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THE MEMPHIS DEPOT
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Generic Remedial Investigation/Feasibility Study Work Plan

Draft Final

for

Defense Distribution Depot Memphis

September 1995

Prepared for

U.S. Army Corps of Engineers
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Errata Sheet
Generic Remedial Investigation/Feasibility Study Work Plan
Defense Depot Memphis, Tennessee
June 14, 1996

The enclosed materials are the replacement pages for the *Generic Remedial Investigation/Feasibility Study Work Plan (RI/FS WP)* for the Defense Depot Memphis, Tennessee (DDMT). Revisions to the document have occurred as a result of regulatory agency comments, to provide clarity in the document, and to remove clerical errors. The instructions below provide the detail needed to convert the existing *RI/FS WP* to its final corrected form.

- Replace p. 2-7
- Replace p. 3-77
- Replace p. 5-15
- Replace p. 5-17

Generic RI/FS Work Plan

Executive Summary
April 17, 1995

Introduction

In October 1992, the Defense Depot Memphis, Tennessee (DDMT), was placed on the National Priorities List (NPL) by the Environmental Protection Agency (EPA). Therefore, DDMT must fulfill requirements under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and National Contingency Plan. A remedial investigation/feasibility study (RI/FS) must be prepared to determine the nature and extent of contamination, to evaluate the risk to human health and the environment, and to screen potential cleanup actions. The *Generic RI/FS Work Plan* was prepared to show how the investigation and study would be accomplished: to investigate the sites that were not previously investigated and to fill data gaps at previously investigated sites.

Description of Work Plan and Other Plans

The *Generic RI/FS Work Plan* includes a facility description, background information, findings of previous studies, and potential ways contamination may have reached and affected people. Preliminary information regarding potential applicable or relevant and appropriate requirements and preliminary cleanup goals are presented. A *Quality Assurance Project Plan* (QAPP) and a *Health and Safety Plan* (HASP) have been prepared to supplement the Work Plan. The QAPP describes general sampling procedures and quality assurance/quality control procedures to be used so that the quality and quantity of the information is adequate to evaluate the nature and extent of the contamination. The HASP was prepared to provide procedures for the safety and health of facility personnel and the general public during the investigation at DDMT. Included in the HASP are the assignment of responsibilities, employee training requirements, medical surveillance requirements, and a list of substances with possible routes of exposure and symptoms of acute exposure.

Information from previous investigations, plans, and procedures that applies to all operable units (OUs) is discussed in the *Generic RI/FS Work Plan*. OU-specific plans are discussed in Field Sampling Plans (FSPs) for each OU. Additionally, a separate FSP for screening sites has been prepared. Screening sites are those sites where additional information is needed to determine whether they warrant RI/FS or no further action.

DDMT is using several concepts to expedite cleanup, including the observational approach, interim remedial actions, early removal, and community relations. By implementing these concepts, DDMT's cleanup will be achieved more efficiently and cost-effectively. Where possible, efforts will be made to verify existing information and to fill data gaps. Future data collection will be evaluated and revised where appropriate, based on information and data collected during the RI/FS process.

Site Background and Location

DDMT covers 642 acres of land in Memphis, Shelby County, Tennessee, in the extreme southwestern portion of the state. The installation contains approximately 110 buildings, 26 miles of railroad track, and 28 miles of paved streets. Approximately 5.5 million square feet is covered storage space and approximately 6.0 million square feet is open storage space. Stored items include food, clothing, electronic equipment, petroleum products, construction materials, and industrial, medical, and general supplies.

Previous Investigations at DDMT

In conformance with Defense Logistics Agency (DLA) environmental programs, a number of technical studies have been conducted at DDMT.

A 1982 geohydraulic study, conducted by the U.S. Army Environmental Hygiene Agency (USAEHA), identified Dunn Field and the Pentachlorophenol (PCP) Dip Vat as having the potential for groundwater contamination. Six monitoring wells were installed, logged, and sampled in the Dunn Field location. Five of the six well analyses indicated the presence of volatile organic compounds (VOCs) at levels requiring further investigation and possible future remediation. An investigation of the Dip Vat Building (Building 737) indicated no groundwater contamination, but did indicate limited soil contamination. Cleanup of the area involved excavation to a depth of 10 feet, removing approximately 602 cubic yards of soil from beneath and adjacent to the Dip Vat Building.

In March 1986, the USAEHA also performed a Water Quality Biological Study that indicated the presence of dichlorodiphenyltrichloroethane (DDT) in the storm water influent to Lake Danielson. Several metals and pesticides also were found in the sediments of Lake Danielson.

Additional studies conducted indicate contamination of the Fluvial Aquifer beneath Dunn Field. A Resource Conservation and Recovery Act (RCRA) Facility Assessment was conducted in December 1989. Assessment data were used to define sites for future investigation that were classified as solid waste management units (49) and areas of concern (8). The RI/FS study focused on the installation; its activities; the study area's environmental setting; the facility's environmental data collection, sample analyses, and data evaluation; and a risk assessment. Environmental Science & Engineering, Inc., performed a groundwater monitoring study in 1993 to assess changes in groundwater quality since the completion of the RI/FS in 1990. The purpose of the sampling was to identify and delineate contaminants in the groundwater, and to evaluate the extent of migration of these contaminants on and around DDMT.

Description of Operable Units

DDMT is divided into four OUs for evaluation purposes. Dunn Field is designated OU-1. The Main Installation is divided into three areas: the southwestern quadrant, OU-2; the southeastern lakes and golf course area, OU-3; and the north-central area, OU-4. Substances found in OU-1 probably resulted from use of the area for landfill operations, mineral stockpiles, pistol range use, and pesticides storage. Potential contamination of OU-2 may have resulted from spills or releases from the hazardous material storage and repouring area, sandblasting and painting activities, or both. Storage of polychlorinated biphenyls (PCBs) and the use of pesticides and herbicides are potential sources of contamination for OU-3. Principal contamination in OU-4 probably resulted from a wood treatment operation and hazardous material storage.

Physical Characteristics

The two main surface water features at DDMT are currently off-limits for recreational purposes and serve primarily as drainage reservoirs. Drainage channels on the facility drain either to Cane Creek or Nonconnah Creek. Cane Creek drains into Nonconnah Creek several miles southwest of DDMT; Nonconnah Creek, in turn, drains into Lake McKellar. Because DDMT lies well above the average Mississippi River alluvial valley flood levels and is generally higher than its adjacent properties, it is unlikely that flooding will occur at the installation.

Five distinct surface soil units have been mapped in the study area: Falaya Silt Loam, Filled Land-Silty, Graded Land, Memphis Silt Loam, and Memphis Silt Loam 2. The primary surface soil type is filled land for the developed portion of the depot.

The following geological units have been identified at DDMT: loess, which can contain "perched" water-bearing zones for short periods of time after a rainfall event; fluvial (terrace) deposits, which contain the site's shallow aquifer; the Jackson Formation/Upper Claiborne Group, which is a confining unit between aquifers; and the Memphis Sand, which represents the region's most important source of water.

Nature and Extent of Known Contamination

OU-1. Soil samples taken in OU-1 during previous investigations indicated the presence of pesticides and polynuclear aromatic hydrocarbons (PAHs).

Groundwater analyses in the Fluvial Aquifer reveal contaminant migration beyond Dunn Field boundaries. Contaminants include VOCs, chlorinated compounds, and metals (including chromium, lead, and mercury). Other potential contaminants may include arsenic and barium.

OU-2. One soil boring (yielding three samples) and 15 surface soil samples were collected from OU-2 during previous investigations. These samples were collected in an effort to better characterize the former hazardous materials recoupment area, the maintenance shop and the sandblasting/painting areas. In general, sample analysis detected the presence of pesticides, PCBs, and PAHs at the sandblasting/painting area, and pesticides, solvents, and PAHs in the area of the maintenance shop. Groundwater investigations in OU-2 have indicated the presence of solvents and metals.

OU-3. In general, soil samples collected from OU-3 (seven surface samples) were insufficient to characterize individual sites or sources. Groundwater analysis in OU-3 detected VOCs and metals. Surface water and sediment samples also were collected from Lake Danielson, the Golf Course Pond, and from storm drainage ditches. Surface water in the drainage ways generally indicated higher levels of potential contaminants (pesticides) than water in either Lake Danielson or the Golf Course Pond. Sediments collected from both Lake Danielson and the Golf Course Pond revealed contamination with PCBs, pesticides, and PAHs.

OU-4. OU-4 contains the former PCP Dip Vat area, which is now used for pesticide storage and hazardous materials storage. Extensive remediation of soils was conducted at this site during 1985 and 1986. Samples taken in 1990 revealed pesticides and solvents. Soil samples were also taken where past spills have occurred. These samples indicated the presences of PAHs, pesticides, and metals. Groundwater samples in OU-4 indicated the presence of solvents, pesticides, and metals.

Potential Pathways of Contaminant Migration

Contamination migration can occur in several ways, depending on the characteristics of the element or compound in question, the medium in which the element or compound is located, and the type(s) of media in close proximity. Possible contaminant pathways could occur through surface water, groundwater, soil, and air.

Identification of Contaminants of Potential Concern

Factors considered in selecting contaminants of potential concern included the measured concentrations and frequency of detection at the site, level of toxicity, physical and chemical characteristics related to environmental mobility, and persistence and relative contribution of chemicals to overall health risks associated with the site. On the basis of these criteria, 28 contaminants for potential concern were identified. Potential public health risks stem from the following: the Fluvial Aquifer contains chlorinated organic compounds that may negatively affect the Memphis Sand Aquifer, surface soils contain potential human carcinogens, and the need exists for additional data to assess the potential effect of contamination to surface waters and sediments.

General response actions were developed from the following: potential contaminants of concern; allowable exposure levels based on compliance with RCRA and CERCLA regulations; EPA guidance for conducting RI/FSs under CERCLA; and known site conditions. The general response actions include no action, implementing institutional controls, excavation and treatment, in-situ treatment, plume and/or source containment for groundwater, pump and treat technologies for groundwater, storm water drainage diversion or treatment, establishment of aquatic vegetation, lake abandonment with sediment removal, and dredging with offsite treatment for surface waters.

Conceptual Site Model

Exposure pathways associated with DDMT include ingestion, inhalation, and dermal absorption of contaminants present in surface soils, groundwater, or surface water. Humans potentially at risk of such exposure could include employees of DDMT, residents and neighbors of DDMT, residents of Memphis, fisherman, and recreational users of surface waters, including Cane Creek and Nonconnah Creek.

Generic RI/FS Objectives

Data quality objectives (DQOs) specify the qualitative and quantitative data required to support the decision-making process during remedial response and sampling activities. DQOs are developed to eliminate collection of extraneous sampling data while simultaneously collecting sufficient data to make substantive decisions.

Up to four data quality levels may be used at DDMT during the field work investigation. Level 1 data provide the most rapid results and will generate environmental characteristics for the site. Level 2 data provide rapid results and limited information on contaminant specification, and can give quantitative results. However, the analytical detection limits for Level 2 data are higher than those of an analytical laboratory. Levels 3 and 4 data are generated by an analytical laboratory that implements specified QA/QC methods. By implementing combinations of data at up to all four levels, cleanup decisions will be resolved expeditiously.

Summary of RI/FS Tasks

A total of 14 standard RI/FS tasks have been defined by EPA to provide consistent reporting and to allow more effective monitoring of RI/FS projects. Project planning is the first task and involves defining the appropriate type and extent of site investigation needed to characterize the site. Community relations (Task 2) will be established to ensure community understanding and input concerning the RI/FS program.

Field investigations (Task 3) will be conducted to characterize soil, groundwater, surface water, and sediments at DDMT and the surrounding areas. Samples of the three media will be analyzed (Task 4) and validated in the field or laboratory to determine if the data are adequate for their intended use. The data will be evaluated (Task 5) to develop knowledge of the nature and extent of contamination. A risk assessment (Task 6) can be conducted using the data to assess the risk to human health and the environment. Should a risk be identified, treatability and pilot testing (Task 7) studies will be conducted to determine effective remedial solutions to eliminate the risk. An RI Report (Task 8) will document all findings during the investigation of each OU.

Remedial alternatives development and screening (Task 9) includes development of a range of distinct management alternatives designed to remediate any contaminated media. A detailed analysis of remedial alternatives (Task 10) will consist of comparing each alternative against 10 criteria, the main criterion being overall protection of human health and the environment. An FS Report (Task 11) will present the results of the remedial alternative development and screening and the detailed analysis of alternatives, along with a description of the preferred remedial alternative. Post-RI/FS support (Task 12) includes preparation and submittal of proposed plans, records of decision, remedial designs, and remedial action work plans. Enforcement support (Task 13) includes efforts associated with enforcement aspects of the project at any time during the RI/FS. The final task (Task 14) is associated with work included in the project, but is outside the RI/FS activities.

Cleanup Actions

Cleanup actions will be based on the contaminants, future land use, potential exposure levels, regulations, and site conditions. The objective of groundwater remediation will be to stop the migration of contaminants and to attenuate the contamination that threatens the Memphis Sand Aquifer.

The objective of the soil remediation will be to prevent the possibility of ingestion, to limit surface water runoff, and to prevent migration of contaminants to the groundwater. The objectives of the surface water cleanup are to protect aquatic life and to mitigate surface water contamination during peak storms.

The ultimate goal of the RI/FS is to select cost-effective cleanup actions that minimize threats and provide protection of public health and the environment. To accomplish this, the nature and extent of the release of hazardous substances to the Fluvial Aquifer must be identified, the source of release must be determined, and proposed cleanup actions must be evaluated.

The ultimate goal of the RI/FS is to select cost-effective cleanup actions that minimize threats and provide protection of public health and the environment. To accomplish this, the nature and extent of the release of hazardous substances to the Fluvial Aquifer must be identified, the source of release must be determined, and proposed cleanup actions must be evaluated.

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Acronyms

AEHA	Army Environmental Hygiene Agency
AOC	Area of concern
ARARs	Applicable or relevant and appropriate requirements
AWQC	Ambient water quality criteria
BAT	Best available technology
beta-BHC	Beta-hexachlorocyclohexane
bgs	Below ground surface
BNA	Base/neutral acid
BRA	Baseline risk assessment
BX	Base exchange
CAA	Clean Air Act
CEHND	United States Army Corps of Engineers, Huntsville Division
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	Contaminants of Concern
CWA	Chemical warfare agents
DDD	Dichlorodiphenyldichloroethane
DDE	1,1,1-Dichloro-2,2-bis(4-chlorophenyl)ethylene
DDMT	Defense Depot Memphis, Tennessee
DDRE	Defense Distribution Region East
DDT	Dichlorodiphenyltrichloroethane
DLA	Defense Logistics Agency
DOD	Department of Defense
DOI	Department of Interior
DQO	Data quality objective
DRMO	Defense Reutilization and Marketing Office
EPA	U.S. Environmental Protection Agency
ESE	Environmental Science & Engineering, Inc.
FDA	Food and Drug Administration
FFA	Federal Facilities Agreement
FRL	Final remediation level
FSP	Field Sampling Plan
GW	Groundwater
HCl	Hydrochloric acid
HOC	Halogenated organic compound
HQ/HI	Hazard quotient/Hazard index
HRS	Hazard Ranking System
HASP	Health and Safety Plan
IA	Installation assessment
IRP	Installation Restoration Program
K_{ow}	Octonal water partitioning coefficient
K_d	Distribution coefficient

Acronyms (cont'd.)

LDR	Land disposal restriction
LOEL	Lowest observed effects level
MCL	Maximum contaminant level
MCLG	Maximum Contaminant level goal
mg/kg	Milligrams per kilogram
mgd	Million gallons per day
MLGW	Memphis Light, Gas, and Water
MSCHD	Memphis-Shelby County Health Department
MW	Monitoring well
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NFA	No further action
NGVD	National geodetic vertical datum
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No observed adverse effects level
NOEL	No observed effects level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OERR	Office of Enforcement and Remedial Response
OPD	Office of Planning and Development
OSWER	Office of Solid Waste and Emergency Response
OU	Operable unit
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCP	Pentachlorophenol
PEL	Permissible exposure level
POL	Petroleum, oils, and lubricants
POTW	Publicly owned treatment works
ppm	Parts per million
PRGs	Preliminary remediation goals
PSC	Potential source of contamination
QA/QC	Quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RAL	Removal action level
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RGO	Remedial goal option
RI/FS	Remedial investigation/feasibility study
ROD	Record of Decision
RPD	Relative percent difference

Acronyms (cont'd.)

RPM	Remedial project manager
SARA	Superfund Amendments and Reauthorization Act
SD	Sediment
SDWA	Safe Drinking Water Act
SMP	Site Management Plan
SMSA	Standard metropolitan statistical area
SS	Surface soil
STB	Statigraphic test boring
SW	Surface water
SWMU	Solid waste management unit
TBC	To be considered
TCA	Tricholorethane
TCE	Trichloroethene
TCLP	Toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TDOH	Tennessee Department of Health
THI	Target hazard index
TM	Technical memorandum
TRL	Target risk level
$\mu g/L$	micrograms per liter
UIC	Underground injection control
USACE	U.S. Army Corps of Engineers
USAEHA	United States Army Environmental Hygiene Agency
USATHAMA	United States Army Toxic and Hazardous Materials Agency (now referred to as the United States Army Environmental Center [AEC])
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UST	Underground storage tank
VOC	Volatile organic compound
WQC	Water quality criteria
yd^3	Cubic yards

TAB

Section I - Introduction

1.0 Introduction

1.1 Purpose

Defense Distribution Depot Memphis, Tennessee (DDMT) has been placed on the National Priorities List (NPL) and must fulfill requirements under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and National Contingency Plan (NCP). The remedial process under CERCLA and the NCP requires the preparation of a Remedial Investigation/Feasibility Study (RI/FS) to determine the nature and extent of contamination, to evaluate public health risks, and to screen potential remedial actions. An overview of the RI/FS process is provided in Section 5.

DDMT's Generic RI/FS Work Plan was prepared by the United States Army Corps of Engineers, Huntsville Division (CEHND) and revised by CH2M HILL, Inc., for the DDMT. The Plan's purpose is to present general information concerning the following: facility background; previous studies; physical characteristics; potential pathways; preliminary screening of technologies to identify specific data needs relative to potential remedial action; preliminary information on potential applicable, relevant, and appropriate requirements (ARARs) and preliminary remediation goals (PRGs); sampling and quality assurance methodologies; and safety and health procedures.

This Work Plan outlines the strategy for achieving the objectives of a CERCLA investigation and remediation program that also fulfills the requirements of DDMT's Resource Conservation and Recovery Act (RCRA) Part B permit. The RCRA Permit identifies the list of sites where hazardous and toxic wastes were managed or stored and requires that DDMT investigate these sites regardless of when the wastes were handled at these sites. This information is provided in support of the operable unit (OU)-specific Field Sampling Plans (FSPs) to minimize repetition of non-site-specific information.

This document summarizes site conditions and previous investigations that have been conducted at DDMT. Detailed descriptions of the tasks to be completed during the course of the RI/FS will be provided in the OU-specific FSPs. The Quality Assurance Project Plan (QAPP) and the Health and Safety Plan (HASP) for DDMT have been prepared as separate documents and will be submitted with this document.

Several reports document those sites where past waste disposal activities have occurred at DDMT. The RCRA Facility Assessment (RFA) (ref. 68), which was performed by the U.S. Environmental Protection Agency (EPA) in 1990, identified 49 Solid Waste Management Units (SWMUs) and 8 Areas of Concern (AOCs) at DDMT. The RFA was performed subsequent to DDMT's application for a RCRA Part B permit. The RFA also specified the level of additional investigation necessary for each SWMU and AOC (for example, no further action [NFA], RCRA Facility Investigation [RFI], and Preliminary RFI/Confirmatory Sampling).

In 1990, a study was prepared by Law Environmental, Inc. (the RI Report, ref. 18), identifying 75 sites of potential contamination and some general storage sites. Because these lists were independently prepared, DDMT needed to consolidate the RFA and RI Report lists into a single, coordinated list; to prepare a work plan to investigate the sites that were not investigated previously; and to fill data gaps at previously investigated sites. Where possible, efforts will be made to verify existing information and to fill data gaps. Conclusions reached during previous investigations will be evaluated and revised where appropriate based on information and data collected during the RI/FS process.

This Work Plan combines both lists into one comprehensive list of 93 sites, as presented in Table 1-1. Table 1-1 was prepared from information contained in the RFA, RI Report, and FFA, and from early removal meetings to determine potential candidates for the early removal process.

Representatives of DDMT, CEHND, EPA, and the Tennessee Department of Environment and Conservation (TDEC) agreed during a technical meeting held January 5 through 7, 1993, to divide the facility into four potential OUs to assist further investigation, as follows:

- OU-1: Dunn Field
- OU-2: Southwestern Quadrant, Main Installation
- OU-3: Southeastern Watershed and Golf Course, Main Installation
- OU-4: North-Central Area, Main Installation

The following general criteria were used to define the OUs:

- Geographic proximity of sites
- Similar contaminants of concern previously identified
- Similar investigation methods
- Scope and complexity of investigation
- Results of previous site studies
- Potential for offsite migration and exposure
- Relative threat to the City of Memphis drinking water supply
- Suspected mobility of contaminants

The OUs may be redefined as more data are collected and evaluated. In addition, a list of screening sites is presented for sites from which more sampling is needed, but which are not currently believed to require an RI/FS type investigation. These sites generally match those SWMUs identified in the RCRA Permit as requiring "Confirmatory Sampling." A Preliminary Assessment/Site Investigation (PA/SI) type of sampling effort will be performed on these screening sites, which will be investigated using a biased sampling approach. These sites will either be added to an OU or placed on the proposed NFA list based on the results of field investigative efforts. Each screening site will remain as a screening site until defensible, validated Level 3 or 4 data become available. Once available, DDMT will use these data to either prepare a report to support an NFA decision with EPA/TDEC concurrence, or to immediately reclassify the site to RI/FS

Table 1-1
Comprehensive List of DDMT Sites
Defense Depot Memphis, Tennessee

Page 1 of 7

Site Number[a]	Previous Location	Description	Current Disposition
Operable Unit 1—Dunn Field			
1/1/1	OU-1	Mustard and Lewsite Training Sets (6) Burial Site (1955)	CWMP[b]
9/9/10	OU-1	Ashes and Metal Burial Site (burning pit refuse) (1955)	CWMP
24/24/31	OU-1	Former Burn Site (1946)	CWMP
2/2/2	OU-1	Ammonia Hydroxide (7 lbs) and Acetic Acid (1 gal.) Burial (1955)	ER[c]
3/3/3	OU-1	Mixed Chemical Burial Site (orthotoluidine dihydrochloride) (1955)	ER
4/4/4	OU-1	POL Burial Site (13 55-gal. drums of oil, grease, and paint: date unknown)	ER
4.1/—/5	OU-1	POL Burial Site (32 55-gal. drums of oil, grease, and thinner) (1955)	ER
5/5/6	OU-1	Methyl Bromide Burial Site A (3 cubic feet) (1955)	ER
7/7/8	OU-1	Nitric Acid Burial Site (1,700 bottles) (1954)	ER
8/8/9	OU-1	Methyl Bromide Burial site B (3,768 1-gal. cans) (1954)	ER
13/13/13	OU-1	Mixed Chemical Burial (Acid, 900 lbs.; Deter., 7,000 lbs; AL_2SO_4; and 200 lbs Na)	ER
17/17/17	OU-1	Mixed Chemical Burial Site C (1969)	ER
85/-/25	OU-1	Old Pistol Range Blgd. 1184/ Temporary Pesticide Storage	ER

[a] a/b/c a = RI/FS Site Number
b = RFA Site Number
c = RI Report (ref. 18) Number
[b] CWMP = Chemical Warfare Management Plan

[c] ER = Early Removal
[d] NFA = No Further Action
[e] RI = Remedial Investigation
[f] TDEC Lead Sites

Table 1-1
Comprehensive List of DDMT Sites
Defense Depot Memphis, Tennessee

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Site Number	Previous Location	Description	Current Disposition
18/18/–	OU-1	Plane Crash Residue (Dunn Field)	NFA[d]
22/22/19	OU-1	Hardware Burial Site (nuts and bolts) (Dunn Field)	NFA
23/23/30	OU-1	Construction Debris and Food Burial Site (Dunn Field)	NFA
63/–/28	OU-1	Fluorspar Storage (Southeastern Quadrant of Dunn Field)	NFA
86/–/29	OU-1	Food Supplies (Dunn Field)	NFA
6/6/7	OU-1	40,037 units ointment (eye) Burial Site (1955)	RI[e]
10/10/74	OU-1	Solid Waste Burial Site (near MW-10) (metal, glass, trash, etc.)	RI
11/11/11	OU-1	Trichloroacetic Acid Burial Site (1,433 1-oz bottles) (1965)	RI
12/12/12	OU-1	Sulfuric and Hydrochloric Acid Burial (quantity?) (1967)	RI
14/14/75	OU-1	Municipal Waste Burial Site B (near MW-12) (food, paper products)	RI
15/15/14	OU-1	Sodium Burial Sites (1968)	RI
15.1/–/15	OU-1	Sodium Phosphate Burial (1968)	RI
15.2/–/33	OU-1	14 Burial Pits: Na_3PO_4, Na, Acid, Medical Supplies, and Chlorinated Lime	RI
16/16/16	OU-1	Unknown Acid Burial Site (1969)	RI

[a] a/b/c a = RI/FS Site Number
b = RFA Site Number
c = RI Report (ref. 18) Number
[b] CWMP = Chemical Warfare Management Plan
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[f] TDEC Lead Sites

Table 1-1
Comprehensive List of DDMT Sites
Defense Depot Memphis, Tennessee

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Site Number	Previous Location	Description	Current Disposition
16.1/–/18	OU-1	Acid, date unknown	RI
19/19/21	OU-1	Former Tear Gas Canister Burn Site (Dunn Field)	Screening
20/20/20	OU-1	Probable Asphalt Burial Site (Dunn Field)	Screening
21/21/22	OU-1	XXCC-3 Burial Site (Dunn Field)	Screening
50/AOCA/23	OU-1	Dunn Field Northeastern Quadrant Drainage Ditch	Screening
60/–/24	OU-1	Pistol Range Impact Area/Bullet Shop	Screening
61/–/26	OU-1	Buried Drain Pipe (Northwestern Quadrant of Dunn Field)	Screening
62/–/27	OU-1	Bauxite Storage (Northeastern Quadrant of Dunn Field)	Screening
64/–/32	OU-1	Bauxite Storage (Southwestern Quadrant of Dunn Field) (1942 to 1972)	Screening
OU-2–Southwestern Quadrant			
30/30/–	OU-2	Paint Spray Booths (2 of 3 total; Bldgs. 770 and 1086)	NFA
40/40/–	OU-2	Safety Kleen Units–5 of 9 total (all located in Building 770)	NFA
41/41/–	OU-2	Satellite Drum Accumulation Areas–2 of 4 total (vicinity Building 770)	NFA
47/47/–	OU-2	Former Cont. Soil Drum Storage Area (300 ft west of Building 689, removed 1988)	NFA

[a]a/b/c a = RI/FS Site Number
b = RFA Site Number
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[b]CWMP = Chemical Warfare Management Plan
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[d]NFA = No Further Action
[e]RI = Remedial Investigation
[f]TDEC Lead Sites

Table 1-1
Comprehensive List of DDMT Sites
Defense Depot Memphis, Tennessee

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Site Number	Previous Location	Description	Current Disposition
29/29/66	OU-2	Former Underground Waste Oil Storage Tank	ER
87/–/64	OU-2	DDT, banned pesticides (Building 1084)	ER
88/–/65	OU-2	POL (Building 1085)	ER
27/27/60	OU-2	Former Recoup Area	RI
32/32/67	OU-2	Sandblasting Waste Accumulation Area	RI
34/34/58	OU-2	Building 770 Underground Oil Storage Tanks	RI
89/–/68	OU-2	Acids (Building 1089)	RI
31/31/–	OU-2	Former Paint Spray Booth (Building 1087)	Screening
33/33/–	OU-2	Sandblasting Waste Drum Storage Area (metal shed south of Building 1088)	Screening
82/–/59	OU-2	Flammables (Building 783)	Screening
84/–/63	OU-2	Flammables, Solvents, Waste Oil, etc. (Building 972)	Screening
OU-3 – Southeastern Quadrant			
30/30/–	OU-3	Paint Spray Booths (1 of 3 total – Building 260)	NFA
40/40/–	OU-3	Safety Kleen Units – 4 of 9 total units (Bldgs. 253, 469, 490, and 689)	NFA
41/41/–	OU-3	Satellite Drum Accumulation Areas – 2 of 4 total areas (Bldgs. 469 and 260)	NFA

[a]a/b/c a = RI/FS Site Number
b = RFA Site Number
c = RI Report (ref. 18) Number
[b]CWMP = Chemical Warfare Management Plan
[c]ER = Early Removal
[d]NFA = No Further Action
[e]RI = Remedial Investigation
[f]TDEC Lead Sites

Table 1-1
Comprehensive List of DDMT Sites
Defense Depot Memphis, Tennessee

Page 5 of 7

Site Number	Previous Location	Description	Current Disposition
49/49/46	OU-3	Medical Waste Storage Area	NFA
25/25/42	OU-3	Golf Course Pond	RI
26/26/43	OU-3	Lake Danielson	RI
48/48/39	OU-3	Former PCB Transformer Storage Area	RI
58/—/38	OU-3	Pesticides, Herbicides (PAD 267)	RI
59/—/40	OU-3	Pesticides, Cleaners (Building 273)	RI
51/AOCB/—	OU-3	Lake Danielson Outlet Ditch	Screening
52/AOCC/—	OU-3	Golf Course Pond Outlet Ditch	Screening
65/—/34	OU-3	XXCC-3 (Building 249)	Screening
66/—/35	OU-3	POL (Building 253)	Screening
67/—/36	OU-3	MOGAS (Building 253)	Screening
68/—/37	OU-3	POL (Building 263) (20 x 40 ft)	Screening
69/—/41	OU-3	2,4-D, M2A1 and M4 Flamethrower Liguid Fuels (surface appl.)	Screening
73/—/73	OU-3	2,4-Dichlorophenoxyacetic Acid (all grassed areas)	Screening
75/—/50	OU-3	Unknown Wastes near Building 689	Screening
76/—/51	OU-3	Unknown Wastes near Building 690	Screening
77/—/52	OU-3	Unknown Wastes near Bldgs. 689 and 690	Screening
78/—/53	OU-3	Alcohol, Acetone, Toluene, Naptha; Hydroflouric Acid Spill	Screening

[a]a/b/c a = RI/FS Site Number
b = RFA Site Number
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[b]CWMP = Chemical Warfare Management Plan
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[f]TDEC Lead Sites

Table 1-1
Comprehensive List of DDMT Sites
Defense Depot Memphis, Tennessee

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Site Number	Previous Location	Description	Current Disposition
OU-4—North Area of Main Installation			
41/41/—	OU-4	Satellite Drum Accumulation Area (1 of 5 total—Building 210)	NFA
44/44/56	OU-4	Former Wastewater Treatment Unit Area	NFA
45/45/56	OU-4	Former Contaminated Soil Staging Area	NFA
53/AOCD/61 and 62	OU-4	X-25 Flammable Solvents Storage Area (near Building 925)	NFA
57/AOCH/49	OU-4	Building 629 Spill Area	RI
28/28/—	OU-4	Recoup Area Building	Screening
35/35/46[f]	OU-4	DRMO Building T-308—Hazardous Waste Storage	Screening
36/36/—[f]	OU-4	DRMO Hazardous Waste Concrete Storage Pad	Screening
37/37/—[f]	OU-4	DRMO Hazardous Waste Gravel Storage Pad	Screening
38/38/—[f]	OU-4	DRMO Damaged/Empty Hazardous Materials Drum Storage Area	Screening
39/39/—[f]	OU-4	DRMO Damaged/Empty Lubricant Container Area	Screening
42/42/56	OU-4	Former PCP Dip Vat Area	Screening
43/43/56	OU-4	Former Underground PCP Tank Area	Screening
46/46/56	OU-4	Former PCP Pallet Drying Area	Screening
54/AOCE/—	OU-4	Main Installation—DRMO East Storm Water Runoff Canal	Screening
55/AOCF/—	OU-4	Main Installation—DRMO North Storm Water Runoff Area	Screening
56/AOCG/—	OU-4	Main Installation—West Storm Water Drainage Canal	Screening

[a]a/b/c a = RI/FS Site Number
b = RFA Site Number
c = RI Report (ref. 18) Number
[b]CWMP = Chemical Warfare Management Plan
[c]ER = Early Removal
[d]NFA = No Further Action
[e]RI = Remedial Investigation
[f]TDEC Lead Sites

Table 1-1
Comprehensive List of DDMT Sites
Defense Depot Memphis, Tennessee

Page 7 of 7

Site Number	Previous Location	Description	Current Disposition
70/–/–	OU-4	POL, Various Chemical Leaks (RR tracks, 1, 2, 3, 4, 5, and 6)	Screening
71/–/–	OU-4	Herbicide (All RR tracks) (used to clear tracks)	Screening
72/–/–	OU-4	Waste Oil (PDO yard) (surf. appl. for dust control)	Screening
73/–/73	OU-4	2,4-Dichlorophenoxyacetic Acid (all grassed areas)	Screening
74/–/45	OU-4	Flammables, Toxics (West End–Building 319)	Screening
79/–/54	OU-4	Fuels, Misc. Liquids, Wood, and Paper (Vicinity S702)	Screening
80/–/55	OU-4	Fuel and Cleaners Dispensing (Building 720)	Screening
81/–/57	OU-4	Fuel Oil (Building 765)	Screening
83/–/69	OU-4	POL (iso-octane, toluene, acetone, MEK, naptha) Areas X-13, 15, and 25	Screening

[a]a/b/c a = RI/FS Site Number
b = RFA Site Number
c = RI Report (ref. 18) Number
[b]CWMP = Chemical Warfare Management Plan
[c]ER = Early Removal
[d]NFA = No Further Action
[e]RI = Remedial Investigation
[f]TDEC Lead Sites

status. If RI/FS activities are recommended, DDMT will either propose incorporation of these sites into existing OUs or will designate them as new OUs following the criteria listed previously. Further discussion about the application of this process is found in the Screening Sites Field Sampling Plan (SSFSP).

Alternatively, screening sites may be designated for removal either as an Interim Remedial Action (IRA) or under EPA's Superfund Accelerated Cleanup Model (SACM) process. Removal of a site involves excavating and removing contaminants for offsite disposal and performing confirmatory sampling. The site is then recommended for NFA or for further RI/FS based on confirmatory sampling results.

1.2 Objectives of the RI/FS

According to the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (ref. 63), the RI/FS has the following overall objectives:

- Collecting and evaluating data to characterize site conditions
- Assessing risks to human health and the environment
- Conducting treatability tests, as necessary, to evaluate the potential performance and cost of the treatment technologies being considered
- Developing alternatives for remedial actions
- Screening the potential remedial alternatives
- Conducting detailed evaluations of remedial alternatives

The overall objective of providing a description of the preferred alternative that is consistent with EPA CERCLA requirements is met in the Proposed Plan for the site. Additional information concerning the RI/FS process (by task) is provided in Section 5.

The RI/FS will be conducted concurrently, but in a manner that allows data collected during the RI to influence the selection of candidate remedial actions for the FS. The candidate removal or remedial actions can, in turn, influence the data needs and scope of potential treatability studies and additional field investigations.

Scoping is the initial planning phase of the RI/FS process, and many of the planning steps begun here are continued and refined as the process develops into later phases. The RI/FS is an iterative process: as the feasibility study progresses, more detailed data may be required as part of the RI to assess the feasibility of an alternative. For instance, in

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addition to a literature survey, more site data or bench-scale testing of a treatment technology may be needed. By separating the RI/FS into phases, data can be collected and evaluated sequentially, with a refinement or redefinition of data collection needs at the completion of each phase.

1.3 Regulatory Background

1.3.1 RCRA Part B Permit and Designation as an NPL Site

DDMT was issued a RCRA Part B permit (No. TN4 210 020 570) by the EPA, Region IV, and the TDEC on September 28, 1990. Subsequently, and in accordance with Section 120(d)(2) of CERCLA, 42 U.S.C. 9620(d)(2), EPA prepared a final Hazard Ranking System (HRS) Scoring Package for DDMT. The final HRS score was 58.06, and EPA added DDMT to the NPL by publication in the *Federal Register*, 199 FR 47180, on October 14, 1992. Future investigation at DDMT will be conducted in accordance with criteria established by the EPA RFA (ref. 68) and the RCRA Part B Permit.

1.3.2 Federal Facilities Agreement

DDMT has entered into a Federal Facilities Agreement (FFA) between the Defense Logistics Agency (DLA), EPA, and TDEC, which was signed on March 6, 1995. The agreement establishes a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at DDMT in accordance with existing regulations and with achieving RCRA/CERCLA integration. In response to the FFA, sites at DDMT have been grouped into four OUs to be addressed under the CERCLA process. Because of DDMT's status as an NPL site, it was agreed that the investigation of all applicable sites (which excludes screening sites) would proceed under the CERCLA process for remediation (remedial investigation, feasibility study, proposed plan, record of decision, remedial design, and remedial action) and that this process will meet RCRA requirements. OU-specific FSPs will be prepared for OUs-1, 2, 3, and 4 and will provide guidelines for conducting the RI/FS for each of those OUs. However, screening sites, which by definition are not assigned to OUs until they have been upgraded to RI status, may be investigated concurrently with an OU. Schedules for completing specific tasks during the process have been submitted separately in the Site Management Plan (SMP).

As established in the NCP (40 *Code of Federal Regulations* [CFR] Part 300.120), the Department of Defense (DOD) is the lead agency at NPL sites involving federal facilities. Accordingly, EPA and TDEC have been identified as support agencies in this process.

1.4 Environmental Restoration Strategic Plan

As described in the SMP, one of DDMT's goals in implementing the RI/FS process is to set priorities for the sites according to the potential threat to human health and the environment. DDMT is using several concepts to help set these priorities and to expedite cleanup. These concepts range from using the observational approach philosophy throughout the project to recognizing the importance of involving the public in decisionmaking throughout the cleanup process. This document has been designated as the master reference document for the environmental restoration work at DDMT. Therefore, this subsection includes a discussion of the various concepts being used at DDMT to achieve cleanup to provide the reader with an overall understanding of the restoration activities.

The concepts include the following:

- Observational Approach
- Interim Remedial Actions (IRAs)
- Early Removal
- Integrate the RI/FS Process—(Identify Cleanup Alternatives Early)
- Community Relations

Each of the concepts described below has one theme in common, which is that use of the concept will enable the goal of site cleanup to be achieved as soon as possible.

1.4.1 Observational Approach

Recognizing the inherent uncertainty in site remediation is a key element in the observational approach. Originally developed and implemented for soil mechanics applications, the observational approach is readily adapted to site remediation.

The traditional approach to site remediation follows the "study-design-build" paradigm fundamental to many engineering problems. As applied to remediation, this paradigm assumes significant investigation of the site or medium of concern to develop a full understanding or characterization of key conditions and parameters. Often, a series of studies is needed before enough information is obtained to complete selection of remedial alternatives and begin design of selected alternatives. Once the remedial design is complete, the selected alternatives are constructed. Gathering such large amounts of data before remedial alternatives are evaluated theoretically reduces uncertainty in the design phase.

However, the approach does not recognize that uncertainty is inherent in site remediation. Regardless of how much investigative work is done, unanticipated conditions are encountered once construction is started. As a result, unnecessary time and effort can be spent collecting data that ultimately do not improve the performance of the implemented remedial strategy significantly.

When applied to remediation problems, the observational approach provides a system for responding to major technical uncertainties, because it assumes that such uncertainties exist and may need to be dealt with during remediation. This goal is accomplished by applying the following four primary elements to the design activities:

- Develop remedial design concepts based on most probable site conditions, as understood through a conceptual site model (working hypothesis)
- Define reasonable deviations from these conditions
- Identify parameters that can be observed to detect variations in site conditions
- Develop contingencies to respond to potential deviations

The observational approach applied at DDMT will allow remediation to begin sooner. The common terms used in the observational approach are as follows:

- Probable Condition—this is the initial assessment of assumed conditions for the contamination at the site based on available data. This condition can include such things as the lateral and vertical extent of the contamination plume, concentration levels of expected constituents, and initial remedial action (for example, number of wells and discharge rates for groundwater pumping systems).
- Reasonable Deviation—is a manageable change (deviation) from the probable condition. This can include such things as a larger contamination plume and higher constituent concentrations, both of which can require additional recovery wells or increases in discharge rate. Some deviations will not be manageable; therefore, they will not be reasonable and a revaluation of the site conditions must be conducted.
- Parameters to Observe—these parameters will be observed during the initial remediation to collect additional data to aid in the early identification of deviations.
- Contingency Plan—is the plan to adjust the remediation process to the deviations encountered. This plan will help finalize the remediation process by continuing to make adjustments to remedy the deviations at the site.

DDMT is also using some support techniques to help implement the observational approach. These include the use of quick turnaround time sample results during the investigation. The quick turnaround time results will allow for a more immediate determination of whether the probable condition or reasonable deviations have been met.

These quick results will provide the flexibility to make "online" decisions, to validate or invalidate the probable conditions, and to more quickly implement contingency plans.

Non-traditional investigation techniques may also be used at DDMT, including hydropunch and a field kit for testing polychlorinated biphenyls (PCBs). The advantages of these techniques are that they provide relatively inexpensive data in a timely manner to facilitate field decisions.

1.4.2 Interim Remedial Actions (IRAs)

IRAs are options under CERCLA that allow DDMT to initiate reasonable actions to attenuate contaminant migration, to expedite cleanup, and to reduce risk to the public. These actions are typically some type of source control or presumptive remedy and are not intended to be the final remedy. Examples of IRAs include source removal and soil vapor extraction. The following section discusses an interim action that is being implemented for contaminated groundwater at Dunn Field.

1.4.2.1 DDMT Groundwater IRA

DDMT has prepared a *Proposed Groundwater Action Plan*, Defense Depot Memphis, Tennessee (December 1994), in compliance with Section 117(a) of CERCLA, that identifies the preferred option for the IRA for the contaminated groundwater beneath Dunn Field. In addition to identifying the preferred IRA, the proposed plan identifies other remedial options in detail, solicits public review and comments, and provides information on how the public can be involved in the remedy selection process.

Data collected in the previously mentioned documents indicated the presence of volatile organic compounds (VOCs) and heavy metals in the Fluvial Aquifer, which is the uppermost aquifer at the site. Because the contaminated Fluvial Aquifer poses a potential threat to the deeper Memphis Sand Aquifer through a possible interconnection, it is considered as a potential threat to human health and the environment. Thus, DDMT is implementing a groundwater IRA to provide a quick response measure that will help prevent the possible contamination of the area's drinking water supply.

The groundwater IRA involves placing a series of containment wells along the leading edge of the plume. Pumping groundwater from these wells will draw down the Fluvial Aquifer water table, thus inducing a hydraulic barrier. This barrier will prevent further migration of the contamination plume.

Locating the leading edge of the plume and containing the plume will be achieved in the following manner:

- A groundwater recovery well will be installed onsite in the middle of the plume to determine aquifer characteristics.
- Additional monitoring wells will be installed to locate the western edge of the contaminant plume.
- Once the aquifer characteristics are determined and the leading edge of the plume is identified, additional groundwater recovery wells, which are located along the leading edge of the plume screened to the confining clay layer of the Memphis Sand Aquifer, will be installed as appropriate to contain the plume.

The groundwater and the associated contamination will be captured by the recovery wells (see Figure 1-1). The spacing and pumping rate of the wells will be such that the contamination should not move beyond the line of wells. Once the recovery wells are operating, the system will be checked frequently and any necessary adjustments made (including the installation of additional recovery wells if needed) to verify that the plume is contained.

DDMT will obtain a discharge permit to allow the groundwater pumped from the wells to be discharged into the T.E. Maxson Wastewater Treatment Plant (WWTP) publicly owned treatment works (POTW). The discharge permit will set maximum levels for groundwater constituent concentrations. If the extracted groundwater exceeds these limits, groundwater will be treated so that the limits are met before discharge.

Follow-on activities include monitoring the groundwater plume migration and response to the IRA. Once the plume has been characterized, subsequent action may be taken to provide long-term definitive protection, including remediation of source areas and potential dense nonaqueous phase liquid (DNAPL). To the extent possible, the interim action will not be inconsistent with, nor preclude implementation of, the expected final remedy.

A discussion of the range of alternatives evaluated and a more complete description of the scope and approach for implementing this IRA is in the *Proposed Groundwater Action Plan*. A public hearing was held on December 22, 1994, to present the Groundwater IRA, and preparation of the Record of Decision (ROD) is currently underway (February 1995). Implementation is planned to occur over a 1-year period. The system of recovery wells will be operated until the risk associated with the contaminants is reduced to acceptable levels or until the final remedy is in place.

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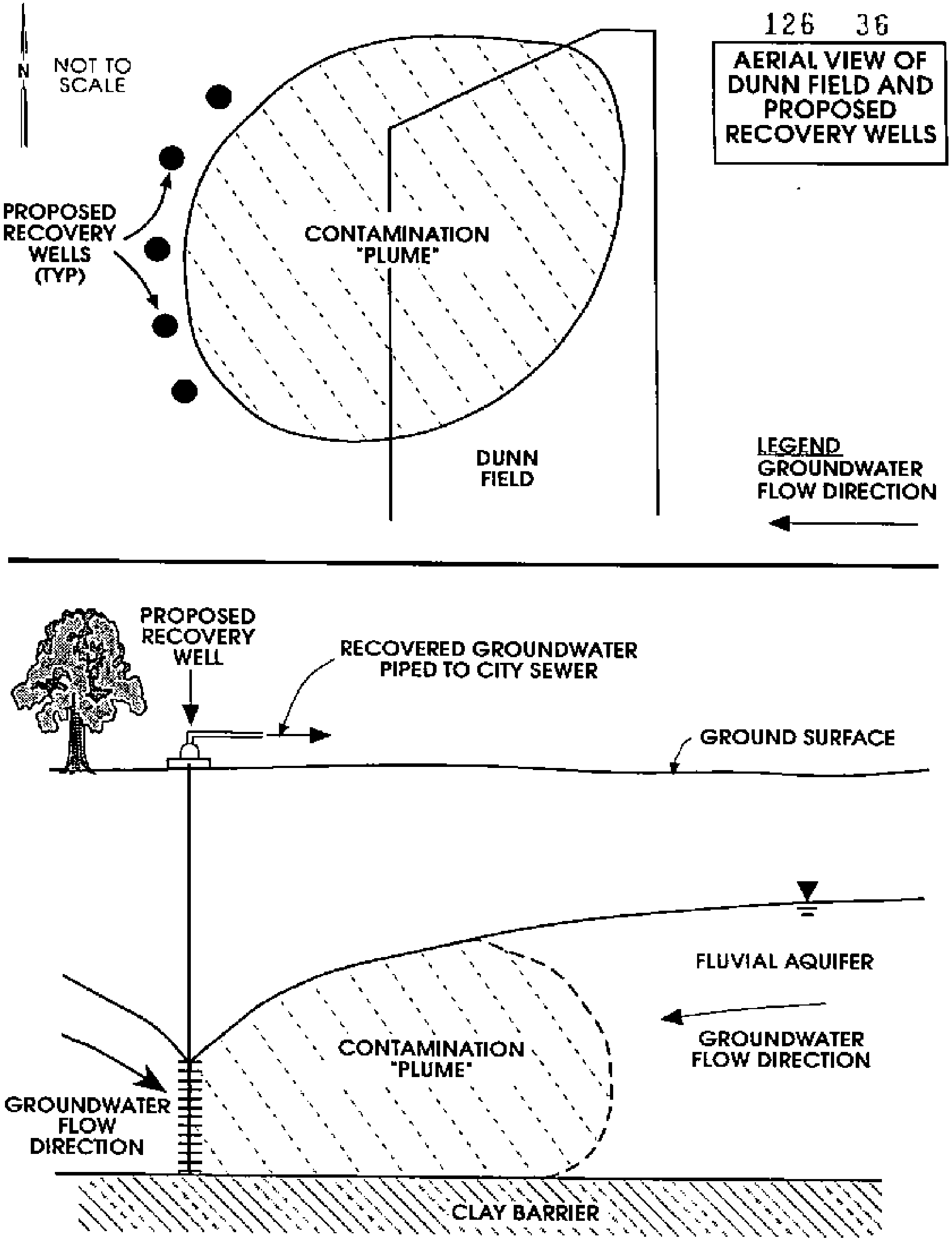

FIGURE 1-1
PROPOSED GROUNDWATER RECOVERY SYSTEM (OU-1)
Defense Depot Memphis, Tennessee

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1.4.3 Early Removals

The early removal process is proposed for selected sites at DDMT as an alternative to the traditional RI/FS/remedial design (RD)/remedial action (RA) process. The primary objectives of the early removal process are to begin cleanup of selected sites and to reduce program costs. Removal activity may involve the excavation of buried waste material and contaminated soils. The advantages of the early removal process include the following:

- In some cases removal of all contaminated materials may be possible so that risks are reduced, an extensive RI is not necessary, and the site can be recommended for NFA.
- By removing the source materials to minimize further migration of contaminants, the RI for the site may be better focused and reduced in scope.
- Cleanup occurs in a timely manner.
- Reduced overall remedial action costs may be realized due to reductions in the costs of studying the site and reductions in costs of performing the work now, instead of later when costs could be higher, especially where removal is ultimately expected to be the primary remedial action.

The approach involves evaluating sites using pre-established criteria to select sites for removal action. Assuming that early removal is a viable option, a ranking system was used as a guide to prioritize the sites for removal. Other factors that were considered include the ability to group sites into efficient contract packages, nominal cost to completely remove lower-ranking sites from the RI list, and ability to begin work more quickly in OU-1. The preliminary results showing early removal candidates are summarized in Table 1-2.

The methodology and recommended sites will be presented to EPA and TDEC in an action memorandum. Once the proposed sites are approved, activities to perform early removal will begin. These activities include performing an ARAR evaluation and an early removal design investigation, preparing an action memorandum and conducting a workshop with EPA and TDEC, preparing site-specific design documents and project control plans, providing services during construction, conducting confirmatory sampling, preparing a post-removal report, and providing decision documents for NFA where appropriate.

Table 1-2
Potential Site Candidates for Early Removal
Defense Depot Memphis, Tennessee

Grouping	Site Number[a]	Description	Potential Contaminants (based on site description/records)
OU-1	2/2/2	Ammonia Hydroxide (7 lbs) and Acetic Acid (1 gal.) Burial (1955)	Possibly metals
	3/3/3	Mixed Chemical Burial Site A (OT Dihydrochloride) (1955)	None expected to be hazardous
	4/4/4	POL Burial Site (13 55-gal. drums of oil, grease, and paint; date unknown)	VOCs, metals
	4.1/-/5	POL Burial Site (32 55-gal. drums of oil, grease and thinner) (1955)	VOCs, metals
	5/5/6	Methyl Bromide Burial Site A (3 cubic feet) (1955)	Methyl Bromide, VOCs
	8/8/9	Methyl Bromide Burial Site B (3,768 one-gal. cans) (1954)	Methyl Bromide, VOCs
	13/13/13	Mixed Chemical Burial Site B (mixed chemicals; acid, 900 lbs; detergent, 7,000 lbs; aluminum sulfate, 200 lbs; sodium)	Metals
	17/17/17	Mixed Chemical Burial Site C (1969)	Possibly VOCs, metals
	85/-/25	Old Pistol Range Building 1184/Temporary Pesticide Storage	Pesticides
	29/29/66	Former Underground Waste Oil Storage Tank (near Building 1086)	Pesticides/PCBs, PAHs, metals
Main Installation	87/-/64	DDT, Banned Pesticides (Building 1084)	Pesticides/PCBs, metals
	88/-/65	POL (Building 1085)	Pesticides/PCBs, metals, VOCs
Acid Sites	7/7/8	Nitric Acid Burial Site (1,700 bottles) (1954)	Metals
	11/11/11	Trichloroacetic Acid Burial Site (1,433 one-oz bottles) (1965)	VOCs, metals
	12/12/12	Sulfuric and Hydrochloric Acid Burial (quantity) (1967)	Metals
	16/16/16	Unknown Acid Burial Site (1969)	Metals
	16.1/-/18	Acid, date unknown	Metals

[a]a/b/c a = Current Site Number
b = RFA Site Number
c = RI Report (1990) number

1.4.4 Integrate the RI/FS Process: Early Identification of FS Alternatives

Initial screening has been performed to forecast the cleanup and remedial alternatives that may be appropriate so that the types of data necessary to determine if the alternative is feasible will also be identified. The RI investigation will be amended to include gathering the data necessary to expedite the alternative selection process. A preliminary list of alternatives and their data needs is found in Section 3 of this report.

1.4.5 Community Relations

DDMT will seek community participation and involvement throughout the environmental restoration process. DDMT recognizes the importance of maintaining adequate community relations, and has employed a specialist in the field to prepare and implement a community relations plan. Mailing lists are maintained, fact sheets are prepared and distributed, and public meetings and hearings are conducted. An Environmental Hotline (telephone number 901-775-4569) also has been established to provide easy access to the latest information about the restoration process. A Restoration Advisory Board, composed of community group leaders and concerned citizens, meets monthly to discuss issues of concern. In addition to these meetings, additional public meetings and hearings are planned. More information about the community relations activities may be found in the Draft Final Community Relations Plan (April 1994).

TAB

Section 2 - Site Background

2.0 Site Background and Setting

This section describes the environmental setting and geologic and hydrogeologic conditions that exist in DDMT's vicinity. A summary of previous investigations conducted as part of the DDMT environmental management program also is provided.

2.1 Site Background

2.1.1 Location

DDMT covers 642 acres of land in Memphis, Shelby County, Tennessee, in the extreme southwestern portion of the state. Approximately 5 miles east of the Mississippi River and just northeast of the Interstate 240—Interstate 55 junction, DDMT is in the south-central section of Memphis, approximately 4 miles southeast of the Central Business District and 1 mile northwest of Memphis International Airport. Airways Boulevard borders DDMT on the east and provides primary access to the installation. Dunn Avenue, Ball Road, and Perry Road serve as the northern, southern, and western boundaries, respectively. Figure 2-1 shows the installation's location within the Memphis area.

2.1.2 Mission

The DLA, an agency of the DOD, provides logistics support to military services. As a major field installation of the DLA, DDMT receives, warehouses, and distributes 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 include food, clothing, electronic equipment, petroleum products, construction materials, and industrial, medical, and general supplies. Approximately 4 million line items are received and shipped by DDMT annually; it ships about 107,000 tons of goods a year. In-stock inventory at DDMT is worth more than $1 billion. DDMT employs approximately 1,486 civilians and 9 military personnel; its annual payroll is $41 million (ref. 18).

The installation contains approximately 110 buildings, 26 miles of railroad track, and 28 miles of paved streets. It has about 5.5 million square ft of covered storage space and approximately 6.0 million square ft of open storage space. The land and buildings are owned by the U.S. Army and leased by DLA. Figure 2-2 illustrates proposed OU boundaries at DDMT. Study area land use, demographics, and land use controls are discussed in Section 2.4.

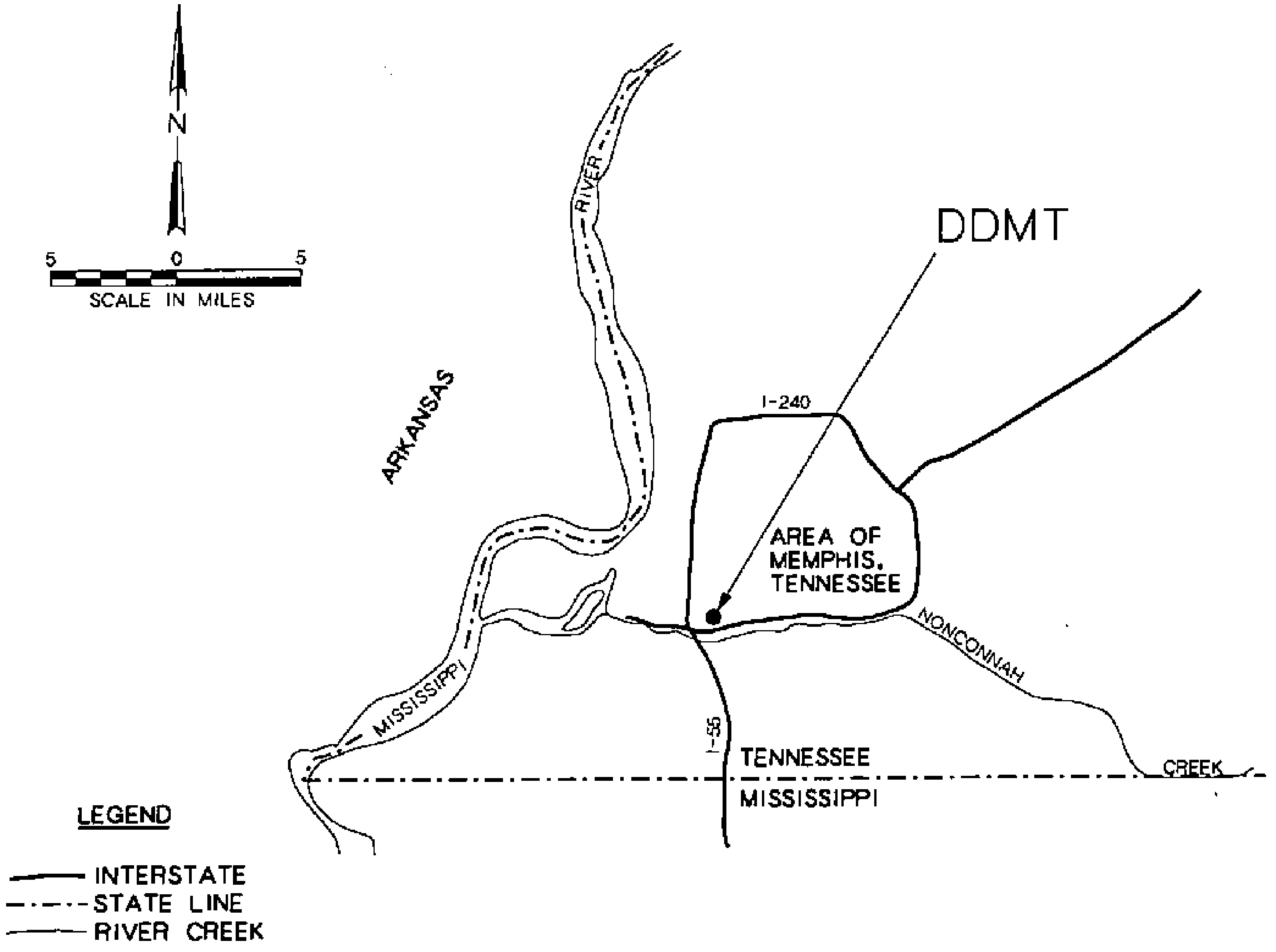

FIGURE 2-1
DDMT LOCATION IN MEMPHIS METROPOLITAN AREA
Defense Depot Memphis, Tennessee

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Source: Engineering-Science, 1993

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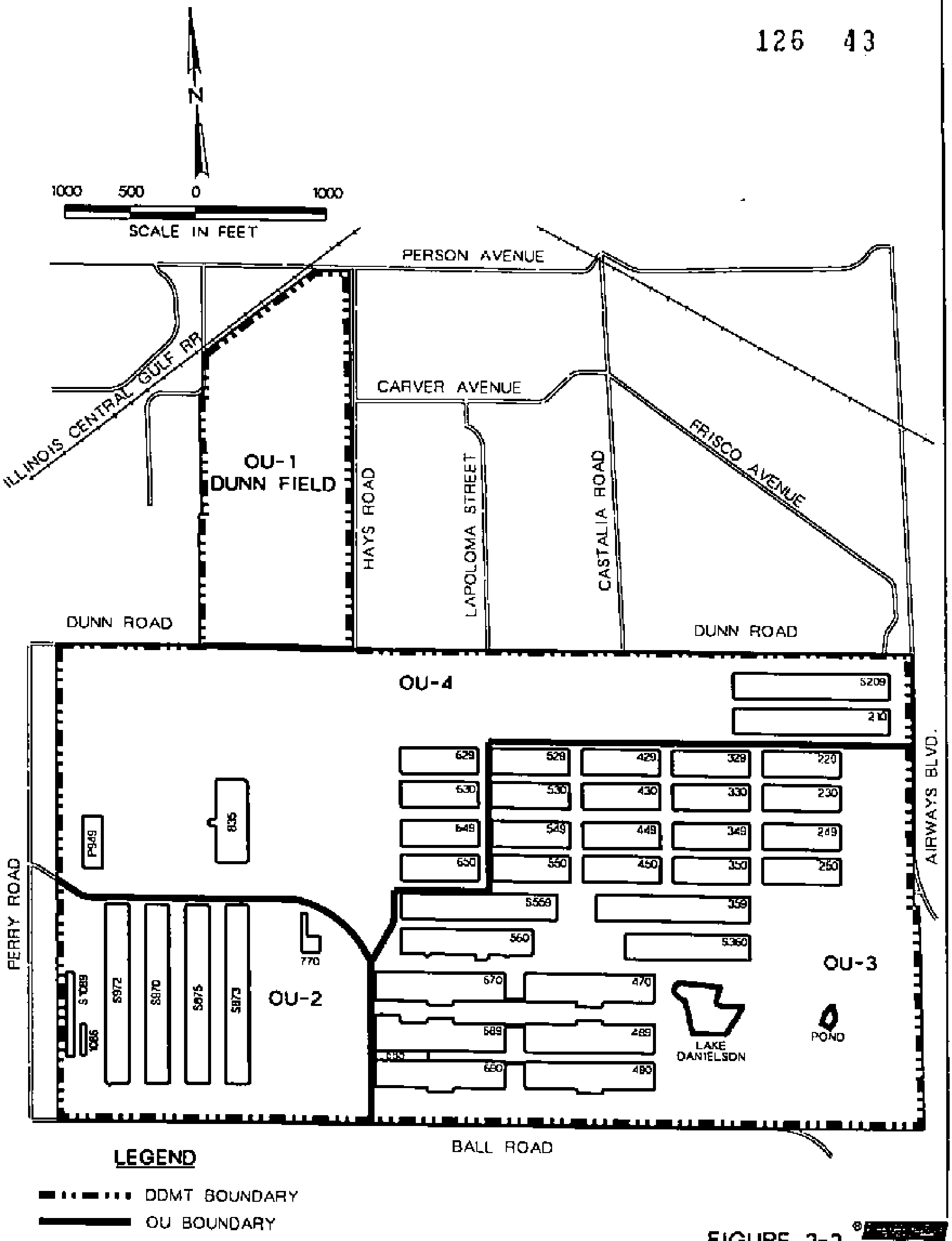

Source: Engineering-Science, 1993

FIGURE 2-2
OPERABLE UNIT LOCATIONS
Defense Depot Memphis, Tennessee

2.1.3 Past Activities at DDMT

Past activities at DDMT include a wide range of storage, distribution, and maintenance practices. Dunn Field (OU-1) has been used as a landfill area (northwestern quadrant), a storage area for mineral stockpiles (southwestern and southeastern areas), and a pistol range, and later as a pesticide storage area (northeastern area). Activities in the southwestern quadrant of the Main Installation (OU-2) have included hazardous material storage and recoupment (Building 873), sandblasting and painting activities (Buildings 1086 through 1089), and maintenance (Building 770). The southeastern portion of the Main Installation (OU-3) includes the bulk of the storage and distribution warehouses at DDMT. Other activities that are documented to have occurred in this area include PCB transformer storage (near Building 274), pesticide and herbicide storage and use (several locations), and fire truck pump testing (Lake Danielson). The northern portion of the installation (OU-4) has a history of the following major activities: hazardous material storage (several locations), treatment of wood products with pentachlorophenol (Building 737), and storage of items awaiting disposal (several locations). Additional information on past activities within each OU is provided in Section 2.3.

2.2 Previous Investigations at DDMT

In conformance with DLA environmental programs, a number of technical studies have been conducted at DDMT (all studies were performed for DDMT by the listed agency or consultant), including those described below. Appendix D contains data summary tables from the previous investigations listed.

2.2.1 Installation Assessment

In 1981, DLA and the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) conducted an installation assessment (IA) to identify previously used waste disposal areas and waste management practices pursuant to the 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. The study identified areas where hazardous materials might have been used, stored, treated, or disposed of at the site. On the basis of this assessment's findings, USATHAMA recommended that DLA conduct a field survey.

2.2.2 Geohydrologic Study

In 1982, the U.S. Army Environmental Hygiene Agency (USAEHA) conducted a geohydrologic study (ref. 51) to characterize the geohydrologic setting and to identify and monitor sources of potential groundwater contamination. The study identified two areas of the site as having the potential for groundwater contamination—Dunn Field and the Pentachlorophenol (PCP) Dip Vat. The study determined that, at that time, the Dunn

Field area had a greater potential for contamination than did the PCP Dip Vat. USAEHA installed, logged, and sampled six monitoring wells in the Dunn Field location.

