Table 2-22a
Capital Cost Estimate: Excavation, Transportation, and Off-site Disposal
Disposal Sites and Associated Subsurface Soil
Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	5.6 Decontamination including waste tank	1	ea	$25,000 /ea	$25,000	Includes decontamination and waste holding tank of 2500 gallons. CH2M HILL estimate: 375 hrs x $60/hr
	5.7 Decon Materials and Solid Waste Disposal	1	ea	$4,000 /ea	$4,000	Estimated. Assuming non-hazardous waste characterization.
	5.8 Confirmation Sampling	30	ea	$1,725 /ea	$51,800	Characterization analyses from bottom of pits
	5.9 Remedial Action Report	1	ea	$15,000 /ea	$15,000	This cost includes the preparation of a technical report, where all field data will be presented with interpretation analysis. Estimated.
Total Capital Costs					**$1,714,810**	

[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.

779 134

Table 2-22a
O&M Cost Estimate: Excavation, Transportation, and Off-site Disposal
Disposal Sites and Associated Subsurface Soil
Rev. 1 Memphis Depot Dunn Field FS

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b,c]	Source/ Comments
6	Annual Evaluation (Year 2-30)						
	6.1 Inspection	8	hr/yr	$75 /hr	$600	$9,100	Annual inspection required to determine if institutional controls are acceptable
	6.2 Annual Report	32	hr/yr	$75 /hr	$2,400	$36,300	Assume 1 report per year.
7	5-Year Review (six over 30 years)	40	hr/yr	$100 /hr	$4000 ($800 averaged over 5 years)	$11,700	Remedial alternative will need to be reviewed every 5 years to ensure adequate protection.
Total O&M Costs (2-30 years)[d]					**$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 is calculated by using an interest rate of 5 percent for all costs beyond year 1.

[d] The Total Annual O&M Costs are equal to an average of the annual cost for a year with semi-annual monitoring and a year with annual monitoring.

779 135

Table 2-22a
Capital and O&M Cost Estimate: Excavation, Transportation, and Off-site Disposal
Disposal Sites and Associated Subsurface Soil
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b,c]	Total PW Cost[c]
1	Institutional Controls (Deed Restrictions)	$7,400	NA	NA	$7,400
2	Plans for Implementation	$10,200	NA	NA	$10,200
3	Pre-Design Engineering/Investigation	$160,310	NA	NA	$160,310
5	Excavation	$190,000	NA	NA	$190,000
6	Transportation and Disposal	$1,346,900	NA	NA	$1,346,900
7	Annual Evaluation (Year 2-30)	NA	$3,000	$45,400	$45,400
8	5-Year Review	NA	$800	$11,700	$11,700
Total Costs		**$1,715,000**	**$3,800**	**$57,000**	**$1,772,000**

[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.

Note: The annual total O&M costs consist of cost for annual evaluation and an average of other costs over time period they occur.

NA = Not applicable

779 136

Table 2-22b
Capital Cost Estimate: SVE Presumptive Remedy for VOCs in Soil
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Institutional Controls (Deed Restrictions)					Deed restrictions would prohibit installation and use of production and consumptive use wells and access to the Disposal Area of Dunn Field
	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	2	ea	$500 /ea	$1,000	
2	Fencing along Perimeter of Disposal Area					
	2.1 Fencing	2,200	ft	$23 /ft	$50,600	Use of existing fence and additional fence; Estimate from RS Means Environmental Remediation Cost Data (2001). Order of magnitude costs.
	2.2 Gate	2	ea	$807 /hr	$1,614	Assumes two field people will be on site for 10 hours per day for 5 days.
3	Signs					
	3.1 Signs	6	ea	$69 ea	$414	Estimate from RS Means Environmental Remediation Cost Data (2001). Order of magnitude costs
	3.3 Labor	4	hr	$50 hr	$200	
4	Plans for Implementation	120	hr	$85 /hr	$10,200	Based on CH2M HILL's professional judgement.
						Plans to develop include Site Safety and Health Plan, Environmental Protection Plan, Quality Assurance Project Plan, and Sampling and Analysis Plan.
						Plans to develop include Site Safety and Health Plan and Environmental Protection Plan.

Table 2-22b
Capital Cost Estimate: SVE Presumptive Remedy for VOCs in Soil
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
5	Soil Investigation and Soil Monitoring Points					Assumes 52 soil monitoring points (2 horizons) for the loess and 48 (2 horizons) soil monitoring points for the fluvial sand will be installed to monitor full-scale soil vapor extraction. Screens will be set at multiple depths in each borehole (2 horizons in the loess and 2 horizons in the fluvial sand). Soil samples will be collected from 20 locations.
	5.1 Mobilization/Demobilization	1	ea	$8,500 /ea	$8,500	Assume Rotasonic drill rig and equipment will not be local.
	5.2 Soil Monitoring Point Drilling	3084	ft	$62 /ft	$191,208	Defense Depot - EBT Treatability Study at the Main Installation. Costs from Boart Longyear (2002). Bore holes will be drilled and continuously sampling using Rotasonic drilling methods Costs per ft are inclusion of all drilling, materials, supplies, T&D of cuttings (assume non-hazardous waste), per diem.
	5.3 Labor (Contractor oversight)	170	hr	$75 /hr	$12,800	Assumes one field person will be on-site for overseeing and soil sampling for 10 hours a day for 17 days.
	5.4 Laboratory Analyses (VOCs)	106	analysis	$192 /analysis	$20,400	Assumes 4 samples from each sampling locations will be sent to Test America in TN. The price includes QA/QC samples.
	5.5 Laboratory Analyses (TCLP)	1	analysis	$955 /analysis	$1,000	Kemron Laboratory , based on 14-day TAT
	5.6 Rental Equipment	19	day	$90 /day	$1,700	MicroFID - quote from Pine Environmental Services, Inc.
	5.7 Mobilization/Demobilization (Oversight and soil sampling)	32	hr	$75 /hr	$2,400	Assumes it will take one field person 8 hours for mobilization and 8 hours for demobilization for each trip. Two trips will be needed.
	5.8 Supplies	2	event	$500 /event	$1,000	CH2M HILL professional judgement

779 138

Table 2-22b
Capital Cost Estimate: SVE Presumptive Remedy for VOCs in Soil
Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
6	Horizontal SVE Wells Installation					Three horizontal SVE wells for loess (15-20 feet in depth and 705 to 840 feet in length) and two horizontal SVE wells for fluvial sand (50-55 feet in depth and 730 to 820 feet in length) will be installed at the site. Both riser casing and screen will be 6-inch SDR-11 HDPE. Slotted screen is 3 rows of 0.020-inch slots
	6.1 Mobilization	1	ea	$75,760 /ea	$75,760	Quoted by Longbore, Inc. The price includes drill rig, pipe trailer, mud system, generator trailer, support truck, steam cleaner, fork lift, back hoe, initial and final decon, surveying, PVC liner material, water PPE, water truck, drilling fluid and additives, vacuum truck services, and etc.
	6.2 Drilling and Well Construction	6325	ft	$59 /ft	$373,175	Quoted by Longbore, Inc.
	6.3 Materials					Quoted by Longbore, Inc
	6.3.1 Sacks Portland cement	100	ea	$16 /ea	$1,600	Quoted by Longbore, Inc.
	6.3.2 SDR 11 HDPE screen	5100	ft	$12 /ft	$61,200	Quoted by Longbore, Inc.
	6 3.3 SDR 11 HDPE riser	1696	ea	$8 /ea	$13,600	Quoted by Longbore, Inc.
	6.4 Development	100	hr	$500 /hr	$50,000	Quoted by Longbore, Inc.
	6.5 Laboratory Analyses (TCLP)	4	analysis	$955 /analysis	$3,800	Kemron Laboratory , based on 14-day TAT
	6.6 Soil Disposal	8	roll-off	$2,000 /roll-off	$16,000	The cost includes roll-off rental, transportation and disposal for non-hazardous soil bore cuttings Assumes a roll-off is 17 cubic yards and 123 cubic yard soil will be generated (estimated by Longbore, Inc.)
	6.7 Labor (Oversight)	500	hr	$75 /hr	$37,500	Assumes one field person will be on-site for overseeing for 10 hours a day for 50 days.
	6.8 Mobilization/Demobilization (Oversight)	64	hr	$75 /hr	$4,800	Assumes it will take one field person 8 hours for mobilization and 8 hours for demobilization for each trip (4 trips is needed).

Table 2-22b
Capital Cost Estimate: SVE Presumptive Remedy for VOCs in Soil
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
7	Vertical SVE Wells Installation					24 vertical SVE wells for loess (total depth=25-30 feet) and 10 vertical SVE wells for fluvial sand (total depth=70-75 feet) will be installed at the site.
	7.1 Mobilization	0	ea	$0 /ea	$0	Assume Mobilization will be at the same time that soil monitoring points are installed, therefore no costs are presented.
	7.2 SVE Wells Drilling and Preparation for Loess	648	ft	$72 /ft	$46,656	Defense Depot - EBT Treatability Study at the Main Installation. Costs from Boart Longyear
	7.3 SVE Wells Drilling and Preparation for fluvial sand	720	ft	$72 /ft	$51,840	Bore holes will be drilled and continuously sampling using Rotasonic drilling methods. Costs per ft are inclusion of all drilling, materials, supplies, T&D of cuttings (assume non-hazardous waste), per diem.
	7.4 Labor (Oversight)	170	hr	$75 /hr	$12,800	Assumes one field person will be on-site for overseeing for 10 hours a day for 17 days.
	7 5 Laboratory Analyses (TCLP)	1	analysis	$955 /analysis	$1,000	Kemron Laboratory , based on 14-day TAT
	7.6 Mobilization/Demobilization (Oversight)	16	hr	$75 /hr	$1,200	Assumes it will take one field person 8 hours for mobilization and 8 hours for demobilization for each trip. Two trips will be needed.
8	Capital Equipment and Construction					
	8.1 Vacuum Pumps for loess	1	ea	$63,500 /ea	$63,500	Quoted by EPG/Catalytic Combustion. A HYVAC 75 HP MPE Systems Nominal 1200 ACFM @ 26" Hg will be used. The cost includes MPE, Vapor/Liquid Separator (VSL), Controls, Wiring panel to skid.
	8.2 Vacuum Pump for sand	1	ea	$13,500 /ea	$13,500	Quoted by EPG/Catalytic Combustion. Low Vac 15 HP Regenerative System 500 ACFM @ 2.3" Hg. The cost includes MPE, VLS, Controls, Wiring panel to skid.
	8.3 Trenching	4,500	LF	$6.50 /LF	$29,250	Based on CH2M HILL's professional judgement. The cost includes construction equipment and labor for 3 feet deep trenching Assumes soil will be placed back in trench.

Table 2-22b

Capital Cost Estimate: SVE Presumptive Remedy for VOCs in Soil

Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	8.4 Piping Cost	4,500	LF	$1.46 /LF	$6,570	Quoted by Michigan Pipe Supply, LLC. The cost includes 4" SDR 11 HDPE pipes x 500' coil.
	8.5 Miscellaneous	1	ea	$13,000 /ea	$13,000	The price includes 4" HDPE SDR 11 MPT transitions, flange adapters, ductile iron back up rings, reducing couplings, throttling valves, air flow meters, vacuum gauges, and well vaults
	8.6 Piping Assembling	1	ea	$81,000 /ea	$81,000	Based on CH2M HILL's professional judgement. The cost includes construction equipment and labor for piping assembling, well vaults installation, and other pipe fitting.
	8.7 Equipment Storage Building	1	ea	$19,800 /ea	$19,800	Quoted by Engineering Management Construction, Inc. Butler building package 15'x20'x15'.
	8.8 Building Heater	1	ea	$500 /ea	$500	
	8 9 Auto Dialer	1	ea	$4,000 /ea	$4,000	
	8.10 Capping	360,000	sq. ft.	$1.75 /sq ft	$630,000	Based on CH2M HILL's professional judgement. The cost includes 3 person crew, grading, putting 20 mm liner down and fill with 6" cover of gravel and stones. There will be less stick-ups through the cap with the horizontal wells.
9	Startup					Project Manager and an engineer will have a kick off meeting and a safety meeting with subcontractors. Assumes Startup will take 10 hours a day for 14 days.
	9.1 Labor (Startup)	560	hr	$85 /hr	$47,600	Assumes 4 people (2 engineers and 2 technicians) will oversee the system startup. It will take 10 hours per day for 14 days.
	9.2 Mobilization/ Demobilization (Startup)	64	hr	$85 /hr	$5,400	Assumes it will take 4 people 8 hours for mobilization and 8 hours for demobilization for the startup.
	9.3 Summary TM	60	hr	$85 /hr	$5,100	A summary Technical Memorandum will be written after the startup.

779 141

Table 2-22b
Capital Cost Estimate: SVE Presumptive Remedy for VOCs in Soil
Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
10	Offgas Treatment					
	10.1 Chlorinated Catalytical Oxidizer	1	ea	$85,000 /ea	$85,000	Quoted by Catalytic Combustion. Base system price for Model HD-CATOX 750G.
	10.2 Scrubber for HCl emissions	1	ea	$61,000 /ea	$61,000	Quoted by Catalytic Combustion. Base system price for Model 1000 HCl Scrubber Module
	10 3 Miscellaneous	1	ea	$15,600	$15,600	The price was quoted by Catalytic Combustion plus 20% contingency. The cost includes freight (SVE & Offgas Treatment equipment) to the job site, subcontractor's start-up cost, and spare parts package for the oxidizer and scrubber.
	10.4 NaOH Required to Neutralize HCl for the first year	66,600	gal	$0.31 /gal	$20,700	Assumes 7.52 gallons per hour of 25% NaOH solution (freeze at 10 degrees F) or 3.13 gallons per hour of 50% NaOH solution (freeze at 45 degrees F) is needed to neutralize HCl generated from the system. 25% NaOH will be $0.31 per gallon and 50% NaOH will
11	Utilities (Year 1)					
	11.1 Electricity for vacuum pumps	685,895	kw-hr	$0.06 /kw-hr	$41,154	Assumes vacuum pumps (total of 105 HP) will run 24 hours a day for 365 days for the first year.
	11.2 Electricity for heater	7,200	kw-hr	$0.06 /kw-hr	$432	Assumes a heater (2 kw) will run 5 months during the winter season for the first year.
	11.3 Electricity for Offgas Treatment	32,662	kw-hr	$0.06 /kw-hr	$1,960	Assumes a fan (5 HP) for offgas treatment will run 24 hours a day for 365 days for the first year.
	11.4 Fuel Consumption for Offgas Treatment	21,024	therms	$1.00 /therm	$21,024	Fuel consumption will be 2.4 therms/hr based on Catalytic Combustion's estimation. The system will consume natural gas 24 hours a day for 365 days for the first year. Assumes natural gas will cost $1.00 per therm. Gasoline connection fee is included.

Table 2-22b

Capital Cost Estimate: SVE Presumptive Remedy for VOCs in Soil

Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	11 5 Water Usage for Offgas Treatment	1,436,640	gal	$0.08 /gal	$115,239	Water usage will be 164 gal/hr based on Catalytic Combustion's estimation. The system will consume water 24 hours a day for 365 days for the first year. Public water will cost $0.60 per cubic foot. Water line connection fee is included.
	11.6 Sewerage for Offgas Treatment	1,174	1000 gal	$0.59 /1000 gal	$693	Water discharge rate will be 134 gal/hr based on Catalytic Combustion's estimation. The system will discharge water 24 hours a day for 365 days for the first year. The sewerage charge will be $0.587 per 1000 gallon. Sewerage connection fee is included.
	11.7 Sewerage for Groundwater Recovered by SVE Systems	105	1000 gal	$0.59 /1000 gal	$62	Water purging rate from SVE systems will be 0.2 gpm (or 12 gal/hr) based on the SVE feasibility study conducted at the site in December 2001. The system will purge water 24 hours a day for 365 days for the first year. The sewerage charge will be $0.587
	11.8 Electricity Hookup	1	ea	$30,000 /ea	$30,000	Three-Phase 460-volt AC Supplies at 100-amp is needed at the site. The cost includes transformers, poles, and subcontractor's labor
12	Air Sampling for VOCs, Air Monitoring, and SVE O&M					Assume first year of air sampling, air monitoring and SVE O&M is a capital expense. Air samples will be collected from discharge stack out of offgas treatment and scrubber, daily for first 3 days and weekly for first 4 weeks for the Startup and monthly thereafter.
	12.1 Labor	2080	hr	$75 /hr	$156,000	Assumes one full time field person will be on-site to conduct O&M, collect air samples, and perform air monitoring for 8 hours a day during the first year SVE operation.
	12.2 Laboratory Analyses (VOCs)	28	analysis	$300 /analysis	$8,400	Quoted by Test America Inc. TN.
	12 3 Laboratory Analyses (HCL)	28	analysis	$35 /analysis	$1,000	Quoted by Test America Inc TN.
	12.4 Rental Equipment	56	day	$90 /day	$5,000	MicroFID - quote from Pine Environmental Services, Inc.
	12.5 Mobilization/Demobilization	0				Assumes one field person will be local.

Table 2-22b
Capital Cost Estimate: SVE Presumptive Remedy for VOCs in Soil
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	12 6 Temp. Field Office Trailer & Storage Trailer	12	month	$338 /month	$4,100	Estimate from RS Means Environmental Remediation Cost Data (2001). Order of magnitude costs.
	12.7 Supplies	12	month	$1,000 /month	$12,000	Based on CH2M HILL's professional judgement.
13	Industrial Discharge Monitoring (Year 1), 12 Events					Assumes 4 samples and QC samples will be collected, discharge effluent to sewer line, from remediation system. This sample will be collected monthly according to the industrial discharge agreement between the city of Memphis and the Depot.
	13.1 Labor	0				Assumes 1 field person will be on-site full time for system O&M.
	13 2 Laboratory Analyses (VOCs)	56	analysis	$198 /analysis	$11,100	Quoted by Test America Inc. TN.
	13 3 Rental Equipment	12	day	$210 /day	$2,500	CH2M HILL: Eglin AFB, FL: AAS System Cost Estimate - Capital Costs This cost includes field measurement probes (Conductivity, pH, temp, turbidity, DO) and water level indicator.
	13 4 Mobilization/Demobilization	0				Assumes sampling events will be performed while conducting monthly air sampling.
	13 5 Supplies	12	month	$200 /month	$2,400	Based on CH2M HILL's professional judgement.
14	Confirmatory Soil Vapor Sampling from existing points (Year 3-4)					Soil vapor samples will be collected and analyzed to confirm soil cleanup at the site at the completion of the SVE remediation.
	14.1 Sampling Labor	200	hr	$75 /hr	$15,000 [PW $12400]	Assumes 2 field persons will be on-site for soil vapor sampling for 10 hours a day for 10 days
	14.2 Laboratory Analyses (VOCs)	245	analysis	$300 /analysis	$73,500 [PW $60500]	Assumes 4 samples from each boring will be sent to Test America in TN. The price includes 3 encores for each sample
	14.3 Rental Equipment	10	day	$90 /day	$900 [PW $800]	MicroFID - quote from Pine Environmental Services, Inc.
	14.4 Mobilization/Demobilization	24	hr	$75 /each	$1,800 [PW $1500]	Assumes 2 field persona will be on-site for soil vapor sampling.
	14.5 Supplies	1	event	$2,000 /event	$2,000 [PW $1700]	CH2M HILL Professional judgement

779 144

Table 2-22b

Capital Cost Estimate: SVE Presumptive Remedy for VOCs in Soil

Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
15	Abandonment of Wells (Year 4-5)					Assumes 54 vertical SVE wells for loess (total depth=25 feet) and 24 vertical SVE wells for fluvial sand (total depth=65 feet) and 20 confirmatory wells (80 ft) will be abandoned at the completion of remedial alternative. This cost will occur in year 5.
	15.1 Mobilization/Demobilization	1	ea	$1,200 /ea	$1,200 [PW $1000]	Local driller
	15.2 Abandon Wells	10777	ft	$4 ft	$43,108 [PW $72800]	Costs from Boart Longyear (2002)
16	Equipment Removal and Site Restoration (Year 4-5)	1	ea	$25,000 /ea	$25,000 52,500	
17	Annual Report (Year 1)	100	hr	$85 /hr	$8,500	A summary O&M report will be produced annually. Assume will take approximately 2 weeks and a half to complete.
Capital Costs					$2,756,351	Assume first year is a capital expense.
	Project Management & Support				$137,818	5% of Capital Costs
					$2,894,169	
	Contingency				$289,417	10% Contingency Costs
Total Capital Costs					**$3,183,585**	

[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.

779 145

Table 2-22b
O&M Cost Estimate: SVE Presumptive Remedy for VOCs in Subsurface Soil
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b,c]	Source/ Comments
18	Utilities						The SVE system will run 3-4 years
	18 1 Electricity for vacuum pumps	685,895	kw-hr	$0.06 /kw-hr	$41,154	$112,100	Assumes vacuum pumps (total of 105 HP) will run 24 hours per day for 365 days each year.
	18 2 Electricity for heater	7,200	kw-hr	$0 06 /kw-hr	$432	$1,200	Assumes a heater (2 kw) will run 5 months during the winter season each year
	18 3 Electricity for Offgas Treatment	32,662	kw-hr	$0 06 /kw-hr	$1,960	$5,400	Assumes a fan (5 HP) for offgas treatment will run 24 hours per day for 365 days each year
	18 4 Fuel Consumption for Offgas Treatment	21,024	therms	$1 00 /therm	$21,024	$57,300	Fuel consumption will be 2 4 therms/hr based on Catalytic Combustion's estimation The system will consume natural gas 24 hours a day for 365 days each year. Assumes natura gas will cost $1.00 per therm
	18 5 Water Usage for Offgas Treatment	1,436,640	gal	$0 08 /gal	$115,239	$313,900	Water usage will be 164 gal/hr based on Catalytic Combustion's estimation The system will consume water 24 hours a day for 365 days each year Public water will cost $0 60 per cubic foot
	18 6 Sewerage for Offgas Treatment	1,174	1000 gal	$0 59 /1000 gal	$693	$1,900	Water discharge rate will be 134 gal/hr based on Catalytic Combustion's estimation. The system will consume water 24 hours a day for 365 days each year The sewerage charge will be $0 587 per 1000 gallon.
	18 7 Sewerage for groundwater recovered by SVE systems	105	1000 gal	$0 59 /1000 gal	$62	$200	Water purging rate from SVE systems will be 0 2 gpm (or 12 gal/hr) based on the SVE feasibility study conducted at the site in December 2001. The system will purge water 24 hours a day for 365 days for the first year The sewerage charge will be $0 587
	18 8 Miscellaneous (NaOH Required to Neutralize HCl)	66,600	gal	$0 31 /gal	$20,700	$56,300	Assumes 7 52 gallons per hour of 25% NaOH solution (freeze at 10 degrees F) or 3 13 gallons per hour of 50% NaOH solution (freeze at 45 degrees F) is needed to neutralize HCl generated from the system 25% NaOH will be $0 31 per gallon and 50% NaOH will

779 146

Table 2-22b
O&M Cost Estimate: SVE Presumptive Remedy for VOCs in Subsurface Soil
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b,c]	Source/ Comments
19	Air Sampling for VOCs, air monitoring, and SVE O&M						Air samples will be collected from discharge stack out of offgas treatment and scrubber monthly for VOCs analysis QA samples (duplicate, ambient, and equipment blank) will be also collected and analyzed Air monitoring at the site and SVE O&M will be conducted at the same time
	19 1 Labor	2080	hr	$75 /hr	$156,000	$424,900	Assumes one full time field person (1 FTE) will be on-site to conduct O&M, collect air samples, and perform air monitoring for 8 hours a day during each year of SVE operation.
	19 2 Laboratory Analyses (VOCs)	28	analysis	$300 /analysis	$8,400	$22,900	Quoted by Test America Inc TN
	19 3 Laboratory Analyses (HCL)	28	analysis	$35 /analysis	$1,000	$2,700	Quoted by Test America Inc. TN
	Laboratory Analyses (VOCs)	64	analysis	$300 /analysis	$19,200	$52,300	Periodic sampling and testing from soil vapor points. Assumes 32 samples semi-annually
	19 4 Rental Equipment	56	day	$90 /day	$5,000	$13,800	MicroFID - quote from Pine Environmental Services, Inc.
	19 5 Mobilization/Demobilization						Assumes one field person will be local
	19 6 Supplies	12	event	$1,000 /event	$12,000	$32,700	Based on CH2M HILL's professional judgement.
20	Industrial Discharge Monitoring (Year 2-4), 36 Events						Assumes 4 samples will be collected, discharge effluent to sewer line and QC samples, from remediation system This sample will be collected monthly according to the industrial discharge agreement between the city of Memphis and the Depot
	20 1 Labor						Assumes 1 field person will be on-site for 8 hours for one day for each event.
	20 2 Laboratory Analyses (VOCs)	56	analysis/yr	$198 /analysis	$11,100	$30,200	Quote from Columbia Analytical Services, Redding, CA
	20 3 Rental Equipment	12	day/yr	$210 /day	$2,500	$6,900	CH2M HILL Eglin AFB, FL· AAS System Cost Estimate - Capital Costs
	20 4 Mobilization/Demobilization	0					Assume samples will be collected while conducting system O&M
	20 5 Supplies	12	event/yr	$200 /event	$2,400	$6,600	Based on. CH2M HILL. Reichhold-Summary Invoice of Site Operations Reduce cost to $200 due to less intensive sampling event

779 147

Table 2-22b
O&M Cost Estimate: SVE Presumptive Remedy for VOCs in Subsurface Soil
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b,c]	Source/ Comments
21	Annual Report	120	hr/yr	$85 /hr	$10,200	$27,600	A summary O&M report will be produced annually Assume will take approximately 2 weeks and a half to complete
Total O&M Costs (2-4 years)					**$429,064**	**$1,169,000**	
	Project Management & Support				$21,453	$58,450	5% of O&M Costs
Total O&M Costs (2-4 years)					**$450,517**	**$1,227,450**	

[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 is calculated by using an interest rate of 5 percent for all costs beyond year 1

[c] The duration of O&M will be 3-4 years Year 1 of O&M is included in Capital Costs

779 148

Table 2-22b
Capital Cost and O&M Cost Estimate: SVE Presumptive Remedy for VOCs in Subsurface Soil
Rev. 0 Memphis Depot Dunn Field ROD

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b]	Total PW Cost[c]
1	Institutional Controls	$9,000	NA	NA	$9,000
2	Fencing along Perimeter of Disposal Area	$52,214	NA	NA	$52,214
3	Signs	$614	NA	NA	$614
4	Plans for Implementation	$10,200	NA	NA	$10,200
5	Soil Investigation and Soil Monitoring Points	$239,008	NA	NA	$239,008
6	Horizontal SVE Wells Installation	$637,435	NA	NA	$637,435
7	Vertical SVE Wells Installation	$113,496	NA	NA	$113,496
8	Capital Equipment and Construction	$861,120	NA	NA	$861,120
9	Startup	$58,100	NA	NA	$58,100
10	Offgas Treatment	$182,300	NA	NA	$182,300
11	Utilities (Year 1)	$210,564	NA	NA	$210,564
12	Air Sampling for VOCs, Air Monitoring, and SVE O&M	$186,500	NA	NA	$186,500
13	Industrial Discharge Monitoring (Year 1), 12 Events	$16,000	NA	NA	$16,000
14	Confirmatory Soil Vapor Sampling from existing points (Ye	$76,900	NA	NA	$76,900
15	Abandonment of Wells (Year 4)	$73,800	NA	NA	$73,800
16	Equipment Removal and Site Restoration (Year 4)	$20,600	NA	NA	$20,600
17	Annual Report (Year 1)	$8,500	NA	NA	$8,500
--	Project Management & Support	$137,818	NA	NA	$137,818
--	Contingency (Year 1)	$289,417	NA	NA	$289,417
18	Utilities	NA	$201,264	$548,300	$548,300
19	Air Sampling for VOCs, air monitoring, and SVE O&M	NA	$201,600	$549,300	$549,300
20	Industrial Discharge Monitoring (Year 2-4), 36 Events	NA	$16,000	$43,700	$43,700
21	Annual Report	NA	$10,200	$27,800	$27,800
--	Project Management & Support	NA	$21,453	$58,450	$58,450
Total Costs		**$3,184,000**	**$451,000**	**$1,228,000**	**$4,411,000**

[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 is calculated by using an interest rate of 5 percent for all costs beyond year 1.

[c] Total PW cost includes capital plus PW O&M costs over 3 years.

779 149

TABLE 2-22c
Capital Cost Estimate: Groundwater Remedy, ZVI Injection, PRB Installation with MNA and ICs
Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
1	Deed Restrictions					Deed restrictions would prohibit installation and use of production and consumptive use wells. They would also permit regulator access to all monitoring wells for the 3-year life of this remedy
	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	120	hr	$85 /hr	$10,200	Based on CH2M HILL's professional judgement. Plans to develop include Site Safety and Health Plan and Environmental Protection Plan.
3	ZVI Injection Procedures					
	3.1 Injection Bench-Scale & Pilot Test	1	ea	$231,600 /ea	$231,600	Quote from ARS Technologies, Inc Assumes 4 well pilot test using new wells.
	3.2 Full-Scale Implementation	1	ea	$4,051,957 /ea	$4,051,957	Quote from ARS Technologies, Inc Assumes 53 wells using pneumatic fracturing and atomized liquid injection. Assumes 40 foot radius of influence per well Includes subcontractor PM labor, reporting, permitting, electricity, and water.
	3 3 Oversight of Pilot Test	80	hr	$75 /hr	$6,000	Assume 2 weeks for pilot test
	3 4 Oversight of Full Scale	1,040	hr	$75 /hr	$78,000	Assume 6 months for implementation
	3 5 Waste Disposal	2	ea	$2,000 /ea	$4,000	Includes rolloff rental, dropoff/pickup Assume soils and other waste is nonhazardous.
	3.6 Temp. Field Office, Trailer, and Storage Trailer	7	mn	$338 mn	$2,366	Estimate from RS Means Environmental Remediation Cost Data (2001) Order of magnitude costs.
	3.7 Initial/Confirmatory Pilot Test GW Sampling					
	3 7 1 Labor	96	hr	$75 /hr	$7,200	Assumes 2 field people will be on-site for 12 hours for 4 days for both events
	3 7 2 Laboratory Analyses (VOCs)	24	analysis	$104 /analysis	$2,500	Quote from Columbia Analytical Services, Redding, CA
	3 7 3 Laboratory Analyses (MNA Parameters)	24	analysis	$300 /analysis	$7,200	Price list from Microseeps Labs

779 150

TABLE 2-22c
Capital Cost Estimate: Groundwater Remedy, ZVI Injection, PRB Installation with MNA and ICs
Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	3.7 4 Rental Equipment	8	day	$330 /day	$2,600	CH2M HILL. Professional estimate This cost includes Grundfos pump and controller, Field measurement probes (Conductivity, pH, temp, turbidity, DO), generator, water level indicator, and Multirae.
	3.7 5 Supplies	1	event	$500 /event	$500	CH2M HILL Professional estimate
4	Permeable Reactive Barriers - Iron					
	4.1 Bench Scale Testing	1	ea	$20,000 /ea	$20,000	Quote from ETI
	4 2 Full-Scale Implementation	1	ea	$1,922,500 /ea	$1,922,500	Quote from Eviron Tech , Inc. Assumes 1050 feet of PRB Includes subcontractor field visits, design, and implementation through jetting
	4 4 Oversight of Full Scale	1,040	hr	$75 /hr	$78,000	Assume 6 months for implementation
	4 5 Waste Disposal	2	ea	$2,000 /ea	$4,000	Includes rolloff rental, dropoff/pickup. Assume soils and other waste is nonhazardous.
	4 6 Temp. Field Office, Trailer, and Storage Trailer	7	mn	$338 mn	$2,366	Estimate from RS Means Environmental Remediation Cost Data (2001). Order of magnitude costs
	4 7 Initial/Confirmatory Pilot Test GW Sampling					
	4 7.1 Labor	96	hr	$75 /hr	$7,200	Assumes 2 field people will be on-site for 12 hours for 4 days for both events
	4 7.2 Laboratory Analyses (VOCs)	24	analysis	$104 /analysis	$2,500	Quote from Columbia Analytical Services, Redding, CA
	4 7.3 Laboratory Analyses (MNA Parameters)	24	analysis	$300 /analysis	$7,200	Price list from Microseeps Labs
	4 7.4 Rental Equipment	8	day	$330 /day	$2,600	CH2M HILL: Professional estimate. This cost includes Grundfos pump and controller, Field measurement probes (Conductivity, pH, temp, turbidity, DO), generator, water level indicator, and Multirae
	4 7.5 Supplies	1	event	$500 /event	$500	CH2M HILL: Professional estimate.