2.2.3 Groundwater Monitoring

USAEHA performed groundwater sampling and analysis in 1986 on groundwater monitoring wells (MW)-3, 4, 5, 6, and 7 in Dunn Field. Groundwater samples were analyzed, using EPA Method 624, for volatile organic compounds (VOCs). The results indicated the presence of low-level contamination. The concentrations of all VOCs detected in the five wells ranged from 3 micrograms per liter (μg/L) to 200 μg/L. Trichloroethene (TCE) and tetrachloroethene (PCE) were the only VOCs detected in all five wells. The concentrations for TCE ranged from 4 μg/L to 150 μg/L, while concentrations for PCE ranged from 3 μg/L to 81 μg/L. Metals, pesticides/PCBs, and base/neutral acid (BNA) extractable organics also were analyzed, but were either not detected or were detected at levels below the applicable maximum contaminant levels (MCLs).

2.2.4 Environmental Audit

USAEHA conducted an environmental audit in 1985 of DDMT's waste management disposal practices. The audit revealed the presence of damaged containers of acids, bases, solvents, and cleaners in the vicinity of Building 873 (the area designated as Site 27). In addition, spill areas and potentially contaminated soil areas were identified adjacent to this building. As a result of the audit, DLA commissioned O. H. Materials Company, a contractor, to reclaim and repackage containers of usable goods in Building 873. Contractor personnel repackaged containers in the "Flammables Storage Area." Approximately 800, 55-gallon drums were recouped in this open storage area and then returned to their original location for storage and distribution.

2.2.5 PCP Dip Tank Investigation

O. H. Materials performed an investigation of the PCP Dip Tank Building (Building 737) in 1985, which revealed levels of chlorinated dioxins and furans. Chlorinated dioxins and furans are contaminants often produced in manufacturing the wood preservative PCP and other chlorinated organic compounds. Beginning in 1952, DDMT personnel treated wood products, especially pallets, in Building 737 with the product "Pol-Nu," which contains approximately 11 percent PCP.

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(Table removed during final comment resolution.)

DLA officials contracted with O. H. Materials in 1985 to place liquid waste product in containers, to remove containers from the site, to sample and investigate surrounding soils and building surfaces, and to remove contaminated soils as necessary to mitigate environmental and health hazards. An extensive sampling program also was undertaken to identify the amount and extent of contamination. The contamination was ultimately discovered to extend to depths below ground surface (bgs), thus requiring excavation.

Consequently, in August 1985, O. H. Materials initiated a cleanup of the PCP Dip Vat area, formerly located adjacent to the east side of Building 737. The contractor excavated to a depth of 10 ft, removing approximately 602 cubic yards (yd^3) of soil from under and adjacent to the dip vat building. The liquid PCP source of contamination was removed directly from the dipping vat. The contaminated soil was removed and disposed of with the approval of EPA, TDEC, and DLA, in accordance with the then current state and federal regulations.

The excavated area was backfilled with approximately 650 yd^3 of native soil backfill and covered with more than 489 tons of crushed rock (gravel). The excavated material (contaminated soil and debris) was packaged in a combination of 725 fiber drums (with overpacking by 55-gallon steel drums) and roll-off containers. This material was stored onsite in two separate staging areas (under approval granted by both the EPA and TDEC) until spring 1988, when it was transported and disposed of at an approved hazardous waste disposal facility.

2.2.6 Water Quality Biological Study

In 1986, USAEHA performed a water quality biological study (ref. 53) at DDMT. This study was conducted to investigate possible metal, pesticide, and other inorganic and organic contamination of Lake Danielson and Golf Course Pond waters, sediment, and associated fish species. The major finding from the water analysis was the presence of dichlorodiphenyltrichloroethane (DDT) in the storm water influent site to Lake Danielson.

Lake Danielson sediment analysis results indicated that several metals (cadmium, chromium, copper, lead, and zinc) and pesticides (chlordane and DDT) were effectively bound up in the sediments.

Worst-case fish tissue samples were as follows: 23.64 milligrams per kilograms (mg/kg) DDT + breakdown products in Lake Danielson, while the Food and Drug Administration

(FDA) action level was 5 mg/kg; for chlordane, 2.13 mg/kg were in Lake Danielson and 0.6 mg/kg in the pond, and the FDA action level was 0.3 mg/kg. PCBs and chlorpyrifos (Dursban®) also were detected in the fish tissue samples. The result of this study was a recommendation to place these water bodies "off-limits" to fishing.

2.2.7 Remedial Investigation/Feasibility Study

In 1989-90, DDMT initiated an RI/FS investigation of several known and suspected sources of contamination. This study was performed by Law Environmental through a contract with the CEHND. The final work plan for this effort was provided to EPA in April 1989. 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 *Remedial Investigation Report* was provided to EPA in August 1990, and the final *Feasibility Study Report* 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.

2.2.8 RCRA Facility Assessment

In January 1990, EPA Region IV conducted an RFA at DDMT through a contract with A. T. Kearney, Inc. The RFA identified 49 SWMUs and 8 AOCs at the site. Of these, 12 SWMUs and 4 AOCs required no further action. Twenty-eight SWMUs and 3 AOCs required further investigation in the form of confirmatory sampling and analysis. Four SWMUs and one AOC were identified as needing RFI characterization. On September 28, 1990, EPA and TDEC issued a RCRA Part B Permit to DDMT, No. TN4 210 020 570, under the Solid Waste Disposal Act, as amended by the RCRA of 1976.

2.2.9 Interim Groundwater Contamination Remediation

As requested by EPA, DDMT has proposed an Interim Remedial Action (IRA) to treat groundwater beneath Dunn Field to initiate cleanup before selecting the final remedial action. The IRA is discussed in detail in Section 1.4.3.

2.2.10 Groundwater Monitoring Study

In 1993, Environmental Science & Engineering, Inc. (ESE), performed a groundwater monitoring study using existing monitor wells at DDMT. The study was conducted to assess changes in groundwater quality since the completion of the RI/FS in 1990. Groundwater samples were collected from 35 existing monitor wells on- and offsite. The results indicated that all parameter concentrations above the federal and State of Tennessee MCLs were detected within the Fluvial (upper) Aquifer. The Memphis Sand Aquifer wells (MW-36 and MW-37) contained only one parameter that exceeded the listed MCLs. Groundwater from MW-37 contained a total lead concentration of 5.7 μg/L (MCL_{lead} = 5μg/L).

2.2.11 Other Studies

DDMT and supporting government agencies and contractor staff reviewed additional studies for the purpose of providing useful background to specific sites by understanding past use, data collected, results, and other pertinent information as it relates to an RI. These additional studies were used in support of the RI Report (ref. 18) and include the following general categories:

- Industrial hygiene
- Facility planning
- Regulatory compliance consultation
- Surface water quality
- Groundwater quality
- Waste management assessment
- Hazardous waste remediation

A list of these studies is provided in Appendix C.

2.3 Description of Operable Units

The general criteria used to define the four OUs (shown in Figure 2-2) are listed in Section 1.1. A brief description of each OU is provided in this section, including a qualitative assessment of past sampling activities. Detailed site descriptions, sample locations, and quantitative sampling results are provided in the OU-specific FSPs. A coordinated list of the sites is presented in Table 1-1. Table 1-1 also contains the sites identified in the RCRA Permit as "TDEC Lead" sites, which are sites regulated by the State of Tennessee's portion of the RCRA Permit. The table contains three numerical designations:

- The RI/FS site number
- The RFA SWMU number
- The site number

These numbers are necessary to coordinate the existing two lists (RFA and RI/FS) into one list (Site). For future reference, only the Site Number will be used. As previously stated, the sites were grouped into OUs, screening sites, and NFA sites at a meeting between DDMT, TDEC, and EPA in January 1993. Sites designated for early removal were agreed upon by these same parties in January 1995.

Brief discussions about the known extent of soil, groundwater, and surface contamination are included in Sections 3.1.1, 3.1.2, 3.1.3 and 3.1.4. The locations of the OUs are illustrated in Drawing 1 (OU-1, all sites at Dunn Field) and in Drawing 2 (OUs-2, 3, and 4).

2.3.1 OU-1 – Dunn Field

Dunn Field is an open, unpaved area located north of the Main Installation and is separated from the installation by Dunn Road. Dunn Field is the only known and documented burial area on DDMT. Dunn Field was established as OU-1 because of its geographic separation and because most of the sites are burial sites that may require similar investigation techniques. Details on the investigation of the sites at OU-1 will be described in the FSP.

Installation records indicate that various types and quantities of wastes were buried in the northwestern corner of Dunn Field. Each burial site within Dunn Field is described in detail in the OU-1 FSP. OU-1 includes 36 sites from the SWMU and RI/FS lists. Of these, 25 are known sites where burial of wastes has been documented by DDMT, documented in other environmental studies, or discovered during the RI Report (ref. 18) field investigations. These locations, which have been recorded by DDMT over the years using dimensions known from landmarks, were summarized in the RFA (ref. 68).

Groundwater monitoring wells were installed into the uppermost (fluvial) aquifer in this area by the USAEHA in 1982 and by Law Engineering during the RI from 1989 through 1990. Groundwater monitoring data collected during the RI and presented in the RI Report (ref. 18) have shown levels of VOCs and metals that suggest a release has occurred from this area. The individual source or sources of the release has not yet been determined.

2.3.2 OU-2 – Southwestern Quadrant of Main Installation

OU-2 is geographically located in the southwestern quadrant of the Main Installation of DDMT and is further characterized primarily as an industrial area where maintenance and repair activities have taken place. The boundaries of OU-2 were defined primarily because of the geographic proximity of the sites and the similar nature of activities that occurred. OU-2 includes the following four key areas:

- The former hazardous materials recoupment area (Building S-873), designated as Site 27
- The sandblasting waste accumulation area, designated as Site 32, and associated Buildings 1084, 1085, and 1089 (Sites 87, 88, and 89)
- The underground oil storage tanks at Building 770, designated as Site 34
- The former underground waste oil storage tank, designated as Site 29

2.3.3 OU-3—Southeastern Watershed

The boundaries of OU-3 were determined because of its geographic location, and to encompass the entire southeastern watershed. OU-3 contains the only surface water bodies on DDMT, so it was desirable to keep the majority of the sampling and analysis associated with surface water and sediments in the same OU. OU-3 includes the following:

- Golf Course Pond (Site 25)
- Lake Danielson (Site 26)
- The former transformer storage area (Site 48)
- Pad 267 (Site 58)
- Building T-273 (Former Pesticide Storage Area) (Site 59)

Past studies of Lake Danielson and the Golf Course Pond have shown that the surface water, sediment, and fish in these water bodies exhibit pesticides and PCBs. The OU-3 investigation will address the storm water runoff from the surrounding industrial and recreational facilities, which may be the source of contaminants identified in the two surface water bodies.

2.3.4 OU-4—North-Central Area

OU-4 is located in the north-central section of the Main Installation at DDMT. Activities in OU-4 are primarily associated with materials storage. The most prominent feature of this OU is the former main hazardous materials storage building (Building 629) at DDMT, designated as Site 57. Pesticides, polynuclear aromatic hydrocarbons (PAHs), and VOCs were detected during the RI (ref. 18) near Site 57. The geographical area of OU-4 also contains the former PCP Dip Vat area sites (near Building 737). In addition, this OU is located in the general area of the installation where a data gap exists concerning the confining unit that separates the Fluvial Aquifer from the Memphis Sand Aquifer, which is discussed in Section 2.4.6.2. The boundaries of OU-4 were determined because of the types of activities that occurred regarding material storage, the central location of the area, and the requirement to fill the data gap regarding information on the confining unit between the Fluvial and Memphis Sand Aquifers.

2.3.5 Screening Sites

The screening sites are sites identified in the RFA (ref. 68) and the RI Report (ref. 18) that appear to have been areas where hazardous materials were managed and where there is a potential for release to have occurred, minor waste disposal areas during past operations or, based on historical records, have less potential for contamination than sites placed into the OUs described above. A wide variety of sites are included in this category: storm water drainage ditches, fuel storage areas, known and suspected spill areas, areas where hazardous substances were used and may have been released, and areas where pesticides had been applied (railroad tracks and vegetation). A brief discussion of the known extent of contamination for some sites is provided in Sections 3.1.1 and 3.1.3. A complete description of each of these sites will be provided in the Screening Sites FSP. Conclusions regarding screening sites will be included in each OU RI Report.

2.3.6 TDEC Lead Sites

The "TDEC Lead" sites, designated in Appendix A-3 of the DDMT RCRA Part B Permit (No. TN2 210 020 570) as sites regulated by the State of Tennessee's portion of the RCRA permit, are shown in Table 1-1 with a footnote. These sites are indicated in Drawing 2.

2.3.7 No Further Action Sites

Table 2-1 contains a summary of proposed NFA sites. A total of 17 sites are proposed for NFA for one or more of the following reasons:

- Solid wastes were never managed or disposed of at the site.
- The site is not a threat for releases because of past waste management activities.
- Previous sampling results have shown no observed contamination.
- Extensive prior removal or remediation activities were conducted.
- Current operational and structural features make NFA probable.

A separate NFA report will be prepared by DDMT for regulatory approval that documents the available information on these sites and the rationale for the NFA determination. The NFA report will be submitted per the FFA schedule.

2.4 Site Physical Characteristics

Physical information for the study area was obtained from published sources (refs. 17, 18, 20, 50, 54, and 55). The available data review focused on background information relative to the nature and extent of contamination, as well as on previous remedial response actions initiated by DLA. The hydrogeologic and environmental quality data collected as a result of earlier studies were particularly useful in providing a frame of reference for this pre-RI discussion.

Table 2-1
Proposed No Further Action Sites
Defense Depot Memphis, Tennessee

Site Number[a]	Previous Location	Description	Current Disposition
18/18/–	OU-1	Plane Crash Residue (Dunn Field)	NFA[b]
22/22/19	OU-1	Hardware Burial Site (Nuts and Bolts) (Dunn Field)	NFA
23/23/30	OU-1	Construction Debris and Food Burial Site (Dunn Field)	NFA
63/–/28	OU-1	Fluorspar Storage (SE Quadrant of Dunn Field)	NFA
86/–/29	OU-1	Food Supplies (Dunn Field)	NFA
30/30/–	OU-2	Paint Spray Booths (2 of 3 total; Bldgs. 770 and 1086)	NFA
40/40/–	OU-2	Safety Kleen Units–5 of 9 total (All located in Bldg. 770)	NFA
41/41/–	OU-2	Satellite Drum Accumulation Areas–2 of 4 total (vicinity Bldg. 770)	NFA
47/47/–	OU-2	Former Cont. Soil Drum Storage Area (300 ft W of Bldg. 689, removed 1988)	NFA
30/30/	OU-3	Paint Spray Booths (1 of 3 total–Bldg. 260)	NFA
40/40/–	OU-3	Safety Kleen Units–4 of 9 total units (Bldgs. 253; 469; 490; 689)	NFA
41/41/–	OU-3	Satellite Drum Accumulation Areas–2 of 4 total areas (Bldgs. 469; 260)	NFA
49/49/46	OU-3	Medical Waste Storage Area	NFA
41/41/–	OU-4	Satellite Drum Accumulation Area–1 of 5 total (Bldg. 210)	NFA
44/44/56	OU-4	Former Wastewater Treatment Unit Area	NFA
45/45/56	OU-4	Former Contaminated Soil Staging Area	NFA
53/AOCD/61 and 62	OU-4	X-25 Flammable Solvents Storage Area (Near Bldg. 925)	NFA

Note: [a]a/b/c a = RF/FS Site Number
b = RFA SWMU Number
c = RI Report (ref. 18) Number
[b]NFA = No Further Action

2.4.1 Geographic/Topographic Setting

DDMT's surface features (natural and man-made) and DDMT's relationship to surrounding areas were investigated by onsite visual reconnaissance, U.S. Army Corps of Engineers (COE) historical (comparative) aerial imagery, U.S. Geological Survey (USGS) 7.5 Minute Series Topographic Quadrangle maps, and installation topographic maps prepared by the COE, Mobile District, dated February 1989. Figure 2-3 shows the topographic features of DDMT and surrounding areas. DDMT is divided into two areas, Dunn Field and the Main Installation, each with its own distinct land surface and use-related features.

Dunn Field lies just north of the Main Installation and Dunn Avenue, and consists of approximately 64 acres of undeveloped land. Most of Dunn Field is unpaved. About one-half the area is grassed; the remaining area contains crushed rock and paved surfaces. A few large deciduous trees are present in the northeastern part of the field. The southwestern quadrant of the field is a grassed, gently sloping area. The southeastern quadrant is a level zone used for both covered and uncovered bulk materials storage (bauxite, fluorspar, and electrical wires).

Dunn Field's topography is a level-to-gently rolling terrain. The land appears to slope to the west from the bauxite piles in the center of the field. An arc-shaped ridgeline separates the field's two northern quadrants. In the northeastern quadrant of the field, the areas surrounding the former pistol range (later used as a pesticide/herbicide storage shed [Building 1184]) and the former burn area are level and grassed. The northwestern quadrant of the field (the waste, chemical, and hazardous materials disposal zone) is a level-to-gently sloping grassed area. Surface elevations range from a low of 273 ft, National Geodetic Vertical Datum of 1929 (NGVD), at the north outfall/installation boundary fenceline to 315 ft NGVD in the field's approximate center. Maximum local relief is about 25 ft at the pistol range bullet stop.

The Main Installation consists primarily (approximately 57 percent) of developed land. Most of the Main Installation's land area has been graded, paved, and built up. Some of the few remaining unpaved areas are used for open storage of various materials and equipment. The only significant grassed, treed area is the golf course, located in the Main Installation's southeastern sector. The Main Installation's topography is nearly level. Surface elevations range from approximately 316 ft NGVD in the Defense Reutilization and Marketing Office (DRMO) storage yard adjacent to Dunn Avenue to 267 ft NGVD in the low area below Lake Danielson's earthen dam. Maximum local relief is approximately 20 ft, measured across the lake's earthen dam.

2.4.2 Meteorology

Information describing study area meteorological conditions was obtained from various USGS reports and from the Climatic Atlas of the United States, National Oceanic and Atmospheric Administration (NOAA), 1983 (ref. 31).

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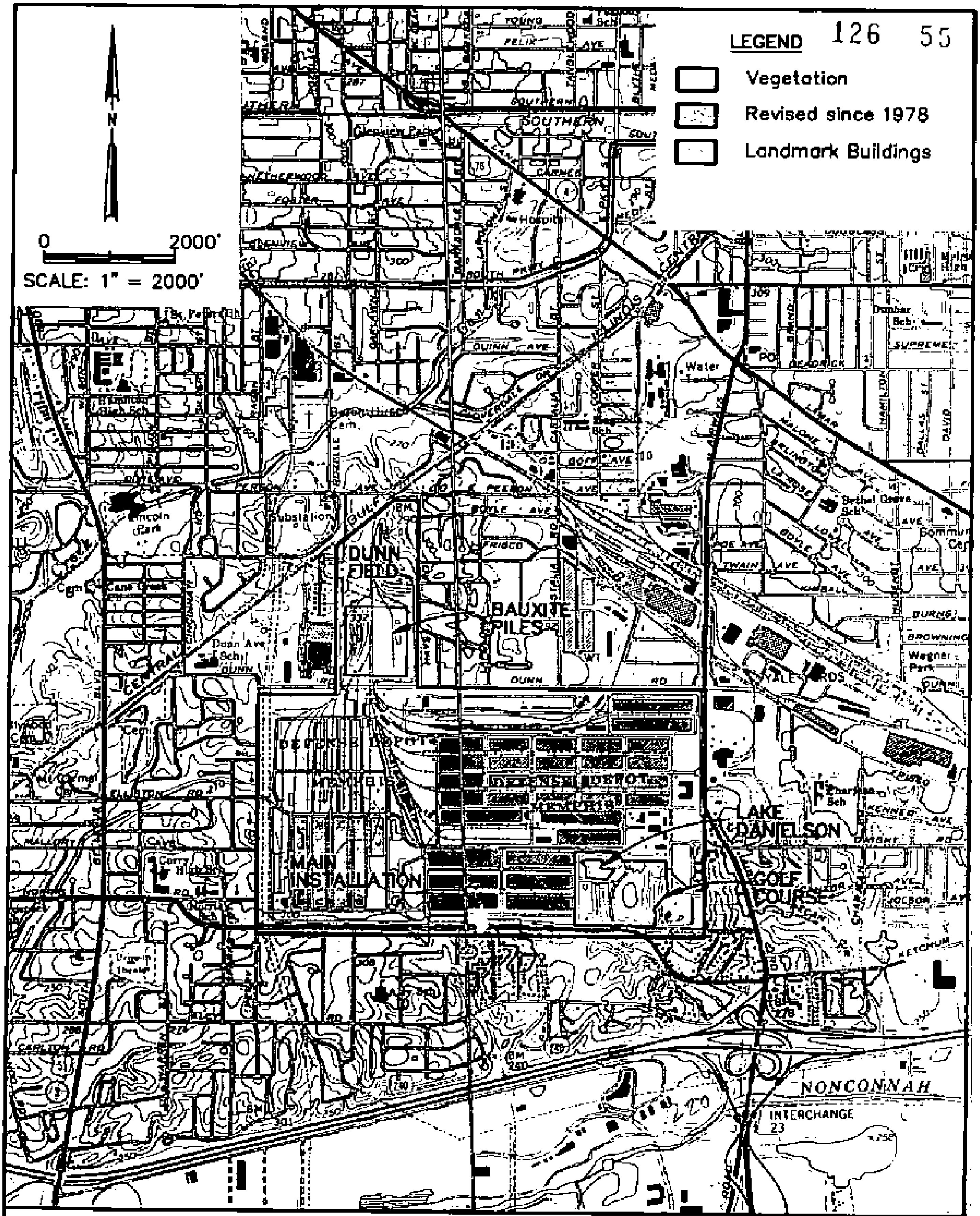

Source:: USGS 7.5 Series Topographic Quadrangle Maps - South West Memphis Tenn. - Ark. and Southeast Memphis, Tenn..

FIGURE 2-3

SURFACE TOPOGRAPHY OF DDMT AND SURROUNDING AREA OF MEMPHIS, TENNESSEE
Defense Depot Memphis, Tennessee

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DDMT is located in the west Tennessee Climatic Division of the United States (ref. 31). This Division experiences a typical continental type of climate with humid, warm summers and cold winters. The Memphis area receives an annual average of 50 inches of precipitation (30-year period of record). Total annual rainfall was reported to vary from 30.54 inches (1941) to 76.85 inches (1957). Normally, precipitation is heaviest during the winter and early spring. A second, less significant rainfall period develops as thundershowers during late spring and early summer. The 1-year, 24-hour rainfall value for the study area is reported to be 3.4 inches in the *Rainfall Frequency Atlas of the United States* (ref. 74).

The net annual precipitation available for groundwater recharge, which is derived from gross annual precipitation less evaporation and runoff, estimated for the Memphis area is 9 inches, based on NOAA (ref. 31) data. The estimate of net precipitation does not consider evapotranspiration, which varies considerably according to season. The estimate was performed in a manner consistent with 40 CFR Part 300, Appendix A, during the RI (ref. 18).

2.4.3 Surface Water Hydrology

The following section describes storm water drainage at DDMT, surface waters, and the potential for floods.

2.4.3.1 Installation Storm Water Drainage

Installation surface drainage is accomplished by overland flow to swales, ditches, concrete-lined channels, and an efficient storm drainage system. Figure 2-4 illustrates the study area's surface drainage features, installation drainage areas, outfalls, and local streams.

Most of DDMT is generally level with, or above, surrounding terrain; therefore, DDMT receives little or no runoff from adjacent areas. Where exposed, undisturbed installation surface soils are predominantly grassed, fine-grained, semi-cohesive materials, which tend to promote large volumes of rapid runoff. Paved and built-up sections of the installation also tend to generate significant amounts of runoff.

Most Dunn Field drainage is achieved by overland flow to the adjacent properties to the north and west. The northeastern quadrant drains east to a concrete-lined channel, or to adjacent properties to the north. The concrete-lined channel consists of two separate segments that join approximately 200 ft north of Building 1184. Both channel segments convey adjacent residential neighborhood storm water through the northeastern quadrant of Dunn Field. The concrete-lined channel directs flow northward to Cane Creek, a tributary of Nonconnah Creek.

The Main Installation's surface drainage is achieved by overland flow to a storm drainage system. The Main Installation has been divided into several small drainage basins (Figure 2-4). The primary drainage directions and outfall locations are to the west (Tarrent Branch), to the east (unnamed ephemeral stream), and to the south (unnamed ephemeral stream). Surface drainage is directed via these alignments to Nonconnah Creek, approximately three-quarters of a mile south of DDMT. Nonconnah Creek drains into Lake McKellar, a Mississippi River tributary.

2.4.3.2 Installation Surface Waters

The ditches, channels, or drainage alignments within DDMT's boundaries convey seasonal (or wet weather) flow. Frequently, they are completely dry. Two permanent surface waters exist at DDMT and are illustrated in Figure 2-4. The largest body of water is Lake Danielson, about 4 acres in size. Lake Danielson receives a significant amount of installation storm water runoff, primarily from the area in which Buildings 470, 489, 490, 689, and 690 are located. Lake overflow is discharged through a drop inlet at the dam through a concrete-lined channel, to the culvert extending beneath N Street and Ball Road. The smaller water area is the Golf Course Pond. It receives runoff from the surrounding golf course, Buildings 249, 250, 251, 265, 270, 271, and the south parking lot. Pond overflow is directed to a culvert extending beneath N Street and Ball Road. Storm water flow is then directed to Nonconnah Creek via unnamed tributaries.

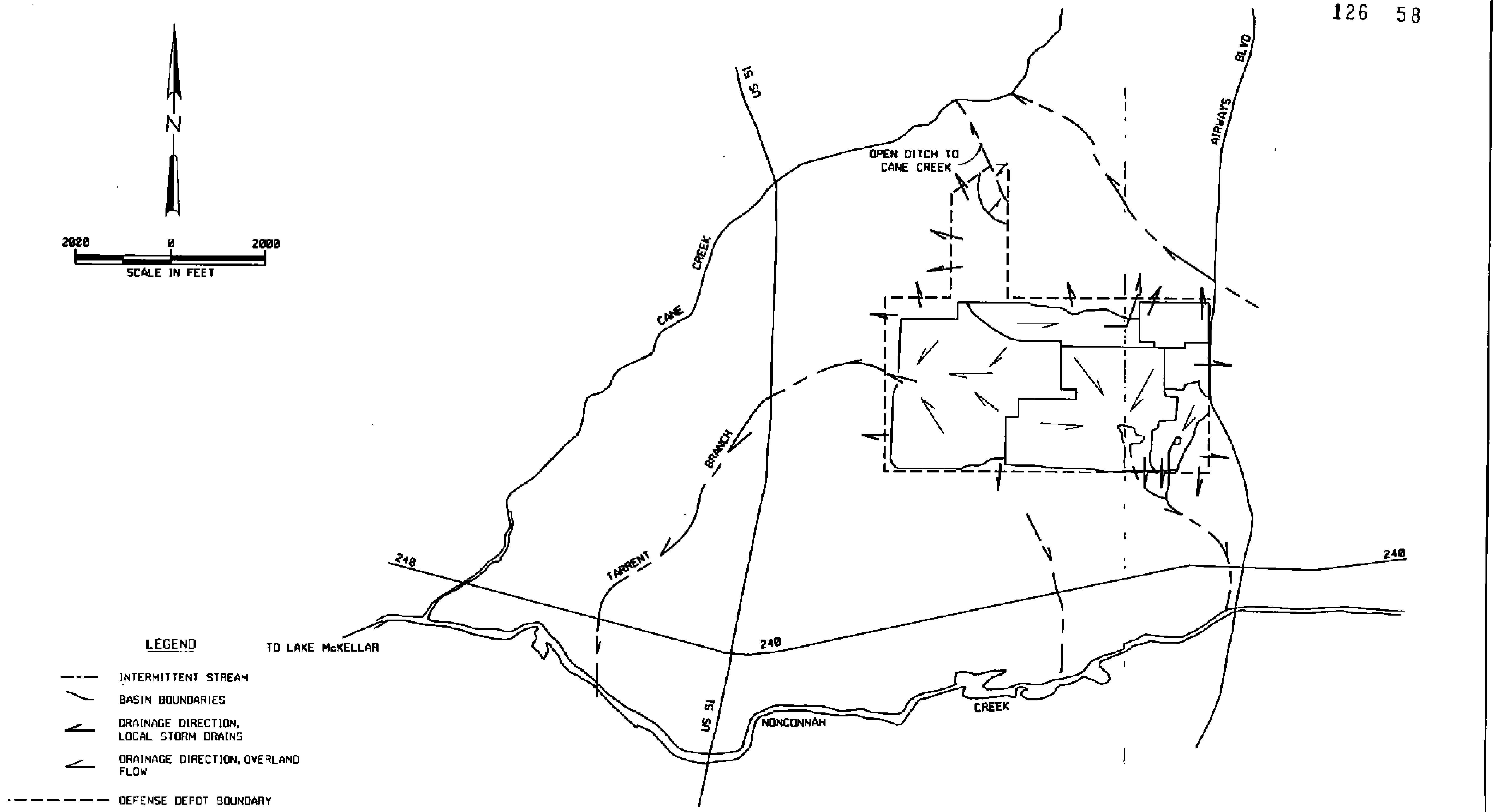
2.4.3.3 Classification of Surface Waters

The DDMT facility has two main surface water features: Lake Danielson and the Golf Course Pond. These waters are currently off-limits for recreational purposes and serve primarily as drainage reservoirs. Drainage channels on the facility and in neighboring areas drain either to Cane Creek, northwest of DDMT, or to Nonconnah Creek, south of DDMT. Cane Creek also drains to Nonconnah Creek at a point several miles southwest of DDMT. In turn, Nonconnah Creek empties into Lake McKellar.

Tennessee Water Quality Standards define uses of waters that are in the public interest. The uses for waters include the following:

- Sources of water supply for domestic and industrial purposes
- Propagation and maintenance of fish and other desirable aquatic life
- Recreation in and on the waters
- Stock watering and irrigation
- Navigation
- Generation of power
- Enjoyment of scenic and aesthetic qualities of waters

Under the Tennessee Water Quality Control Act, when waters are classified for more than one use, the most stringent criteria will be applicable. In addition, waters



SOURCE: MODIFIED FROM DDMT, 1982. DRAFT SPILL PREVENTION, CONTROL AND COUNTERMEASURES PLAN.
MODIFIED FROM HARLAND, BARTHOLOMEW & ASSOCIATES, INC., 1988. MASTER PLAN REPORT, DDMT.
MODIFIED FROM DDMT, 1992. NPDES STORM DRAINAGE SAMPLING MAP, DRAWING NUMBER 45-90.

Source: RI Report, 1990

FIGURE 2-4
STUDY AREA SURFACE DRAINAGE
Defense Depot Memphis, Tennessee

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designated as wet weather conveyances (natural watercourses) shall be protective of wildlife and humans that may come in contact with them and shall maintain standards applicable to all downstream waters.

Nonconnah Creek and Cane Creek have been classified for the following stream uses: propagation of and maintenance of fish and other aquatic species, livestock and wildlife watering, and irrigation. In addition, the portion of Cane Creek flowing near the DDMT facility is classified for recreation. The most stringent applicable criteria protects fish and aquatic life and states that the waters shall not contain toxic substances that cause death or serious illness to aquatic biota, and reference criteria promulgated under the Clean Water Act and Safe Drinking Water Act (ref. 47).

2.4.3.4 Flood Potential

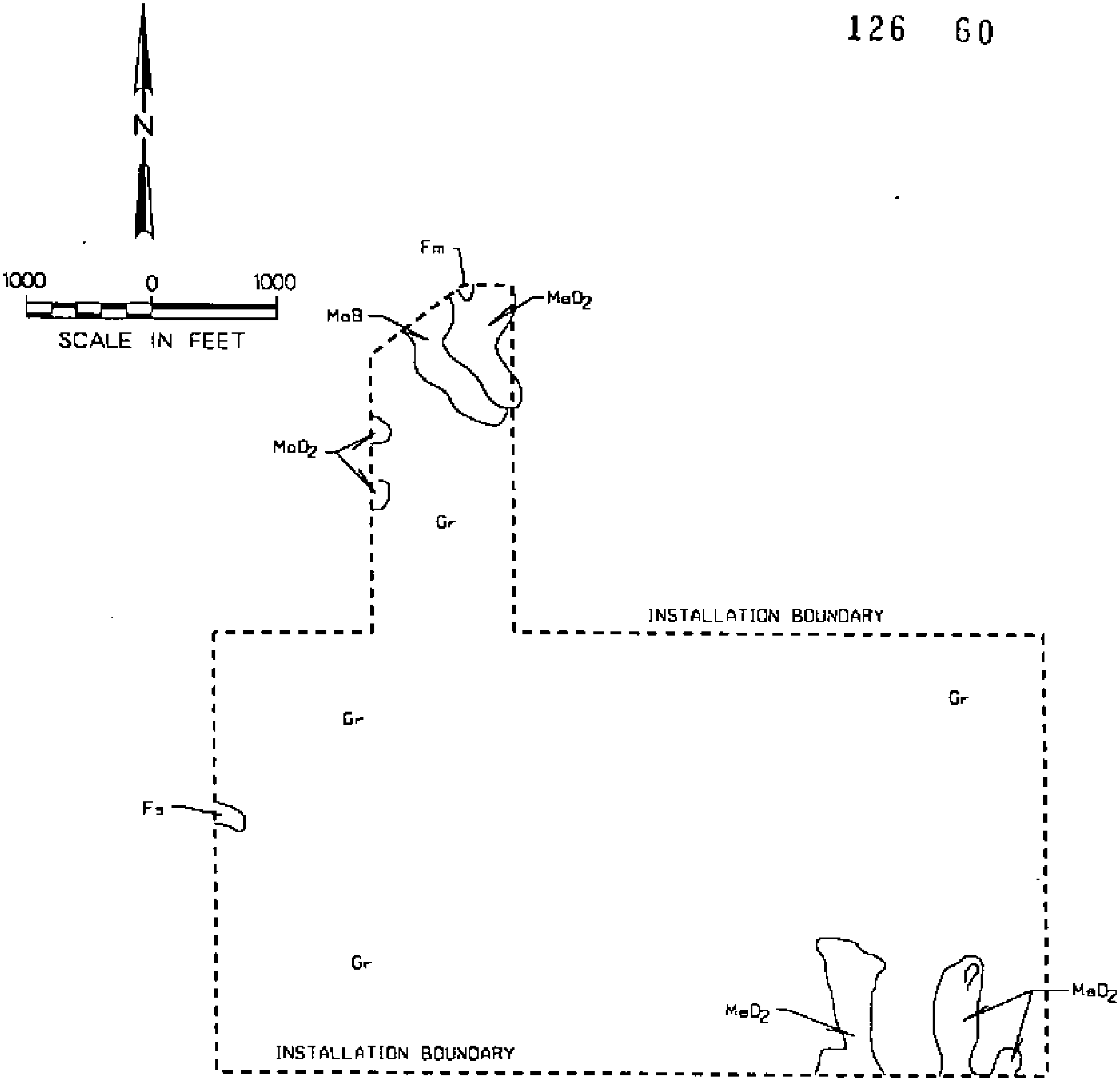
DDMT's surface elevations (276 to 316 ft NGVD) are well above the average Mississippi River alluvial valley flood levels (185 to 230 ft NGVD). Furthermore, the installation's land mass is at least equal to, or slightly higher than, adjacent properties. Therefore, it is unlikely that any installation property would be subject to inundation, even for short periods of time. During the performance of Phase I field data collection activities for the RI Report (ref. 18), the study area received 6 inches of continuous precipitation during the weekend of February 18 and 19, 1989. Despite the intense, sustained rainfall, no installation areas flooded.

2.4.4 Surface Soils

According to information furnished by the U.S. Department of Agriculture, Soil Conservation Service (1970), five distinct surface soil units have been mapped in the study area. The distribution of these units relative to the installation is illustrated in Figure 2-5. A brief description of each unit follows:

- **Falaya Silt Loam (Fm).** This soil unit may have originally developed as a narrow strip of alluvium occupying a bench above a stream channel. The unit has been mapped on a small portion of northern Dunn Field. It is generally described as a silt loam, with poor-to-moderate drainage, and possessing a shallow water table and typically low-to-moderate permeabilities.

- **Filled Land-Silty (Fs).** This soil unit has been artificially developed as a result of backfilling a small portion of the Main Installation's west boundary. It consists of a mixture of generally silty soils. Unit characteristics are estimated to include poor-to-moderate drainage and low permeabilities.



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Fm	FALAYA SILT LOAM
Fs	FILLED LAND-SILTY
Gr	GRADED LAND
MeB	MEMPHIS SILT LOAM
MeD_2	MEMPHIS SILT LOAM

Source: Modified from USDA, Soil Conservation Service, 1970

FIGURE 2-5
STUDY AREA SURFACE SOILS
Defense Depot Memphis, Tennessee

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- **Graded Land (Gr).** This soil unit has been artificially developed from silty native upland materials as a result of numerous site-use modifications throughout the installation's operational history. The unit generally consists of silty sandy clay or clayey sandy silt, and its permeability is reported to be highly variable. It is significant to this study because it occupies more than 90 percent of the installation's land area. Forty-seven of the surface soil samples collected during the RI (ref. 18) were taken from this unit.

- **Memphis Silt Loam (MeB).** This unit has developed in silty native upland materials on low hilltops, benches, and adjacent gradual slopes. The unit is described as a silt loam or silty clay loam. It is well-drained and possesses low-to-moderate permeabilities. This unit is significant because of its location in north Dunn Field with respect to burial areas.

- **Memphis Silt Loam (MeD2).** This unit has developed in silty native upland material on intermediate slopes and benches. It is described as a silt loam or a silty clay loam. It is deep and well-drained, and possesses low-to-moderate permeabilities. The unit is significant because of its Dunn Field location. Surface soil samples SS-12, SS-13, and SS-14 in the RI Report (ref. 18) were collected from this unit.

Table 2-2 summarizes the engineering use data for each soil unit mapped in the installation study area. USDA texture, Unified Soil Classification System symbols, estimated permeability, and likely use constraints are described for each of the five soil units.

2.4.5 Geology

This section discusses the general geology of the region and that of DDMT.

2.4.5.1 Regional Geology

Physiography. The Memphis, Tennessee, area straddles two major subdivisions of the Atlantic Coastal Plain Physiographic Province (Figure 2-6). Figure 2-7 shows a general geologic cross section of the Memphis area. The western Memphis urban area lies within the Mississippi Alluvial Plain subdivision, which is characterized by fluvial depositional features including young, recently deposited point bars, natural levees, and abandoned channels.

Table 2-2
Study Area Soil Units
Defense Depot Memphis, Tennessee

Map Symbol	Unit Description	USDA Texture (Major Fraction)	Typical Thickness (inches)	Unified Classification System (Major Fraction)	Permeability (Inches/Hour)	Construction or Use Constraints
Fm	Falaya Silt Loam	Silt loam or silty clay loam	60	ML, CL	0.63 to 2.0	Seasonal wetness and high water table; occasional flooding
Fs	Filled Land—silty	Silty fill (mixed)	36 to 60	ML	0.63 to 2.0	Uncertain
Gr	Graded Land	Silty sandy clay, clayey sandy silt	36	SP-SM, ML, CL	Varies	Uncertain
MeB	Memphis Silt Loam, 2.5 percent slopes	Silty loam or silty clay loam	108	ML, CL, ML-CL	0.63 to 2.0	Erosion potential
MeD2	Memphis Silt Loam, 8 to 12 percent slopes, eroded	Silty loam or silty clay loam	108	ML, CL, ML-CL	0.63 to 2.0	Slopes; severe erosion hazards

Source: Modified from USDA, Soil Conservation Service, 1970

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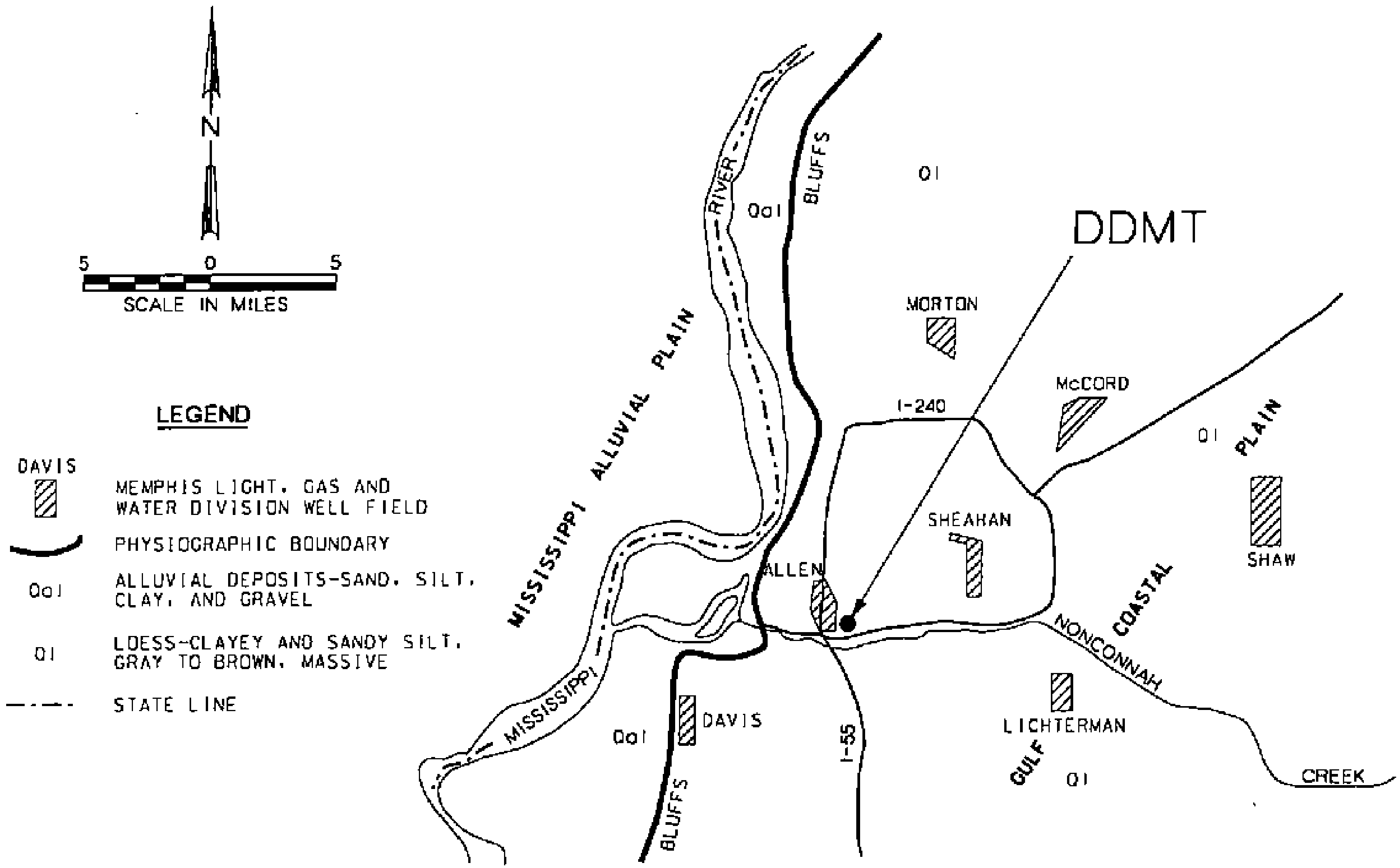

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FIGURE 2-6
GEOLOGIC MAP OF MEMPHIS AREA
Defense Depot Memphis, Tennessee

Source: Engineering-Science, 1993

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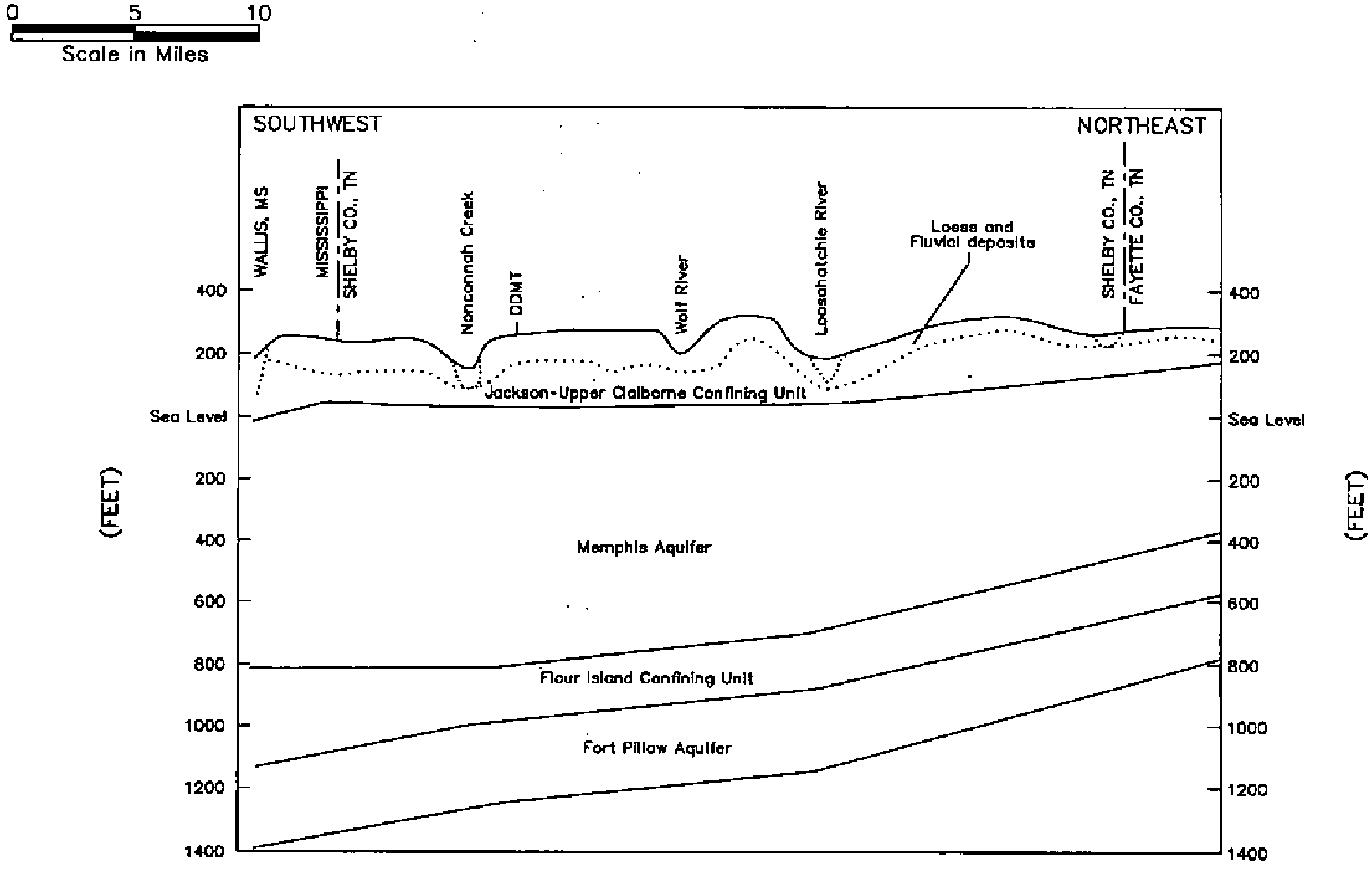

Source: Parks, 1990

FIGURE 2-7
GENERAL GEOLOGIC CROSS SECTION OF THE MEMPHIS AREA
Defense Depot Memphis, Tennessee

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DDMT and eastern Memphis are situated within the Gulf Coastal Plain subdivision. The area, characterized by dissected loess-covered uplands, generally lacks distinct features. The erosion-controlled land surface appears nearly level to markedly rolling, and the visual perspective offers little spatial variation. Local slopes range from level to approximately 10 percent. The study area elevations average 300 ft NGVD. Locally, relief is attributed to erosion or stream channel development and seldom exceeds 30 ft.

Generally, Gulf Coastal Plain drainage systems are well-developed, and the region is classified as being in a late youthful stage of dissection. The uplands tend to be low with respect to major streams, and the valley is relatively shallow. Most principal streams have low gradients and occupy broad alluviated and terraced valleys (Nonconnah Creek). Secondary streams have developed narrow V-shaped valleys in fine-grained soils.

Geologic Setting. The Memphis area is situated within a major structural feature termed the Mississippi embayment. This area is described as a youthful to mature, belted coastal plain. The principal river in the area is the Mississippi River; the major tributaries are the Wolf River, the Loosachatchie River, and Nonconnah Creek, according to Graham and Parks (ref. 11).

The Mississippi embayment is a structural reentrant extending into the North American craton from the Gulf of Mexico north to Cairo, Illinois. The embayment is a wedge-shaped, down-warped structure composed of stratified sediments. It begins inland as a thin accumulation of clastic materials, thickening substantially at the Gulf of Mexico. Late and post-Cretaceous strata fill the trough. Formation of the Mississippi embayment began in the latest Mesozoic with the onset of renewed subsidence of the underlying Reelfoot rift. The axis of the trough (N50°E) roughly parallels the current course of the Mississippi River. The embayment experienced its greatest subsidence during Early Tertiary time and has been tectonically stable since its emergence during the widespread uplift of the continent in Neogene time.

The New Madrid seismic zone (NMSZ) is located at the northern end of the Mississippi embayment and is the most seismically active area in the central and eastern United States. At least two great earthquakes occurred in this area in 1811 and 1812, and more than 2,500 microearthquakes have been recorded since 1974. Johnston and Nava (ref. 16) have estimated a recurrence interval for great earthquakes in the Memphis area to be 425 to 675 years, with a recurrence interval of 70 years for moderate earthquakes.

Geologic Units. Information describing major regional geologic units has been obtained from Wells (ref. 71), Moore (ref. 29), Nyman (ref. 33), and Graham and Parks (ref. 11). Table 2-3 summarizes the regionally important post-Cretaceous study area geologic units and their hydrologic significance. Figure 2-6 shows the major physiographic subdivisions in the Memphis area.

The Quaternary and Tertiary strata in the Memphis area are composed of loosely consolidated deposits of marine, fluvial, fluvioglacial, and deltaic sediments. In

Table 2-3
DDMT Study Area
Geologic Strata
Defense Depot Memphis, Tennessee

System	Series	Group	Stratigraphic Unit	Thickness (feet)[b]	Lithology and Hydrologic Significance
Quaternary	Holocene and Pleistocene		Alluvium[a]	0 to 175	Sand, gravel, silt, and clay. Underlies the Mississippi Alluvial Plain and alluvial plains of streams in the Gulf Coastal Plain. Thickest beneath the alluvial plain, where commonly between 100 and 150 ft thick: generally less than 50 ft thick elsewhere. Provides water to domestic, farm, industrial, and irrigation wells in the Mississippi Alluvial Plain.
	Pleistocene		Loess	0 to 65	Silt, silty clay, and minor sand. Principal unit at the surface in upland areas of the Gulf Coastal Plain. Thickest on the bluffs that border the Mississippi Alluvial Plain; thinner eastward from the bluffs. Tends to retard downward movement of water, thus providing recharge to the fluvial deposits.
Quaternary and Tertiary (?)	Pleistocene and Pliocene (?)		Fluvial Deposits (terrace deposits)	0 to 100	Sand, gravel, minor clay, and ferruginous sandstone. Generally underlie the loess in upland areas, but are locally absent. Thickness varies greatly because of erosional surfaces at top and base. Provide water to many domestic and farm wells in rural areas.
Tertiary	Eocene	Claiborne	Jackson Formation and upper part of Claiborne Group; includes Cockfield and Cook Mountain Formations (Capping Clay)	0 to 360	Clay, silt, sand, and lignite. Because of similarities in lithology, the Jackson Formation and upper part of the Claiborne Group cannot be reliably subdivided based on available information. Most of the preserved sequence is the Cockfield and Cook Mountain formations undivided, but locally the Cockfield may be overlain by the Jackson Formation. Serves as the upper confining bed for the Memphis Sand.
			Memphis Sand ("500-Foot" sand)	500 to 890	Sand, clay, and minor lignite. Thick body of sand with lenses of clay at various stratigraphic horizons and minor lignite. Thickest in the southwestern part of the Memphis area; thinnest in the Northeastern part. Principal aquifer providing water for municipal and industrial supplies east of the Mississippi River; sole source of water for the City of Memphis.
		Wilcox	Flour Island Formation	160 to 310	Clay, silt, sand, and lignite. Consists primarily of silty clays and sandy silts with lenses and interbeds of fine sand and lignites. Serves as the lower confining bed for the Memphis Sand and the upper confining bed for the Fort Pillow sand.
	Paleocene		Fort Pillow Sand ("1,400-Foot" Sand)	125 to 305	Sand with minor clay and lignite. Sand is fine to medium. Thickest in the southwestern part of the Memphis Area; thinnest in the northern and northeastern parts. Once the second principal aquifer supplying the City of Memphis; still used by an industry. Principal aquifer providing water for municipal and industrial supplies west of the Mississippi River.
			Old Breastworks Formation	180 to 350	Clay, silt, sand, and lignite. Consists primarily of silty clays and clayey silts with lenses and interbeds of fine sand and lignite. Serves as the lower confining bed for the Fort Pillow Sand, along with the underlying Porters Creek Clay and Clayton Formation of the Midway Group.

[a] Alluvium is shown here in the conventional position as the youngest stratigraphic unit. Actually, it almost nowhere overlies the loess but may overlie any of the older stratigraphic units.

[b] Note this is the thickness of the unit – not the depth below grade.

Source: Modified from Graham and Parks, 1986

Tennessee, unconsolidated sediments (Cretaceous through Quaternary) reach their maximum thickness at Memphis, where they range from 2,700 to 3,000 ft.

Cyclic Pleistocene glaciation has been directly or indirectly responsible for the origin, character, and distribution of virtually all of the Quaternary deposits and formation in the Mississippi embayment. Although continental ice sheets did not actually extend into the Lower Mississippi Valley area, they nevertheless were responsible for deranging preglacial drainage and creating the southward-trending river and valley, which subsequently have carried large volumes of glacial meltwater and outwash. Equally important controls were exerted by cyclic glaciation in the form of major changes in base levels of erosion and deposition and the form of climatic changes (ref. 37).

The following geologic units have been specifically identified at DDMT, with the exception of the Alluvial deposits, and the Flour Island, Fort Pillow, and Old Breastworks formations:

- **Alluvium.** Alluvial deposits consisting of Holocene and Pleistocene sand, gravel, silt, and clay have been deposited in the channel systems and floodplains of modern streams. Alluvial deposits may reach their maximum thickness of 175 ft in the valleys of primary streams (Mississippi River). At other locations, the unit seldom exceeds 50 ft in thickness. Although it is a significant unit within the region, no alluvial deposits were encountered at DDMT during the RI (ref. 18).

- Loess. Loess is a semi-cohesive eolian deposit composed of silt, silty clay, silty fine sand, or mixtures thereof. It mantles the ground surface over wide areas of the central United States. It typically occurs above the alluvial (terrace) deposits and is thickest along the bluffs overlooking the Mississippi Alluvial Plain. Its maximum thickness is reported to be about 65 ft; it thins considerably toward the east. Locally, it may contain thin, discontinuous, fine sandy layers enclosed within silts and silty clays.

- **Fluvial (Terrace) Deposits.** Quaternary and possibly Pliocene age fluvial deposits occur beneath the uplands and valley slopes of the Gulf Coastal Plain and are the remnants of ancient alluvial deposits of either present streams or an ancient drainage system. The fluvial deposits consist primarily of sand and gravel with minor lenses of clay and thin layers of iron-oxide cemented sandstone or conglomerate. These fluvial deposits range from zero to 100 ft in thickness. The thickness is highly variable because of erosional surfaces at both top and base. Locally, in the Memphis area, the fluvial deposits may be absent (ref. 11). This deposit represents the upper aquifer at DDMT.

- **Jackson Formation/Upper Claiborne Group.** The Late Eocene Jackson Formation and upper part of the Claiborne Group lie beneath the fluvial (terrace) deposits. Because of lithologic similarities, the Jackson

Formation and upper part of the Claiborne Group cannot be reliably subdivided in the subsurface of the Memphis area. These units include strata of the Cockfield and Cook Mountain Formations undivided in the upper part of the Claiborne Group and, locally, of the Jackson Formation. The Jackson Formation/Upper Claiborne Group consists primarily of clay, silt, and fine sand with minor lenses of lignite. Within this unit, sediments are lenticular, and locally individual beds may not be really extensive. The clays are predominantly of the montmorillonite type. The thickness of the Jackson Formation/Upper Claiborne Group is highly variable in the Memphis urban area, ranging from zero to 360 ft, with aggregate thickness of clay beds ranging from zero to 250 ft (ref. 13). These formations represent the confining unit below the fluvial deposits and above the Memphis Sand at DDMT.

- **Memphis Sand ("500-foot sand").** The widespread terrace deposits of the Memphis Sand were deposited during the Middle Eocene time when streams carried extensive quantities of sand and gravel into the Mississippi embayment area. The Memphis Sand unit 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 Sand ranges from 500 to 890 ft in thickness, and the depth to the top of the Memphis Sand Aquifer in the area ranges from approximately 120 ft to 300 ft below ground surface. It is thinnest in the northeastern part of the Memphis area in northwestern Fayette County, Tennessee, and thickest near the Mississippi River in southwestern Shelby County, Tennessee, (ref. 33). The City of Memphis obtains its drinking water from this aquifer.

- **Flour Island Formation.** Beneath the Memphis Sand lies the lower Eocene and Paleocene Flour Island Formation. The Flour Island Formation consists primarily of silty clay and sandy silt with lenses of fine sand and lignite that are not really extensive. The thickness of this formation is variable in the Memphis urban area, ranging from 160 to 310 ft (ref. 33).

- **Fort Pillow Formation ("1400-foot sand").** The Fort Pillow Sand occurs beneath the Flour Island Formation throughout the Memphis area. It consists primarily of fine-to-medium sand with some local interbedded clay and lignite. The Fort Pillow Sand ranges from 125 to 305 ft in thickness (ref. 33).

- **Old Breastworks Formation.** The Old Breastworks Formation is the oldest of the Tertiary units identified in the study area. It consists of silty clays and clayey silts with interbeds and lenses of fine sand and lignite. This unit has been reported to range from 180 to 350 ft in thickness.

2.4.5.2 DDMT Geology

The geology of DDMT was investigated by reviewing the existing published geologic information and work performed during the RI (ref. 18). Eight deep soil borings (STB 1 through 8) and 31 monitoring wells (MW-8 through MW-39) were installed onsite and offsite. The borings ranged from 80 to 220 ft deep, while the monitoring wells ranged from 54 to 209 feet deep. Twenty-nine of the monitoring wells were installed in the Fluvial Aquifer, and two monitoring wells were installed in the Memphis Sand Aquifer. Well logs from eight wells previously installed by USAEHA also were used to develop site geology. Monitoring wells in the Fluvial Aquifer range from 29 to 157 ft bgs. Table 2-4 shows pertinent data for the existing monitoring wells.

Because soil borings are considered to be representative of geologic conditions only for the exact point where they were advanced, care was taken in the development of subsurface interpretations that may or may not infer the continuity of specific strata between widely spaced borings. Professional judgment was exercised by Law Environmental in the interpretations that are depicted on cross sections and other figures. The conditions encountered at DDMT appear to be reasonably consistent with those reported by a number of investigators in the professional technical literature relative to the geologic units underlying Memphis. STB and monitoring well logs are located in Appendix B of Reference 19.

On the basis of the STBs and monitoring wells installed during the RI (ref. 18), five cross sections are included that illustrate the postulated occurrence, attitude, and relationships of the geologic units encountered. The cross sections, Figures 2-8 through 2-12, are generalizations; local variations in subsurface conditions should be expected. Refer to STB Records in Appendix B of Reference 19 for descriptions of specific subsurface conditions at individual boring locations. The strata encountered during the performance of the Law study included loess, fluvial deposits, Jackson Formation/Upper Claiborne Group clays (based on interpretation), and what has been interpreted to be the Memphis Sand. These geologic units generally exist throughout the Memphis area and are reported to be laterally extensive, although individual formation members may not be correlative over even short distances.

Loess. The uppermost geologic unit at or near ground surface in the study area is loess—eolian deposits consisting of brown silty clay, clayey silt, and fine sandy clayey silt. The loess was encountered at all drilling locations. This unit is described as a brown to yellowish low plasticity silt (ML) or low plasticity clay (CL). Thin, discontinuous fine-grained sand zones may occur locally. The unit ranges in thickness from 6 ft at MW-25 to some 40 ft at MW-16, MW-17, and MW-20. Four samples were collected from this unit for analysis of their physical properties. Atterberg Limits analysis (liquid limit average = 35, and plasticity index average = 15) and grain size analysis (average 96.8 percent passing the No. 200 sieve) indicate a lean clay classification.