779 151

TABLE 2-22c
Capital Cost Estimate: Groundwater Remedy, ZVI Injection, PRB Installation with MNA and ICs
Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	4.8 Clearing and Grubbing	2	ac	$1,620 /ac	$3,200	Estimate from RS Means Environmental Remediation Cost Data (2001). Order of magnitude costs.
5	Additional Monitoring Wells					
	5 3 Drilling Mobilization/Demobilization	1	ea	$2,500 00 /ea	$2,500	Assume rotosonic drilling mobilization
	5 5 Installation 15 Monitoring Wells - Rotasonic	1,350	ft	$62 /ft	$83,700	Defense Depot - Groundwater Remedial Act, U S. Army Corps of Engineers, Groundwater Interim Remedial, (Dunn Field).
	5 6 Labor (well installation oversight)	150	hr	$75 /hr	$11,300	Assume 1 field person will be required to oversee and prepare site for well installation Assume it will take approximately 12 hours per day for 85 days.
	5.7 Mobilization/ Demobilization (well installation oversight)	40	hr	$75 /hr	$3,000	Assumes it will take one field person 4 hours for mobilization and 4 hours for demobilization for each trip. 8 trips is needed.
6	Groundwater Monitoring (Year 1), 4 Events					Assume first year of groundwater monitoring is a capital expense This includes 4 quarterly sampling events Groundwater monitoring will entail the sampling of 43 wells. An additional 15 percent (of groundwater samples) will be collected as QC samples.
	6.1 Labor	640	hr	$75 /hr	$48,000	Assumes 2 field people will be on-site for 10 hours for 8 days for each event.

TABLE 2-22c
Capital Cost Estimate: Groundwater Remedy, ZVI Injection, PRB Installation with MNA and ICs
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Capital Cost[a]	Source/ Comments
	6 2 Laboratory Analyses (VOCs)	200	analysis	$104 /analysis	$20,800	Quote from GEL Labs
	6 3 Laboratory Analyses (MNA Parameters)	200	analysis	$300 /analysis	$60,000	Price list from Microseeps Labs and GEL
	6 4 Rental Equipment	32	day	$330 /day	$10,600	CH2M HILL Professional Estimate This cost includes Grundfos pump and controller, Field measurement probes (Conductivity, pH, temp, turbidity, DO), generator, water level indicator, and Multirae
	6.5 Mobilization/Demobilization					Assumes groundwater monitoring will be performed while conducting O&M.
	6 6 Supplies	4	event	$1,000 /event	$4,000	CH2M HILL Professional Estimate.
7	Abandonment of Wells (Year 15)					Assume 62 100-foot 2-inch monitoring wells and 11 100-foot 4-inch recovery wells (all are existing wells), and 6 new 4-inch recovery wells, and 192 injection wells will be abandoned at the completion of the remedial alternative. This cost will occur in year 10.
	7.1 Mobilization/Demobilization	1	ea	$1,200 /ea	$1,200 [PW $800]	
	7 2 Abandon Monitoring Wells (2-inch)	62	ea	$1,000 /ea	$62,000 [PW $40000]	CH2M HILL American Scrap Metal Site, Panama City: Remedy Implementation Cost Estimate - Capital Costs
	7 3 Abandon Extraction Wells (4-inch)	21	ea	$2,000 /ea	$42,000 [PW $27100]	
	7 4 Abandon injection wells	99	ea	$1,000 /ea	$99,000 [PW $63900]	Assume this cost includes removal of protective covers, grouting to the surface, and removing the concrete surface pad
8	Annual Report (Year 1)	160	hr	$85 /hr	$13,600	A summary monitoring report will be produced annually. They will include a potentioemtric surface map, a plume map, summary tables, interpretative text. Asume will take approximately a week and a half to complete Assume first year is a capital expense.
Subtotal Capital Costs					**$6,805,789**	
9	Contingency - Capital Costs (10%)	10%	ea	$6,805,789 /ea	$680,579	
10	Contingency - Project Management (5%)	5%	ea	$6,805,789 /ea	$340,289	
Total Capital Costs					**$7,826,657**	

779 153

TABLE 2-22c
O&M Cost Estimate: Groundwater Remedy, ZVI Injection, PRB Installation, and Enhanced Bioremediation
Rev 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b,c]	Source/ Comments
11	Groundwater Monitoring (Year 2-15), 23 Events						Groundwater samples will be collected semiannually from years 2 through 10, and annually for years 11 through 15. This includes 23 events. Groundwater monitoring will entail the sampling of 28 wells. An additional 15 percent (of groundwater samples) will be collected as QC samples.
	11.1 Labor (sampling)	400	hr/yr	$75 /hr	$30,000	$297,000	Assumes 43 wells (including QC samples) will be sampled semiannually for years 2 - 10 and annually for years 11-15 4 field people will be on-site for 12 hours for 4 days.
	11.2 Laboratory Analyses (VOCs)	110	analysis/yr	$104 /analysis	$11,440	$113,200	Quote from GEL Labs
	11.3 Laboratory Analyses (MNA Parameters)	110	analysis/yr	$300 /analysis	$33,000	$326,700	Price list from Microseeps Labs and GEL Labs.
	11 4 Rental Equipment	12	day/yr	$330 /day	$4,000	$39,200	CH2M HILL Professional Estimate This cost includes Grundfos pump and controller, Field measurement probes (Conductivity, pH, temp, turbidity, DO), generator, water level indicator, and Multirae.
	11.5 Supplies	2	event /yr	$500 /event	$800	$7,900	CH2M HILL Professional Estimate
12	Annual Report (Year 2-15)	100	hr/yr	$85 /hr	$8,500	$84,100	A summary monitoring report will be produced annually. They will include a potentiometric surface map, a plume map, summary tables, interpretative text. Assume will take approximately a week and a half to complete.

779 154

TABLE 2-22c
O&M Cost Estimate: Groundwater Remedy, ZVI Injection, PRB Installation, and Enhanced Bioremediation
Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Quantity	Unit	Unit Cost	Annual O&M Cost[a]	Present Worth O&M Cost[a,b,c]	Source/ Comments
13	5-Year Review (six over 30 years)	80	hr/yr	$100 /hr	$8000 ($800 averaged over 5 years)	$23,400	Remedial alternative at site will need to be reviewed every 5 years to ensure that institutional controls are providing adequate protection. Assume will take approximately a week to complete.
	Total O&M Costs (2-15 years)				**$87,740**	**$892,000**	
	Project Management & Support				$8,774	$89,200	10% of O&M Costs
	Total O&M Costs (2-15 years)				**$97,000**	**$981,200**	

[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 is calculated by using an interest rate of 5 percent for all costs beyond year 1.
[c] The duration of O&M will be 3 years

TABLE 2-22c

Cost Estimate Summary: Groundwater Remedy, ZVI Injection, PRB Installation, and Enhanced Bioremediation

Rev. 1 Memphis Depot Dunn Field ROD

Item	Activity/Component	Capital Cost[a]	Annual O&M Cost[a]	Present Worth O&M Cost[a,b,c]	Total PW Cost[c]
1	Deed Restrictions	$7,400	NA	NA	$7,400
2	Plans for Implementation	$10,200	NA	NA	$10,200
3	ZVI Injection Procedures	$4,393,923	NA	NA	$4,393,923
4	Permeable Reactive Barriers - Iron	$2,050,066	NA	NA	$2,050,066
5	Additional Monitoring Wells	$100,500	NA	NA	$100,500
6	Groundwater Monitoring (Year 1), 4 Events	$143,400	NA	NA	$143,400
7	Abandonment of Wells (Year 15)	$86,700	NA	NA	$86,700
8	Annual Report (Year 1)	$13,600	NA	NA	$13,600
9	Contingency - Capital Costs (10%)	$680,579	NA	NA	$680,579
10	Contingency - Project Management (5%)	$340,289	NA	NA	$340,289
11	Groundwater Monitoring (Year 2-15), 23 Events	NA	$79,240	$784,000	$784,000
12	Annual Report (Year 2-15)	NA	$8,500	$84,100	$84,100
13	5-Year Review (six over 30 years)	NA	$800	$23,400	$23,400
--	Project Management and Support	NA	$8,774	$89,200	$89,200
Total Costs		**$7,827,000**	**$98,000**	**$981,000**	**$8,807,000**

[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 is calculated by using an interest rate of 5 percent for all costs beyond year 1.

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

NA = Not applicable

Note: The annual O&M costs are an average of total cost over time period item occurs occur. For example, the annual cost for 5-year review is total $4000 averaged over 5 years ($800).

Table 2-23
Chemical-specific ARARs and TBC Guidance
Rev. 2 Memphis Depot Dunn Field Record of Decision

Action/medium	Requirements	Prerequisite	Citation(s)
Restoration of groundwater to its designated use(s)	May not exceed MCLs and MCLGs above zero established under the Safe Drinking Water Act for public water systems	Presence of contaminants in ground water of the State designated as *General Use* as defined in TDEC 1200-4-3-.07(2)(b) - **relevant and appropriate**	TDEC 1200-5-1-.06 40 CFR 141 *et seq.*
	Except for naturally occurring levels, shall not contain constituents in excess of the concentrations listed in Table 1. *Inorganic Criteria for General Use Ground Water*		TDEC 1200-4-3-.08(2)(a)
	Except for naturally occurring levels, shall not contain constituents exceeding those in TDEC 1200-4-3-.03 except that the criteria for *Fish and Aquatic Life* and *Recreational Use* shall not apply		TDEC 1200-4-3-.08(2)(b)

ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
TBC = to be considered
TCA = *Tennessee Code Annotated*
TDEC = Rules of the Tennessee Department of Environment and Conservation, Chapter as noted
MCLs = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goals

779 157

Table 2-24
Action-specific ARARs and TBC Guidance
Rev. 2 Memphis Depot Dunn Field Record of Decision

Action	Requirements	Prerequisite	Citation(s)
	General construction standards - all land-disturbing activities (i.e., excavation, trenching, clearing, etc.)		
Activities causing fugitive dust emissions	Shall take reasonable precautions to prevent particulate matter from becoming airborne; reasonable precautions shall include, but are not limited to, the following:	Fugitive emissions from demolition of existing buildings or structures, construction operations, grading of roads, or the clearing of land - **applicable**	TDEC 1200-3-8-.01(1)
	• use, where possible, of water or chemicals for control of dust; and		TDEC 1200-3-8-.01(1)(a)
	• application of asphalt, oil, water, or suitable chemicals on dirt roads, materials stock piles, and other surfaces which can create airborne dusts.		TDEC 1200-3-8-.01(1)(b)
	Shall not cause or allow fugitive dust to be emitted in such a manner as to exceed 5 minute/hour or 20 minute/day beyond property boundary lines on which emission originates.		TDEC 1200-3-8-.01(2)
Activities causing storm water runoff (e.g., clearing, grading, excavation)	Implement good construction management techniques (including sediment and erosion controls, vegetative controls, and structural controls) in accordance with the substantive requirements of *General Permit No. TNR10-0000 Appendix F,* to ensure that storm water discharge	Dewatering or storm water runoff discharges from land disturbed by construction activity - disturbance of ≥5 acres total - **applicable**; <5 acres - **relevant and appropriate**	TCA 69-3-108(j) TDEC 1200-4-10-.03(2)
	• does not violate water quality criteria as stated in TDEC 1200-4-3-.03 including but not limited to prevention of discharges that causes a condition in which visible solids, bottom deposits, or turbidity impairs the usefulness of waters of the state for any of the designated uses for that water body by TDEC 1200-4-4;	Storm water discharges from construction activities – **TBC**	*General Permit No. TNR10-0000* Part III D.2.a
	• does not contain distinctly visible floating scum, oil, or other matter;		*General Permit No TNR10-0000* Part III D.2.b
	• does not cause an objectionable color contrast in the receiving stream; and		*General Permit No TNR10-0000* Part III D.2.c

779 158

Action	Requirements	Prerequisite	Citation(s)
	• results in no materials in concentrations sufficient to be hazardous or otherwise detrimental to humans, livestock, wildlife, plant life, or fish and aquatic life in the receiving stream.		*General Permit No. TNR10-0000* Part III D.2.d
	Underground injection well construction and operation		
Injection of nutrients (or other treatments) into groundwater	Wells shall be designed, constructed, and operated in such a manner that does not present a hazard to existing or future use of groundwater and may not cause a violation of water quality standards.	Class V injection well for innovative or experimental technologies – **relevant and appropriate**	TDEC 1200-4-6-.14(1)(b) TDEC 1200-4-6-.14(7)(b) and (8)(a)
	Groundwater monitoring well installation and closure		
Installation and maintenance of groundwater monitoring well(s) and soil borings	All wells shall be constructed in a manner that will guard against contamination of the groundwater aquifers underlying Shelby County.	Construction, modification, and repair of groundwater monitoring well(s) and boreholes - **relevant and appropriate**	*Rules and Regulations of Wells in Shelby County* Section 6 and Section 7 *et. seq.*
Closure of groundwater monitoring well(s)	Well shall be completely filled and sealed in such a way as to prevent vertical movement of water from one aquifer to another.	Permanent plugging and abandonment of a well - **relevant and appropriate**	*Rules and Regulations of Wells in Shelby County* Section 9 *et. seq.*
	SVE treatment system - air emissions control		
Emissions from SVE treatment system	Discharge of air contaminants must be in accordance with the appropriate provisions of Rules of the TDEC Chapter 1200-3 *et seq.*, any applicable measures of control strategy and provisions of the Tennessee Pollution Control Act.	Emissions of air pollutants from new air contaminant sources – **applicable**	TDEC 1200-3-9-.01(1)(d) Memphis Code 16-77
	Waste generation, characterization, segregation, and storage - primary remediation wastes (excavated contaminated soil, disposal pit materials) and secondary wastes (wastewaters, spent treatment media, etc.)		
Characterization of solid waste	Must determine if solid waste is hazardous waste or if waste is excluded under 40 CFR 261.4(b); and	Generation of solid waste as defined in 40 CFR 261.2 and which is not excluded under 40 CFR 261.4(a) - **applicable**	40 CFR 262.11(a) TDEC 1200-1-11-.03(1)(b)(1)
	Must determine if waste is listed under 40 CFR Part 261; or		40 CFR 262.11(b) TDEC 1200-1-11-.03(1)(b)(2)

779 159

Action	Requirements	Prerequisite	Citation(s)
	Must characterize waste by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used.		40 CFR 262.11(c) TDEC 1200-1-11-.03(1)(b)(3)
	Must refer to Parts 261, 262, 264, 265, 266, 268, and 273 of Chapter 40 for possible exclusions or restrictions pertaining to management of the specific waste.	Generation of solid waste which is determined to be hazardous – **applicable**	40 CFR 262.11(d); TDEC 1200-1-11-.03(1)(b)(4)
Characterization of hazardous waste	Must obtain a detailed chemical and physical analysis on a representative sample of the waste(s), which at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with pertinent sections of 40 CFR 264 and 268.	Generation of RCRA-hazardous waste for storage, treatment or disposal - **applicable**	40 CFR 264.13(a)(1) TDEC 1200-1-11-.06(2)(d)(1)
	Must determine the underlying hazardous constituents [as defined in 40 CFR 268.2(i)] in the waste	Generation of RCRA characteristic hazardous waste (and is not D001 non-wastewaters treated by CMBST, RORGS, or POLYM of Section 268.42 Table 1) for storage, treatment or disposal – **applicable**	40 CFR 268.9(a) TDEC 1200-1-11-.10(1)(I)(1)
	Must determine if the waste is restricted from land disposal under 40 CFR 268 *et seq.* by testing in accordance with prescribed methods or use of generator knowledge of waste.		40 CFR 268.7 TDEC 1200-1-11-.10(1)(g)(1)(i)
	Must determine each EPA Hazardous Waste Number (Waste Code) to determine the applicable treatment standards under 40 CFR 268.40 *et. seq.*		40 CFR 268.9(a) TDEC 1200-1-11-.10(1)(I)(1)
Temporary storage of hazardous waste in containers	A generator may accumulate hazardous waste at the facility provided that:	Accumulation of RCRA hazardous waste on site as defined in 40 CFR 260.10 - **applicable**	40 CFR 262.34(a); TDEC 1200-1-11-.03(4)(e)
	• waste is placed in containers that comply with 40 CFR 265.171-173; and		40 CFR 262.34(a)(1)(i); TDEC 1200-1-11-.03(4)(e)(2)(ii)(I)
	• the date upon which accumulation begins is clearly marked and visible for inspection on each container;		40 CFR 262.34(a)(2); TDEC 1200-1-11-.03(4)(e)(2)(ii)

779 160

Action	Requirements	Prerequisite	Citation(s)
	• container is marked with the words "hazardous waste" or		40 CFR 264.34(a)(3) TDEC 1200-1-11-.03(4)(e)(2)(iv)
	• container may be marked with other words that identify the contents.	Accumulation of 55 gal. or less of RCRA hazardous waste at or near any point of generation - **applicable**	40 CFR 262.34(c)(1) TDEC 1200-1-11-.03(4)(e)(5)(i)(II)
Use and management of hazardous waste in containers	If container is not in good condition (e.g. severe rusting, structural defects) or if it begins to leak, must transfer waste into container in good condition.	Storage of RCRA hazardous waste in containers – **applicable**	40 CFR 265.171 TDEC 1200-1-11-.05(9)(b)
	Use container made or lined with materials compatible with waste to be stored so that the ability of the container is not impaired.		40 CFR 265.172 TDEC 1200-1-11-.05(9)(c)
	Keep containers closed during storage, except to add/remove waste.		40 CFR 265.173(a) TDEC 1200-1-11-.05(9)(d)(1)
	Open, handle and store containers in a manner that will not cause containers to rupture or leak.		40 CFR 265.173(b) TDEC 1200-1-11-.05(9)(d)(2)
Storage of hazardous waste in container area	Area must have a containment system designed and operated in accordance with 40 *CFR* 264.175(b).	Storage of RCRA-hazardous waste in containers with free liquids – **applicable**	40 CFR 264.175(a) TDEC 1200-1-11-.06(9)(f)(1)
	Area must be sloped or otherwise designed and operated to drain liquid from precipitation, or	Storage of RCRA-hazardous waste in containers that do not contain free liquids - **applicable**	40 CFR 264.175(c) TDEC 1200-1-11-.06(9)(f)(3)
	Containers must be elevated or otherwise protected from contact with accumulated liquid.		
	Treatment/disposal of wastes - primary and secondary wastes		
Disposal of RCRA-hazardous waste in a land-based unit	May be land disposed if it meets the requirements in the table "Treatment Standards for Hazardous Waste" at 40 CFR 268.40 before land disposal.	Land disposal, as defined in 40 CFR 268.2, of restricted RCRA waste - **applicable**	40 CFR 268.40(a) TDEC 1200-1-11-.10(3)(a)
	Must be treated according to the alternative treatment standards of 40 CFR 268.49(c) or according to the UTSs [specified in 40 CFR 268.48 Table UTS] applicable to the listed and/or characteristic waste contaminating the soil prior to land disposal.	Land disposal, as defined in 40 CFR 268.2, of restricted hazardous soils - **applicable**	40 CFR 268.49(b) TDEC 1200-1-11-.10(3)(j)(2)

779 161

Action	Requirements	Prerequisite	Citation(s)
Disposal of RCRA wastewaters in an CWA wastewater treatment unit	Are not prohibited, unless the wastes are subject to a specified method of treatment other than DEACT in 40 CFR 268.40, or are D003 reactive cyanide.	Restricted RCRA characteristic hazardous wastewaters managed in a wastewater treatment system which is NPDES permitted - **applicable**	40 CFR 268.1(c)(4)(iv) TDEC 1200-1-11-.10(1)(a)(3)(iv)(IV)
		Transportation	
Transportation of hazardous materials	Shall be subject to and must comply with all applicable provisions of the HMTA and HMR at 49 CFR 171-180.	Any person who, under contract with a department or agency of the federal government, transports "in commerce," or causes to be transported or shipped, a hazardous material - **applicable**	49 CFR 171.1(c)
Transportation of hazardous waste off site	Must comply with the generator requirements of 40 CFR 262.20–23 for manifesting, Sect. 262.30 for packaging, Sect. 262.31 for labeling, Sect. 262.32 for marking, Sect. 262.33 for placarding and Sect. 262.40, 262 41(a) for record keeping requirements and Sect. 262.12 to obtain EPA ID number.	Off-site transportation of RCRA hazardous waste – **applicable**	40 CFR 262.10(h) TDEC 1200-1-11-.03(1)(a)(8)
	Must comply with the requirements of 40 CFR 263.11–263.31.	Transportation of hazardous waste within the United States requiring a manifest – **applicable**	40 CFR 263.10(a) TDEC 1200-1-11-.04(1)(a)(1)
	A transporter who meets all applicable requirements of 49 CFR 171–179 and the requirements of 40 CFR 263.11 and 263.31 will be deemed in compliance with 40 CFR 263.		
Management of treatability samples (*i.e.*, contaminated soils, wastewaters)	Are not subject to any requirements of 40 CFR Parts 261 through 263, nor are such samples included in the quantity determinations of 40 CFR 261.5 and 262.34(d) when:	Generation of samples of hazardous waste for purpose of conducting treatability studies as defined in 40 CFR 260.10 - **applicable**	40 CFR 261.4(e)(1) TDEC 1200-1-11-.02(1)(d)(5)(i)
	• The sample is being collected and prepared for transportation by the generator or sample collector;		40 CFR 261.4(e)(1)(i) TDEC 1200-1-11-.02(1)(d)(5)(i)(I)
	• The sample is being accumulated or stored by the generator or sample collector prior to transportation to a laboratory or testing facility; or		40 CFR 261.4(e)(1)(ii) TDEC 1200-1-11-.02(1)(d)(5)(i)(II)

Table 2-24 (cont'd)
Action-specific ARARs and TBC Guidance
Rev. 2 Memphis Depot Dunn Field Record of Decision

Action	Requirements	Prerequisite	Citation(s)
	• The sample is being transported to the laboratory or testing facility for purpose of conducting a treatability study.		40 CFR 261.4(e)(1)(iii) TDEC 1200-1-11-.02(1)(d)(5)(i)(III)
Transportation of hazardous waste on site	The generator manifesting requirements of 40 CFR 262.20–262.32(b) do not apply. Generator or transporter must comply with the requirements set forth in 40 CFR 263.30 and 263.31 in the event of a discharge of hazardous waste on a private or public right-of-way.	Transportation of hazardous wastes on a public or private right-of-way within or along the border of contiguous property under the control of the same person, even if such contiguous property is divided by a public or private right-of-way – **applicable**	40 CFR 262.20(f) TDEC 1200-1-11-.03(3)(a)(6)

ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
CWA = Clean Water Act of 1972
NPDES = National Pollutant Discharge Elimination System
DEACT = deactivation
DOT = U.S Department of Transportation
EPA = U S Environmental Protection Agency
RCRA = Resource Conservation and Recovery Act of 1976
HMR = Hazardous Materials Regulations
HMTA = Hazardous Materials Transportation Act
TBC = to be considered
TCA = *Tennessee Code Annotated*
TDEC = Rules of the Tennessee Department of Environment and Conservation, Chapter as noted
UTS = Universal Treatment Standard

Figures for Section 2, Rev2 Dunn Field ROD

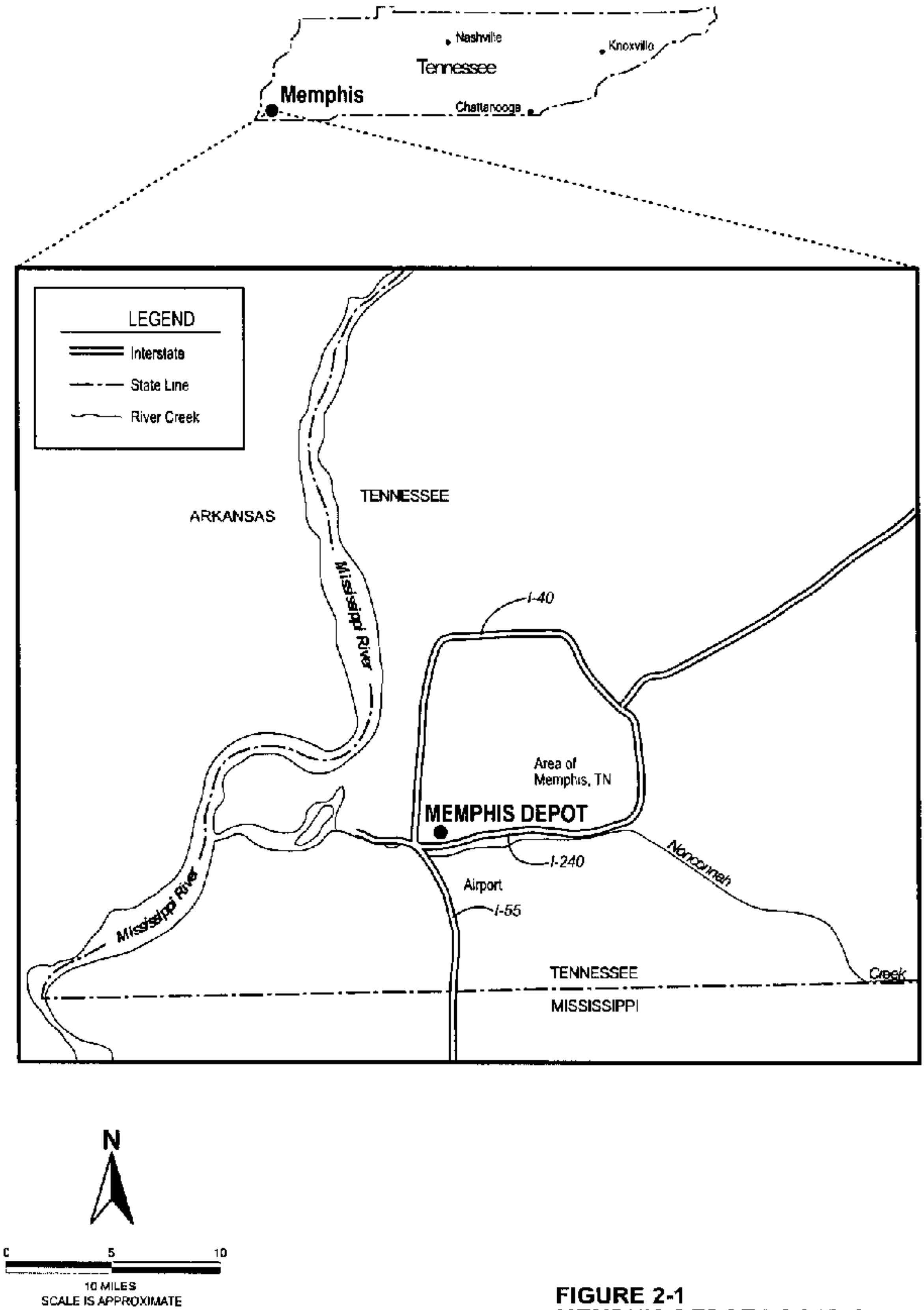


FIGURE 2-1
MEMPHIS DEPOT LOCATION IN THE MEMPHIS METROPOLITAN AREA
REV. 0 MEMPHIS DEPOT DUNN FIELD ROD

E082002008ATL \ Dunn126 FH8

CH2MHILL

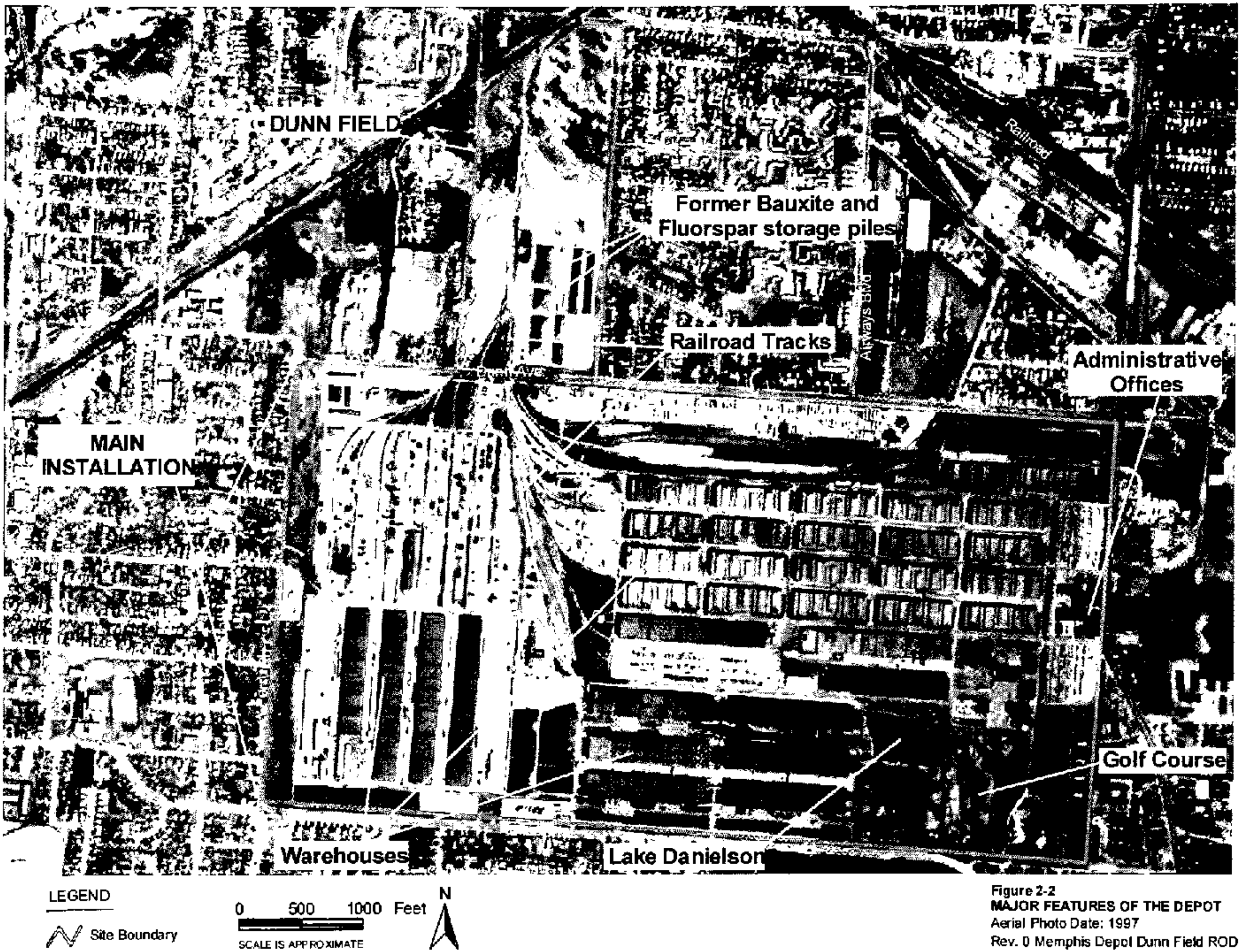


Figure 2-2
MAJOR FEATURES OF THE DEPOT
Aerial Photo Date: 1997
Rev. 0 Memphis Depot Dunn Field ROD

ATL\\Boomer\...Projects3\Memphis\aprs\dunnfield_aerial.apr

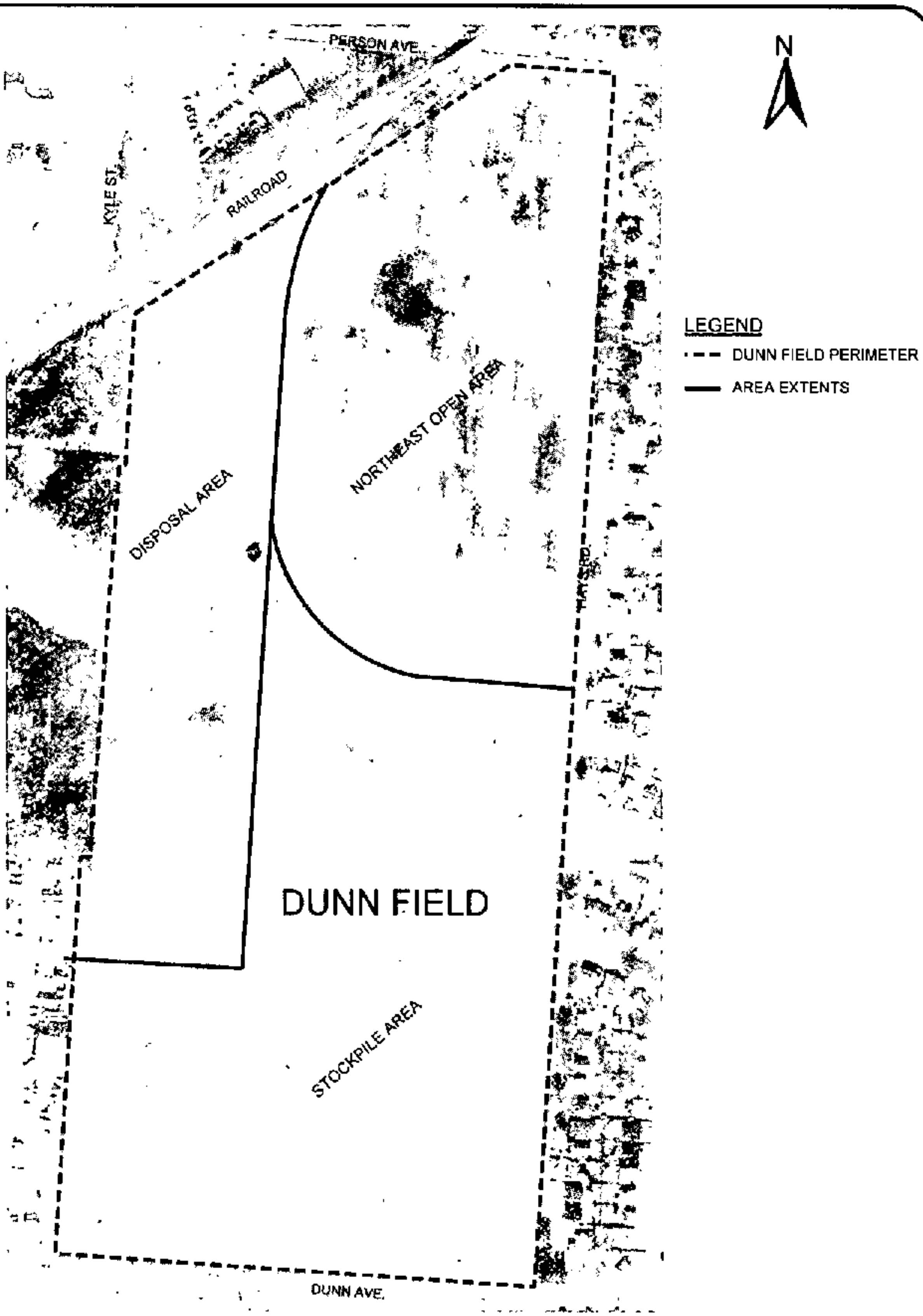


FIGURE 2-3
AREA DESIGNATIONS AT DUNN FIELD
Rev. 0 Memphis Depot Dunn Field ROD

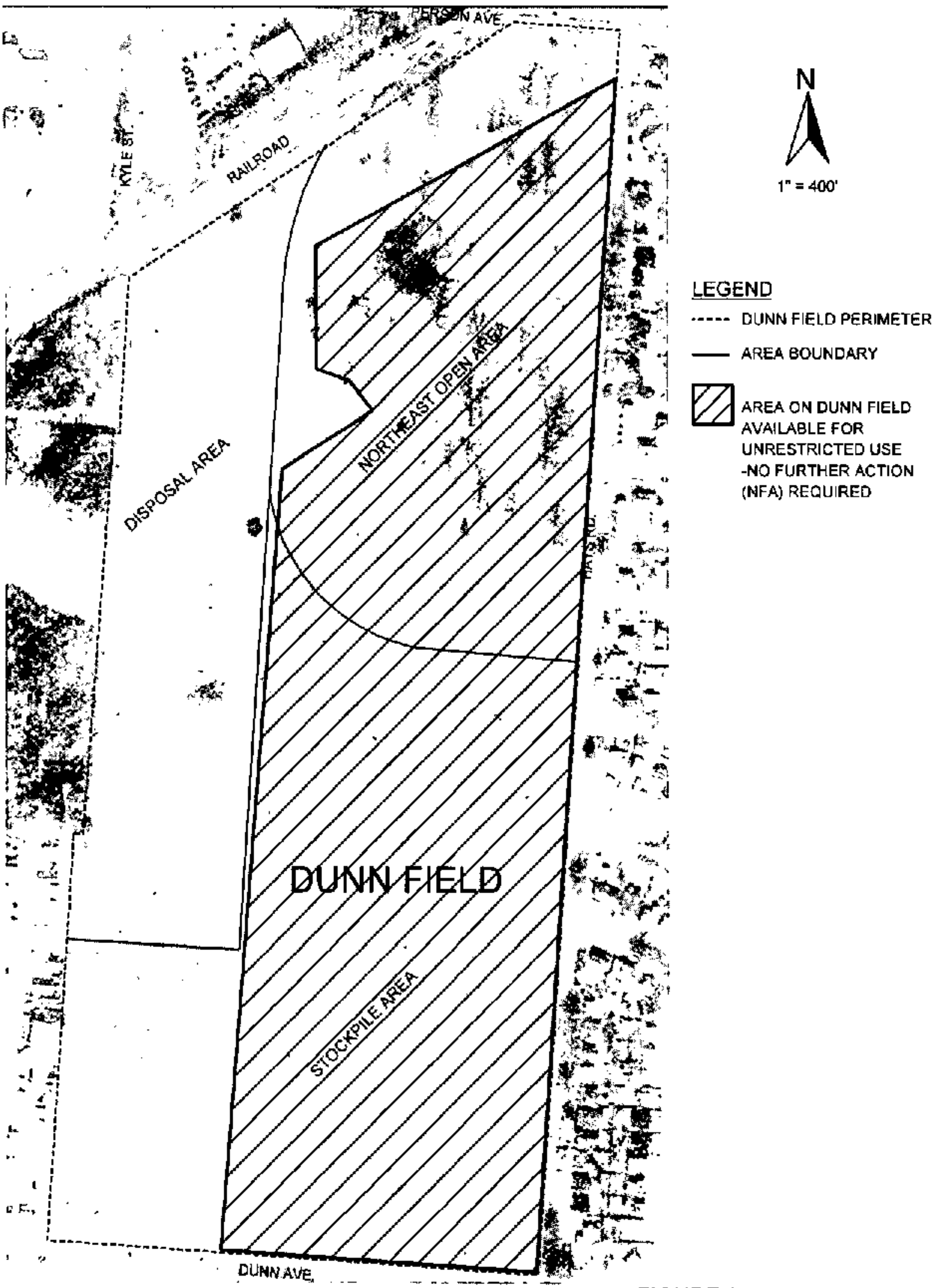


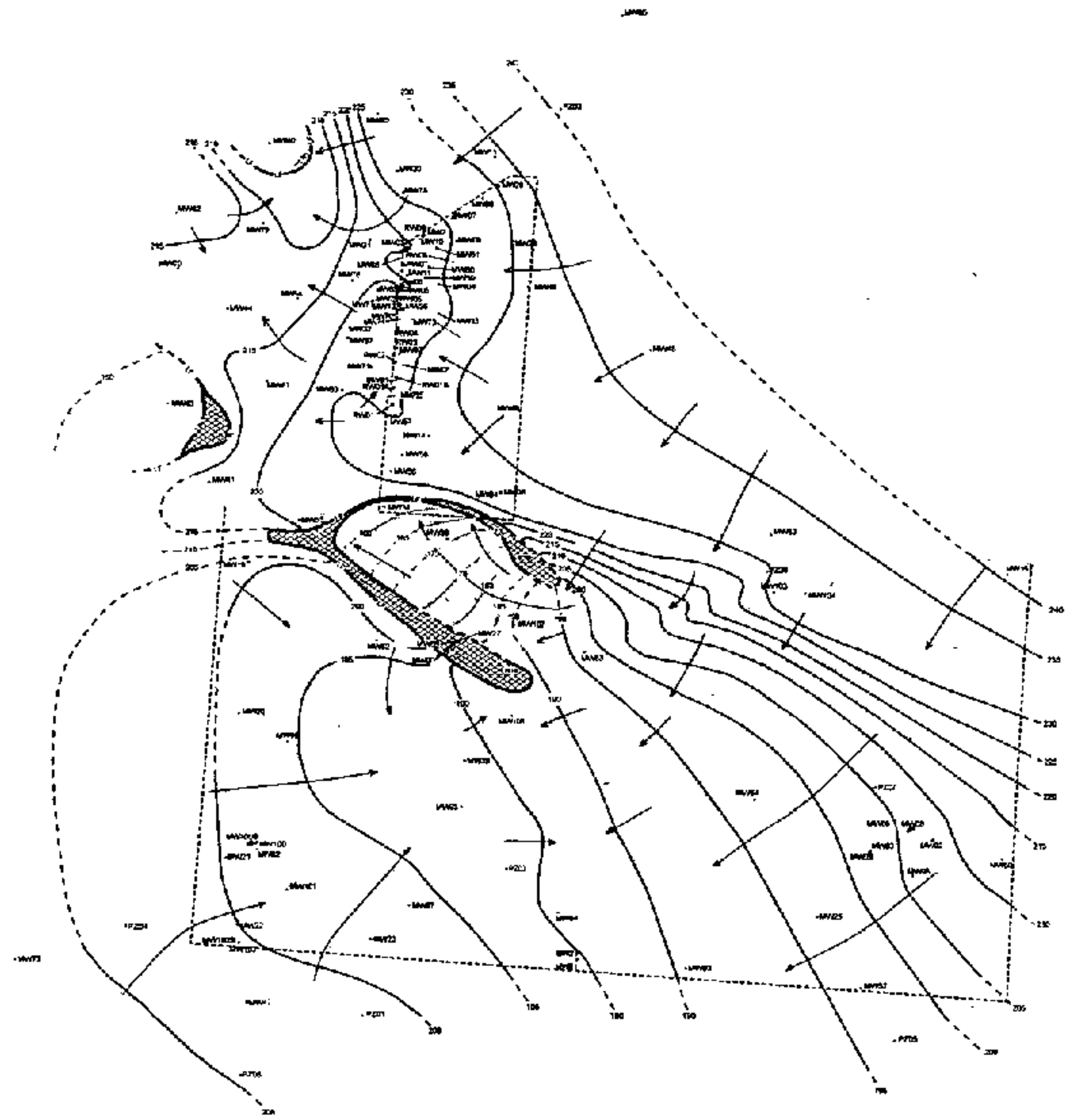
FIGURE 2-4
DUNN FIELD AREA AVAILABLE FOR UNRESTRICTED USE (NFA)
Rev. 2 Memphis Depot Dunn Field ROD

CH2MHILL

ATL/CAD1/PROJECTS/148071 DDMT/Dunn Field ROD 2003

Well ID	Water Level Elevation (feet MSL)
MW03	221.86
MW04	224.84
MW06	224.00
MW07	226.71
MW08	228.86
MW09	226.43
MW10	223.18
MW11	222.68
MW12	224.11
MW13	224.81
MW14	227.22
MW15	224.49
MW16	241.44
MW18	175.70
MW19	200.92
MW20	199.30
MW21	199.95
MW22	200.03
MW23	198.57
MW24	190.62
MW26	203.03
MW27	DRY
MW28	233.85
MW29	233.52
MW30	226.59
MW31	218.34
MW32	221.41
MW33	224.18
MW34	158.66
MW35	222.34
MW36	151.53
MW37	151.12
MW38	169.97
MW39	191.89
MW40	171.05
MW41	217.88
MW42	217.70
MW43	162.75
MW44	212.97
MW45	236.86
MW46	232.05
MW47	203.89
MW49	230.58
MW50	217.21
MW51	234.62
MW52	197.25
MW53	232.87
MW54	213.60
MW55	221.05
MW56	225.61
MW57	224.97
MW58	226.29
MW59	223.82
MW60	224.15
MW61	224.73
MW62	199.71
MW63	187.46

Well ID	Water Level Elevation (feet MSL)
MW64	196.83
MW65	252.65
MW67	151.59
MW68	221.79
MW69	222.44
MW70	273.06
MW71	222.43
MW72	205.91
MW73	223.87
MW74	223.38
MW75	222.98
MW76	217.04
MW77	221.42
MW78	225.11
MW79	212.63
MW80	212.64
MW81	154.67
MW82	151.50
MW83	157.46
MW84	228.45
MW85	204.16
MW86	208.06
MW87	223.70
MW88	224.17
MW89	183.57
MW90	183.94
MW91	223.76
MW92	207.86
MW93	191.62
MW94	189.87
MW95	228.82
MW96	205.60
MW97	195.19
MW98	192.43
MW99	195.73
MW100	199.21
MW101	198.38
MW102	200.64
MW103	231.92
MW104	232.75
MW107	190.49
MW108	169.86
PZ01	202.74
PZ02	241.91
PZ03	191.47
PZ04	203.96
PZ05	186.54
PZ06	229.22
PZ07	205.74
PZ08	204.86
RW04	223.38
RW06	220.62
RW08	219.24
RW09	221.89
SB105	DRY
SB106	DRY



0 500 1000
SCALE IN FEET

LEGEND

- DEPOT BOUNDARY
- BASE FEATURES
- 215 WATER TABLE ELEVATION IN THE FLUVIAL AQUIFER (FEET MSL)
- 215 INFERRED WATER TABLE ELEVATION IN THE FLUVIAL AQUIFER FROM LIMITED DATA (FEET MSL)
- WATER TABLE ELEVATION IN THE INTERMEDIATE AQUIFER (FEET MSL)
- INFERRED WATER TABLE ELEVATION IN THE INTERMEDIATE AQUIFER FROM LIMITED DATA (FEET MSL)
- LF LIMITED TO NO FLOW BOUNDARY (SEE NOTE)
- LF INFERRED LIMITED TO NO FLOW BOUNDARY (SEE NOTE)
- MONITORING WELL
- PIEZOMETER
- SOIL BORING
- GROUNDWATER FLOW DIRECTION
- CLAY ELEVATION EXCEEDS GROUNDWATER ELEVATION

NOTES

- THE LIMITED TO NO FLOW BOUNDARY BOUNDS AN AREA WHERE THE WATER LEVEL IN THE FLUVIAL AQUIFER INTERSECTS THE CLAY DIRECTLY UNDERLYING THE FLUVIAL DEPOSITS, LEAVING FLUVIAL DEPOSITS UNSATURATED
- [illegible] AND 90 ARE WELLS SCREENED WITHIN THE INTERMEDIATE AQUIFER
- [illegible] AND 108 ARE LOCATED IN A TRANSITION ZONE BETWEEN THE FLUVIAL AQUIFER AND THE INTERMEDIATE AQUIFER
- [illegible] ARE NOT INCLUDED IN THIS POTENTIOMETRIC SURFACE MAP
- [illegible] IS SCREENED IN THE MEMPHIS AQUIFER AND THEREFORE NOT INCLUDED IN THIS POTENTIOMETRIC SURFACE MAP
- NO MEASUREABLE WATER LEVELS WERE RECORDED IN [illegible] 17 AND 27
- DEPTH TO WATER MEASUREMENTS WERE NOT COLLECTED IN [illegible]
- SB-105 AND 106 WERE MEASURED ON OCTOBER 16, 2001 AND OCTOBER 17, 2001 RESPECTIVELY
- EXCLUDES [illegible] GROUNDWATER ELEVATION DATA.

FIGURE 2-5a
Potentiometric Surface Map of the Fluvial Aquifer, Including Intermediate Aquifer
November 01, 2001
REV. 0 MEMPHIS DEPOT, DUNN FIELD ROD

CH2MHILL

ATLANTA/CAD1/PROJECTS/148071 DDMT/DUNNFIELD ROD 2003 13-JUNE-2003 figure2-5a.dgn

7779 169

Well ID	Water Level Elevation (feet MSL)
MW03	221.66
MW04	224.84
MW06	224.00
MW07	225.71
MW08	226.86
MW09	225.43
MW10	223.18
MW11	222.66
MW12	224.11
MW13	224.61
MW14	227.22
MW15	224.49
MW16	241.44
MW18	175.20
MW19	200.92
MW20	195.30
MW21	195.95
MW22	200.03
MW23	198.57
MW24	190.82
MW25	203.03
MW27	DRY
MW28	233.86
MW29	233.52
MW30	226.50
MW31	218.34
MW32	221.41
MW33	224.18
MW34	158.66
MW35	222.34
MW36	151.53
MW37	151.12
MW38	189.57
MW39	191.89
MW40	171.05
MW41	217.86
MW42	217.70
MW43	152.75
MW44	212.87
MW45	236.96
MW46	232.55
MW47	203.89
MW49	230.56
MW50	212.21
MW51	234.92
MW52	187.75
MW53	232.67
MW54	213.80
MW55	221.05
MW56	225.61
MW57	224.97
MW58	226.29
MW59	223.92
MW60	224.15
MW61	224.73
MW62	196.71
MW63	197.45

Well ID	Water Level Elevation (feet MSL)
MW64	198.63
MW65	252.65
MW67	151.59
MW68	221.79
MW69	222.44
MW70	223.06
MW71	222.43
MW72	205.91
MW73	223.87
MW74	223.36
MW75	222.99
MW76	217.04
MW77	221.42
MW78	225.11
MW79	212.63
MW80	212.54
MW81	154.87
MW82	161.50
MW83	157.48
MW84	228.46
MW85	204.16
MW86	206.09
MW87	223.70
MW88	224.17
MW89	183.57
MW90	183.94
MW91	223.76
MW92	201.56
MW93	181.53
MW94	189.87
MW95	228.82
MW96	206.00
MW97	196.19
MW98	197.43
MW99	195.73
MW100	196.21
MW101	198.38
MW102	200.66
MW103	231.92
MW104	232.75
MW107	190.49
MW108	189.86
PZ01	202.74
PZ02	241.91
PZ03	191.47
PZ04	203.96
PZ05	196.54
PZ06	229.22
PZ07	205.74
PZ08	204.66
RW04	223.39
RW05	220.62
RW06	219.24
RW09	221.69
SB105	DRY
SB106	DRY

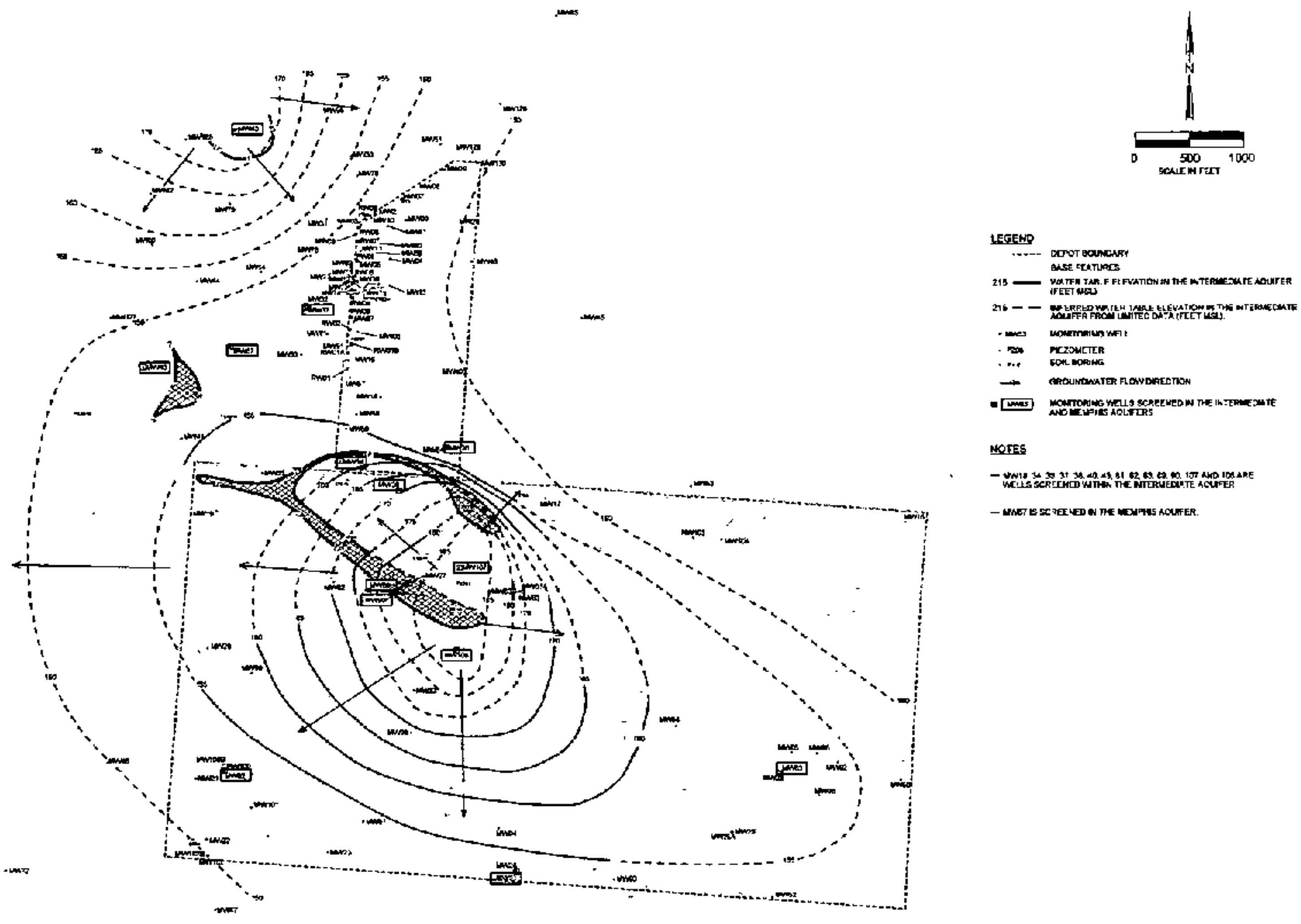


FIGURE 2-5b
Potentiometric Surface
Map of the Intermediate Aquifer
November 01, 2001
REV 2 MEMPHIS DEPOT, DUNN FIELD ROD

CH2MHILL

ATL/CAD1/PROJECTS/146071 DDMT/DUNNFIELD ROD 2003 13-JUNE-2003 figure2-5b.dgn

779 170

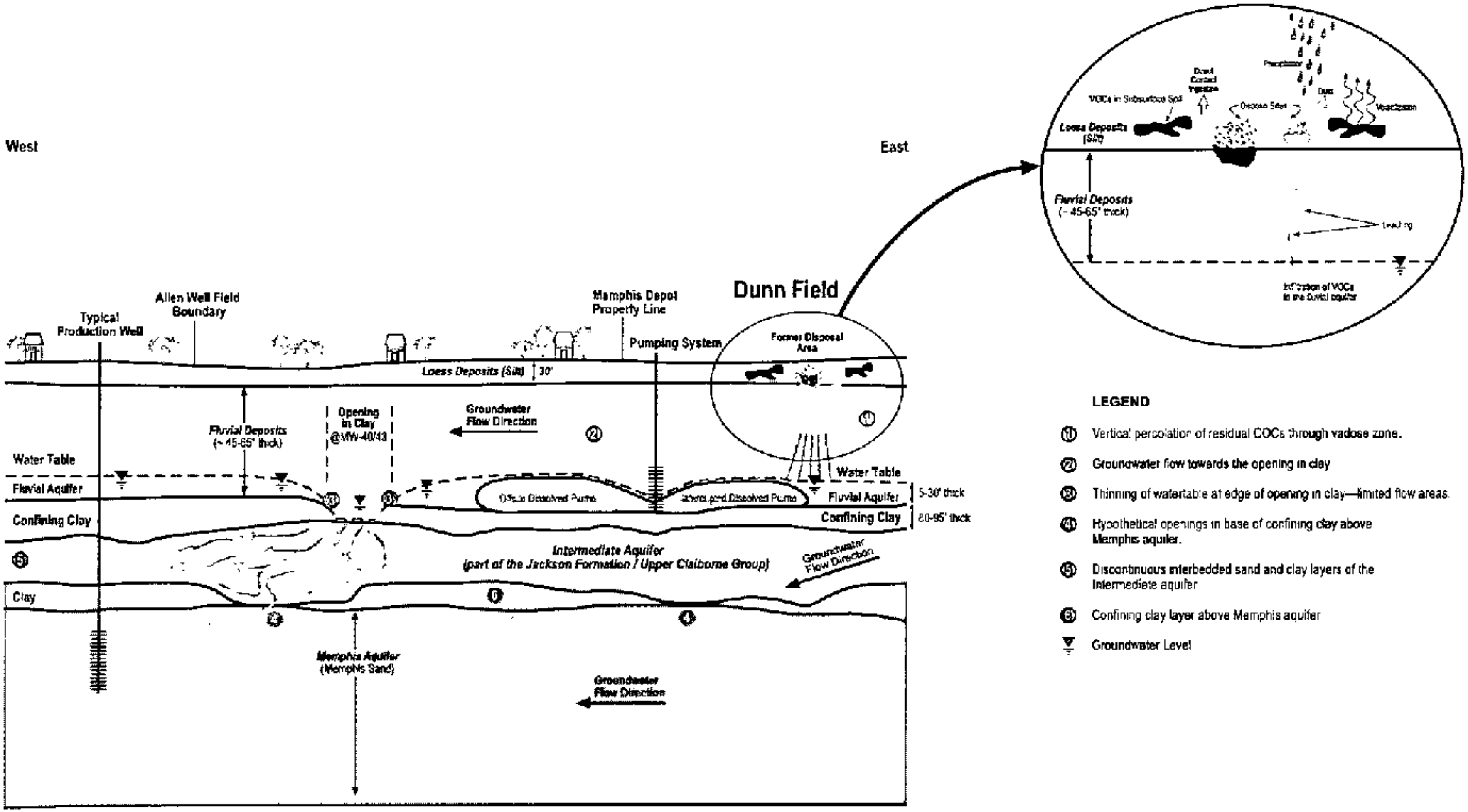


FIGURE 2-6
CONCEPTUAL MODEL OF CONTAMINANT MIGRATION FROM DUNN FIELD
REV. 0 MEMPHIS DEPOT DUNN FIELD ROD

CH2MHILL

779 171

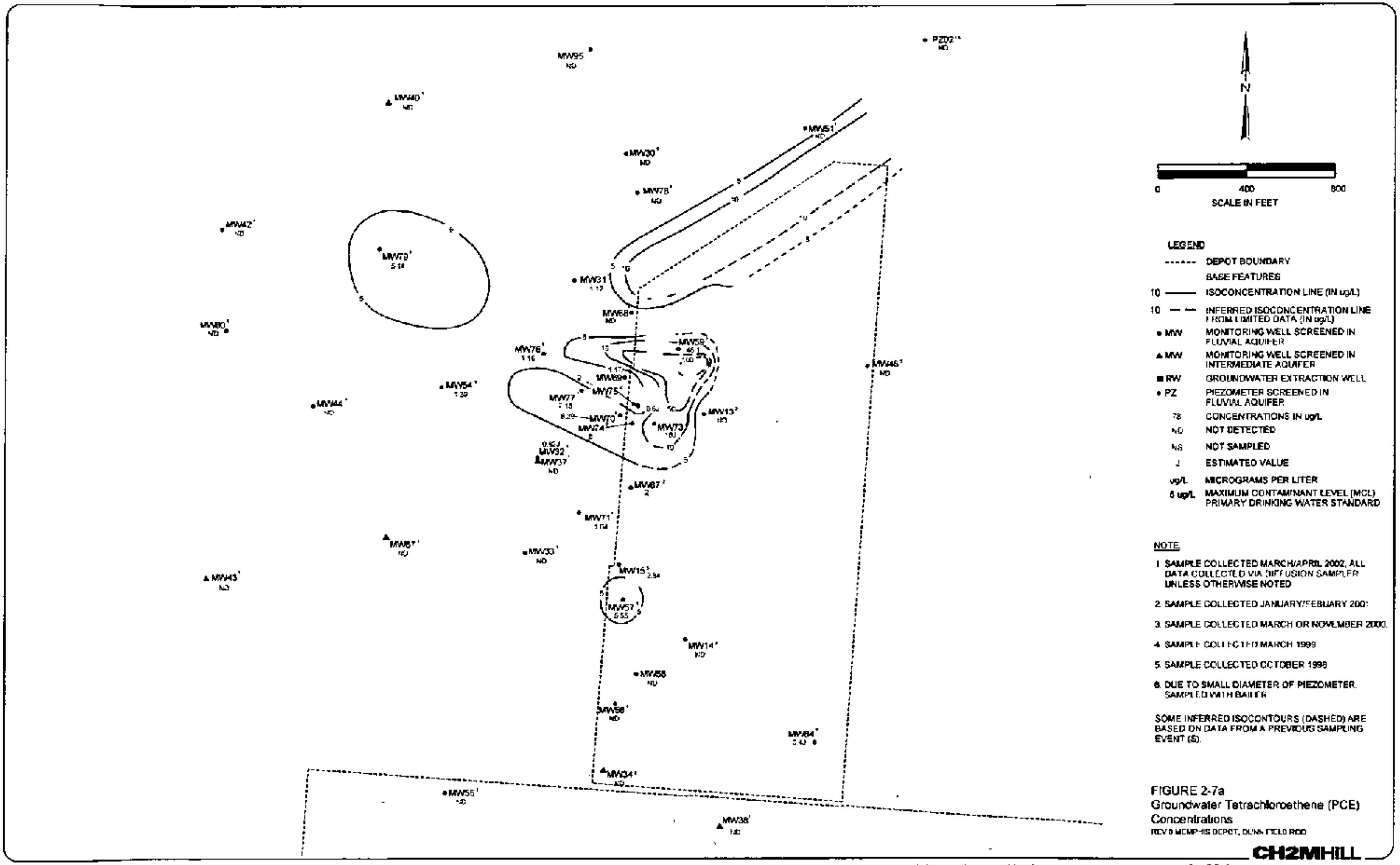
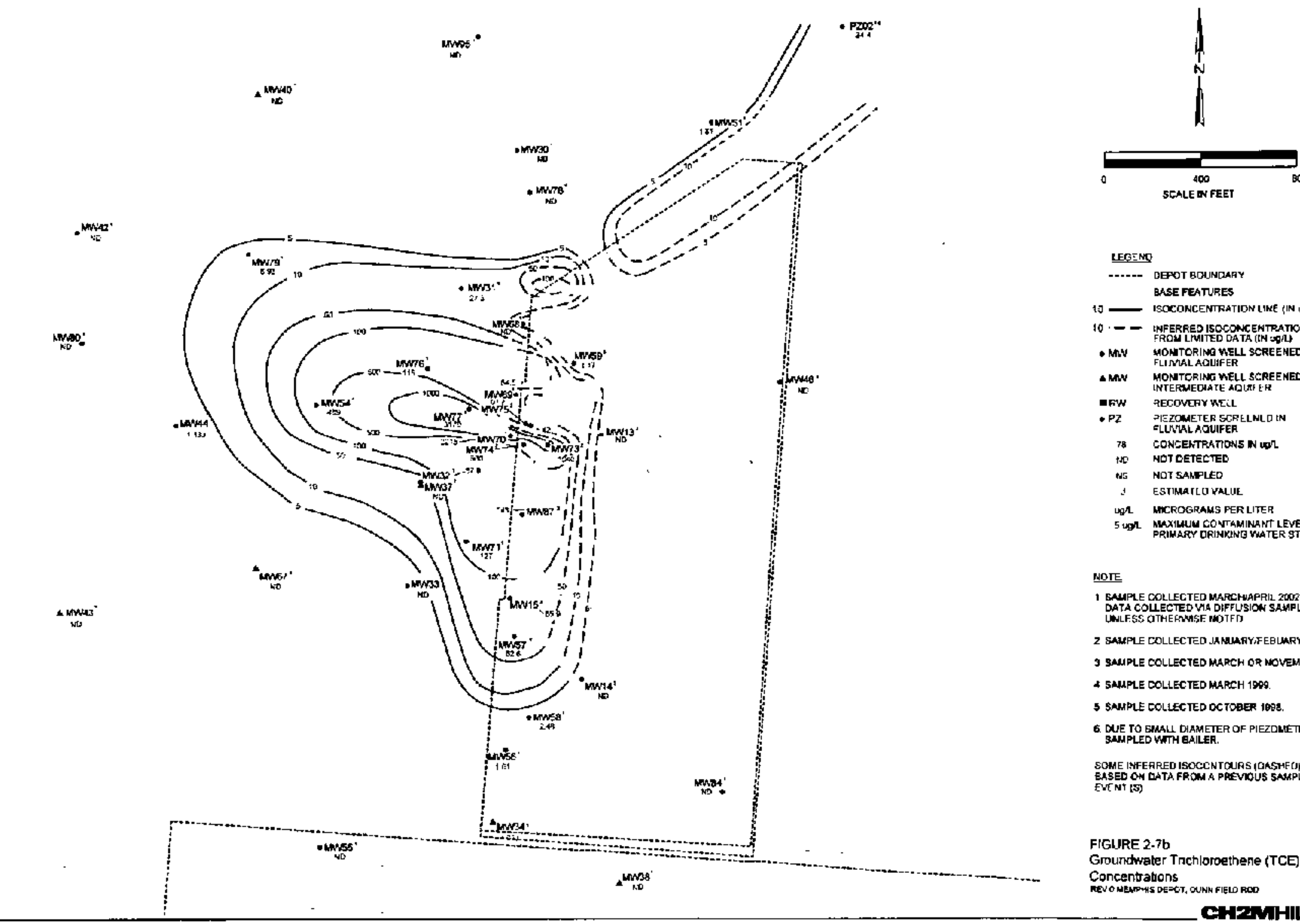