Table 2-4
Summary of Existing Well Construction
Defense Depot Memphis, Tennessee

Page 1 of 2

Well ID	Location	Drilling Method	Land Surface (NGVD)	Total Depth (ft)	Screen Length (ft)	Depth Top of Screen (ft)	Static Water Level (ft)
MW-2	Dunn Field NW	HSA	289.7	32.0	14	18.0	20.3
MW-3	Dunn Field NW	HSA	290.4	73.5	10	63.5	61.6
MW-4	Dunn Field NE	HSA	300.0	78.5	20	58.5	69.8
MW-5	Dunn Field NE	HSA	301.3	77.0	20	57.0	72.8
MW-6	Dunn Field NE	HSA	288.1	70.0	20	50.0	59.0
MW-7	Dunn Field NC	HSA	293.1	74.0	10	64.0	62.0
MW-8	Dunn Field NC	HSA	292.7	69.1	10	56.5	59.2
MW-9	Dunn Field NC	HSA	304.7	82.5	10	70.1	73.0
MW-10	Dunn Field NW	HSA	289.0	71.0	10	58.6	57.5
MW-11	Dunn Field NW	HSA	299.6	85.3	15	67.9	70.3
MW-12	Dunn Field WC	HSA	301.4	86.8	15	69.4	71.6
MW-13	Dunn Field C	HSA	300.0	83.4	15	66.0	69.0
MW-14	Dunn Field SC	HSA	302.4	80.0	15	65.0	72.3
MW-15	Dunn Field WC	HSA	295.2	80.8	15	63.4	65.3
MW-16	Main Post NE (near S209)	Mud Rotary	300.2	75.0	15	57.6	57.0
MW-17	Main Post NC (near DRMO)	HSA	316.2	95.0	15	77.6	86.7
MW-18	Main Post NW (near Gate 15)	HSA	308.3	140.0	15	122.6	–
MW-19	Main Post NW (near Gate 925)	HSA	290.9	96.4	10	83.1	88.9
MW-20	Main Post WC (near P949)	HSA	285.2	100.5	15	83.1	85.6
MW-21	Main Post SW (near S1089)	HSA	295.1	109.5	15	92.1	95.0
MW-22	Main Post SW (near 1087)	HSA	298.1	107.8	10	95.4	97.7
MW-23	Main Post SW (near S873)	HSA	299.0	113.6	10	101.2	100.2
MW-24	Main Post SC (near 690)	HSA	299.6	114.7	15	97.3	108.7
MW-25	Main Post SE (near 489)	HSA	270.3	81.4	10	69.0	73.4
MW-26	Main Post SE (near S360)	HSA	303.7	110.0	10	97.6	100.1
MW-27	Main Post NW (near 737)	Mud Rotary	304.2	93.6	15	76.2	–

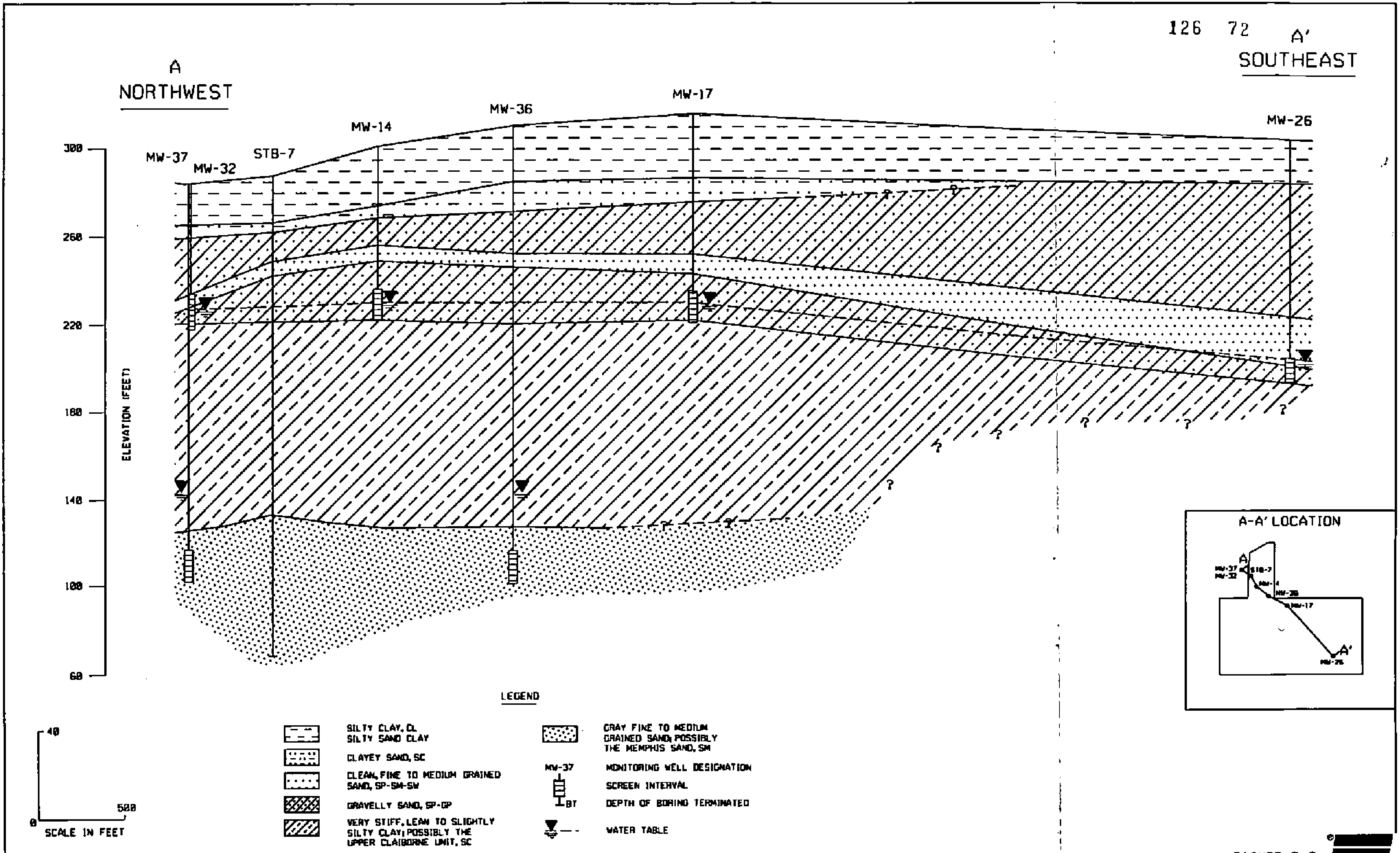
Table 2-4
Summary of Existing Well Construction
Defense Depot Memphis, Tennessee

Page 2 of 2

Well ID	Location	Drilling Method	Land Surface (NGVD)	Total Depth (ft)	Screen Length (ft)	Depth Top of Screen (ft)	Static Water Level (ft)
MW-28	Dunn Field NE	HSA	294.9	69.4	15	54.3	57.2
MW-29	Dunn Field NE	HSA	273.4	54.3	20	34.2	37.0
MW-30	MLGW	HSA	273.9	59.1	20	39.0	42.5
MW-31	MLGW	HSA	287.4	79.2	15	64.1	61.6
MW-32	Roselle St.	HSA	285.4	67.8	15	52.7	58.9
MW-33	Roselle St.	HSA	277.5	60.0	15	44.6	48.2
MW-34	Dunn Field SW	Mud Rotary	300.8	156.9	20	136.6	145.6
MW-35	Dunn Field NW	HSA	301.6	89.7	20	69.6	71.7
MW-36	Dunn Field SE	Mud Rotary	311.2	209.4	15	192.3	166.1
MW-37	Roselle St.	Mud Rotary	285.5	182.8	15	165.7	142.1
MW-38	Main Post (near Gate 15)	Mud Rotary	308.4	155.0	15	139.9	137.2
MW-39	Main Post (near 770)	Mud Rotary	296.4	115.6	20	95.5	104.9

All wells screened in Fluvial aquifer except MW-36 and MW-37.
MW-18 and MW-27 are screened above the water table.
HSA = Hollow Stem Auger

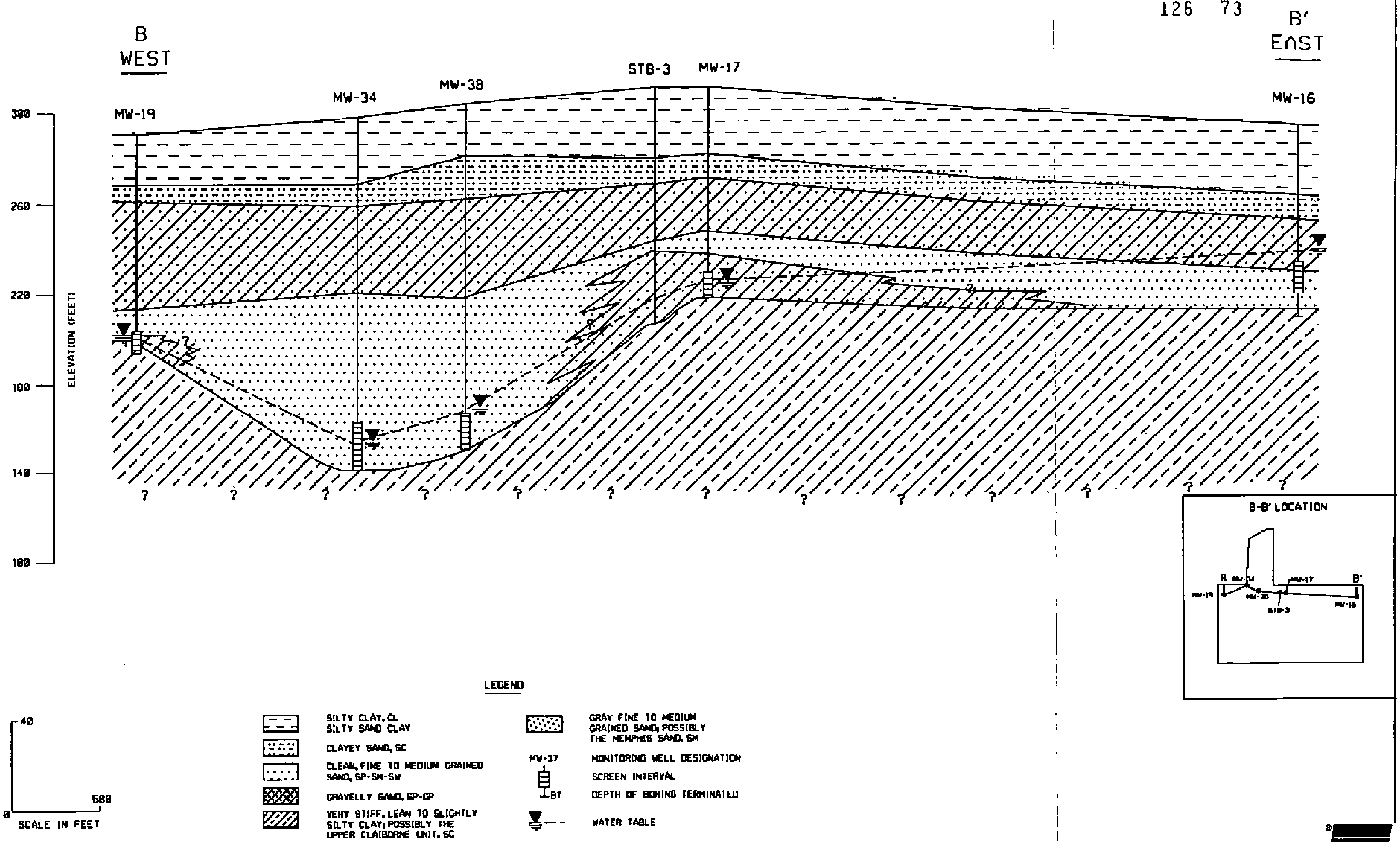
126 72



NOTE: THIS ILLUSTRATION REPRESENTS AN INTERPRETATION OF NATURAL CONDITIONS.

Source: RI Report, 1990

FIGURE 2-8
CROSS SECTION A-A', NORTHWEST TO SOUTHEAST
Defense Depot Memphis, Tennessee



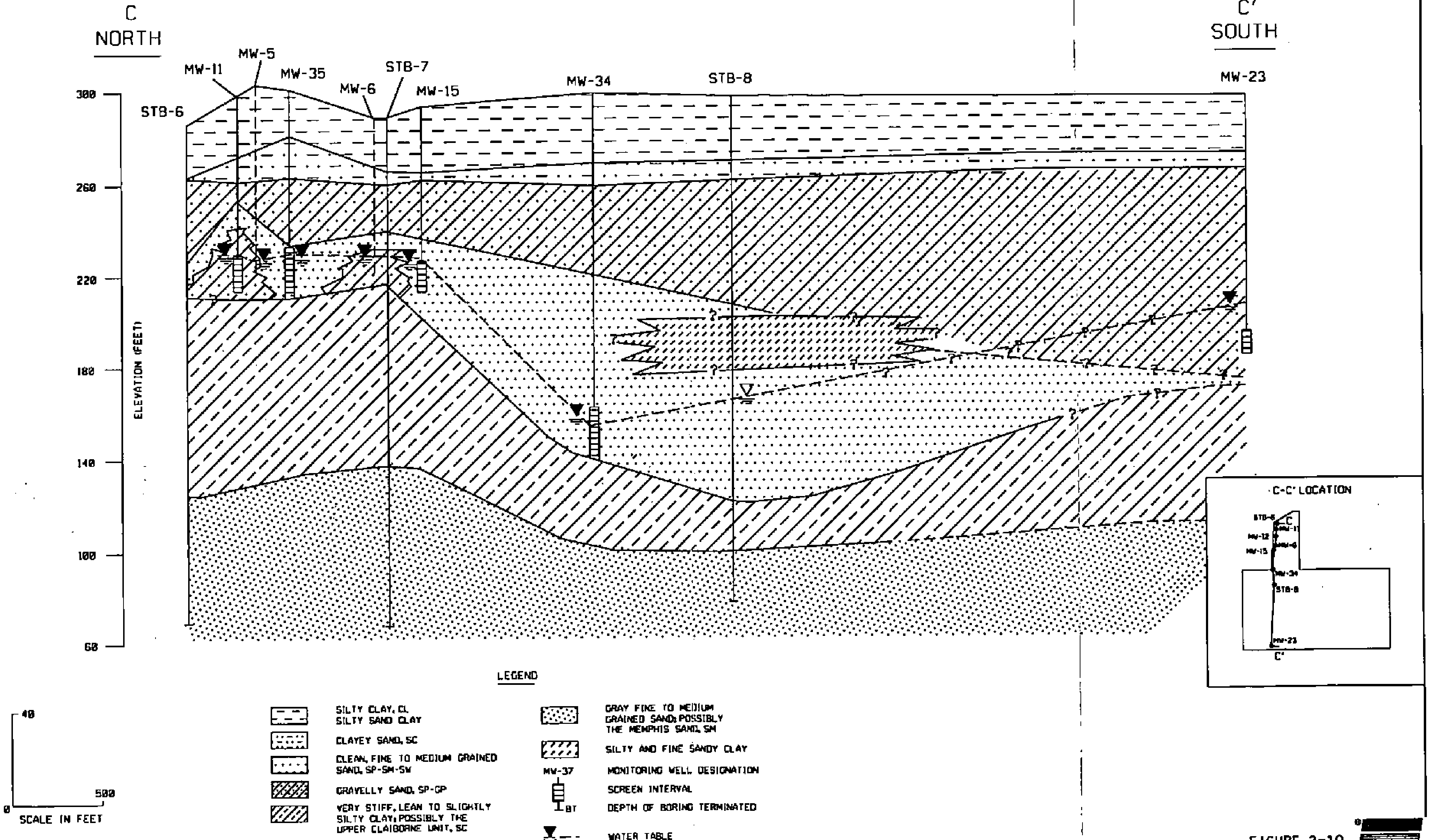
NOTE: THIS ILLUSTRATION REPRESENTS AN INTERPRETATION OF NATURAL CONDITIONS.

Source: RI Report, 1990

FIGURE 2-9
CROSS SECTION B-B', WEST TO EAST
Defense Depot Memphis, Tennessee

13-SEP-1995

126 74

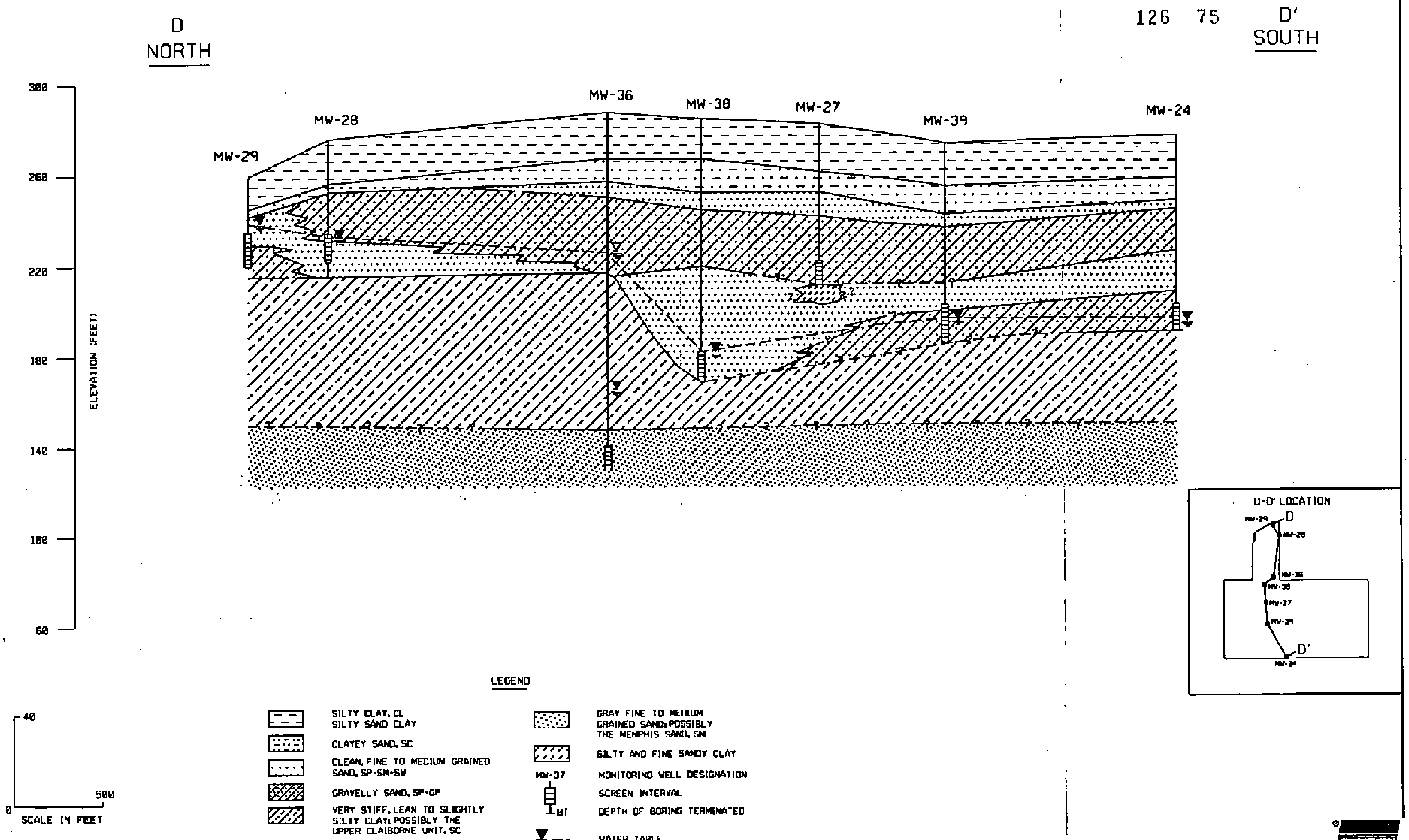


Source: RI Report, 1990

NOTE: THIS ILLUSTRATION REPRESENTS AN INTERPRETATION OF NATURAL CONDITIONS.

FIGURE 2-10
CROSS SECTION C-C', NORTH TO SOUTH
Defense Depot Memphis, Tennessee

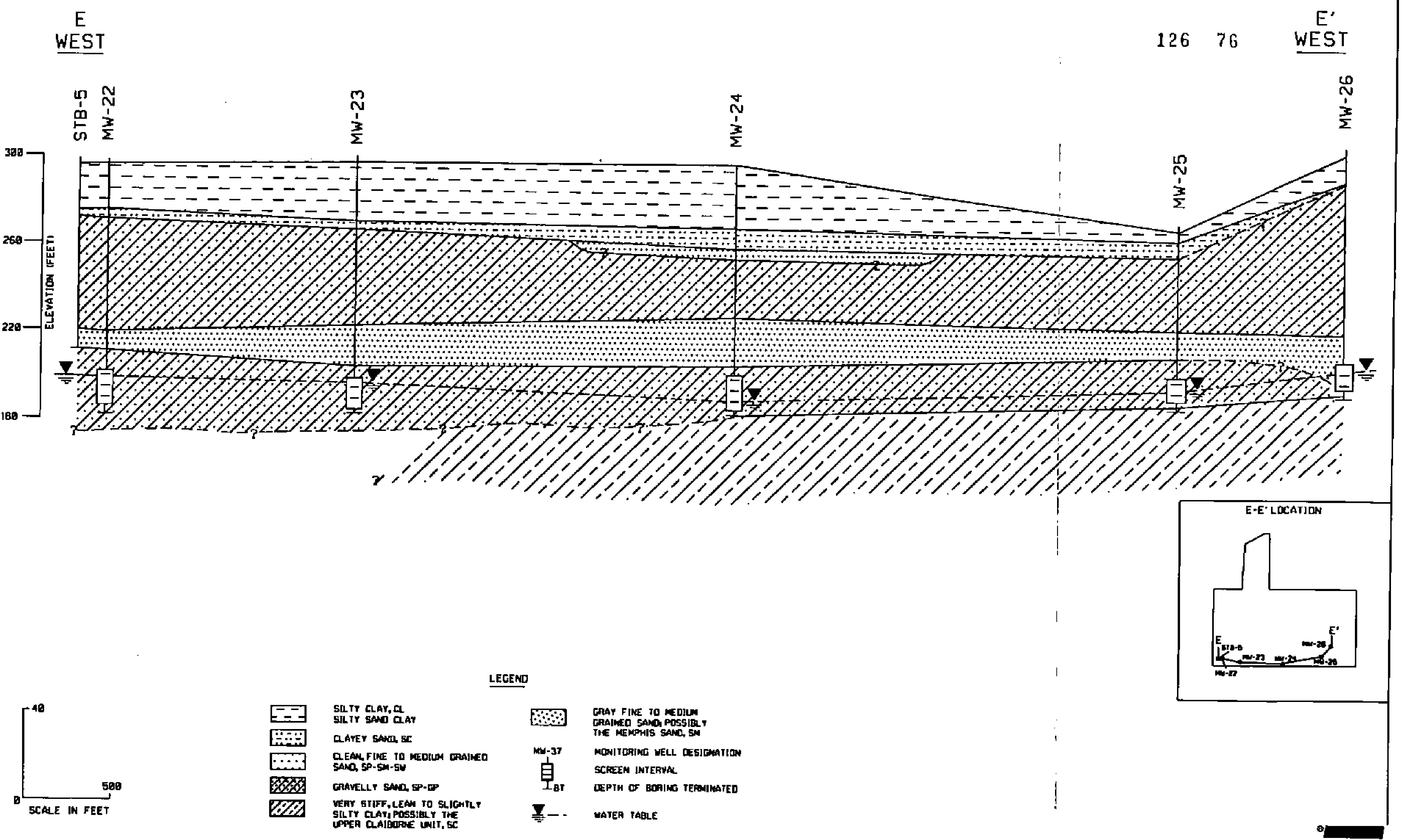
126 75



NOTE: THIS ILLUSTRATION REPRESENTS AN INTERPRETATION OF NATURAL CONDITIONS.

Source: RI Report, 1990

FIGURE 2-11
CROSS SECTION D-D', NORTH TO SOUTH
Defense Depot Memphis, Tennessee



NOTE: THIS ILLUSTRATION REPRESENTS AN INTERPRETATION OF NATURAL CONDITIONS.

Source: RI Report, 1990

FIGURE 2-12
CROSS SECTION E-E', WEST TO EAST
Defense Depot Memphis, Tennessee

Fluvial Deposits. Fluvial deposits underlie the loess and were encountered at all drilling locations during the RI (ref. 18). The unit is composed of three generalized members that can be traced through the study area:

- Silty clay, silty sandy clay, or clayey sand
- Poorly graded (less than 5 percent silt or clay), fine to medium-grained sand
- Gravelly sand

The upper member is the silty clay, silty sandy clay, or clayey sand. It averages approximately 5 ft in thickness and directly underlies the loess. It thins in the vicinity of Lake Danielson at MW-25 and is not present in MW-26.

Beneath the silty clay, sandy clay/clayey sand are layers of sand and sandy gravel. These layers may alternate, as shown on the cross sections. A conspicuous pink, white, or gray low plasticity clay occurs as a thin discontinuous seam within the gravelly sand sequence. Apparently this seam thickens near STB-8, where 35 ft of clay was encountered. MW-27 terminated at the top of this clay seam before reaching the saturated zone of the aquifer.

The sand layers range from poorly graded to well graded fine- to coarse-grained, very well-sorted to poorly-sorted quartz grains. The upper sand layers are generally a bright orange, indicating an oxidizing environment. The lower sand layers are poorly graded, and are tan to white. The sand layers show a coarsening downwards into a gravelly sand, with chert being the primary gravel constituent. Gravel size ranges from small pebble size up to 4 inches in diameter. The coarsening downward sequences and the lateral facies changes over short distances are indicative of fluvial deposits (ref. 38). The fluvial deposits range in thickness from approximately 40 ft at MW-29 to 131 ft at MW-38.

Most of the samples collected for mechanical testing were taken from within the fluvial deposits. Geotechnical analysis confirmed the primary field classification as poorly sorted sands and gravels (SP).

Jackson Formation/Upper Claiborne Group. Clayey soils that have been interpreted as the Jackson Formation/Upper Claiborne Group were penetrated in STB-6, STB-7, STB-8, MW-36, and MW-37. This unit is represented in the study area by a distinctive stiff gray or orange, low to high plasticity lignitic clay. This member underlies the fluvial deposits and is a regionally significant confining unit. The maximum thickness of the confining unit was 92 ft in MW-36. This unit appears to be laterally persistent and fairly uniform in thickness throughout most of northern Dunn Field. In the southern portion of Dunn Field and on the Main Installation, post-Eocene erosion on the upper surface of the Jackson Formation/Upper Claiborne Group resulted in a deep channel-like feature. The eroded surface was indicated by drastically increased depths to the top of the clay unit encountered during drilling operations. The thickness of the clay unit in boring STB-8 was 15 ft, which was the minimum thickness of the clay unit that was encountered by soil borings at DDMT.

Memphis Sand. The upper portion of the Memphis Sand Formation was encountered in the same five borings as was the Jackson Formation/Upper Claiborne Group. This Formation is represented in the study area by a gray, very fine-grained, silty sand.

2.4.6 Hydrogeology

In the following sections, the hydrogeology of the region and of DDMT is described.

2.4.6.1 Regional Hydrogeology

Information describing the groundwater conditions and resources of Shelby County was obtained from Wells (ref. 71), Moore (ref. 29), Terry, et. al. (ref. 49), and Graham and Parks (ref. 11). Water table (fluvial) aquifer quality information was derived from McMaster and Parks' 1988 report (ref. 11).

Hydrogeologic Setting. The region's hydrogeologic setting consists of a series of thick, generally unconsolidated sedimentary units deposited in a broad trough or syncline (Mississippi embayment). The trough's greatest depth is defined by its axis, which extends N50°E in an alignment generally following that of the Mississippi River. The trough dips southward along its axis. Large-scale sedimentary units deposited within this structural feature tend to thicken from east to west where they reach their greatest accumulation, at the axis, and tilt gently southward, following the trough's orientation.

Individual sedimentary sequences have been deposited in the trough, roughly following its physical orientation. The most permeable of these units are identified as aquifers and the least permeable are termed confining units.

Principal Aquifers. The Memphis area is located within a region where several aquifers of local and regional importance exist. These aquifers are identified in descending order by their geologic names:

- Alluvium
- Fluvial (Terrace) Aquifer
- Memphis ("500-foot") Sand Aquifer
- Fort Pillow ("1400-foot") Sand Aquifer

These aquifers correspond to the geologic units described in the geology subsection. The Alluvial Aquifer's distribution is limited to the channels of primary streams; therefore, it does not occur at DDMT. The Fluvial, Memphis Sand, and Fort Pillow Sand aquifers underlie the installation and are discussed in following subsections.

2.4.6.2 *DDMT Hydrogeology*

Site-specific hydrogeologic conditions were investigated by physical inspection, test borings, groundwater quality, monitoring well installation, and direct measurement of in situ hydraulic properties during the RI (ref. 18). The investigation consisted of three interrelated tasks: a review of the available groundwater data, performance of eight STBs to further describe aquifer characteristics, and monitoring well installation. A total of 29 groundwater quality monitoring wells were installed into the study area's Fluvial Aquifer, and 2 monitoring wells were installed into the Memphis Sand.

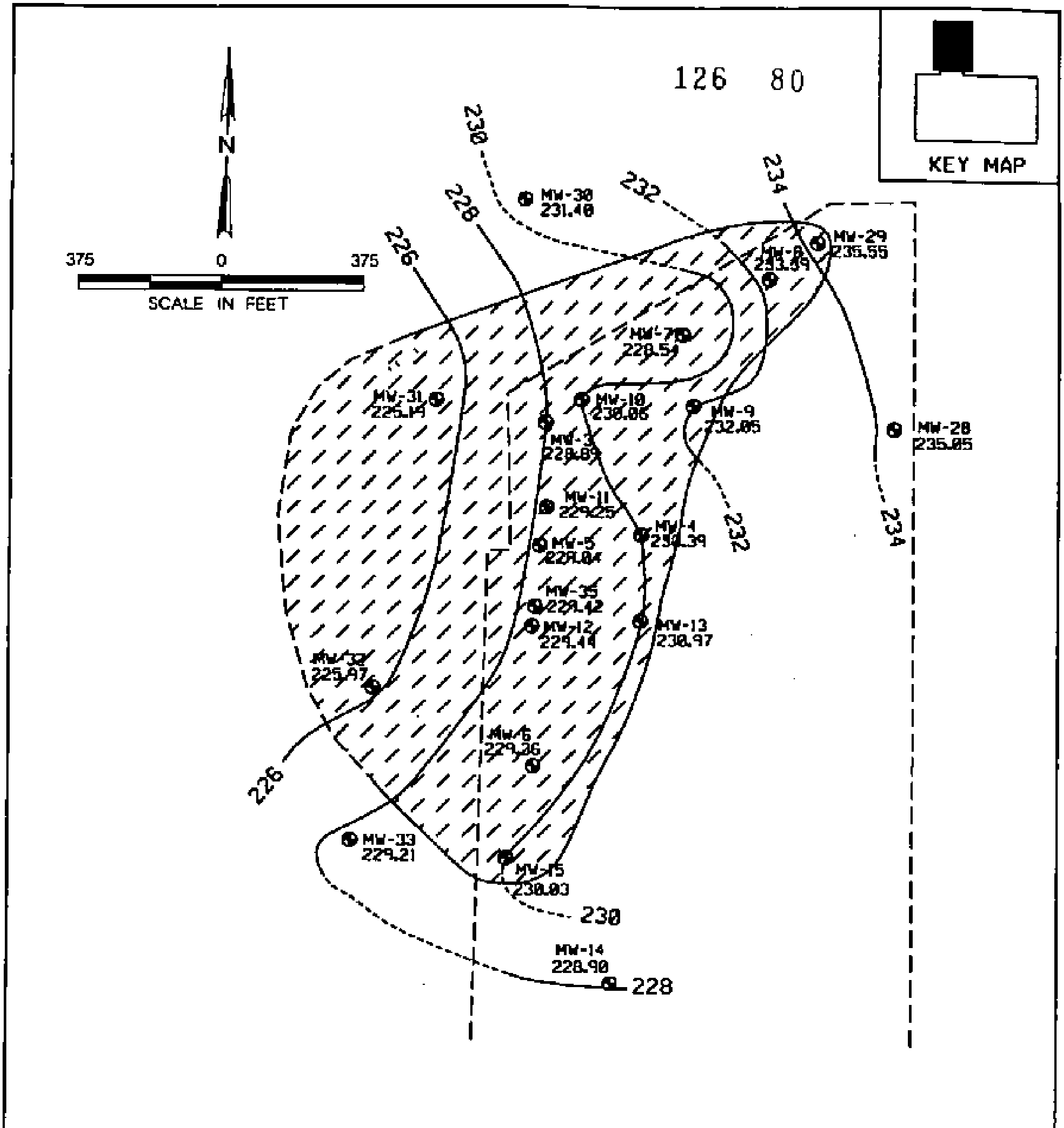
Loess. The uppermost hydrogeologic unit encountered at DDMT is the loess, a firm silty clay or clayey silt. While not usually a water-bearing unit, these materials are of interest to this investigation because they tend to limit precipitation infiltration (recharge) to significant underlying aquifers where the loess remains intact and undisturbed. Sandy zones occurring within the loess may become seasonal "perched" water-bearing zones that contain water for short periods of time after rainfall events. Usually, the perched water-bearing zones discharge their groundwater to adjacent units in hydraulic communication with them. One USAEHA monitoring well (MW-2) and several of the monitoring wells installed as part of the RI (ref.18) encountered one or more perched water-bearing zones in Dunn Field. Typically, the perched zone consisted of a fine sandy layer enclosed within the loess, approximately 20 ft bgs.

Fluvial (Terrace) Deposits. Fluvial (Terrace) deposits underlie the loess within the study area. The fluvial deposits form the site's shallow (water table) aquifer. It consists of clayey sand, sand, and gravelly sand strata, ranging in thickness from 40 to 131 ft at DDMT. Recharge to this unit is primarily from the infiltration of rainfall (ref. 11). Discharge from the unit is generally directed toward underlying units in hydraulic communication with the fluvial deposits, or laterally into the adjacent stream channel.

According to the water levels measured in the monitoring wells during the RI and presented in the RI Report (ref. 18), only the base of the unit is saturated. The actual saturated thickness varies from 5.7 ft at MW-24 to 18 ft at MW-16 and MW-35. The upper surface of the unit's saturated thickness ranges from an elevation of 243 ft NGVD at MW-16 to a low of 155 ft NGVD at MW-34. Published seasonal water levels indicate that the groundwater levels fluctuate several ft. However, during the RI (ref. 18), no significant fluctuations were seen in the water levels measured at DDMT.

DDMT's general water level data were used to prepare a water table surface map (ref. 18) of the Fluvial Aquifer underlying DDMT (Figure 2-13). This figure represents an interpolation of the water level information obtained from widely spaced monitoring wells and is an interpretation of natural conditions on the date of measurement. The figure suggests that two general flow directions exist within the fluvial deposits at DDMT.

126 80



LEGEND

●	MONITORING WELL LOCATION
———	ISOPLETHS OF EQUAL ELEVATIONS
-------	INFERRED ELEVATIONS CONTOUR INTERVAL = 2 FEET

** SHADED AREA REPRESENTS CHLORINATED VOLATILE ORGANIC CONTAMINATION OF GROUND WATER; EXTENT OF CONTAMINATION IS UNKNOWN AND ALL BOUNDARIES OF THE PLUME HAVE BEEN INFERRED.

NOTE: THIS ILLUSTRATION REPRESENTS AN INTERPRETATION OF NATURAL CONDITIONS ON THE DATE OF MEASUREMENT.

FIGURE 2-13
WATER TABLE SURFACE OF FLUVIAL AQUIFER
AT DUNN FIELD, NOVEMBER, 1993
Defense Depot Memphis, Tennessee

CH2MHILL

Source: ESE, 1994

mwp-0028.dgn 19-SEP-1995

In the Dunn Field area, a westerly direction of flow is apparent in the installation's shallow aquifer (Figures 2-13 and 2-14).

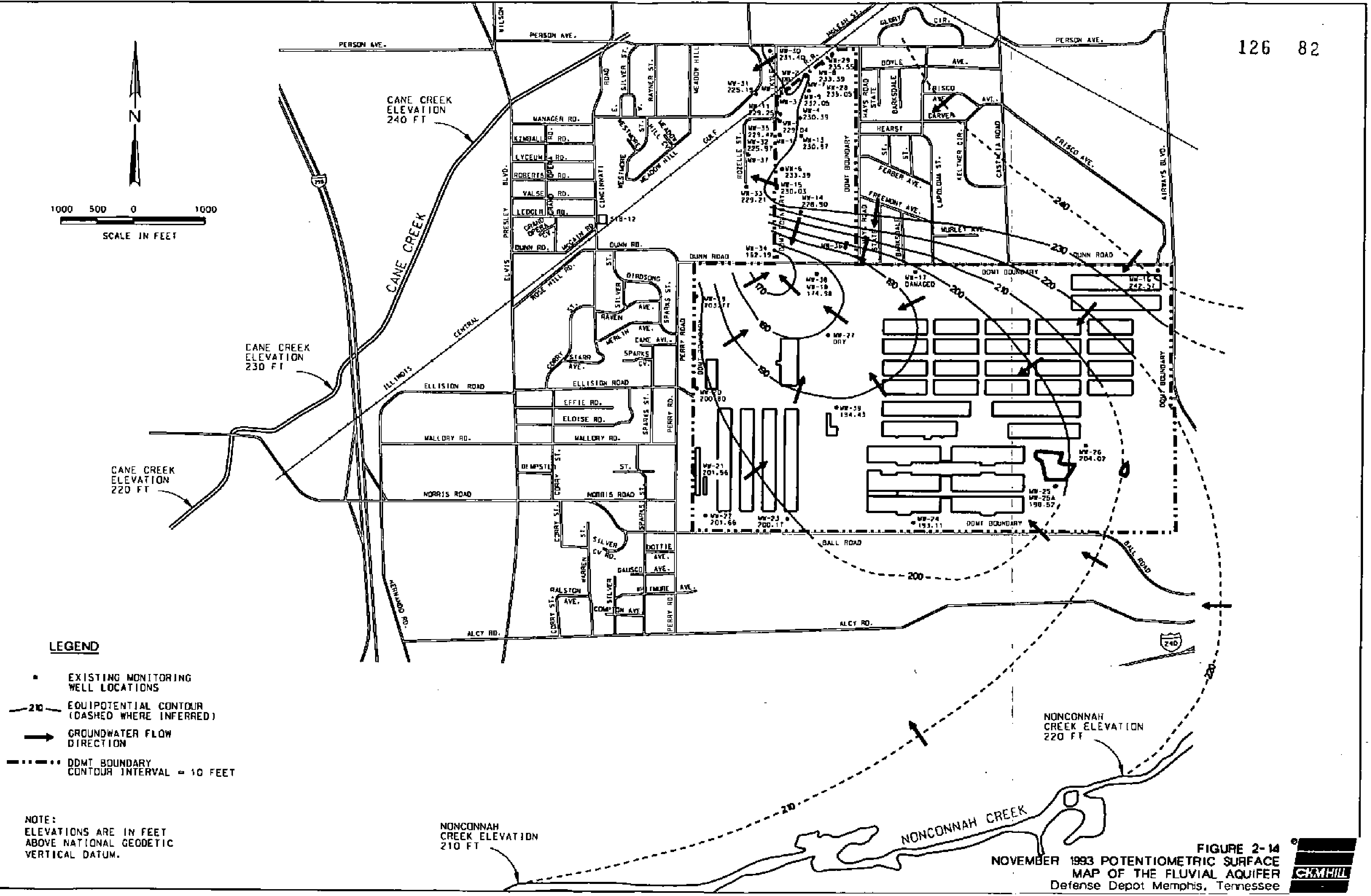
At the Main Installation, a different flow regime is suggested by the water level data (Figure 2-14). The closure of water level contours around MW-34 and STB-8 suggests that groundwater flow in this area is directed toward what may be a "sink" or a buried stream channel of poorly defined proportions. More information is needed to properly define groundwater flow in this area. A general west to southwest groundwater flow is indicated for the rest of the Main Installation. However, local variations in this trend are not well-defined.

Site groundwater and surface water levels were compared to evaluate the possibility of groundwater discharge to surface waters at or near DDMT. On the basis of a generalized hydrogeologic section created during the RI and presented in the RI Report (ref. 18), groundwater elevations fall below local stream base elevations in the vicinity of DDMT (Figure 2-15); therefore, the fluvial deposits probably do not contribute to the stream base at this location. The higher elevation of both Cane Creek and Nonconnah Creek in relation to the groundwater table indicates that the two creeks discharge into the aquifer. The apparent southward flow away from Cane Creek, and northward flow away from Nonconnah Creek, in conjunction with the drop in elevation of the water table associated with MW-38, supports the possibility of downward vertical leakage into the deeper Memphis Sand Aquifer.

To better interpret subsurface conditions, a geologic map of the fluvial deposits' saturated zone at DDMT was prepared during 1989-90 as part of the RI Report (Figure 2-16). This figure suggests the possible presence of a paleo-stream channel in the study area, which is a feature known to be consistent with conditions existing in the region (refs. 71, 29, and others). This figure shows a contouring of in situ permeability values in comparison with a soil classification of the saturated thickness, suggesting that a correlation exists between conductivity test data and the basal unit's sedimentary characteristics.

Jackson Formation/Upper Claiborne Group. The Jackson Formation/Upper Claiborne Group was encountered at more than half of the monitoring well and soil boring installation locations. The unit is represented in the study area by a distinct gray or orange clay. The unit is significant because it is a regionally important confining bed separating shallow water-bearing zones from underlying major aquifers (ref. 33).

The top of the Jackson Formation/Upper Claiborne Group at DDMT was contoured to interpret the project drilling data in the RI Report (ref. 18), as illustrated by Figure 2-17. Where encountered, the elevation of the confining unit's upper surface ranges from 223 ft NGVD at MW-14 to 118 ft NGVD at STB-8. In addition, the elevation of the Jackson/Upper Claiborne surface encountered at the Allen Well Field was compared to those encountered at DDMT. The elevation of the Jackson Formation/Upper Claiborne Group's upper surface within the Allen Well Field varies from 182 ft NGVD at Well 133 to a low of 150 ft NGVD at Well 138. This comparison indicates that the variation in



LEGEND

- • EXISTING MONITORING WELL LOCATIONS
- —210— EQUIPOTENTIAL CONTOUR (DASHED WHERE INFERRED)
- → GROUNDWATER FLOW DIRECTION
- —··—·· DDMT BOUNDARY

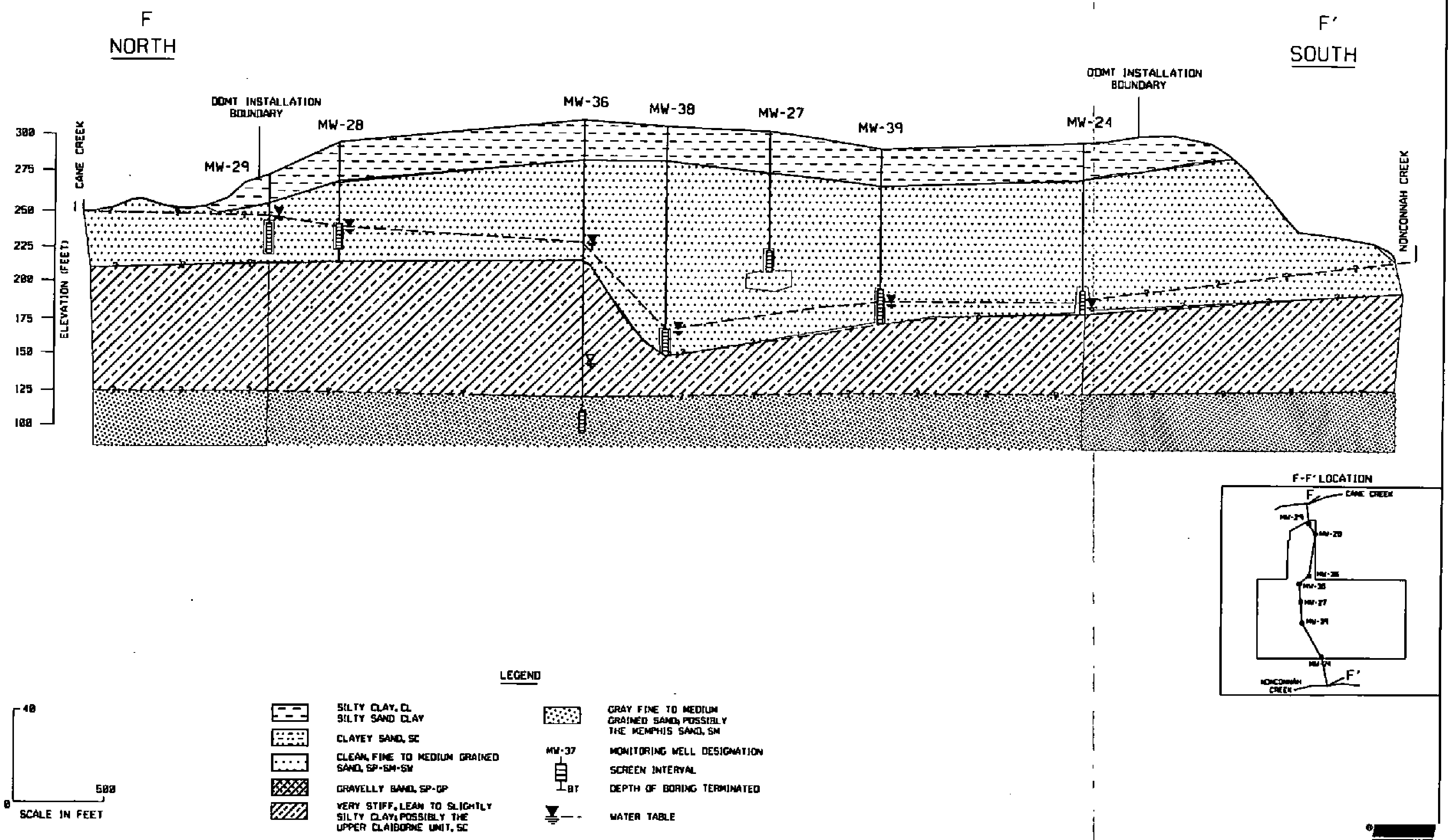
CONTOUR INTERVAL = 10 FEET

NOTE:
ELEVATIONS ARE IN FEET ABOVE NATIONAL GEODETIC VERTICAL DATUM.

FIGURE 2-14
NOVEMBER 1993 POTENTIOMETRIC SURFACE MAP OF THE FLUVIAL AQUIFER
Defense Depot Memphis, Tennessee

CH2MHILL

126 83



NOTE: THIS ILLUSTRATION REPRESENTS AN INTERPRETATION OF NATURAL CONDITIONS.

Source: RI Report, 1990

FIGURE 2-15
CROSS SECTION F-F', NORTH TO SOUTH
Defense Depot Memphis, Tennessee

CH2MHILL

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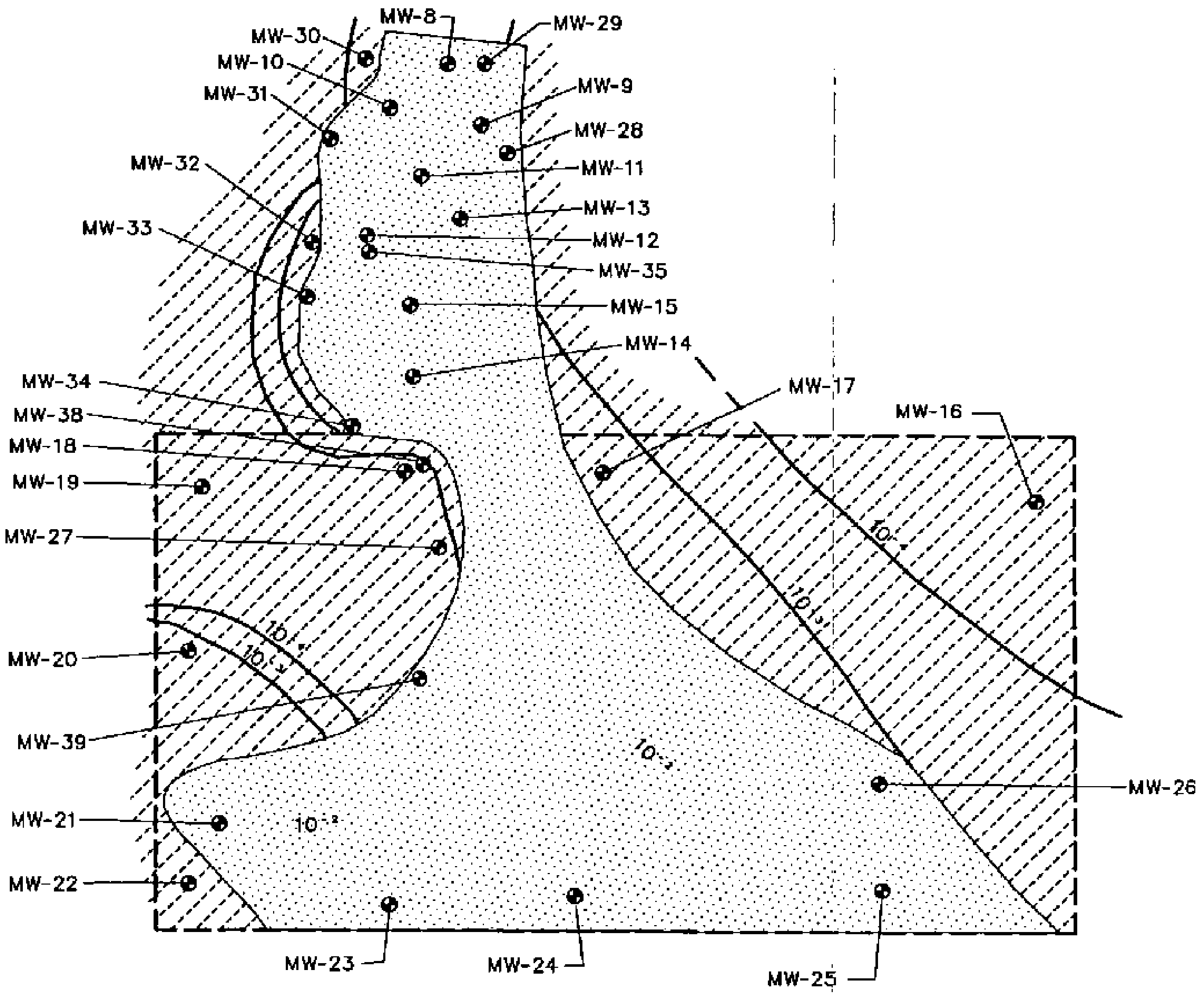
126 84



N

0 375 750

SCALE IN FEET

LEGEND

▨ POORLY SORTED SAND WITH SILT & GRAVEL SP-SM: ~ 10^{-3} - 10^{-5} CM/SEC

░ POORLY SORTED SAND SP: ~ 10^{-1} - 10^{-3} CM/SEC

— — — — DDMT BOUNDARY

● MONITORING WELL

NOTES:

1. CONTOUR LINES REPRESENT: HYDRAULIC CONDUCTIVITY CALCULATED FROM SLUG-OUT TEST.
2. SHADED AREAS ARE UNIFIED SOIL CLASSIFICATIONS FROM SAMPLES TAKEN WITHIN THE WATER-TABLE AQUIFER.
3. MW-18 AMD MW-27 NOT USED AS DATA POINTS SINCE SATURATED PORTION OF FLUVIAL AQUIFER WAS NOT SAMPLED AND NO HYDRAULIC CONDUCTIVITY INFORMATION WAS OBTAINED.

Source: RI Report, 1990

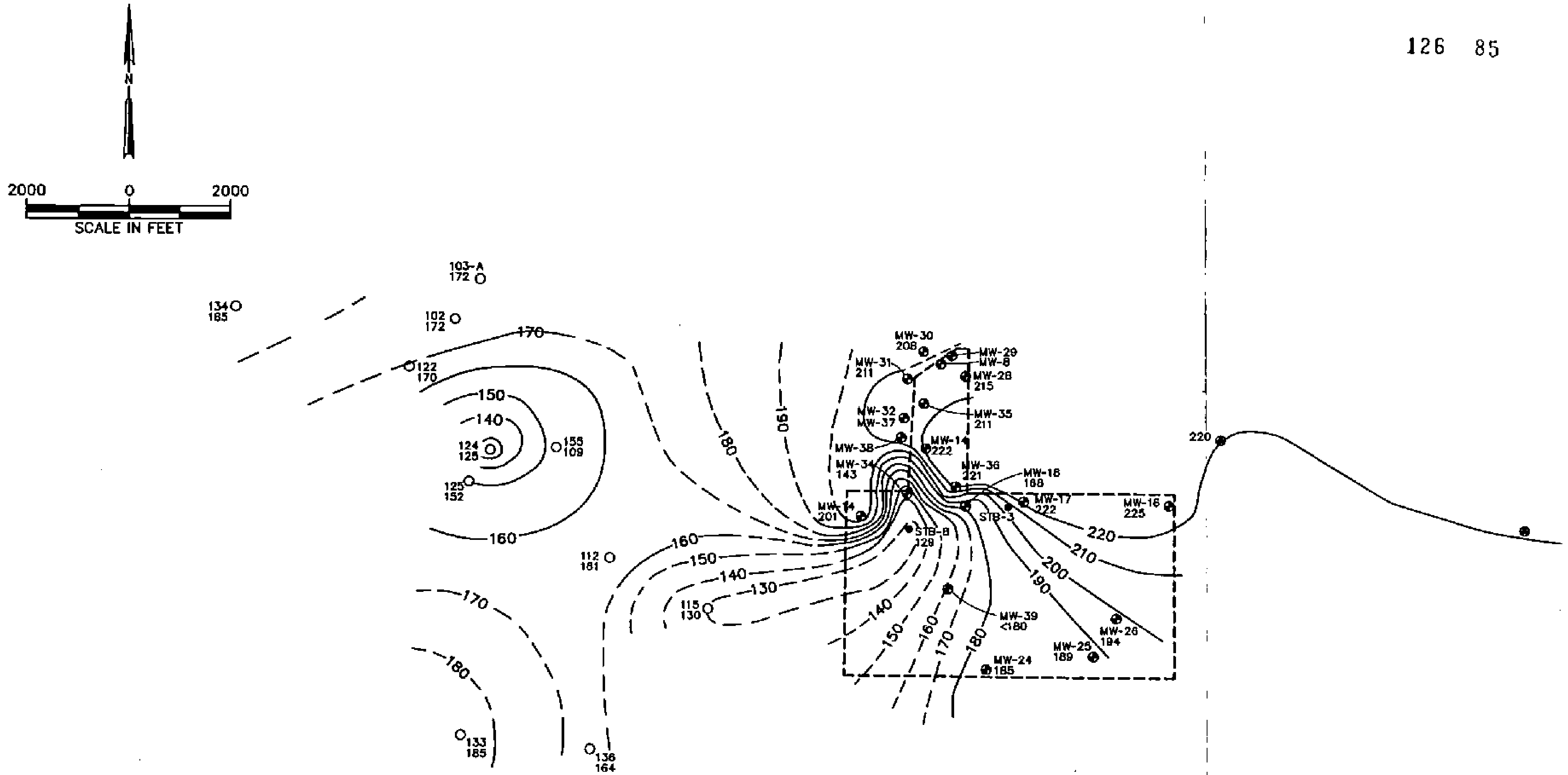
FIGURE 2-16

GEOLOGIC MAP OF UNIT HYDRAULIC CONDUCTIVITIES OF SATURATED FLUVIAL DEPOSITS
Defense Depot Memphis, Tennessee

CH2M HILL

MWP-0029.DWG 03-Mar-1995

126 85



LEGEND

- ⊗ WELL DRILLED BY LAW ENVIRONMENTAL
- ○ MLG & W WELLS
- ⊕ OTHER WELLS
- • SOIL BORING LOCATION
- —160— CONTOUR LINE
- 134 ○ 185 — 134 = WELL NUMBER, 185 = ELEVATION IN FEET, DATUM SEA LEVEL

NOTES: 1. CONTOUR INTERVAL = 10 FEET DATUM SEA LEVEL
2. CONTOURS ARE DASHED WHERE INFERRED

FIGURE 2-17
STRUCTURE CONTOUR MAP OF TOP OF JACKSON/
UPPER CLAIBORNE CONFINING UNIT
Defense Depot Memphis, Tennessee

CH2MHILL

MMP-0008.DWG 03-Mar-1995

the top of the confining unit is not atypical for the area. The highly variable nature of this surface is interpreted to be due to post-Eocene erosion.

An inspection of the study area's cross sections (Figures 2-8 through 2-12) indicates that the strata in the vicinity of MW-34, MW-38, and STB-8 do not conform to the more pervasive flat-lying conditions. The extreme depth at which the confining unit was encountered at these three locations and the reduced thickness of the unit in STB-8 suggests that the confining unit has been significantly eroded in this area. An investigation to determine the presence of the confining unit and hydraulic communication (if any) between the two aquifers is planned during the OU-4 RI field activities. The continuity and actual thickness of the confining unit can only be estimated from the available information.

The Jackson Formation/Upper Claiborne Group appears to be laterally persistent and fairly uniform in thickness in most of the Dunn Field area. In the southwestern portion of Dunn Field and on the Main Installation, this unit both deepens and thins (see Figure 2-10, specifically, STB-7 and STB-8).

Graham and Parks (ref. 11) present several lines of evidence to suggest that the Jackson Formation/Upper Claiborne Group is not laterally continuous throughout the Memphis area. In some areas, the Memphis Sand is directly overlain by the alluvial or fluvial deposits, permitting the downward vertical leakage from shallow water-bearing zones into the regional aquifer. Bell and Nyman (in ref. 11) estimated the quantity of this downward leakage to be on the order of 2 million gallons per day (mgd). These indications are drawn from a comparison of the piezometric surfaces of the Memphis Sand Aquifer and the Fluvial Aquifer at DDMT.

Leakage through the Jackson Formation/Upper Claiborne Group is possible even where it is continuous, because of the significant positive head difference between the two aquifers separated by the confining unit. The unit is composed of permeable fine sand and lignitic lens in addition to the less permeable clay and silt strata.

Groundwater seepage through the confining unit at Dunn Field was estimated during the RI (ref. 18). In that area, the borings indicated the confining unit was relatively thick and consisted of a uniform clay. Permeability data were not available for the specific site soils; therefore, a range of typical values for clayey soils was assumed. The average interstitial seepage velocity may be estimated by using the equation

$V = \dfrac{K\,h/l}{n^c}$, where:

V = average interstitial velocity

K = average estimated coefficient of permeability, the assumed range is 3×10^{-3} to 3×10^{-5} ft/day (1×10^{-6} to 1×10^{-8} cm/sec) for tight, plastic clays (from Cedergren, 1989, pp. 31 and 32)
h = difference in hydraulic head between two aquifers (82.7 ft); this information was obtained for the Fluvial Aquifer at MW-32 (226.02 NGVD) and the Memphis Sand Aquifer at MW-37 (143.36 NGVD)
l = thickness of the confining unit (75 ft at MW-37)
h/ l = hydraulic gradient (dimensionless)
n^e = estimated effective porosity (dimensionless), assumed as 0.40 for clays

The calculated range of downward seepage velocities is 3.3×10^{-2} to 3.3×10^{-4} ft per day. This approach indicates that the confining unit in the Dunn Field area near MW 37, where the confining unit is 75 ft thick, could be penetrated by water flow in a time frame from 25 to 2,500 years. These calculations are based on assumptions that will be refined and verified during future remedial investigations.

Memphis Sand ("500-foot sand"). The Memphis Sand represents the region's most important source of water resources. This unit was investigated by drilling three deep soil borings and installing MW-36 and MW-37 during the RI (ref. 18). Information describing the unit was obtained from the two wells, three borings, and published sources.

The Memphis Sand is reported to underlie the entire Memphis area. At DDMT, the top of the Memphis Sand is approximately 125 to 150 ft NGVD. The base of the unit is on the order of -750 ft NGVD, based on interpolation of Moore's work (ref. 29). The Memphis Sand contains groundwater under strong artisan (confined) conditions. Locally, extensive pumping has lowered water levels considerably. The Memphis Sand potentiometric level at MW-36 and MW-37 ranges from 143 to 146 ft NGVD. Flow in the unit is directed generally westward, toward the Allen Well Field, a major local pumping zone.

The Memphis Sand is reported to derive most of its recharge from areas where it crops out. The outcrop area forms a wide northeast trending belt several miles east of Memphis. The outcrop belt extends from the east of Shelby, Fayette, and Hardemen Counties northeast across much of west Tennessee.

Fort Pillow Sand. The Fort Pillow Sand (also called the "1400-foot sand") underlies DDMT and the Memphis region at great depth, on the order of 1,400 ft bgs. It is reported to average some 200 ft thick in the study area. The unit contains groundwater under strong artisan (confined) conditions. It derives most of its recharge from its area of outcrop well east of the study area and from hydrogeologic units in hydraulic communication with it. The Fort Pillow Sand potentiometric level in the DDMT area was interpolated to be on the order of 180 ft NGVD in the fall of 1985 (ref. 11).

2.4.6.3 Groundwater Pumpage and Use

The fluvial deposits provide water to many domestic and farm wells in rural areas of the Gulf Coastal Plain, but none are located within the immediate vicinity of DDMT (see Section 2.4.6.6 for results of the well survey from the RI Report (ref. 18). The fluvial deposits have a limited saturated thickness and are subject to groundwater level fluctuations.

The Memphis Sand currently provides about 95 percent of the water used for municipal and industrial water supplies in the Memphis area and is the sole source of water for the City of Memphis. The Memphis Sand was first used as a source of water at Memphis in 1886; since then, withdrawals have increased in proportion to industrial and population growth. In 1984, municipal and industrial pumpage from the Memphis Sand in the Memphis area averaged about 180 mgd. The remaining 5 percent of the water used for municipal and industrial supplies comes from the Fort Pillow Sand (10 mgd in 1984) (ref. 11).

Published maps of water levels in wells completed in the Fluvial Aquifer and Memphis Sand in the Allen Well Field are inconclusive in indicating a hydraulic connection between the two units. The 15- to 20-foot drawdown in the Memphis Sand is not reflected in the immediately overlying Fluvial Aquifer. However, the well density used on the published maps is not sufficient to address this issue, and it should be considered a data gap in the knowledge base for this aspect of the project.

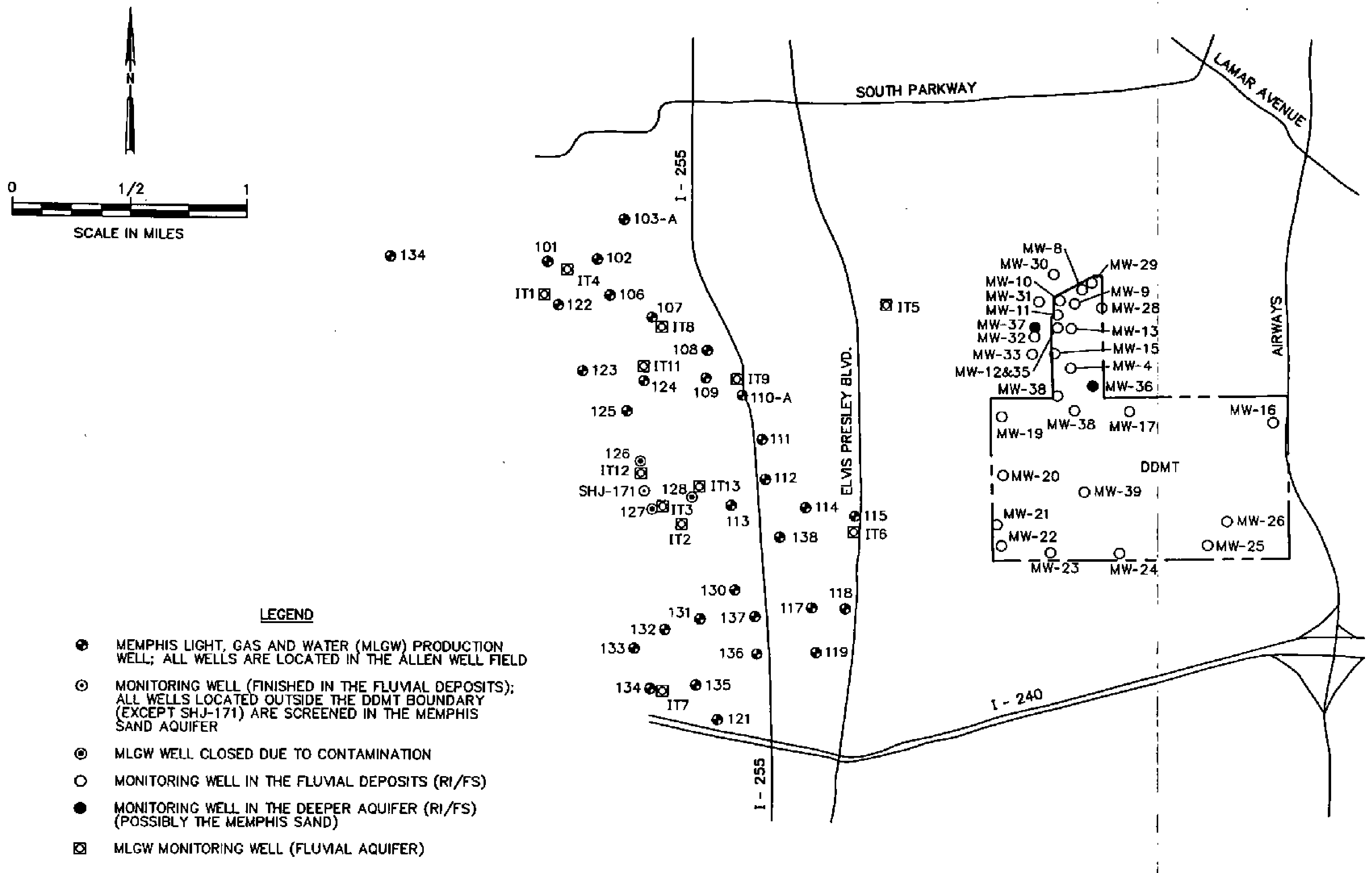
2.4.6.4 Water Quality

McMaster and Parks (ref. 22) report on water quality of the Fluvial Aquifer in the Memphis area. In their study, 28 wells were sampled in 1986 and 1987 and analyzed for selected trace inorganic constituents and synthetic organic compounds. Seven additional wells were installed in Memphis Light, Gas, and Water (MLGW) wellfields (see Figure 2-18 for locations of MLGW wellfields), and were sampled and analyzed for the same constituents. From their studies, the authors concluded that water from the Fluvial deposits has low concentrations of dissolved solids, generally is moderately hard, and has low concentrations of iron. The MLGW field study indicated that all major and trace inorganic constituents in the Fluvial Aquifer were within the known range of values for natural, uncontaminated water. Synthetic organic compounds were not detected in any of these samples. Comparisons between the MLGW and USGS studies, and the associated data, are discussed in the next section.

2.4.6.5 Allen Well Field

DDMT is located east of the Allen Well Field, one of six pumping centers owned and operated by the MLGW. The Allen Well Field draws water from the Memphis Sand Aquifer, which is the potable water source for the City of Memphis and most of Shelby

126 89



LEGEND

- ● MEMPHIS LIGHT, GAS AND WATER (MLGW) PRODUCTION WELL; ALL WELLS ARE LOCATED IN THE ALLEN WELL FIELD
- ⊙ MONITORING WELL (FINISHED IN THE FLUVIAL DEPOSITS); ALL WELLS LOCATED OUTSIDE THE DDMT BOUNDARY (EXCEPT SHJ-171) ARE SCREENED IN THE MEMPHIS SAND AQUIFER
- ◉ 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)
- ☒ MLGW MONITORING WELL (FLUVIAL AQUIFER)

Source: RI Report, 1990

MWP-0021.DWG 03-Mar-1995

FIGURE 2-1B
ALLEN WELL FIELD LOCATION RELATIVE TO DDMT
Defense Depot Memphis, Tennessee

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County. Studies have implied that suspected areas of hydraulic interconnection may exist in the confining layer overlying the Memphis Sand Aquifer, which may allow migration of contaminants from water table aquifers (ref. 11). It is important to note that, to date, none of the studies performed at DDMT have conclusively shown that any of these areas exist beneath DDMT. However, one of the investigation's purposes is to assess whether one of these areas exists beneath the Main Installation. Contaminants migrating from DDMT possibly could reach surrounding water table aquifers and could potentially contaminate the Memphis Sand Aquifer. Of the 33 Allen Well Field wells, 13 lie within one mile of DDMT (see Figure 2-18). A detailed map showing the locations of the Allen Well Field monitoring and production wells is provided in Figure 2-18. DDMT will coordinate with MLGW to obtain available information regarding the integrity of the Allen Well Field wells.

Analyses in 1988 and 1989 of groundwater samples obtained from wells within the Allen Well Field show no contaminants exceeding drinking water standards. When analyzed during 1988, Wells 113, 114, 115, 117, 118, and 138, which all lie within one mile of DDMT (see Figure 2-18), had levels of volatile organic chemicals that were below gas chromatographic detection limits. In 1988, MLGW detected low levels of chlorinated solvents in Allen Well Field Wells 126, 127, and 128. At that time, MLGW officials believed the source of contamination was an industrial concern located close to the three wells. They did not consider DDMT as a potential source because DDMT was located more than a mile away from the problem wells, and wells located closer to DDMT did not exhibit contamination. The wells were resampled in 1989 and continued to have detectable levels of chlorinated compounds. One of the three wells is no longer used (127), while the other two are used only during periods of peak demand (ref. 26).

Table 2-5 shows the contaminants detected in the Allen Wells as well as the constituents detected in the DDMT monitoring wells, while Tables 2-6 and 2-7 show the analytical results for the operating production wells and the "IT-" series wells in the Allen Well Field. It is important to note that the Allen Wells are screened in the Memphis Sand. In response to an agency review comment, analytical results for the operating production wells and the "IT-" series wells in the Allen Well Field were obtained. These data are presented in Tables 2-6 and 2-7, and were obtained for the same period of record as the data presented in Table 2-7.

DDMT well locations shown in Table 2-7 are screened in the Fluvial Aquifer. An analysis of water, dated September 30, 1988, which was taken at the post-chlorination distribution point for the Allen Well Field, contained low levels of bromodichloromethane, chlorodibromomethane, and chloroform (ref. 23). These constituents, which are common by-products in water that has undergone chlorination (ref. 32), have not been detected at the DDMT, but the wells will continue to be analyzed for them. Figure 2-18 shows the location of both production and monitoring wells in the Allen Well Field.

Table 2-5
Comparison of Volatile Contaminants Found at DDMT to Contaminants in Closed Wells at Allen Water Well Field (1988 - 1990)
Defense Depot Memphis, Tennessee

Chemical Name	DDMT Groundwater Concentrations (ppb)		DDMT Groundwater Concentrations (ppb)		Closed Wells, Allen Pumping Station			
	Maximum, 4/89	Well Location	Maximum, 1/90	Well Location	Well 126 (ppb) 8/30/88	Well 126 (ppb) 6/14/89	Well 127 (ppb) 8/30/88	Well 128 (ppb) 8/30/88
VOLATILE ORGANICS								
Tetrachloroethene	210	MW-5	240	MW-10	ND	ND	ND	ND
Carbon Tetrachloride	77	MW-6	52	MW-32	ND	ND	ND	ND
Benzene	ND		ND		ND	ND	22.00	0.17
1,1,1-Trichloroethane	9	MW-10	10	MW-10	ND	ND	ND	ND
Chloroform	15	MW-6	33	MW-31	ND	ND	ND	ND
1,1-Dichloroethane	3	MW-10	5	MW-29	0.11	ND	2.86	0.08
1,2-Dichloroethene	ND		3	MW-10	ND	ND	1.94	ND
1,1-Dichloroethene	130	MW-10	160	MW-10	0.17	ND	0.11	0.16
1,2-Dichloroethene	520	MW-11	1100	MW-31	0.17	0.15	2.33	0.17
1,1,2-Trichloroethane	7	MW-6	12	MW-31	ND	ND	ND	ND
Trichloroethene	1700	MW-12	5100	MW-12	1.10	0.95	0.13	ND
1,1,2,2-Tetrachlorethane	340	MW-12	1900	MW-12	ND	ND	ND	ND
Acetone	34	MW-6	3500	MW-37	ND	ND	ND	ND
Vinyl Chloride	ND		ND		ND	ND	0.17	ND
1,2-Dichloropropane	ND		ND		0.92	0.72	ND	ND
2-Methyl-2-Pentanone	ND		8	MW-37	ND	ND	ND	ND
Toluene	1	MW-27	ND		0.90	ND	ND	ND

Table 2-6
Analytical Results from the Allen Well Field Production Wells (1988 - 1989)
All results in µg/L

Page 1 of 2

		Analytical Compound															
Well #	Date	Benzene	Carbon Tetrachloride	Chloroform	Dibromo-chloromethane	1,1-Dichloro-ethane	1,3-Dichloro-benzene	1,2-Dichloro-ethane	1,1-Dichloro-ethene	cis 1,2-Dichloro-ethene	1,2-Dichloro-propane	Naphthalene	Tetrachloro-ethene	Toluene	Trichloro-ethene	1,2,3-Trichloro-propane	Vinyl Chloride
101	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
102	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
103	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
106	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
107	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
108	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
109	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
110	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
111	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
112	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
113	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
114	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
115	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
117	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
118	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
122	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
123	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Table 2-6
Analytical Results from the Allen Well Field Production Wells (1988 - 1989)
All results in µg/L

Page 2 of 2

		Analytical Compound															
Well #	Date	Benzene	Carbon Tetrachloride	Chloroform	Dibromo-chloromethane	1,1-Dichloro-ethane	1,3-Dichloro-benzene	1,2-Dichloro-ethane	1,1-Dichloro-ethene	cis 1,2-Dichloro-ethene	1,2-Dichloro-propane	Naphthalene	Tetrachloro-ethene	Toluene	Trichloro-ethene	1,2,3-Trichloro-propane	Vinyl Chloride
124	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
125	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
126	1988	BDL	BDL	BDL	BDL	0.11	BDL	BDL	0.17	0.17	1.11	BDL	BDL	BDL	1.08	BDL	BDL
	4/25/88	BDL	BDL	BDL	BDL	0.09	BDL	0.07	0.48	0.14	1.04	BDL	BDL	BDL	0.85	BDL	BDL
	1989	0.88	BDL	BDL	BDL	0.12	BDL	BDL	0.18	0.22	0.83	BDL	BDL	BDL	1.1	BDL	BDL
127	1988	10.8	BDL	BDL	BDL	2.08	BDL	2.93	0.11	2.31	BDL	BDL	BDL	BDL	0.13	BDL	0.52
	4/25/88	BDL	BDL	BDL	BDL	2.76	BDL	3.53	0.28	2.06	BDL	BDL	BDL	BDL	0.12	BDL	0.41
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
128	1988	BDL	BDL	BDL	BDL	0.08	BDL	BDL	0.16	0.17	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
130	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
136	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
137	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
138	1988	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	1989	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Table 2-7
Analytical Results from the Allen Well Field
IT Series Wells (1988 - 1989)
All results in mg/L

		Analytical Compound															
Well #	Date	Benzene	Carbon Tetrachloride	Chloroform	Dibromo-chloromethane	1,1-Dichloro-ethane	1,3-Dichloro-benzene	1,2-Dichloro-ethane	1,1-Dichloro-ethene	cis 1,2-Dichloro-ethene	1,2-Dichloro-propane	Naphthalene	Tetrachloro-ethene	Toluene	Trichloro-ethene	1,2,3-Trichloro-propane	Vinyl Chloride
IT1	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT2	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT3	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT4	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT5	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT6	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT7	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT8	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT9	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT10	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT11	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT12	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IT13	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not analyzed
BDL = Below detection limit

The USGS has also analyzed selected wells in the alluvial and fluvial deposits in the Memphis area. One well, SH:J-171, is physically located near the Allen Well Field, and is screened in the Fluvial Aquifer at a depth of 71 ft bgs. The results of analyses for dissolved metals and volatile organic constituents are summarized in Table 2-8 (ref. 11). No levels of metals or volatile organic constituents exceeded drinking water standards for contaminant concentrations. However, these data are not directly comparable to the data from DDMT monitoring wells, because wells at DDMT were analyzed for total metals rather than dissolved metals.

2.4.6.6 Well Survey

The State of Tennessee and the local health department monitor the number of wells in the Memphis area by requiring drilling permits and annual permit renewals for continuous well operation. A preliminary well survey of the area (conducted during the RI [ref. 18]) within a 1-mile radius of DDMT did not reveal the existence of any private residential wells. Four industrial wells (Cochran, Kellogg, and two at United Refrigeration) are located within a 2-mile radius, but are not used as potable water sources (ref. 28). The Memphis-Shelby County Health Department (MSCHD) has analyzed groundwater samples collected from the Cochran (January 30, 1989) and United Refrigeration (October 10, 1988), industrial wells for total phenols, metals, total coliforms, and nitrates. All three wells were found to have acceptable water quality for the parameters analyzed. All four industrial wells are screened in the Memphis Sand Aquifer at depths of approximately 450 to 500 ft (ref. 28).

2.4.7 Land Utilization

Land use of the specific zones located within the area of interest was determined by visual reconnaissance during the RI (ref. 18) and by previous investigations (Section 2.2). Figure 2-19 shows most current land use information for the area surrounding DDMT.

2.4.7.1 Demographics

DDMT is located in the southern portion of the City of Memphis. Table 2-9 shows the census data for the total Memphis Standard Metropolitan Statistical Area (SMSA) city area.

The 1988 estimated median age for the areas surrounding the DDMT is 29.5, with 25 percent of the population under the age of 15 and 11 percent over the age of 65. Females make up 54 percent of the population. Most of the residents have lived in the area fewer than 5 years or more than 15 years (ref. 6). Two additional zip codes are within 1 mile of DDMT, but no census data was available for these codes (38132 and 38131) (ref. 5).

Table 2-8
Dissolved Metals and Volatile Organic Compounds
USGS Fluvial Well
Defense Depot Memphis, Tennessee

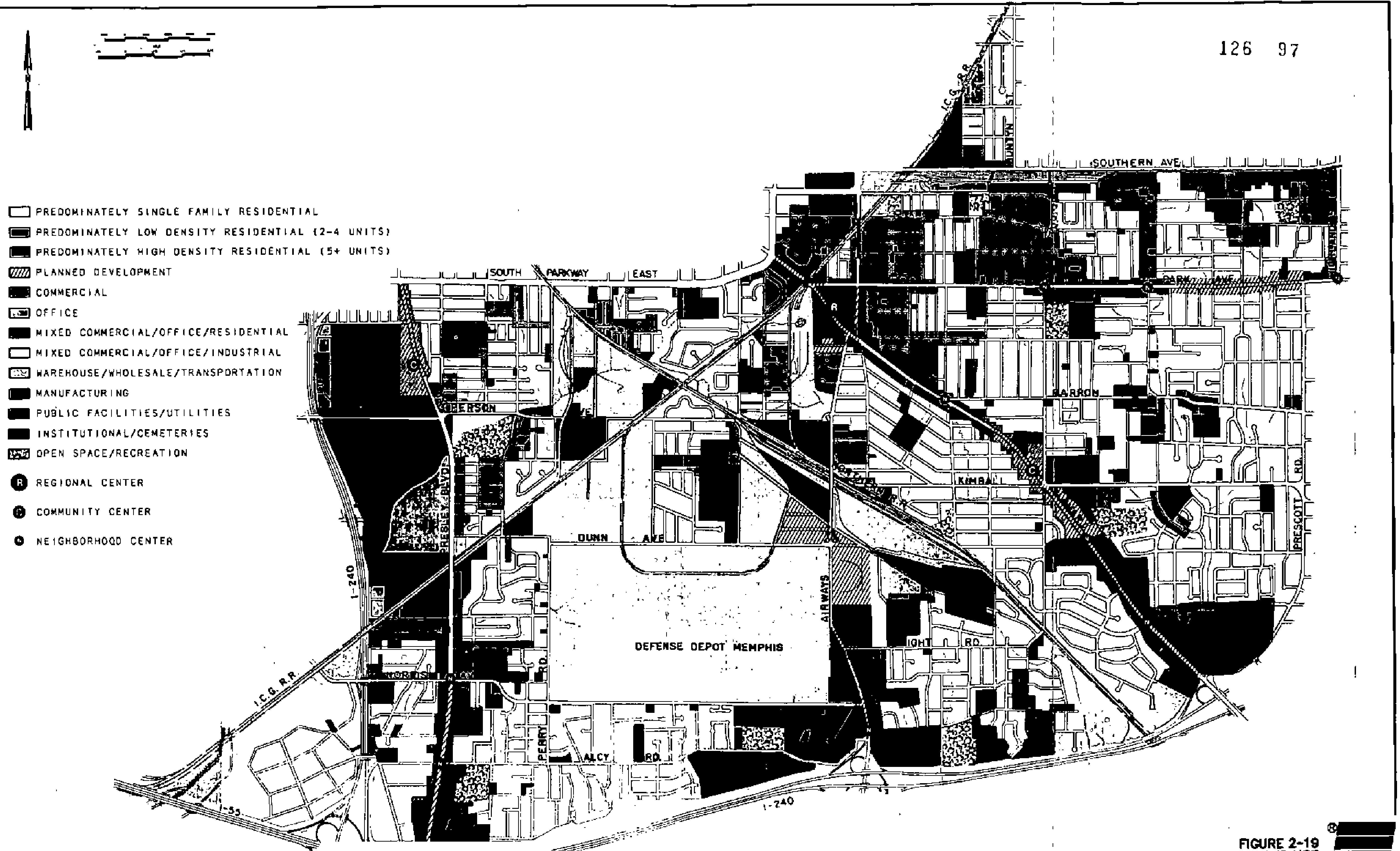
Well Name	Depth, Ft.	Sample Date
SH: J-171	71	02-03-87

Concentrations of Constituents (μg/L)

Arsenic, Dissolved	Barium, Dissolved	Cadmium, Dissolved	Chromium, Dissolved	Lead, Dissolved	Mercury, Dissolved	Total Volatile Organic Compounds
<1	92	2	4	<5	<0.1	<3

Source: USGS, 1988.

126 97



Source: Memphis and Shelby County Office of Planning and Development.
Map Prepared May, 1983.

FIGURE 2-19
LAND USE
Defense Depot Memphis, Tennessee

CH2M HILL

Table 2-9
1990 Census Data for DDMT and Surrounding Area
Defense Depot Memphis, Tennessee

	1980 Census	1988 Estimate	1993 Projection
Total Population	646,356	652,875	659,441
Total Households	230,474	244,545	253,588
Average Household Size	2.8	2.6	2.6

1990 Census Data for Zip Code 38114

	1980 Census	1988 Estimate	1993 Projection
Total Population	47,781	47,109	46,587
Total Households	15,502	16,315	16,562
Average Household Size	3.1	2.9	2.8

1990 Census Data for Zip Code 38106[a]

	1980 Census	1988 Estimate	1993 Projection
Total Population	46,686	43,956	43,108
Total Households	14,588	14,214	14,312
Average Household Size	3.2	3.1	3.0

[a] DDMT is surrounded by zip codes 38114 and 38106.

2.4.7.2 Land Use

The summary below was obtained from Harland, Bartholomew and Associates, 1988 (ref. 15).

Adjacent Land Use. DDMT is located in south-central Memphis in an area of widely varying uses. To the north of DDMT are the rail lines of the Frisco Railroad and Illinois Central Gulf Railroad. A number of large industrial and warehousing operations are located along the rail lines in this area including Kellogg Company; Laramie Tires; Lanigan Storage and Van Company; the Kroger Company; National Manufacturing Company, Incorporated; and United Uniforms. A triangular area immediately to the north of DDMT along Dunn Road also contains several industrial firms. Formerly a residential neighborhood, the area is characterized by small commercial and manufacturing uses with a few single-family residences remaining.

Airways Boulevard is the most heavily traveled thoroughfare in the vicinity and is developed with numerous small, commercial establishments, particularly from DDMT southward to the Airways interchange with Interstate 240. Businesses along Airways Boulevard are typical of highway commercial districts and include convenience stores, liquor stores, restaurants, used car dealers, and service stations. Other commercial establishments are located to the north, south, and west of DDMT. Most are small groceries or convenience stores that serve their immediate neighborhoods.

DDMT is surrounded by residential development. Several large, multi-family developments are in the area, ranging from an older apartment complex (Castalia Heights Apartments) north of DDMT along Carver Avenue and Keltner Circle, to a newly constructed development (Orchid Manor) south of DDMT on Ball Road.

Institutional uses include numerous small church buildings scattered throughout the residential neighborhoods. Several schools are located in the area: Alcy Road Elementary to the south of DDMT; Norris Elementary, Dunn Elementary, Corry Junior High, Hamilton High, Hamilton Junior High, and Hamilton Elementary to the west; Magnolia Elementary to the northeast; and Charjean Elementary and Airways Junior High to the east. Five cemeteries are located near DDMT: Anshei-Sphard, located directly across Airways Boulevard; Baron Hirsch, located to the northwest on Rozelle Street; and Calvary, Forest Hill, and Temple Israel in the vicinity of Person Avenue and Bellevue Boulevard, to the west. MLGW operates a large substation to the northwest of DDMT along Person Avenue.

Two neighborhood parks are in the immediate vicinity of DDMT. Alcy Samuels Park is located on Alcy Road to the south of DDMT. Lincoln Park is located on Person Avenue to the west of DDMT.

Most of the land surrounding DDMT is intensely developed. However, three relatively large, undeveloped sites exist in the general area. The largest is located to the north of DDMT at Person Avenue and Rozelle Street. Other areas are located south of DDMT along Ball Road and Ketchum Road in the vicinity of the Orchid Manor Apartments, and east of DDMT on Dwight Street.

Land Use Controls. In Memphis and Shelby Counties, zoning controls and subdivision requirements are under the jurisdiction of the Office of Planning and Development (OPD). The DDMT property itself is zoned Light Industrial (I-L). This designation extends to several contiguous parcels east of DDMT along Airways Boulevard, in the vicinity of the Kellogg plant westward past Rozelle Street. Several smaller areas adjacent to those mentioned above are zoned Heavy Industrial (I-H).

Commercially zoned areas predominate along Airways Boulevard from DDMT southward to the Airways Boulevard intersection with Interstate 240. Other commercially zoned areas exist along Castalia, Hearst, and Ragan (north of DDMT) and along Alcy and Ketchum (south of DDMT).

Most of the remaining land in the vicinity of DDMT is zoned for single-family or duplex residential. However, several large parcels have been zoned to allow multi-family developments, particularly to the north of DDMT in the Castalia Heights area; to the west of DDMT on Dunn Avenue near Lincoln Park; to the south of DDMT along Alcy and Ketchum roads; and to the east of DDMT along Airways, Dwight, Pecan, and Ketchum.

2.4.8 Ecology

The following sections discuss the flora and flauna at DDMT.

2.4.8.1 Flora

Most of the facility is restructured surfaces with little observable vegetation. The unsurfaced areas have native Bermuda grass and some deciduous black oak (*Quercus velutina*). Some decorative plant species have been used in landscaping the housing area, golf course, administrative areas, and the lake (ref. 15).

2.4.8.2 Fauna

No habitats of threatened or endangered species are known to exist on the DDMT facility; however, DDMT personnel have reported sighting migratory birds that may be considered threatened or endangered using surface water bodies at DDMT. Lake Danielson has been stocked in the past with bass (*Micropterus sp.*) and bluegill (*Lepomis sp.*) and also contains catfish (*Letalurus sp.*). However, as mentioned previously, Lake Danielson and the Golf Course Pond have been placed off-limits for recreational uses since 1986. Dunn Field is a large open area with mature oak trees and grass. Several additional species have been noted at Dunn Field, including squirrels (*Sciurus niger*), the red fox (*Vulpes vulpes fulva*), mourning doves (*Zenaidura macroura*), quail (*Colinuus virginianus*), and turtles (*Terrpaene carolina*) (ref. 15).

2.4.9 Summary of Physical Characterization Information

Information compiled and evaluated for this study suggests the following:

- The Dunn Field area is essentially undeveloped. It has slight to moderate relief. The Main Installation has been extensively developed and is essentially level.
- The study area receives about 50 inches of annual precipitation. Net precipitation was calculated to be 9 inches annually, a value suggesting the possible generation of leachate and migration of waste-related contamination.
- Few surface water drainage controls are present in Dunn Field. The Main Installation has an extensive storm water drainage system. Lake Danielson and the Golf Course Pond receive installation surface drainage.
- It is unlikely that DDMT will flood.
- Site surficial soils (loess) are predominantly fine-grained, low permeability materials that promote rapid runoff and limit percolation where they remain intact and undisturbed.
- The study area's shallow aquifer is composed of the Fluvial deposits, of which only the lower extent is saturated. The unit's water levels are some 37 to 145 ft bgs. The unit obtains recharge from precipitation infiltration. A Fluvial Aquifer water level map (see Figure 2-14) was contoured using water levels recorded by ESE in November 1993 (ref. 88). The groundwater flow directions indicate a water level depression in the northern portion of OU-4, in the approximate location of a depression in the top of underlying clay layer. This portion of DDMT is a suspected area of hydraulic interconnection between the Fluvial Aquifer and the underlying Memphis Sand Aquifer. The extent of the suspected area of hydraulic interconnection is currently unknown. The groundwater elevations range from approximately 160 ft NGVD in the depression to approximately 230 ft NGVD in the eastern portion of the Main Installation.
- The fluvial deposits are underlain by the Jackson Formation/Upper Claiborne Group, a documented confining unit in the study area. The top

of this unit may influence flow directions in the overlying fluvial deposits. The unit appears to be persistent in the Dunn Field area, where the highest concentration of contaminants was found. It both deepens and thins in other areas beneath DDMT.

- The Memphis Sand Aquifer is a regionally significant source of potable water supplies in the Memphis area. This hydrogeologic unit underlies DDMT at a depth of approximately 180 ft and receives most of its recharge from the outcrop area, several miles east of Memphis. Some recharge is derived from overlying or hydraulically communicating units.

- The Fort Pillow Sand, a second regionally significant aquifer, underlies the Memphis Sand at great depth.

- Study area land use includes mixed residential, commercial, and industrial. Numerous residences border Dunn Field.

- DDMT is an intensely developed area. As such, it offers little habitat. No threatened or endangered species habitats have been observed on the installation.

TAB

Section 3 Initial Evaluation

3.0 Initial Evaluation

This section briefly describes the nature and extent of soil, groundwater, surface water and sediment contamination at each of the OUs at DDMT on the basis of data obtained from the site characterization activities to date. A conceptual model of DDMT, including information from the preliminary baseline public health evaluation during the RI (ref. 18), is presented in this section. OUs are discussed by media to provide a general qualitative overview of the known nature and extent of contamination. Table 3-1 presents the potential constituents of concern. Detailed information regarding the analytical results is provided in Appendix D.

3.1 Nature and Extent of Known Contamination

A detailed description of contamination including contaminant concentrations and figures showing sample locations will be provided in the OU-specific FSPs to justify sample locations and proposed chemical analysis. In addition, figures showing locations of all previous sampling sites and tables showing corresponding data from these sampling locations for the four OUs are provided in Appendix D of this report, and in this section. Findings are summarized by OU, for each media, in the following subsections.

During the 1990 RI (ref. 18), 50 surface soil samples and 24 subsurface samples were collected from 8 stratigraphic soil borings (3 per boring) throughout DDMT (1990). All soil samples (surface and subsurface) were analyzed for volatile organic compounds (EPA Method 8240), semivolatile organic compounds (EPA Method 8250), pesticides/PCBs (EPA Method 8080), total metals (EPA Method 3050/6010), and mercury (EPA Method 7471). EPA methodologies listed above are found in EPA SW-846, 3rd Edition. Surface soil and subsurface soil samples collected during the RI and presented in the RI Report (ref. 18) are designated as "SS" (Surface Soil) and "STB" (Stratigraphic Test Boring), respectively.

Groundwater samples were analyzed for VOCs (EPA Method 8240), SVOCs (EPA Method 8270), pesticides/PCBs (EPA Method 8080), total metals (EPA Method 6010, including antimony, arsenic, barium, cadmium, chromium, copper, lead, silver, selenium, nickel, and zinc), and mercury (EPA Method 7470). The EPA methodologies listed above are found in EPA SW-846, 3rd Edition. All water matrix samples were measured for pH, temperature, and specific conductance in the field. Groundwater samples collected during the RI and presented in the RI Report (ref. 18) are designated by monitoring well (MW) in Appendix D.

MW-16, located in the extreme northeastern corner of the Main Installation (Drawing 2), was installed during the RI (ref. 18) to provide background water quality information at DDMT. MW-16 is screened in the Fluvial Aquifer. No chlorinated VOCs were detected

Table 3-1
Potential Constituents of Concern
Defense Depot Memphis, Tennessee

	Groundwater	Soil	Surface Water and Sediment
VOLATILE ORGANICS:			
Acetone	X	X	X
Carbon Tetrachloride	X		
1,1-Dichloroethene	X		
1,2-Dichloroethene	X		
1,1,2,2-Tetrachloroethane	X		
Tetrachloroethene	X		
Trichloroethene	X	X	
Methylene Chloride		X	
BASE/NEUTRAL/ACID EXTRACTABLES:			
Antracene		X	
Benzo(a)antracene		X	
Benzo(a)pyrene		X	
Benzo(b)fluoranthene		X	
Benzo(K)fluoranthene		X	
Crysene		X	
Fluoranthene		X	
Ideno(1,2,3-cd)pyrene		X	
Phenanthrene		X	
Pyrene		X	
PESTICIDES AND PCBS:			
4,4'-DDD		X	X
4,4'-DDE		X	X
4,4'-DDT		X	X
Beta-BHC		X	X
Dieldrin	X	X	X
METALS:			
Arsenic	X	X	X
Barium	X		
Chromium	X	X	X
Lead	X	X	X
Mercury	X		

Note: Potential Constituents of Concern based on results presented in the RI Report (ref. 18) in this well in two separate phases of sampling during the RI (ref. 18). Samples analyzed from MW-16 in Phase I and Phase II of the RI (ref. 18) indicated the presence of arsenic, barium, chromium, copper, lead, and zinc. Samples taken from MW-16 during groundwater monitoring by Environmental Science & Engineering, Inc., (ref. 88) in 1993 indicated the presence of trichloroethene, aluminum, arsenic, barium, chromium, copper, lead, and zinc. The positive results reported for total metals may be indicative of natural background concentrations. This assumption will be evaluated through the background sampling plan discussed in Section 5.3.2.

All surface water samples were analyzed for the same constituents using the same analytical procedures as groundwater. Surface water samples collected during the RI and presented in the RI Report (ref. 18) have an "SW" prefix.

The sediment samples collected from Lake Danielson and the Golf Course Pond were analyzed using the same analytical methods described for soils previously. No sediment samples were taken from the previously identified ephemeral water bodies because no saturated sediments were available to sample. AOCs A, B, C, and G are all concrete-lined, storm water drainage channels. Sediment samples are referred to with the "SD" prefix.

3.1.1 Nature and Extent of Known Contamination at OU-1—Dunn Field

OU-1 at Dunn Field includes 10 RI/FS sites, 10 early removal sites, 8 screening sites, 3 chemical warfare management plan sites, and 5 proposed NFA sites. Of the 10 RI/FS sites, all are sites where burial of wastes has either been documented or was discovered during the RI (ref. 18). The other two sites include an area where open burning periodically took place and an area where pesticides were stored. A short description of these sites is found in Table 1-1.

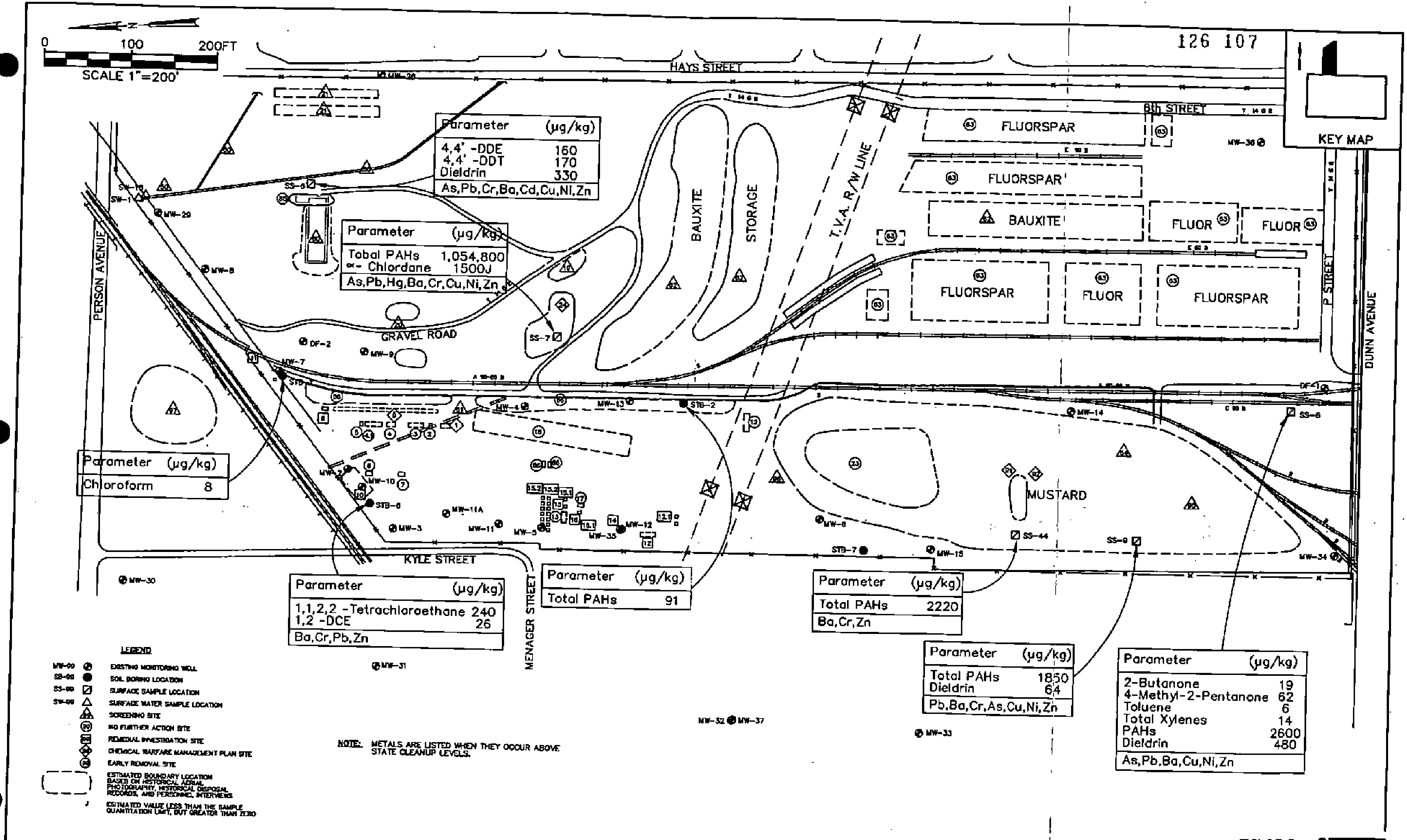
Groundwater, surface soil, subsurface soil, and surface water have been previously sampled at OU-1. Previous sample locations are shown in Drawing 1. Highlights of previous investigation results are summarized below.

3.1.1.1 Soil

The 23 burial sites in OU-1 (10 RI sites, 2 CWMP sites, 9 ER sites, and 2 screening sites) have not been individually investigated during the RI/FS or during previous investigations. DDMT has recorded the burial site locations through the years, using dimensions from known landmarks, and summarized them in the RFA (ref. 68) on a map. Drawing 1 shows site locations in this OU.

Building 1184 (Site 85) was formerly used to support a pistol range and was subsequently used to store pesticides and herbicides. A soil sample (SS-6) taken near this building (ref. 18) (see Figure 3-1) exhibited pesticides (DDT, DDE, and dieldrin). MW-9 was

126 107



Parameter	(µg/kg)
4,4' -DDE	160
4,4' -DDT	170
Dieldrin	330
As,Pb,Cr,Ba,Cd,Cu,Ni,Zn	

Parameter	(µg/kg)
Tobal PAHs	1,054,800
∝- Chlordane	1500J
As,Pb,Hg,Ba,Cr,Cu,Ni,Zn	

Parameter	(µg/kg)
Chloroform	8

Parameter	(µg/kg)
1,1,2,2 -Tetrachloroethane	240
1,2 -DCE	26
Ba,Cr,Pb,Zn	

Parameter	(µg/kg)
Total PAHs	91

Parameter	(µg/kg)
Total PAHs	2220
Ba,Cr,Zn	

Parameter	(µg/kg)
Total PAHs	1850
Dieldrin	64
Pb,Ba,Cr,As,Cu,Ni,Zn	

Parameter	(µg/kg)
2-Butanone	19
4-Methyl-2-Pentanone	62
Toluene	6
Total Xylenes	14
PAHs	2600
Dieldrin	480
As,Pb,Ba,Cu,Ni,Zn	

NOTE: METALS ARE LISTED WHEN THEY OCCUR ABOVE STATE CLEANUP LEVELS.

Source: RI Report, 1990

MWP-0003.DWG 03-Mar-1995

FIGURE 3-1
PREVIOUS SOIL SAMPLING DATA
DUNN FIELD (OU-1)
Defense Depot Memphis, Tennessee

sampled, and these contaminants were not found in the groundwater in this area. MW-9 is downgradient from Building 1184.

The open burning area (Site 24) was investigated with one surface soil sample (SS-7) (see Figure 3-1) at a depth of approximately 1 foot during the RI (ref. 18). The results of this analysis revealed PAHs and alpha-chlordane. Results in this sample possibly show evidence of buried burned material. The existence of PAHs can be an indication of buried burned material, because these contaminants are readily formed during the combustion of oil, gas, or organic material.

Sample SS-8 (see Figure 3-1) was collected in the south-central portion of OU-1 at a site that contained drums of what appeared to be used motor oil. The location of this sample does not correspond to an existing site. The surrounding ground was discolored from the drums' contents. This sample contained levels of VOCs including ethyl benzene, 4-Methyl-2-pentanone, xylene, and toluene. The pesticide dieldrin also was detected in this sample. Metals that were detected include arsenic, lead, barium, and chromium.

Sample SS-9 was collected during Phase I from the lowest drainage point in the southwestern portion of OU-1. SS-44 was collected approximately 200 ft northwest of SS-9. PAHs were detected in both samples at approximately the same levels. Dieldrin was detected in SS-9. The locations of these samples correspond to Site 64, where bauxite was stored from 1942 through 1972.

Soils analyzed from STB-1 and STB-2 contained barium and cadmium. Chloroform, was present in STB-1 at 14 ft. Pyrene and fluoranthene were present in STB-2.

The pump test well and three piezometers were installed during 1992, and soil cuttings from those wells were analyzed for agent mustard, chloroform, and thiodiglycol (the breakdown product of mustard) in addition to other analyses. Agent mustard, chloroform, and thiodiglycol were not detected. Metals detected in the cuttings include arsenic, barium, chromium, lead, and zinc. VOCs detected include 1,1-DCE, vinyl chloride, TCE, and 1,1,2,2-Tetrachloroethene. Pesticides detected include 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and dieldrin.

3.1.1.2 Groundwater

Groundwater, both in the Fluvial and Memphis Sand aquifers, has been studied extensively at OU-1, and therefore a reasonable understanding of the nature and extent of groundwater contamination at this OU currently exists. Major findings of the groundwater investigation to date are as follows:

- Contaminant migration past the boundaries of OU-1 has occurred.
- Metals of concern include chromium, lead, mercury, arsenic and barium.
- VOCs of concern include TCE, tetrachloroethane, and 1,1-DCE.

Groundwater samples were collected in OU-1 from MW-2 through MW-15 during Phase I of the RI (ref. 18). MW-1 through MW-7 are wells that were installed by USAEHA in 1985. MW-8 through MW-15 were installed during Phase I of the RI (ref. 18). MW-1 was destroyed before the RI (ref. 18) and was not accessible for sampling. MW-2 is screened in a perched water table at a depth of 29 ft. With the exception of MW-36 and MW-37, monitoring wells are screened in the Fluvial Aquifer. Drawing 1 shows the location of monitoring wells at OU-1.

Analytical results from Phase I of the RI (ref. 18) indicate possible contaminant migration past the boundaries of OU-1. As a result, five monitoring wells (MW-30, MW-31, MW-32, MW-33, and MW-37) were installed west of OU-1. Except for MW-37, all of the wells were screened in the Fluvial Aquifer. MW-37 was installed in the Memphis Sand Aquifer. An interpretation of the potentiometric groundwater contours (November 1993), as prepared by ESE and Memphis State University, is shown in Appendix D, Figure D-1.

Groundwater samples were collected and analyzed again during Phase II of the RI and presented in the RI Report (ref. 18) from the same wells as in Phase I, except for MW-2, which was dry at the time of sampling. In addition to these wells, the five new wells installed in OU-1 during Phase II also were sampled. Four of the new monitoring wells (MW-28, MW-29, MW-34, and MW-35) were screened in the Fluvial Aquifer. MW-36 was installed in the Memphis Sand Aquifer.

Of the metals identified as potential constituents of concern in the RI Report (ref. 18), chromium, lead, and mercury were identified in most wells. The highest levels detected were chromium (800 μg/L, MW-7), lead (653 μg/L, MW-10), and mercury (3.6 μg/L, MW-6). By comparison, the primary drinking water standards for chromium, lead, and mercury are 50 μg/L, 50 μg/L, and 2 μg/L, respectively. Arsenic and barium also were identified as potential contaminants of concern; however, they were less widespread.

Total metals concentrations were reported from several wells on the facility in excess of MCLs. Isoconcentration maps of the distribution of these metals concentrations were not prepared, however, because the total metals concentrations may be more representative of the turbidity in a specific well than they are of a plume of contamination. As implied in the EPA guidance (1989), the results of total, or unfiltered, metals analyses are representative of the metals' actual presence, but the filtered or dissolved metal analytical results may be more representative of the mobile fraction of the metallic species in the groundwater.

Analytical results from the RI (ref. 18) also detected VOCs and total metals concentrations in the Fluvial Aquifer at OU-1. The constituents that were detected include carbon tetrachloride, chloroform, TCE, tetrachloroethane, 1,1-Dichloroethene, 1,1-Dichloroethane, 1,1,1-Trichloroethane, 1,1,2,2-Tetrachloroethane, 1,2-Dichloroethene, 1,1,2-Trichloroethane, and 1,2-Dichloroethane.

Chlorinated VOCs were detected in two of the wells located west of OU-1 (MW-31 and MW-32). Both wells were contaminated with the same constituents that were detected in the wells in Dunn Field. The concentration of the VOCs found in these two wells was within the same order of magnitudes as levels encountered in the northwestern quadrant of Dunn Field.

MW-30 and MW-33, west of Dunn Field, did not contain detectable levels of chlorinated VOCs at the time of Phase II sampling. These two wells were used to define the northern and southern extent of the contaminant plume in this area at the time of the RI (ref. 18).

TCE was the constituent present at the highest levels in samples collected during both phases of sampling. Results from Phase I of the RI (ref. 18) indicated TCE, except in MW-13 and MW-14, with levels ranging from 2 μg/L in MW-15 to 1,500 μg/L in MW-12. In Phase II, the levels of TCE ranged from 4 μg/L in MW-9 to 5,100 μg/L in MW-12. The MCL for TCE is 5 μg/L.

Tetrachloroethene was another major groundwater contaminant found in both rounds of sampling. Analytical results from Phase I of the RI (ref. 18) showed tetrachloroethene in most of the northern wells in Dunn Field, with levels ranging from 3 μg/L in MW-6 and MW-13 to 190 μg/L in MW-10. Measurements in Phase II obtained similar results, with levels ranging from 2 μg/L in MW-6 to 240 μg/L in MW-10. By contrast, the MCL for tetrachloroethene is 5 μg/L.

Samples from MW-10, MW-11, MW-12, and MW-6 tested positive for 1,1,2,2-Tetrachloroethane in Phase I. In Phase II the same wells, along with MW-13, tested positive for this constituent. The highest concentration levels of 1,1,2,2-Tetrachloroethane were found in MW-12 (340 μg/L in Phase I and 1,900 μg/L in Phase II).

Samples from Phase I and Phase II of the RI (ref. 18) detected 1,1-Dichloroethene in MW-3, MW-7, MW-8, MW-9, and MW-10. MW-29 also tested positive in Phase II. Levels of contamination did not change significantly between Phase I and Phase II.

Contaminant contours of the major organic compounds for OU-1, prepared from sampling and analysis conducted in 1993, are shown in Appendix D, Figures D-2 through D-4 (ref. 88). Additional details on the specific contaminants found in each well are provided in both Appendix D of this report and the OU-1 FSP. The OU-1 FSP also addresses previous sampling results by individual sites and data gaps, and the overall strategy for completing these data gaps.

In summary, the analytical results from groundwater samples taken at Dunn Field indicate that the downgradient wells (Figure D-1) west and northwest of Dunn Field are contaminated with chlorinated VOCs and metals.

3.1.2 Nature and Extent of Known Contamination at OU-2—Southwestern Quadrant of Main Installation

OU-2 is illustrated in Drawing 2, with a short description of the individual sites in Table 1-1. Detailed information is provided in Appendix D.

3.1.2.1 Soil

During previous investigations, 15 surface soil samples and three subsurface samples (depths of 16 ft, 78 ft, and 83 ft) from STB-5 were collected in OU-2. The sample locations and analytical results are shown in Figures 3-2 and 3-3. Samples were collected to aid in the evaluation of the former hazardous materials recoupment area (Site 27), the maintenance shop—Building 770 (Site 34), and the sandblasting and painting areas (Sites 32 and 34).

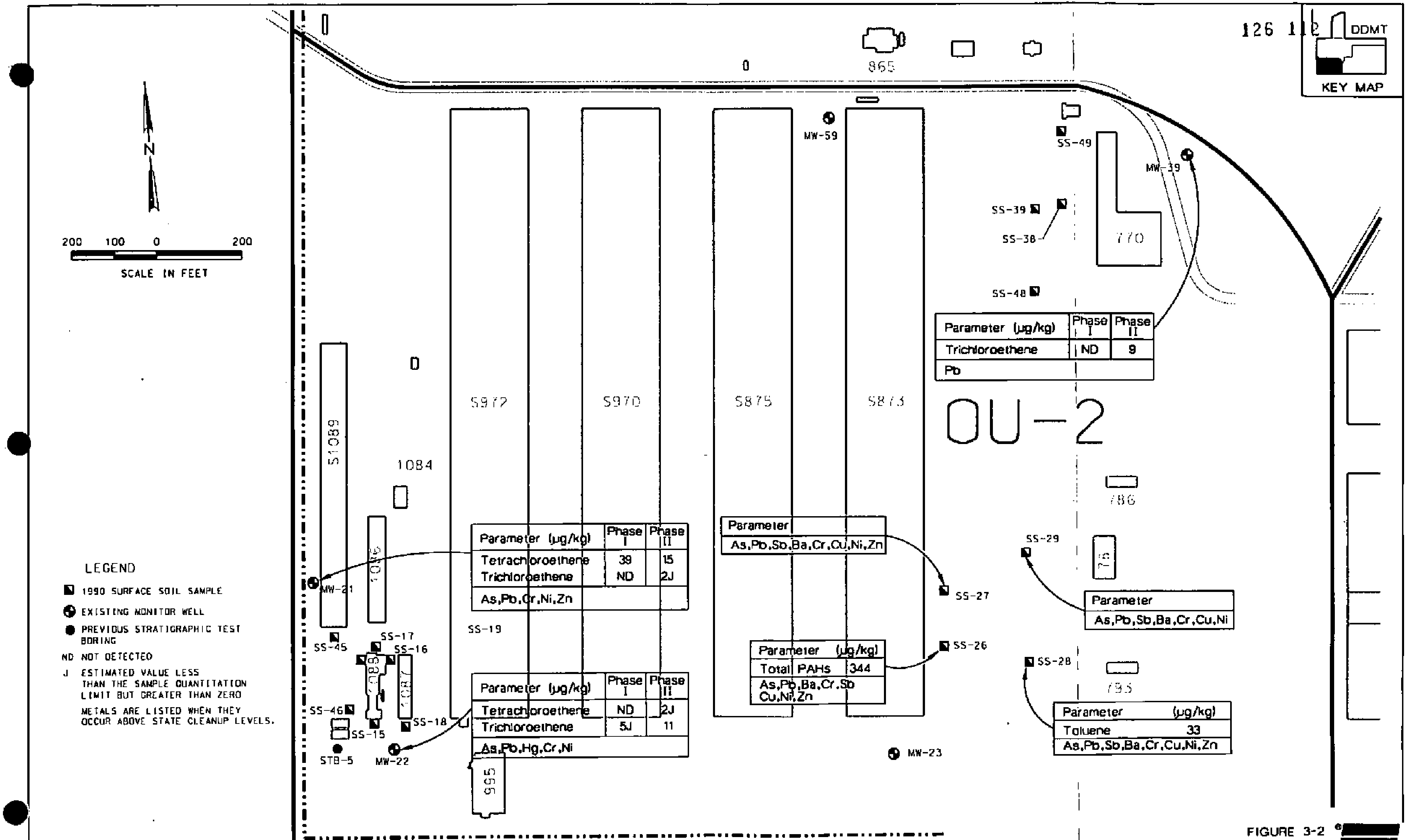
Samples collected at Site 27 were collected at a 1-foot depth (labeled surface soils), because the top foot of soil had been previously removed and backfilled to address pesticide contamination in the soils, based on a sampling investigation conducted by O.H. Materials in 1985 (ref. 72). Four samples were collected to evaluate the presence or absence of residual contamination, and did not detect pesticides. However, PAHs were detected in one sample. Toluene was detected in another sample (Figure 3-2), and metals were detected in all samples.

In general, sample analysis detected the presence of pesticides, PCBs, and PAHs at the sandblasting and painting area and pesticides, solvents, and PAHs in the area of the Maintenance Shop, as illustrated in Figure 3-3, although the samples were not sufficient to characterize the full nature and extent of contamination. Additional data to be collected are detailed in the OU-2 FSP.

3.1.2.2 Groundwater

Four groundwater monitoring wells have been installed in OU-2 with one located northeast of the maintenance shop (MW-39) and three existing wells located in the south (MW-23) and southeast (MW-21 and MW-22) of the unit. On the basis of the current understanding of the direction of groundwater flow (Figure D-1), these wells may be upgradient of potential source areas in OU-2.

Previous sampling events have detected both tetrachloroethene and trichloroethene in MW-21 and trichloroethene in MW-22. A summary of current pertinent information is provided in Figure 3-6. In November 1993, monitoring performed by ESE indicated the presence of metals in MW-23 and tetrachloroethene, trichloroethene, and metals in MW-39. Because of the limited information, neither a definite source area nor a trend in water quality can be determined.



Parameter (µg/kg)	Phase I	Phase II
Trichloroethene	ND	9
Pb		

Parameter (µg/kg)	Phase I	Phase II
Tetrachloroethene	39	15
Trichloroethene	ND	2J
As,Pb,Cr,Ni,Zn		

Parameter (µg/kg)	Phase I	Phase II
Tetrachloroethene	ND	2J
Trichloroethene	5J	11
As,Pb,Hg,Cr,Ni		

Parameter
As,Pb,Sb,Ba,Cr,Cu,Ni,Zn

Parameter	(µg/kg)
Total PAHs	344
As,Pb,Ba,Cr,Sb Cu,Ni,Zn	

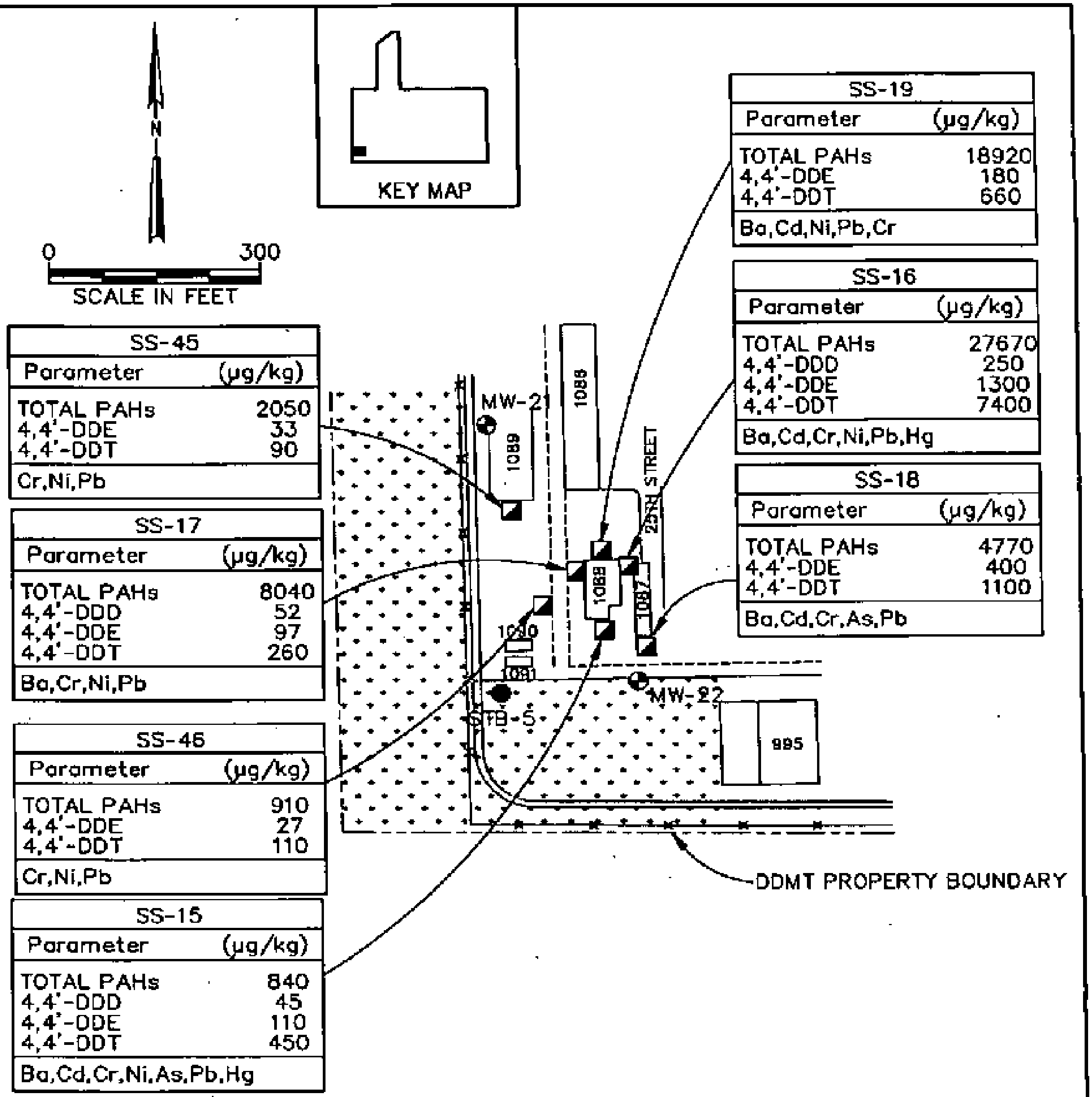
Parameter
As,Pb,Sb,Ba,Cr,Cu,Ni

Parameter	(µg/kg)
Toluene	33
As,Pb,Sb,Ba,Cr,Cu,Ni,Zn	

FIGURE 3-2
POSITIVE SOIL AND GROUNDWATER SAMPLE RESULTS COLLECTED FOR OU-2
Defense Depot Memphis, Tennessee

CH2M HILL

Source: RI Report, 1990



SS-19	
Parameter	(µg/kg)
TOTAL PAHs	18920
4,4'-DDE	180
4,4'-DDT	660
Ba,Cd,Ni,Pb,Cr	

SS-16	
Parameter	(µg/kg)
TOTAL PAHs	27670
4,4'-DDD	250
4,4'-DDE	1300
4,4'-DDT	7400
Ba,Cd,Cr,Ni,Pb,Hg	

SS-18	
Parameter	(µg/kg)
TOTAL PAHs	4770
4,4'-DDE	400
4,4'-DDT	1100
Ba,Cd,Cr,As,Pb	

SS-45	
Parameter	(µg/kg)
TOTAL PAHs	2050
4,4'-DDE	33
4,4'-DDT	90
Cr,Ni,Pb	

SS-17	
Parameter	(µg/kg)
TOTAL PAHs	8040
4,4'-DDD	52
4,4'-DDE	97
4,4'-DDT	260
Ba,Cr,Ni,Pb	

SS-46	
Parameter	(µg/kg)
TOTAL PAHs	910
4,4'-DDE	27
4,4'-DDT	110
Cr,Ni,Pb	

SS-15	
Parameter	(µg/kg)
TOTAL PAHs	840
4,4'-DDD	45
4,4'-DDE	110
4,4'-DDT	450
Ba,Cd,Cr,Ni,As,Pb,Hg	

LEGEND

- ◪ SURFACE SOIL SAMPLING LOCATION
- ● SOIL TEST BORING LOCATION
- ⊕ MONITORING WELL LOCATION

NOTE: METALS ARE LISTED WHEN THEY OCCUR ABOVE STATE CLEANUP LEVELS.

FIGURE 3-3
POSITIVE SURFACE SOIL SAMPLE RESULTS
COLLECTED NEAR SITES 29-33 (OU-2)
Defense Depot Memphis, Tennessee

Source: RI Report, 1990

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3.1.3 Nature and Extent of Contamination at OU-3—Southwestern Watershed

OU-3 includes the Golf Course Pond (Site 25), Lake Danielson (Site 26), the former PCB transformer storage area (Area 272) (Site 48), Pad 267 (Site 38), and Building T-273 (Site 59). OU-3 sites are shown in Drawing 2 and presented in Table 1-1.

3.1.3.1 Soil

Seven limited surface soil samples have been collected from the Golf Course grounds and near Buildings 274 (Site 46) and Building T-273 (Site 59) during the RI, with results presented in the RI Report (ref. 18). In general, the samples were not sufficient to characterize any individual site or source; however, the data indicates the presence of PAHs and pesticides, as illustrated in Figure 3-4.

3.1.3.2 Groundwater

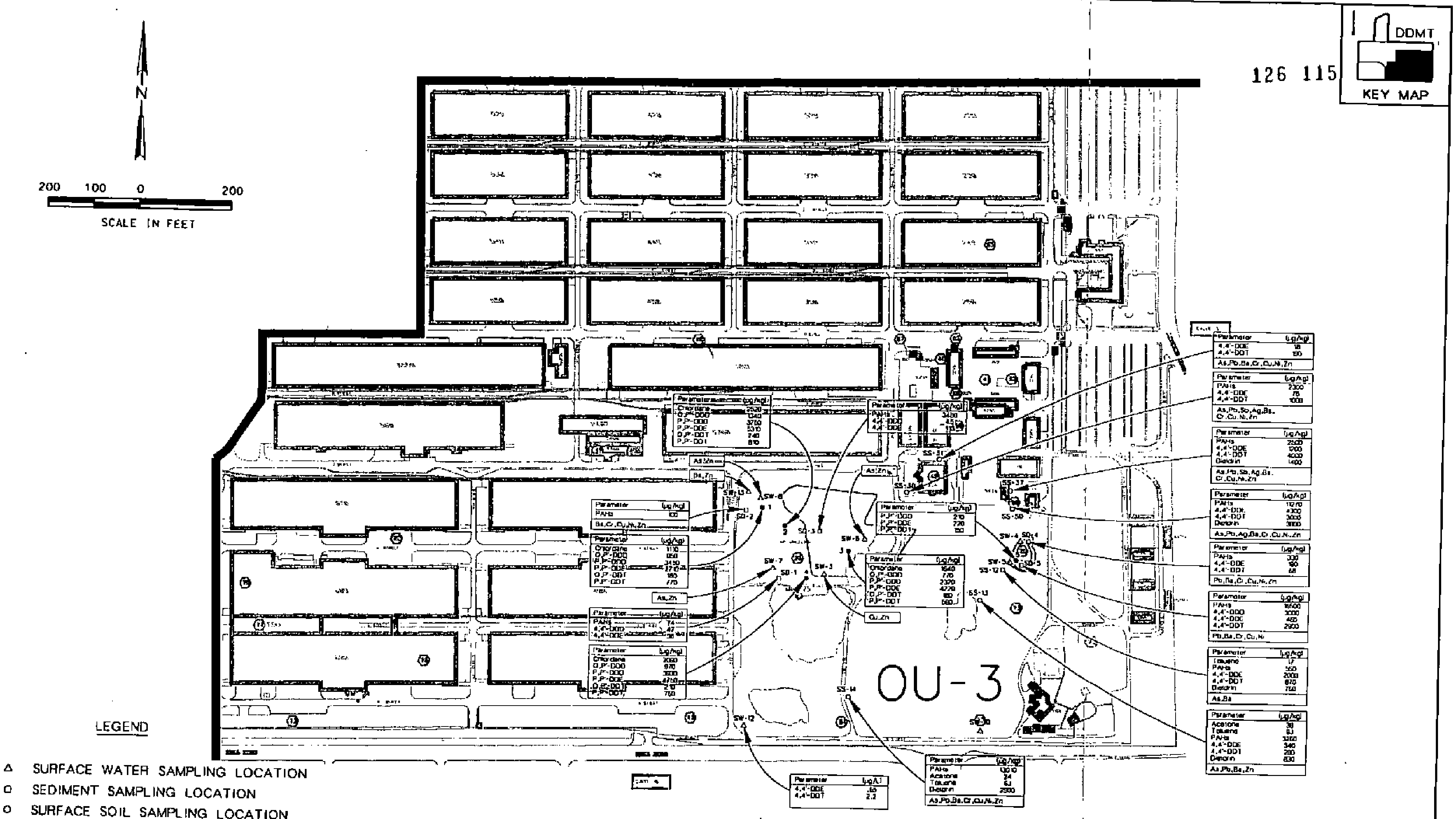
Analysis of two rounds of groundwater samples (1990, 1994) from MWs-24, 25, and 26 in OU-3 detected VOCs and metals. Figure 3-5 illustrates the summarized data. Samples from MW-25 and MW-26 showed the presence of tetrachloroethene. MW-26 also detected levels of TCE, carbon tetrachloride, and chloroform present in both sampling phases. A variety of PAHs were detected in 1994 in MW-24 that were not detected in the other two wells during either round of sampling or in MW-24 during 1990 sampling. Analytical data from the original reports is provided in Appendix D.

3.1.3.3 Surface Water/Sediment

OU-3 has two perennial water bodies, Lake Danielson and the Golf Course Pond, both manmade structures. Previous investigations have included three separate surface water and sediment sampling efforts, which are illustrated in Figure 3-4, with detailed analytical results located in Appendix D. While surface water and sediment samples have primarily consisted of samples from the lake and pond, samples also have been collected from storm drainage ditches.

Surface water samples were collected (nine from Lake Danielson and related outfall, three from the Golf Course Pond, and four from drainage ways) during three investigations. In general, results indicated low levels of pesticides in the surface water (illustrated in Figure 3-5 and presented in Table 3-2), probably attributable to disturbed sediments, as discussed below. Surface water in the drainage ways indicated higher levels of potential contaminants than water in either Lake Danielson or the Golf Course Pond.

In general, both Lake Danielson (9 locations with 5 locations having samples collected from the surface and 9-inch depth) and the Golf Course Pond (3 locations with one location having samples collected from two depths, surface and 9-inch) sediments have



LEGEND

- △ SURFACE WATER SAMPLING LOCATION
- ▢ SEDIMENT SAMPLING LOCATION
- ○ SURFACE SOIL SAMPLING LOCATION
- ● SURFACE WATER & SEDIMENT SAMPLING LOCATION
- DL DETECTION LIMIT
- J ESTIMATED VALUE LESS THAN THE SAMPLE QUANTITATION LIMIT, BUT GREATER THAN ZERO

NOTE: SAMPLING LOCATIONS ARE APPROXIMATE METALS ARE LISTED WHEN THEY OCCUR ABOVE STATE CLEANUP LEVELS.

Source: RI Report 1990
Source: USAHA 1986
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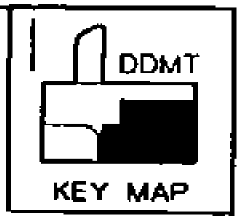
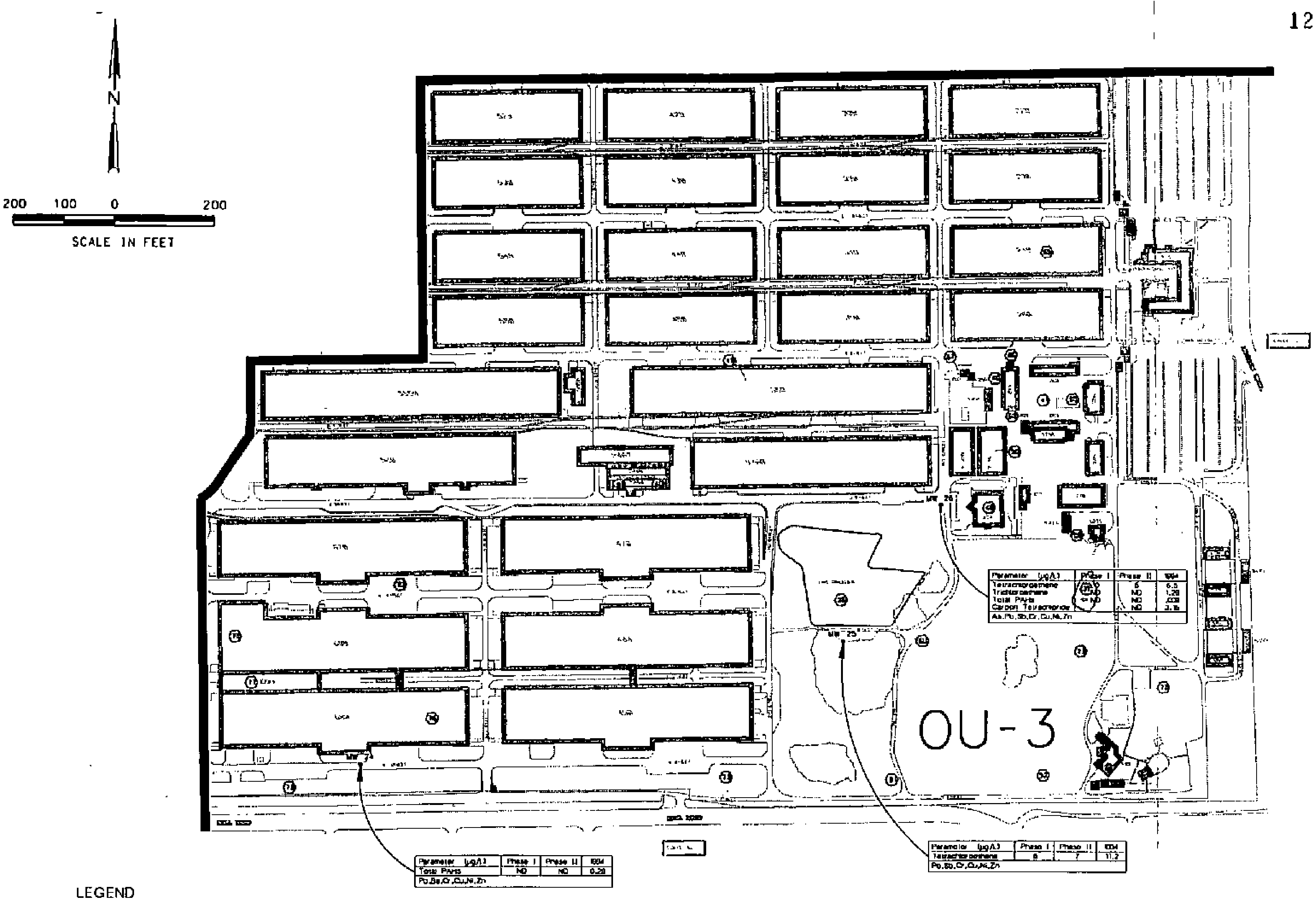
FIGURE 3-4
SURFACE SOIL, WATER, AND SEDIMENT SAMPLE RESULTS COLLECTED FOR OU-3
Defense Depot Memphis, Tennessee

CH2M HILL





Parameter (μg/L)	Phase I	Phase II	1994
Tetrachloroethene	ND	6	6.5
Trichloroethene	ND	ND	1.28
Total PAHs	ND	ND	.008
Carbon Tetrachloride	ND	ND	3.16
As,Pb,Sb,Cr,Cu,Ni,Zn			

Parameter (μg/L)	Phase I	Phase II	1994
Tetrachloroethene	6	7	11.2
Pb,Sb,Cr,Cu,Ni,Zn			

Parameter (μg/L)	Phase I	Phase II	1994
Total PAHs	ND	ND	0.28
Pb,Be,Cr,Cu,Ni,Zn			

LEGEND

- ● EXISTING MONITORING WELL
- ND NOT DETECTED

NOTE: METALS ARE LISTED WHEN THEY OCCUR ABOVE STATE CLEANUP LEVELS.