FIGURE 2-7a
Groundwater Tetrachloroethene (PCE) Concentrations
REV 0 MEMPHIS DEPOT, DUNN FIELD ROD

779 172



LEGEND

------	DEPOT BOUNDARY
	BASE FEATURES
10 ———	ISOCONCENTRATION LINE (IN ug/L)
10 – – –	INFERRED ISOCONCENTRATION LINE FROM LIMITED DATA (IN ug/L)
• MW	MONITORING WELL SCREENED IN FLUVIAL AQUIFER
▲ MW	MONITORING WELL SCREENED IN INTERMEDIATE AQUIFER
■ RW	RECOVERY WELL
• PZ	PIEZOMETER SCREENED IN FLUVIAL AQUIFER
78	CONCENTRATIONS IN ug/L
ND	NOT DETECTED
NS	NOT SAMPLED
J	ESTIMATED VALUE
ug/L	MICROGRAMS PER LITER
5 ug/L	MAXIMUM CONTAMINANT LEVEL (MCL) PRIMARY DRINKING WATER STANDARD

NOTE

1. SAMPLE COLLECTED MARCH/APRIL 2002; ALL DATA COLLECTED VIA DIFFUSION SAMPLER UNLESS OTHERWISE NOTED
2. SAMPLE COLLECTED JANUARY/FEBUARY 2001
3. SAMPLE COLLECTED MARCH OR NOVEMBER 2000.
4. SAMPLE COLLECTED MARCH 1999.
5. SAMPLE COLLECTED OCTOBER 1998.
6. DUE TO SMALL DIAMETER OF PIEZOMETER, SAMPLED WITH BAILER.

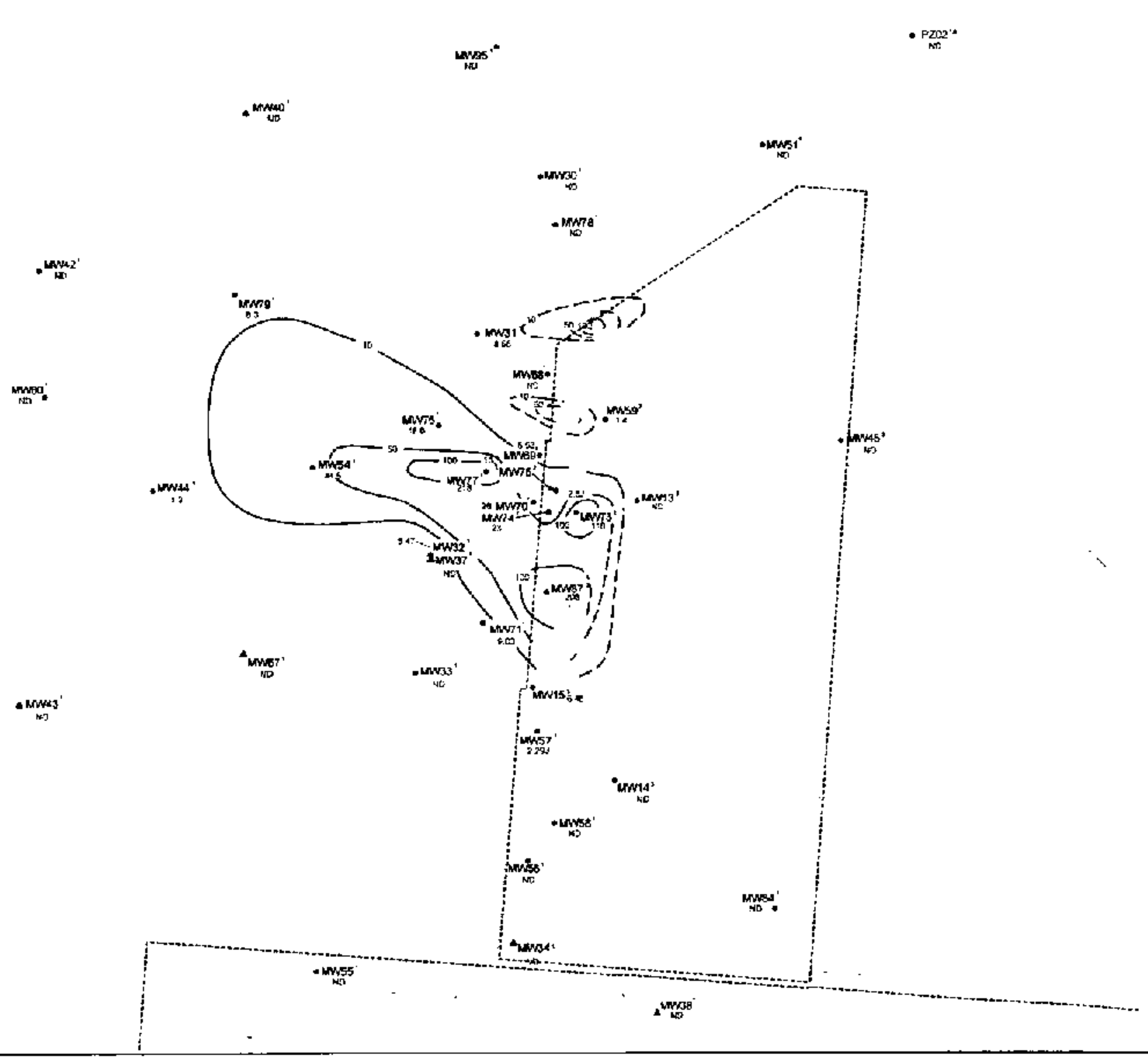
SOME INFERRED ISOCONTOURS (DASHED) ARE BASED ON DATA FROM A PREVIOUS SAMPLING EVENT (S)

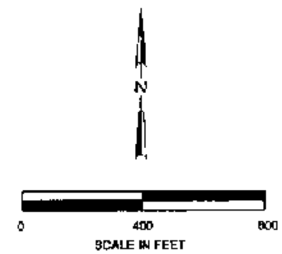
FIGURE 2-7b
Groundwater Trichloroethene (TCE) Concentrations
REV 0 MEMPHIS DEPOT, DUNN FIELD ROD

CH2MHILL

ATL/CAD1/PROJECTS/148C71 DDMT/DUNNFIELD ROD 2003 13-JUNE-2003 figure2-7b.dgn

779 173





LEGEND

------	DEPOT BOUNDARY
	BASE FEATURES
10 ———	ISOCONCENTRATION LINE (IN ug/L)
10 - — —	INFERRED ISOCONCENTRATION LINE FROM LIMITED DATA (IN ug/L)
• MW	MONITORING WELL SCREENED IN FLUVIAL AQUIFER
▲ MW	MONITORING WELL SCREENED IN INTERMEDIATE AQUIFER
■ RW	RECOVERY WELL
• PZ	PIEZOMETER SCREENED IN FLUVIAL AQUIFER
78	CONCENTRATIONS IN ug/L
ND	NOT DETECTED
NS	NOT SAMPLED
J	ESTIMATED VALUE
ug/L	MICROGRAMS PER LITER
70 ug/L	MAXIMUM CONTAMINANT LEVEL (MCL) PRIMARY DRINKING WATER STANDARD FOR CIS 1,2-DCE

NOTE:

1. SAMPLE COLLECTED MARCH/APRIL 2002, ALL DATA COLLECTED VIA DIFFUSION SAMPLER UNLESS OTHERWISE NOTED.
2. SAMPLE COLLECTED JANUARY/FEBUARY 2001
3. SAMPLE COLLECTED MARCH OR NOVEMBER 2000.
4. SAMPLE COLLECTED MARCH 1999
5. SAMPLE COLLECTED OCTOBER 1998
6. DUE TO SMALL DIAMETER OF PIEZOMETER, SAMPLED WITH BAILER

SOME INFERRED ISOCONTOURS (DASHED) ARE BASED ON DATA FROM A PREVIOUS SAMPLING EVENT (S).

FIGURE 2-7c
Groundwater 1,2 - Dichloroethene (Total) (1,2 - DCE) Concentrations
REV D MEMPHIS DEPOT DUNN FIELD ROD

CH2MHILL

ATL/CAD1/PROJECTS/145071 DDMT/DUNNFIELD ROD 2003 13-JUNE-2003 figure2-7c.dgn

779 174

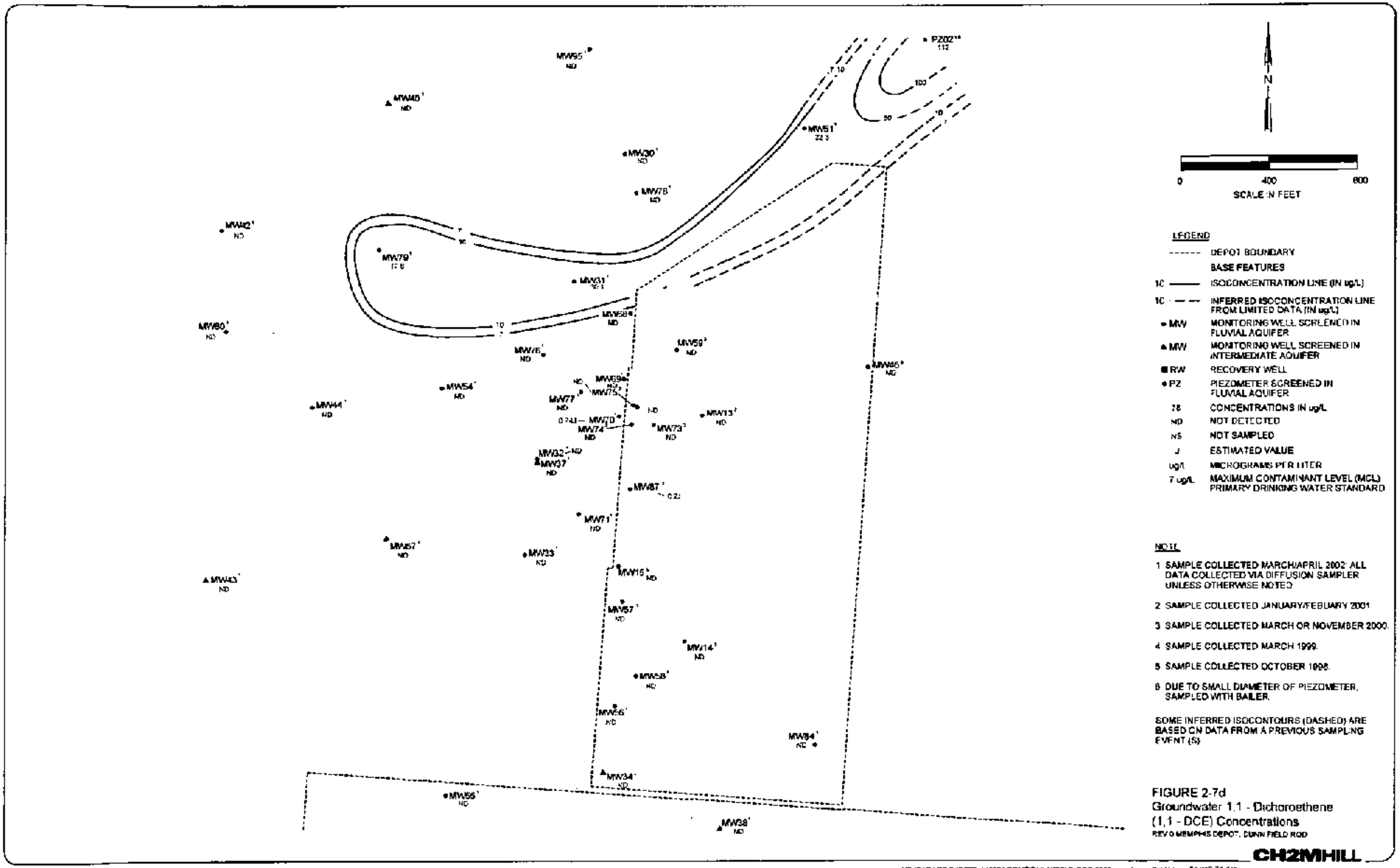


FIGURE 2-7d
Groundwater 1,1 - Dichoroethene (1,1 - DCE) Concentrations
REV 0 MEMPHIS DEPOT, DUNN FIELD ROD

779 175

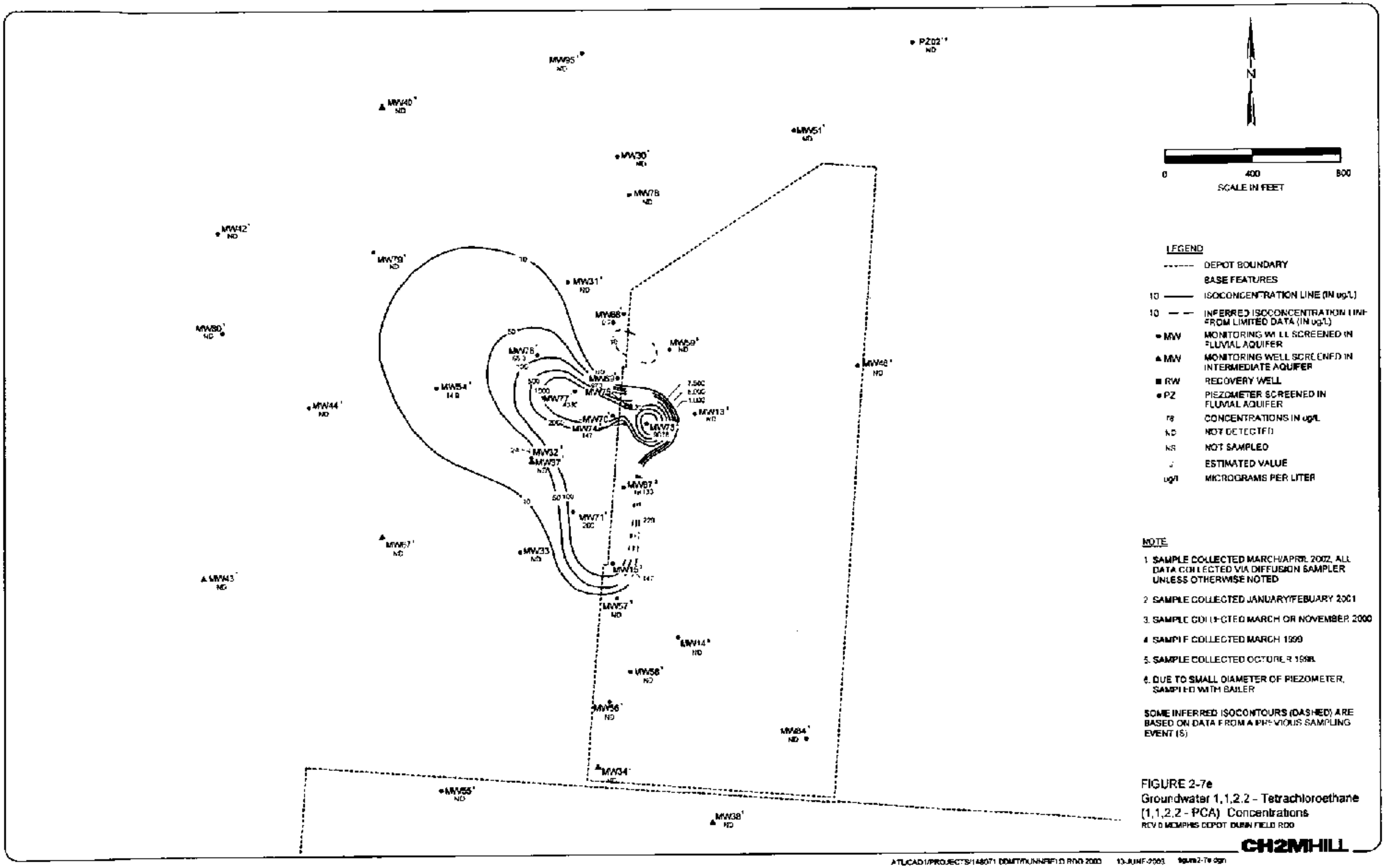


FIGURE 2-7e
Groundwater 1,1,2,2 - Tetrachloroethane (1,1,2,2 - PCA) Concentrations
REV 0 MEMPHIS DEPOT DUNN FIELD ROD

779 176

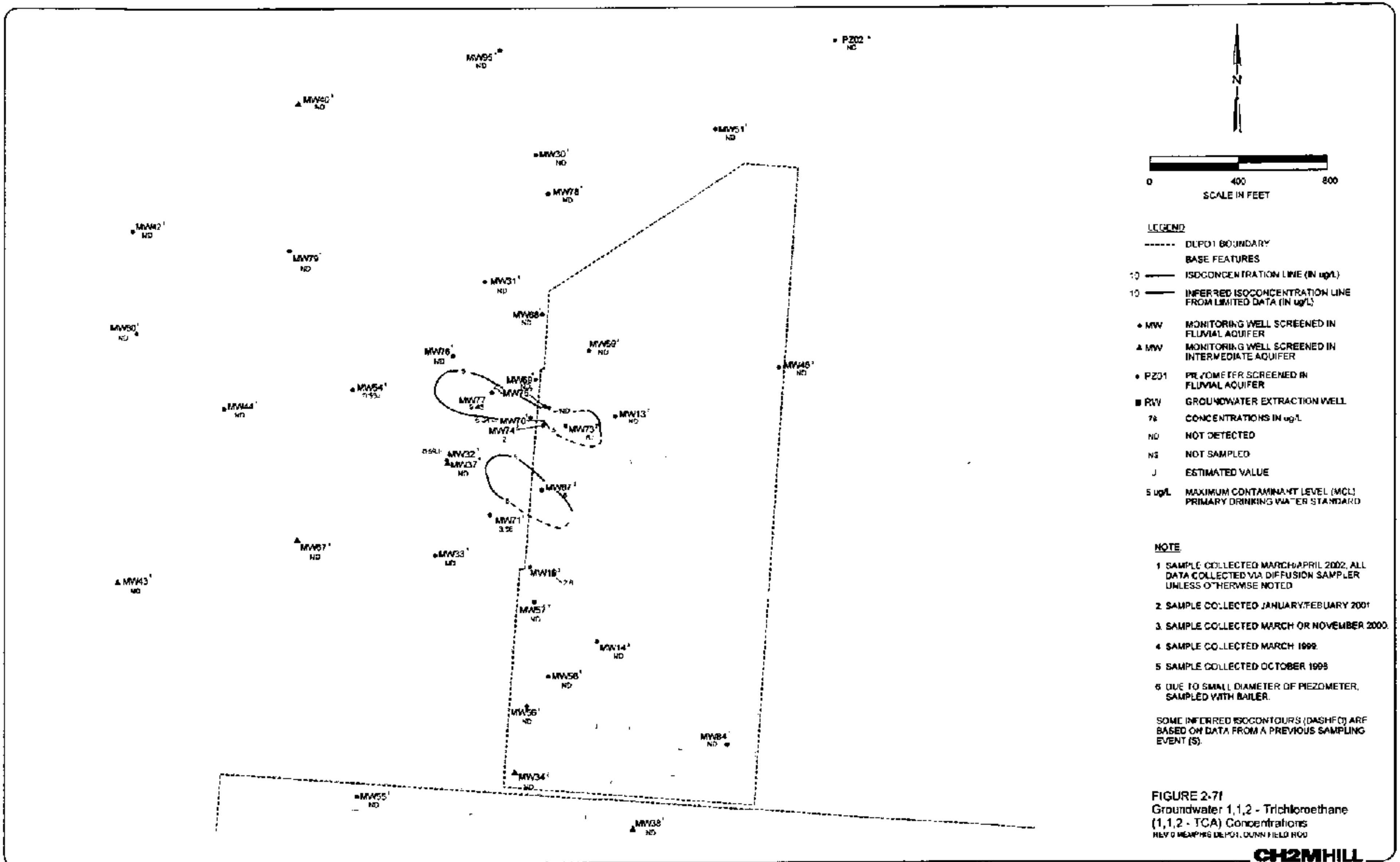


FIGURE 2-7f
Groundwater 1,1,2 - Trichloroethane
(1,1,2 - TCA) Concentrations
REV 0 MEMPHIS DEPOT, DUNN FIELD ROD

ATL/CAD/PROJECTS/... DUNN FIELD ROD 2003 13-JUNE-2003 figure2-7f.dgn

779 177

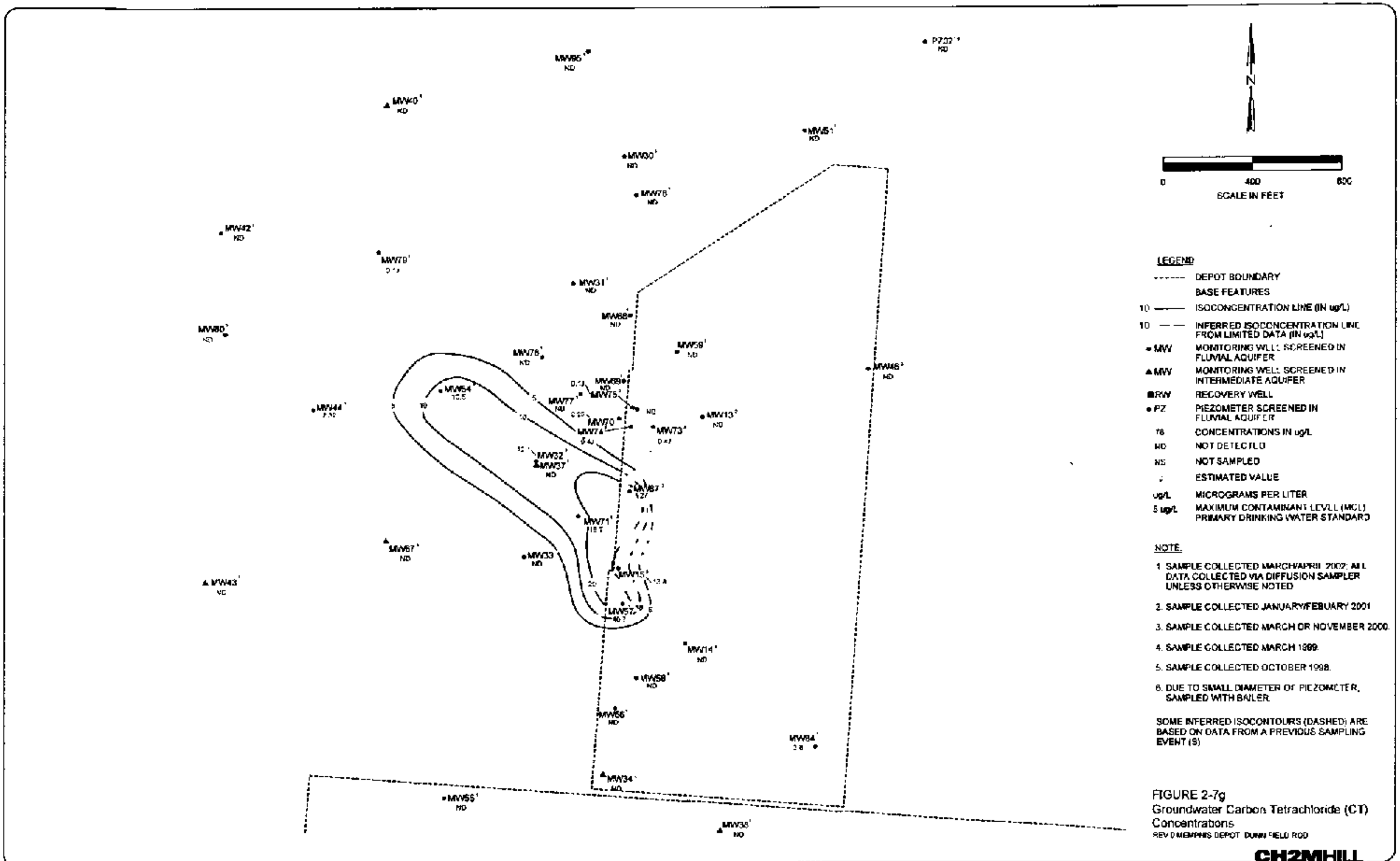


FIGURE 2-7g
Groundwater Carbon Tetrachloride (CT) Concentrations
REV 0 MEMPHIS DEPOT DUNN FIELD ROD