Source: RIReport 1990
Source: ESE 1994

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FIGURE 3-5
POSITIVE GROUNDWATER SAMPLE RESULTS
COLLECTED FOR OU-3
Defense Depot Memphis, Tennessee

CH2MHILL

Table 3-2
Positive Results in Surface Water
Main Installation
Defense Depot Memphis, Tennessee

Page 1 of 3

	Ambient Water Quality Criteria Aquatic Life (fresh)(a)		Lake Danielson							Golf Course Pond				Drainage Ditches	
			Lake Water				Lake Inlet	Lake Drainage		Pond Water		Pond Drainage			
Parameter	Acute	Chronic	SW3	SW6	SW7	SW8	SW13	SW9	SW12	SW4	SW5	SW10	SW11	SW12	SW14
Halogenated Volatiles (µg/L)															
Methylene chloride	11,000	N/A	1BJ	–	2BJ	1BJ	–	1BJ	–	–	–	–	–	1BJ	–
Nonhalogenated Volatiles (µg/L)															
2-Butanone	N/A	N/A	–	–	–	–	–	–	–	–	–	–	–	–	4J
Acetone	N/A	N/A	3BJ	–	2BJ	2BJ	–	18B	4J	2BJ	2BJ	1BJ	4J	5BJ	110
Total Xylenes	N/A	N/A	–	–	–	–	–	–	–	–	–	–	1J	–	–
Nonhalogenated Semivolatiles (µg/L)															
Benzoic acid	N/A	N/A	–	–	–	–	5BJ	–	6BJ	–	–	–	–	–	3BJ
bis(2-Ethylhexyl) phthalate[1]	940	3	3BJ	–	2BJ	3BJ	6BJ	12BJ	3BJ	3BJ	5BJ	7BJ	3J	–	3BJ
Butyl benzyl phthalate[1]	940	3	–	–	–	–	–	–	–	–	–	–	3J	–	–
Di-n-butyl phthalate[1]	940	3	–	–	–	–	–	–	–	–	–	3J	–	–	–
Di-n-octyl phthalate[1]	940	3	–	–	–	–	–	–	–	–	–	3BJ	–	–	–

Table 3-2
Positive Results in Surface Water
Main Installation
Defense Depot Memphis, Tennessee

Page 2 of 3

Parameter	Ambient Water Quality Criteria Aquatic Life (fresh)(a)		Lake Danielson							Golf Course Pond				Drainage Ditches	
			Lake Water				Lake Inlet	Lake Drainage		Pond Water		Pond Drainage			
	Acute	Chronic	SW3	SW6	SW7	SW8	SW13	SW9	SW12	SW4	SW5	SW10	SW11	SW12	SW14
Fluoranthene	N/A	N/A	–	–	–	–	–	–	–	–	–	–	2J	–	–
N-Nitro-sodiphenylamine	N/A	N/A	–	–	3J	–	–	–	7BJ	–	3J	2J	–	–	–
Pyrene	N/A	N/A	–	–	–	–	–	–	–	–	–	3J	3J	–	–
Pesticides (µg/L)															
4,4'-DDE	1050	N/A	–	.21	–	–	–	–	.65D	–	–	.14	.88D	–	–
4,4'-DDT[1]	1.1	0.001	–	–	–	–	–	.16	2.2D	–	–	.27	1.9D	–	–
Endosulfan-I	N/A	N/A	–	–	–	–	–	–	–	–	–	–	–	.16Z	–
Volatile Metals (µg/L)															
Arsenic	360	190	–	48	41	37	–	47	30	–	–	–	–	–	–
Lead[1]	82	3.2	–	–	–	–	–	295	100	–	–	–	50	–	–
Nonvolatile Metals (µg/L)															
Barium	N/A	N/A	15B	17B	15B	15B	60	60B	98	14B	14B	26B	55	76B	42
Cadmium	N/A	N/A	–	–	–	–	–	5	19	–	–	–	–	–	–
Chromium	N/A	N/A	–	–	–	–	–	–	20	–	–	–	–	20	10

Table 3-2
Positive Results in Surface Water
Main Installation
Defense Depot Memphis, Tennessee

Page 3 of 3

	Ambient Water Quality Criteria Aquatic Life (fresh)(a)		Lake Danielson							Golf Course Pond				Drainage Ditches	
			Lake Water				Lake Inlet	Lake Drainage		Pond Water		Pond Drainage			
Parameter	Acute	Chronic	SW3	SW6	SW7	SW8	SW13	SW9	SW12	SW4	SW5	SW10	SW11	SW12	SW14
Copper[1]	18	12	27	24B	20B	19B	–	68	20	46	30	25	30	23B	–
Silver	N/A	N/A	–	–	–	–	–	13	–	–	–	–	–	–	–
Zinc[1]	120	110	68	41	32	37	54	400	150	22	22	81	110	29	36

[1] Values that are equal to or exceed either the acute or chronic Ambient Water Quality Criteria Guidelines.

N/A = Not Available

(a) Source: Integrated Risk Information System (USEPA, 1990); Interim Final RFI Guidance (USEPA, 1989).

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL) but greater than the Instrument Detection Limit (IDL).

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

J = Estimated value less than the sample quantitation limit but greater than zero.

Z = Matrix interference; compound not positively identifiable.

– = Not detected.

PCBs, pesticides, and PAHs, which also have been detected in fish tissue samples (results in Table 3-2 and Appendix D). Generally, when analytical results from Lake Danielson samples are compared to samples from the Golf Course Pond, Lake Danielson samples have higher levels of pesticides and metals while the Golf Course Pond samples indicate higher levels of PAHs. Fish samples mirror that distribution of contaminants, with the addition of indications of PCB, higher in the Golf Course Pond than Lake Danielson.

3.1.4 Nature and Extent of Known Contamination at OU-4—North-Central Area

OU-4 contains the former pentachlorophenol (PCP) dip vat area, now occupied by Building 737, which has been used for pesticide storage, and Building 629 (Site 57), which was the hazardous materials storage area. Locations of OU-4 sites are shown in Drawing 2. A short description of the site is found in Table 1-1.

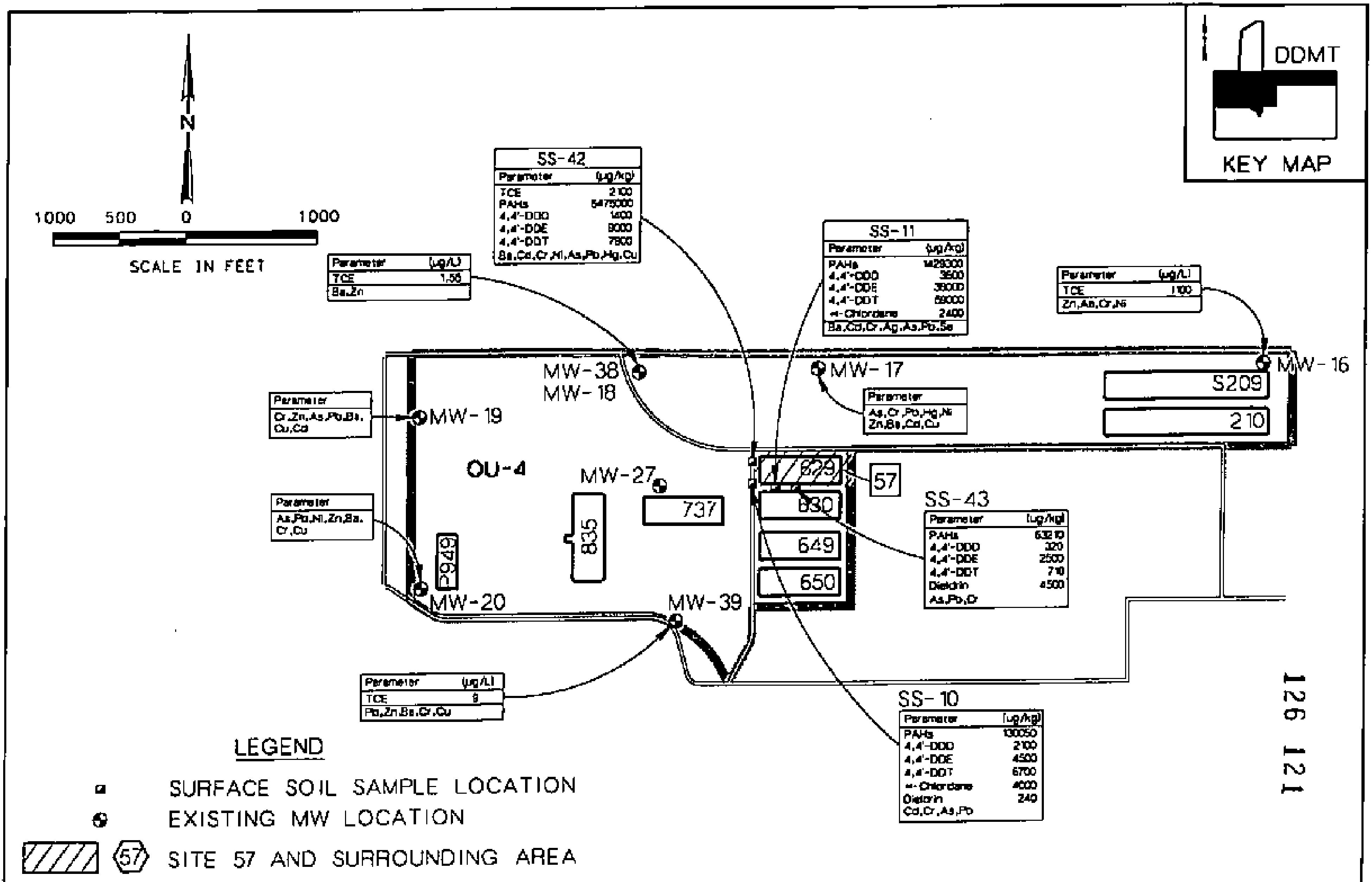
3.1.4.1 Soil

Remediation of soils was conducted at the dip vat area during 1985 and 1986, resulting in removal of soils down to 10 ft below ground surface (bgs) (ref. 72). During the RI (ref. 18), one soil sample (SS-47) and one stratigraphic test boring (STB-4) yielding three subsurface soil samples were analyzed from the former dip vat area. The surface soil sample exhibited pesticides that are associated with Building 737. DDE, DDT, alpha-chlordane, gamma-chlordane, and beta-BHC were all detected in this sample. Toluene and trichloroethene also were detected at quantitation levels.

Four soil samples, illustrated in Figure 3-6, were taken around Building 629 in areas where past spills have occurred. Building 629 formerly stored toxic, corrosive, and oxidizing materials. Surface soil samples SS-10 and SS-11 were collected adjacent to Building 629. Two more samples, SS-42 and SS-43, were collected several feet away from the building to provide information on the extent of contamination. PAH contamination is present in all of the samples, with SS-42 having the highest level of these constituents. Pesticide (including DDE, DDT, dieldrin, methoxychlor, gamma-chlordane, and beta-BHC) levels were detected in the soil samples from this area, along with metal contamination. The major metal contaminants were lead, zinc, copper, and mercury. Toluene was detected in all four of the samples. 1,1,2-Trichloroethane, tetrachloroethene, and trichloroethene were detected in SS-42. The concentration of trichloroethene (2,100 μg/kg) reported is a minimum value (the concentration level found in SS-42 exceeded the calibration range of the laboratory instrument).

3.1.4.2 Groundwater

Groundwater samples were collected during the RI (ref. 18) from monitoring wells MW-39, MW-38, MW-17, MW-19, and MW-20. Their locations are shown in Figure 3-6. Like the other monitoring wells on the Main Installation, these wells are all screened in the Fluvial Aquifer. Analytical results detected tetrachloroethene and



LEGEND

▫ SURFACE SOIL SAMPLE LOCATION

● EXISTING MW LOCATION

▨ (57) SITE 57 AND SURROUNDING AREA

NOTE: METALS ARE LISTED WHEN THEY
OCCUR ABOVE STATE CLEANUP LEVELS

FIGURE 3-6
POSITIVE SURFACE SOIL AND GROUNDWATER
SAMPLE RESULTS COLLECTED FOR OU-4
Defense Depot Memphis, Tennessee

Source: RI Report, 1990

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126 121

trichloroethane in MW-39. Samples collected in 1993 (ref. 88) detected TCE in MWs-38 and 16 at 1.55 μg/L and 1.10 μg/L, respectively. The pesticide dieldrin was detected in MW-38 at 0.062 μg/L. Metals were detected in all wells, namely, chromium, arsenic, lead, and zinc.

3.2 Potential Pathways of Contaminant Migration

3.2.1 Contaminant Fate and Transport

The fate and transport of contamination depends on the site's physical condition, source characteristics, contaminant characteristics, media characteristics and extent of contaminant release. The behavior of the contaminants found in each of the media sampled (groundwater, surface water, sediment, surface soil, and subsurface soil) will be discussed, with consideration given to the various chemical, physical, or biological processes that are possible at DDMT. The following topics will be discussed in this subsection:

- Potential routes of contaminant migration
- Persistence
- Migration

3.2.1.1 Potential Routes of Contaminant Migration

Contaminant migration can occur in several ways, depending on the characteristics of the element or compound in question, the medium in which the element or compound is located, and the type(s) of media in close proximity. Various physical processes may be involved. The transport of pollutants by water to receptors is a central theme because of the importance of water to life, its contribution to the generation of leachate, and its ability to mobilize contaminants from source areas. The water solubility of the compound or element will play a significant role in determining what migration route, if any, will be taken. Transformation into a gaseous state (volatilization) or adherence to soil or sediment particles (adsorption) are migration routes. Extraction from sediments or soils (leaching) or the movement of soil or sediment particles, with adsorbed pollutants attached, by the movement of water are also possible. Accumulation within the body of aquatic life forms or bacteria (bioaccumulation) can also be a pathway from waters, soils, or sediments.

The discussions provided in this section are intended only to provide a brief, general overview of the potential environmental transport mechanisms for the potential indicator chemicals and chemicals of concern that were identified for DDMT in the RI Report (ref. 18). This section will be expanded in the final RI/FS reports to include additional constituents or additional transport mechanisms, as needed.

3.2.1.2 Metals

The migration of metals in the environment is complicated because metals can exist in a variety of forms. For instance, metals can exist in different oxidation states. Metals can also exist as charged particles (such as ions in solution) or in a chargeless or neutral state. Metals may combine with other metals or organic chemicals to form many different compounds. In any case, the potential for migration will then depend on the solubility of these forms in water. Metals in solution will exist in an ionic form; non-ionic forms will precipitate and remain bound to sediments in soil.

The 12 metals analyzed for were detected in at least one of the four matrices (groundwater, surface water, sediment, and soil) sampled. Five of the metals were selected during the RI (ref. 18) as potential indicator chemicals because of the concentrations detected at DDMT and the toxicity associated with these metals. These metals are arsenic, barium, chromium, lead, and mercury. Unfiltered data will be used in the BRA.

The mobility of metals in the subsurface also depends on their mode of occurrence as either solid suspended sediment particles or as dissolved components of the groundwater matrix. Because metals are naturally occurring, their reported presence in a groundwater sample may or may not indicate a contaminant release. In accordance with direction from EPA Region IV and TDEC, only total metals (unfiltered) samples will be collected and analyzed. Following EPA guidance (EPA, 1989) for the evaluation and interpretation of groundwater data, total metals analytical results will be used to assess whether a particular metallic species is present at a given location.

Arsenic. Because of its multiple oxidation states and its tendency to form soluble complexes, the geochemistry of arsenic is both intricate and not well characterized. The adsorption of arsenic onto clays, iron oxides, and organic (humic) material is an important transport pathway. Arsenic is also mobile in the aquatic environment; it cycles through water columns, sediments, and biota. The solubility of arsenic varies widely according to the oxidation state. In the natural environment, four oxidation states are possible for arsenic: the (-3) state, the metallic (0) state, the (+3) state, and the (+5) state. The (+3) and (+5) states are common in a variety of complex minerals and in dissolved salts in natural waters. Sulfur is the element most commonly associated with arsenic in nature. In all, there are 100 or more arsenic-bearing minerals known to occur in nature. The oxo acids, arsenious acid (H_3AsO_3), and arsenic acid (H_3AsO_4), are the prevalent forms of arsenic in aerobic (oxygen-containing) waters. Arsenic can form complexes with a number of organic compounds, most of which increase its water solubility (refs. 1, 3, and 57).

Barium. Barium exists in nature as a salt. Several salts including the most common (barite [BaSO4] and witherite [$BaCO_3$]) have low solubility, so precipitation into sediments is likely. Because of low vapor pressures and high boiling points, these salts are unlikely to volatilize. Bioaccumulation of barium is not a common migration process except in systems in which the barium concentration exceeds that of calcium and magnesium (ref. 57).

Chromium. Chromium exists in two oxidation states in aqueous systems: (+3) and (+6) oxidation states. The hexavalent form is soluble, existing in solution as an anion complex, and is not absorbed to any significant degree by clays or hydrous metal oxides. It is, however, absorbed strongly to activated carbon. Hexavalent chromium is a moderately strong oxidizing agent and reacts with organic or other oxidizable material to form trivalent chromium. Trivalent chromium combines with aqueous hydroxide ion (^-OH) to form insoluble chromium hydroxide ($Cr(OH)_3$). Precipitation of this material is thought to be the dominant transport pathway of chromium in natural waters. Adsorption processes also result in the removal of dissolved chromium to the bed sediments. Chromium is bioaccumulated by aquatic organisms, and the passage of chromium through the food chain has been documented. Chromium in soil can occur as the insoluble oxide dichromate (Cr_2O_3) and may be aerosolized into the atmosphere or transported to surface waters and groundwaters in runoff and leachates (refs. 1, 3, and 57).

Lead. Lead is transferred continuously between air, water and soil. Soil leaching of lead into groundwater is determined by the chemical characteristics of the soil. The availability of lead in soils is related to moisture content, soil pH, organic matter, and the concentration of calcium and phosphates. Lead is bioaccumulated in shellfish and plants (refs. 1, 3, and 57). However, increasing pH and calcium ion (Ca^{2+}) concentrations diminishes the capacity of plants to absorb lead, because Ca^{2+} ions compete with the Pb^{2+} for exchange sites on the soil and root surfaces.

Mercury. Mercury's major removal mechanism from a natural system is adsorption onto the surfaces of clay particles and subsequent settling as part of the sediment. The overwhelming majority of any dissolved mercury is removed in this manner within a relatively short time, generally in the immediate vicinity of the source. Much smaller portions of the dissolved mercury are ingested by the aquatic biota or transported by current movement and dilution. Secondary transformations of mercury in the sediments can occur; these include precipitation as mercury sulfide and methylation reactions caused by bacteria. Because mercury itself is not destroyed, these inorganic and organic forms of mercury may then release ionic or metallic mercury into the water column as part of a recycling process. Resuspension of sediments by turbulence or the activity of benthic organisms also can release these compounds of mercury directly into the water column (refs. 1, 3, and 57).

3.2.1.3 *Volatile Organic Compounds (VOCs)*

By their nature, the concentrations of VOCs tend not to remain at constant levels in any of the media under consideration. Only media from which volatilization is hindered would be likely to retain significant amounts. Several of the groundwater samples and a few surface and soil boring samples contained measurable levels of VOCs. Eight potential indicator chemicals of concern were selected during the RI (ref. 18) because of their prevalence at DDMT: 1,1-Dichloroethene, 1,1,2,2-Tetrachloroethane, TCE, tetrachloroethene, methylene chloride, 1,2-Dichloroethene, carbon tetrachloride, and acetone. The brief discussions concerning the transport mechanism of these chemicals provided in following sections are based on Callahan, 1979, and ATSDR, 1988 (refs. 1, 3, and 57).

1,1-Dichloroethene. Volatilization is the major process whereby 1,1-Dichloroethene is removed from the aquatic and soil environment. 1,1-Dichloroethene is slightly water soluble. Adsorption onto soils or sediments with high organic content also is possible. 1,1-Dichloroethene probably does not bioaccumulate to a significant extent.

1,1,2,2-Tetrachloroethane. The primary transport process for 1,1,2,2-Tetrachloroethane is volatilization. Because it is slightly soluble in water, leaching is a possible migration pathway. Bioaccumulation is possible.

TCE. Volatilization is the most important transport process for TCE. It has been found to be highly mobile in soil, so leaching from subsurface soil to groundwater is possible. Removal from the atmosphere in rain (wet deposition) is also a likely process, but bioaccumulation potential is low.

Tetrachloroethene. While volatilization is the dominant transport mechanism for this compound, leaching into the groundwater is also likely, as is return to the soil through wet deposition. Adsorption is not a primary transport mechanism except perhaps in dry soils with high clay content. Leaching into subsurface soil and groundwater is likely, but bioaccumulation is not.

Methylene Chloride. Volatilization is a transport process for the removal of methylene chloride from aquatic systems. Once in the atmosphere, methylene chloride can, at high altitudes, react with hydroxyl radicals or undergo photodissociation. Methylene chloride does not readily undergo oxidation or hydrolysis in aquatic systems. Photo-oxidation should not occur with methylene chloride, because this compound does not contain a chromophore that can absorb visible or near-UV light. Methylene chloride does not bioaccumulate.

1,2-Dichloroethene. Volatilization is the major process for removal of 1,2-Dichloroethene from aquatic systems. At high altitude, 1,2-Dichloroethene is attacked by hydroxyl radicals, resulting in degradation products. Photodissociation does not appear to be a significant fate for 1,2-Dichloroethene in aquatic systems. Information is not available for this compound to indicate that it would bioaccumulate, bio-degrade (microorganism), or adsorb to sediments or solids. 1,2-Dichloroethene is also resistant to hydrolysis.

Carbon Tetrachloride. Carbon tetrachloride is volatile and can be expected to leave from aquatic environments when its volatilization is not hindered. Carbon tetrachloride is stable to attach from hydroxyl radicals, and photodissociation in the high-altitude atmosphere is slow. Photodissociation in aquatic environments is not significant. Oxidation, sorption, bioaccumulation, bio-transformation, hydrolysis, and biodegradation do not readily occur with carbon tetrachloride.

Acetone. Acetone can be expected to volatilize from aquatic media where its volatilization is unhindered (such as in surface water). However, acetone is very soluble in water and should accumulate in wet soil and groundwater if its volatilization is hindered. Information on the fate of acetone regarding biodegradation, bio-transformation, susceptibility to hydrolysis and oxidation, or sorption to sediments in aquatic environments is not readily available.

3.2.1.4 Semivolatiles and Base/Neutral/Acid Extractables

Polycyclic Aromatic Hydrocarbons. Of the SVOCs analyzed, only PAHs were found at measurable levels with regularity in soil samples during the RI (ref. 18). Several different PAHs were detected. Of these, the three potential indicator chemicals of primary concern, because of their prevalence at DDMT and their toxicity, are benzo(a)pyrene, benzo(a)anthracene, and dibenzo(a,h)anthracene. PAHs have low vapor pressures and boiling points greater than 100°C. They also are characterized by their relatively low solubility in water. The primary transport processes are different from those of volatile organics, with adsorption onto soil or other organic matter being most important. Adsorption onto particulates is the primary transport process for PAHs. Adsorption onto mobile soil or sediments is largely responsible for their movement (for example, the erosion of soil and the movement of suspended sediments). Adsorption onto soot particles that can be carried on wind currents and then returned to the surface (dry deposition) are important pathways to and from the atmosphere. Short-term bioaccumulation also occurs, but is not important because of the rapid metabolism and excretion of PAHs by most aquatic organisms (refs. 1 and 3).

Pesticides and PCBs. Pesticides and PCBs also are classified as SVOCs. Volatility is generally of little importance with respect to transport; adsorption and bioaccumulation are much more important. The potential indicator chemicals of primary concern identified during the RI (ref. 18), because of their prevalence at DDMT and their toxicity, are DDT and its degradation products: dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethene (DDE); dieldrin; and PCBs.

DDT, DDE, and DDD. DDD and DDE are degradation products of DDT; all have generally similar properties. Adsorption onto airborne particulates and sediments is the primary transport pathway that results from the relative insolubility of these compounds in water. Removal from the atmosphere through particulate fallout is likely. Bioaccumulation and magnification up through the food chain (bioconcentration) also are important. Volatilization is a possible transport process (refs. 1, 3, and 57).

Dieldrin. Sorption of dieldrin to soils and sediments is the most prevalent transport pathway, but there is a tendency to bioaccumulate and biomagnify. Co-movement with suspended particulates in water is a likely transport mechanism, but leaching into groundwater usually does not occur because of the relatively low solubility of dieldrin. Volatilization is generally slow for dieldrin but is relatively high for aldrin, which is readily converted to dieldrin. This reaction probably is initiated by UV radiation. It is therefore possible that aldrin might migrate and then react to form dieldrin in its new location (refs. 1 and 3).

Chlordane. Volatilization from aquatic environments, sorption to sediments, and bioaccumulation are important fates for chlordane. Chlordane is photosensitive and should undergo light-induced reaction to produce isomers and other products. The biotransformation of chlordane probably is similar to dieldrin. Chlordane could be susceptible to oxidation in the presence of oxidizing substances in aquatic environments, but is somewhat susceptible to hydrolysis, with a half-life of 4 years (refs. 1 and 3).

Heptachlor. A major fate of heptachlor in aquatic systems will be the hydrolysis to 1-hydroxyl chlordane. Heptachlor also shows strong tendencies for bioaccumulation. Sorption to sediments could be an important process for heptachlor that does not undergo hydrolysis. Volatilization also is possible (refs. 1 and 3).

Beta-BHC. Volatilization, biotransformation, and biodegradation appear to be important transport paths for Beta-BHC. Hydrolysis, however, does not occur in aquatic systems. Photolysis can occur, but the data supporting photolysis in aquatic systems is conflicting.

PCBs. PCBs are prepared in mixtures of different compounds characterized by the number and arrangement of chlorine atoms attached. Different mixtures contain different chlorine to carbon ratios, are called aroclors, and usually have a number designation associated with them. All PCBs behave in essentially the same manner. Adsorption of PCBs onto soil particles and sediments is the most prevalent transport mechanism. However, bioaccumulation is also likely and results in biomagnification. Although not nearly as prevalent, adsorption onto airborne particulates and entrainment through fugitive dust emissions are responsible for spreading PCBs throughout the world; they are redeposited through wet deposition (ref. 3).

3.2.1.5 Chemical Warfare Agents (CWAs)

Although not identified as a potential contaminant of concern during the RI (ref. 18), three sites within OU-1 may contain either CWAs or decomposition/degradation by-products of CWAs. Fortunately, DDMT records concerning decontamination and disposal of these items are specific. Both the RFA (ref. 68) and the RI Report (ref. 18) identified Site 1 in Dunn Field as containing six sets of 1-inch by 9-inch mustard and lewisite detection kits. The OU-1 FSP contains an additional discussion of the CWAs, their disposal, and potential transport processes.

Ashes and metal refuse from the Burn Site (Site 24) were transported to Site 9 and buried in a trench approximately 240 ft by 8 ft. Site 9 is located in the northwestern portion of OU-1.

The other documented instance of CWAs being disposed in OU-1 (Dunn Field) occurred in 1946 near Site 24. This incident consisted of decontaminating, burning, and burying approximately thirty 500-pound German mustard bombs from World War II. Facility, DOD, and newspaper records document the decontamination, open burning of the casings and decontamination by-products, and burial of the casings. The migration of chemical agents or products of decontamination or decomposition from a waste site occurs in a manner similar to that of any chemical migration. The causes of migration are primarily leaching through the soils, air evaporation, or physical transport in groundwater. The migration of material through leaching depends primarily on the solubility of the material in water and the amount of precipitation received in the area. Chemical agents or products of decontamination or decomposition exhibit relatively low solubilities in water; these low solubilities effectively limit their leaching potential.

3.2.2 Contaminant Persistence

The persistence of a contaminant in a particular medium will be determined by its resistance to chemical or biological changes, as well as to the transport mechanisms discussed above. A toxic pollutant may be subject to a variety of chemical reactions depending on susceptibility to natural radiation and the presence of suitable reactants in the environment. In general, chemical reactions will occur where the oxidation state of one or more of the atoms within the reactants changes. For organic compounds, oxygen is usually the atom whose oxidation state changes, although nitrogen, sulfur, bromine, and chlorine may undergo chemical reaction. The metal atom in inorganic complexes is usually the atom whose oxidation state changes. Reaction with water (hydrolysis) is possible for some compounds. UV radiation can remove an electron from a compound to form a reactive species called a radical in a process known as photolysis. Contaminants can be transformed or degraded through photolysis either directly or indirectly by reaction with other radical species. Metabolism of compounds or elements by microbes or aquatic life may result in slight alteration (biotransformation) or a significant breakdown (biodegradation) of the contaminant.

3.2.2.1 Metals

The persistence of the five elements discussed previously (arsenic, barium, chromium, lead, and mercury) depends on their rate of transport from the site of interest, which in turn depends on their form. As mentioned earlier, metals generally have more than one naturally occurring state and exist in several different chemical forms.

Arsenic. The fate of arsenic in the aquatic environment depends largely on prevailing pH and oxidation-reduction conditions. Sediments are the primary sink for arsenic. A number of organisms can metabolize arsenic to form organometallic compounds, thereby increasing arsenic mobility in the environment. Arsenic can be reduced and methylated by soil organisms, though the rate at which arsenic is subsequently volatilized may vary according to site conditions. Arsenic in soil is predominantly in soluble forms (refs. 1, 3, and 57).

Barium. Little information is available concerning the ultimate fate of barium in the environment. Because barium is commonly found in soils and in most surface water and groundwater, it is assumed to be persistent in these media (ref. 57).

Chromium. Hexavalent chromium is the species usually found in industrial wastes; it will eventually be reduced to trivalent chromium by inorganic matters present in water. As discussed in Section 3.2.1.2, trivalent chromium reacts with aqueous hydroxide ion to form insoluble chromium hydroxide. Although chromium can react to form a variety of organic complexes, chromium persists in sediments after precipitating out of solution (refs. 1, 3, and 57).

Lead. Lead is present in soils as Pb^{+2}, which may precipitate as lead sulfate, hydroxides, and carbonates. Lead is extremely persistent in soil and water, and the species of lead found depends on temperature, pH, and the presence of organic matter. Lead is relatively immobile in soils and associates primarily with suspended solids and sediments in aquatic systems. Below pH 6, anglesite ($PbSO_4$) is dominant, while $PbCO_3$ is most stable at pH values above 7. The hydroxide $Pb(OH)_2$ controls solubility around pH 8, and lead phosphates, of which there are many forms, may control Pb^{2+} solubility at intermediate pH values (refs. 1, 3, and 57).

Mercury. The primary sink for mercury release to the environment is sediments. Mercury can exist in the natural environment in three oxidation states: as the native element itself, in the (+1) (mercurous) state, and in the (+2) (mercuric) state. The nature of the species that will occur in a given complex or exist in solution depends on the potential for oxidation or reduction and the pH of the environment. Deposition of mercury in sediments that can cause reduction can result in precipitation of the sulfide. Biotransformation of mercury in the sediments can result in remobilization. An example is dimethyl mercury, which has a low solubility in water and is a gas at room temperature; volatilization may occur (refs. 1, 3, and 57).

3.2.2.2 Volatile Organic Compounds

Chlorinated VOCs are basically unreactive and unlikely to undergo chemical or biological transformation unless the medium in which they are contained slows the volatilization process. However, they can undergo reactions, either chemical or biological, when their concentration is large enough that volatilization and reaction rates can achieve equilibrium. The slight solubility of most VOCs in water generally results in small but measurable persistence in groundwaters where reactions with bacteria can occur (ref. 1).

1,1-Dichloroethene. 1,1-Dichloroethene does not undergo measurable photolysis and it is not readily oxidized. 1,1-Dichloroethene is also stable toward hydrolysis. 1,1-Dichloroethene is slightly soluble in water and can be expected to persist in groundwaters.

1,1,2,2-Tetrachloroethane. 1,1,2,2-Tetrachloroethane is essentially non-reactive in the atmosphere. In water, however, base-catalyzed hydrolysis to form TCE is an important degradation path under aerobic and anaerobic conditions. Anaerobic biodegradation is also to be considered an important loss pathway in water and soils with TCE as the reaction product. With its solubility, persistence in groundwater is likely.

TCE. Upon volatilization, TCE reacts readily with hydroxyl radicals in the atmosphere. After leaching to groundwater where volatilization is hindered, it is persistent because of its solubility. Biodegradation and other chemical reactions are slow and do not measurably contribute to its fate.

Tetrachloroethene. Reaction of tetrachloroethane with hydroxyl radicals in the atmosphere is the most likely degradation process for this compound. However, tetrachloroethane is persistent in the atmosphere except during periods of heavy rainfall, because of the relative stability of the hydroxyl radical as indicated by its long half-life (approximately 96 days). As volatilization from groundwater is hindered, slow biodegradation and hydrolysis processes may occur. However, tetrachloroethane is persistent under such anaerobic conditions.

Methylene Chloride. If volatilization is hindered, methylene chloride could be persistent in the groundwater environment. Methylene chloride does not bioaccumulate, biodegrade, or adsorb to sediments.

1,2-Dichloroethene. 1,2-Dichloroethene does not bioaccumulate, biodegrade, or adsorb to sediments or solids. It does not hydrolyze, so it should persist in any aquatic media where volatilization is hindered.

Carbon Tetrachloride. Carbon tetrachloride is extremely stable and should persist in any aquatic environment where volatilization is hindered.

Acetone. Acetone should be expected to persist in groundwater because of its solubility in water. Acetone in surface soils will quickly volatilize.

3.2.2.3 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs generally are amenable to photolysis reactions and subject to rapid degradation upon reaction with strong oxidants, but do not undergo hydrolysis. While oxidation initiated by photolysis is possible for PAHs in solution, it is not a major degradation process because of the minimal amount that exists in these forms. Direct photolysis results in rapid degradation of the minimal amounts that do dissolve. Biodegradation is considered the major transformation process. However, because this process is slow and competing processes (solubilization, oxidation initiated by photolysis, and volatilization) occur only to minimal extents, PAHs are persistent in the soils and sediments in which they adsorb, as discussed above (refs. 1 and 3).

3.2.2.4 Pesticides and Polychlorinated Biphenyls (PCBs)

The pesticides and PCBs discussed earlier are persistent because of their chemical stability and affinity for organic matter. Although photolysis is a potential loss pathway, it may not be possible if the medium is not exposed to ultraviolet radiation, as is the case with sediments under deep water and subsurface soils. Biological action usually is the only removal mechanism; however, it may be slow.

DDT, DDE, and DDD. Biotransformation of DDT to DDE (aerobic conditions), to DDD (anaerobic conditions), or to both is the primary loss mechanism. However, DDE and DDD do not undergo further degradation. Direct photolysis of DDT and DDD is slow, but for DDE it is rapid. Indirect photolysis can occur quickly for all three compounds. Chemical oxidation and hydrolysis are too slow to be competitive. Because of their insolubility, these three compounds are persistent in soils and sediments (refs. 1 and 3).

Dieldrin. Dieldrin is persistent in soils and sediments and is relatively insoluble in water. Oxidation and hydrolysis are not important factors, and the contribution of oxidation initiated by photolysis is uncertain. It is resistant to biodegradation, although this may be its ultimate fate (refs. 1 and 3).

Chlordane. Chlordane is persistent in soils and sediments and is relatively insoluble in water. Hydrolysis, however, is slow. Chlordane should persist in soil, but should be degraded slowly in groundwater.

Heptachlor. Heptachlor should not persist in the environment because it is easily hydrolyzed, then biotransformed or bioaccumulated.

Beta-BHC. Beta-BHC does not hydrolyze. However, it is biotransformed and biodegraded. Beta-BHC should persist where these processes are hindered.

PCBs. PCBs are resistant to oxidation and hydrolysis. The heavier PCBs may be amenable to oxidation initiated by photolysis, although this is unlikely because they are not generally found in media that are exposed to UV radiation. They are resistant to biodegradation and biotransformation; only those molecules with fewer than four chlorine atoms are generally susceptible. Because of their insolubility, PCBs are persistent in soils, sediments, and animal tissues (ref. 3).

3.2.2.5 Chemical Warfare Agents

The rate of formation of CWA degradation compounds depends on many factors, such as pH, moisture content, and temperature. Hydrolysis products for the persistent compounds are formed over periods ranging from days to years. Additional information will be provided in the OU-1 FSP.

3.2.3 Contaminant Migration

Typically, landfilled solid waste materials such as those located in Dunn Field are buried in the dry state. Liquid wastes were stored in containers and the documented fluid spill events were local in nature, involving small quantities. Contaminant releases can occur by the water saturation of dry solid wastes (ref. 56), by the leakage of corroding liquid waste containers, or by the spillage of fluids at ground surface. The chief source of water at disposal sites is precipitation. Given enough data, the likelihood of contamination generation and the quantification of leachate production may be estimated by the water balance method (ref. 56). A calculation of the study area's net precipitation (the amount of rainfall potentially available for infiltration and waste saturation) was 9 inches annually. This value is adequate to both generate and mobilize waste-related contamination at DDMT. If contamination at the available source is mobilized, contaminants will move along the path of least resistance to adjacent receptors. Surface contamination may migrate overland to surface waters via runoff, or may infiltrate into local shallow groundwater. Buried waste-related constituents may migrate to site groundwater.

Actual migration routes of contaminants and their rates can be inferred from site physical characterization, contaminant release information, and data from chemical analyses of the media that are potentially associated with their fate and transport.

3.2.3.1 Metals

Leaching and precipitation of indicator metals are likely transport systems, as indicated by the presence of metal contamination of the groundwater, soils, and sediments. Metals contamination probably has entered the groundwater through leaching of the soil. In Dunn Field, the Fluvial Aquifer groundwater flows westward. Metals contamination can be expected to migrate with groundwater in a westerly direction. The analytical results for the off-post wells support this hypothesis. Shallow aquifer groundwater flow at the Main Installation is not as well known as are similar conditions at Dunn Field. Shallow aquifer conditions suggests discharge to the underlying regional aquifer in the northwestern quadrant of the installation. However, groundwater flow direction in the shallow aquifer in most of the Main Installation is not well defined.

3.2.3.2 Volatile Organic Compounds

Chlorinated VOCs have been detected as surface soil contaminants at both Dunn Field and the Main Installation. These compounds also have been encountered as subsurface soil contaminants in Dunn Field. The contaminants detected are assumed to occur as an unknown number of localized source areas. These areas are significant because they may continue to release VOCs to the shallow groundwater system through leaching and percolation. The only clearly defined zone of groundwater contamination to date extends beyond the west boundary at the north end of Dunn Field. Contaminant concentrations are consistent enough to permit data contouring at wells that encounter the compounds of interest.

Some of the constituents are denser than water and thus tend to migrate vertically downward. MW-35 was screened in the lower portion of the shallow aquifer adjacent to MW-12, which is screened in the upper portion. Comparison of analytical data from these two wells indicates that although the constituents are present throughout the shallow aquifer, at these locations it is not accumulating at higher levels near the bottom of the aquifer.

A review of monitoring well, soil boring, and analytical data, as well as current literature, describing the likelihood of such a contaminant migration potential may be summarized as follows:

- Potentiometric or water table elevations within the site's shallow aquifer were measured to be approximately 80 ft higher than the potentiometric elevations noted in Memphis Sand wells at Dunn Field in 1989. This difference in head creates a potential for mixing of water from the shallow aquifer and the Memphis Sand Aquifer, and subsequent diffusion of Fluvial Aquifer contaminants into the Memphis Sand's water. Pumpage from the nearby Allen Well Field could increase the gradient between the two aquifers. It should be noted that the piezometric head of the Memphis Sand exceeds the lowest measured confining layer surface.

- The general class of compounds possesses low solubilities in water and does not readily adsorb on mineral surfaces (ref. 30). These characteristics may enhance the potential for migration.

- The class of encountered contaminants is considered to be persistent and relatively mobile in groundwater (ref. 10). Further, Griffin and Roy (ref. 12) classified a number of organic compounds according to their mobility in saturated soil-water systems. The compounds detected in DDMT groundwater samples may be described as follows:

Compound	Mobility Class
Acetone	Very highly mobile
Methylene Chloride	Very highly mobile
1,1,1-Trichloroethane	Medium mobility
Carbon Tetrachloride	Medium mobility
1,1,2,2-Tetrachloroethane	Medium mobility

- Some organic solvents have been shown to increase clay hydraulic conductivities. This effect was noted especially for acetone, methanol, and xylene (ref. 12).

3.2.3.3 Polycyclic Aromatic Hydrocarbons

PAHs were detected in surface soils at several installation locations. PAHs apparently have not migrated far from their point of introduction. Because of their insoluble nature and strong tendency to adsorb to soils, the leaching of PAHs is not expected. PAHs were not found in groundwater and surface water samples during the RI (ref. 18). The presence of PAHs in sediments from Lake Danielson and the adjacent pond may be attributed to soil containing adsorbed PAHs being transported during surface runoff.

3.2.3.4 Pesticides and Polychlorinated Biphenyls

While dieldrin and DDT (and degradation products DDD and DDE) were detected in surface soils at several installation locations, PCBs were only detected at two places—near Building 1088 (OU-2) and near Building 925 (along RR Tracks 3 and 4). It appears that the pesticides and PCBs found at DDMT have not moved from their point of release. Adsorption to soil particles is the probable explanation for the persistence of these compounds. The movement of soil particles containing adsorbed pesticides probably is responsible for their presence in sediments in Lake Danielson and the adjacent pond. Their low solubility and high K_d explain why concentrations in 13 surface water samples were observed at concentrations from 0.14 μg/L to 2.2 μg/L.

3.2.3.5 Chemical Warfare Agents

Hydrolysis of the various agents buried at Burial Site 3-A may produce contaminants that could migrate into the shallow groundwater through leaching. Thiodiglycol, a primary degradation product of mustard, is miscible in water. The hydrolysis of lewisite and mustard forms hydrochloric acid (HCl), which could then react with metals and insoluble metals salts in the soil to transform them to leachable salts. However, as mentioned previously, because of the limited nature of the documented CWA burial activities in Dunn Field, it is not likely that metals contamination in Dunn Field groundwater is due to CWA. Additional information concerning this issue is provided in the OU-1 FSP.

3.2.4 Preliminary Exposure Pathways

From the results of previous studies, DDMT has identified several potential pathways of concern. Note that this is a preliminary identification of possible pathways that will be expanded in the RI/FS report(s). There is a potential for contaminants present in the soils to reach human and animal receptors in numerous ways. The routes of primary concern are as follows:

- Inhalation of soil particulates
- Ingestion of soil particulates
- Dermal absorption of contaminants in soils
- Inhalation of VOCs present in soils

There is a potential for groundwater constituents to reach receptors via the following routes:

- Ingestion of groundwater (Memphis Sand Aquifer only)
- Dermal contact with potentially contaminated potable water during bathing
- Inhalation of vapors from volatile contaminants present in potable water that are emitted during household use

The potential routes of exposure associated with potentially contaminated surface water and surface water sediments include the following:

- Ingestion of fish and other aquatic life from contaminated lakes and creeks
- Dermal absorption of contaminants present in surface waters and sediments

Because VOCs do not tend to persist in surface water and sediments, inhalation of vaporized constituents present in surface water currently is considered an unlikely exposure pathway at DDMT.

3.2.5 Groundwater Sources and Potential Pathways

DDMT is located east of the Allen Well Field, one of six pumping centers owned and operated by MLGW. The Allen Well Field draws water from the Memphis Sand Aquifer, which is the main potable water source for the City of Memphis and most of Shelby County. Studies have implied that suspected areas of hydraulic interconnection might exist in the confining layer overlying the Memphis Sand Aquifer, allowing leakage of contaminants from water table aquifers (ref. 11). To date, none of these suspected areas have been conclusively found to exist beneath DDMT. However, past drilling logs and hydraulic information on water levels taken during the RI and presented in the RI Report (ref. 18) have suggested that one of these areas might exist in the north-central portion of the Main Installation. The next phase of field work is designed to evaluate whether the Fluvial Aquifer and Memphis Sand Aquifer are in direct intercommunication in this area. If so, it is possible that constituents migrating from DDMT could reach surrounding water table aquifers and could potentially enter the Memphis Sand Aquifer. Thirteen of the 33 Allen Well Field wells lie within one mile of DDMT (see Figure 2-18).

Section 2.4.6.5 contains a summary of previous analyses of the Allen Wells and the well search conducted during the RI (ref. 18). In summary, the water well survey associated with DDMT site assessment did not reveal any water table aquifer wells (Alluvial or Fluvial) within a 1-mile radius of DDMT that are used for potable water sources. The primary potential pathway of water table contamination would be via leakage through permeable zones in the confining unit that could allow migration of contamination from the Fluvial deposits to the Memphis Sand Aquifer. The potential for this occurrence has been addressed by Graham and Parks, 1986 (ref. 11) and Brahana, et al., 1987 (ref. 2). The Memphis Sand Aquifer is the primary water source for the City of Memphis, which has a population of approximately 650,000 people. Analysis of groundwater from onsite wells screened in the Memphis Sand Aquifer (MW-36 and MW-37) did not show evidence of VOCs present in the Fluvial Aquifer.

3.2.6 Surface Water and Sediment Sources and Potential Pathways

There are two primary surface water sources and several secondary sources located at DDMT. The two primary sources are Lake Danielson and the Golf Course Pond, which are located in the southeastern corner of the facility. Analysis of surface water and sediments indicates a possible history of releases to surface runoff from transformer storage and biocide applications in this area. Pesticides previously detected in sediments and fish tissue in samples collected from Lake Danielson and the Golf Course Pond include 4,4'-DDT, dieldrin, chlordane, and chlorpyrifos. PCB levels ranging from 0.34 mg/kg to 2.84 mg/kg were detected in fish tissue samples taken in 1986 by USAHEA. Fishing was discontinued at Lake Danielson in 1986.

Sediment investigations at Lake Danielson and the Golf Course Pond during the RI (ref. 18) detected metals, some pesticides, and numerous PAHs. No PCBs were detected during the sampling of the sediments or surface water samples collected from Lake Danielson or the Golf Course Pond.

Potential constituents of concern in the Golf Course Pond include PAHs and 4,4'-DDT, and its degradation products (DDD and DDE), which were detected in the pond sediments and in one surface water sample downstream with respect to the pond (SW-10). The only constituents detected in the pond water during the RI and presented in the RI Report (ref. 18) were barium, copper, and zinc at near background levels, and some VOCs and SVOCs that were believed to be lab contaminants.

The list of constituents detected at Lake Danielson during the RI and presented in the RI Report (ref. 18) was similar in identity and levels to those present at the pond. Potential constituents of concern at the lake include arsenic and the degradation products of 4,4'-DDT.

Surface water sample SW-1 was taken at a point where surface drainage from Dunn Field leaves the facility and travels in a north-northwest direction toward Cane Creek. Dieldrin was detected in this sample. When this point was resampled (SW-16), no dieldrin was detected. Other constituents were present at near background levels or were also present in the trip blank.

An exposure point for residents living in the vicinity of DDMT is via exposure to surface runoff traveling in the city's aboveground, open storm canals. Dermal contact with potentially contaminated water and soil present in storm canals is an exposure pathway of concern at DDMT, and will be considered in risk characterizations of DDMT facility.

3.2.7 Air and Soil Sources and Potential Pathways

The preliminary potential effects of the air and soil pathways would be as follows:

- Dermal (absorption) contact with contaminated surface soils
- Ingestion of contaminated surface soils
- Airborne entrainment and inhalation of contaminated soil particles

The first two exposure pathways would be limited primarily to employees working at DDMT. The third pathway mentioned (inhalation) is possible, but not likely, given the fact that many of the areas at DDMT are covered with either pavement or gravel or are well vegetated.

3.2.7.1 Subsurface Soil Sources

Five soil borings were collected and analyzed during the RI (ref. 18) at Dunn Field, but only samples STB-2-2 and STB-2-3 obtained from Dunn Field had any obvious contaminants. Pyrene and fluoranthene were detected at depths of 17.5 and approximately 70 ft. The sampling location was near the center of Dunn Field. All values were flagged as estimates by the laboratory during the RI (ref. 18). Three additional soil borings were collected and sampled during the second phase of the RI (ref. 18). STB-6 showed evidence of chlorinated hydrocarbons at all four depths, including trace amounts of 1,1,2,2-Tetrachloroethane and 1,2-Dichloroethene at 182 ft NGVD. Additional subsurface sampling is planned for many areas at DDMT to further characterize the nature and extent of subsurface soil contamination.

3.2.7.2 Surface Soil Sources

Areas of surface vegetation at DDMT vary widely. For example, Dunn Field, the Golf Course, and the Family Housing area are moderately to heavily vegetated. However, some areas of the Main Installation either are not paved or are covered with a gravel surface. Therefore, in some areas, absorption of contaminants present in surface soils via dermal contact, incidental ingestion of soil particulates and inhalation of fugitive dust, and any volatile compounds present in the soils are exposure pathways for employees of the DDMT facility. DDMT has a history of surface spills. The presence of surface contaminants has been confirmed at several locations during the sampling events of the RI (ref. 18).

3.3 Preliminary Public Health and Environmental Effects

3.3.1 Identification of Contaminants of Potential Concern

A total of 103 constituents were identified in the four matrices sampled during the RI (ref. 18). Twenty-eight contaminants of potential concern were selected from this total (see Table 3-1) during the RI (ref. 18). Factors considered in selecting these included the following:

- Measured concentrations and frequency of detection at the site
- Toxicity
- Physical and chemical characteristics related to environmental mobility and persistence
- Relative contribution of chemicals to overall health risks associated with the site

Methods discussed in *Risk Assessment Guidance for Superfund: Human Health Manual, Part A* (ref. 66) were used in ranking groundwater constituents during the RI (ref. 18). Constituents also were compared to available health standards and criteria.

Table 3-1 shows the contaminants of potential concern for DDMT that were identified during the RI (ref. 18) using the factors listed above. This is a preliminary list. Additions or deletions to this list will occur during the RI/FS process, with involvement from the FFA parties. Current EPA and TDEC guidance will be used in the development of future lists.

3.3.2 Toxicological Assessment of Contaminants of Potential Concern

A toxicological description of each of the identified compounds is provided in Appendix B. Descriptions will be expanded or updated in future RI/FS report(s).

3.3.3 Preliminary Human Risk Characterization

A preliminary human risk characterization is made in this section according to the results of previous studies. Potential health risks will be thoroughly examined during the BRAs prepared for all DDMT OUs.

3.3.3.1 *Potential Risks from Groundwater*

The contamination found at DDMT is primarily limited to the Fluvial Aquifer, which is not currently used as a drinking water source within the City of Memphis. Currently, there is no known exposure pathway to these groundwater contaminants through either the potable water supply of the City of Memphis or through private wells. Possible pathways and routes for contaminant migration will be further investigated during the RI/FS. Data provided by MLGW indicate that the water produced by MLGW meets all federal and state water quality standards. However, the local quality of groundwater within the Fluvial Aquifer may potentially have an adverse effect on the Memphis Sand Aquifers because of possible existence of areas where Fluvial and Memphis Sand Aquifers intercommunicate, it is necessary to consider that groundwater in the Fluvial Aquifer may adversely affect the Memphis Sand Aquifer.

Although the main facility had evidence of VOC contamination, the potential compounds of concern are primarily localized in Dunn Field. The maximum concentrations of 1,1,2,2-Tetrachloroethane, tetrachloroethylene, and TCE exceed all current drinking water standards. Of additional concern is the fact that the chlorinated compounds have a tendency to leach through the soil, and the extent of contamination now extends beyond the installation boundaries. The horizontal and vertical extent of contamination in the Fluvial Aquifer is not yet defined. In general, the potential metals of concern (arsenic, barium, chromium, lead, and mercury) exceeded drinking water standards at several times greater than background levels present in MW-16 during the RI (ref. 18). However, it should be noted that the selected background well also exceeded drinking water criteria for several metals of concern. Background levels in groundwater will be established during RI activities for all OUs.

The presence of groundwater constituents found at Dunn Field during the first phase of groundwater sampling during the RI (ref. 18) was confirmed by the data from the second phase of groundwater sampling. Groundwater contamination extends beyond the northwest corner of Dunn Field (MW-31 and MW-32). While no chlorinated compounds were found in the deeper wells (MW-36 and MW-37), acetone was detected in MW-37 at 3,500 μg/L. As a degradation product of isopropanol, acetone's presence may be attributed to improperly rinsed sampling equipment. Subsequent sampling and analysis in 1993 did not indicate the presence of acetone. Further sampling at Dunn Field will be performed during the RI to confirm the presence and quantitation levels of all VOCs and to define the extent of contamination in the Fluvial Aquifer.

3.3.3.2 *Potential Risks from Surface Water*

Lake Danielson and the Golf Course Pond are not currently used for swimming or fishing because of restrictions instituted based on the presence of PCBs and pesticides. Surface water is not a drinking water source at the facility or in the surrounding area. Metals and pesticides were detected in the surface water samples taken at DDMT and are summarized in Table 3-2. The maximum surface water concentrations of arsenic

(48 µg/L in Lake Davidson), lead (295 µg/L in Lake Danielson Drainage), and 4,4'-DDT exceeded Water Quality Criteria (WQC) for the ingestion of water and fish or fish alone. No criteria were available for 4,4'-DDE (max = 0.88 µg/L in Golf Course Pond drainage detected). The three pesticides are considered carcinogenic and are likely to bioaccumulate in the food chain.

Pesticides and PCBs previously were detected (summarized in Table 3-3) in fish tissue at Lake Danielson by USAEHA (ref. 53). The continued presence of arsenic and DDT (max in catfish of 23.64 mg/kg) in Lake Danielson suggests that a source for these constituents may still exist. DDT and DDE were detected in the sediments of Lake Danielson (Table 3-3). DDT, DDE, DDD, and several PAH compounds were present in the sediments from the Golf Course Pond (select data in Table 3-3, with all data in Appendix D).

Another potential exposure point via surface water is the potential releases to Nonconnah and Cane Creeks, which are classified for fishing and recreational use. The risks associated with the consumption of potentially contaminated fish or dermal contact with contaminated water are expected to be minimal, primarily because of the levels of concentrations of contaminants observed in the surface water drainage ditches to date, coupled with the effects of mixing and dilution. The concentrations of contaminants observed in the drainage canals and exposure via dermal absorption are not expected to pose a significant health risk to humans wading in these waters.

Exposure to volatile compounds via vaporization from surface water is not considered a viable pathway at DDMT because no volatiles have been detected in the surface water discharged from the facility into the storm system. Lead, arsenic, DDT, and DDE were present in SW-9, SW-10, SW-11, and SW-12, which are sample points on the southeastern boundaries of the facility. Dieldrin was present in a surface water discharge point for Dunn Field. All these constituents tend to absorb to sediments and are not highly volatile.

3.3.3.3 Potential Risks from Sediments

Levels of PAHs, as well as DDT, DDE and DDD, were found in the Golf Course Pond sediments (SD-5-SS). However, the RI Report (ref. 18) concluded that sediments do not pose a direct human health risk at DDMT because of the lack of pathways to human receptors. Sediments may serve as a reservoir for contaminants that tend to bioaccumulate in the food chain. Sediment contamination and potential pathways will be evaluated and quantified during the RI.

3.3.3.4 Potential Risks from Surface and Subsurface Soil

Subsurface soil contamination detected at the site during the RI and presented in the RI Report (ref. 18) was determined not to pose a public health risk at this time. However, several source areas of surface soil contamination exist and need further investigation.

Table 3-3
Select Summary of USAEHA Fish and Sediment Analyses
Defense Depot Memphis, Tennessee

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Fish Tissue (mg/kg)	Lake Danielson				Golf Course Pond	
	A[a]	B	C	D	A	B
Chlordane (total)	2.13	2.13	2.01	1.82	0.14	0.60
O,P' DDD	0.51	0.57	0.55	0.43	0.02	0.07
P,P' DDD	4.06	4.76	3.66	3.68	0.18	1.02
P,P' DDE	15.55	15.65	8.44	11.82	1.25	3.61
O,P' DDT	0.59	0.63	0.29	0.47	BDL	BDL
P,P' DDT	2.16	2.03	1.38	1.66	BDL	BDL
Dieldrin	0.31	0.19	0.16	0.16	0.03	0.17
PCB (1260)	0.45	0.48	0.34	0.44	1.13	2.84
Sediment (mg/kg)	1[a]	2	3	4	5[b]	
Chlordane (total)	1.11	2.52	1.64	2.09	BDL	
O,P' DDD	0.95	1.34	0.77	0.97	BDL	
P,P' DDD	3.45	3.75	2.32	3.93	0.21	
P,P' DDE	2.71	5.31	4.22	4.75	0.22	
O,P' DDT	0.18	0.24	0.18	0.21	BDL	
P,P' DDT	0.77	0.81	0.59	0.75	0.15	

[a] A = Sample Identification
1 = Sample Number

[b] Only one sediment sample was taken from the Golf Course Pond

Potential human exposure routes that have been considered on a preliminary basis at DDMT include ingestion, dermal absorption, and inhalation of contaminants present in soil and dust. Dunn Field, the Golf Course, and the Family Housing Area all have significant vegetation to limit the generation of fugitive dust during active site use. The rest of the facility is predominantly paved, but some exposed areas are present.

Levels of VOCs detected during the RI and presented in the RI Report (ref. 18) were determined not to pose a health risk at this time, but the levels of PAHs, pesticides, PCBs, arsenic, and chromium observed may potentially pose a health risk, depending on the exposure scenario. Soils at Building 629 (SS-10, SS-11, SS-42, SS-43) and Dunn Field (SS-7) are the potential source areas for PAH compounds and for pesticides. Dieldrin was detected at SS-14 on the golf course and at SS-43. Beta-BHC and heptachlor were present in SS-50 north of the golf course. In the southwestern corner of the main facility, contamination with PCBs has been noted. PCBs also were detected at the hardstand area (SS-21 and SS-23). The highest arsenic concentration was detected at SS-37, while chromium was found at SS-20 in the hardstand area.

3.3.3.5 Summary of Human Risk Characterization

A preliminary assessment of DDMT facility conducted during the RI and presented in the RI Report (ref. 18) revealed a number of constituents present in groundwater, surface water, surficial soils, and sediments. Potential public health risks have been associated with the following matrices:

- The Fluvial Aquifer contains VOCs, which could negatively affect the Memphis Sand Aquifer under certain conditions. Further investigation is needed to establish the extent of groundwater contamination at and near Dunn Field, and whether leakage to the Memphis Sand Aquifer is occurring at or near DDMT.

- Surficial soils contain potential human carcinogens at relatively high concentrations at some sites. Further investigation is necessary to establish the extent of contamination at facility source areas and to characterize potential releases at other sites.

- Additional data needed to assess the potential effect that contamination of surface waters and sediments could have on public health.

3.3.4 Preliminary Ecological Risk Characterization

3.3.4.1 Development and Use

Most of DDMT facility has been developed for urban use and does not support extensive vegetative or animal life. Dunn Field, the Golf Course, the Administrative Area, and the Family Housing Area support vegetation.

3.3.4.2 *Wildlife*

Two areas, Dunn Field and the golf course, have evidence of typical urban wildlife such as squirrels, chipmunks, red foxes, opossums, quail, mourning doves, and turtles. Rats, mice, and other pests are attracted to the subsistence stocks and are commonly found in the storage buildings (ref. 35). In addition, small numbers of waterfowl (ducks) occasionally have been observed at Lake Danielson and the Golf Course Pond.

3.3.4.3 *Aquatic Life*

Lake Danielson was stocked periodically with bluegill and bass before the restriction on fishing in these water bodies. Catfish also have been observed in the lake. Several fish kills have reportedly occurred in the lake (1976, 1980, and 1989); one incident in 1976 was associated with pesticide runoff into the lake. Lake Danielson receives much of the surface drainage from the southeastern corner of the installation. Pesticide and herbicide contamination is also in evidence at the Golf Course Pond and probably is associated with routine grounds care of the golf course (refs. 15 and 35).

3.3.4.4 *Endangered Species*

Although previous reports indicated that no threatened or endangered species are known to inhabit or use DDMT facility or the area within 1 mile of the facility (ref. 15), concern exists that this conclusion may not be correct. DDMT has proposed a study of ecological conditions at the facility for application in RI/FS conclusions.

3.3.4.5 *Vegetation*

Bermuda grass, black oaks, decorative shrubs, and trees are the primary vegetation at DDMT facility. Grass and trees are found predominantly at Dunn Field and the golf course. Most landscape shrubs are located around the family quarters, the golf course, and the administrative buildings in the southeastern corner (ref. 15).

3.3.4.6 *Potential Exposure Pathways for Ecological Effects*

Aquatic life in Lake Danielson and the Golf Course Pond potentially is exposed to soil contaminants carried by surface runoff. Offsite aquatic life in Cane Creek and Nonconnah Creek is potentially affected by contact with surface drainage flowing into these creeks. Aquatic life in the Mississippi River is potentially affected by contact with groundwater discharged from the Fluvial Aquifer. Plants and animals are potentially exposed through intake of contaminated surface water and soil constituents.

3.3.4.7 *Environmental Fate Processes*

Some of the potential chemicals of concern have the ability to accumulate within the food chain (such as 4,4'-DDT and dieldrin). The VOCs volatilize from water and surface soil.

They do not tend to bioaccumulate and are persistent in the aqueous environment under anaerobic conditions. The PAHs are readily absorbed by living aquatic species (ref. 1). The PAHs have low vapor pressure and low water solubility, but a high propensity to adsorb to organic soils. Therefore, these compounds persist in surface soils for long periods (for example, the half-life of dibenzo(a,h)anthracene is 750 days in soil) (ref. 1).

Mercury is a compound that can potentially bioaccumulate in aquatic species, but was not detected in surface waters at DDMT. Lead and chromium are associated with some accumulation in vegetation and animals. In general, in aqueous environments, metals, PAHs, and pesticides tend to adsorb to sediments. The pesticides eventually are recycled to the aquatic environment, where they tend to bioaccumulate in fish tissue.

3.3.4.8 Summary of Preliminary Ecological Risks

Vegetation and animal life are limited at DDMT. Therefore, any effect on land flora and fauna is reduced. Aquatic life in Lake Danielson and the Golf Course Pond has been affected by storm water runoff of pesticides at the facility. Traces of pesticides are still detected in surface water and sediments at the installation. An ecological risk assessment will be prepared for the various RI reports.

3.4 Preliminary Identification of Remedial Alternatives

Contaminated groundwater, surface water, sediments, and surface soils were detected during the RI (ref. 18) and previous studies. These environmental media were considered individually in developing potentially applicable remedial alternatives. Several process options within each remedial technology type were evaluated for each contaminated media. Potentially applicable technologies were considered for each OU, with the potential technologies and additional data needs for each of those technologies shown in Table 3-4. However, alternatives that will not require data collection during the RI field activities are not included in Table 3-4.

Feasibility study work plans are intended to be prepared as separate submittals. However, a schedule for development and implementation of the feasibility studies is provided in Table 3-5.

General response actions were developed considering the following: potential contaminants of concern; allowable exposure levels based on the RI Report (ref. 18); compliance with regulations (RCRA and CERCLA); the EPA Guidance for Conducting RI/FSs under CERCLA (ref. 63); and known site conditions. The following sections identify applicable technologies for remediation of groundwater, soil, and surface water at DDMT.

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Table 3-4
Potential Additional Data Needs to Aid in Preliminary Screening of Remedial Alternatives for RI Sites[a]
Defense Depot Memphis, Tennessee

Page 1 of 2

Operable Units	Remedial Options	Typical Media	Information Required for Alternative Evaluation
OU-1	Bioremediation	Soil, Waste	Nutrients, moisture content, porosity, pH, T, dissolved oxygen in water and subsurface, TOC
	Containment	GW[b]	Slug and pump tests
	Cover	Soil, Waste	Adequate blow count information on Boring Logs (to 15′ or so)
	Incineration	Soil	Metals (TCLP and total), chlorine, BTU as higher heating value and ash content (use reference values)
	In-Situ Bioremediation	GW	Nutrients, electron acceptors, moisture content, dissolved oxygen, T, pH
	Land Disposal	Soil	TCLP, HW characteristics
	Landfill (solids)	Soil	TCLP, HW characteristics
	Neutralization	Soil, Waste	pH, alkalinity, moisture content
	Removal/Treatment	GW	COD, BOD, TDS, TSS, pH, conductivity, cations/anions, ammonia, nitrate/nitrite, total phosphorus, alkalinity, hardness
	Sanitary Sewer (liquid)	Liquid Waste	None
	Stabilization, Solidification	Soil, Liquid Waste	pH, moisture content, grain size, porosity
	SVE	Soil	Grain size (if clay do Atterburg), moisture content, soil boring profiles to water table, pump tests (slug tests if pump tests not possible)
OU-2	Bioremediation	Soil, Waste	Nutrients, moisture content, porosity, pH, T, dissolved oxygen in water and subsurface, TOC
	Containment	GW	Slug and pump tests
	Cover	Soil	Slug and pump tests COD, BOD, TDS, TSS, pH Adequate blow count information on Boring Logs (to 15′ or so)
	Land Disposal	Soil	TCLP, HW characteristics
	Incineration	Soil	Metals (TCLP and total), chlorine, BTU as higher heating value and ash content (can probably just use reference values)
	In-Situ Bioremediation	GW	Nutrients, electron acceptors, moisture content, dissolved oxygen, T, pH
	Neutralization	Soil, Waste	pH, alkalinity, moisture content
	Removal/Treatment	GW	COD, BOD, TDS, TSS, pH, conductivity, cations/anions, ammonia, nitrate/nitrite, total phosphorus, alkalinity, hardness

Table 3-4
Potential Additional Data Needs to Aid in Preliminary Screening of Remedial Alternatives for RI Sites[a]
Defense Depot Memphis, Tennessee

Page 2 of 2

Operable Units	Remedial Options	Typical Media	Information Required for Alternative Evaluation
OU-2	Solidification/Stabilization	Soil, Liquid Waste	pH, moisture content, grain size, porosity
	SVE	Soil	Grain size (if clay do Atterburg), moisture content, soil boring profiles to water table, pump tests (slug tests if pump tests not possible)
OU-3[d]	Cover	Soil	Site-specific water level data with piezometers, geotechnical properties (grain size distribution, Atterberg limits, permeability, direct shear) of pond embankments and immediately adjacent soils
	Containment/Removal	GW	Slug and pump tests
	Fill	Sed	None
	Incineration	Soil	Metals (TCLP and total), chlorine, BTU as higher heating value and ash content (use reference values)
	Land Disposal	Soil	TCLP, HW characteristics
	Remove/Landfill	Sed	TCLP, moisture content, HW characteristics
	Treatment	GW	COD, BOD, TDS, TSS, pH, conductivity, cations/anions, ammonia, nitrate/nitrite, total phosphorus, alkalinity, hardness
OU-4	Containment	GW	Slug and pump tests
	Cover	Soil	Adequate blow count information on Boring Logs (to 15 ft or so)
	Incineration	Soil	Metals (TCLP and total), chlorine, BTU as higher heating value and ash content (use reference values)
	In-Situ Bioreclamation	GW	Nutrients, electron acceptors, moisture content, dissolved oxygen, T, pH
	Land Disposal	Soil	TCLP, HW characteristics
	Solidification/Stabilization	Soil	pH, moisture content, grain size, porosity
	Treatment	GW	COD, BOD, TDS, TSS, pH, conductivity, cations/anions, ammonia, nitrate/nitrite, total phosphorus, alkalinity, hardness

Note: [a] This table is a generalized list of potential data needs for the RI to aid in the scoping of field activities. It is not intended for use as the preliminary remedial alternatives screening for the Feasibility Study nor is it intended to collect data for all potential remedial alternatives to be evaluated. Alternatives that will not require data collection during the RI field activities are not included. Similar technologies would be grouped under a specific name, i.e., incineration would generally also represent thermal desorption, cement kilns, incinerators, pyrolysis, or wet air oxidation as similar technologies.

[b] GW = Groundwater

[c] Sed = Sediment

[d] Due to the construction of the ponds, it may require significant engineering review of current design and conditions to ensure that the pond walls will not collapse if full or partial draining of the pond is required for dredging, removal, or cover placement.

Table 3-5
Schedule for Development and Implementation of Feasibility Study
Defense Depot Memphis, Tennessee

Activity	Duration (months)
Approval of Generic RI/FS Work Plan	starting milestone
FS Work Plan Draft	2
EPA/TDEC Review	2
Prefinal FS Work Plan	1.5
EPA/TDEC Review	1
Final FS Work Plan	1
FS Screening	2
Draft FS Report	2
EPA/TDEC Review	2
Prefinal FS Report	1.5
EPA/TDEC Review	1
Final FS Report	1

3.4.1 Groundwater Cleanup Alternatives

3.4.1.1 Preliminary Remedial Action Objectives for Groundwater

The overall goal for groundwater remediation at DDMT is to stop the migration of contaminants in the Fluvial Aquifer and to protect human health by eliminating groundwater contamination that might threaten the Allen Well Field. The specific objectives to meet this goal are to accomplish the following:

- Remediate groundwater contamination in the Fluvial Aquifer.
- Minimize the possibility of contaminant migration to the Memphis Sand Aquifer through local manipulation of groundwater flow patterns in the Fluvial Aquifer (using groundwater extraction wells) and treatment of contaminated groundwater if needed with discharge to the city sewer.
- Adequately mitigate the source of contamination.

Section 1.4.2 provides a more complete discussion of the interim remedial action.

Two areas must be examined in developing the groundwater remedial alternatives: the source areas where the contamination is being generated and the contaminated portion of the Fluvial Aquifer. The information obtained in performing the RI (ref. 18) indicates that a principal contaminant source area is located within Dunn Field. Although the exact location of the trench, or trenches, contributing the contamination was not identified, several sites (such as Sites 4 and 4.1) could be likely source candidates based on the documented types and quantities of waste buried. Although the areal extent of groundwater contamination was not fully determined during the RI (ref. 18), remedial action alternatives may still be evaluated.

Groundwater clean-up levels will be determined from information obtained during the RI/FS, the ARARs analysis, and determination of risk-based concentrations. Groundwater clean-up levels may also be governed by treatability studies using the best available technology (BAT), which may dictate levels exceeding risk-based criteria if BAT cannot achieve these values.

3.4.1.2 General Response Actions for Groundwater

General response actions were developed to address the remedial action objectives for the groundwater and contaminant source(s) in the Dunn Field area. Potentially applicable general response actions were developed, as follows:

- No action
- Institutional controls
- Plume containment

- Source containment
- Pump and treat technologies
- In-situ treatment
- Time critical removal action (excavation of source areas and offsite treatment and disposal)

3.4.2 Surface Soil Cleanup Alternatives

Alternatives for preliminary remedial and general response actions for surface soils are discussed below.

3.4.2.1 Preliminary Remedial Action Objectives for Surface Soils

The primary remedial action objective for surface soils is the protection of human health and the environment, which requires the prevention of ingestion of or direct contact with soils having contaminant levels exceeding target levels. A secondary remedial action objective is to limit the potential effect that surface soil contamination might have on surface water runoff. A third remedial action objective is to prevent migration of contaminants from the surface soils to the groundwater.

3.4.2.2 General Response Actions for Surface Soils

General response actions were identified to address the remedial action objectives for surface soils. The general response actions fall within the following main categories:

- No action
- Institutional controls
- Excavation and onsite treatment and replacement
- In-situ treatment
- Excavation and offsite treatment and disposal
- Excavation and offsite disposal
- Capping

Excavation of contaminated soils at DDMT may require compliance with RCRA's Land Disposal Restrictions (LDR) regulations. These regulations apply to soils transported offsite for disposal and may apply to some forms of onsite treatment and replacement. The regulations are generally based on the generation process for each contaminant. Contaminated soils that can be traced to a specific identified source can be classified as a "Listed Waste." This category of soils has definite standards to which soils should be treated before disposal. To categorize the waste at DDMT as "Listed Wastes," a thorough examination of the records (waste manifests) would have to be performed by facility personnel. If the contaminants detected in the RI and presented in the RI Report (ref. 18) can be identified from any of these records, the wastes may be considered as "Listed."

Contaminated soils that are not "Listed" are evaluated on the basis of their "Characteristics" (ignitability, corrosivity, reactivity, and toxicity). For soils, this means their toxicity, as currently defined by the toxicity characteristic leaching procedure (TCLP) tests. Soils that are above the toxicity standards are defined as "Characteristic Wastes." These soils would have to be treated to meet the Land Disposal Requirements under RCRA. The TCLP test applies to RCRA metals, pesticides, and some organics. Once defined as a "Characteristic Waste," the soil would also need to comply with the California List Waste rule. This rule is particularly significant for halogenated organic compounds (HOCs). These soils would have to be treated to below the California List for total HOCs (1,000 milligrams per kilogram [mg/kg]) before land disposal. Clean-up levels should be negotiated between DDMT, TDEC, and the EPA.

3.4.3 Surface Water Cleanup Alternatives

Surface water preliminary remedial and general response actions are discussed in the following sections.

3.4.3.1 Preliminary Remedial Action Objectives for Surface Water

The remedial action objective for Lake Danielson and the Golf Course Pond is to protect the health of anyone who might be exposed through the consumption of contaminated fish and to protect the aquatic life (particularly the fish) within the water bodies. Lake Danielson and the Golf Course Pond are both currently under "No Fishing" and "No Swimming" restrictions. Ultimately, DDMT would like to increase the utility of these two surface water bodies, specifically by allowing activities such as picnicking and potentially fishing. Water quality could be affected by short-term increases in contaminant levels as the result of peak storm events.

Sediment contamination was detected in Lake Danielson and the Golf Course Pond. PAH, pesticide, and metal contamination levels were significantly higher in the pond than levels detected in the lake. Three general areas must be addressed in developing remediation alternatives for the Lake Danielson area: surface water, sediments, and the current storm water drainage system that supplies the lake and pond.

3.4.3.2 General Response Actions for Surface Water

General response actions were identified for the three areas in developing remedial alternatives for the surface water bodies. These actions include the following:

- No action
- Institutional control
- Storm water drainage diversion or treatment
- Establish aquatic vegetation for sediment
- Lake abandonment with contaminated sediment removed
- Dredge sediments/offsite treatment and disposal

- Source determination, excavation, and treatment (accompanied by one of above)

3.5 Preliminary Identification of Applicable, Relevant, and Appropriate Requirements and Preliminary Remediation Goals

3.5.1 Introduction

The purpose of this section is to present information in the scoping phase of DDMT projects on issues relating to compliance with applicable or relevant and appropriate requirements (ARARs), including identification of preliminary remediation goals (PRGs). This information guides the development of appropriate sampling and analysis plans and early removal actions, or facilitates the development of a range of appropriate remedial alternatives and can focus selection on the most effective remedy. Terms used in this section are defined in Table 3-6.

The procedures for identification and evaluation of ARARs and PRGs are presented in several important sources, particularly the following:

- The NCP, specifically 55 FR 8741-8766 for a description of ARARs, and 8712-8715 for using ARARs as PRGs; also 53 FR 51394
- CERCLA Compliance Manuals (EPA 1988 and 1989)
- *Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual.* Part B, Development of Risk-Based Preliminary Remediation Goals. EPA, 1991, (RAGS Part B)

Three types of federal and state ARARs have been identified and are presented in this section:

- **Chemical-specific**—Health or risk management-based numbers or methodologies that result in the establishment of numerical values for a given media that would meet the NCP "threshold criteria" of overall protection of human health and the environment and compliance with ARARs. The development and presentation of these "threshold criteria" are a major focus during this initial phase because of their role in the development of the specific sampling plans and their use in initial data interpretation.
- **Location-specific**—Restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because they are in special locations (such as wetlands).

Table 3-6
ARARs and PRGs Definitions
Defense Depot Memphis, Tennessee

Term	Definition
Applicable or Relevant and Appropriate Requirements (ARARs)	"Applicable" requirements are those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal, state, or local law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site. "Relevant and appropriate" requirements are those clean-up standards which, while not "applicable," addresses problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. ARARs can be action-specific, location-specific, or chemical-specific.
Final Remediation Levels (FRLs)	Chemical-specific clean-up levels are documented in the Record of Decision (ROD). They may differ from preliminary remediation goals (PRGs) because of modifications resulting from consideration of various uncertainties, technical and exposure factors, as well as all nine selection-of-remedy criteria outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).
Preliminary Remediation Goals (PRGs)	Initial clean-up goals that (1) are protective of human health and the environment, and (2) comply with ARARs. They are developed early in the process based on readily available information and are modified to reflect results of the baseline risk assessment. They also are used during analysis of remedial alternatives in the remedial investigation/feasibility study (RI/FS).
Risk-based PRGs	Concentration levels set at scoping for individual chemicals that correspond to a specific cancer risk level of 10^{-6} or a Hazard Quotient/Hazard Index (HQ/HI) of 1. They are generally selected when ARARs are not available.
Screening Risk-based PRGs	Conservative risk-based estimates and guidance concentrations to be used for site and pathway screening. Lower values than typically estimated after a baseline risk assessment are presented—values correspond to an HQ/HI of 0.1.
Remedial Goal Options (RGOs)	Remedial goal options are typically developed during the baseline risk assessment to present risk managers with a range of possible target FRLs.
Removal Action Levels (RALs)	Concentrations that trigger consideration of removal actions based on potential for acute or long-term chronic effects.

- **Action-specific**—Usually technology or activity-based requirements or limitations on actions taken with respect to hazardous waste.

The ARAR and PRG information presented in the work plan documents are initial guidelines. They do not establish that cleanup to meet these goals is warranted. As more information is obtained about all OUs and as remedial alternatives are considered, federal and state requirements will be narrowed to those that are potential ARARs for each alternative.

3.5.2 Chemical-specific Threshold Concentrations

Threshold criteria were developed for each media of potential concern, specifically groundwater, surface water, soil, and sediment. These are presented in Tables 3-7 to 3-10. These include ARAR-based PRGs, guidance values that are "to be considered," and screening risk-based PRGs.

The screening PRGs presented during this phase represent the most conservative approach to the interpretation of the site data. These data are intended for use in screening sites to evaluate the appropriate disposition of the site. At these sites, a more limited data set may be available; no site-specific BRA will be performed to identify remedial goal options for the site that may be more appropriate target concentrations.

The screening PRGs were developed from information provided in Risk Assessment Guidance for Superfund (RAGS) Part B and guidance from EPA Region IV. Region III publishes screening PRGs, and the table is updated quarterly. Region III PRGs were used for guidance in developing the PRGs presented in Tables 3-7 to 3-10. However, the screening values in these tables are more conservative than the Region III values. The following factors were considered and led to the development of these screening PRGs:

- Presence of multiple contaminants
- Pathways not considered in the published values (soil to groundwater pathways)
- Potential ecological effects
- Appropriate land-use assumptions

The specific derivation of the screening PRGs is presented in Section 3.6. The important factors in the approach are summarized, as follows:

- Residential land-use assumptions
- Guidance values for potential ecological effects presented for surface water and sediments.

Table 3-7

Preliminary Remediation Goals (PRGs)[a] for Groundwater[b]

Defense Depot Memphis, Tennessee

	ARARs[c] Based PRGs			Risk-based PRGs		
Chemical Name	MCL[d] (mg/L)	MCLG[e] (mg/L)	TN Guidance Level[f] (mg/L)	Risk-based PRG (mg/L)	PRG Basis	Minimum[i]
VOLATILE ORGANIC COMPOUNDS						
Acetone				0.183	S[g]	0.18
Benzene	0.005	0	0.005	0.001	C[h]	0.001
Bromodichloromethane	0.1			0.001	C	0.001
Bromoform	0.1			0.005	C	0.005
Bromomethane				0.003	S	0.003
Carbon Disulfide			0.038	0.183	S	0.038
Chlorobenzene	0.1	0.1	0.488	0.037	S	0.037
Chloroethane						N/A
Chloroform	0.1		0.00019	0.007	C	0.00019
Chloromethane				0.003	C	0.003
Dibromochloromethane	0.1		0.05	0.001	C	0.001
1,1-Dichloroethane				0.183	S	0.183
1,2-Dichloroethane	0.005	0	0.005	4.7E-04	C	4.7E-04
1,1-Dichloroethene	0.007	0.007	0.007	7.1E-05	C	7.1E-05
1,2- (mixed isomers) Dichloroethene				0.016	S	0.016
cis-1,2-Dichloroethene	0.07	0.07	0.35	0.018	S	0.018
trans-1,2-Dichloroethene	0.1	0.1		0.037	S	0.037
1,2-Dichloropropane	0.005	0		0.001	C	0.001
1,3-Dichloropropene				2.4E-04	C	2.4E-04
cis-1,3-Dichloropropene						N/A
trans-1,3-Dichloropropene						N/A
Ethyl benzene	0.7	0.7	1.4	0.183	S	0.18
2-Hexanone						N/A
Methyl Ethyl Ketone				1.095	S	1.095
4-Methyl-2-Pentanone				0.091	S	0.091
Methylene Chloride	0.005	0	1.5	0.006	C	0.005
Styrene	0.1	0.1	70	1.72E-05	C	1.7E-05
1,1,2,2-Tetrachloroethane			0.0017	2.13E-04	C	2.1E-04
Tetrachloroethene	0.005	0	0.008	0.001	C	0.001
Toluene	1	1	14.3	0.365	S	0.365
1,1,1-Trichloroethane	0.2	0.2	0.2	0.164	S	0.164
1,1,2-Trichloroethane	0.005	0.003	0.0006	0.001	C	0.0006
Trichloroethene	0.005	0	0.005	0.004	C	0.004
Vinyl Chloride	0.002	0	0.002	2.24E-05	C	2.24E-05
Xylene, Mixture	10	10	2.2	3.650	S	2.2
SEMIVOLATILE ORGANIC COMPOUNDS						
Acenaphthene			0.02	0.219	S	0.02
Acenaphthylene						N/A
Anthracene				1.095	S	1.095
Benzo(A)Anthracene				1.17E-04	C	1.17E-04
Benzo(A)Pyrene	0.0002	0		1.17E-05	C	1.17E-05
Benzo(B)Fluoranthene				1.17E-04	C	1.17E-04
Benzo(G,H,I)Perylene						N/A
Benzo(K)Fluoranthene				0.001	C	0.001
Bis(2-Chloroethoxy)Methane						N/A
Bis(2-Chloroethyl)Ether				7.74E-05	C	7.74E-05
Bis(2-Chloroisopropyl)Ether			0.0347	0.001	C	0.001
Bis(2-Ethylhexyl)Phthalate	0.006	0	15	0.006	C	0.006
Bis(Chloromethyl)Ether				3.87E-07	C	3.87E-07
4-Bromophenylphenylether						N/A
N-Butylbenzyl Phthalate				0.730	S	0.730
4-Chloroaniline				0.015	S	0.015
2-Chlorophenol			0.001	0.018	S	0.001
Chrysene				0.012	C	0.012
Di-N-Butyl-Phthalate				0.365	S	0.365
Di-N-Octyl-Phthalate				0.073	S	0.073
Dibenz(A,H)Anthracene				1.17E-05	C	1.17E-05
Dibenzofuran				0.015	S	0.015
1,2-Dichlorobenzene	0.6	0.6	0.4	0.329	S	0.329
1,3-Dichlorobenzene			0.4	0.325	S	0.325

Table 3-7
Preliminary Remediation Goals (PRGs)[a] for Groundwater[b]
Defense Depot Memphis, Tennessee

	ARARs[c] Based PRGs			Risk-based PRGs		
Chemical Name	MCL[d] (mg/L)	MCLG[e] (mg/L)	TN Guidance Level[f] (mg/L)	Risk-based PRG (mg/L)	PRG Basis	Minimum[g]
1,4-Dichlorobenzene	0.075	0.075	0.075	0.004	C	0.004
3,3-Dichlorobenzidine			8.00E-05	1.89E-04	C	8.00E-05
2,4-Dichlorophenol			3.09	0.011	S	0.011
Diethylphthalate			350	2.920	S	2.920
2,4-Dimethylphenol				0.073	S	0.073
Dimethylphthalate				36.500	S	36.500
2,4-Dinitrophenol				0.007	S	0.007
2,4-Dinitrotoluene				1.25E-04	C	1.25E-04
2,6-Dinitrotoluene				1.25E-04	C	1.25E-04
Fluoranthene				0.146	S	0.146
Fluorene				0.146	S	0.146
Hexachlorobenzene	0.001	0	7.20E-07	5.32E-05	C	7.20E-07
Hexachlorobutadiene			0.0045	0.001	S	0.001
Hexachlorocyclopentadiene	0.05	0.05	0.206	0.026	S	0.026
Hexachloroethane			0.0019	0.004	S	0.0019
Indeno(1,2,3-Cd)Pyrene				1.17E-04	C	1.17E-04
Isophorone			5.2	0.090	C	0.090
2-Methylphenol				0.183	S	0.183
4-Methylphenol				0.018	S	0.018
Naphthalene			0.025	0.146	S	0.025
2-chloro Napthalene						N/A
4-chloro Napthalene						N/A
O-Nitroaniline						N/A
P-Nitroaniline						N/A
Nitrobenzene			0.0013	0.002	S	0.0013
2-Nitrophenol						N/A
P-Nitrophenol				0.029	S	0.029
N-Nitroso-Di-N-Propylamine				1.22E-05	C	1.22E-05
N-Nitrosodiphenylamine			4.90E-05	0.017	C	0.000
Pentachlorophenol	0.001	0	1.01	0.001	C	0.001
Phenanthrene						N/A
Phenol			3.5	2.190	S	2.190
2-methyl-,4,6-dinitro-Phenol						N/A
3-methyl-,4-chloro-Phenol						N/A
4-chlro-phenyl-Phenylether						N/A
Pyrene				0.110	S	0.110
indeno(1,2,3-cd) Pyrene						N/A
1,2,4-Trichlorobenzene	0.07	0.07		0.037	S	0.037
2,4,5-Trichlorophenol			2.6	0.365	S	0.365
2,4,6-Trichlorophenol			0.0012	0.008	C	0.0012
PESTICIDES						
Polychlorinated Biphenyls (PCBs)	0.0005	0		1.11E-05	C	1.11E-05
Aldrin			7.40E-08	5.01E-06	C	7.40E-08
Alpha-BHC						N/A
Beta-BHC						N/A
Delta-BHC						N/A
Chlordane	0.002	0	4.60E-07	6.55E-05	C	4.60E-07
4,4'-DD				3.55E-04	C	3.55E-04
4,4'-DDE				2.50E-04	C	2.50E-04
4,4'-DDT			2.40E-08	2.50E-04	C	2.40E-08
Endosulfan				0.022	S	0.022
Endosulfan II						N/A
Endrin	0.002	0.002	0.002	0.001	S	0.001
Endrin Ketone						N/A
Heptachlor	0.0004	0	2.80E-07	1.89E-05	C	2.80E-07
Heptachlor Epoxide	0.0002	0		9.36E-06	C	9.36E-06
Lindane	0.0002	0.0002		6.55E-05	C	6.55E-05
Methoxychlor	0.04	0.04		0.018	S	0.018
Toxaphene	0.003	0		7.74E-05	C	7.74E-05

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Table 3-7
Preliminary Remediation Goals (PRGs)[a] for Groundwater[b]
Defense Depot Memphis, Tennessee

Chemical Name	ARARs[c] Based PRGs MCL[d] (mg/L)	MCLG[e] (mg/L)	TN Guidance Level[f] (mg/L)	Risk-based PRGs Risk-based PRG (mg/L)	PRG Basis	Minimum[i]
METALS						
Aluminum						N/A
Antimony	0.006	0.006	0.146	0.001	S	0.001
Arsenic	0.05	0.05	0.05	4.87E-05	C	4.87E-05
Barium	2	2	1	0.256	S	0.2555
Beryllium	0.004	0.004	3.70E-06	2.0E-03	C	0.0000037
Cadmium (Water)	0.005	0.005	0.01	0.002	S	0.002
Chromium (Hexavalent)	0.1	0.1	0.05	0.018	S	0.018
Copper	1.3	1.3	1	0.135	S	0.135
Cyanide	0.2	0.2		0.073	S	0.073
Iron						N/A
Lead	0.015	0	0.05			0.015
Manganese (Water)				0.018	S	0.018
Mercury	0.002	0.002	0.002	0.001	S	0.001
Nickel, Soluble Salts	0.1	0.1	0.0134	7.30E-02	S	0.0134
Selenium	0.05	0.05	0.01	0.018	S	0.01
Silver			0.05	0.018	S	0.018
Thallium	0.002	0.0005	0.013			0.0005
Vanadium				0.026	S	0.026
Zinc			5	1.095	S	1.095

[a] PRG = Preliminary Remediation Goal

[b] When no value is listed, no applicable ARAR was identified or no health data were available (or both).

[c] ARAR = Applicable, Relevant and Appropriate Requirements

[d] MCL = Maximum Contaminant Level

[e] MCLG = Maximum Contaminant Level Goal

[f] Source: Hazardous Substance Guidelines, TDEC, Division of Superfund, Draft, December 14, 1987.

[g] S = Calculated based on Systemic Effects

[h] C = Calculated based on Carcinogenic Effects

[i] Minimum value of PRGs presented in this table (columns to the left) to be used for screening the site on a conservative basis. When the MCLG is zero the next lowest value is used.

N/A = Not applicable

Table 3-8
Preliminary Remediation Goals (PRGs)[a] for Surface Water[b]
Defense Depot Memphis, Tennessee

	ARARs[c] Based PRGs	Risk-Based PRGs		
Chemical Name	TN State Guidance[d] (mg/L)	AWQC-HH Fish and Water[e] (mg/L)	AWQC-AQ Freshwater[f] (mg/L)	Minimum[g]
VOLATILE ORGANIC COMPOUNDS				
Acetone				
Benzene	0.005	0.0012	0.053	0.0012
Bromodichloromethane		0.00027		0.00027
Bromoform		0.0043	0.293	0.0043
Bromomethane		0.048		0.048
Carbon Disulfide	0.038			0.038
Chlorobenzene	0.488	0.68	0.195	0.195
Chloroethane				0
Chloroform	0.00019	0.0057	0.289	0.00019
Chloromethane				0
Dibromochloromethane	0.05	0.00041		0.00041
1,1-Dichloroethane				0
1,2-Dichloroethane	0.005	0.00038	2	0.00038
1,1-Dichloroethene	0.007	0.000057	0.303	0.000057
1,2-(mixed isomers) Dichloroethene				0
1,2-Dichloropropane			0.525	0.525
1,3-Dichloropropene		0.01	0.0244	0.01
Ethyl benzene	1.4	3.1	0.453	0.453
2-Hexanone				0
Methyl Ethyl Ketone				0
4-Methyl-2-Pentanone				0
Methylene Chloride	1.5	0.0047	1.93	0.0047
Styrene	70			70
1,1,2,2-Tetrachloroethane	0.0017	0.00017	0.24	0.00017
Tetrachloroethene	0.0008	0.0008	0.084	0.0008
Toluene	14.3	6.8	0.175	0.175
1,1,1-Trichloroethane	0.2		0.528	0.2
1,1,2-Trichloroethane	0.0006	0.0006	0.94	0.0006
Trichloroethene	0.005	0.0027		0.0027
Vinyl Chloride	0.002	0.002		0.002
Xylene, Mixture	2.2			2.2
cis-1,2-Dichloroethene	0.35			0.35
trans-1,2-Dichloroethene			1.35	1.35
cis-1,3-Dichloropropene			0.0244	0.0244
trans-1,3-Dichloropropene			0.0244	0.0244
SEMIVOLATILE ORGANIC COMPOUNDS				
Acenaphthene	0.02		0.017	0.017
Acenaphthylene				0
Anthracene		9.6		9.6
Benzo(A)Anthracene		0.0000028		0.0000028
Benzo(A)Pyrene		0.0000028		0.0000028
Benzo(B)Fluoranthene		0.0000028		0.0000028
Benzo(G,H,I)Perylene				0
Benzo(K)Fluoranthene		0.0000028		0.0000028
Bis(2-Chloroethoxy)Methane				0
Bis(2-Chloroethyl)Ether		0.000031	2.38	0.000031
Bis(2-Chloroisopropyl)Ether	0.0347	1.4		0.0347
Bis(2-Ethylhexyl)Phthalate	15	0.0018	< 0.0003	0.0018
Bis(Chloromethyl)Ether				0
4-Bromophenylphenylether			0.0122	0.0122
N-Butylbenzyl Phthalate			0.022	0.022
4-Chloroaniline				0
2-Chlorophenol	0.0001		0.0438	0.0001
Chrysene		0.0000028		0.0000028
Di-N-Butyl-Phthalate		2.7	0.0094	0.0094
Di-N-Octyl-Phthalate				0
Dibenz(A,H)Anthracene		0.0000028		0.0000028
Dibenzofuran				0
1,2-Dichlorobenzene	0.4	2.7	0.0158	0.0158
1,3-Dichlorobenzene	0.4	0.4	0.0502	0.0502
1,4-Dichlorobenzene	0.075	0.4	0.0112	0.0112

Table 3-8
Preliminary Remediation Goals (PRGs)^a for Surface Water^b
Defense Depot Memphis, Tennessee

Chemical Name	ARARs^c Based PRGs	Risk-Based PRGs		
	TN State Guidance^d (mg/L)	AWQC-HH Fish and Water^e (mg/L)	AWQC-AO Freshwater^f (mg/L)	Minimum^g
3,3-Dichlorobenzidine	0.00008	0.00004		0.00004
2,4-Dichlorophenol	3.09	0.093	0.0365	0.0365
Diethylphthalate	350	23	0.521	0.521
2,4-Dimethylphenol			0.53	0.53
Dimethylphthalate		313	0.33	0.33
2,4-Dinitrophenol		0.07	0.0062	0.0062
2,4-Dinitrotoluene		0.00011	0.31	0.00011
2,6-Dinitrotoluene				0
Fluoranthene		0.3	0.0398	0.0398
Fluorene		1.3		1.3
Hexachlorobenzene	0.00000072	0.00000075		0.00000072
Hexachlorobutadiene	0.00045	0.00044	0.00093	0.00044
Hexachlorocyclopentadiene	0.206	0.24	0.00007	0.00007
Hexachloroethane	0.0019	0.0019	0.0098	0.0019
Indeno(1,2,3-Cd)Pyrene		0.0000028		0.0000028
Isophorone	5.2	0.0084	1.17	0.0084
2-Methylphenol				0
4-Methylphenol				0
Naphthalene	0.025		0.062	0.025
O-Nitroaniline				0
P-Nitroaniline				0
Nitrobenzene	0.0013	0.017	0.27	0.0013
P-Nitrophenol				0
N-Nitroso-Di-N-Propylamine				0
N-Nitrosodiphenylamine	0.000049	0.005	0.0585	0.000049
Pentachlorophenol	1.01	0.00028	0.013	0.00028
Phenanthrene				0
Phenol	3.5	21	0.256	0.256
Pyrene		0.96		0.96
1,2,4-Trichlorobenzene			0.0449	0.0449
2,4,5-Trichlorophenol	2.6			2.6
2,4,6-Trichlorophenol	0.0012	0.0021	0.0032	0.0012
2-Nitrophenol			3.5	3.5
2-chloro-Napthalene				0
3-methyl-,4-chloro-Phenol				0
4-chloro-Napthalene				0
4-chloro-phenyl-Phenylether				0
2-methyl-,4,6-dinitro-Phenol			0.0023	0.0023
indeno(1,2,3-cd) Pyrene				0
	PESTICIDES			
Aldrin	0.000000074	0.00000013	0.0003	0.000000074
Chlordane	0.00000046	0.00000057	0.0000043	0.00000046
4,4'-DDD		0.00000083	0.0000064	0.00000083
4,4'-DDE		0.00000059	0.0105	0.00000059
4,4'-DDT	0.000000024	0.00000059	0.000001	0.000000024
Endosulfan			0.000056	0.000056
Endrin	0.0002	0.00076	0.0000023	0.0000023
Heptachlor	0.00000028	0.00000021	0.0000038	0.00000021
Heptachlor Epoxide		0.0000001	0.0000038	0.0000001
Lindane		0.000019	0.00008	0.000019
Methoxychlor			0.00003	0.00003
Toxaphene		0.00000073	0.0000002	0.0000002
alpha-BHC			0.5	0.5
beta-BHC			5	5
gamma-BHC			0.00008	0.00008
Endosulfan II			0.000056	0.000056
Endrin Ketone				0
Polychlorinated Biphenyls (PCBs)		0.000000044	0.000014	0.000000044

Table 3-8
Preliminary Remediation Goals (PRGs)[a] for Surface Water[b]
Defense Depot Memphis, Tennessee

	ARARs[c] Based PRGs	Risk-Based PRGs		
Chemical Name	TN State Guidance[d] (mg/L)	AWQC-HH Fish and Water[e] (mg/L)	AWQC-AO Freshwater[f] (mg/L)	Minimum[b]
	METALS			
Aluminum			0.087	0.087
Antimony	0.146	0.014	0.16	0.014
Arsenic	0.05	0.000018	0.19	0.000018
Barium	1			1
Beryllium	0.0000037		0.00053	0.0000037
Cadmium (Water)	0.01		0.0011	0.0011
Chromium	0.05		0.011	0.011
Copper	1		0.012	0.012
Cyanide		0.7	0.0052	0.0052
Iron			1	1
Lead	0.05		0.0032	0.0032
Manganese (Water)				0
Mercury	0.002	0.000144	0.000012	0.000012
Nickel, Soluble Salts	0.0134	0.61	0.16	0.0134
Selenium	0.01		0.005	0.005
Silver	0.05		0.000012	0.000012
Thallium	0.013	0.0017	0.0004	0.0004
Vanadium				0
Zinc	5		0.11	0.11

Notes:

[a] PRG = Preliminary Remediation Goal

[b] When no value is listed, no applicable ARAR was identified or no health data were available (or both).

[c] ARAR = Applicable, Relevant and Appropriate Requirements

[d] Source: Hazardous Substance Guidelines, TDEC, Division of Superfund, Draft, December 14, 1987.

[e] AWQC - HH = Federal Ambient Water Quality Criteria for the Protection of Human Health for the Ingestion of Organisms and Water

[f] AWQC - AO = Federal Ambient Water Quality Criteria, Chronic for the Protection of Freshwater Aquatic Life

Table 3-9
Preliminary Remediation Goals (PRGs)[a] for Soil[b]
Defense Depot Memphis, Tennessee

Chemical Name	Soil Risk-Based PRGs			
	Soil PRG (mg/kg)	Soil PRG Basis	Soil-GW PRGs (mg/kg)	Minimum[c]
	VOLATILE ORGANIC COMPOUNDS			
Acetone	3.89E+03	S[d]	4.02E-03	4.02E-03
Benzene	6.51E-01	C[e]	1.22E-03	1.22E-03
Bromodichloromethane	6.09E-01	C	1.04E-03	1.04E-03
Bromoform	1.20E+01	C	5.28E-03	5.28E-03
Bromomethane	5.13E+01	S		5.13E+01
Carbon Disulfide	4.38E+02	S	9.86E-02	9.86E-02
Chlorobenzene	7.06E+02	S	1.20E-01	1.20E-01
Chloroethane	N/A		N/A[f]	N/A
Chloroform	2.47E-01	C	2.16E-03	2.16E-03
Chloromethane	7.29E+00	C	1.15E-03	1.15E-03
Dibromochloromethane	1.13E+00	C	4.26E-04	4.26E-04
1,1-Dichloroethane	3.63E+03	S	5.48E-02	5.48E-02
1,2-Dichloroethane	2.04E-01	C	6.55E-05	6.55E-05
1,1-Dichloroethene	3.43E-02	C	4.61E-05	4.61E-05
1,2- (mixed isomers) Dichloroethene	3.66E+02	S	9.69E-03	9.69E-03
cis-1,2-Dichloroethene	3.44E+02	S	8.94E-03	8.94E-03
trans-1,2-Dichloroethene	7.06E+02	S	2.15E-02	2.15E-02
1,2-Dichloropropane	3.26E-01	C	3.19E-04	3.19E-04
1,3-Dichloropropene	5.27E-01	C	1.14E-04	1.14E-04
cis-1,3-Dichloropropene	N/A		N/A	N/A
trans-1,3-Dichloropropene	N/A		N/A	N/A
Ethyl benzene	4.02E+03	S	2.01E+00	2.01E+00
2-Hexanone	N/A		N/A	N/A
Methyl Ethyl Ketone	2.27E+04	S	4.93E-02	4.93E-02
4-Methyl-2-Pentanone	2.03E+03	S	9.67E-02	9.67E-02
Methylene Chloride	4.52E+00	C	5.00E-04	5.00E-04
Styrene	3.84E-02	C	4.47E-05	4.47E-05
1,1,2,2-Tetrachloroethane	2.67E-01	C	1.26E-04	1.26E-04
Tetrachloroethene	5.10E+00	C	1.52E-03	1.52E-03
Toluene	7.35E+03	S	5.48E-01	5.48E-01
1,1,1-Trichloroethane	3.51E+03	S	1.25E-01	1.25E-01
1,1,2-Trichloroethane	5.51E-01	C	2.09E-04	2.09E-04
Trichloroethene	2.77E+00	C	2.44E-03	2.44E-03
Vinyl Chloride	9.93E-03	C	6.39E-06	6.39E-06
Xylene, Mixture	7.62E+04	S	4.38E+00	4.38E+00
	SEMIVOLATILE ORGANIC COMPOUNDS			
Acenaphthene	2.43E+03	S	5.04E+00	5.04E+00
Acenaphthylene	N/A		N/A	N/A
Anthracene	1.22E+04	S	7.67E+01	7.67E+01
Benzo(A)Anthracene	1.30E-01	C	8.05E-01	1.30E-01
Benzo(A)Pyrene	1.30E-02	C	3.21E-01	1.30E-02
Benzo(B)Fluoranthene	1.30E-01	C	3.21E-01	1.30E-01
Benzo(G,H,I)Perylene	N/A		N/A	N/A
Benzo(K)Fluoranthene	5.55E+00	C	3.21E+00	3.21E+00
Bis(2-Chloroethoxy)Methane	N/A		N/A	N/A
Bis(2-Chloroethyl)Ether	6.05E-02	C	5.38E-06	5.38E-06
Bis(2-Chloroisopropyl)Ether	1.07E+00	C	3.71E-04	3.71E-04
Bis(2-Ethylhexyl)Phthalate	6.77E+00	C		6.77E+00
Bis(Chloromethyl)Ether	4.31E-04	C	2.32E-09	2.32E-09
4-Bromophenylphenylether	N/A		N/A	N/A
N-Butylbenzyl Phthalate	8.13E+03	S	6.21E+01	6.21E+01
4-Chloroaniline	1.63E+02	S		1.63E+02
2-Chlorophenol	2.03E+02	S		2.03E+02
Chrysene	5.55E+01	C	1.17E+01	1.17E+01
Di-N-Butyl-Phthalate	4.06E+03	S	5.99E+00	5.99E+00
Di-N-Octyl-Phthalate	8.13E+02	S		8.13E+02
Dibenz(A,H)Anthracene	1.30E-02	C	1.93E-01	1.30E-02
Dibenzofuran	1.63E+02	S	4.00E-01	4.00E-01
1,2-Dichlorobenzene	3.59E+03	S	2.79E+00	2.79E+00
1,3-Dichlorobenzene	3.56E+03	S	2.76E+00	2.76E+00

Table 3-9
Preliminary Remediation Goals (PRGs)[a] for Soil[b]
Defense Depot Memphis, Tennessee

Chemical Name	Soil Risk-Based PRGs Soil PRG (mg/kg)	Soil PRG Basis	Soil-GW PRGs (mg/kg)	Minimum[c]
1,4-Dichlorobenzene	2.57E+00	C	3.02E-02	3.02E-02
3,3-Dichlorobenzidine	2.11E-01	C	1.47E-03	1.47E-03
2,4-Dichlorophenol	1.22E+02	S	2.08E-02	2.08E-02
Diethylphthalate	3.25E+04	S	2.07E+00	2.07E+00
2,4-Dimethylphenol	8.13E+02	S	1.55E-01	1.55E-01
Dimethylphthalate	4.06E+03	S	2.92E+01	2.92E+01
2,4-Dinitrophenol	8.13E+01	S	6.06E-04	6.06E-04
2,4-Dinitrotoluene	1.39E-01	C	2.82E-05	2.82E-05
2,6-Dinitrotoluene	1.39E-01	C	5.76E-05	5.76E-05
Fluoranthene	1.63E+03	S	2.77E+01	2.77E+01
Fluorene	1.62E+03	S	5.33E+00	5.33E+00
Hexachlorobenzene	5.93E-02	C	1.04E-03	1.04E-03
Hexachlorobutadiene	1.22E+00	C	1.06E-01	1.06E-01
Hexachlorocyclopentadiene	2.84E+02	S	6.13E-01	6.13E-01
Hexachloroethane	6.77E+00	C	3.65E-01	3.65E-01
Indeno(1,2,3-Cd)Pyrene	5.55E-01	C	9.33E-01	5.55E-01
Isophorone	4.26E+02	C	1.39E-02	1.39E-02
2-Methylphenol	2.03E+03	S		2.03E+03
4-Methylphenol	2.03E+02	S	3.29E-02	3.29E-02
Naphthalene	1.61E+03	S	6.36E-01	6.36E-01
2-chloro-Napthalene	N/A		N/A	N/A
4-chloro-Napthalene	N/A		N/A	N/A
O-Nitroaniline	N/A		N/A	N/A
P-Nitroaniline	N/A		N/A	N/A
Nitrobenzene	2.01E+01	S	1.64E-04	1.64E-04
N-Nitrophenol	N/A		N/A	N/A
P-Nitrophenol	3.25E+02	S		3.25E+02
N-Nitroso-Di-N-Propylamine	1.35E-02	C		1.35E-02
N-Nitrosodiphenylamine	1.93E+01	C		1.93E+01
Pentachlorophenol	7.90E-01	C	9.40E-02	9.40E-02
Phenanthrene	N/A		N/A	N/A
Phenol	2.44E+04	S	7.77E-02	7.77E-02
2-methyl-,4,6-dinitro-Phenol	N/A		N/A	N/A
3-methyl-,4-chloro-Phenol	N/A		N/A	N/A
4-chloro-phenyl-Phenylether	N/A		N/A	N/A
Pyrene	1.22E+03	S	1.04E+01	1.04E+01
indeno (1,2,3-cd) Pyrene	N/A		N/A	N/A
1,2,4-Trichlorobenzene	3.97E+02	S	8.40E-01	8.40E-01
2,4,5-Trichlorophenol	3.99E+03	S	8.12E-02	8.12E-02
2,4,6-Trichlorophenol	3.68E+01	C	3.87E-02	3.87E-02
	PESTICIDES			
Aldrin	2.38E-02	C	2.40E-03	2.40E-03
alpha-BHC	N/A		N/A	N/A
beta-BHC	N/A		N/A	N/A
delta-BHC	N/A		N/A	N/A
Chlordane	7.29E-02	C	4.59E-02	4.59E-02
4,4'-DDD	3.95E-01	C	1.37E+00	3.95E-01
4,4'-DDE	2.79E-01	C	5.51E+00	2.79E-01
4,4'-DDT	2.79E-01	C	3.04E-01	2.79E-01
Endosulfan	2.44E+02	S		2.44E+02
Endosulfan II	N/A		N/A	N/A
Endrin	1.22E+01	S	1.86E-01	1.86E-01
Endrin Ketone	N/A		N/A	N/A
Heptachlor	2.11E-02	C	1.14E-03	1.14E-03
Heptachlor Epoxide	1.04E-02	C	1.03E-05	1.03E-05
Lindane	3.12E-01	C	3.54E-04	3.54E-04
Methoxychlor	2.03E+02	S	9.13E+00	9.13E+00
Toxaphene	8.62E-02	C	1.87E-04	1.87E-04
Polychlorinated Biphenyls (PCBs)	1.23E-02	C		1.23E-02

Table 3-9
Preliminary Remediation Goals (PRGs)[a] for Soil[b]
Defense Depot Memphis, Tennessee

Chemical Name	Soil Risk-Based PRGs Soil PRG (mg/kg)	 Soil PRG Basis	 Soil-GW PRGs (mg/kg)	Minimum[g]
		METALS		
Aluminum	N/A		N/A	N/A
Antimony	6.94E+01	S		6.94E+01
Arsenic	2.31E-01	C	8.76E-04	8.76E-04
Barium	1.22E+04	S		1.22E+04
Beryllium	2.20E-02	C		2.20E-02
Cadmium (Food)	1.74E+02	S		1.74E+02
Chromium (Hexavalent)	8.68E+02	S	3.29E+01	3.29E+01
Copper	6.42E+03	S	4.50E+01	4.50E+01
Cyanide	3.47E+03	S		3.47E+03
Iron	N/A		N/A	N/A
Lead	N/A		N/A	N/A
Manganese (Water)	8.68E+02	S	1.83E+02	1.83E+02
Mercury	5.21E+01	S		5.21E+01
Nickel, Soluble Salts	3.47E+03	S		3.47E+03
Selenium	8.68E+02	S	7.85E-02	7.85E-02
Silver	8.68E+02	S	9.13E+00	9.13E+00
Thallium	N/A		N/A	N/A
Vanadium	1.22E+03	S		1.22E+03
Zinc	5.21E+04	S		5.21E+04

Notes:

[a] PRG = Preliminary Remediation Goal

[b] When no value is listed, no applicable ARAR was identified or no health data were available (or both).

[c] ARARs = Applicable, Relevant and Appropriate Requirements

[d] S = Calculated based on Systemic Effects

[e] C = Calculated based on Carcinogenic Effects

[f] N/A = No toxicity value available for calculations

[g] Minimum value of PRGs presented in this table (column to left) to be used for screening the site on a conservative basis.

Table 3-10

Preliminary Remediation Goals (PRGs)[a] for Sediment
Defense Depot Memphis, Tennessee

	Sediment PRGs (mg/kg)		
Chemical Name	Protection of Aquatic Life[b]	NOAA ER-L[c]	Minimum[d]
VOLATILE ORGANIC COMPOUNDS			
Acetone	-	-	-
Benzene	-	-	-
Bromodichloromethane	-	-	-
Bromoform	-	-	-
Bromomethane	-	-	-
Carbon Disulfide	-	-	-
Chlorobenzene	-	-	-
Chloroethane	-	-	-
Chloroform	-	-	-
Chloromethane	-	-	-
Dibromochloromethane	-	-	-
1,1-Dichloroethane	-	-	-
1,2-Dichloroethane	-	-	-
1,1-Dichloroethene	-	-	-
1,2- (mixed isomers) Dichloroethene	-	-	-
1,2-Dichloropropane	-	-	-
1,3-Dichloropropene	-	-	-
Ethyl benzene	-	-	-
2-Hexanone	-	-	-
Methyl Ethyl Ketone	-	-	-
4-Methyl-2-Pentanone	-	-	-
Methylene Chloride	-	-	-
Styrene	-	-	-
1,1,2,2-Tetrachloroethane	-	-	-
Tetrachloroethene	-	-	-
Toluene	-	-	-
1,1,1-Trichloroethane	-	-	-
1,1,2-Trichloroethane	-	-	-
Trichloroethene	-	-	-
Vinyl Chloride	-	-	-
Xylene, Mixture	-	-	-
cis-1,2-Dichloroethene	-	-	-
trans-1,2-Dichloroethene	-	-	-
cis-1,3-Dichloropropene	-	-	-
trans-1,3-Dichloropropene	-	-	-
SEMIVOLATILE ORGANIC COMPOUNDS			
Acenaphthene	0.022	0.15	0.022
Acenaphthylene	-	-	-
Anthracene	0.085	0.085	0.085
Benzo(A)Anthracene	0.16	0.23	0.16
Benzo(A)Pyrene	0.23	0.4	0.23
Benzo(B)Fluoranthene	-	-	-
Benzo(G,H,I)Perylene	-	-	-
Benzo(K)Fluoranthene	-	-	-
Bis(2-Chloroethoxy)Methane	-	-	-
Bis(2-Chloroethyl)Ether	-	-	-
Bis(2-Chloroisopropyl)Ether	-	-	-
Bis(2-Ethylhexyl)Phthalate	-	-	-
Bis(Chloromethyl)Ether	-	-	-
4-Bromophenylphenylether	-	-	-
N-Butylbenzyl Phthalate	-	-	-
4-Chloroaniline	-	-	-
2-Chlorophenol	-	-	-
Chrysene	0.22	0.4	0.22
Di-N-Butyl-Phthalate	-	-	-
Di-N-Octyl-Phthalate	-	-	-
Dibenz(A,H)Anthracene	0.031	0.06	0.031
Dibenzofuran	-	-	-
1,2-Dichlorobenzene	-	-	-
1,3-Dichlorobenzene	-	-	-
1,4-Dichlorobenzene	-	-	-

Table 3-10

Preliminary Remediation Goals (PRGs)^a for Sediment
Defense Depot Memphis, Tennessee

Chemical Name	Sediment PRGs (mg/kg) Protection of Aquatic Life^b	NOAA ER-L^c	Minimum^d
3,3-Dichlorobenzidine	-	-	-
2,4-Dichlorophenol	-	-	-
Diethylphthalate	-	-	-
2,4-Dimethylphenol	-	-	-
Dimethylphthalate	-	-	-
2,4-Dinitrophenol	-	-	-
2,4-Dinitrotoluene	-	-	-
2,6-Dinitrotoluene	-	-	-
Fluoranthene	0.38	0.6	0.38
Fluorene	0.018	0.035	0.018
Hexachlorobenzene	-	-	-
Hexachlorobutadiene	-	-	-
Hexachlorocyclopentadiene	-	-	-
Hexachloroethane	-	-	-
Indeno(1,2,3-Cd)Pyrene	-	-	-
Isophorone	-	-	-
2-Methylphenol	-	-	-
4-Methylphenol	-	-	-
Naphthalene	0.13	0.34	0.13
O-Nitroaniline	-	-	-
P-Nitroaniline	-	-	-
Nitrobenzene	-	-	-
P-Nitrophenol	-	-	-
N-Nitroso-Di-N-Propylamine	-	-	-
N-Nitrosodiphenylamine	-	-	-
Pentachlorophenol	-	-	-
Phenanthrene	0.14	0.225	0.14
Phenol	-	-	-
Pyrene	0.29	-	0.29
1,2,4-Trichlorobenzene	-	-	-
2,4,5-Trichlorophenol	-	-	-
2,4,6-Trichlorophenol	-	-	-
2-Nitrophenol	-	-	-
2-chloro-Napthalene	-	-	-
3-methyl-,4-chloro-Phenol	-	-	-
4-chloro-Napthalene	-	-	-
4-chloro--phenyl-Phenylether	-	-	-
2-methyl-,4,6-dinitro-Phenol	-	-	-
indeno (1,2,3-cd) Pyrene	-	-	-
PESTICIDES			
Aldrin	-	-	-
Chlordane	-	0.0005	0.0005
4,4'-DDD	-	0.002	0.002
4,4'-DDE	0.0017	0.002	0.0017
4,4'-DDT	-	0.001	0.001
Endosulfan	-	-	-
Endrin	-	0.00002	0.00002
Heptachlor	-	-	-
Heptachlor Epoxide	-	-	-
Lindane	-	-	-
Methoxychlor	-	-	-
Toxaphene	-	-	-
alpha-BHC	-	-	-
beta-BHC	-	-	-
delta-BHC	-	-	-
Endosulfan II	-	-	-
Endrin Ketone	-	-	-
Polychlorinated Biphenyls (PCBs)	0.24	0.5	0.24

Table 3-10
Preliminary Remediation Goals (PRGs)[a] for Sediment
Defense Depot Memphis, Tennessee

Chemical Name	Sediment PRGs (mg/kg) Protection of Aquatic Life[b]	NOAA ER-L[c]	Minimum[d]
METALS			
Aluminum	-	-	-
Antimony	-	2	2
Arsenic	8	3.3	3.3
Barium	-	-	-
Beryllium	-	-	-
Cadmium (Water)	1	5	1
Chromium	33	80	33
Copper	28	70	28
Cyanide	-	-	-
Iron	-	-	-
Lead	21	35	21
Manganese (Water)	-	-	-
Mercury	0.1	0.15	0.1
Nickel, Soluble Salts	-	30	30
Selenium	-	-	-
Silver	0.5	1	0.5
Thallium	-	-	-
Vanadium	-	-	-
Zinc	68	120	68

[a] PRG = Preliminary Remediation Goal

[b] No ARARs available for sediment; PRGs adopted from Florida Coastal Sediment Criteria (No Observed Effect Level [NOEL])

[c] NOAA ER-L = National Oceanic and Atmospheric Administration

[d] Minimum value of PRGs presented in this table (column to left) to be used for screening the site on a conservative basis.

- Estimate of potential effect for the soil to groundwater pathway
- Use of 10 percent of the PRG estimate as criteria for noncarcinogenic compounds, to address the potential presence of multiple chemicals
- Including the dermal exposure pathway for surface soil contact in the PRG equation.

In all cases, the approach is conservative, because the initial intended use of these values is for screening sites. The screening values are estimated or identified for the TCL/TAL compounds, and additions or modifications will be made as additional data become available.

In addition to screening PRGs, other chemical concentration-based levels are of potential concern and will be developed as the investigations proceed. Early removal actions are one of the primary objectives of the screening process. Two of the evaluation criteria for early removal sites are toxicity and relative mobility. As a guide to decisions for early removal actions, alternate criteria will be developed for the screening sites to identify Removal Action Levels (RALs). DDMT will negotiate RALs for each contaminants of concern (COC) to facilitate decisions on early removal before starting the field screening activities.

Remedial goal options (RGOs), consistent with EPA Region IV guidance, will be developed during the RI process and will provide a more realistic basis for the development of final remediation levels (FRLs).

3.5.2.1 Groundwater Media

Risk-based and ARARs-based PRGs for screening groundwater are shown in Table 3-7. For cleaning up groundwater that may be used for drinking, 40 CFR Section 300.430 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) states that maximum contaminant level goals (MCLGs), established under the Safe Drinking Water Act (SDWA), that are set at concentrations above zero shall be attained if relevant and appropriate to the circumstances of the release. Where the MCLG for a contaminant has been set at a concentration of zero, the MCL promulgated for that contaminant under the SDWA shall be attained. MCLGs and MCLs are relevant and appropriate as cleanup levels for groundwater that is a current or a potential source of drinking water. The only exception to the above is that the cleanup value for lead in groundwater used for drinking is not its MCL. In an EPA memorandum from Henry Longest, director of the Office of Enforcement and Remedial Response (OERR), to Patrick Tobin, director of Waste Management Division, Region IV, dated June 21, 1990, Mr. Longest recommended a final action level for lead of 15 parts per billion (ppb). The State of Tennessee groundwater and surface water guidance concentrations as presented in Tables 3-7 and 3-8 mix standards applicable to each of these media. Additional definitions of state standards and guidance concentrations will be presented as the site chemicals are identified.

Risk-based levels for domestic (residential) potable water use assume that humans are exposed via the direct ingestion of contaminants as well as the inhalation of volatile constituents during activities such as showering and dishwashing. The groundwater screening levels were calculated by assuming that the exposure from inhalation is approximately equal to the exposure from ingestion (for volatiles with a Henry's constant $< 1X10^{-5}$ and molecular weight of < 200), and applying the RAGS Part B methodology for estimating a PRG for ingestion of potable water with a consumption rate of 4 liters per day (L/day) for volatile compounds and 2 L/day for other chemicals. Consistent with this guidance, exposure is assumed for 350 days per year for a 30-year exposure period.

No ecological receptors are identified for groundwater, and no current potable use of shallow groundwater onsite was present.

3.5.2.2 Surface Water Media

Risk-based and ARARs-based screening concentrations for surface water are shown in Table 3-8. For cleaning up non-drinking surface waters where there are effects on aquatic organisms, the remedial action will attain, where relevant and appropriate, the Federal Aquatic Water Quality Criteria or the State of Tennessee's water criteria, whichever is the most stringent. Water Quality Criteria may be considered as relevant and appropriate when 1) the protection of aquatic life is a concern, and 2) human exposure from consumption of contaminated fish is a concern. A possible exposure point for residents living in the vicinity of DDMT is from the surface runoff traveling in the city's aboveground, open-storm canals and creeks.

The surface water bodies at DDMT are not used for potable water supply. The screening surface water PRGs include the State of Tennessee's water criteria and the federal Ambient Water Quality Criteria (AWQC) for surface water are based on protection of aquatic life and protection of human health from the ingestion of both water and fish.

The protection of freshwater aquatic life is evaluated based on chronic criteria that is protective of most organisms. If no AWQC is available, a no observed effects level (NOEL) or lowest observed effects level (LOEL) may be used for preliminary consideration; also, criteria have been proposed for screening by EPA Region IV. AWQC for the protection of human health for the ingestion of aquatic organisms and water is more conservative than the assumption of fish ingestion only, because it assumes that surface water will be consumed along with the dietary intake of fish and other freshwater organisms. This is a conservative application at this site. In most cases, the aquatic life criteria is substantially lower than the corresponding human health criteria.

3.5.2.3 Soil

The ARAR-based and risk-based PRGs for screening soil concentrations are summarized in Table 3-9. The EPA has identified an action level for PCBs that is dependent on the types of exposure that will occur because of land use, such as current or future residential or industrial. The EPA-recommended soil action levels are 1 part per million (ppm) for residential land use and 10 to 25 ppm for industrial land use. These guidelines are presented in the EPA document *Guidance on Remedial Actions for Superfund Sites with PCB Contamination*, Office of Solid Waste and Emergency Response (OSWER) Directive 9355.4-01. In a memorandum dated September 7, 1989, from Henry Longest to the Waste Management Division Directors in EPA Regions I through X, Mr. Longest proposed an interim soil cleanup level for total lead at 500 to 1,000 ppm. On August 6, 1993, EPA Region IX published a technical memorandum identifying PRGs for soils on the basis of standard exposure assumptions. PRGs for most of DDMT Preliminary Contaminants of Concern (COCs) have been provided in Table 3-9. The final remediation goals for all COCs will be based on the BRAs performed for each OU.

Soil PRGs are the most difficult media to estimate PRGs because of potentially multiple pathways and receptors. Because this is an industrial area with no sensitive terrestrial habitats, PRGs estimated for protection of human health would be considered protective of ecological receptors. EPA has issued draft soil screening level guidance that focus on three pathways of exposure as follows:

- Ingestion of soil
- Inhalation of volatiles and fugitive dusts
- Migration of contaminants through soil to an underlying potable aquifer

When risk assessments are performed, dermal absorption frequently contributes significantly to the risks for many chemicals. There are greater uncertainties in the estimation of exposure because of dermal absorption; however, the risk-based soil PRGs derived for DDMT include contribution from this exposure route in addition to the ingestion and inhalation.

Surface Soil Exposure. Frequently, only the risk from soil ingestion is considered in the determination of residential soil action levels (RCRA Action Levels or RAGS Part B PRGs for residential soil). However, in a typical BRA, exposures to surface soil may include ingestion, inhalation, and dermal absorption routes of exposure. Therefore, risk-based PRGs for DDMT were derived assuming that dermal absorption also occurs. For ingestion and inhalation, RAGS Part B methodology was followed in deriving the screening levels, with the inhalation calculation being adjusted to reflect the residential exposure scenario. As with groundwater consumption, inhalation is a significant pathway for soils only for chemicals with substantial volatility.

Soil-to-Groundwater Pathway. The screening PRG for this pathway is a simple estimation of equilibrium conditions between soil and groundwater and maintaining the water concentration below potable risk-based standards. Calculations were carried out using the residential groundwater screening level in the following equation (assuming no dilution of groundwater):

$$PRG = Koc \times Foc \times Cw$$

where

Koc = Organic carbon partition coefficient (parameter specific)
Foc = Fraction organic carbon (assumed 0.005)
Cw = Screening risk-based groundwater concentration
PRG = Soil screening concentration protective of groundwater

3.5.2.4 Sediment

Guidance concentrations for sediment screening are shown in Table 3-10. Direct human exposure to contaminated sediments frequently is limited. For shallow drainage ways, child exposures may be similar to estimates for surface soils. Sediments pose risks to both the surface water ecosystem and to humans, typically because of toxicity or bioconcentration as chemicals are released to the overlying surface water body.

Sediment standards have not been promulgated. Many factors affect the availability and toxicity of chemicals in sediments, and elevated levels may not pose similar threats in different locations. For purposes of screening, studies of potential effects of some chemicals in sediments have been evaluated. Specific freshwater sediment criteria are not available. Sediment screening criteria proposed for use as screening PRGs were adopted from the Florida Marine sediment guidance documents as recommended by EPA Region IV. The No Observed Adverse Effects Levels (NOAELs) are proposed. If exceedances occur, further evaluation may include use of the permissible exposure level (PEL).

Values are presented for only a selected subset of chemicals where guidance concentrations have been proposed. Other approaches (for example, assuming equilibrium of the sediment with water and maintaining protective levels in surface water) could be estimated as required for specific chemicals.

3.5.3 Action-specific ARARs

Action-specific ARARs usually are technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes, or requirements to conduct certain actions to address particular circumstances at a site. Remedial alternatives that involve, for example, closure or discharge of dredged or fill material may be subject to ARARs under RCRA and the Clean Water Act, respectively.

3.5.3.1 Groundwater and Surface Water Media

The remediation of groundwater using pump-and-treat techniques would require the discharge of the treated water to surface waters, to a Publicly Owned Treatment Works (POTW), or into the same formation from which it was withdrawn.

Both onsite and offsite direct discharges from CERCLA sites to surface waters are required to meet the substantive requirements of NPDES. These substantive requirements include discharge limitations (both technology- and water quality-based), certain monitoring requirements, and best management practices. These requirements will be contained in a NPDES permit for offsite CERCLA discharges. For an onsite discharge from a CERCLA site, these substantive requirements must be identified and complied with, even though onsite discharges are not required to have an NPDES permit. The discharge of CERCLA wastewater to POTW's is considered an offsite activity. However, the discharge of a CERCLA wastewater onsite to a receiving water body (either perennial or ephemeral) in close proximity to the area of contamination is considered an onsite discharge, even if the water body eventually flows offsite (ref. 64). An NPDES permit will be obtained if necessary, and proper treatment facilities will be provided if required.

The NPDES program establishes administrative requirements that must be complied with both before and after permit issuance. These requirements would not be considered ARARs for onsite direct discharges to surface waters because they are administrative in nature. However, there would be requirements to be complied with in the NPDES permitting process for offsite direct discharges to a POTW. These NPDES administrative requirements include the following:

- Certification: The CWA 401 requires that any applicant for a federal license or permit to conduct an operation that may result in any discharge to navigable waters shall provide to the licensing/permitting agency a certification from the State that the discharge will comply with applicable provisions of CWA 301, 302, 303, 306, and 307.

- Permit Application Requirements: NPDES regulations (40 CFR 122.29) require that applications for permits for a new discharge must be made within 180 days before discharges actually begin.

- Reporting Requirements: The NPDES permit program requires dischargers to maintain records and to report periodically on the amount and nature of pollutants in the wastewaters discharged (40 CFR 122.44(i) and 122.48).

- Public Participation: NPDES discharge limitations and requirements developed for a CERCLA site are subject to public participation requirements in 40 CFR 124.10, including public notices and public comment.

The operation and construction of Class IV wells, as defined in the Underground Injection Control (UIC) program, is prohibited unless the wells are used to reinject treated groundwater into the same formation from which it was withdrawn as part of a CERCLA cleanup or an RCRA corrective action (40 CFR 144.13[d]). The UIC program defines Class IV wells as those used to inject hazardous waste or radioactive waste into or above a formation that, within 1/4 mile of the well, contains an underground drinking water source.

Underground injection wells that are constructed offsite are subject to all provisions of the SDWA relating to underground injection of fluids, and must be permitted by an authorized state agency or EPA and must comply with the UIC permit requirements. Superfund sites that construct underground injection wells onsite are not required to comply with the administrative requirements of the UIC program; however, they must meet the substantive requirements of this program where the requirement is determined to be applicable or relevant and appropriate to the CERCLA remedial action.

3.5.3.2 Sediment and Soil Media

Remediation of Lake Danielson and the Golf Course Pond by the dredging of sediments may require a local permit, an Aquatic Resources Alteration Permit, or both. The dredging of these two ponds need not comply with Section 10.0 of the Rivers and Harbor Act, because neither Lake Danielson nor the Golf Course Pond are navigable waters (the Rivers and Harbors Act prohibits the unauthorized obstruction or alteration of any navigable water of the United States. Navigable waters of the United States are defined as waters that are subject to the ebb and flow of the tide shoreward to the mean high water mark, or are now used, have been used in the past or may be susceptible to use to transport interstate or foreign commerce. Examples of use include dredging, filling, installation of pilings, and construction of structures such as berms, levees, coffer dams, and piers). To determine if the sediments are to be disposed into a hazardous or solid waste landfill, a toxicity characteristic leaching procedure (TCLP) test will need to be conducted on a small number of sediment samples collected from these two water bodies.

The excavation, onsite solidification, and placement of soil and debris that contains RCRA restricted waste may trigger the RCRA land disposal restrictions (LDRs). In general, RCRA's LDRs were established for waste streams that differ significantly from Superfund wastes. Because the LDRs are not based on treating wastes that contain soil and debris, a treatability variance may be appropriate. Under a treatability variance, alternative treatment levels based on data from actual treatment of soil, or best management practices for debris, become the "treatment standard" that must be met.

The excavation and offsite treatment of soil and debris that contains a RCRA hazardous waste must comply with transporter regulations under 40 CFR Part 263 (Subtitle C). A transporter under Subtitle C is defined as any person engaged in offsite transportation of hazardous waste within the United States. Such transportation requires a manifest under 40 CFR Part 262.

The capping of onsite sites may need to comply with RCRA Subtitle C landfill closure requirements. Subtitle C landfill closures require post-closure care and maintenance of the unit for at least 30 years. The landfill unit must be capped with a final cover designed and constructed to accomplish the following:

- Provide long-term minimization of migration of liquids
- Function with minimum maintenance
- Promote drainage and minimize erosion
- Accommodate settling and subsidence
- Have a permeability less than or equal to any bottom liner system or natural subsoils present

Post-closure care includes maintenance of the final cover and maintenance of a groundwater monitoring system in accordance with 40 CFR Parts 264.117 and 264.310(b) and with 264 Subpart F.

The capping of onsite surface impoundments in accordance with RCRA Subtitle D is similar to the requirements described above, except that a 5-foot-thick soil cap would be placed over the disposal cell rather than a RCRA cap. Post-closure care requirements would be the same as those described previously.

3.5.3.3 Air Media

The remediation of groundwater by pump-and-treat techniques may cause the emission of VOCs into the atmosphere. Before groundwater remediation activities begin, coordination with Shelby County air quality regulators should be done to determine if the quantity of VOCs emitted into the atmosphere needs to be reduced to comply with National Ambient Air Quality Standards (NAAQS) regulations for use of best available technology (BAT) to reduce emissions.

3.5.4 Location-specific ARARs

Location-specific ARARs generally are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in special locations. Some examples of special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats. Discussions with TDEC, Division of Solid Waste Management, have indicated that the State is not aware of any natural resources for which it acts as a trustee that are potentially threatened or damaged as a result of past or current waste disposal practices conducted at DDMT. Furthermore, a search for possible location-specific ARARs was conducted during the RI (ref. 18), and no federal, state, or local natural resources were found to be near the site. Before the completion of the final RI/FS report(s), a CERCLA 104B.2 Notification Form will be submitted to the Department of Interior (DOI) by DDMT to determine if the DOI is a trustee of any natural resources that may be threatened by a release of hazardous substances from the site.

3.6 Risk-based PRGs

The PRGs developed for use in DDMT work plans are designed to be protective using conservative assumptions. In this way, they may be used for screening sites where a focused investigation is conducted to select locations that represent "worst-case conditions," and decision makers can be confident that chemicals reported below these concentrations would result in unacceptable risks at the site after a baseline risk assessment. For risk-based PRGs, the following general assumptions are used:

> Residential Land Use
> Target Risk Level (TRL) of 10-6; Target Hazard Index (THI) of 0.1

The current land use is industrial, and many areas of the facility are located where worker exposures would be relatively infrequent. Risk estimates based on the TRL of 10-6 or THI of 0.1 would be protective if several chemicals were present below the specified concentrations. However, under conditions where 10 or more chemicals were reported, additional review would be required.

Many of the chemicals have only toxicity values for oral pathways, but not for inhalation. According to RAGs Part B guidance, the inhalation pathway would not be included in the derivation of the target concentration when the specific inhalation toxicity value was not available. However, consistent with the more conservative approach recommended by Region III, when the inhalation value was not available, the oral toxicity factor was used to estimate the contribution from this pathway.

The facility is an urban/industrial setting with no identified sensitive habitats. Potential ecological effects are evaluated for surface water bodies or drainage systems where higher ecological exposures may occur and values protective of human health may not be sufficiently protective.

The risk-based PRG concentration tables presented in Section 3.5 were based on several specific conservative assumptions. The values and terms in Table 3-11 were used to calculate the risk-based PRGs.