CH2MHILL

779 178

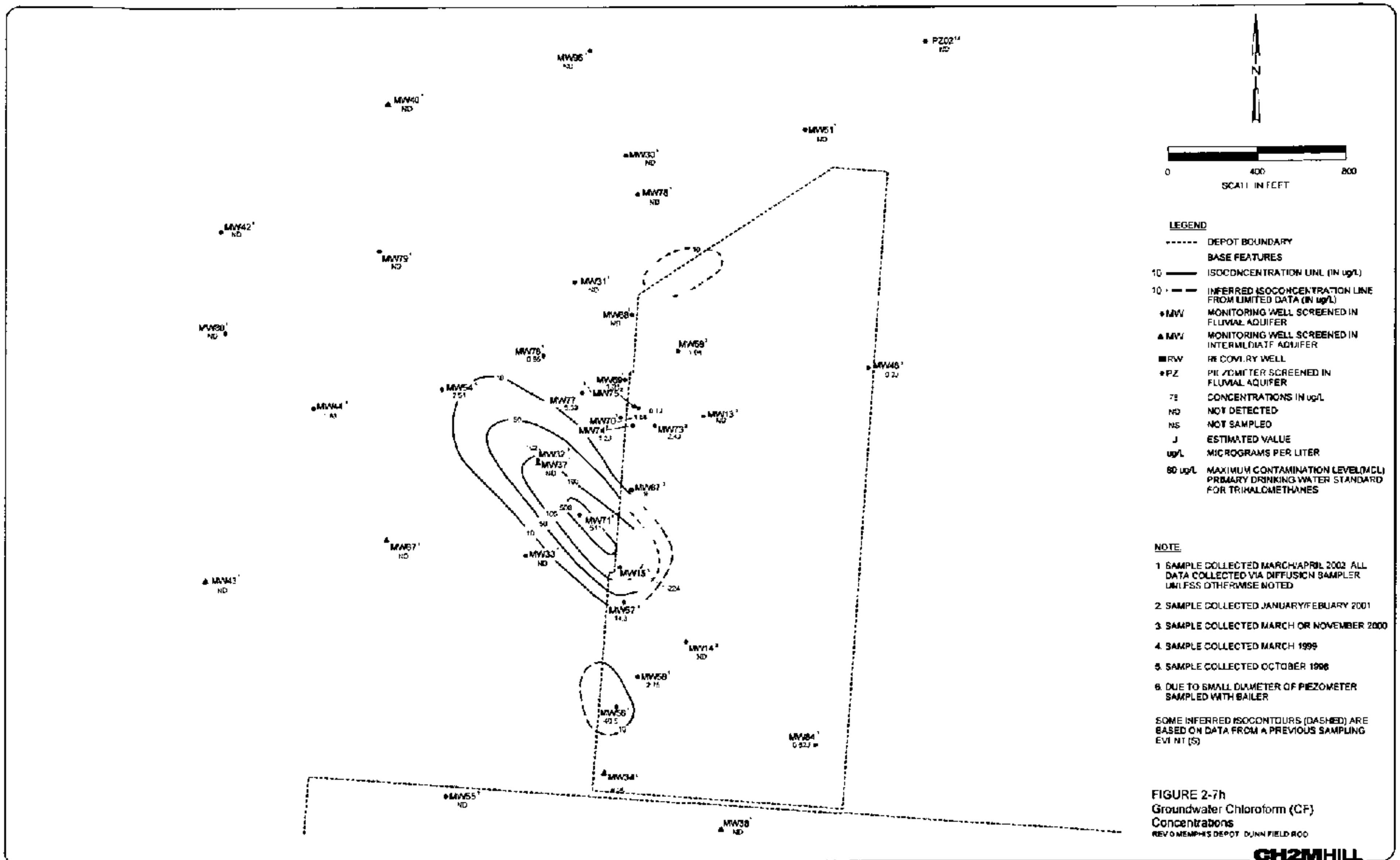
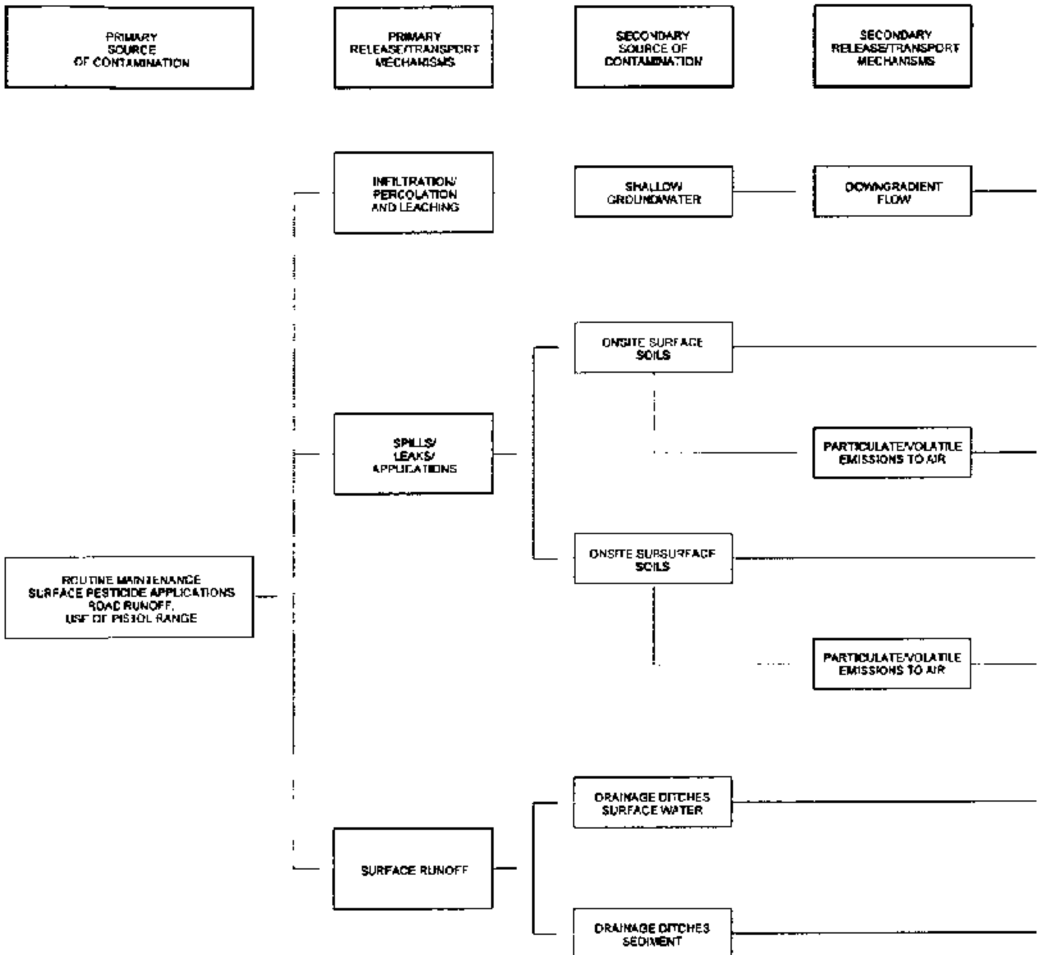


FIGURE 2-7h
Groundwater Chloroform (CF) Concentrations
REV 0 MEMPHIS DEPOT DUNN FIELD ROD

ATL/CAD1/PROJECTS/148071 DDMT/DUNNFIELD ROD 2003 13-JUNE-2003 figure2-7h.dgn



Secondary source / mechanism	Potential Exposure Routes	Human Receptors: Maintenance Worker	Future Utility Workers	Future Industrial Workers	Future Recreational	Future Residential	Biota: Terrestrial	Aquatic
Shallow Groundwater – Downgradient Flow	Ingestion			●		●		
	Inhalation			●		●		
	Dermal			●		●		
Onsite Surface Soils	Ingestion	●	●	●	●		●	
	Dermal	●	●	●	●		●	
Onsite Surface Soils – Particulate/Volatile Emissions to Air	Inhalation	○	○	○	○		○	
Onsite Subsurface Soils	Ingestion		●	●				
	Dermal		●	●				
Onsite Subsurface Soils – Particulate/Volatile Emissions to Air	Inhalation		○	○				
Drainage Ditches Surface Water	Ingestion				●			○
	Dermal				●			○
Drainage Ditches Sediment	Ingestion				●			○
	Dermal				●			○

○ = MINOR EXPOSURE ROUTE

● = PRIMARY EXPOSURE ROUTE

FIGURE 2-8a
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES - NORTHEAST OPEN AREA
REV 0 MEMPHIS DEPOT, DUNN FIELD ROD

CH2MHILL

ATL/CAD1/PROJECTS/148071 DDMT/DUNNFIELD ROD 2003 13 JUNE 2003 ...dgn

779 180

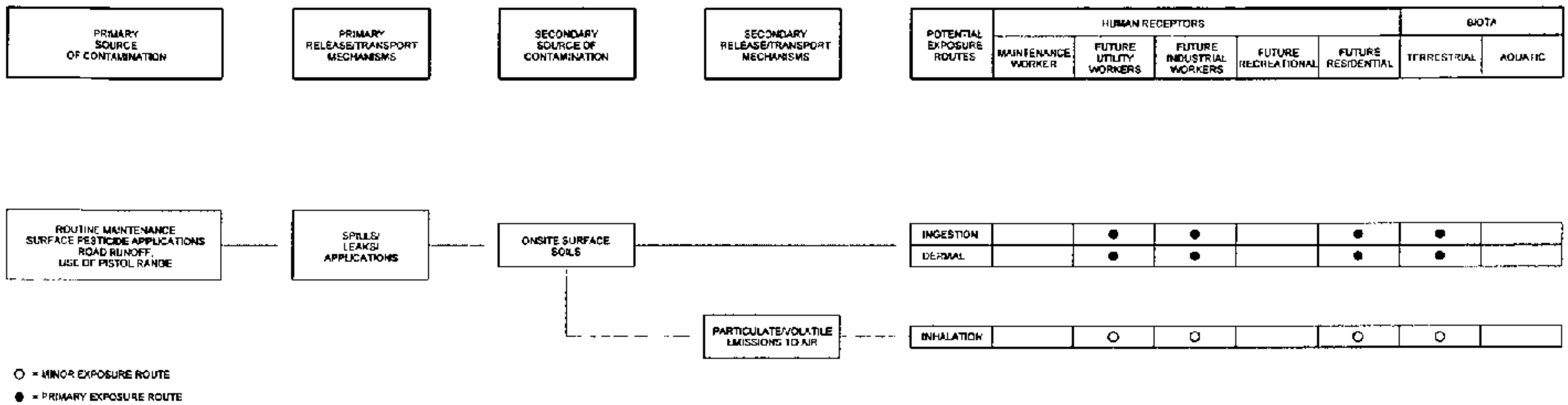


FIGURE 2-8b
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES DUNN FIELD SURROGATE SITE 60/85

REV. 0 MEMPHIS DEPOT DUNN FIELD ROD

CH2MHILL

ATL/CAD1/PROJECTS/146071 DDMT/DUNNFIELD ROD 2003 13-JUNE-2003 607 (dfn01-9-5.dgn

7779 181

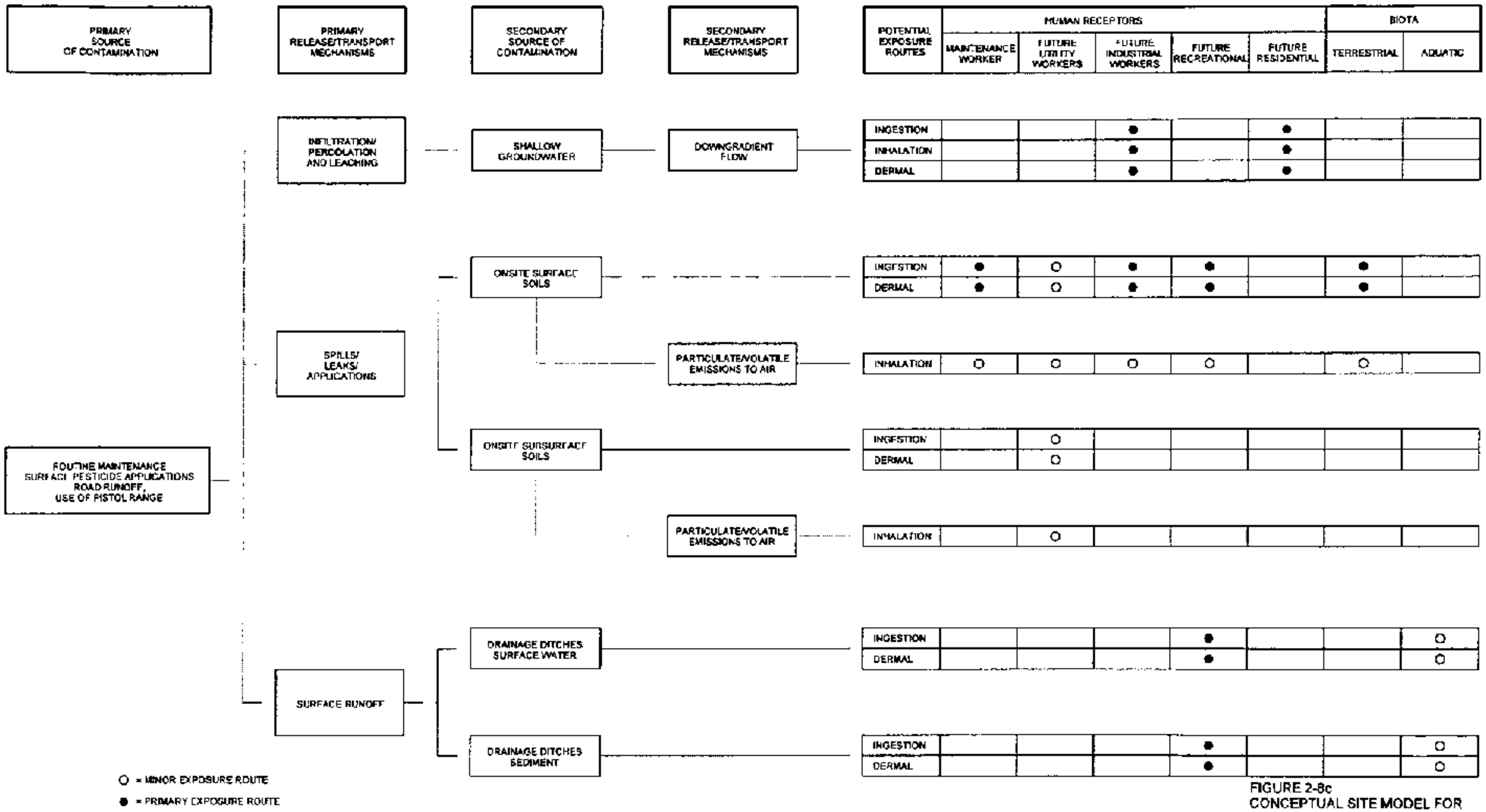


FIGURE 2-8c
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES DUNN FIELD DISPOSAL AREA

REV 0 MEMPHIS DEPOT DUNN FIELD ROD

CH2MHILL

ATL/CAD1/PROJECTS/146071 DDMT/DUNNFIELD ROD 2003 13-JUNE-2003 ...

779 182

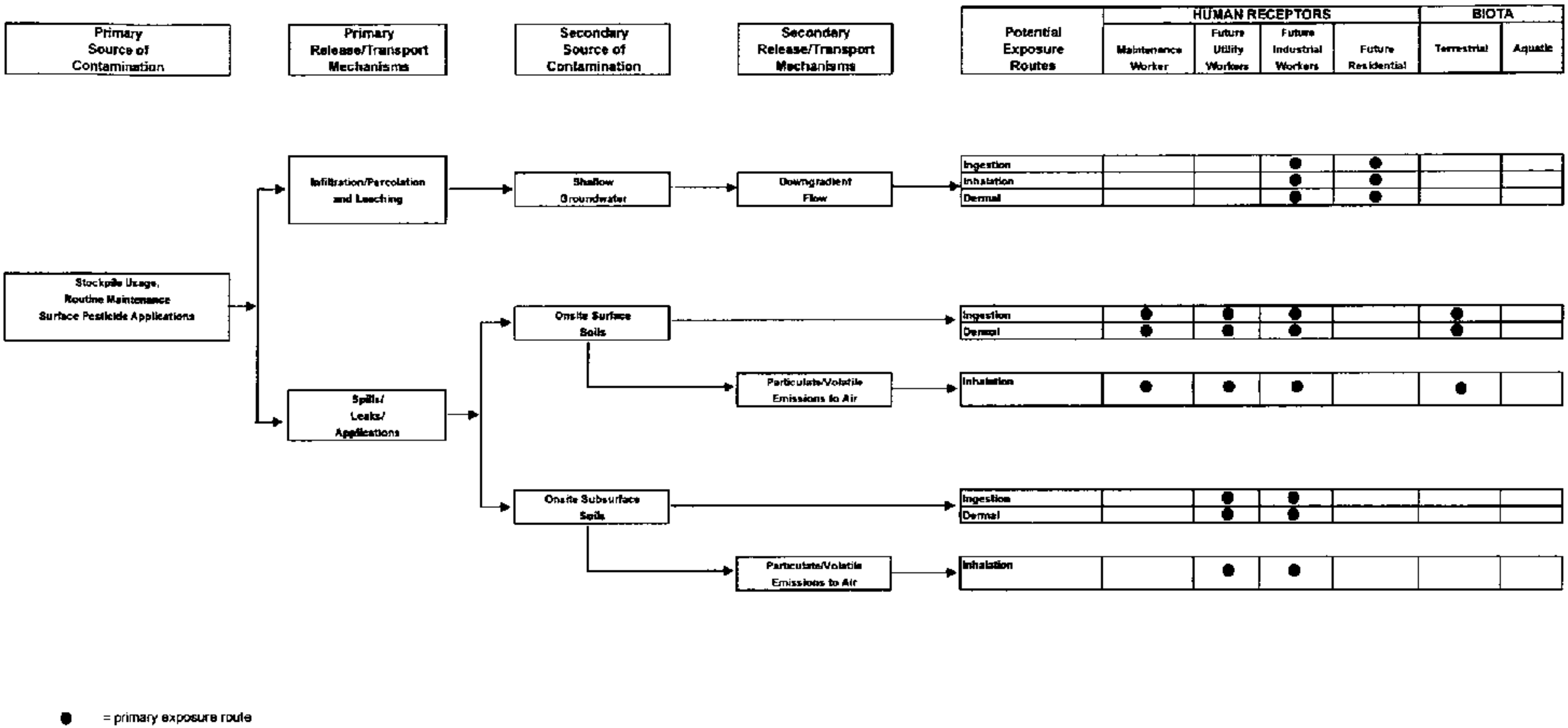


Figure 2-8d

Conceptual Site Model for Potential Human and Ecological Exposures - Stockpile Area

Rev. 0 Memphis Depot Dunn Field ROD

CH2MHILL

779 183

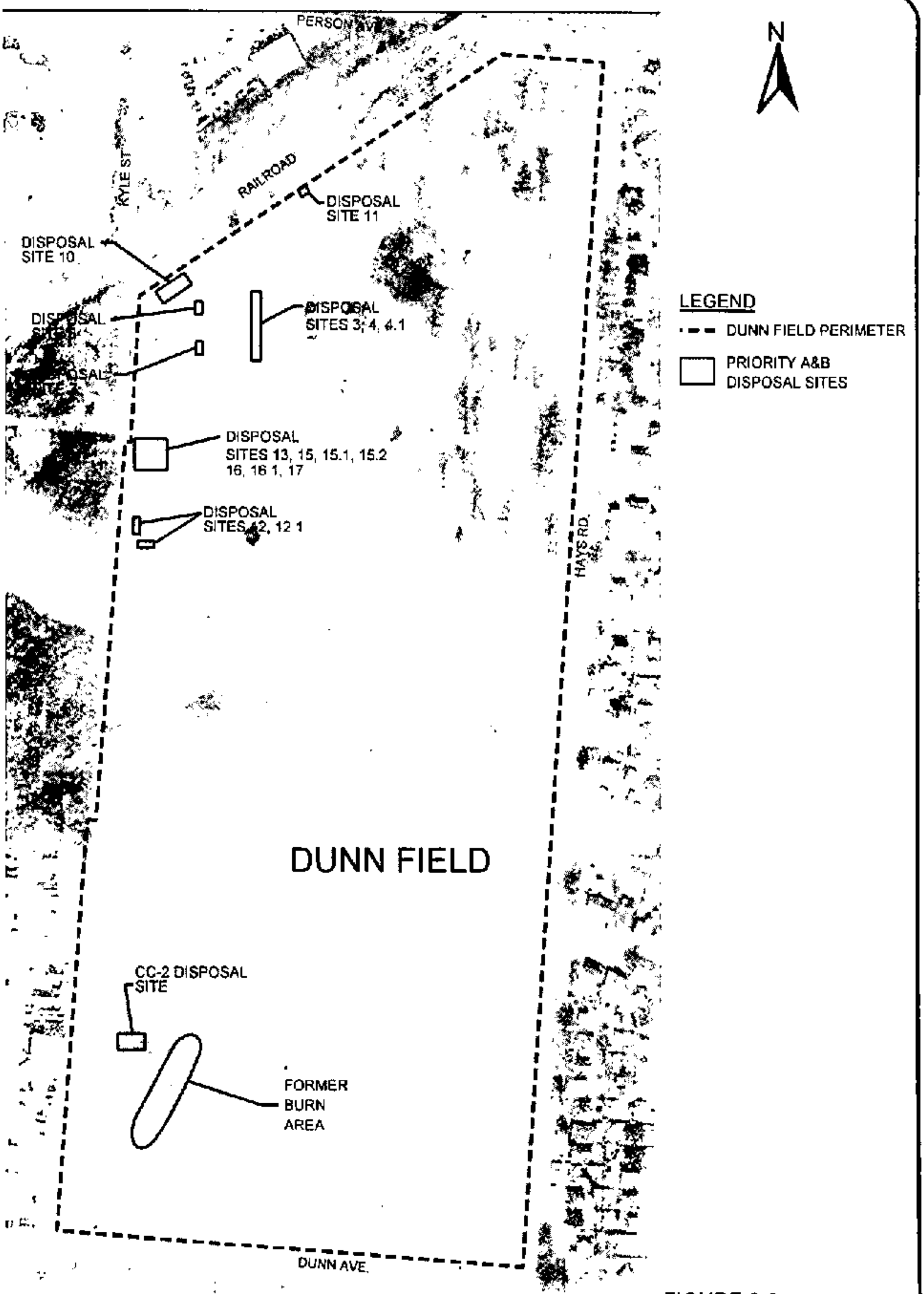


FIGURE 2-9
PRIORITY DISPOSAL
SITE LOCATIONS
Rev. 2 Memphis Depot Dunn Field ROD

CH2MHILL

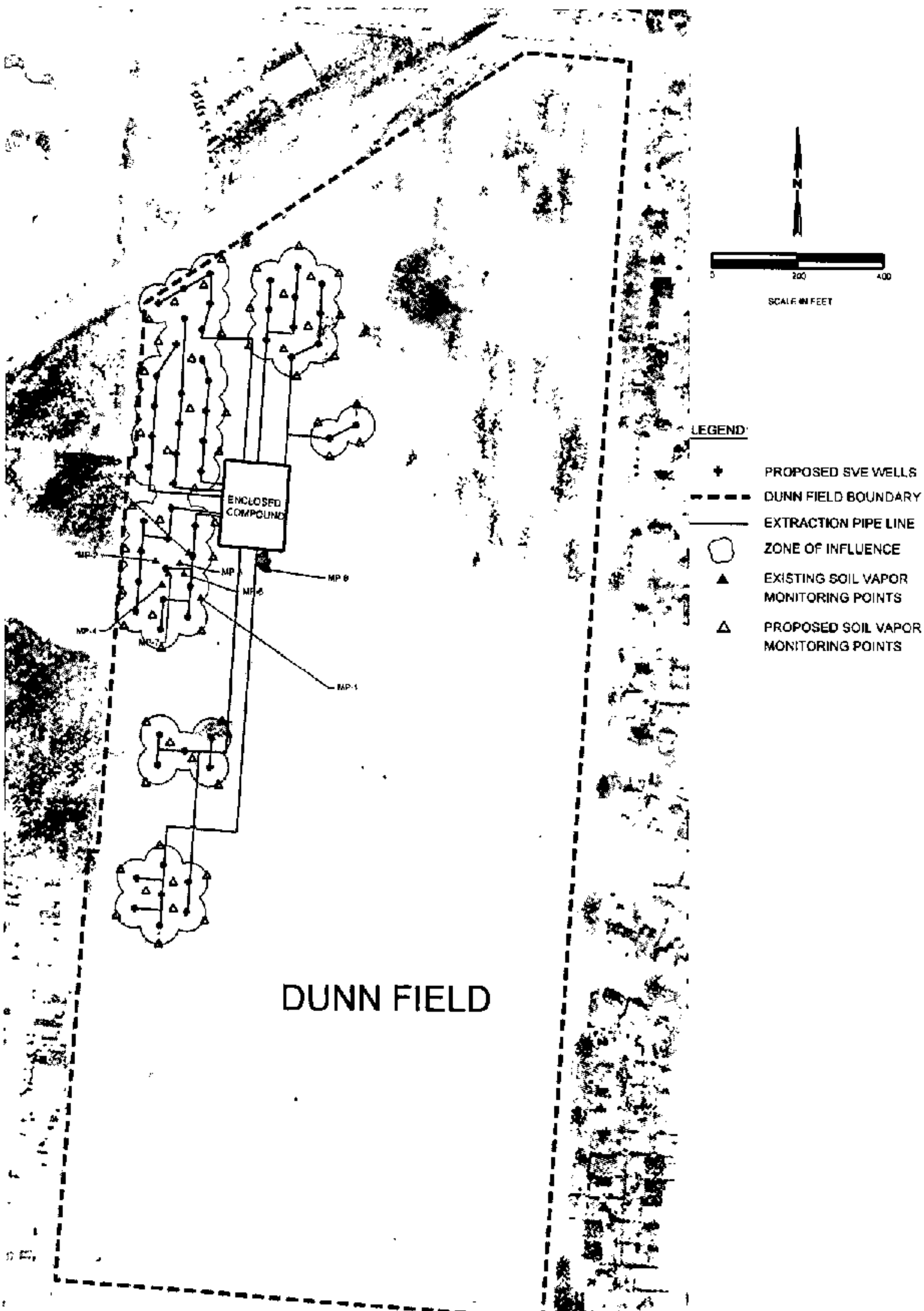
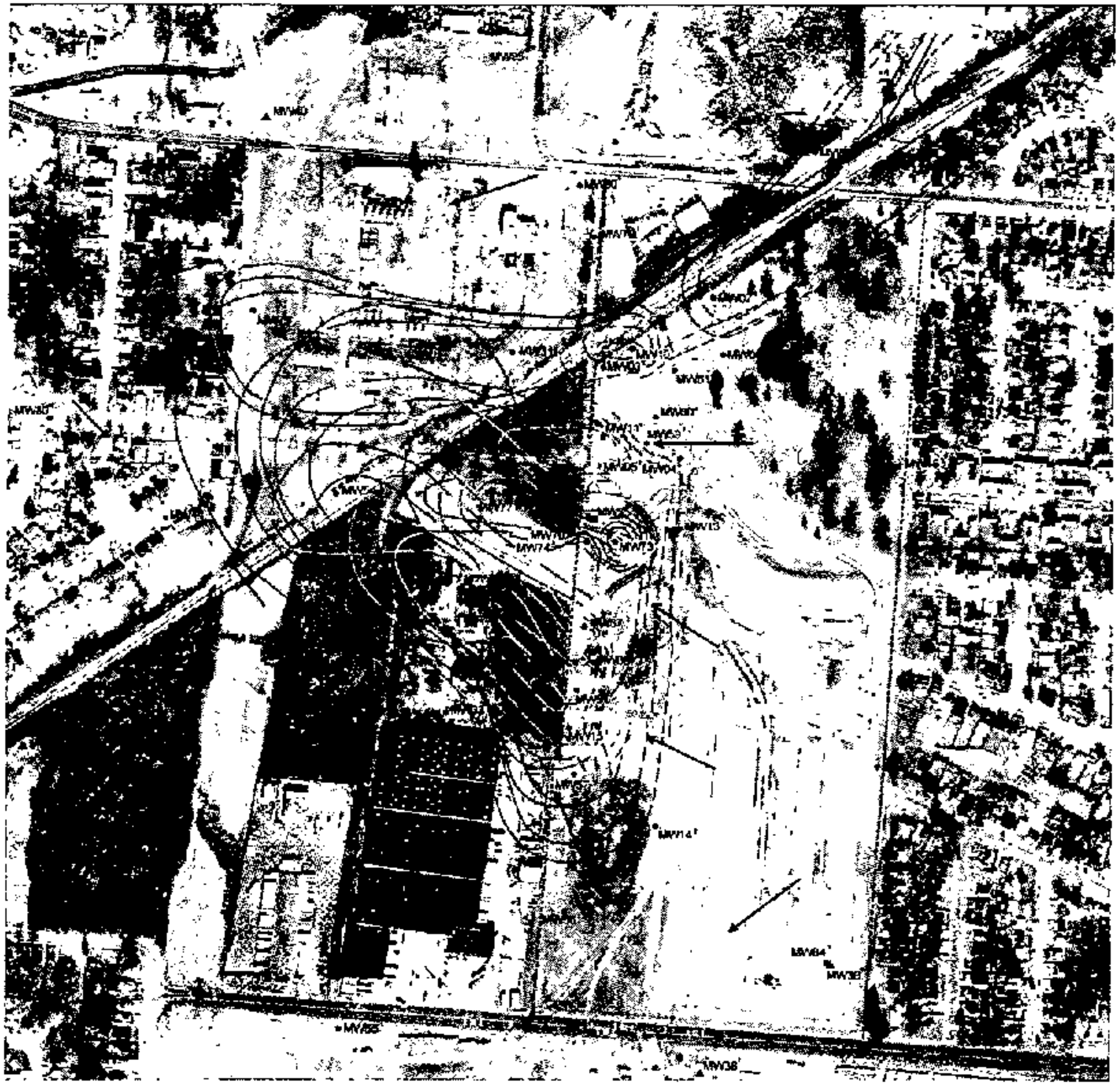


FIGURE 2-10
CONCEPTUAL SVE SYSTEM LAYOUT
Rev. 0 Memphis Depot
Dunn Field ROD

CH2MHILL

ATL/CAD1/PROJECTS/148071 ODMT/DUNNFIELD PP 2003



0 400 800

SCALE IN FEET

LEGEND

- - - - - - - DUNN FIELD BOUNDARY

10 ——— 1,1,2,2-PCA ISOCONCENTRATION LINE (IN ug/L)

10 ——— 1,1-DCE ISOCONCENTRATION LINE (IN ug/L) (OFFSITE SOURCE FOR THE 1,1-DCE)

10 ——— TCE ISOCONCENTRATION LINE (IN ug/L)

10 ——— CARBON TETRACHLORIDE ISOCONCENTRATION LINE (IN ug/L)

10 ——— CHLOROFORM ISOCONCENTRATION LINE (IN ug/L)

10 ——— 1,2-DCE ISOCONCENTRATION LINE (IN ug/L)

10 ——— PCE ISOCONCENTRATION LINE (IN ug/L)

• MW MONITORING WELL SCREENED IN FLUVIAL AQUIFER

▲ MW MONITORING WELL SCREENED IN INTERMEDIATE AQUIFER

← GROUNDWATER FLOW DIRECTION AS OF NOVEMBER 1, 2001

NOTE:

1. SAMPLE COLLECTED MARCH/APRIL 2002, ALL DATA COLLECTED VIA DIFFUSION SAMPLER UNLESS OTHERWISE NOTED.
2. SAMPLE COLLECTED JANUARY/FEBRUARY 2001
3. SAMPLE COLLECTED MARCH OR NOVEMBER 2000.
4. SAMPLE COLLECTED MARCH 1999.
5. SAMPLE COLLECTED OCTOBER 1998.
6. DUE TO SMALL DIAMETER OF PIEZOMETER, SAMPLED WITH BAILER.