3.6.1 Groundwater PRGs

I. Residential Scenario

A. Carcinogens: groundwater concentration (mg/L) =

$$\frac{TR*BW*AT*365\ days/year}{SFo*IRw*EF*ED}$$

Table 3-11
Conservative Assumptions for Screening Values
Defense Depot Memphis, Tennessee

Exposure Values	Value	Name
Carcinogenic potency slope factor, oral (1/mg/kg-day)	*	SFo
Carcinogenic potency slope factor, inhalation (1/mg/kg-day)	*	SFi
Reference dose, oral (mg/kg/day)	*	RfDo
Reference dose, inhalation (mg/kg/day)	*	RfDi
Target cancer risk	1E-6	TR
Target hazard quotient	0.1	THQ
Body weight, adult (kg)	70	BW
Averaging time, carcinogens (years)	70	AT
Averaging time systemic toxicants (years)	30	AT
Soil ingestion factor, age adjusted (mg-year/kg-day)	114.29	IRSadj
Inhalation rate, age adjusted (m^3-year/kg-day)	11.66	IRIadj
Dermal contact rate, age adjusted (mg-year/kg-day)	655 (organics) 65 (metals)	IRDadj
Tap water ingestion rate, (L/day)	2	IRW
Exposure frequency (days/year)	350	EF
Averaging time systemic toxicants (year)	70	AT
Exposure duration (years)	30	ED
Volatilization factor (m^3/kg)	*	VF
Particulate Emission factor (m^3/kg)	4.63E+9	PEF
Organic carbon partition coefficient (mL/g)	*	Koc
Fraction organic carbon (site specific)	0.005	*foc*

Note: * chemical-specific

B. Systemic Toxicants

$$\frac{THQ*AT*BW*365\ day/year}{1/RfDo*IRw*EF*ED}$$

3.6.2 Soil PRGs

I. Residential Scenario: Direct Contact - Soil concentration (mg/kg) =

A. Carcinogens

$$\frac{TR*AT*365\ day/year}{EF*\{[SFo*(IRDadj+IRIadj)*10E-6]+[SFi*IRAadj*(1/VF+1/PEF)]\}}$$

B. Systemic Toxicants

$$\frac{THQ*AT*365\ day/year}{EF*\{[1/RfDo*(IRDadj/1E6+IRIadj/1E6)]+[RfDi*(IRAadj*(1/VF+1/PEF))]\}}$$

II. Soil to Groundwater Pathway:

Soil concentration (mg/kg) = Groundwater PRG (mg/L) * Koc * *foc*

3.7 Generic Conceptual Site Model

A conceptual model of DDMT environment will aid in planning the RI activities. This model considers the potential sources of contamination and the pathways for migration and exposure leading to human and environmental receptors in the site vicinity.

The potential sources of contaminants at DDMT can be geographically divided into activities within the Main Installation and activities in Dunn Field. At the Main Installation, potential sources include storage of petroleum, oils, and lubricants (POL); storage of hazardous materials (oxidizers, corrosives, reactives, and solvents); storage of excess property items (DRMO); metal cleaning and painting activities; vehicle maintenance operations; a wood treating operation (dismantled and remediated in 1985); past storage of PCB-containing transformers; and use of herbicides and pesticides around the installation. At Dunn Field, the potential sources include burial sites for past waste materials, burn sites for wastes, and a former pistol range area. There is a potential for contaminants to have been released from these activities through normal operations, or through spills and leaks onto soils or into routes of surface drainage.

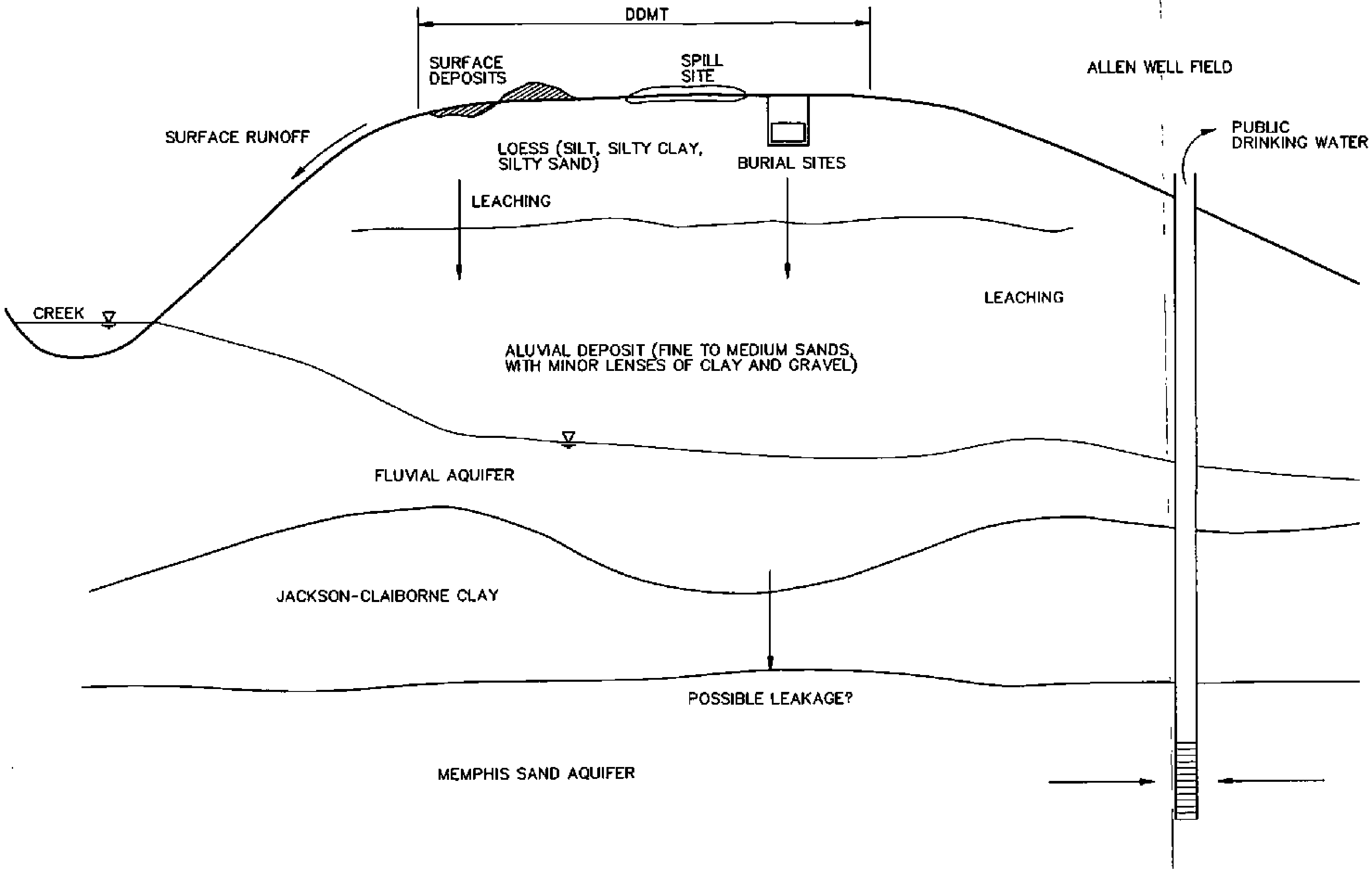
The exposure pathways associated with DDMT include ingestion, inhalation, and dermal absorption of contaminants present in surface soils, groundwater, or surface water. A cross-sectional view of DDMT vicinity (Figure 3-7) illustrates some of these pathways and exposure routes. The three principal pathways are summarized below.

First, contaminated soils at the surface provide opportunities for dermal contact, inhalation of dust, or ingestion of dirt or dusts by humans working at DDMT or wildlife within the installation boundaries (and subsequent human ingestion of wildlife). Skin contact with contaminated soils could lead to dermal absorption of contaminants. Contaminated surface soils in unpaved or unvegetated areas could become entrained in the atmosphere and subsequently lead to inhalation of contaminants. Ingestion of these contaminants could occur from soils deposited on hands after activities in these areas. This pathway is potentially present at locations in all four OUs (OUs-1, 2, 3 and 4).

Surface soil contamination has been found in various locations during the RI (ref. 18). At Dunn Field (OU-1), pesticides and PAHs were detected at the burn site and the pistol range. In the southwestern quadrant of the Main Installation (OU-2), PAHs and metals were detected along with pesticides and PCBs. In the southeastern watershed (OU-3), PAHs, pesticides, PCBs, and metals were detected near Building T-273 (formerly used for pesticide storage). In the north-central area (OU-4), PAHs, pesticides, metals, and some VOCs were detected near the former hazardous materials storage area (Building 629).

The significance of many of the soil analyses during the RI (ref. 18), particularly for metals and PAHs, cannot be determined until more is known about background concentrations. Soil samples taken during the RI (ref. 18) are from locations within DDMT that may have received contamination from past activities. Background conditions in DDMT environment will be hard to determine because of the urban setting and the possibility of encountering previously unsuspected contamination. For this reason, offsite locations will be desirable to define background conditions. Furthermore, several samples are needed in the background group to minimize the influence of unknown contamination.

Second, the leaching of waste constituents from sites in Dunn Field (OU-1) or spill sites (OUs-2, 3, and 4) can transport these constituents into the shallow aquifer beneath DDMT. This aquifer, known as the Fluvial Aquifer, is found at the bottom of fluvial deposits of fine to medium sand that underlie the region. These deposits and the associated aquifer lie on top of a low-permeability clay layer known as the Jackson Formation/Upper Claiborne Group. Below the Jackson Formation/Upper Claiborne Group lie the Memphis Sand deposits and the Memphis Sand Aquifer, which serves as the drinking water supply for the Memphis metropolitan area. DDMT is located east



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Source: CEHND, 1994

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FIGURE 3-7
CROSS SECTIONAL VIEW CONCEPTUAL SITE MODEL
Defense Depot Memphis, Tennessee

(upgradient) of the Allen Well Field, which is one of many wellfields operated by the MLGW for public water supply. The Allen Well Field draws water from the Memphis Sand Aquifer.

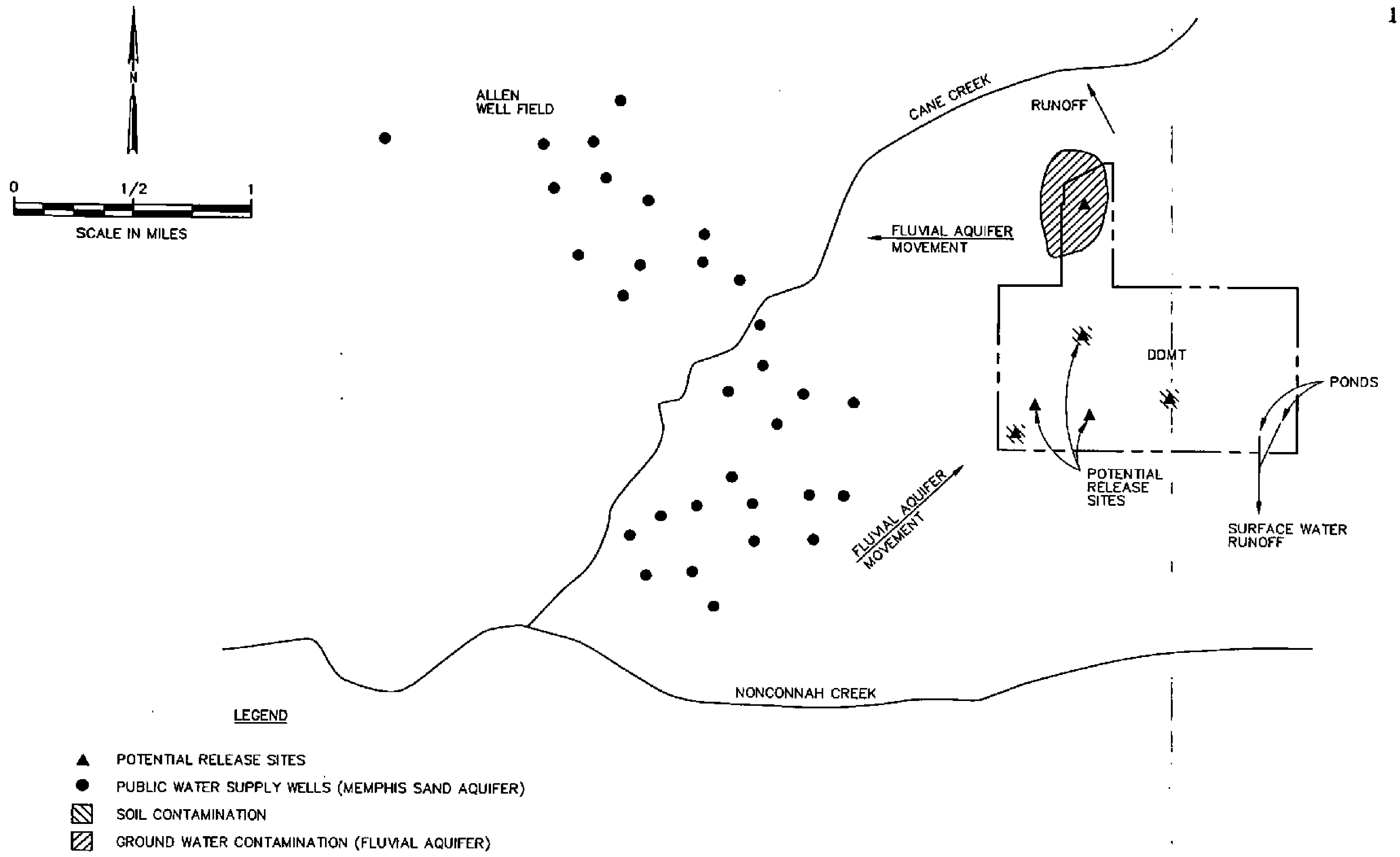
The Fluvial Aquifer has been found to occupy the bottom 10 to 20 ft of the fluvial deposits in monitor wells in DDMT vicinity. The elevation of the aquifer appears to follow the elevation of the underlying Jackson Formation/Upper Claiborne Group. The Jackson Formation/Upper Claiborne Group provides the base for the Fluvial Aquifer and confines the underlying Memphis Sand Aquifer. The thickness of the Jackson Formation/ Upper Claiborne Group varies across the region and is reported to thin out at scattered sites. These sites, which have been occasionally discovered by drillers in the Memphis region, may provide a pathway between the Fluvial and Memphis Sand Aquifers. If such an interconnection occurs in DDMT area, then a groundwater pathway could transport waste constituents westerly into the public drinking water supply.

Future data collection should include water level monitoring of well pairs completed in both units. A pump test of the Memphis Sand should be accompanied by an intense water level monitoring effort in both the Memphis Sand (to gather data on hydraulic conductivity and transmissivity of the Memphis Sand) and also in the Fluvial Aquifer (specifically to assess the influence of water levels of the overlying unit and to evaluate the nature of the clay confining bed). These data could be combined with the geotechnical data planned to be collected on the hydraulic conductivity of the confining clay unit to assess the degree, if any, of hydraulic interconnection between the two units.

A potential zone for aquifer interconnection was discovered during the RI (ref. 18). An area in the north-central part of the Main Installation (OU-4) was found to exhibit sands and interbedded clays more than 100 ft below the land surface. Two monitoring wells installed in this area (MW-18 and MW-27) were originally thought to penetrate the Fluvial Aquifer, but ultimately have proven to be dry. Stratigraphic test boring STB-8 encountered clay lenses within sandy fluvial deposits as deep as 150 ft below the surface. Static water levels in the Fluvial Aquifer (measured at MW-34, 38, and 39) suggest a depression in the Fluvial Aquifer water table. This area needs further study during the OU-4 investigation activities.

Potential contaminants of concern have been found in monitoring wells screened in the Fluvial Aquifer beneath Dunn Field (OU-1) and the southwestern corner (OU-2). These same contaminants have not been found in the Memphis Sand Aquifer beneath DDMT. A plan view of the conceptual model (Figure 3-8) at DDMT illustrates the direction of movement in the Fluvial Aquifer and the zone of groundwater contamination discovered during the RI (ref. 18).

The third pathway in the conceptual model involves surface runoff from areas of spills or releases (OUs-1, 2, 3 and 4). This runoff collects in drainage channels that lead off government property, creating a potential for dermal absorption of contaminants during wading or swimming. Aquatic species could also potentially ingest contaminants and accumulate contaminants in tissues. Both terrestrial and aquatic wildlife can ingest



Source: CEHND, 1994

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FIGURE 3-8
PLAN VIEW CONCEPTUAL SITE MODEL
Defense Depot Memphis, Tennessee

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contaminants by drinking surface waters or eating other species with contaminated tissues. This pathway includes fishermen that ingest aquatic species taken from surface water bodies in DDMT vicinity. Contaminants have been found in sediments from both the Golf Course Pond and Lake Danielson (OU-3). The plan view (Figure 3-8) illustrates the surface runoff pathways from DDMT toward Cane Creek to the north and Nonconnah Creek to the south.

Potential human receptors in DDMT vicinity include the following:

- Employees of DDMT
- Residents and neighbors of DDMT
- Residents of Memphis
- Fishermen and recreational users ("waders") of surface waters, including Cane Creek and Nonconnah Creek

Even though the potential for exposure to contaminants exists, the health risk assessment conducted by the Agency for Toxic Substance and Disease Registry (ATSDR) concluded that no apparent public health hazards existed for groundwater, surface water, sediment, air, and soil. ATSDR came to this conclusion by comparing potentials for exposure and levels of contaminants identified at DDMT, and whether there would be any harmful effects from these levels. As DDMT continues investigating potential sources of contamination and more information becomes available, ATSDR will update the health risk assessment of DDMT.

3.8 Data Gaps

Table 3-12 attempts to summarize the data gaps from previous studies for all OUs (facilitywide data gaps) and OU-specific data gaps that will be addressed in OU-specific FSPs. Data gaps appropriate to be filled during the Screening Sites investigation also are identified.

Table 3-12
Data Gaps from Previous Studies at DDMT
Defense Depot Memphis Tennessee

Page 1 of 2

Facilitywide or OU	Data Need/Use	Existing Data	Future Data Collection
Facilitywide	Groundwater (GW) Flow—Fluvial	Dunn Field—fairly well defined Main Installation—not well defined North and west of facility—not well defined	Quarterly GW level measurements
	Background water quality (metals)	Limited data for upgradient wells	Additional wells upgradient and offsite
	Background soil chemistry	None available	Soil samples from offsite locations
	Meet RCRA permit requirements for confirmatory sampling/RFI	Available only for small number of sites	Sampling at sites
	Evaluate offsite exposures for BRA	Very limited offsite data	Additional sampling offsite; records review
OU-1	Identify western extent of plume in Fluvial Aquifer	Offsite wells just west of OU-1 show contamination	Install/monitor additional MWs
	Identify current condition of Allen Well Field water supply wells	To be determined through access to MLGW records	Obtain available information from MLGW concerning water supply wells
	Determine available raw water quality data on Allen Well Field water supply wells	To be determined through access to MLGW records	If no data are available, two samples of raw water will be collected from the production wells closest to DDMT.
	Characterize sites/find source areas for VOCs; better define metal contamination	Primarily installation records; some sampling data	Install/analyze soil borings and MWs geophysical survey
	Contaminant transport/migration. Fluvial and Memphis Sand Aquifers.	Little site-specific data from suspected sources to Fluvial Aquifer; boring/well information on confining unit; USGS and MLGW study information	Confirm presence of confining unit using wells/borings; additional study review; modeling; log deep wells
	Characterize surface soils	Little site-specific data	Surface soil sampling

Table 3-12
Data Gaps from Previous Studies at DDMT
Defense Depot Memphis Tennessee

Page 2 of 2

Facilitywide or OU	Data Need/Use	Existing Data	Future Data Collection
OU-2	Characterize sites/find source areas	Primarily installation records; some sampling data	Install/analyze soil borings, MWs surface samples
	Evaluate presence/extent of GW contamination	MWs at western boundary of DDMT	Confirm presence/levels/install downgradient wells to determine extent
OU-3	Characterize sites/find source areas for lake/pond contaminants in sediments/fish	Installation records; sampling data; fish tissue analysis from AEHA (1986)	Install/analyze soil borings, and surface soil/water samples at suspected sites
	Evaluate presence/extent of surface water and sediment contamination offsite	None	Fish tissue, surface water, sediment samples from offsite areas
	Determine extent of sediment and fish contamination in lake and pond	Sampling data for both water bodies	Additional sediment and fish sampling
OU-4	Confirm presence/thickness of confining unit; aquifer intercommunication	Boring and well logs; regional reports; water level information; pump test	Seismic study; additional wells and borings; water level information (site and local/regional)
	Characterize sites	Installation records; actual sampling data (several sites)	Install/analyze soil borings, surface soil and GW samples at suspected sites

TAB

Section 4 - Generic RI/FS Objectives

4.0 Generic RI/FS Objectives

4.1 Objectives of DDMT RI/FS

In a broad sense, the ultimate RI/FS objective is to characterize the risks posed by hazardous substances and to select remedial actions that minimize or eliminate threats to public health and the environment. To achieve such a broad objective, it is necessary that several more specific objectives be met. Table 4-1 provides a list of RI/FS objectives for DDMT and the associated RI and FS activities that will be conducted to achieve those objectives. Although most of the objectives are geared toward specific media or source areas, each is consistent with the ultimate objective of selecting a remedial alternative.

4.2 Data Quality Objectives

4.2.1 Purpose of DQOs

The purpose of developing DQOs is to help managers and planners focus the data collection activities at a site under investigation to minimize unnecessary data, and yet collect sufficient data to support decisions. The primary objectives of the DQOs are as follows:

- Clearly identify the study objective
- Determine the most appropriate type of data to collect
- Determine the most appropriate conditions from which to collect the data
- Specify an acceptable level of error to determine the quality and quantity of data needed to support the decision to be made

Data collection at a site may be conducted in several phases, each with a specific focus and different data need. For example, defining the nature and extent of contamination to assist in the selection of a remedial alternative may indicate collection of biased samples, whereas support of a risk assessment to determine "No Further Action" may indicate use of a statistically based sampling strategy. DQOs will assist in optimizing a sampling and analysis plan.

4.2.2 DQOs Defined

DQOs are qualitative and quantitative statements that specify the quality of the data required to support the decision-making process during remedial response and sampling activities. The statements are based on the end uses of the data to be collected. The qualitative aspect of DQOs assists with planning for field investigations, and the quantitative aspect of DQOs uses statistics to help plan a field investigation that limits the likelihood of making an incorrect decision.

Table 4-1
DDMT RI/FS Objectives
Defense Depot Memphis, Tennessee

Objective	RI Activity	FS Activity
Determine presence or absence of contaminants in each medium.	Confirm/establish presence or absence of contaminants at each source and in all pathways.	Evaluate the applicability of no action alternative.
Determine types of contaminants.	Establish the "nature" of contaminants at each source and in pathways.	Identify applicable remedial technologies.
Determine concentrations and distribution of contaminants.	Establish concentrations and concentration gradients.	Evaluate alternatives and costs to achieve applicable or relevant and appropriate standards.
Determine the mechanism of contaminant release to pathways.	Establish mechanics of source/pathway interfaces.	Evaluate the effectiveness of containment technologies.
Determine direction of transport.	Establish pathways and transport routes and identify potential receptors.	Identify most effective points in the pathway to control transport of contaminants.
Determine boundaries of sources and pathways.	Establish horizontal/vertical boundaries of sources and pathways of contamination.	Evaluate costs to achieve ARARs; identify applicable remedial technologies. Assess risk reduction.
Characterize environmental and public health factors.	Evaluate exposure and concentrations to characterize environmental and public health threat.	Evaluate applicable standards or risk; identify applicable remedial technologies. Assess risk reduction.
Determine source and pathway characteristics with respect to mitigation (bench studies).	Establish the range of contaminants and their concentrations.	Evaluate treatment schemes.
Determine most probable conditions.	Establish ranges of conditions present onsite.	Evaluate most probable conditions and reasonable deviations.

Source: *Data Quality Objectives for Remedial Response Activities—Development Process* (ref. 75).

For the Generic RI/FS Work Plan, only qualitative DQOs will be developed. Quantitative DQOs may be developed in the field sampling plans, but not in all cases. Statistical considerations are generally only necessary when contaminant levels are close to action levels or when there is considerable variability in the data.

The DQOs for this study were developed with consideration of the guidance in the EPA document, *Data Quality Objectives Process for Superfund, Interim Final Guidance* (ref. 87).

4.2.3 DQO Development Process

The DQO process is a series of planning steps based on the scientific method that are designed to help determine what type, quantity, and quality of environmental data collected will be adequate to provide information for making a sound remediation decision. Criteria are developed to determine when enough data has been collected. The process helps to improve the design of the sampling and analysis program, saves time and money, and improves decision making. Application of the DQO steps should help to result in collection of data that will give results of sufficient quality to make a defensible decision.

Each of the steps in the DQO process is presented in Table 4-2. However, a number of the steps in the process are more specific in nature and generate site-specific DQOs. These will be addressed in the OU-specific FSPs. More information on the DQO process can be found in *Data Quality Objectives Process for Superfund, Interim Final Guidance* (ref. 87).

4.2.4 Specific DQOs for DDMT

A summary of the DQOs for the Generic RI/FS Work Plan is provided in Table 4-3. The DQOs are broken up into three categories:

- **Background Evaluation** DQOs address the activities that will be performed to fully characterize the quality of soil and groundwater upgradient of DDMT.

- **Site Evaluation** DQOs apply to all of the sites that will be investigated at DDMT. The DQOs primarily address issues related to physical and chemical data that will be collected to characterize a given site to make a sound and defensible remedial decision.

- **Early Removal Evaluation** DQOs apply to the sites that will initially be considered for early removal. The DQOs address whether early removal is the appropriate action and the status of the site after completion of early removal.

Table 4-2
DQO Process Steps
Defense Depot Memphis, Tennessee

Process Steps	Description
State the Problem	Summarize the contamination problem that will require new environmental data, and identify the resources available to resolve the problem.
Identify the Decision	Identify the decision that requires new environmental data to address the contamination problem.
Identify Inputs to the Decision	Identify the information needed to support the decision, and specify which inputs require new environmental measurements.
Define the Study Boundaries	Specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision.
Develop a Decision Rule	Develop a logical "if...then..." statement that defines the conditions that would cause the decision maker to choose among alternative actions.
Specify Limits on Decision . Errors	Specify the decision maker's acceptable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data.
Optimize the Design for Obtaining Data	Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs.

Source: EPA, 1993 (ref. 87)

Table 4-3
Generic RI/FS Work Plan Data Quality Objectives
Defense Depot Memphis, Tennessee

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Category	Data Quality Objectives	Comments
Background Evaluation	Collect soil, groundwater, surface water and sediment data of sufficient quality and quantity to be used in statistical comparisons with results from onsite field sampling.	
Offsite Source Evaluation	Establish the presence of offsite contamination that may be contributing to the environmental conditions found at DDMT.	
Site Evaluation	Develop an understanding of site geology and hydrogeology to evaluate contaminant fate and transport.	
	Evaluate the nature and extent of potential contamination.	
	Judgmental samples to confirm NFA	NFA will only be confirmed if all results are below applicable action levels. If all results are not below action levels, a second phase of sampling will be required to obtain statistical samples.
	Statistical samples to demonstrate the average (UCL95) concentration is below the PRG	The FSPs will define the basis for collection of statistical samples.
	Judgmental samples to evaluate the most appropriate remedial action	
	Provide reliable data results supported by QC measures implemented during sampling and analysis.	
	Collect data useful for evaluation in comparison to background concentrations, EPA Risk-Based Concentrations, and other ARARs.	
	Collect groundwater and soil data that are representative of site conditions.	The rationale regarding the location of where samples will be collected will be included in the FSPs.

Table 4-3
Generic RI/FS Work Plan Data Quality Objectives
Defense Depot Memphis, Tennessee

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Category	Data Quality Objectives	Comments
Early Removal Evaluation	Determine if early removal is the most appropriate action. Confirm that the source of materials has been removed. Confirm the contents of the waste that was disposed of at the site; or confirm the contaminants that were released to the environment. Determine the condition of remaining soils to determine further action.	

Specific site investigation DQOs for the data collection activities at each of the sites will be presented in the OU-specific FSPs.

4.2.5 Data Quality Levels at DDMT

The data collected during field activities at DDMT will be Level 1, 2, 3, or 4. Level 1 data is at a screening level. It provides the most rapid results, but the least amount of information to defend the data quality. The data generated will typically provide general environmental characteristics, not information related to contaminant speciation. Level 1 data may include pH, conductivity, temperature, and organic vapor concentrations. Level 2 data is field analysis data. Level 2 provides rapid results and more documented data quality than Level 1. Level 2 data can provide limited information on contaminant speciation and can give quantitative results. However, the reporting limits for a Level 2 analysis would be much higher than for a Level 3 or 4 analysis. A common Level 2 data measurement may be analysis for specific indicator volatile organics by a field-operated gas chromatograph.

Level 3 and 4 data are generated by an analytical laboratory, typically from a permanent laboratory with documented quality control procedures. The difference between Level 3 and 4 is the amount of supporting information provided by the laboratory. Level 3 data packages typically have only QC summary information, while Level 4 data packages will provide all of the supporting information necessary to define the quality of the data. Level 4 data is confirmational, and it provides the highest level of data quality. Data validation can be performed on Level 4 data.

At DDMT, Level 2, field screening, data will be used to determine the extent of contamination, to select samples for Level 3 and possibly Level 4 analyses, and to make field decisions. The majority of offsite laboratory analytical data will be Level 3 QA/QC for target parameters. There is a potential that Level 4 data will be required in the future at this facility. Samples analyzed using Level 4 QC are analyzed using the same analytical methods as Level 3 samples, but different data package deliverables are provided. Confirmatory samples will be analyzed using Level 3 QC, and no Level 4 QC is proposed at this time. However if in the future Level 4 information becomes necessary, this information will be requested from the analytical laboratory.

Of all the soil samples collected, at least 5 percent will be analyzed for TCL/TAL, and at least one sample from each site will be analyzed for TCL/TAL. In the characterization of background soil and groundwater quality, TCL/TAL analyses will be performed.

An analysis for TCL/TAL indicates that specific listed parameters will be analyzed by specific methods. The analytical methods used are the CLP methods. These methods have specific analytical reporting limits. The categories of compounds that will be analyzed in a TCL/TAL scan include VOCs, SVOCs, pesticides/PCBs, metals, and cyanide.

TAB

Section 5-RI/FS Tasks

5.0 RI/FS Tasks

A total of 14 standard RI/FS tasks have been defined by EPA (ref. 63) to provide consistent reporting and to allow more effective monitoring of RI/FS projects. A detailed description of each of the RI/FS tasks and the work that will be performed under each is provided in the following discussion.

5.1 Task 1—Project Planning

The purpose of the project planning (or scoping) task is to define the appropriate type and extent of site investigation and analytical studies necessary to characterize the site. The main objectives of scoping are to identify the types of decisions that need to be made, to determine the types of data needed (including quantity and quality), and to design the studies necessary to collect these data. Initially, the task involves a site inspection of the study area and an analysis of existing information for DDMT. This task also includes development of the Generic RI/FS Work Plan, the SAP, the HASP, and the Community Relations Plan.

During project planning, a conceptual model of the site is established that considers the source of contamination, potential pathways of exposure, and potential receptors. Data gathered during the site characterization activities will build on that model. A conceptual model of DDMT has been developed as described in Section 3.0. The identification of potential ARARs and other criteria, advisories, and guidance to be considered has been initiated. Tables of potential PRGs (Tables 3-7 through 3-10) have been developed for regulatory review. So that ARARs are identified "in a timely manner," as required by CERCLA, a formal letter will be issued by DDMT to both TDEC and EPA Region IV to request a list of proposed state and federal ARARs for DDMT.

Following is a description of the contents of each of the work plans that will be provided as part of the planning task. All of the work plans described will be written in accordance with the current NCP and the October 1988 EPA RI/FS Guidance Document (ref. 63).

5.1.1 Generic RI/FS Work Plan

The purpose of the Generic RI/FS Work Plan (this document) is to present the general rationale and methodology for conducting the RI/FS. Because much of the site background information is not subject to change, it has been consolidated in this document for future reference. Each OU, as well as the Screening Sites, will have a detailed FSP that describes site history, previous sampling results, proposed future sampling locations, analytes, and rationale. The Generic RI/FS Work Plan includes the following elements:

- A general description of the project, along with discussions of the site background
- A general conceptual model, including the nature and extent of contamination
- A history of regulatory and response actions
- A general discussion of data quality and quantity objectives
- A general description of the work tasks to be performed
- A description of the deliverables that will be submitted and their schedule for delivery
- Project management, organization, and responsibilities

5.1.2 Sampling and Analysis Plan

The SAP contains the FSP and the QAPP. For each sampling event, the FSP outlines the sampling objectives; necessary equipment; sample types, locations, and frequency; analyses to be performed; and a schedule of when the particular sampling events will occur. The FSP includes a separate plan for the following sampling events—shallow soil/surface sampling, stratigraphic borings, and groundwater monitoring well installation and sampling. In addition to the other guidance documents listed above, the FSP is written in accordance with the *Compendium of Superfund Field Operations* (ref. 62) and the *Data Quality Objectives for Remedial Response Activities* (ref. 75).

The purpose of the QAPP is to provide a detailed description of the quality assurance/quality control (QA/QC) procedures to be employed during the RI/FS. The objective of the QAPP is to ensure that the RI/FS is based on the correct level and extent of sampling and analysis required to produce enough data for evaluating remedial alternatives. A second objective is to ensure the quality of the data collected during the RI/FS. The QAPP, which has been written in accordance with the Current RI/FS Guidance (ref. 63), the *Data Quality Objectives for Remedial Response Activities* (ref. 75), the *Guidelines and Specification for Preparing Quality Assurance Plans* (ref. 76), the *Users Guide to the EPA Contract Laboratory Programs* (ref. 77), and the proposed NCP, addresses all of the field investigations conducted as a part of the DDMT site characterization activities and includes the following discussions:

- A project description
- Project organization illustrating the lines of responsibility to the personnel involved in the sampling phase of the project
- QA objectives for the data acquired, including accuracy, completeness, representativeness, comparability, and intended use of the data
- Sample custody procedures
- The type and frequency of calibration procedures for field and laboratory instrument, internal quality control checks, QA performance audits, and system audits
- Analytical procedures
- Data reduction, validation, and reporting procedures
- Internal QC procedures
- Performance and systems audits
- Preventive maintenance procedures
- Specific routine procedures used to assess data
- Corrective actions
- QA project reports

5.1.3. Health and Safety Plan

The HASP is developed on the basis of expected site conditions to protect personnel involved in site activities, as well as the surrounding community. The plan addresses all applicable regulatory requirements under 29 CFR 1910.120. The HASP provides a site background discussion and describes personnel responsibilities, protective equipment, health and safety procedures and protocols, decontamination procedures, personnel training, and medical surveillance.

5.2 Task 2—Community Relations

The community relations task is designed to ensure community understanding of actions taken during the remedial response activities and to obtain community input on the RI/FS program. A Community Relations Plan has been prepared and submitted to EPA and the State of Tennessee by DDMT. The Community Relations Plan documents the community relations history with respect to DDMT and describes the techniques that will be needed to achieve the objectives of the program. The plan has been prepared in accordance with *Community Relations in Superfund: A Handbook* (ref. 78), and *Community Relations Activities at Superfund Enforcement Sites—Interim Guidance* (ref. 79).

Additional community relations activities to be conducted by DDMT personnel include the following:

- Establishing a community information repository that will house a copy of the administrative record
- Preparing and disseminating news releases, fact sheets, slide shows, and exhibits designed to inform the community of current or proposed activities at DDMT
- Analyzing community attitudes toward the proposed actions

Although most of the community relations activities will be conducted by DDMT personnel, technical support will be provided by outside agencies (COE and contractors) at public meetings.

5.3 Task 3—Field Investigations

5.3.1 Objectives of the DDMT Site Investigation Activities

The primary objective of the DDMT remedial investigation is to provide additional data to characterize the nature and extent of surface and subsurface soil, groundwater, and surface water/sediment contamination resulting from past operations at DDMT. To accomplish this objective, DDMT will perform the following activities:

- Satisfy the confirmatory sampling and corrective measures study requirements of the installation's RCRA Part B Permit.
- Collect additional data to determine the extent of groundwater contamination from burial sites located in the Dunn Field area (OU-1).
- Evaluate the degree of hydraulic interconnection between the Fluvial Aquifer and the underlying Memphis Sand Aquifer at DDMT.

- Provide additional information for the BRA and the selection of appropriate remedial alternatives.
- Provide sufficient information to establish most probable conditions and reasonable deviations.

Soil samples will be collected from surface soil samples, soil borings, stratigraphic test borings, and new monitoring well locations. Investigation goals of these samples will be to make determinations such as the nature and extent (lateral/vertical) of contamination from past waste disposal activities, background soil concentrations, and the presence (or absence) of the confining bed that separates the Fluvial Aquifer from the Memphis Sand Aquifer. With the exception of the background sampling locations, which are discussed below, specific rationale is provided for each sampling location in the OU-specific FSP. Other subsurface soil data will be collected to further characterize the source of contamination at a number of sites, particularly in OU-1. The subsurface soil data will be acquired through collecting and analyzing subsurface soil samples and making visual examinations and field measurements during drilling activities.

To fully characterize the extent of both the groundwater contamination beneath DDMT and the extent of the plume offsite, approximately 20 additional groundwater monitoring wells are proposed to be installed. Samples will be collected and analyzed from both new and existing wells to further characterize the nature and extent of the potential contaminants of concern in groundwater.

5.3.2 Background Sampling Program

DDMT is conducting a multimedia background sampling program to support its environmental restoration program. The purpose of the background sampling program is to provide sufficient data to establish representative background concentration data for naturally occurring constituents at DDMT. Background is defined as samples collected in locations where chemicals present are representative of naturally occurring and anthropogenic (human made, non-site) sources. Once the background data have been collected, it is the risk assessor's task to construct a representative data set considered to be background. Care will be taken to include analytical data that do not fit a particular statistical data set distribution.

Constituent concentrations detected in various media as part of the remedial activities at the site will be compared to background data established herein, in order to evaluate whether the reported concentrations of those constituents were caused by DDMT operations, are naturally occurring, or whether they are caused by ambient effects from the urban environment surrounding DDMT. In general, the background data will be used

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to support several aspects of the environmental program at DDMT, including the following:

- Development of action levels to be used in further-action/no-further-action decision making
- Potential/future risk assessments
- Development of clean-up criteria and PRGs

(Remainder of page intentionally left blank, after final comment resolution.)

Final decisions regarding how the background data will be used in site analyses will be developed as DDMT environmental projects occur; however, one of the most appropriate uses of the data will be to compare the distribution of the entire data set obtained during site investigations to the distribution of the background data set.

Background concentrations for the following media will be addressed: surface and subsurface soil, surface water and sediment, and shallow groundwater. This section of the Generic RI/FS Work Plan describes the rationale for the number and locations of samples for each media. As additional background data become available as part of possible future investigations, they will be incorporated into the background data base as appropriate. Sampling locations have been selected in areas believed to be unaffected by past or present DDMT industrial activities. An important aspect of the sampling program is the consideration of potential effects of urban pollutants from the area surrounding the site.

A statistical approach has been used to select the number of samples required to provide an appropriate level of confidence for each media. Sample sizes appropriate to estimate tolerance intervals (Conover, 1980) were used to estimate the number of samples required for each media. Nonparametric tolerance intervals make no assumptions about the underlying distribution of the chemical or compound. However, independent samples are assumed to be randomly drawn from an infinite population. The desired level of confidence and coverage must be specified to determine the number of samples. Coverage is the percent or quantile of the population distribution to be bounded by the largest concentration in the sample. An upper tolerance bound is designed to contain at least 100 percent of the sampled population from a sample of size n with 100 (1-a) percent confidence. The level of confidence reflects the probability that the maximum concentration detected from a collection of samples will bound the pre-specified quantile of the population distribution. The equation used to generate the minimum sample size is as follows:

$$n = \ln(a)/\ln(p)$$

where a = significance level $(0 < a < 1)$
p = percentile of the population to be contained by the upper bound $(0 < p < 1)$
n = minimum number of samples required

For example, half of the population is greater than and half of the distribution is less than the 50th quantile, the population median value. The upper and lower quantiles of the distribution, the 75th and 25th quantiles, respectively, are the concentration levels at which 25 percent and 75 percent of the population are greater. A prespecified confidence level of 5 percent and prespecified 50th quantile means that the maximum concentration from the sample of size "n" will not be less than the median (from chance alone) more than 5 times out of 100. "N" increases as either the preselected quantile (upper tolerance limit) or preselected level of confidence increases. The effect of raising the quantile of interest dominates the increase in required sample size. For example, to be 90 percent certain that the maximum concentration from a sample exceeds the median of the population being sampled requires a sample size of 4; to be 95 percent certain requires a sample size of 5—a comparatively negligible increase in sample size. To be 90 percent confident that the maximum sample concentration is greater than the 95th quantile requires a sample size of 45; to be 95 percent confident requires an N of 59.

Table 5-1 tabulates sample sizes to meet a range of prespecified coverages and a range of prespecified confidence levels.

Table 5-1
Sample Sizes for Prespecified Confidence Levels
Defense Depot Memphis, Tennessee

Estimated Quantile	85% Confidence	90% Confidence	95% Confidence
50th [Median]	3	4	5
75th [Upper Quantile]	7	9	11
85th	12	15	19
90th	19	22	29
95th	37	45	59

Levels of confidence for each media (sediment, surface water, and groundwater) were calculated according to the project objectives, and other considerations. In general, as shown by the above equation, a larger number of samples is required to support either a higher confidence interval or a greater proportion of the distribution. A larger number of samples increases the probability of sampling more "rare" events (extreme values), thereby increasing (biasing high) the overall calculated background value. There are also cost considerations in implementing higher confidence intervals: in general, it costs incrementally more per sample to obtain small increases in the confidence interval. The selection of confidence intervals for DDMT was based on both the need to obtain a relatively representative data set and the cost of obtaining such data. A specific discussion of the confidence intervals and sampling rationale for each media is presented below.

5.3.2.1 Surface and Subsurface Soil

As identified by the Soil Conservation Service (SCS, 1970), five major surface soil series have been mapped at DDMT: Falaya Silt Loam (Fm), Filled Land—Silty (Fs), Graded Land (Gr), and Memphis Silt Loam (MeB and MeD_2). Most of the surface soil at DDMT is classified as graded land (meaning cut-and-fill or other surface disturbance) for installation development. During grading and land development, the surface soil probably originated as one of the Silt Loam series soils, but probably was mixed and reworked. Native surface soil is only apparent in the stream and swale channels. The areas covered by the other soil types are too small to warrant separate consideration. Therefore, for purposes of this background sampling program, no distinction between different surface soil mineralogies will be attempted, although the soil type will be classified in the field for identification purposes.

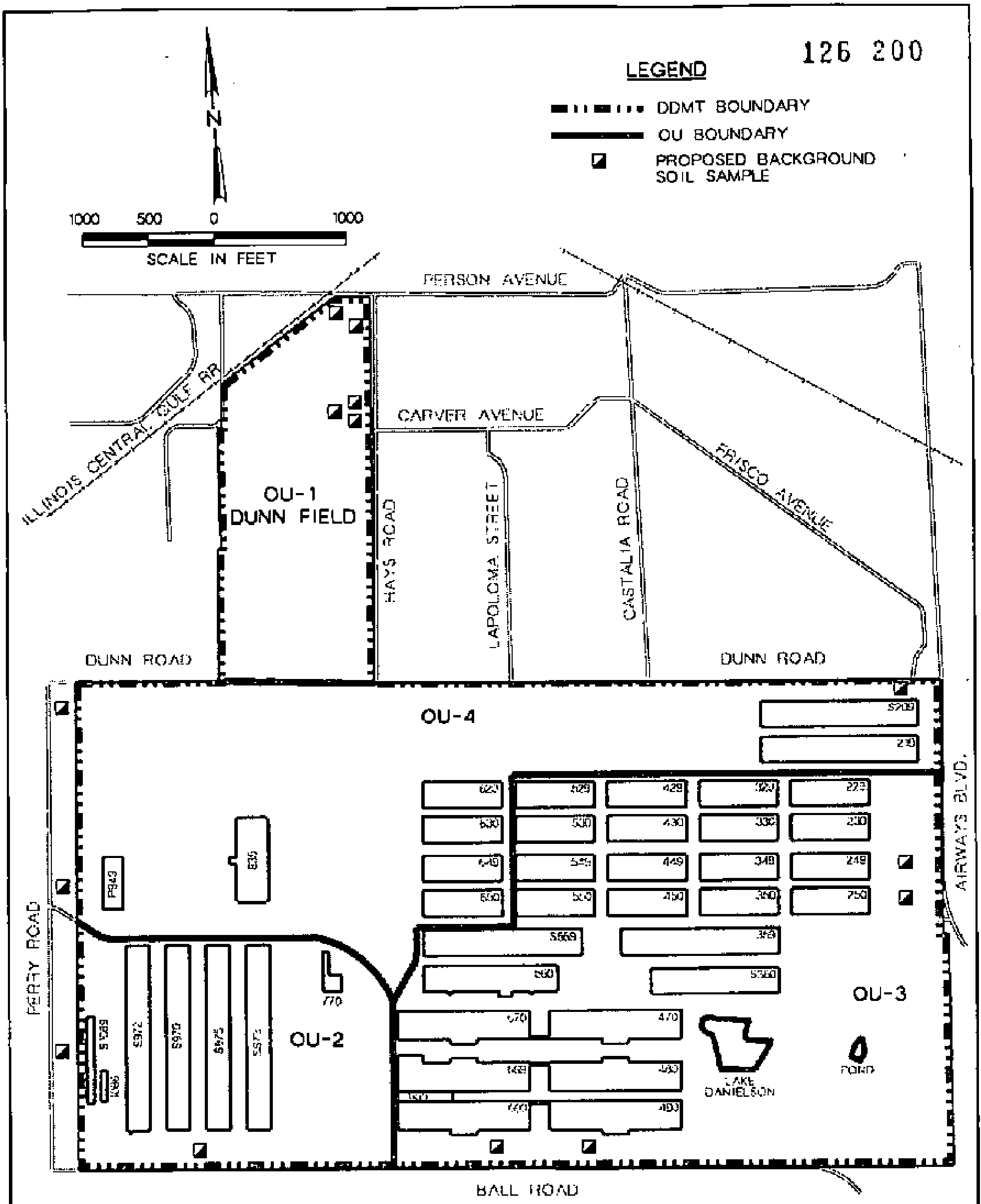
To obtain a set of background surface soil data representative of the diversity (non-homogeneity because of mixing and grading) of soil conditions anticipated at the site, samples will be obtained from a combination of onsite and offsite areas. The number of samples for regional surface and subsurface soils was selected to provide at least a 90 percent confidence and a 90 percent coverage of the sample population. Therefore, surface and subsurface soil samples will be obtained from a total of 22 locations.

At DDMT, areas have been selected that do not appear to be affected by operations, based on information regarding former and current land usage and on existing soil analytical data, avoiding those areas with known or potential contamination. Potential sample locations were chosen by, first, delineating areas throughout the installation that were not appropriate for sampling, including areas of known or suspected contamination and areas covered by buildings or roads. Because DDMT is heavily developed, relatively few potential locations were available for sampling. A total of 11 onsite sample locations (presented in Figure 5-1) have been chosen to represent the most reasonable geographical distribution possible over the site, considering the site limitations. Before the sampling program, a visual field reconnaissance will be conducted at each sample location to verify its accessibility and suitability. Three potential alternate sampling locations have been designated in Figure 5-1 in case an originally proposed location is deemed unsuitable (based on field observation).

For the offsite locations, several golf courses, parks, and schools were targeted as possible background soil sampling areas. Proposed sampling locations are shown in Figure 5-2. A total of 18 offsite sampling locations have been designated, 11 primary sites and 7 potential alternative sites. Permission for site access will be obtained before field sampling activities begin.

At each sampling location, samples will be obtained from the ground surface (at a depth interval of approximately zero to 1 feet bgs), and at a depth sufficient to be representative of native soil. The actual depth of native (undisturbed) soil will be evaluated in the field based on visual soil classification; it is anticipated that the depth will be approximately 5 to 6 feet bgs. All samples will be scanned in the field with a photoionization detector (PID) or a flame ionization detector (FID) to eliminate sampling locations that contain PID/FID detectable VOCs.

The entire Memphis area was formerly used for agriculture (cotton and possibly other crops), so it is possible that some residual pesticide, herbicide, or fertilizer residual could remain in the surface soil. Pesticides and herbicides were typically also applied to DDMT and the nearby parks and schools as part of routine grounds maintenance. Similarly, because DDMT is in a heavily developed urban area, other constituents (for example, PAHs from asphalt roads or lead from automobile exhaust) might be detected in the surface soil. The background soil sampling program has been designed to consider and include these regional effects. Therefore, the background soil samples will be analyzed for the target compound list used for the remainder of the DDMT sampling program, including VOCs, SVOCs, pesticides/PCBs, dioxins, PAHs, and TAL metals.



NOTE: Onsite soil locations are to be field selected. Sample locations will be placed in areas unaffected by facility operations and drainage.

FIGURE 5-1
PROPOSED ONSITE SOIL SAMPLING LOCATIONS
Defense Depot Memphis, Tennessee

Source: Engineering-Science, 1993

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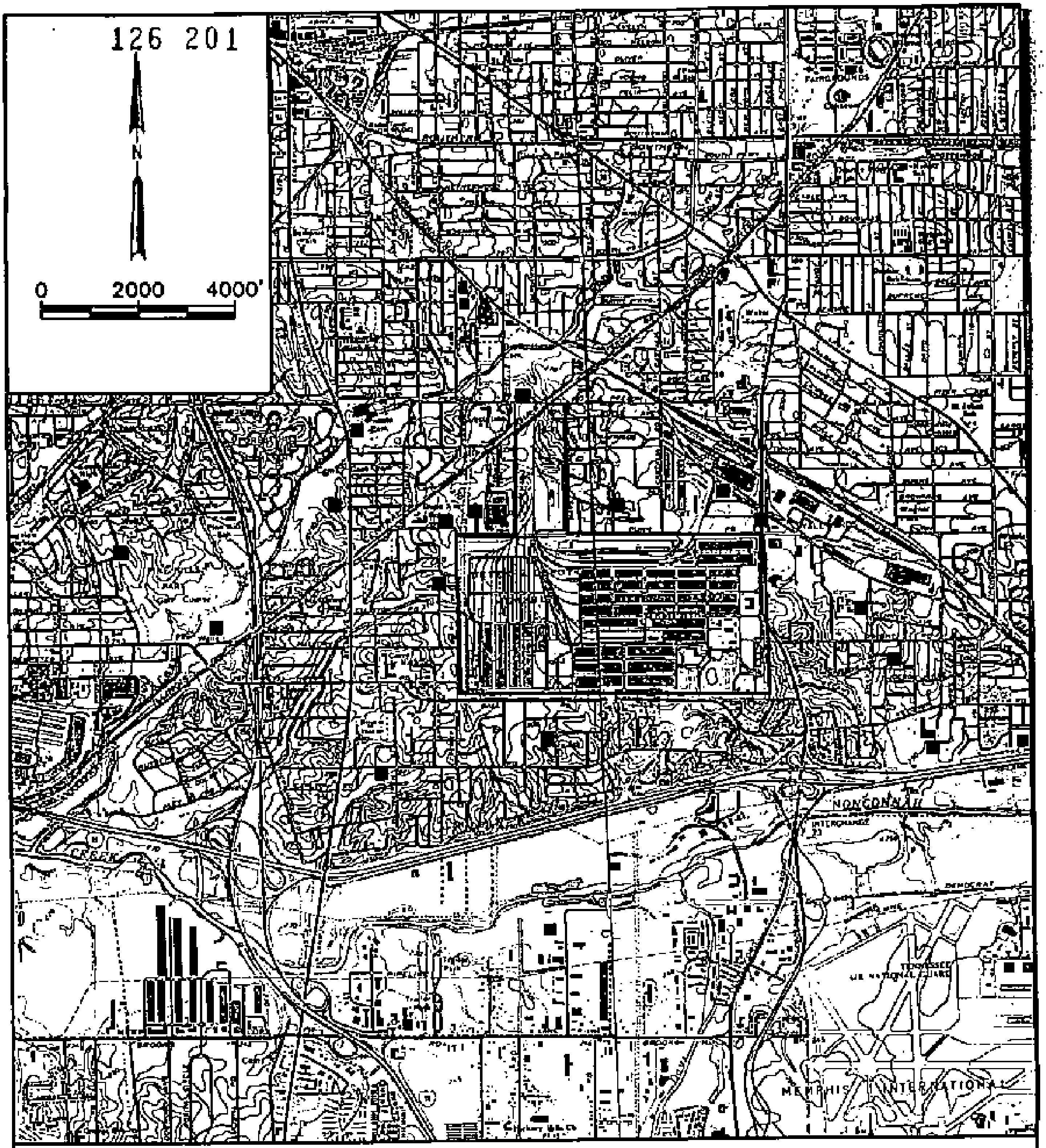

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■ PROPOSED BACKGROUND SOIL SAMPLING LOCATIONS

Note: Placement of the soil samples are intended to be in areas unaffected by contaminant source areas and drainage.

Source: USGS 7.5 SeriesTopographic Quadrangle Maps - South West Memphis Tenn. - Ark. and Southeast Memphis, Tenn.

FIGURE 5-2
PROPOSED OFFSITE BACKGROUND
SOIL SAMPLING LOCATIONS
Defense Depot Memphis, Tennessee

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Results will be analyzed using statistical evaluations to derive a range of possible background values for each constituent. Box plots, probability plots, and other statistical plots will be graphed for each parameter (using the contract-required detection limits [CRDLs] for non-detected values) to provide an overall assessment of the distribution of data. Outlying data will be flagged and possibly removed from the data set. Once the distributions of each parameter are determined, both parametric and nonparametric tolerance intervals will be evaluated. The upper tolerance bound will constitute one possible background value for each constituent. Another possible background value is twice the mean of the data. A table will be developed that shows, per analytical constituent, the number of samples, frequency of detection, maximum and minimum detected values, the mean and standard deviations, the upper tolerance bound, and the twice-mean value.

5.3.2.2 Surface Water and Sediment

Surface water from DDMT drains through overland flow to swales, ditches, concrete-lined channels, and a storm drainage system to nearby streams. Most of the drainage channels at DDMT convey only seasonal (wet weather) flow, and are frequently dry. DDMT is generally level with or above the surrounding terrain, so that DDMT receives only a minor amount of run-on from adjacent areas, primarily at Dunn Field from the neighborhood to the east. Major drainage features are shown in Figure 2-4. Surface water from Dunn Field flows northward to Cane Creek. Surface water from the western portion of the Main Installation flows westward toward Tarrent Branch, which flows to Nonconnah Creek. Surface water from the eastern and southern portion of the installation (including outfalls from Lake Danielson and Golf Course Pond) also flows to Nonconnah Creek. Finally, surface water from the northern portion of the main installation flows to Cane Creek. Considering the hydrology at the site, two types of surface water features will be evaluated as part of the background sampling program: ponds and streams.

For the pond sampling program, the two ponds onsite (Lake Danielson and Golf Course Pond) would not be suitable for use in the sampling program because they have received runoff from the installation. Therefore, we propose to sample offsite ponds located in a similar setting (such as on a golf course or in a park-like setting) as DDMT's ponds. Two ponds are considered, one at Audubon Park (northeast of DDMT) and the other at Medal of Honor Park (southeast of DDMT).

For the stream sampling program, the number of suitable locations for surface water and sediment sampling is limited by the number of active flowing streams on or near DDMT. Cane and Nonconnah Creeks sustain perennial flow. Therefore, surface water samples will be obtained from portions of Cane Creek and Nonconnah Creek upgradient of the outfalls from DDMT. These samples will be used to represent background surface water chemistry for DDMT; however, the surface water and sediment obtained from these sampling locations may demonstrate effects of upstream industrial and residential land use.

To obtain a minimum 90 percent confidence and 90 percent coverage of the sample population, 22 surface water samples are required. Sampling locations are shown in Figure 5-3. Five surface water samples each will be collected from Cane Creek and Nonconnah Creek upgradient of the outfall from the site. An equal number of sediment samples will be collected from low-flow velocity areas at or near the stream locations used for surface water sampling. Six surface water and sediment samples each from the Pine Hills golf course and Lincoln Park ponds will be obtained. All samples will be analyzed for VOCs, SVOCs, pesticides/PCBs, and TAL metals.

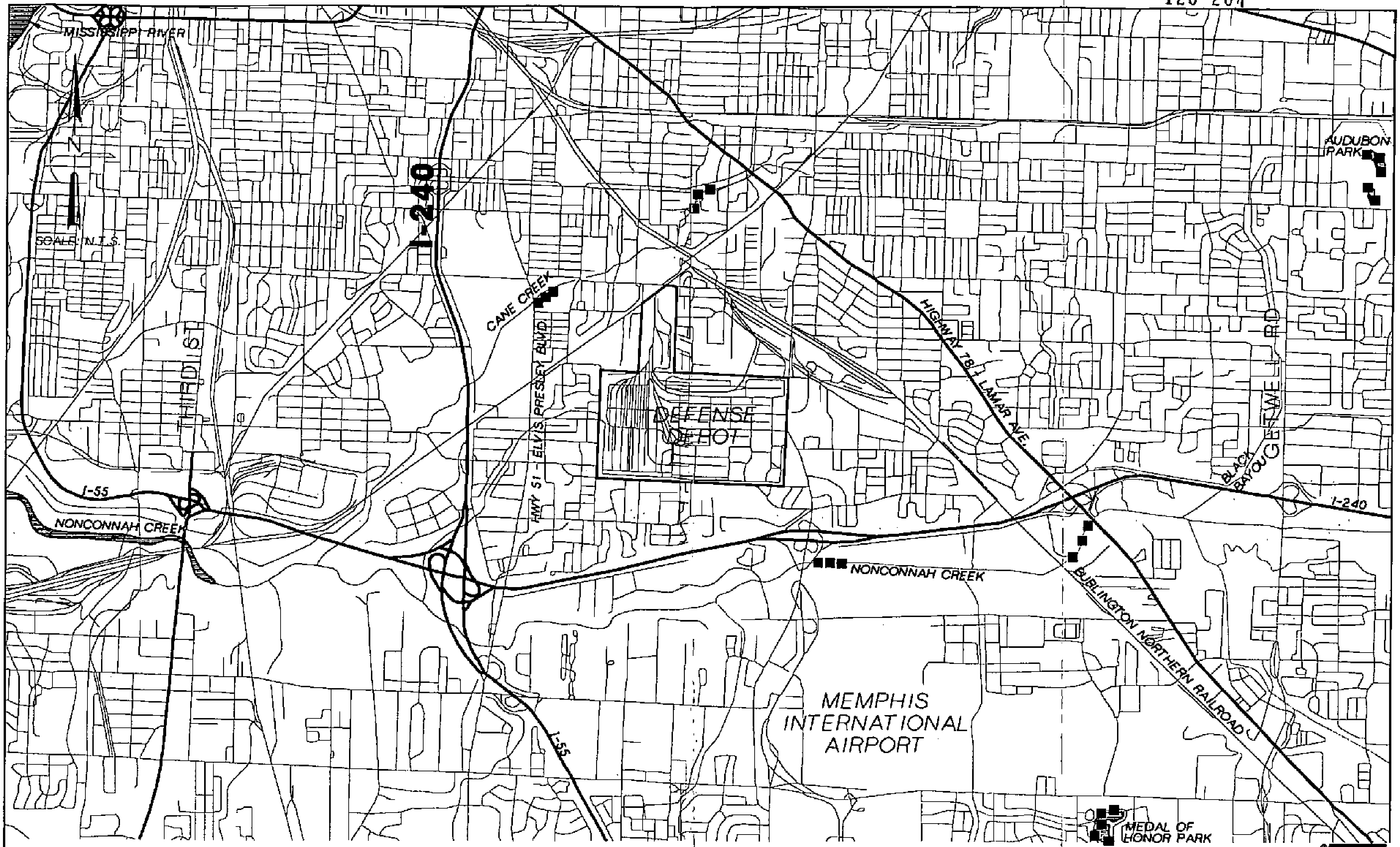
The two data sets (stagnant data and running water data) will be compared using an analysis of variance (ANOVA) statistical approach. If the ANOVA indicates that the mean contaminant values from the stagnant and running water data sets are from the same population, at a 95 percent confidence level, then the data sets will be combined; otherwise, they will be kept separate. Surface water and sediment samples will be considered separately.

5.3.2.3 Aquatic Biota

Fish collected in Lake Danielson during previous studies were found to contain concentrations of pesticides and PCBs. Lake Danielson is located within the golf course at DDMT and may receive pesticides from the onsite storm water system or direct runoff from the golf course. Golf course maintenance typically requires high levels of pesticide and herbicide applications, which may be transported to the adjacent ponds or surface water streams. Although pesticides have been stored at DDMT and may have been introduced to Lake Danielson through spills onsite, maintenance activities on the golf course probably also have introduced pesticides directly to the ponds.

To provide representative background data on pesticides in fish for comparison with the fish collected in Lake Danielson, fish will be collected from golf course ponds in the Memphis area and analyzed for pesticides and PCBs. In addition, data available from TDEC's Division of Water Pollution Control on tissue analyses from fish collected in the area will be used for comparison purposes. This combination of data sources will provide a more representative background estimate of pesticide and PCB concentrations in fish within the project area.

Fish will be collected from two ponds within one of the Memphis City Parks golf courses and analyzed using EPA Methods 8080 (organochlorines) and 8140 (PCBs and organophosphates). Fish will be collected using a back pack electro-shocker, wrapped in aluminum foil and then placed in ziploc plastic bags, and placed directly on dry ice for shipment to CH2M HILL's Montgomery, Alabama, laboratory for analysis. Fish will be



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■ PROPOSED BACKGROUND SEDIMENT AND SURFACE WATER SAMPLE LOCATION

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FIGURE 5-3
PROPOSED BACKGROUND SEDIMENT AND SURFACE WATER SAMPLE LOCATIONS
Defense Depot, Memphis, Tennessee

CH2MHILL

fileted in the laboratory and approximately 10 grams of tissue extracted for the analysis. The fish in these ponds probably will be small and it may require more than one fish to provide 10 grams of tissue filet. Therefore, depending on the size of fish collected, up to three fish may be combined to make up one sample. Compositing of fish samples will follow procedures outlined in EPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1, Fish Sampling and Analysis, EPA/823-R-93-002* (EPA, 1993). A total of three samples will be analyzed from each pond for a total of six samples.

As recommended by EPA (EPA, 1993), catfish (*Ictalurus sp.*) or common carp (*Cyprinus carpio*) will be the target organisms because of their bottom-feeding habits and potential exposure to contaminated sediments. These species have been consistently sampled for monitoring of a number of contaminants, including pesticides. If sufficient catfish or carp are not available for comparison purposes, the next most abundant species will be collected to conduct the aquatic biota study.

TDEC's Division of Water Pollution Control conducts annual surveys to evaluate contaminant levels in freshwater fish. Data from the last 5 years for streams in the Memphis area will be summarized and evaluated with background sampling data for the fish collected in golf course ponds to develop appropriate background fish tissue levels for pesticides and PCBs.

5.3.2.4 Fluvial Aquifer Groundwater

Shallow (water table) groundwater is contained within the fluvial deposits at the site. The fluvial deposits consist of clayey sand, sand, and gravely sand strata, ranging in thickness from about 40 to 130 feet. Only the base of the fluvial deposits are saturated; total saturated thickness varies from about 6 to 23 feet. Seasonal fluctuations (up to several feet) are anticipated within the Fluvial Aquifer. It is not known whether groundwater flow directions have changed over time, caused, for example, by pumping in nearby wellfields.

VOCs, SVOCs, or pesticides/PCBs are not expected to be naturally occurring in the Fluvial Aquifer, although inorganics, such as metals, are expected to be present in background groundwater. Land use to the north (and upgradient in the Fluvial Aquifer) of DDMT generally consists of heavy industry and warehousing. To the east (also upgradient) of DDMT along Airways Drive, there are numerous commercial establishments as well. Operations in the area surrounding DDMT may have affected groundwater quality; for example, there is known groundwater contamination at the Kellogg facility just west of the site. Therefore, the background sampling program has been designed to consider these potential effects.

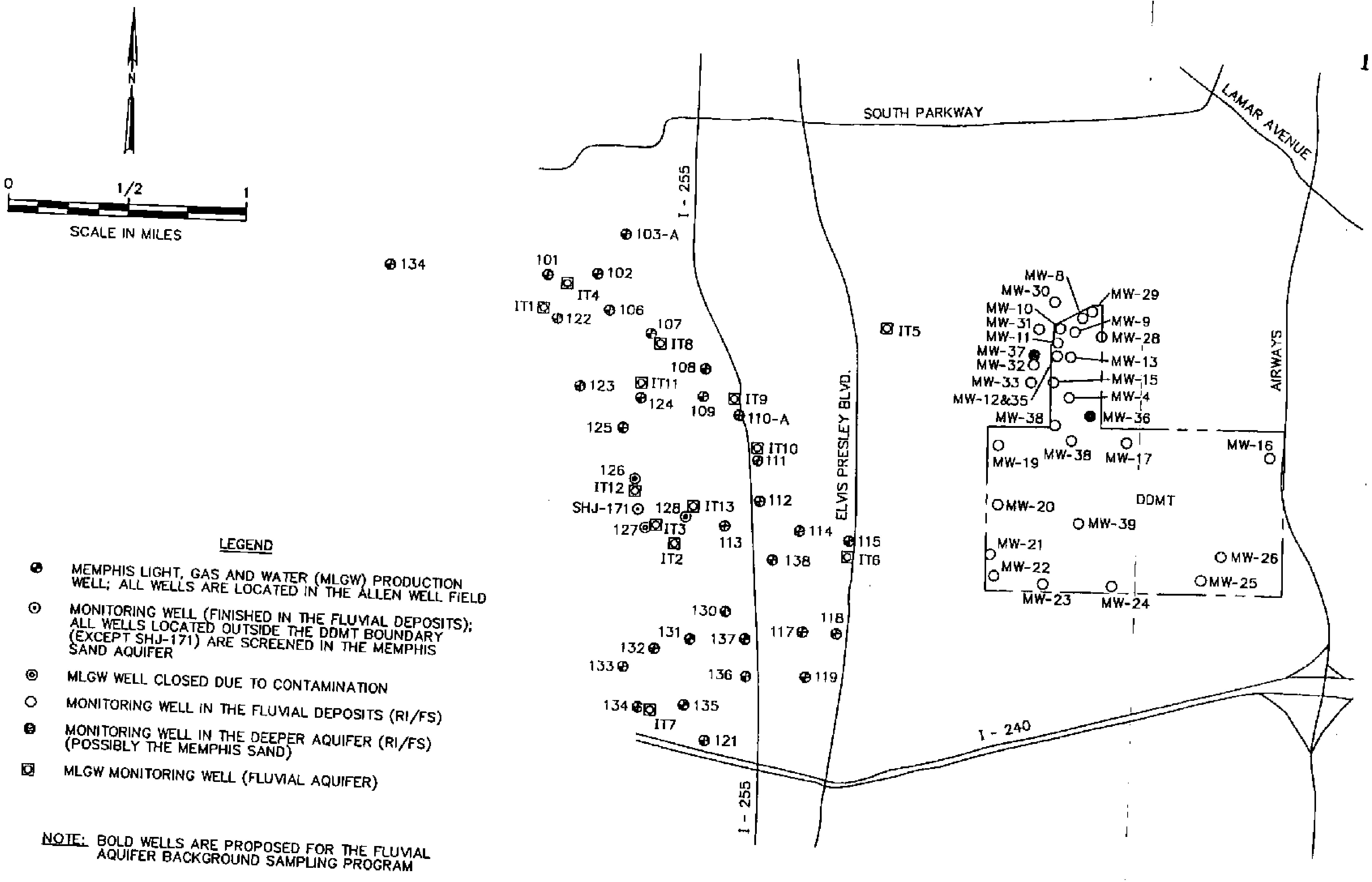
USGS (McMaster and Parks, 1988) has performed an evaluation of selected inorganic and organic constituents in the Fluvial Aquifer in the Memphis area. The laboratory analyses were performed on filtered groundwater samples (probably filtered with a 0.45 μ filter) to assess the concentrations of dissolved inorganic constituents (arsenic, barium, cadmium, chromium, lead, and mercury). These data are probably representative of background concentrations in the Fluvial Aquifer. Analytical results at DDMT are for total metals (not dissolved), so the data are not currently comparable. As part of the background sampling program, only unfiltered (total) groundwater samples will be obtained for total metals analyses.

The approach to selecting wells for use in the background sampling program is to use the presence of VOCs, SVOCs, or pesticides/PCBs as an indicator regarding the potential effect of groundwater from either DDMT or surrounding industrial operations. Areas outside known organic contamination, wells that have non-detected organic constituents, and areas that are primarily upgradient (or far downgradient) of the site have been considered as potential sampling locations.

On the basis of these criteria, the following onsite wells have been evaluated for use as background wells: MWs-14, 16, 19, 23, 24, 28, and 30. These anticipated Fluvial Aquifer monitoring well sampling locations are shown in Figure 5-4. These wells have non-detected levels of organic constituents. MW-16, located in the far northeastern corner of the Main Installation, was specifically installed to provide background groundwater quality data. The remaining wells also appear to be in the upgradient areas of DDMT. The distribution of inorganic constituents is also important; wells with outlying (excessively high) inorganic constituents may reflect inorganic contamination rather than background concentrations. Because of higher-than-average metals concentrations, MW-14 was eliminated from consideration, although it is not known whether concentrations reflect groundwater contamination or other effects (such as well construction, for example).

There are an additional 14 Fluvial Aquifer monitoring wells installed and sampled by USGS in 1987 in and around the Allen Well Field (including well SHJ-171, and MGLW wells IT-1 through 13). Several of these exhibit organic contamination, and will not be considered for use as background wells. The Fluvial Aquifer wells that will be used for background data are discussed in Section 4 of the OU-4 FSP. These wells will be sampled in conjunction with the OU-4 field sampling effort. The background data will be collected as part of the installation of wells A through K (shown in Figure 4-4 of the OU-4 FSP).

The total combined number of potential Fluvial Aquifer background wells (6 onsite and 7 offsite) is 13 wells. Thirteen samples will give a 90 percent confidence and approximately 82 percent coverage. Both filtered and unfiltered samples will be obtained from all Fluvial Aquifer wells; samples will be analyzed for VOCs, SVOCs, pesticides/PCBs, and TAL metals. Analytical results will be analyzed by statistical evaluations similar to those proposed for soil, above. Onsite wells that show evidence of organic contamination may be eliminated from consideration as background wells; similarly, wells with statistically significant outlying concentrations will be eliminated.



Source: RI Report, 1990

HBS-0004.DWG 26-Feb-1993

FIGURE 5-4
FLUVIAL AQUIFER SAMPLING LOCATIONS
Defense Depot Memphis, Tennessee

5.3.2.5 *Memphis Sand Groundwater*

The Memphis Sand reportedly underlies all of the Memphis area, including DDMT. At DDMT, the top of the unit is approximately 125 to 150 feet NGVD. In the vicinity of DDMT, the potentiometric surface appears to slope generally westward toward the Allen Well Field, approximately 0.5 to 2.5 miles west of DDMT, a major local pumping zone with wells screened in the Memphis Sand. The Sheahan Well Field (approximately 5 miles east of DDMT) has 23 production wells screened in the Memphis Sand, and the Mallory Well Field (approximately 5 miles north of DDMT) has 25 production wells in the Memphis Sand. Only two wells at DDMT are installed in the Memphis Sand: MW-36 and -37. The potentiometric level in these two wells ranged from 143 to 146 feet NGVD. The Memphis Sand Aquifer will not be sampled as part of the background sampling effort. However, the groundwater quality of the Memphis Sand Aquifer beneath DDMT will be evaluated as part of the OU-4 investigation (OU-4 FSP, Section 4.6).

As with the Fluvial Aquifer, VOCs, SVOCs, or pesticides/PCBs are not expected to be naturally occurring in the Memphis Sand. MLGW routinely analyzes groundwater from the Allen, Sheahan, and Mallory Well Field production wells. Low levels of chlorinated solvents have been detected in some production wells in the Allen Well Field.

5.3.2.6 *Fort Pillow Sand Groundwater*

The Fort Pillow Sand underlies DDMT and the Memphis area at a depth of approximately 1,400 feet. It is reportedly approximately 200 feet thick. The Fort Pillow Sand will not be investigated as part of the RI/FS, nor of the background sampling program.

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5.3.3 OU Site Characterization Activities

Subsurface soil data will be collected to further characterize the source of contamination at a number of sites, particularly in OU-1. The subsurface soil data will be acquired through collecting and analyzing subsurface soil samples and making visual examinations and field measurements during drilling activities.

The OU field investigations will be conducted under the guidance of the OU-specific FSPs, and the generic QAPP and HASP work plans developed during Task 1. All of the sample locations have been identified on maps provided in the OU-specific FSPs. Data management and QA/QC activities will be conducted in accordance with the procedures outlined in the generic QAPP, and onsite health and safety procedures described in the generic HASP will be followed. The following field activities will be conducted:

- Installation and sampling of new monitoring wells
- Collection and laboratory analysis of surface soil samples
- Drilling, sampling, and geotechnical and chemical analysis of shallow soil borings and stratigraphic test borings
- Surveying of stratigraphic test borings and monitoring wells
- Sampling and analyzing groundwater samples from existing monitoring wells
- Collecting and analyzing appropriate QA/QC samples
- Surface water and sediment sampling of both perennial and ephemeral water bodies and drainage canals
- Geophysical surveys of documented burial sites

5.4 Task 4—Sample Analysis and Validation

This task involves development of a data management system, including field logs, sample management and tracking procedures, and QA/QC procedures for both laboratory data and field measurements. The purpose of the data management system is to ensure that the data collected during the investigation are of adequate quality and quantity to support the risk assessment and the FS. The data collected will be validated at the field or laboratory QC level to determine whether it is adequate for its intended use. A detailed description of the field and laboratory data validation procedures are described in the QAPP.

In general, all field and analytical data will be reviewed for the following:

- Completeness—Completeness, expressed as a percentage, is a measure of the amount of valid data obtained from the measurement system compared to the amount that was expected.
- Comparability—The comparability between data gathered during different sampling rounds will be determined and described in the DDMT RI/FS report.
- Correctness—A check will be made of all mathematical calculations, units, significant figures, and data transpositions.
- Accuracy—Measured values will be compared to known values (spiked samples). Accuracy will be reported as a relative percent difference (RPD).
- Precision—The reproducibility of measurements will be determined by making repeated measurements of the same quantity (split) samples. Precision will be reported as a standard deviation.
- Representativeness—In a laboratory setting, criteria are usually evaluated according to data credibility, on the basis of the QA officer's past experience with similar samples.

5.5 Task 5—Data Evaluation

This task includes reduction, tabulation, and evaluation of data obtained from the site investigation phases to be included in the RI/FS report(s). Results of analyses will be summarized and tabulated in a logical manner so that the relationships between site investigation measurements in the different media are readily apparent. The data will be summarized in the RI/FS report to describe the nature and extent of contamination, as well as the expected fate of the contaminants and the expected transport mechanisms that influence the migration of the contaminants.

A copy of all data collected will be supplied to TDEC and to EPA as specified in the FFA.

5.6 Task 6—Risk Assessment

A BRA will be conducted to assess the potential human health and environmental risks posed by the DDMT sites. This effort will involve the following components—contaminant identification, exposure assessment, toxicity assessment, and risk characterization. The BRA will be prepared in accordance with the *Risk Assessment Guidance for Superfund (Volumes I and II)* (ref. 66), the *Superfund Exposure Assessment Manual* (ref. 81), the *Exposure Factors Handbook* (ref. 80), and the Supplemental Region IV Risk Assessment Guidance (ref. 82).

After completion of the site characterization activities, including data validation, a detailed outline of the BRA will be provided to the state and EPA for review. Upon acceptance of the outline by both parties, a draft BRA will be developed and submitted for approval. The BRA will then be incorporated in the RI/FS report. Its components of the BRA are discussed in detail in the following sections.

Although the potential contaminants of concern were identified in the BRA portion of the RI Report (ref. 18) for DDMT), they will be re-evaluated, based on results of the additional investigation activities in the OU FSPs. The contaminants of concern will be selected on the basis of their concentration and health-based exposure criteria, their presence in large quantities or high concentrations, or because they are currently in, or potentially may migrate into, critical exposure pathways.

An exposure assessment will be conducted to identify actual or potential exposure pathways, to characterize potentially exposed populations, and to evaluate the actual or potential extent of exposure. A water well survey was conducted as part of the RI (ref. 18) to identify potential shallow groundwater users. Identification of potential human and ecological receptors, which was also conducted as part of the RI and presented in the RI Report (ref. 18), will be augmented.

Although a toxicity assessment of the originally identified potential contaminants of concern was conducted during the RI (ref. 18), additional toxicity information will be obtained during the next phase of activities. This information will be used to expand the assessment of adverse health or environmental effects associated with the contaminants found at DDMT.

The information obtained from the studies cited above will be integrated to determine the current or potential risk to human health and the environment posed by DDMT.

5.7 Task 7—Treatability Study and Pilot Testing

This task involves conducting bench or pilot studies to determine the suitability of remedial technologies to site conditions, if necessary. Technologies that may be suitable to the site will be identified as soon as possible to determine whether there is a need to conduct treatability studies. A treatability work plan will be prepared if deemed necessary.

The treatability work plan will identify the types and goals of the study, the level of effort needed for the study, a schedule for completion, and the data management guidelines to be used in the study. The work plan will be submitted to the state and EPA for review and approval. Upon approval, the test facility and equipment needed for the study will be procured by DDMT.

Upon completion of the treatability testing, the effectiveness of the technologies tested will be assessed. A report summarizing the testing program and its results will be submitted as part of the final RI/FS report.

5.8 Task 8 – Remedial Investigation Report

The DDMT RI report(s) will document the conclusions drawn during the remedial investigation of each OU and will include results of the BRA. The RI report(s), along with the FS report(s), will be submitted to the state and EPA for review and approval, and a final RI/FS report will be prepared reflecting those comments.

In addition to the RI report, brief quarterly progress reports will be prepared for submittal to the state and EPA project managers. The following items will be included in the quarterly reports:

- A description of actions taken since the previous report toward completing the RI/FS, updates or results, and findings
- The date such actions were completed
- A description of all work, procedures, and submittals for the next two reporting periods
- A description of all major modifications to the work plans made in the field
- The identification of any event that might cause a delay in the work and a summary of efforts made to mitigate the delay
- A list of documents, including field logs, drilling logs, surveys, laboratory test results, and other field data produced or generated since the previous report

5.9 Task 9—Remedial Alternatives Development and Screening

This task includes development of a range of distinct management alternatives designed to remediate any contaminated media, including soil, groundwater, surface water, and sediments, to provide adequate protection of human health and the environment. The proposed alternatives will encompass the following range: (1) alternatives in which treatment is used to reduce the toxicity, mobility, or volume of the waste while varying in the degree to which long-term management of the waste is required; (2) alternatives involving containment with little or no treatment; and (3) alternatives involving no action.

The following steps will be conducted to determine the range of alternatives for DDMT:

- Establish most probable conditions and reasonable deviations
- Establish remedial action objectives and general response actions
- Identify and screen technologies
- Configure and screen alternatives

On the basis of the information available after the site characterization activities, remedial action objectives to protect human health and the environment will be developed for DDMT. The objectives established early in the investigation process will specify the contaminants and media of concern, the exposure routes and receptors, and PRGs. A draft technical memorandum (TM) specifying the remedial action objectives will be prepared and submitted to the state and EPA for review and comment. A final remedial action objective TM will be submitted incorporating the comments. Upon completion of the RI and the BRA, final remediation goals will be established.

After approval of the remedial action objectives by the state and EPA, general response actions for DDMT will be developed. On the basis of the general response actions, treatment technologies will be identified and screened to ensure that only the technologies applicable to the contaminants present will be considered. The need for treatability testing for the most probable technologies will be determined during this phase.

The potential technologies and process options will be combined into medium-specific alternatives. All of the information necessary for evaluation of the alternatives, including remediation time, flow and treatment rates, and required permits, will be obtained. The alternatives will then be screened with respect to effectiveness, implementability, and cost. Uncertainties are allowed for by developing contingency actions for each alternative.

A TM detailing the screened alternatives will be submitted to the state and EPA for comments. A meeting between the parties will be conducted to discuss which alternatives will be evaluated in the detailed analysis and to facilitate the identification of action-specific ARARs.

5.10 Task 10–Detailed Analysis of Remedial Alternatives

A detailed analysis of alternatives will be conducted for DDMT. The analysis will consist of an individual comparison of each alternative against the set of ten criteria listed below:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance
- Contingencies

Each individual analysis will include a technical description of each alternative that outlines the waste management strategy involved and identifies the pertinent ARARs associated with each alternative, and a description of the performance of that alternative with respect to each of the evaluation criteria. A table summarizing the results of the comparison, along with the description of each alternative, will be prepared and submitted in the form of a TM to the state and EPA for review and comment. A meeting will be held so that all parties can discuss the alternatives and select a preferred remedial alternative for DDMT.

5.11 Task 11–Feasibility Study Report

The RI portion of each RI/FS report will present a complete summary of the nature and extent of contamination and the BRA, as described in Section 5.6. The FS portion of the report will present the results of the remedial alternatives development and screening and the detailed analysis of alternatives. A draft RI/FS report will be submitted to the state and EPA for review and comment. Comments will then be incorporated into the final DDMT RI/FS report.

5.12 Task 12–Post-RI/FS Support

The tasks to be performed after submittal and approval of the RI/FS report include preparation and submittal of Proposed Plan(s) and RODs. Finally, remedial design(s) will be developed, followed by a remedial action work plan(s).

5.12.1 Proposed Plan

The Proposed Plan(s) for DDMT will summarize the results of the RI/FS and identify the alternative that appears to best satisfy the criteria for site remediation as well as presenting plans for site monitoring and for dealing with contingencies. The Proposed Plan will also summarize the position of the state resulting from its review of the RI/FS and the draft Proposed Plan. After review and comment of the draft document by the state and EPA, the revised Proposed Plan will be issued for public review and comment.

5.12.2 Responsiveness Summary

A Responsiveness Summary will be prepared as part of the ROD to provide a summary of public comments on the Proposed Plan.

5.12.3 Record of Decision

After the public comment period on the RI/FS and the Proposed Plan, the final selection of a remedial action will be made for DDMT. If the original preferred alternative is determined to be the most appropriate remedy, that alternative will be selected. If not, the DLA, in conjunction with the state and EPA, will select another alternative that is more appropriate. In any case, the selected remedy will be documented in the ROD. The ROD will summarize the problems posed by the site, the technical analysis of alternatives, and the technical aspects of the selected remedy that will later be refined into design specifications. The ROD acts as a legal document that demonstrates that the RI/FS has been carried out in accordance with statutory and regulatory requirements. The ROD also presents the long-term monitoring plan to evaluate risk reduction and, further, presents a plan to deal with contingencies at the site. A draft ROD will be prepared in accordance with the *Draft Guidelines on Preparing Superfund Decision Documents* (ref. 83), and submitted to EPA and to the state for review and comment. The final ROD will then be submitted, approved and signed, and made available for public inspection before remedial action begins.

5.12.4 Post-ROD Activities

After approval of the ROD, a remedial design work plan will be developed for DDMT. Upon approval of the work plan by the state and EPA, the development of the remedial design will begin, with EPA and state review and comment periods at negotiated stages

of design completion (such as 30 percent, 60 percent and 95 percent completion). After submittal and approval of the final remedial design, a remedial action work plan will be developed and approved, after which the remedial action will begin. Monitoring during remediation and long-term monitoring may be required.

5.13 Task 13 – Enforcement Support

This task includes efforts associated with enforcement aspects of the project at any time during the RI/FS. Typical activities include the following:

- Attending negotiation meetings
- Preparing briefing materials
- Providing task management and QC

5.14 Task 14 – Miscellaneous Support

This task includes work that is associated with the project, but that is outside the RI/FS activities described previously.

TAB

Section 6 - Project Schedule

6.0 Project Schedule

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It is of critical importance to meet the schedules imposed by the FFA and the SMP for DDMT. This section describes the management techniques that will be employed to monitor project progress. Although the FFA specifies procedures for the extension of agency comment periods, dispute resolution procedures, or for other items that may affect the project schedule, these items will not be described in this section.

6.1 Preparation of a Project Schedule

A detailed project schedule has been prepared for each OU and for the Screening Sites to show all the activities required by the FFA according to their start dates, end dates, and their durations. These schedules have been submitted to the regulatory agencies in the SMP (ref. 84). To minimize the need to update multiple documents because of schedule changes, these schedules will be kept in the SMP and will not be added to any other RI/FS work plan document.

6.1.1 Submittal Schedule

The deliverables listed in the SMP are classified as primary or secondary documents, in accordance with the FFA. A primary document is one in which a document in draft form is submitted to the state and EPA for review and comment. In general, the comment period will be 60 days. In most cases, after the comment period, a meeting will be held to discuss the comments and how they will be incorporated into the final document. The comments will then be incorporated into the final document as the parties have agreed, and the final document will be submitted to the state and EPA for approval.

In the case of a secondary document, the document will be submitted to the state and EPA for review and comment. As specified in the FFA, DDMT will prepare a written response to the comments stating how they will be addressed. The comments will then be incorporated into the next scheduled primary document submittal.

6.1.2 Meeting Schedule

As part of the project schedule, a number of scheduled meetings will be held. These meetings will generally be held at the end of a state and EPA comment period for primary or secondary documents, depending on the particular document. The purpose of the meetings will be to discuss the comments and how they will be incorporated into the revised document(s) and to resolve any differences that may exist.

In addition to the meetings described above, quarterly meetings between the state, EPA, and DDMT will be held to discuss project progress.

6.2 Monitoring Project Progress

The project schedule is monitored by comparing weekly estimates of project progress with actual project progress. The estimated percentages of each task completed are compared weekly with the percent of time budgeted for that task that has elapsed. Similarly, the percentage of the project completed is compared with the percent that was planned to be completed at that time.

The project schedule will be updated regularly using actual completion dates and revised estimates of time to perform major items of work, to predict the completion dates of future activities as accurately as possible. In addition, the schedule will be revised when work days are lost to adverse weather, mechanical failures, or other problems.

6.3 Corrective Action for a Schedule Breakdown

Because meeting the schedule is of paramount importance to the success of the project, corrective actions must be formulated and implemented immediately after a schedule breakdown has been detected. In the event of a schedule breakdown, the procedures outlined in the FFA will be followed.

TAB

Appendix A - References

Appendix A
References

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TAB

Appendix B - Toxicity Profiles

Appendix B
Toxicity Profiles

ARSENIC

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Introduction:

Arsenic is a naturally occurring element in air, water and food and is usually found in combination with other elements. In general, inorganic arsenic is more toxic than organic arsenic. Arsenic enters the environment as a result of natural forces (volcanoes, weathering) and human activities such as metal smelting, glass manufacturing, pesticide production and application and fossil-fuel burning (ATSDR,1987).

Metabolism:

Ingestion of arsenic in food or water is the the most common exposure route. Inhalation and skin contact are secondary routes. Arsenic is quickly absorbed through the lungs or digestive tract into the bloodstream. Within a few hours, most arsenic is cleared from the blood and is excreted in the urine. Inorganic arsenic is metabolized to the organic forms monomethlyarsonic acid (MMA) and dimethlyarsinic acid (DMA). Methylation is considered the primary detoxification scheme for inorganic arsenic (ATSDR,1987).

Animal studies indicate that low levels of arsenic may be necessary to good health, though no cases of arsenic deficiency in humans have been reported. The human diet normally represents the largest source of arsenic exposure with an average rate of ingestion of 25-50 ug/day of arsenic (ATSDR, 1987; USEPA, 1987).

Acute and Chronic Effects:

Large oral doses (human oral L_{D50}: 0.6-2 mg/kg) of inorganic arsenic induce death, while smaller doses produce systemic effects such as irritation of the digestive tract, with pain, nausea, vomiting and diarrhea. In addition, there are hematopoietic effects, abnormal heart function, blood vessel damage, liver and/or kidney injury and impaired nerve functioning (i.e.,. tingling of the hand and the feet).

Oral exposure to inorganic arsenic produces characteristic hyperpigmentation and "corn"-like skin eruptions called hyperkeratoses. A small number of hyperkeratoses digress to skin cancer.

Low level exposure to inhaled arsenic can also produce the systemic effects seen with ingestion. Dermatitis and mucous membrane irritation are the primary symptoms reported with occupational exposures to inorganic arsenic (ATSDR, 1987).

Carcinogenic Effects:

Reliable epidemiological data demonstrates an association between occupational exposure to inhaled arsenic and lung cancer. Human populations studied include smelter workers, pesticide manufacture workers and arsenical pesticide applicators. The OSHA PEL is set at 10 ug/m^3 (29 CFR 1910.1018). ACGIH suggests a TLV TWA of 0.2 mg/m^3. and soluble compounds. NIOSH has a ceiling Recommended Exposure Limit of 2 ug/m^3 (ACGIH,1987; ATSDR, 1987).

An excess prevalence of non-melanoma skin cancer is seen in Taiwanese populations which consume drinking water with above average arsenic concentrations. Arsenic-containing medicinals also are thought to contribute to a higher risk of skin cancer. This Taiwanese population also exhibited a higher prevalence of internal organ cancers (bladder, liver, kidney) (USEPA, 1987; 1988) U.S. epidemiological studies have not supported the skin cancer and inorganic arsenic relationship, but are hampered by small sample size.

Various forms of inorganic arsenic have been administered to various species of test animals by ingestion and inhalation. Animal studies have provide no consistent indication that arsenic is carcinogenic. The animal oral LD_{50} is approximately 20-150 times greater than the human LD_{50}. Animal data has little value in estimating a dose-response relationship in humans(ATSDR,1987; USEPA, 1988).

Arsenate and arsinite transform Syrian hamster embryo cells and produces sister-chromatid exchange in cultured mammalian cells. Arsenic is a weak inducer of gene mutations in vivo (USEPA, 1988).

Quantitative Estimate of Carcinogenic Risk:

The EPA has calculated a quantitative estimate of carcinogenic risk (lung cancer) for the inhalation exposure route. The Inhalation Slope factor is set at 1.5E+01 mg/kg/day. The slope factor is the cancer risk (proportion effected) per unit of dose and can be used to compare the relative potency of different substances on the basis of chemical weight. The unit risk is the increased risk of cancer associated with a lifetime exposure of 1 ug/m^3 and is set ate 4.3E-03. The unit risk for skin cancer from oral arsenic exposure in drinking water is 5E-05 for 1 ug/L lifetime exposure (proposed) (USEPA, 1988).

Regulatory levels of concern:

Safe Drinking Water Act:
    MCL and MCLG for Drinking Water: 50 ug/L

Clean Water Act:
    Ambient Water Quality Criteria, Protection of Human Health:
        Water & Fish Consumption:2.2E-03 ug/L
        Fish Consumption: 1.75E-02 ug/L
    Ambient Water Quality Criteria, Aquatic Organisms:
        Freshwater:Acute-3.6E+02 ug/L;Chronic-1.9E+02 ug/L
        Marine: Acute-6.9E+01 ug/L;Chronic-3.6E+01 ug/L

Kentucky Water Quality Solid Waste Standards:

Warm Water Aquatic Habitat Criteria:50 ug/L
Maximum Ground Water Contaminant Levels:50 ug/L

EPA Health Advisories: 50 ug/l proposed for all HAs

No reference dose (RfD) has been proposed for arsenic. Bioaccumulation of arsenic to toxic levels within the food chain is a concern. Arsenic is listed under RCRA for ground water monitoring. Under CERCLA, the reportable quantity (RQ) of arsenic for release into the environment is set at one pound (ATSDR, 1987).

Environmental Concerns:

Inorganic arsenic is a non-volatile solid. Solubility varies widely according to the compound. Soluble inorganic compounds of As(III) are the principal toxic species, but soluble inorganic compounds of As(V) are also of concern. Mobility of arsenic in the environment is related to the solubility of the species. Eighty-one percent of the arsenic released is deposited on land. Surface water sources include urban run-off, pesticide application and zinc production. Most arsenic in the air is adsorbed to particulate matter and settles out according to particle size.

Arsenic in the soil is predominantly an insoluble, adsorbed form. Some soils, such as limestone, have a greater holding capacity for arsenic. A pH change or a change in redox potential may lead to resolubilization of fixed arsenic. Arsenic in soil and water may be reduced and methylated by soil organisms, but the rate of volatilization into the air may vary considerably.

For freshwater aquatic species, the one-hour average concentration once every 3 years for inorganic As(III) should not exceed 360 ug/L (USEPA, 1987b). Embryos and larvae of aquatic vertebrates suffer damage at acute levels as low as 40 ug/L. Freshwater crustacean species are more than twice as sensitive to trivalent arsenic than the fish species tested. Of the seven fish species studied, the LC_{50} ranged from 13,340 to 41,760 ug/L. The sensitivity of freshwater aquatic plants is comparable to that for sensitive invertebrate species in acute toxicity testing (USEPA, 1980). Freshwater plants appear to be considerably more sensitive to As(V) than to As(III) (USEPA, 1987b). The Commonwealth of Kentucky has set the Warm Water Aquatic Habitat Criteria at 50 ug/L (401 KAR 5:031 (4)).

Acute values for trivalent inorganic As range from 232 to 16,030 ug/L in the 12 saltwater species studied (USEPA, 1987b). For saltwater aquatic species, the one-hour average concentration should not exceed 69 ug/L more than once every three years on the average. Fish species are less sensitive than bay scallops or oyster embryos. Shellfish show a greater bioaccumulation of arsenic than fish species.

One freshwater life-cycle study done on Daphnia magna found a chronic toxicity value of 912 ug/l. There is little data on saltwater chronic toxicity. No Residue Limited Toxicant Concentration (RLTC) for inorganic arsenic has been determined, since no maximum permissible tissue concentration for arsenic is available (USEPA, 1980).

The EPA Office of Pesticide Programs has restricted the use of inorganic arsenic for pressure-treated wood and is reviewing the use of inorganic arsenic for non-wood preservative use (ATSDR, 1987).

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BARIUM

Introduction:

Barium is a reactive yellowish-white metal of the alkaline earth group. It is not found free in nature, but as salts. The most common salts found are barite, $BaSO_4$, and witherite, $BaCO_3$, both of which are highly insoluble. The metal is stable in dry air, but readily oxidizes in humid air or water. Many barium salts are soluble in both water and acid. Barium ions are generally thought to be rapidly precipitated or removed from solution by absorption and sedimentation. Barium occurs at low levels in most surface and ground waters with reported levels of less than 340 ug/L (USEPA,1987).

Barium is a malleable, ductile metal, but its primary commercial value is in its compounds. Barium compounds are used in a variety of industrial applications including the metallurgic, paint, glass, and electronics industries, as well as for medicinal purposes. Although it is used in a number of commercial processes, contamination of drinking water is usually the result of naturally-occurring barium and not industrial releases (USEPA,1987).

Food is the primary exposure route for humans since most foods contain a low level of contamination. Many edible plants and fish take up barium from soil or water sources. Barium is also found in most drinking water supplies, at concentrations usually less than 200 ug/L (USEPA,1987).

Metabolism:

Barium is absorbed into the blood stream from the gastrointestinal tract after ingestion or the lungs after inhalation. Little is absorbed through the skin. Barium absorption after oral ingestion has been estimated to be approximately 5% in adults, but it may be greater than this, especially in children. The skeletal metabolism of barium in humans is qualitatively similar to that of calcium, although the incorporation of these two elements is quantitatively very different. It is not likely that barium accumulates in the bone, muscle, kidney or other tissues. In humans, ingested barium is readily eliminated principally via fecal excretion (approximately 72%) (USEPA,1987).

Acute Toxicity:

Ingestion of high doses (>550 mg.) of barium are reportedly fatal to man. Ingestion of soluble barium compounds may also result in effects on the gastrointestinal tract, causing vomiting and diarrhea, and on the central nervous system, causing violent tonic and clonic spasms followed in some cases by paralysis. Barium salts are considered to be muscle stimulants, especially for the heart muscle (USEPA,1987).

Chronic Toxicity:

High blood pressure has been seen in animal tests. No other organ systems have been reported as being affected by chronic doses of barium. There have not been adequate studies on the carcinogenicity, teratogenicity, or mutagenicity of barium to date. The National Academy of Sciences has derived a chronic Suggested No-Adverse-Response Level (SNARL) value for barium of 4.7 mg/L (USEPA,1987).

Regulatory Standards:

Occupational exposures:

OSHA PEL (for soluble compounds)	0.5 mg/m3	TWA
OSHA PEL (proposed for Barium sulfate)	10.0 mg/m3	TWA
ACGIH	0.5 mg/m3	TWA

Safe Drinking Water Act:
    MCL: 1.0 mg/L

Clean Water Act:
    Ambient Water Quality Criteria, Human Health
        Water and Fish Ingestion: 1.0 mg/L
    Ambient Water Quality Criteria, Aquatic Organisms
        None

RCRA Health-based Criteria, Rfd:
    900 mg/kg
(ACGIH,1988).

Environmental Effects:

Experimental data indicate that the soluble barium concentrations in fresh and marine water generally would have to exceed 50 mg/L before toxicity to aquatic life would be expected. In most natural waters, there is enough sulfate or carbonate to precipitate the barium present in the water as virtually insoluble, non-toxic compounds (USEPA,1987).

Reference:

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CHROMIUM

Introduction:

Chromium(Cr) is a steel-gray lustrous metal which exists in nature in three valence states:+2, +3 and +6. Chromium is used in metal alloys, chromeplating, photography, pigments, textiles, cooling water, leather tanning, fungicides and wood preservatives (HSDB,1988).

Metabolism:

Chromium occurs naturally in foods and is considered vital to the metabolism of fats and sugars. Chromium in the environment is absorbed via ingestion, inhalation and skin contact. Physiological responses to chromium and its compounds are varied. Hexavalent Cr is considered the most toxic valence state and is the form seen in most waste streams. The following discussion will be confined to hexavalent chromium[Cr(IV)] unless otherwise noted.

Approximately two percent of ingested chromium is absorbed from the gastrointestinal tract. Soluble chromate compounds are quickly absorbed through the skin. In man, the most efficient means of absorption is via the lungs. After absorption, hexavalent Cr is quickly converted to trivalent Cr. While chromium accumulates in the fat and the lungs, the majority of absorbed chromium is quickly excreted via the urinary tract (80%) (HSDB, 1988).

Acute Toxicity:

Inhaled chromium irritates the mucous membranes causing sneezing, redness of the throat and generalized bronchial spasms. Dermal chromium exposures result in skin ulcers which may penetrate deeply into soft tissues via sweat glands. Secondary skin infections often follow, but dermal exposure to chromium is not associated with skin cancer.

Ingested chromium may cause intense GI irritation, violent epigastric pain, nausea, vomiting, severe diarrhea, hemorrhage, circulatory collapse, unconsciousness and death. The lethal dose for hexavalent chromium is estimated to be 10 mg/kg of body weight. A chromium dose of 0.2 mg/kg or greater produces marked necrosis of the kidneys. Chromium exposure depletes the body's ascorbic acid which is normally protective against strong oxidizers such as hexavalent chromium. At 1.56 mg/kg Cr, respiratory enzymes in rat and heart muscle mitochondria are powerfully inhibited (HSDB, 1989).

Chronic Toxicity:

Within one year of employment, workers from a chrome plating plant demonstrated nasal perforation or ulceration. Airborne concentrations for this plant ranged from 0.71 to 9.12 ug/m^3 in the plating areas.

Prolonged inhalation of chromium dust is associated with chronic respiratory irritation with an abnormal increase in the blood supply, emphysema, and chronic inflammation and congestion of the upper respiratory tract. A concentration of 134 ug/L Cr in drinking water over 2 to 3 months produced liver and kidney lesions in rats.

The human fetus accumulates chromium ten times faster than adults. Chromium concentrations in body tissues decrease with increasing age. Impaired reproductive function and sterility were found in rats receiving 0.125% chromium in feed. Chromium interacts with bacterial DNA by causing frameshift mutations and basepair substitutions (HSDB,1988).

Carcinogenicity:

Epidemiological evidence indicates a strong relationship between occupational chromium exposure and lung cancer. The latency period was 10.6 to 21 years. Workers exposed to 400 ug/m^3 for an average of 6.6 years showed an increased incidence in papillomas of the oral cavity and larynx (benign).

Rats injected with varying doses of chromium developed round-cell sarcomas, hemangiomia, papillary adenomas of the lungs and squamous-cell carcinoma. Vegetables from gardens containing high levels of Cr in the soil were associated with an excess incidence of stomach and intestinal cancers. Total chromium in U.S. soils ranges from less than 1 to 1,000 mg/kg with an average of 100 mg/kg (IRIS, 1988; HSDB, 1988).

Levels of Concern:

Occupational guidelines for soluble chromic or chromous salts include:

OSHA PEL	500 ug/m^3	TWA
NIOSH	25 ug/m^3	TWA, non-carcinogenic Cr(VI)
	1 ug/m^3	TWA, carcinogenic Cr(VI)
ACGIH TLV	50 ug/m^3	TWA, water soluble Cr(VI)

Safe Drinking Water Act:
MCL: 0.05 mg/L
MCLG: 0.12 mg/L

Clean Water Act: Chromium (VI)
Ambient Water Quality, Human Health
Water and Fish Consumption-5.0E+01 ug/L
Fish Consumption-None
Ambient Water Quality, Aquatic Life
Freshwater:Acute-1.6E+01 ug/L; Chronic-1.1E+01 ug/L
Saltwater: Acute-1.1E+03 ug/L; Chronic-5.0E+01 ug/L

Chromium is listed under RCRA for ground water monitoring. The Reportable quantity for release into the environment is 1 pound (proposed) (IRIS, 1988).

Environmental Effects:

Airborne chromium is primarily removed from the atmosphere by fallout and precipitation and enters surface water and soil. Most Cr(VI) exists as $Cr_2O_7(-2)$ or $CrO_4(-2)$. Chromium is present in small quantities in all soils and plants, but is considered an agriculturally deleterious element. Toxic plant effects begin as low as 0.1 mg/kg Cr(VI). Exposed plants show growth retardation, leaf rolling, wilting and discolorations. Greatest plant toxicity occurs in acid sandy soils with low organic content (USEPA, 1979).

In water, Cr(VI) is eventually reduced to Cr(III) by organic matter in the water. Residence time of chromium in lake water is 4.6 to 18 years. The 96 hr. LC_{50}s for fathead minnows and goldfish in softwater is 3 and 18 ug/L, respectively. Inhibition of algal growth occurs at 0.03 to 64 ug/L. The bioconcentration factors for several forms of aquatic life range from 1 for rainbow trout to 2,300 for phytoplankton. Cr(VI) is mobile in ground water and is sometimes used as a tracer to follow ground water flows. Hexavalent chromium is not strongly absorbed to clays, but is quickly reduced to insoluble chromium(III) compounds in soils with a high organic content (USEPA,1989).

References:

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LEAD

Lead is a commonly used, naturally occurring metal which is ubiquitous throughout the environment. Lead is found in construction materials, leaded gasoline, radiation protection gear, paint, ceramics, plastics, lead oxide and antimonial lead storage batteries and ammunition.

Metabolism:

Lead is well absorbed from all portions of the respiratory tract including the nasal passages. Absorption from the gastrointestinal tract is less rapid and complete than from the respiratory tract. Dermal absorption is a much less significant route of lead absorption than inhalation or ingestion. Most of the absorbed lead is distributed to the soft tissues of the body with the greatest distribution to the kidneys and the liver. Lead is eventually transferred to the skeleton where 90% of the body's long-term burden is stored. Approximately 70% of the absorbed lead dose is excreted.

Acute Toxicity:

Lead intoxication can occur by ingestion and inhalation of dust or fumes in humans. Lead interferes with the synthesis of heme, oxidative phosphorylation and synaptic transmission in the peripheral nervous system at blood levels of 30-50 ug/dL. Symptoms of lead intoxication include anorexia, malaise, headaches and intestinal spasms. The neuromuscular syndrome, lead palsy, is a manifestation of advanced subacute poisoning (lead blood levels of 70 ug/dL and less) and is characterized by muscle weakness leading to paralysis. Lead encephalopathy is the term for the central nervous system manifestation which is commonly seen in children when lead blood levels reach 80 ug/dL. Symptoms include clumsiness, vertigo, ataxia, delirium, convulsions and coma. The mortality rate is 25% for cerebral involvement with survivors suffering long-term neurological sequelae.

Chronic Toxicity:

Lead toxicity is exhibited by the brain and central and peripheral nervous system, the kidneys and the hematopoietic system. Lead poisoning causes peripheral neuropathy in adults and children. Chronic low level lead exposure (lead blood levels of 30-50 ug/dL) is associated with learning disabilities. Lead toxicity is defined by the Centers of Disease Control as a blood level of > 30 ug/dL (child). Damage at lower levels has been reported and the blood level will be revised to approximately 25 ug/dL.

Renal insufficiency occurs after prolonged exposures and is apparently reversible. In epidemiological studies, lead intoxication is also associated with increased blood pressure which is symptomatic of renal damage. Hematopoietic effects include decreases in heme production, microcytosis and anemia.

Lead exposure is associate with reproductive effects such as miscarriages and transitory sterility. Lead readily crosses the placenta. Human studies searching for chromosomal aberrations in exposed populations have been equally positive and negative. Genotoxicity testing in nonhuman, mammalian cell assays have given mixed results. In all systems, the concentrations of essential nutrients and elements have a significant impact on the degree of toxicity seen with lead exposures.

Carcinogenicity:

Occupational exposure to airborne lead is associated with an increased incidence of total malignant neoplasms, cancers of the digestive tract and cancers of the respiratory tract. An increased incidence in renal cancer was seen in lead smelter workers exposed via inhalation and in various animal species exposed via ingestion at levels of 500 ppm and above.

Levels of Concern:

The USEPA has set a primary National Ambient Air Quality Standard (NAAQS) for lead of 1.5 ug/m^3. The USEPA has proposed a 10-fold reduction in the Maximum Contaminant Level (MCL) for Drinking Water to 5 ug/L. Other environmental criteria include:

Ambient Water Quality Criteria, Protection of Human Health:

Fish and Water Consumption:	50 ug/L
Fish Consumption:	none

Ambient Water Quality Criteria, Aquatic Life:

Freshwater:Acute-82 ug/L; Chronic-3.2 ug/L

Saltwater: Acute-140 ug/L:Chronic-5.6 ug/L

The FDA regulates the amount of lead leaching from ceramics and flatware.

Occupational guidelines for lead exposure include:

NIOSH TWA: 0.10 mg/m^3

ACGIH TLV: 0.15 mg/m^3

Environmental Concerns:

The mobility of lead in soil is dependent on the cation exchange capacity and pH of the soil. Lead can react with anions such as sulfates, carbonates and phosphates or combine with clays and organic matter which limits the further migration of lead through the soil matrix. Lead in surface waters is usually present as suspended solids. Atmospheric lead is removed by dry deposition and rainout.

Lead does not significantly bioaccumulate in fish with the BCFs for freshwater fish ranging from 1.38 to 1.65. Lead localizes in fish skin which serves to reduce human exposures via fish consumption. Lead is toxic to wildlife, particularly water fowl, by their consumption of lead shot. The growth of algae is inhibited at levels above 500 ug/L. Tetraethyl lead is biogradable, but inorganic lead concentrations above 5 ug/L can be toxic to microorganisms.

The acute sensitivities of 10 freshwater species range from 142.5 ug/L (amphipod) to 235,000 ug/L (midge). As water hardness increases, the acute toxicity of lead to freshwater aquatic species decreases.

References:

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2) Callahan et al., Quality Criteria for Water, 1986. USEPA:OWERS. EPA 440/5-5-86-001.

3) HSDB, 1988. Hazardous Substances Data Base, National Library of Medicine, Bethesda, Maryland.

4) USEPA, 1983. US Environmental Protection Agency. Hazardous Waste Land Treatment. USEPA:OSWER. SW-874.

5) USEPA, 1988. US Environmental Protection Agency. IRIS Database, Cincinnati, Ohio: Environmental Criteria & Assessment Office.

MERCURY

Introduction:

Mercury is a common constituent of the earth's crust and is found as a sulfide, chloride or oxide at levels ranging from 10 to 500 PPB. Organic mercury can bioaccumulate in the food chain, but is not commonly found in ground and surface waters. Naturally occurring mercury in ground and surface water is generally less than 0.5 UG/L.

Metabolism:

Seven to fifteen percent of ingested inorganic mercury is absorbed by humans. Most of the body burden for mercury accumulates in the kidney. Most inorganic mercury (85%) is excreted in the feces. With organic mercury, most is excreted via the urine.

Acute Toxicity:

The lethal dose for mercuric salts in humans is 1 to 4 grams. Ingestion of 1.5 grams of $HgCl_2$ produced vomiting, severe abdominal pain with a brief loss of consciousness.

Rats, receiving subcutaneous doses of $HgCl_2$, developed renal disease with deposits in glomeruli and renal arteries. Proteinurea and a nephrotic syndrome were observed.

Chronic Toxicity:

There is no data on long-term exposure of humans to inorganic mercury. Rats receiving mercuric acetate orally showed a decrease in body weight gain and pathologic change in the proximal convoluted tubules of the kidney. Inorganic mercury, very possibly, has a developmental effect, but no reproductive, mutagenic or carcinogenic effects have been documented.

Levels of Concern:

Occupational guidelines include:
ACGIH TLV:alkyl compounds-0.01 MG/M^3, TWA
OSHA PEL:Organo mercury compds.-0.01 MG/M^3, TWA

Environmental guidelines include:
Safe Drinking Water Act:
MCLG:2 UG/L
Clean Water Act:
Ambient Water Quality Criteria, Human Health:
Water and Fish Consumption:144 NG/L
Fish Consumption: 146 NG/L
Ambient Water Quality Criteria, Aquatic Life:
Freshwater:Acute-2.4 UG/L;Chronic-0.012 UG/L
Saltwater: Acute-2.1 UG/L;Chronic-0.025 UG/L

Environmental Concerns:

Mercury has a strong tendency to bioaccumulate in aquatic life. Mercury enters the environment from numerous industrial sources. Mercury moves very slowly through soils. It readily precipitates out of leachate at pH values above seven. Aquatic plants such as algae tend to accumulate Hg relative to its concentration in the water. Uptake by plants can be minimized by maintaining a soil pH above 6.5 or reacting Hg with selenium and cadmium in the soil.

References:

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POLYCYCLIC AROMATIC HYDROCARBONS

Introduction:

Polycyclic aromatic hydrocarbons (PAHs) are a diverse class of compounds formed as a result of incomplete combustion of organic compounds with insufficient oxygen. This leads to the formation of C-H free radicals which can polymerize to form various PAHs. Among these PAHs are compounds such as benzo[a]pyrene (B[a]P), benz[a]anthracene (B[a]A) and dibenz[a,h]anthracene(DB[a,h]A) (ATSDR(a)(b)(c),1988).

PAHs are present in the environment from both natural and anthropogenic sources. As a group, they are widely distributed in the environment, having been detected in animal and plant tissue, sediments, soils, air, and surface water. Humans may be exposed to PAHs in the environment, in tobacco smoke and cooked food, and in the work place. Typically, individuals are not exposed to a single type of PAHs, but to a mixture of related chemicals (ATSDR(a)(b)(c),1988).

Metabolism:

PAHs are readily absorbed into the blood stream from the gastrointestinal tract after ingestion or the lungs after inhalation. PAHs in animals has been reported to be excreted primarily through the hepatobilliary system and the feces. From the studies on the excretion of PAHs in animals, extensive bioaccumulation is not thought to occur (ATSDR(a)(b)(c),1988).

Toxicity:

There is no direct information available for the effects of PAHs on humans. All of the information available for PAHs are from studies on experimental animals. PAHs are well-established as experimental carcinogens for all routes for which humans would normally be expected to be exposed by. Noncarcinogenic effects reported for PAHs include skin lesions and noncancer lung diseases such as bronchitis. Benzo[a]pyrene has been associated with developmental toxicity and adverse reproductive effects in experimental animals (ATSDR(a)(b)(c),1988).

Regulatory Standards:

Occupational exposures:

OSHA PEL (B[a]P)	0.2 mg/m3	TWA
ACGIH		
(coal tar pitch volatiles)	0.2 mg/m3	TWA
(B[a]A)	0.1 mg/m3	TWA
NIOSH (coal tar products)	0.1 mg/m3	TWA

Safe Drinking Water Act:
No data available

Clean Water Act:
None

Benzo[a]pyrene is listed under RCRA for ground water monitoring. The World Health Organization European standards for drinking water recommend a concentration of PAHs not to exceed 0.2 ug/L (USEPA,1988).

Environmental Effects:

The environmental fate of PAHs are determined largely by their low water solubilities and high propensity for binding to particulate or organic matter. In the atmosphere they are associated with particulate matter, especially soot. In aquatic environments, PAHs are usually bound to suspended particles or bed sediments. PAHs suspended in the air is thought to undergo direct photolysis very quickly. The ultimate fate of PAHs in the sediment is believed to be biodegradation and biotransformation by benthic organisms (USEPA,1986).

PAHs in the water column also accumulate in organisms, but many organisms metabolize and excrete PAHs rapidly, resulting in short-lived bioaccumulation (USEPA,1986).

References:

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USEPA.1988. US Environmental Protection Agency. Iris Chemical File on Benzo[a]pyrene; CASRN 50-32-8 (3/1/88). Cincinnati, Ohio: USEPA, Env. Criteria & Assessment Office.

DIELDRIN

Introduction:

Dieldrin, a chlorinated hydrocarbon compound and member of a group of synthetic cyclic hydrocarbons called cyclodienes, has been widely used as a domestic pesticide. The primary use of the chemical in the past was for control of corn pests, although it was also used by the citrus industry. Current uses are restricted to those where there is no effluent discharge. Production in the United States has been restricted for all pesticide products containing dieldrin; however, formulated products containing dieldrin are imported each year from Europe for termite control by subsurface soil injection and for non-food seed and plant treatment (USEPA,1986).

Dieldrin is a white crystalline substance with a melting point between 176 and 177 C. It is soluble in organic solvents. The chemical name for dieldrin is 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,exo-1,4:5,8-dimethanonaphthalene (USEPA,1986).

Human exposure can result from water, food products, and air. Dieldrin is very persistent in the environment and is concentrated as it moves up the food chain. Dieldrin has been detected in all major river basins in the U.S. and the Mississippi delta. Because it is used in may parts of the world outside of the U.S., it can be assumed that imported food products contain residues of dieldrin. The overall concentration of dieldrin in the U.S. diet has been estimated at 43 ng/g of food consumed. Dieldrin enters the air through various mechanisms such as spraying, wind action, water evaporation and adhesion to particulates. An EPA study from 1970 to 1972 found dieldrin in over 85% of the air samples tested. Dermal exposure is limited to those involved in manufacturing or application of pesticides containing dieldrin, by dermal absorption. The potential for this exposure route has been reduced due to the bans on the manufacture and use of dieldrin (USEPA,1986).

Metabolism;

Dieldrin is absorbed into the bloodstream from the gastrointestinal tract after ingestion or the lungs after inhalation. It is widespread in the body immediately after intake, but within hours is usually concentrated in the fat tissues which it has a high affinity for due to it being extremely apolar. Other organs which tend to have high concentrations are the liver, kidneys, brain and blood. The concentration in the body tissues will continue to increase until an equilibrium is reached. If exposure to dieldrin is discontinued, dieldrin will be excreted, mainly in the feces, in the form of several metabolites that are more polar than the parent compounds. The dieldrin half-life in human blood has been found to be 0.73 years. It is thought that this value may reflect the overall half-life in other human tissues as well (USEPA,1986).

Acute Toxicity

The toxicity of dieldrin is highest by the intravenous route, followed by oral and then dermal. (The toxicity in experimental studies has been dependant upon the dieldrin to solvent ratio.) The oral acute lethal dose for man has been reported to be 70 mg/kg. Toxicity appears to be related to the central nervous system with symptoms of headache, dizziness, nausea, general malaise, and vomiting followed by muscle twitching, myoclonic jerks and even convulsions. Death may result from anoxemia (USEPA,1986).

Chronic Toxicity

The sub-acute or chronic dose of dieldrin for man has been reported to be between 3.1 ug/kg/day and 33.2 ug/kg/day. Studies of the National Cancer Institute and other groups have shown that dieldrin produces hepatic carcinomas in test animals and a higher liver-to-body weight ratio. Studies of pesticide workers in Holland have shown no long term effects (including cancer) from their exposures (mean average of 6.6 years). The findings of this and follow up studies have not been accepted by the entire scientific community due to the small number of workers studied and the short term of the study (USEPA, 1986).

Regulatory Standards

Occupational exposures:

OSHA PEL	0.25 mg/m3	TWA
ACGIH	0.25 mg/m3	TWA

Clean Water Act:

Ambient Water Quality Criteria, Human Health
    Water and Fish Ingestion - 7.1E-08 mg/L
    Fish Consumption Only - 7.6E-08 mg/L
Ambient Water Quality Criteria, Aquatic Organisms
    Freshwater: Acute - 2.5E-03 mg/L; Chronic - 1.9E-06 mg/L
    Saltwater: Acute 7.0E-02 mg/L; Chronic - 1.9E-06 mg/L

Dieldrin, under 40 CFR 261 is a P-listed hazardous waste. The U.S. Public Health Service Advisory Committee has recommended a drinking water standard of 17 ug/L (1969). The U.N. Food and Agricultural Organization/World Health Organization have recommended an acceptable daily intake of 0.0001 mg/kg/day (ACGIH, 1988) (USEPA, 1986).

Environmental Effects

Dieldrin is extremely persistent in the environment due to its extremely low volatility (i.e., a vapor pressure of 1.78E-07 mmHg at 20°C). The time required for 95% of dieldrin to disappear from soil has been estimated to vary from 5-25 years (depending on the microbial flora in the soil). Since dieldrin is extremely apolar, it is very fat soluble and is progressively accumulated in the food chain. It is retained in animal fats, plant waxes, and other such organic matter in the environment. Many organisms not in direct contact with contaminated water and sediment accumulate dieldrin from the food supply. Once it is in the fatty tissues of organisms, dieldrin remains stable when equilibrium is reached with the environment. Dieldrin is eliminated from the organisms when the environmental concentrations become lower. This dieldrin is then available for other organisms. Equilibrium is attained when the chemical concentration is constant. Bio-Concentration Factor (BCF) values range from 128 to 5,558 for lower plants and invertebrates and 2,385 to 68,286 for fish (USEPA,1986).

Plants are effected by concentrations over 100 times higher than that affecting fish and invertebrate species, so they are protected by animal derived criteria. The freshwater acute values range from 5.0 ug/L (isopods) to 740 ug/L (crayfish). Freshwater chronic values range from 0.22 ug/L (rainbow trout) to 57 ug/L (cladoceran) (USEPA,1986).

References:

ACGIH. 1988. American Conference of Governmental Industrial Hygienists. Threshold Limit Values and Biological Exposure Indices for 1988-1989.

USEPA. 1986. US Environmental Protection Agency. Quality Criteria for Water.

Introduction:

DDT, 1,1,1-trichloro-2,2-bis-(p-chlorophenyl)ethane, was one of the most widely used chemicals for the control of insect pests on agricultural crops and for control of insects which carry such diseases as malaria and typhus. Technical DDT is primarily composed of three forms (p,p'-DDT,o,p'-DDT, and o,o'-DDT), which are white, crystalline, tasteless, and almost odorless solids. In addition, DDE and DDD, 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene and 1,1-dichloro-2,2-bis(p-chlorophenyl)ethane, respectively, are found in small amounts as contaminants in technical DDT. DDD was also used as a pesticide and one form of DDD was used medically in the treatment of cancer of the adrenal gland (ATSDR,1987) (USEPA,1986).

DDT does not occur in the natural environment. The presence of DDT in the environment is generally a result of contamination due to its past production and use and its subsequent movement from sites of application to land, water, and air. DDT can no longer be used in the United States except in cases of public health emergency. However, it is still used in several other areas of the world. In addition, use of DDD as a pesticide was also banned (ATSDR,1987) (USEPA,1986).

Food is the primary exposure route for humans. Even though they have not been used in this country since 1972, small amounts of DDT and DDE can remain in soil for a long time and may be transferred to crops grown on this soil. In addition, imported foods may have been directly exposed to DDT. In the past, so much DDT was used that DDT or its degradation products are still found in virtually all air, water, and soil samples. Levels in most air and water samples are low and exposure by these pathways is of little concern (ATSDR,1987) (USEPA,1986).

Metabolism:

DDT, DDE, or DDD enter the body primarily by eating foods contaminated with these compounds. DDT, DDE, and DDD may also be inhaled and absorbed through the lungs. These compounds are not readily absorbed by the skin (ATSDR,1987) (USEPA,1986).

Once in the body, these compounds are stored most readily in fatty tissue. Once stored, they are eliminated from the body very slowly, which means that levels in fatty tissue may remain relatively constant over time or will increase with continued exposure over time. These compounds are eliminated from the body primarily in urine but breast milk is an additional route (ATSDR,1987) (USEPA,1986).

Acute Toxicity:

With acute exposure to high doses, the nervous system appears to be the major target in both human and experimental animals. Symptoms include hyperexcitability, tremors, and convulsions. The effects appear to be reversible once the exposure ceases. The liver has been shown to be the major target organ for DDT toxicity in animal studies, but no liver damage has been reported in humans following DDT ingestion. Oral doses of 10 mg/kg by humans have produces illness in some, but not all subjects. Smaller doses generally do not produce illness. Doses as high as 285 mg/kg have been taken by humans without fatal results, but these large doses are usually followed by vomiting, so the amount of DDT retained is variable (ATSDR,1987).

Chronic Toxicity:

Chronic exposure studies in both humans and experimental animals have reported that the liver is the major target organ. There is no evidence that liver function in humans occupationally exposed has been impaired, however the data are limited. Carcinogenic effects have been reported in some animal studies, with liver and lung tumors being reported. It has been reported that exposure to DDT will enhance the carcinogenic effects of known carcinogens. The information available from animal studies indicates that DDT is not a structural teratogen. However, embryotoxicity and fetotoxicity including infertility have bee reported in experimental animals in the absence of maternal toxicity (ATSDR,1987).

Regulatory Standards:

Occupational exposures:

OSHA PEL	1 mg/m3	TWA
ACGIH TLV	1 mg/m3	TWA

Safe Drinking Water Act:

No data available

Clean Water Act:

Ambient Water Quality Criteria, Human Health
 Water and Fish Ingestion: 2.4E-08 mg/L
 Fish Consumption Only: 2.4E-08
Ambient Water Quality Criteria, Aquatic Organisms
 Freshwater: Acute-1.1E-03 mg/L; Chronic-1.0E-06
 Saltwater: Acute-1.3E-04 mg/L; Chronic-1.0E-06 mg/L

DDT is listed under RCRA for ground water monitoring. The reportable quantity for release into the environment under CERCLA is 10 pounds (proposed) (ACGIH,1988) (USEPA,1988).

Environmental Effects:

Because of its persistence in nature, its hydrophobic properties and its solubility in lipids, DDT and its metabolites are concentrated by aquatic organisms at all trophic levels from water, enter the food web, and are bioaccumulated by organisms at higher trophic levels. Freshwater acute values range from 0.18 to 1,800 ug/L. The Freshwater Final Acute Value is 1.1 ug/L (based pm 42 species). Saltwater acute values range from 0.14 to 89 ug/L. The Saltwater Final Acute Value is 0.13 ug/L (based on 17 species) (USEPA,1986).

References:

ACGIH.1988. American Conference of Governmental Industrial Hygienists. Threshold Limit Values and Biological Exposure Indices for 1988-1989.Cincinnati, Ohio:ACGIH.

ATSDR.1987. Agency for Toxic Substances and Disease Registry. Toxicological Profile for p,p'-DDT,p,p'-DDE and p,p'-DDD. Atlanta, Georgia: US Public Health Service.

USEPA.1986. US Environmental Protection Agency. Quality Criteria for Water. Atlanta, Georgia: USEPA

USEPA.1988. US Environmental Protection Agency. Iris Chemical File on DDT;CASRN 50-29-3 (5/24/89). Cincinnati, Ohio: USEPA, Env. Criteria & Assessment Office.

POLYCHLORINATED BIPHENYLS

Introduction:

Polychlorinated biphenyls (PCBs) are mixtures of chlorinated biphenyls. The degree of chlorination is indicated by the commercial nomenclature of these compounds. In the Aroclor series, a four digit code is used whereby the last two digits represent the percentage by weight of chlorine in the product. PCBs are relatively nonflammable, have useful heat exchange and dielectric properties and are primarily used in electrical transformers and capacitors. They are also used in the formulation of lubricating and cutting oils, in pesticides, adhesives, plastics, inks, paints and sealants (Verschueren, 1983).

Metabolism:

Almost without exception, PCBs contain polychlorinated dibenzofurans as contaminants which play an unknown role in PCB toxicity. PCBs are readily absorbed through the gut, respiratory system and skin. The compounds initially concentrate in the liver, blood and muscle tissue, but long term body storage is primarily via the adipose tissue and skin. Degradation and elimination occurs via the hepatic microsomal enzyme system. PCBs are very active inducers of the liver enzyme systems with the most active enzyme inducers containing the highest degree of chlorination. Excretion in urine is predominant in the least chlorinated PCBs with excretion in bile more common in the highly chlorinated species (i.e., Arochlor 1254). Highly chlorinated isomers are refractive to metabolism and accumulate in the fatty tissues as long as exposure to PCBs continue (HSDB, 1989).

Acute and Chronic Toxic Effects:

The first documentation of acute human poisoning occurred in the 1968 with the ingestion of contaminated rice oil in Yusho, Japan.

Most victims consumed approximately two grams of PCBs. Symptoms included dark pigmentation of nails and skin, chloracne, increased eye discharge, increased sweating of the palms and weakness (HSDB, 1989).

Occupationally exposed workers complain of sore throats, skin rash, gastrointestinal distress, eye irritation and headaches following inhalation exposures. The breathing zone concentrations ranged from 0.014 to 0.073 mg/m^3. Chronic occupational exposures are also associated with male infertility, liver function fluctuations, the birth of hyperpigmented and hyperkeratotic infants or infants with a mild disturbance in porphyrin metabolism after intrauterine exposure. PCBs bioaccumulate in mother's milk and pass through the placenta (HSDB,1989).

Carcinogenic Effects:

An occupational cohort showed an excess risk of cancer in the liver, gall bladder and biliary tract. Experimentally exposed animals demonstrated benign and malignant liver cell tumors, lymphomas and leukemia, and carcinomas of the gastrointestinal tract. Fatty deposits in animal livers were noted after infection, dermal application and ingestion of PCBs. In animal studies, PCBs have been shown to act both as promoters and inhibitors of tumor induction. Most genotoxicity assays have been negative. PCBs are considered to be potential human carcinogens by the USEPA and the International Agency for Research on Cancer (HSDB, 1989; IRIS, 1989).

Quantitative Estimate of Carcinogenic Risk:

The USEPA has calculated a quantitative estimate of carcinogenic risk (hepatocellular carcinoma) for the oral exposure route. The Oral Slope factor is set at 7.7 mg/kg/day (based on Arochlor 1260). The slope factor is the cancer risk (proportion effected) per unit of dose and can be used to compare the relative potency of different substances on the basis of chemical weight. The drinking water unit risk is the increased risk of cancer associated with a lifetime daily exposure of 1 ug/L and is set at 2.2E-04. The drinking water concentration associated with an estimated excess risk of 1E-06 is 5.0E-03 ug/L (IRIS, 1989).

Regulatory levels of concern:

Safe Drinking Water Act: Not available

Clean Water Act:

Ambient Water Quality Criteria, Protection of Human Health:
Water & Fish Consumption: 7.9E-05 ug/L
Fish Consumption: 7.9E-05 ug/L

Ambient Water Quality Criteria, Aquatic Organisms:
Freshwater: Acute-2.0 ug/L; Chronic-1.4E-02 ug/L
Marine: Acute-10 ug/L; Chronic-3E-02 ug/L

No specific Tennessee Standards for PCBs were located.

Reference Dose, Oral or Inhalation: Not available

Environmental Concerns:

PCBs are lipophilic and tend to bioconcentrate in living tissues. The average log bioconcentration factors range from 3.26 to 5.28. PCBs have been found in fish, birds, sea mammals and processed food products in diverse locations over the globe. Bioaccumulation in species such as the golden eagle were found to contain PCBs in tissues from the brain, heart, kidney, liver, muscle and fat. PCBs are associated with decreased shell thickness in contaminated bird species. In general, detected tissue levels in wildlife have slowly decreased since PCBs use was discontinued in the 1970's.

References:

Hazardous Substances Data Base, 1989. Polychlorinated Biphenyls. National Library of Medicine. Bethesda, Maryland.

Integrated Risk Information System (IRIS), 1989. Polychlorinated Biphenyls. USEPA, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

Verschueren, Karel, 1983. Handbook of Environmental Data on Organic Chemicals, 2nd ed. Van Nostrand Reinhold Co. New York.

CARBON TETRACHLORIDE

Introduction:

Carbon Tetrachloride is a clear, heavy liquid with a sweet aromatic odor. It is a synthetic chemical with no natural sources. Carbon tetrachloride evaporates very easily, so it is not usually encountered in its liquid state in the environment. Most carbon tetrachloride in the environment is found as gas in the atmosphere (ATSDR,1987) (USEPA,1986).

The major source of carbon tetrachloride release to the environment is accidental releases from production and uses. Once in the environment, carbon tetrachloride is fairly stable. When it is released to the air it is broken down by chemical reactions very slowly. If released to surface waters, it will migrate to the atmosphere in a few days. If it is released to land, it does not sorb onto the soil but migrates readily to the ground water (ATSDR,1987) (USEPA,1986).

The major source of exposure to carbon tetrachloride is from contaminated air, usually around areas where carbon tetrachloride is used. Water and food are minor sources of exposure. Carbon tetrachloride is rare in ground and surface waters. In the past, carbon tetrachloride has been used as a fumigant for grains, and low levels have been reported to occur in some foods (ATSDR,1987) (USEPA,1986).

Metabolism:

Carbon tetrachloride is readily absorbed from the gastrointestinal tract, and more slowly through the respiratory tract and the skin. Most carbon tetrachloride leaves the body by being exhaled out through the lungs within a few hours. It has been shown that some carbon tetrachloride will be incorporated into fatty acids by the liver. The carbon tetrachloride that remains in the body is excreted in some form in