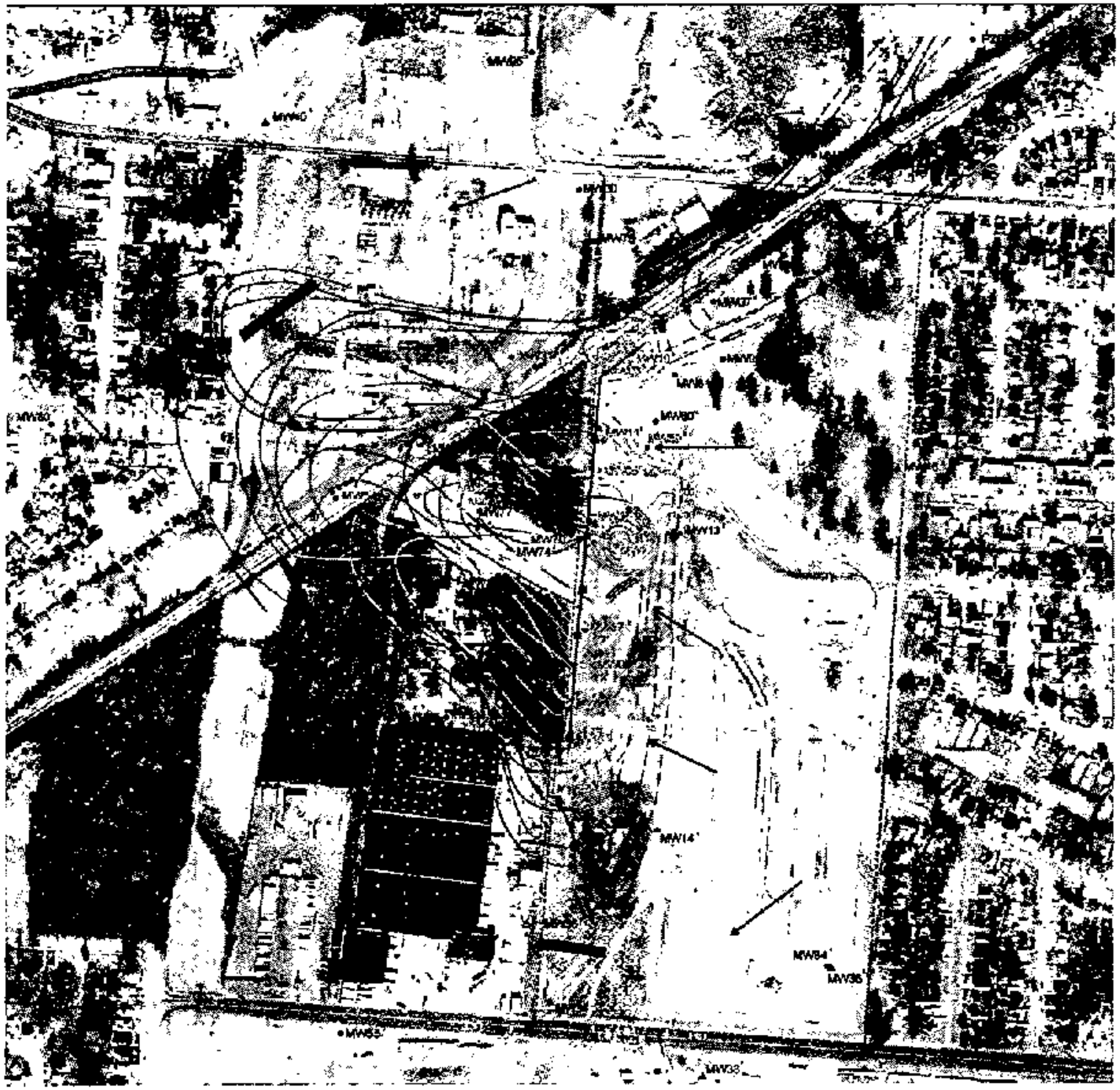
SOME INFERRED ISOCONTOURS (DASHED) ARE BASED ON DATA FROM A PREVIOUS SAMPLING EVENT (S)

FIGURE 2-11
VOC COMPOSITE PLUME MAP
OF THE FLUVIAL AQUIFER
REV 0 MEMPHIS DEPOT DUNN FIELD ROD

CH2MHILL

ATL/CAD/PROJECTS/145071 COM T/DUNNFIELD ROD 2003 15-JUNE-2003 Figure2-11.dgn

779 186



N

0 400 800

SCALE IN FEET

LEGEND

- - - - - DUNN FIELD BOUNDARY

10 —— 1,1,2,2-PCA ISOCONCENTRATION LINE (IN ug/L)

10 —— 1,1-DCE ISOCONCENTRATION LINE (IN ug/L) [OFFSITE SOURCE FOR THE 1,1-DCE]

10 —— TCE ISOCONCENTRATION LINE (IN ug/L)

10 —— CARBON TETRACHLORIDE ISOCONCENTRATION LINE (IN ug/L)

10 —— CHLOROFORM ISOCONCENTRATION LINE (IN ug/L)

10 —— 1,2-DCE ISOCONCENTRATION LINE (IN ug/L)

10 —— PCE ISOCONCENTRATION LINE (IN ug/L)

• MW MONITORING WELL SCREENED IN FLUVIAL AQUIFER

▲ MW MONITORING WELL SCREENED IN INTERMEDIATE AQUIFER

← GROUNDWATER FLOW DIRECTION

AREA OF ENHANCED BIOREMEDIATION

AREAS WHERE CONTINGENCY REMEDIAL ACTION MAY BE IMPLEMENTED

ZVI SOURCE AREA INJECTION ZONES

ENHANCED GW EXTRACTION SYSTEM

NOTE:

1 SAMPLE COLLECTED MARCH/APRIL 2002; ALL DATA COLLECTED VIA DIFFUSION SAMPLER UNLESS OTHERWISE NOTED.

2 SAMPLE COLLECTED JANUARY/FEBUARY 2001

3 SAMPLE COLLECTED MARCH OR NOVEMBER 2000

4 SAMPLE COLLECTED MARCH 1999

5 SAMPLE COLLECTED OCTOBER 1998.

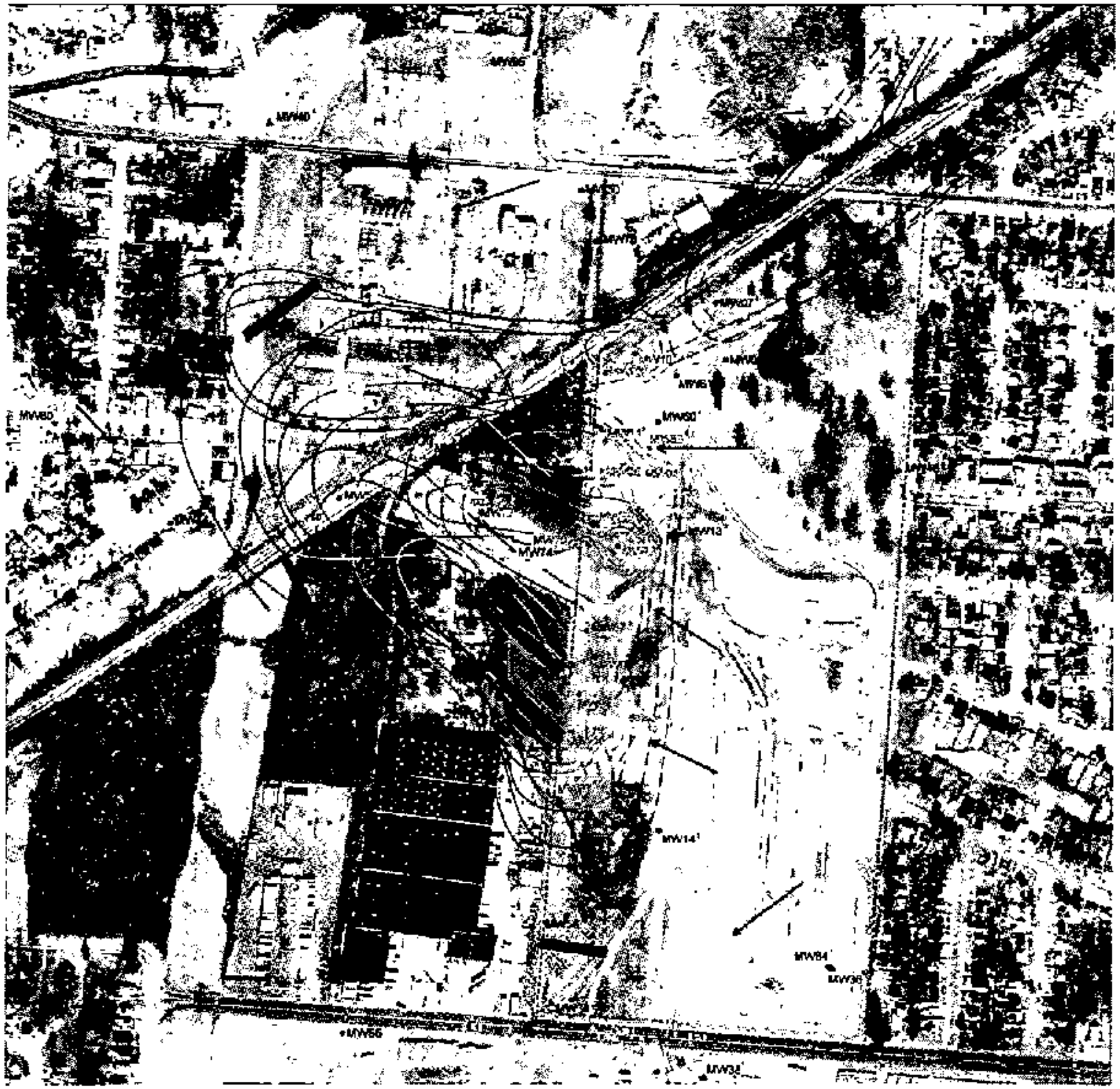
6 DUE TO SMALL DIAMETER OF PIEZOMETER, SAMPLED WITH BAILER

SOME INFERRED ISOCONTOURS (DASHED) ARE BASED ON DATA FROM A PREVIOUS SAMPLING EVENT (S)

FIGURE 2-12
GROUNDWATER ALTERNATIVE 2
ZVI INJECTION WITH EXTRACTION ENHANCEMENT AND ENHANCED BIOREMEDIATION

REV 0 MEMPHIS DEPOT DUNN FIELD ROD

CH2MHILL



N

0 400 800

SCALE IN FEET

LEGEND

DUNN FIELD BOUNDARY

10 — 1,1,2,2-PCA ISOCONCENTRATION LINE (IN ug/l)

10 — 1,1-DCE ISOCONCENTRATION LINE (IN ug/L) (OFFSITE SOURCE FOR THE 1,1-DCE)

10 — TCE ISOCONCENTRATION LINE (IN ug/L)

10 — CARBON TETRACHLORIDE ISOCONCENTRATION LINE (IN ug/L)

10 — CHLOROFORM ISOCONCENTRATION LINE (IN ug/l)

10 — 1,2-DCE ISOCONCENTRATION LINE (IN ug/L)

10 — PCE ISOCONCENTRATION LINE (IN ug/L)

● MW MONITORING WELL SCREENED IN FLUVIAL AQUIFER

▲ MW MONITORING WELL SCREENED IN INTERMEDIATE AQUIFER

GROUNDWATER FLOW DIRECTION

IRON PRB TREATMENT ZONE

AREAS WHERE CONTINGENCY REMEDIAL ACTION MAY BE IMPLEMENTED

ZVI SOURCE AREA INJECTION ZONES

NOTE.

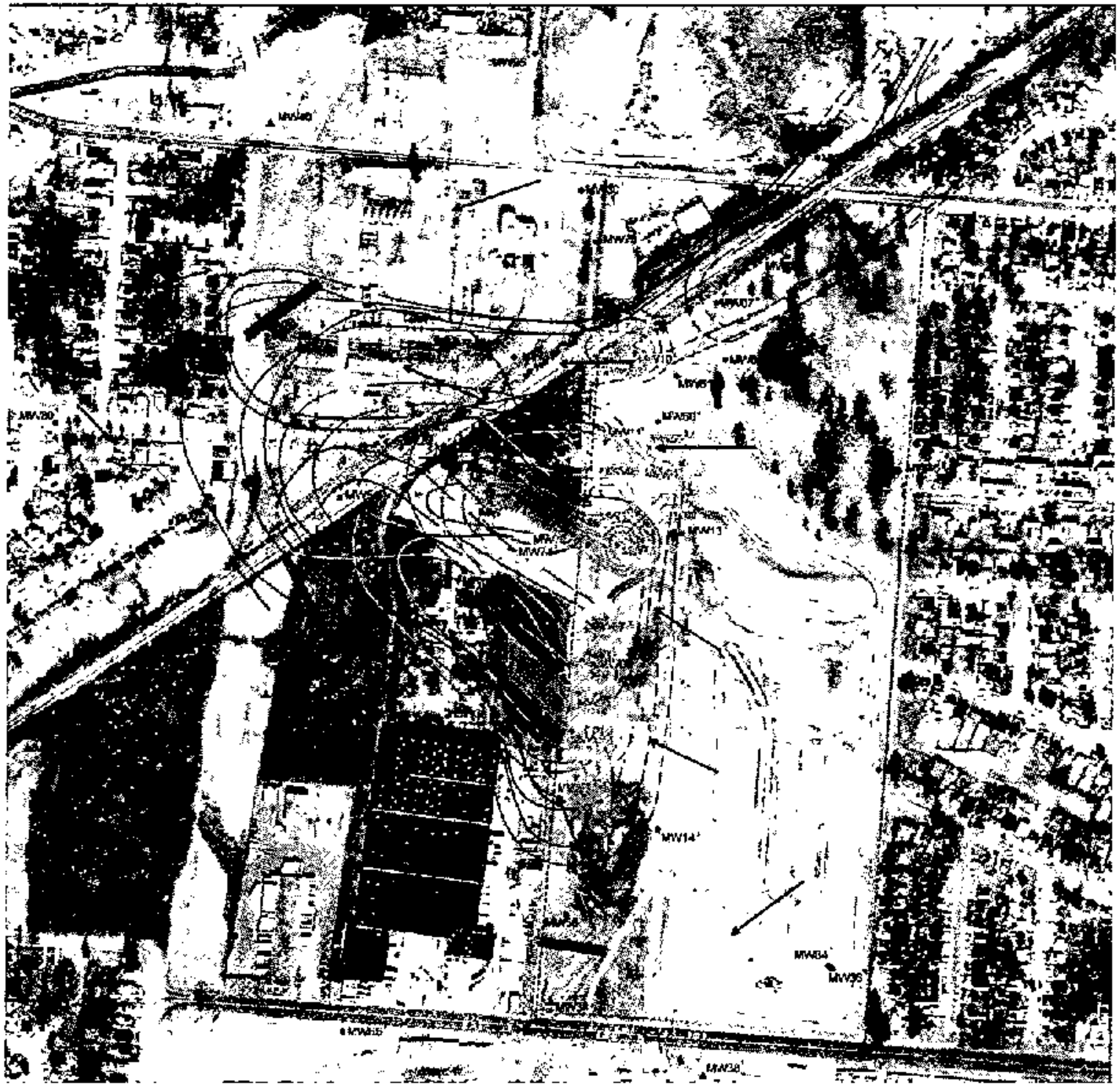
1 SAMPLE COLLECTED MARCH/APRIL 2002 ALL DATA COLLECTED VIA DIFFUSION SAMPLER UNLESS OTHERWISE NOTED
2 SAMPLE COLLECTED JANUARY/FEBUARY 2001
3 SAMPLE COLLECTED MARCH OR NOVEMBER 2000
4 SAMPLE COLLECTED MARCH 1999
5 SAMPLE COLLECTED OCTOBER 1998.
6. DUE TO SMALL DIAMETER OF PIEZOMETER, SAMPLED WITH BAILER

SOME INFERRED ISOCONTOURS (DASHED) ARE BASED ON DATA FROM A PREVIOUS SAMPLING EVENT (S)

FIGURE 2-13
GROUNDWATER. ALTERNATIVE 3
ZVI INJECTION AND IRON PRB
REV 0 MEMPHIS DEPOT, DUNN FIELD ROD

CH2MHILL

ATUCAD\PROJECTS\148071 DDMT\DUNN\FIELD ROD 2003 13-JUNE-2003 figure2-13.dgn



N

0 400 800

SCALE IN FEET

LEGEND

- DUNN FIELD BOUNDARY
- 10 — 1,1,2,2-PCA ISOCONCENTRATION LINE (IN ug/L)
- 10 — 1,1-DCE ISOCONCENTRATION LINE (IN ug/L) [OFFSITE SOURCE FOR THE 1,1-DCE]
- 10 — TCE ISOCONCENTRATION LINE (IN ug/L)
- 10 — CARBON TETRACHLORIDE ISOCONCENTRATION LINE (IN ug/L)
- 10 — CHLOROFORM ISOCONCENTRATION LINE (IN ug/L)
- 10 — 1,2-DCE ISOCONCENTRATION LINE (IN ug/L)
- 10 — PCE ISOCONCENTRATION LINE (IN ug/L)
- • MW MONITORING WELL SCREENED IN FLUVIAL AQUIFER
- ▲ MW MONITORING WELL SCREENED IN INTERMEDIATE AQUIFER
- GROUNDWATER FLOW DIRECTION
- IRON PRB TREATMENT ZONE
- AREAS WHERE CONTINGENCY REMEDIAL ACTION MAY BE IMPLEMENTED
- AIR SPARGE AND SVE TREATMENT ZONES

NOTE:

1. SAMPLE COLLECTED MARCH/APRIL 2002, ALL DATA COLLECTED VIA DIFFUSION SAMPLER UNLESS OTHERWISE NOTED
2. SAMPLE COLLECTED JANUARY/FEBUARY 2001
3. SAMPLE COLLECTED MARCH OR NOVEMBER 2000.
4. SAMPLE COLLECTED MARCH 1999.
5. SAMPLE COLLECTED OCTOBER 1998.
6. DUE TO SMALL DIAMETER OF PIEZOMETER, SAMPLED WITH BAILER.

SOME INFERRED ISOCONTOURS (DASHED) ARE BASED ON DATA FROM A PREVIOUS SAMPLING EVENT (S)

FIGURE 2-14
GROUNDWATER: ALTERNATIVE 4
AIR SPARGING WITH SVE AND
IRON PRB
REV 0 MEMPHIS DEPOT, DUNN FIELD ROD

CH2MHILL

ATL/CAD/PROJECTS/148071 DDMT/DUNNFIELD ROD 2003 13-JUNE-2003 figure2-14.dgn

779 189

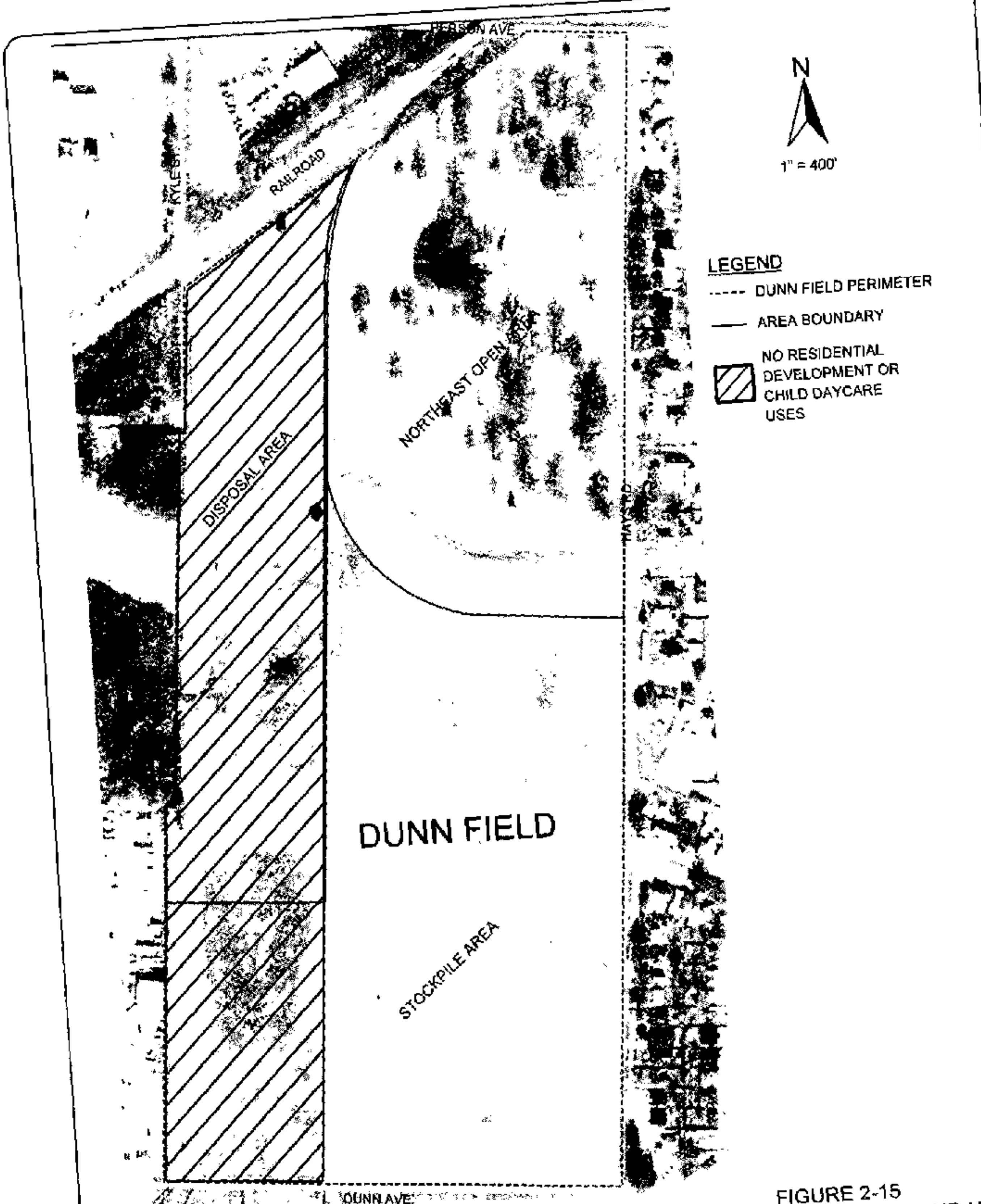


FIGURE 2-15
DUNN FIELD LAND USE RESTRICTIONS
Rev. 2 Memphis Depot Dunn Field ROD
CH2MHILL

ATL/CAD1/PROJECTS/148071 DDMT/Dunn Field ROD 2003

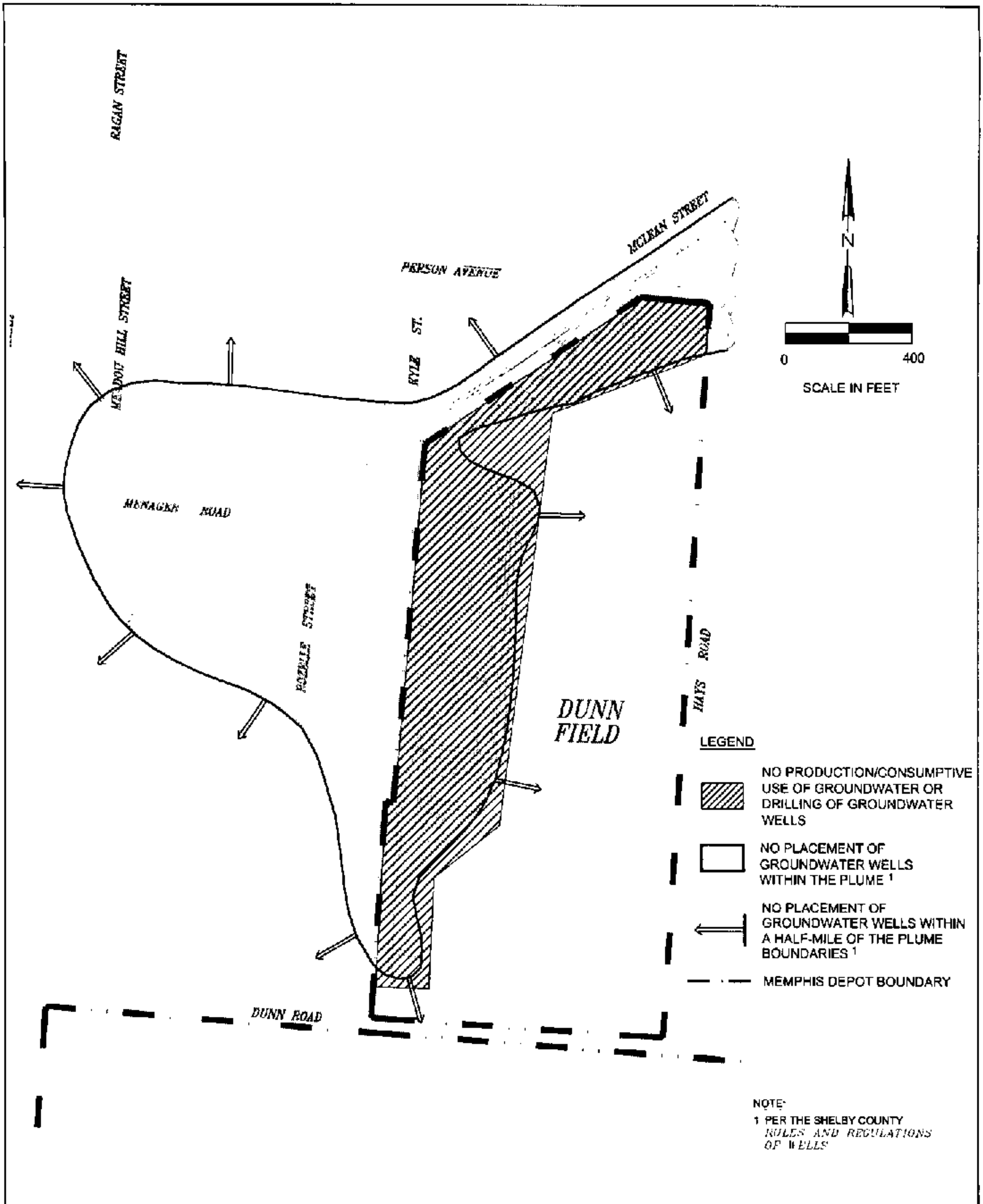
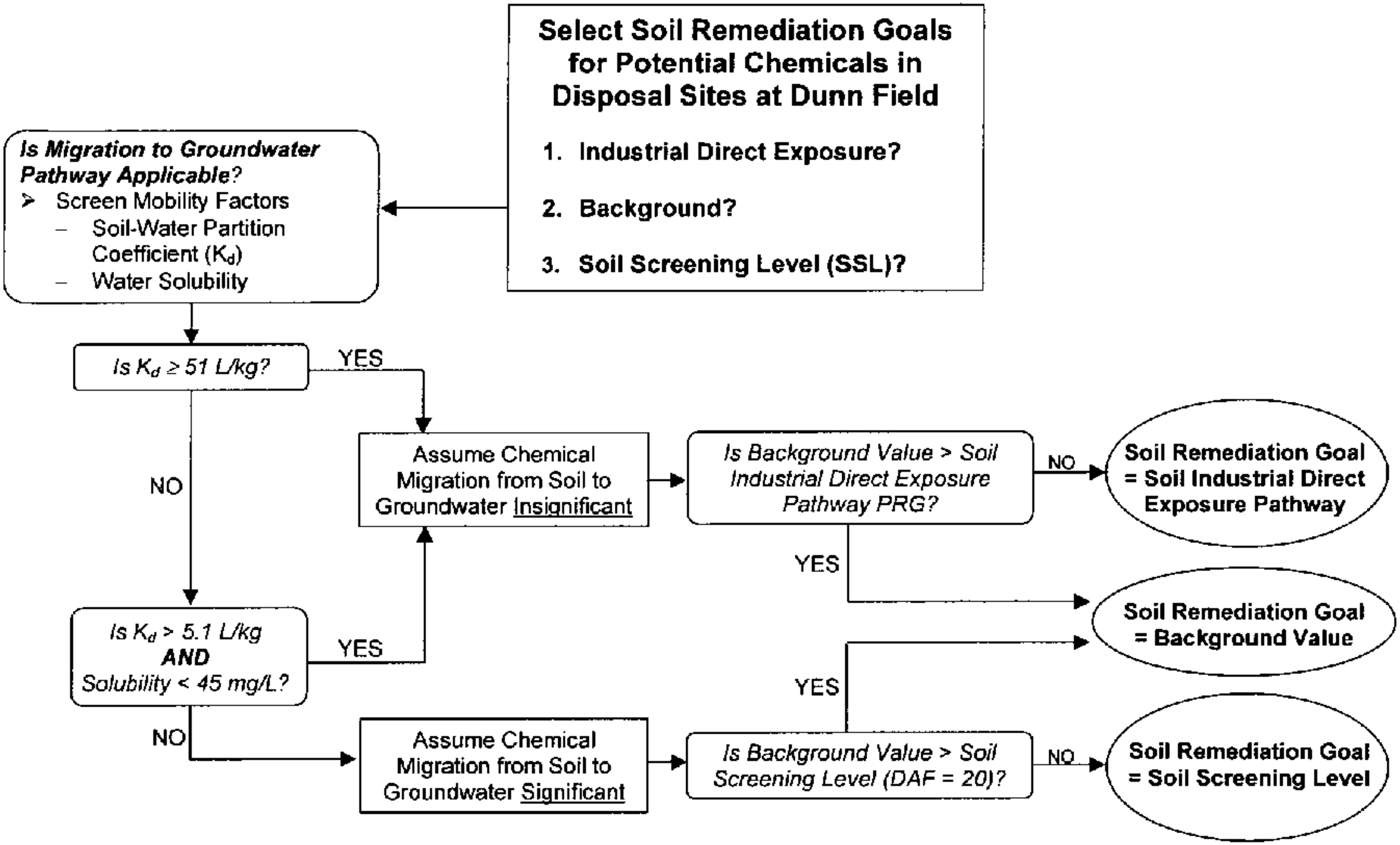


FIGURE 2-16
GROUNDWATER USE RESTRICTIONS
REV 2 MEMPHIS DEPOT, DUNN FIELD ROD

CH2MHILL

FIGURE 2-17
Decision Tree Process: Development of Soil Remediation Goals for Potential Chemicals in Disposal Sites
Rev. 2 Memphis Depot Dunn Field ROD



779 192

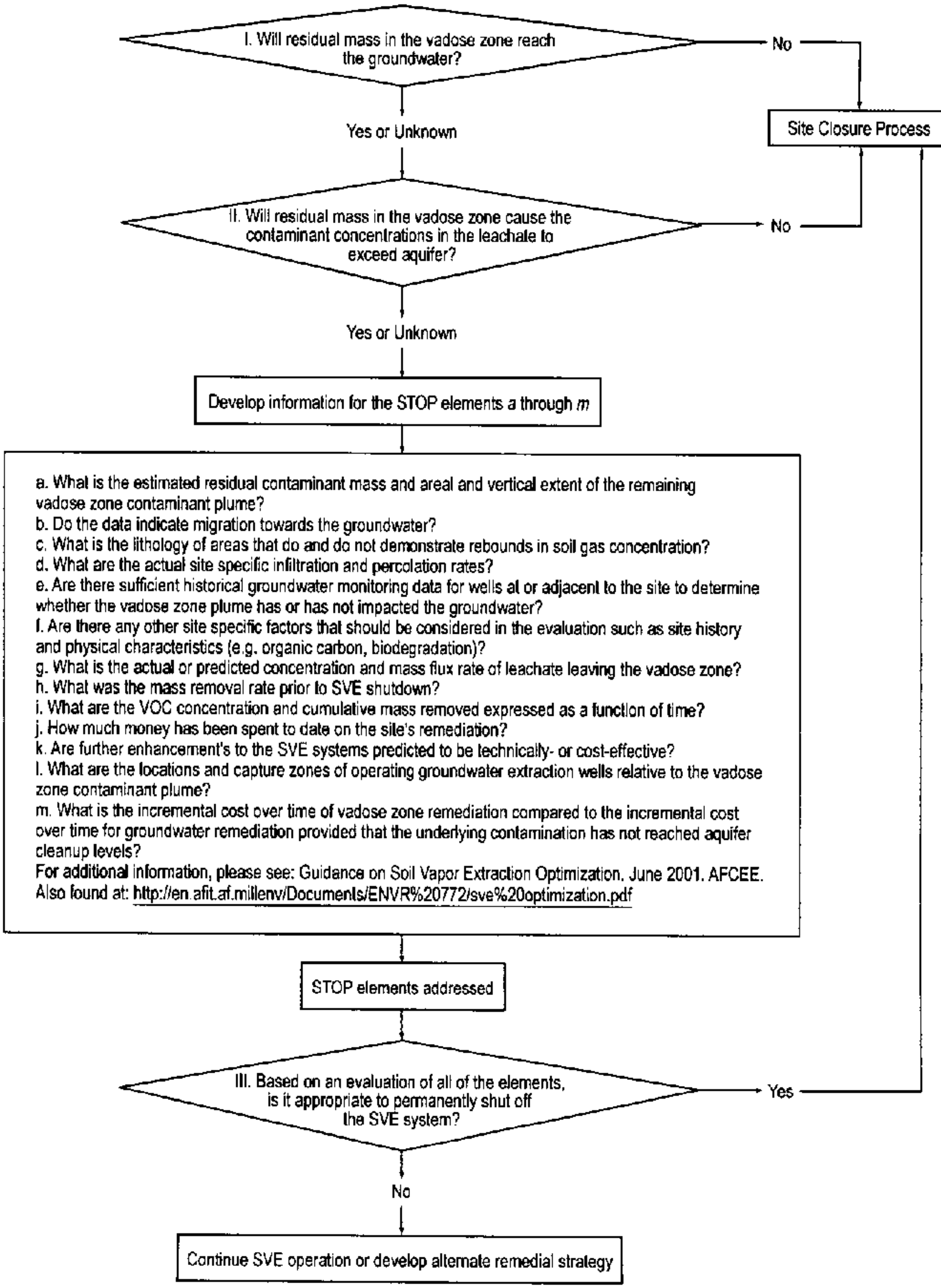


Figure 2-18 - STOP Decision Tree *Rev. 2 Dunn Field ROD*

3.0 Responsiveness Summary

Public comments on the environmental remedial action proposed at Dunn Field have been requested and received. The Defense Logistics Agency (DLA) placed the Dunn Field Proposed Plan, which documents and recommends a cleanup alternative, into three Depot Information Repositories before May 8, 2003, when the 30-day public comment period began. A public meeting was held on May 15, 2003, to describe the preferred alternative and to solicit comments from the public. The comment period was extended for 39 days until July 15, 2003. During that 69-day period, 25 comments were received by DLA from the public. Comments were received verbally during the public comment meeting and in writing.

Please note that some comments were submitted in the form of a statement or opinion and may not require a response. Where this occurs, DLA will note the comment and, if necessary, provide clarification or cite the legal requirement.

DLA, as the lead agency performing this remedial action, requested and received assistance in developing these responses from the U.S. Environmental Protection Agency (EPA) Region 4, the Tennessee Department of Environment and Conservation (TDEC), the U.S. Army Corps of Engineers (USACE), and its environmental contractor CH2M HILL.

3.1 Stakeholder Issues and Lead Agency Responses

All issues that may be of concern to the public regarding the Dunn Field Proposed Plan and have been expressed to the BRAC Cleanup Team (BCT) are presented within this section.

1. The question that I wanted to know [is] that at any point before the restoration started on Dunn Field, was the community or the employees of the Defense Depot -- at any point was the environment dangerous to them or the community or was the contamination in the water of such that it would harm the vegetables, the flower beds or contaminate the soil?

The Human Health Risk Assessment (RA), conducted as part of the Dunn Field Remedial Investigation, concluded that the drinking water supply has not been affected by past Depot operations. Affected groundwater is in the shallow aquifer, approximately 80 to 100 ft. underground, while our drinking water is drawn from the deeper Memphis aquifer, approximately 275 ft. below ground. According to available historical records, the affected groundwater has not been exposed to workers at the Depot. The RA report concluded that there are specific disposal areas on Dunn Field that contain buried waste, which may present unacceptable risks if exposed. There is also evidence that some of this buried material may have contributed to environmental conditions in the surrounding soil and shallow groundwater, which will require remedial action. The soil is contained on Dunn Field and is not exposed to community gardens. In addition, the soils at the former Pistol Range on Dunn Field were found to contain elevated levels of lead in the shallow layer of earth that was previously used for target practice in war fighter training. The lead was primarily in solid form and presented no unacceptable risk of exposure if left in place.

However, the soil containing lead was removed in 2003 to meet health protective standards for recreational use in the future.

The Agency for Toxic Substances and Disease Registry (ATSDR) is the agency responsible for public health. In 1999, ATSDR released a Public Health Assessment, which concluded that past Depot operations have not presented unacceptable risks to workers or the community. For more information on this report, or general inquiries concerning health issues, contact ATSDR at (404) 498-0441.

2. In pumping the air into the aquifers to pull the vapors up, how would that not spread the contaminants further? How would you stop that from exposing other areas that's not contaminated?

The process of pumping air into the underground aquifer is called air sparging. This technology was not selected as the preferred alternative for groundwater remediation at Dunn Field. The preferred remedial alternative includes Soil Vapor Extraction (SVE), which is conducted to draw the vapors through the soil using a vacuum system. Once these vapors reach the surface, they are captured and treated to ensure they meet safety standards before being released into the air. In addition, the area being treated by the SVE system will be capped during operation. This cap is composed of thick plastic sheeting covered by soil and gravel. This helps concentrate the vapors towards the SVE system. Also, groundwater monitoring wells and soil vapor monitoring points are installed and monitored throughout the remedial action to ensure the system is working effectively and safely at all times.

3. The cost for cleanup of the water (groundwater) -- one was $14.8 million for Groundwater 2. Groundwater 3 had $8.8 million, and Groundwater 4 had $9.1 million. This cost is per month, year? What tine frame? And could you put a time limit on that?

Based on the preferred alternative for groundwater (GW3), the projected cost for groundwater remediation at Dunn Field will be approximately $8.8 million. Costs for environmental cleanup are typically based on a total estimated cost over the life of the project, including ongoing long-term monitoring. The total costs for groundwater remediation at Dunn Field will be affected by the remedial technologies used at the site and the length of time the remedy will be in place. Beginning this fall, the Depot's contractors will conduct a groundwater treatability study to determine the most effective methods of groundwater treatment. The technologies being tested include Zero-Valent Iron (ZVI) and a Permeable Reactive Barrier (PRB). For more information on these technologies, consult past issues of the EnviroNews newsletter, available at the Community Outreach room. For more information on projected costs for the remedial action, refer to Tables 2-18a to 2-18c in this document.

4. I would like to take this time to make a comment about not having adequate enough time to review the plant. And I put forth a proposal to extend the comment period so the community can look at each plan and learn the information. And also look at the cost and reward ratio of each plan to see what are some of the setbacks and what are the pluses, too. And also to be able to offer other plans if these are not the plans that the community would like.

The request for an extension was approved. The required 30-day public comment period began May 8, 2003, and was extended through July 15, 2003, for a total of 69 days.

5. About this historical record. The only thing historical about Dunn Field on the record is we all know that it was a dump. And at a dump -- you never know exactly what was put, when it was put and how much was put. Case in point, Hollywood Dump. So we just can't say with historical certainty that we know what's there and how much is there and when it was put there. That's the first comment.

As this comment is a statement, a response is not provided in this report.

6. The second comment [is] about these connections or fissures: I was at a seminar, and they explained to me the fissure or connections are openings between clay aquifers. Now, exactly how many? And where are they and the length and width of them? You know, like, are they three feet in diameter, six feet, eight feet? That has not been discussed, and I would like to make that comment. I would like to know the diameter of the openings or the fissures or the connections so we know what monster we're dealing with.

Based on the conclusions of the Dunn Field Remedial Investigation (RI), the environmental team is confident that conditions in the shallow aquifer have not affected the quality of drinking water in Memphis/Shelby County. The upper clay layer, located beneath the affected shallow aquifer under Dunn Field is intact except for a gap that appears between monitoring wells MW-56 and MW-34 at the southwestern boundary of Dunn Field (and extends to the south, under the Main Installation). Offsite, there are gaps in the clay west (at MW-43) and northwest (at MW-40) of Dunn Field. These gaps or 'fissures' are connections down to the intermediate aquifer, approximately 150 feet below the ground surface. The Memphis Sand drinking water aquifer is approximately 275 feet below the ground surface. Specifically, the clay-confining layer is absent in the area of MW-34, MW-40 and MW-43, allowing recharge water to vertically percolate into the lower aquifer(s). As shown in the RI Report:

- the estimated width of the gap in the clay confining layer near MW-34 is approximately 600 ft. (see Figure 2-8e). MW-34 is located on the southwest portion of Dunn Field;
- the estimated width of the gap in the clay confining layer near MW-40 is approximately 1,1 00 ft. (see Figure 2-8g). MW-40 is located 1,400 ft. northwest of Dunn Field; and
- the estimated width of the gap in the clay confining layer near MW-43 is approximately 900 ft. (see Figure 2-8h). MW-43 is located 1,800 ft. west of Dunn Field.

As presented in this Record of Decision for Dunn Field, one of the remedial action objectives for groundwater on Dunn Field is to remediate groundwater in the affected shallow aquifer to be protective of the deeper drinking water aquifer.

7. This is an entirely large amount of information to consume, and one 30-day Comment Period is not enough. And hopefully I'm the second person to ask that we would like a second 30-day extension so we can comment on this properly.

See response to Comment #4 (above).

8. I'm concerned when all of the studies have been finished, that we are getting this information here today -- will there be any danger of any chemicals coming out into the air harming the community? That's what I'm concerned about You get the data you -- maybe ordinary citizens might not understand all what you are talking about the chemicals. But what I'm trying to find out with all the studies that has been done over the years and with all that -- when it is finished, how will it affect the health of people who live in this community?

The Public Health Assessment conducted by ATSDR (1999) concluded that the community is not exposed to unacceptable risks from living near the Depot. This conclusion was further supported by the findings of the Dunn Field Risk Assessment (2002). Environmental scientists studied indoor air quality using the industry-accepted Johnson-Ettinger conceptual exposure model. Results of these tests confirmed that most areas of Dunn Field are safe for unrestricted re-use, specifically the Northeast Open Area and the Stockpile Area. In the Disposal Area, located in the northwest quadrant of Dunn Field, indoor air quality was found to be unacceptable in areas above some disposal sites. For that reason, the Disposal Area is considered unsafe for indoor workers and residents. However, since there are no homes or other structures in this area, there is no exposure to indoor air by workers or residents. Any vapors from disposed waste that move up through the soil and reach the surface will dissipate quickly into the atmosphere and do not pose any unacceptable risks to the community. During the remedial action in this area, air quality monitoring will be conducted to ensure that the health and safety of the community is protected at all times. Also, see response to Comment #2 (above) for more information.

9. For those of us who reside right across the street from Dunn Field, is there the possibility that our homes can be bought or we can be relocated? Basically, my house has lost value. I don't even have a fraction of what I paid for it. Will that be taken into consideration? Is there some kind of financial remuneration for those of us who live directly in that area right across from Dunn Field who, unknowingly, bought homes?

According to all studies conducted to date, the community around the Depot is a safe place to live and work. Since our investigations have confirmed that the community is not exposed to unacceptable risks from living near the former Main Installation or Dunn Field, DLA has no plans to relocate any residents at this time. The Memphis/Shelby County Division of Planning and Development and the Land Use Control Board make land-use decisions related to zoning within the City of Memphis. For more information on past, current and future land-use requirements for residential property, contact the Memphis/Shelby County Division of Planning and Development at (901) 576-6601 or the Land Use Control Board at (901) 576-6619.

10. I would like for it to be possible that Steve [Steve Offner, CH2M HILL) come back so we can have intelligent dialogue about all the processes after adequate enough time to go over this technical information that takes people years to get degrees for.

Community involvement continues to be a primary focus of the Environmental Restoration program at the Memphis Depot. The studies conducted by the environmental scientists, such as those from Depot contractor CH2M HILL, generate technical reports that are necessary to reach appropriate cleanup decisions. These reports and decisions are presented to the public at the Restoration Advisory Board (RAB) meetings, public comment meetings and other community information sessions. In 2002, the RAB received a Technical Assistance for Public Participation (TAPP) grant from the Department of Defense (DOD). The TAPP grant was used to by the RAB community members to hire independent scientific support services to review and explain technical reports related to the environmental program. Executive summaries, fact sheets and articles in EnviroNews are provided for further clarification of studies, reports and other complex issues. The Community Relations Office is also available to answers calls from residents and direct inquiries to the appropriate source of information. Phone (901) 544-0613.

11. I would like for an itemized budget showing how much money is going to what and to who and how each dollar is going to be spent.

The estimated, itemized costs for the selected remedy at Dunn Field can be found in Tables 2-18a to 2-l8c in this document. Based on these approved estimates, the funds are provided by DLA to the local or regional contracting authorities for the cleanup program. Funds are then awarded to the environmental contractors who are hired to conduct the remedial investigations and cleanup activities at the Depot. For more information, refer to the response to Comment #3 (above).

12. Why [would] the government allow homes to be built right across the street from Dunn Field? Why was it allowed? Why were con tractors allowed to even build homes, and then for years, decades and decades not allow people to know?

According to the Human Health Risk Assessment for Dunn Field (2002) and the Public Health Assessment (ATSDR 1999), environmental conditions at the Depot do not present any unacceptable risks to residents living in the community. Until it was closed in 1997, the Memphis Depot was a major employer in South Memphis. As with economic development patterns in many urban areas, homes are often built where there are opportunities for employment. Many of the homes located around the Depot property were built between the 1940s and 1960s as people moved into the area to find jobs. At that time, the environmental conditions from disposed industrial waste were not known. Today, we understand the environmental risks associated with buried waste and are taking steps to restore the site through this environmental restoration program. For land-use controls and zoning inquiries, please refer to the contact information provided in response to Comment #9 (above).

13. Please explain what "Institutional Controls" means in Alternative SB1: Presumptive Remedy (SVE) with Institutional Controls

Institutional controls, including deed restrictions, are protective measures put in place to restrict the use of affected land areas and/or other resources where risks to human health may be unacceptable based on the standards set by the federal and state environmental authorities (EPA and TDEC in this region). These institutional controls are usually legally enforced to limit exposure to unacceptable risks on a site following active cleanup work. Most institutional controls include ongoing monitoring and/or maintenance until exposure to the area is considered safe.

The land use controls for Dunn Field consist of institutional controls, including deed restrictions, a Notice of Land Use Restrictions, zoning restrictions, and groundwater well restrictions. The inclusion of multiple land use controls (some of which already apply at the site) as part of the selected remedy, is designed to help ensure protectiveness. The land use control objectives are as follows:

- Prevention of direct contact/ingestion of contaminated surface soils in the Disposal Area/western portion of Dunn Field in excess of human health risk assessment criteria for residents.

- Prevent ingestion of water contaminated with Volatile Organic Compounds (VOCs) in excess of Maximum Contaminant Levels (MCLs) from potential future onsite and offsite wells.

The following land use restrictions for Dunn Field are required to meet the LUC objectives:

- Prohibit residential use or other child-occupied facilities (including daycare) in the Disposal Area/western portion of Dunn Field (see Figure 2-15).

- Restrict installation of production/consumptive use groundwater wells or drilling groundwater wells in contaminated groundwater associated with Dunn Field (see Figure 2-16).

14. Alternative SB1 states that "a vapor seal at the land surface" will be included. What specific land surface vapor seal will be used?

The Remedial Design of the vapor seal has not yet been completed. However, information collected for the Dunn Field Feasibility Study (FS) indicates that the seal will consist of 20-millimeter-thick polyethylene sheeting (similar to the material used as liners for solid waste landfill sites). The sheeting will act as a base layer and will be covered by a layer of sand and then a mixture of gravel and sand for vehicle support purposes. Pipes that enter or exit through the seal will have sealant around them and will be connected to the sheeting to ensure vapors are controlled at each point. In addition, the edges of the polyethylene sheeting will be set five feet down into the earth to control horizontal and vertical leakage of vapors at the perimeter.

15. How will excess moisture be collected and treated?

Although the Remedial Design of the selected subsurface soil remedy has not been completed, information gathered for the Dunn Field FS indicates that excess moisture will be captured by an air-water separator or "knockout pot" and then treated by being passed through activated carbon canisters. The canisters, which absorb and hold VOCs, will be changed frequently to ensure maximum effectiveness. Wastewater that is collected will be analyzed and disposed of through the City of Memphis Sanitary Sewer System or sent to an approved offsite industrial wastewater treatment facility.

16. How Will Volatile Organic Compounds (VOCs) in the excess moisture be treated to prevent release to tire ambient air?

See response to Comment #15 (above).

17. How Will soil constituent concentrations be measured while Soil Vapor Extraction (SVE) is operating?

Although the Remedial Design of the soil remedy is still in progress, the Dunn Field ES provides information on the recommended procedure for measuring soil constituent concentrations. The procedure includes development of soil screening levels (SSLs) for VOCs. These will be compared to VOC concentrations in vapors pulled through the SVE system. This is based on the assumption that, during operation of the SVE system, VOC concentrations found in soil vapor are in equilibrium with concentrations in the soil. Appendix C of the Dunn Field Feasibility Study provides further information on the calculation of the SSLs. The soil concentrations will be tested in samples collected from soil vapor monitoring points and from the total air entering the treatment system.

18. Will the SVE result in equilibrium being reached within the soil matrix?

Yes. SVE is frequently used to clean soil that contains VOCs, which will evaporate readily until the vapor pressure reaches equilibrium with concentrations in the soil. The vapors fill the spaces between the grains of the soil. Once an SVE system is operating, soil gas concentrations at the monitoring points or at the extraction well can become diluted with soil gas from clean soils and give an overly optimistic estimate of the VOC concentrations remaining in the soil. One of the most important indicators of SVE performance is the equilibrium (or rebound) test. This involves the temporary shutdown of the SVE system to monitor VOCs that are trapped within the soil matrix with the surrounding soil. The SVE system is then restarted, allowing more vapors to be drawn to the surface. Also, please see the response to Comment #17 (above).

19. Will the SVE be used to pulse the soil matrix to reduce or prevent equilibrium problems within the soil matrix?

Please see responses to Comments #17 and #18 (above).

20. How will air sparging be incorporated into the SVE, [if it] is used?

Air sparging is not part of the selected remedy for Dunn Field at this time.

21. What process controls will be used to minimize the release of fugitive emissions of VOCs into the ambient air?

The SVE treatment system is designed to be a "closed" system that will contain and treat vapors before they are released into the atmosphere. According to the Dunn Field FS, controls will include automated warning devices on pressure gauges that indicate loss of vacuum across the system; inspection and field monitoring of the vapor seal or cap that maintains vacuum within the subsurface layers; routine inspection of piping, valves, and filters to ensure that no leaks have developed along the system; and collection of volume measurements from each wellhead and the treatment system. Thermal or catalytic oxidation will be used to treat the extracted vapors. Hydrochloric acid (HCI) (potentially produced through the oxidation of chlorinated hydrocarbons) will be treated (e.g., by a chlorinated catalytic oxidizer and a scrubber, with sodium hydroxide [NaOH]). This on-site treatment will comply with the requirements of the Tennessee Air Quality Act and TDEC Rule 1200-3-9. These requirements include the monitoring and control of the release of volatile organics to the atmosphere, the control of fugitive dust emissions, and compliance with ambient air quality standards. Actual VOC levels will be calculated during design of the SVE system.

22. What are "the acceptable levels" of fugitive emissions and other releases of VOCs?

Please refer to the response to Comment #21 (above).

23. If VOC levels exceed "the acceptable levels", what capture or destruction measures will be used to prevent release into the ambient air?

Although the Remedial Design of the selected subsurface soil remedy has not been completed, information gathered for the Dunn Field FS indicates that all VOC-containing vapors brought into the above-ground system will be treated to ensure that emissions of total VOCs meet health-protective standards. For more information, refer to the response to Comment #21 (above).

24. Has an emissions impacts analysis been performed that shows the expected transport of the VOCs from the site?

An impact analysis will be part of the Remedial Design of the SVE system. The Remedial Design phase of the environmental program begins after the Record of Decision (ROD) is completed.

25. City of Memphis Code Section 16-77 requires an application for an air pollution control permit for air contaminant sources, in advance of their construction and operation. Certain activities are exempted, and these are listed in the ordinance. A copy of applicable requirements is attached.

The Defense Distribution Center (DDC) is operating this environmental remediation program under the authority of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). As such, all remedial activities will adhere to this permit and other applicable safety regulations enforced by municipal, state and federal authorities.

The following comments were originally received by DLA in writing from a representative of the Memphis Depot Restoration Advisory Board (RAB) in July 2002. The representative of the RAB requested a response to his/her letter as part of the public comment period for the Dunn Field Proposed Plan. The comments are not specifically related to the Proposed Plan or the Administrative Record for this Record of Decision for Dunn Field. John R. Crellin, Ph.D., Senior Environmental Epidemiologist with the Agency for Toxic Substances and Disease Registry (ATSDR) and William Turpin Ballard, Remedial Project Manager with the U.S. Environmental Protection Agency, Region 4 provided responses to these comments in June 2003.

I have been informed that the transcriber is having difficulty in understanding the report I gave during the last Meeting. In light of that fact I am sending this written statement citing the notes that I used.

My notes were taken from the Now TV series of Bill Moyers entitled "Kids and Chemicals-Facts of Law" which aired on 5/10/02. I am asking you to make copies for the RAB members that may want a copy.

This report is important to me because it brings out some new information and approaches that I have not heard from the EPA representative and environmentalist at our RAB meetings. I also feel that the BRAC members are all in a mode of finishing the job and moving on. I am not intending this report to sensationalize the state of our environment but to inform the RAB members and my Rozelle neighbors of the results reported by M.D.'s, PHD's, and other professional investigators that were involved in this report in light of what exist in Dunn field, the old paint shop and the fishing ponds for example.

Kids and Chemicals is a report on the search for everyday chemicals that may be harming our kids. Since it emphasizes kids the report is different from most of the reports of this type.

"There is an increase in the evidence of childhood cancer. Home and garden pesticides are showing up in their urine. Women have termite poisons and toilet deodorizers, flame retardants in their breast milk. Asthma is on the increase and is the leading cause of admissions. 75,000 synthetic chemicals and metals are used in the USA. They kill insects, weeds, used on clothes, carpets, unclog drains, create produce and lawns. Most of these chemicals have never been tested for there toxic effects on children. Scientists are concerned that increases in childhood illnesses like asthma, cancer, learning disabilities (5% to 10%), attention deficit disorder, dyslexia, autism are related to what kids eat, drink and breath.

In Fallon, Nevada, Dr. Mary Guinan is using a new approach in her study. She is looking for environmental toxins in the body disregarding the exposure. Concentrate on how many toxins have been absorbed into the human body. This has not been done before."

ATSDR/CDC should up date the RIAB on their approach to investigating toxin exposure in light of the Fallon, Nevada investigation.

"Blood and urine samples were brought to the CDC labs in Atlanta. They are being analyzed for minute traces of chemical suspects: pesticides, meta Is, solvents and PCB's which is a chemical that has been banded years ago.

Dr. Jackson looked at 125-130 different chemicals in blood and urine rather than what is in the air, water and food, a procedure which is more difficult and expensive to accomplish.

Why aren't we doing the same thing?

"Of the 3000 high production volume chemicals used in the USA only 43% have been minimally tested. Only 10% have been thoroughly tested to examine their potential effects on children's health and development."

Is this true? If so what is being done about it?

"Dr. Landrigan stated that prior to 1996 all environmental agencies were based on the entire population consisting of healthy young adults. EPA since then is learning how children come in contact in order to comply with the law.

No one said children are different. They are heavily exposed lb for lb. Eat more food. Drink more water. Breath more air. Play on the ground. Live low. Put hands in their mouths.

Animal studies lead scientists to believe that even minute exposure to certain pesticides can harm the developing brain and diminish intelligence. Dr. Needleman says he cannot say there is a safe level. A critical question is, "what does combinations of the chemicals at low levels, actually do to children?"

We have had a lot of information on thresholds but Dr. Needleman cannot say there is a low level and poses the question about combinations of chemicals at low levels. What is EPA's current position on this?

"In New York 500 expectant Mothers put on back packs in their 3rd trimester designed to trap the chemicals they breath.

Dr. Perera advocates that the fetus is sensitive to a variety of low levels of toxins since it does not have tire saute defense mechanisms of adults. Exposure to even relatively small amount and the timing during fetal development can cause serious problems.

Dr. Steingraber believes the developing fetus may not have a safe threshold level at certain key windows of vulnerability. No woman has uncontaminated breast milk on this planet according to Dr. Steingraber. Scientists have found PCB's, dioxins and, methyl mercury in the breast milk."

Has EPA and other responsible government agencies taken the fetus and time of vulnerability into consideration? "Studies done in urban areas apply to suburban and rural areas. Rural areas are not unique in this regard at all in fact it's pervasive."

The entire report may be seen by going to www.pbs.org and then to Now.

The www.scorecard.org has given a scathing report on the Memphis Defense Depot as a super fund site. I request that EPA give us an update on the data included in the report and/or does it still apply? The following is an example of what is being reported for pubic consumption. "The depot has conducted numerous operations dealing with hazardous substances. A total of 75 waste disposal areas and other areas of concern have been: identified at the facility, most of them in Dunn Field. Among the wastes disposed of, according to the Department of Defense (DOD), are oil, grease, paints and paint thinners, methyl bromide, and pesticides. More. Were wells shut down due to contamination: NO. Are drinking water well potentially threatened? Yes. Population served

by the threatened wells: >100,000. Aquifer discharges into: A drinking water aquifer. Population served by water wells in the aquifer: >100,000.

I have asked EPA, ATSDR, CDC and any other applicable agency to comment on six questions. They should be clear enough to identify.

Response from John R. Crellin, Ph. D., with ATSDR (on June 16, 2003): This is in response to your recent letter to John De Back, the Memphis Depot Base Transition Coordinator. In your letter, you referenced a May 8, 2003 letter to Clyde Hunt in which you raised issues related to the Center for Disease Control and Prevention (CDC) investigation of the childhood leukemia cluster in Fallon, Nevada. The Agency for Toxic Substances and Disease Registry (ATSDR) was also involved in Fallon. I never received a copy of your letter to Mr. Hunt so I will respond to the two issues raised in your letter to Mr. De Back that relate to CDC and ATSDR.

You asked why CDC only tested for 125+ chemicals in blood and urine rather than also testing air, water, and food. You also requested information on the procedures used in this testing. Air, water, household dust, and soil were collected and tested as indicated in the attached executive summary [not included in this response] of the investigation done by CDC's National Center for Environmental Health (NCEH). You can download the entire report, which was released in February from http://www.cdc.gov/niceh/clusters/Fallon/study.htm. As indicated in the attached summary, NCEH conducted an exposure assessment of the families in Fallon with a child with leukemia and a comparison population of Fallon families without a child with leukemia. Members of all these families did have biological samples (blood, urine, and cheek cells) tested for a wide variety of chemicals. Indoor air, play yard soil, household dust, and tap water was also collected and tested from each home. The full report has detailed information on the procedures used.

ATSDR evaluated seven possible exposure pathways in the Fallon area. Five of these seven evaluations have been released. I have attached the ATSDR press release related to this activity [not included in this response].

Both COG and ATSDR's reports identify tungsten in drinking water as a possible chemical of concern. Little is known about the toxicity of the tungsten levels found in Fallon.

The second issue you raised was whether ATSDR should update the approach used at Memphis Depot in light of the situation at Fallon. Specifically you asked, "Why aren't we doing the same thing?"

The short answer to that question is that the information provided by the community, and the environmental and cancer data evaluated by ATSDR did not justify an in-depth analysis such as done in Fallon. Before ATSDR or CDC conduct such analyses, we need to have a good indication of significant site-related contamination or disease cluster. ATSDR's evaluations are recorded in Memphis Depot Public Health Assessment (PHA) and the recent public health consultation that I did, and the review of cancer done by Dee Williamson.

In contrast, there was a cluster of leukemia in children in Fallon, which is why CDC is evaluating possible exposures that these children might have had. In Anniston, Alabama, ATSDR followed up on community concerns about polychlorinated biphenyl (PCBs) in the environment by conducting PCB blood testing. The high levels found stimulated cleanup actions by EPA and a full health study by ATSDR.

Let me assure you that ATSDR would have conducted an in-depth analysis in the Memphis Depot area, if we had found evidence of significant off-site exposure in the Memphis Depot area or an indication of a disease cluster. As I related previously, we did not.

If you would like to discuss these issues further, please contact me toll free at (888) 422-8737 ext. 0441, direct at 404-498-4441, or by Email at JCrellin@cdc.gov.

Response from William Turpin Ballard, RPM with EPA Region 4 (on June 13, 2003): I apologize for the length of time it has taken me to reply to the questions raised in your letter of July 25, 2002 to Mr. Clyde Hunt at the Memphis Depot. Because it was addressed to Mr. Hunt, it was not readily apparent to me that you had directed questions specifically to the U.S. Environmental Protection Agency (EPA). In reviewing the letter, which I have attached here [not included in this response], I see that I am remiss in that assumption, and attempt here to correct my oversight.

Your questions were prompted by viewing the Bill Moyers Now program "Kids and Chemicals- Facts of Law." I will attempt to address your questions to the best of my ability, in light of my 16 years with EPA. My answers will be based on professional judgement and knowledge of policies, procedures, and guidance followed by the Superfund program. I will defer some questions to replies from the Agency for Toxic Substances and Disease Registry (ATSDR), from whom you also request input.

You asked why we are not analyzing for chemicals in people's blood and urine, rather than looking for them in the environmental media (soil, sediment, ground water) on and around the Depot. In reply, it is important to note that people, including children, can be exposed to contamination from multiple sources in the course of their daily lives, and that total exposure would be what is measured in the blood and urine. If we collected these data, we would not be able to separate the total exposures to the individual from exposure that may have occurred due to chemicals at the site. The purpose of the remedial investigation and risk assessment at the Depot is to determine whether chemicals from the Depot are causing, or have the potential to cause, an unacceptable increase in the risk of toxic or carcinogenic effects on human health or the environment, including children. As presented to you in several meetings of the Restoration Advisory Board (RAB), the risk assessment process developed by the EPA is the tool we use across the Nation to estimate these increased risks. The process is inherently conservative (health-protective) due to conservative assumptions in virtually all of its steps.

The Moyers program stated that only 43% of the 3000 high volume production chemicals have been tested for toxic effects, and only 10% tested for children's health effects. You asked what is being done about this. While I cannot speak to the accuracy of the numbers you present, I can state that EPA has several programs that evaluate new chemicals, but not all classes of chemicals are covered. The Toxic Substances and Control Act (TSCA) is the primary Federal statute regulating the use of certain chemicals and substances, including asbestos, PCBs, radon and lead. The Federal Insecticide. Fungicide and Rodenticide Act (FIFRA) regulates the sale and use of pesticides in the United States. For risk assessment purposes at Superfund sites such as the Memphis Depot, EPA maintains a database called the Integrated Risk Information System (IRIS), which contains the most current consensus among toxicologists about health effects and dose-response relationships for a large number of chemicals commonly found at Superfund sites. The risk assessment process also includes methods for deriving health-protective cleanup levels when specific chemicals are not found in IRIS. Admittedly, this still, leaves a lot of chemicals not fully evaluated for health effects. EPA tries to address the worst first in all aspects of implementing its programs of environmental protection.

Another statement ascribed to the Now program is that, *"... prior to 1996, all environmental agencies were based on the entire population consisting of health young adults [sic]. EPA is since then learning how children come in contact in order to comply with the law."* I can state from my own experience that EPA has always considered sensitive sub-populations in its risk assessments, including children and the elderly. When evaluating a residential risk scenario, the assessment divides the life of the "receptor" or hypothetical resident, into three stages over a 30-year period: a child age 1-6, an adolescent from through approximately age 16, and the remainder as an adult. Exposure to carcinogens is averaged over a lifetime. We do this because a receptor displays different behaviors at different times of his/her life, which may result in exposure to different types and levels of chemicals.

Your letter goes on, *"We have a lot of information on thresholds but Dr. Needleman cannot say there is a low level and poses the question about combinations of chemicals at low levels. What is EPA's current position on this?"* In risk assessment, the threshold concept generally applies to evaluation of carcinogens. EPA's position has always been that there is no threshold of exposure below which cancer would not occur. That is one reason why the Safe Drinking Water Act (SDWA), for example, establishes Maximum Contaminant Level Goals (MCLGs) alt zero. Practically speaking, we cannot truly analyze to a zero level, so we default to the detection limits of very sensitive analytical methods developed or approved by EPA. MCLGS, however, are not enforceable under the SDWA, and EPA promulgates MCLs as enforceable drinking water standards. These are non-zero standards which are still considered health-protective, and with which all public drinking water supplies must comply. The point here is that EPA does incorporate the concept of thresholds in its program decisions, but must, by law, also consider costs associated with achieving the lowest possible concentrations.

With respect to combinations of chemicals, it has been EPA policy since at least 1991, and EPA practice before then, to assume that carcinogenic chemicals have a cumulative effect. Therefore, during the final steps in a risk assessment, we calculate risks due to individual carcinogens and then sum them to arrive at a total excess lifetime cancer risk (ELCR) that takes into account exposure from all reasonable pathways, such as ingestion of ground water from drinking, inhalation from showering, absorption from water through the skin, ingestion of soil and sediment, absorption of chemicals from soil through the skin, etc.

"Dr. Steingraber believes the developing fetus may not have a safe threshold level at certain key windows of vulnerability. No woman has uncontaminated breast milk on this planet, according to Dr. Steingraber. Scientists have found PCB, dioxins, and methyl mercury in the breast milk. Has EPA and other responsible government agencies taken the fetus and time of vulnerability into consideration?"

This is a difficult question for me to answer in the context of the Memphis Depot Superfund site, because is goes to issues discussed earlier about people being exposed to more than one source of contamination. For example, dioxins are a product of incomplete combustion, and are found everywhere due to emissions from combustion engine exhausts, power plants, and other sources of air pollution. For more information on this I suggest you view the website of EPA's Office of Children's Health Protection at http://yosemite.epa.gov/ochp/ochpweb.nsf/homepage.

At the close of your letter you request an update from EPA on a report you saw at www. scorecard. or. Scorecard. org is a non-governmental website that provides environmental information of various types and vintages. In the case of the Memphis Depot, the information you cite in your letter is derived from the scoring package that EPA used to put the Depot on the National Priorities List (NPL) in 1992. At that time in the life of a Superfund site, the available data are generally preliminary and sparse. EPA's Hazard Ranking System compensates for this lack by incorporating conservative assumptions about the site and the nature of any release, as well as the potentially affected population and environment Since 1992 we have completed detailed investigations and have a better understanding about the nature and extent of contamination, the potential risks f rom exposure to site-related chemicals, and have selected or proposed (in the case of Dunn Field) remedial actions to address the contamination. Scorecard. org contains a link to EPA's NPL Book, which presents a snapshot summary of the site. The summary was last updated in 2002. I can state this with certainty because I wrote it. Since then we have made additional progress toward cleanup, and we expect the final Record of Decision (ROD) for the Depot to be executed this fall. Many of the issues you highlight from the Scorecard information are updated in the Proposed Plan for Dunn Field, including the potential threats to ground water and drinking water, and plans to clean it up.

Thank you for the interest you have shown, both in environmental protection in general and in the Memphis Depot cleanup through your participation in the RAB. I hope you find these answers to be informative and complete.

4.0 References

Agency for Toxic Substances and Disease Registry. *Toxicological Profiles for Arsenic, Benzo(g,h,i) perylene, Benzo(k) fluoranthene, Cyanide, Dieldrin, Manganese, Phenanthrene*. U.S. Dept. of Health & Human Services, Public Health Service. Atlanta, Georgia. 1992.

Air Force Center for Environmental Excellence (AFCEE). *Guidance on Soil Vapor Extraction Optimization*. 2001

Castle Air Force Base Memorandum. *Revision to SVE Turn-Off Criteria*. 1999

CH2M HILL. *Final Generic Quality Assurance Project Plan*. Defense Distribution Depot Memphis, Tennessee. Prepared for the United States Army Engineering Support Center, Huntsville, AL. February 1995a

CH2M HILL. *Final Generic Health and Safety Plan*. Defense Distribution Depot Memphis, Tennessee. Prepared for the United States Army Engineering Support Center, Huntsville, AL. February 1995b.

CH2M HILL. *Final Generic Remedial Investigation/Feasibility Work Plan*. Defense Distribution Depot Memphis, Tennessee. Prepared for the U.S. Army Engineering Support Center, Huntsville, AL. August 1995c.

CH2M HILL. *Operable Unit I Field Sampling Plan*. Defense Distribution Depot Memphis, Tennessee. Prepared for the U.S. Army Engineering Support Center, Huntsville, AL. September 1995e.

CH2M HILL. *Record of Decision for the Interim Remedial Action of the Groundwater at Dunn Field (OU-1) at the Defense Distribution Depot Memphis, Tennessee*. Prepared for the U.S. Army Engineering Support Center, Huntsville, AL. January 1996a.

CH2M HILL. *Quarterly Groundwater Monitoring Report* (February 1996). Prepared for the U.S. Army Corps of Engineers, Huntsville Division. March 1996b.

CH2M HILL. *Groundwater Interim Remedial Action, Defense Depot, Memphis, Tennessee: Final Remedial Design*. Prepared for the U.S. Army Corps of Engineers, Huntsville Division and Defense Logistics Agency. August 1997.

CH2M HILL. *Final Groundwater Characterization Data Report*. Prepared for the U.S. Army Engineering Support Center, Huntsville, AL. August 1997a.

CH2M HILL. *Quarterly Groundwater Monitoring Report* (June 1997). Prepared for the U.S. Army Corps of Engineers, Huntsville Division. September 1997b.

CH2M HILL. *Quarterly Groundwater Monitoring Report* (September I997). Prepared for the U.S. Army Corps of Engineers, Huntsville Division. November 1997c.

CH2M HILL. *Groundwater Interim Remedial Action, Defense Depot, Memphis, Tennessee: Operation and Maintenance Plan*. Prepared for the U.S. Army Corps of Engineers, Huntsville Division and Defense Logistics Agency. May 1998.

CH2M HILL. *Final Background Sampling Program Report, Defense Distribution Memphis, Tennessee*. Prepared for the U.S. Army Engineering Support Center, Huntsville, AL. May 1998c.

CH2M HILL. *Groundwater Monitoring Report March 1998.* Prepared for the U.S. Army Corps of Engineers, Huntsville Division. June 1998e.

CH2M HILL. *Updated Groundwater Interim Remedial Action, Defense Depot, Memphis, Tennessee: Operation and Maintenance Plan*. Prepared for the U.S. Army Corps of Engineers, Huntsville Division and Defense Logistics Agency. August 1999.

CH2M HILL. *Updated Groundwater Interim Remedial Action, Defense Depot, Memphis, Tennessee: Final Remedial Design*. Prepared for the U.S. Army Corps of Engineers, Huntsville Division and Defense Logistics Agency. January 2000.

CH2M HILL. *Final Memphis Depot Main Installation Remedial Investigation Report*. Prepared for the U.S. Army Corps of Engineering and Support Center, Huntsville. January 2000.

CH2M HILL. *Final Memphis Depot Main Installation Proposed Plan*. Prepared for the U.S. Army Corps of Engineering and Support Center, Huntsville. August 2000.

CH2M HILL. *Final Memphis Depot Main Installation Record of Decision*. Prepared for the U.S. Army Corps of Engineering and Support Center, Huntsville. February 2001.

CH2M HILL. *Memphis Depot Dunn Field Remedial Investigation Report* - Volumes I through III Prepared for the Defense Logistics Agency and presented to U.S. Army Engineering and Support Center, Huntsville, Alabama. July 2002.

CH2M HILL. *Memphis Depot - Dunn Field Five-Year Review - Final*. Defense Distribution Center (Memphis). Prepared for the U.S. Army Engineering and Support Center, Huntsville, Alabama. January 2003.

CH2M HILL. *Memphis Depot - Dunn Field Feasibility Study Report* - Final. Defense Distribution Center (Memphis). Prepared for the U.S. Army Engineering and Support Center, Huntsville, Alabama. May 2003.

CH2M HILL. *The Memphis Depot - Dunn Field Proposed Plan*. Defense Distribution Center (Memphis). Prepared for the U.S. Army Engineering and Support Center, Huntsville, Alabama. May 2003.

CH2M HILL. *Evaluation of Less than Lifetime Risk for Scheduling of Land Use Control Monitoring for Dunn Field at former Defense Distribution Depot, Memphis, TN (DDMT)*. Prepared for the U.S. Army Engineering and Support Center, Huntsville, Alabama. November 2003.

CH2M HILL. *Potential Offsite Source of Groundwater Contamination, Northeast of Dunn Field*. Technical Memorandum. Prepared for the U.S. Army Corps of Engineering and Support Center, Huntsville. November 2003.

CH2M HILL. *Results of a Soil Investigation at the Former PCP Dip Vat and Underground PCP Storage Tank Sites, Main Installation, Memphis Depot (Rev.1)*. Technical Memorandum. Prepared for the U.S. Army Corps of Engineering and Support Center, Huntsville. January 2004.

CH2M HILL. *Disposal Sites Pre-Design Investigation Data Collection Technical Memorandum, Dunn Field, Memphis Depot (Rev.1)*. Prepared for the U.S. Army Corps of Engineering and Support Center, Huntsville. January 2004.

CH2M HILL. *Results of a Fate and Transport Model for PCP Contamination at Dunn Field Disposal Sites (Rev. 0)*. Technical Memorandum. Prepared for the U.S. Army Corps of Engineering and Support Center, Huntsville. February 2004.

Denise Cooper and Associates, Inc. *BRAC Cleanup Plan Version 8 (Final Report)*. The Memphis Depot (formerly the Defense Distribution Depot, Memphis, Tennessee). December 2003.

Engineering Science. *Engineering Report-- Removal Action for Groundwater for Defense Distribution Region Central Memphis, Tennessee*. Prepared for the U.S. Army Corps of Engineers, Huntsville Division. July 1994.

Graham, D. D. and W. S. Parks. *Potential for Leakage among Principal Aquifers in the Memphis Area, Tennessee*. U.S. Geological Survey Water Reservoir Investigation Report 85-4295. 1986.

IT Corporation. *Quarterly Groundwater Quality Report (Year Two, Quarter One) Groundwater Interim Remedial Action, Dunn Field, Memphis Defense Depot*, Tennessee. Prepared for Sverdrup Civil, Inc. May 2000.

IT Corporation. *Quarterly Groundwater Quality Report (Year Two, Quarter Two) Groundwater Interim Remedial Action, Dunn Field, Memphis Defense Depot*, Tennessee. Prepared for Sverdrup Civil, Inc. July 2000.

Jacobs-Sverdrup. *Quarterly Groundwater Quality Report (Year Two, Quarter Three) Groundwater Interim Remedial Action, Dunn Field, Memphis Defense Depot, Tennessee*. Prepared for the U.S. Army Corps of Engineers, Mobile District. October 2000.

Jacobs Engineering Group. *Semi-annual Groundwater Quality Report (Year Two, Quarter Four) Groundwater Interim Remedial Action, Dunn Field, Memphis Defense Depot, Tennessee*. Prepared for the U.S. Army Corps of Engineers, Mobile District. January 2001.

Jacobs Engineering Group. *Semi-annual Groundwater Quality Report (Year Three, First Half) Groundwater Interim Remedial Action, Dunn Field, Memphis Defense Depot, Tennessee*. Prepared for the U.S. Army Corps of Engineers, Mobile District. June 2001.

Jacobs Federal Group. *Semi-annual Groundwater Quality Report (Year Three, Second Half) and Annual Operation and Maintenance Summary Report for Year 2001 (Rev. 1) Groundwater Interim Remedial Action, Dunn Field, Memphis Defense Depot, Tennessee*. Prepared for the U.S. Army Corps of Engineers, Mobile District. February 2002.

Jacobs Federal Group. *Semi-annual Groundwater Quality Report (Year Four, First Half, Groundwater Interim Remedial Action, Dunn Field, Memphis Defense Depot, Tennessee*. Prepared for the U.S. Army Corps of Engineers, Mobile District. June 2002.

Jacobs Federal Group. *Semi-annual Groundwater Quality Report (Year Four, Second Half and Annual Operation and Maintenance Summary Report for Year 2002 Groundwater Interim Remtedial Action, Dunn Field, Memphis Defense Depot, Tennessee*. Prepared for the U.S. Army Corps of Engineers, Mobile District. February 2003.

Jacobs Federal Programs. *Removal Action at Former Pistol Range, Site 60.* For U.S. Army Corps of Engineers Mobile District, Mobile, Alabama. August 2003.

Jacobs Federal Programs. *Installation of Up-gradient Monitoring Wells near Dunn Field*. For U.S. Army Corps of Engineers Mobile District, Mobile, Alabama. August 2003.

Kingsbury, J. A. and W.S. Parks. *Hydrogeology of the Principal Aquifers and Relation of Faults to Interaquifer Leakage in the Memphis Area, Tennessee*. U.S. Geological Survey Water-Resources Investigations Report 93-4075. 1993.

Law Environmental, Inc. *Defense Distribution Depot Memphis, Tennessee (DDMT) Remedial Investigation Final Report*. For U.S. Army Corps of Engineers Huntsville Division, Huntsville, Alabama. August 1990.

Law Environmental, Inc. *Final Feasibility Study for the Defense Distribution Depot Memphis, Tennessee*. For U.S. Army Corps of Engineers Huntsville, Division, Huntsville, Alabama. September 1990.

OHM Remediation Services Corp. *Remedial Action Report*. For U.S. Army Corps of Engineers Mobile District, Mobile, Alabama. July 1999.

Parks, W.S. *Hydrogeology and Preliminary Assessment of the Potential or Contamination of the Memphis Aquifer in the Memphis Area, Tennessee*. U.S. Geological Survey Water-Resources Investigations Report 90-4092. 1990.

Parsons Engineering Science, Inc., June 1999. *Engineering Evaluation/Cost Analysis (EE/CA) for the Removal of Chemical Warfare Materiel, Former Defense Distribution Depot, Memphis, Tennessee*. US Army Corps of Engineers - Huntsville Center.

The Pathfinders Woolpert ETI Toles and Associates Trust Marketing Verner, Liipfert, Bernhard, McPherson and Hand. *Memphis Depot Redevelopment Plan*. May 1997.

U.S. Army Environmental Hygiene Agency. July 8-18, 1985. *Environmental Audit No. 43-21-1387-86.* Defense Depot Memphis, Memphis Tennessee. 1985.

U.S. Army Environmental Hygiene Agency. *Geohydrologic Study No. 38-26-1095-83.* Defense Depot Memphis, Memphis Tennessee. June 21 to July 2, 1982.

U.S. Army Topographic Engineering Center (TEC). Historical Environmental Aerial Photographic Analysis of the Main Depot Area South of Dunn Avenue. Prepared for U.S. Army Engineering and Support Center, Huntsville, Alabama. September 1998.

U.S. Army Toxic and Hazardous Materials Agency. *Installation Assessment of the Defense Depot Memphis, Tennessee*. July 1982.

U.S. Environmental Protection Agency (EPA). *Integrated Risk Information System Database*. Environmental Criteria and Assessments Office. 1999.

U.S. Environmental Protection Agency (EPA). *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and other Remedy Selection Decision Documents*. Office of Solid Waste and Emergency Response. Washington, D. C. July 1999.

U.S. Environmental Protection Agency (EPA). *Region 3 Risk-based Concentrations Table*. October 1998.

U.S. Environmental Protection Agency (EPA). *Region 9 Preliminary Remediation Goals Table*. October 2002.

U.S. Environmental Protection Agency (EPA). *Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil*. 1996.

U.S. Environmental Protection Agency (EPA). *RCRA Facility Assessment Plus RCRA Permit Portions*. Defense Depot Memphis, Tennessee, January 1990.

U.S. Environmental Protection Agency (EPA). *Guidance for Conducting Remedial Investigations and Feasibility Studies tinder CERCLA*. Office of Emergency and Remedial Response. Washington, D.C. October 1988.

U.S. Army Corps of Engineers, Huntsville. *Archives Search Report - Findings*. Memphis Defense Depot, Memphis, Tennessee. Defense Environmental Restoration Program for Department of Defense Sites. Ordnance and Explosive Waste. Chemical Warfare Materials. January 1995.

U.S. Army Corps of Engineers, Huntsville. *Archives Search Report - Conclusions and Recommendations*. Memphis Defense Depot, Memphis, Tennessee. Defense Environmental Restoration Program for Department of Defense Sites. Ordnance and Explosive Waste. Chemical Warfare Materials. January 1995.

U.S. Army Toxic and Hazardous Materials Agency. *Installation Assessment of Defense Depot Memphis, Tennessee*. Report No. 191. Chemical Systems Laboratory, Environmental Technical Division, Installation Restoration Branch, Aberdeen Proving Ground, Maryland. March 1981

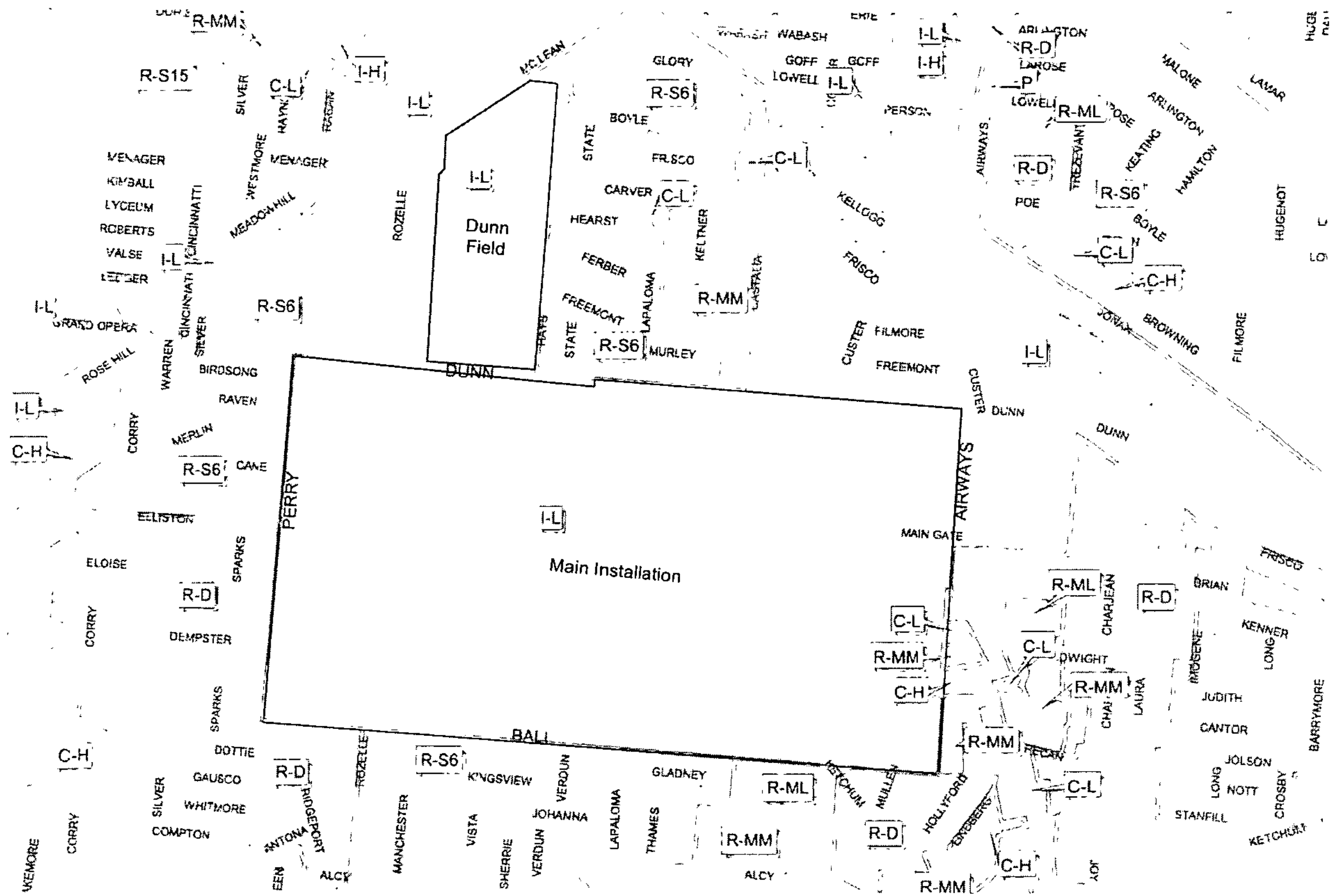
U.S. Environmental Protection Agency. *A Guide to Principal Threat and Low Level Threat Wastes*. Office of Emergency and Remedial Response. Washington, D.C. November 1991.

U.S. Environmental Protection Agency. *Feasibility Study Analysis for CERCLA Sites with VOCs in Soil*. Office of Emergency and Remedial Response. Washington

Woodward-Clyde. *U.S. Army Base Realignment and Closure 95 Program Environmental Baseline Survey Report.* Defense Distribution Depot Memphis, Tennessee. Prepared for the USACE Seattle District. November 6, 1996.

APPENDIX A

Memphis and Shelby County Zoning Map of the Memphis Depot (September 2003)



ZONING in and around Memphis Depot Business Park

current as of September 15, 2003

N W E S

0.3 0 0.3 Miles

Prepared by Memphis and Shelby County Office of Planning and Development 15 September 2003.

\\boomer\H\projects3\Memphis\DDMT\RDD_data\Memphis_Business_Park.mxd JHenderson 9/16/2003

779 216

APPENDIX B

Statement of Clearance (August 2003)

Statement of Clearance
Chemical Warfare Materiel (CWM)
Dunn Field, Former Defense Depot
Memphis, Tennessee

Dunn Field, located within the boundary of Former Defense Depot, Memphis, Tennessee, has been carefully researched, and a field search was conducted using the best available technology. Dunn Field has been cleared of all CWM and explosive ordnance reasonably possible to detect. Two live bursters (ordnance items) were found and destroyed. Activities are described in the Final Removal Report for Chemical Warfare Materiel Investigation/Removal Action, performed by UXB under contract to the Engineering and Support Center, Huntsville, Alabama (Contract No. DACA87-97-D-0006, DO 0006).

It is recommended that:

Dunn Field may be used for any purpose for which the land is suited.

This action has been conducted in accordance with Army Regulation 385-61 (The Army Chemical Agent Safety Program), Army Regulation 384-64 (Ammunition and Explosives Safety Standards), AR 405-90 (Disposal of Real Estate), and the DDESB approved Explosives Safety Submission.

SIGNED BY: [signature] 26 August 2003

John D. Rivenburgh Date
COL, EN
Commander, Engineering and Support Center,
Huntsville

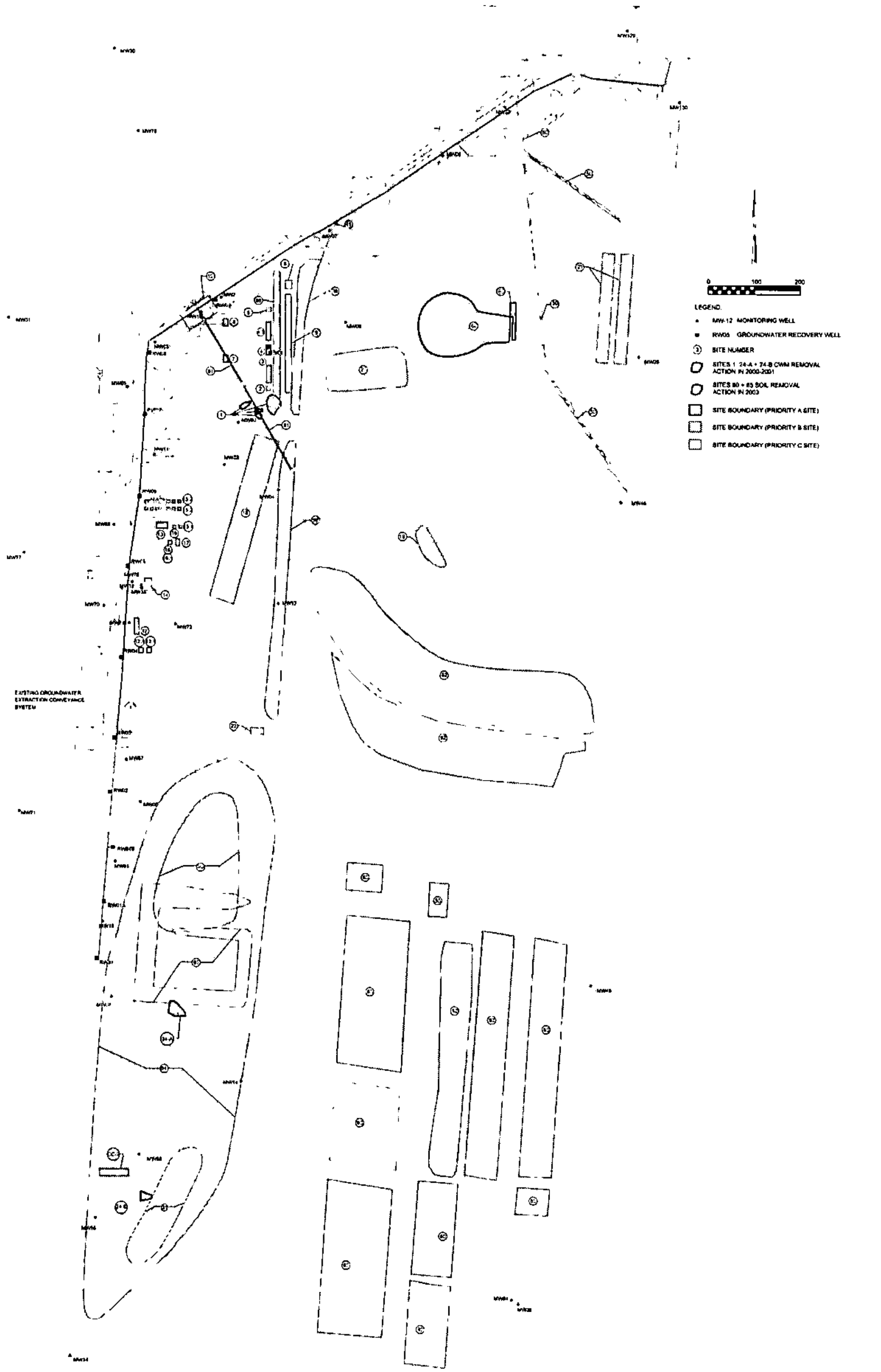
APPROVED BY:

[signature] 26 September 2003

Dennis J. Lillo Date
Division Chief, Environmental Quality
Defense Logistics Agency

APPENDIX C

Dunn Field Disposal Sites Location Map

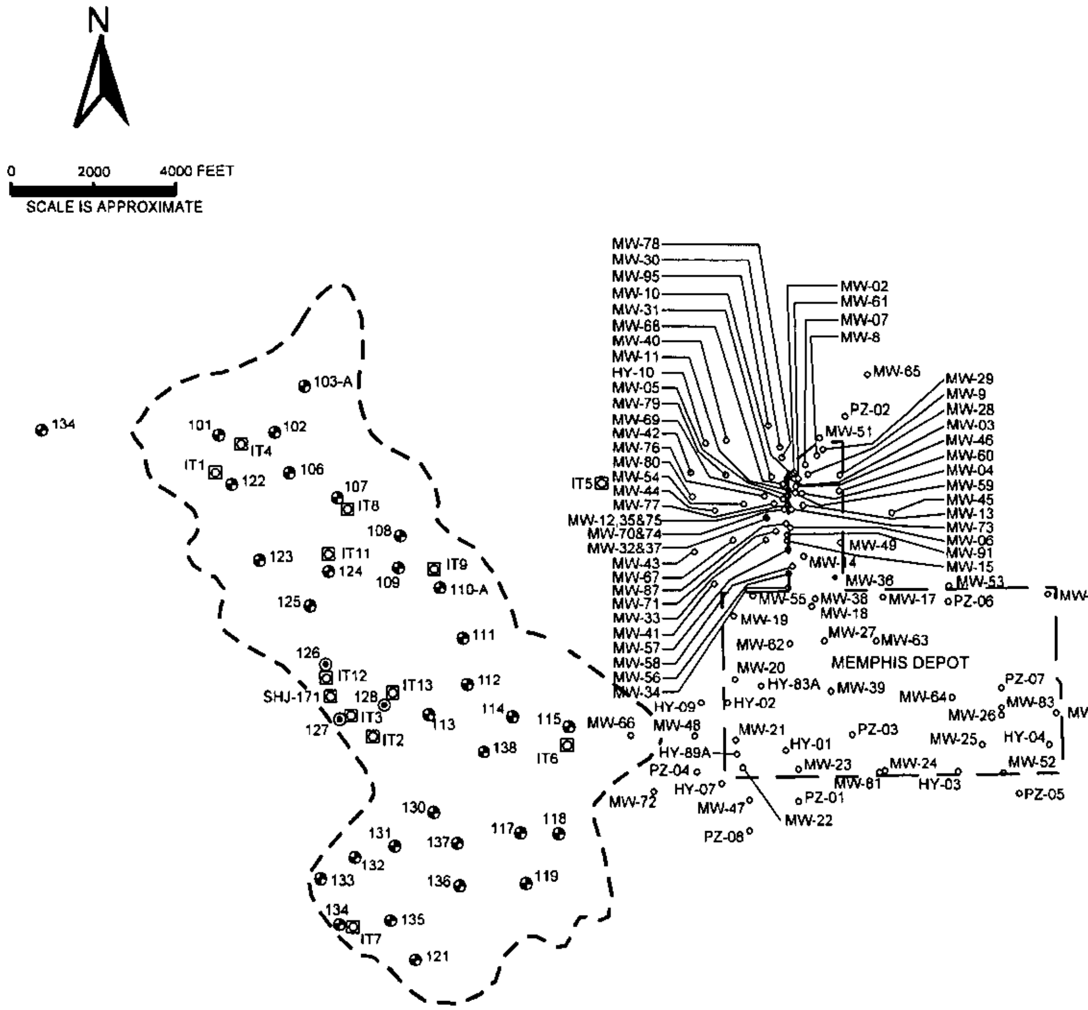


DUNN FIELD
DISPOSAL SITE LOCATION MAP

CH2MHILL

APPENDIX D

Allen Well Field Location Map



LEGEND

- MEMPHIS LIGHT, GAS AND WATER (MLGW) PRODUCTION WELL, ALL WELLS ARE LOCATED IN THE ALLEN WELL FIELD
- MLGW MONITORING WELL
- MLGW WELL CLOSED DUE TO CONTAMINATION
- MONITORING WELL IN THE FLUVIAL DEPOSITS (RI/FS)
- MONITORING WELL IN THE DEEPER AQUIFER (RI/FS) (POSSIBLY THE MEMPHIS SAND)
- APPROXIMATE EXTENT OF ALLEN WELL FIELD CAPTURE ZONE WITHIN THE MEMPHIS SAND (FROM UNIVERSITY OF MEMPHIS GROUND WATER INSTITUTE TECHNICAL BRIEF #6, NOV., 1994)

CAD1\PROJECTS\0071 DDMT\DUNNFIELD RI 2001\

FIGURE 2-14
ALLEN WELL FIELD LOCATION
RELATIVE TO THE MEMPHIS DEPOT
REV 2 MEMPHIS DEPOT DUNN FIELD RI

Source RI Report 1990

CH2MHILL

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE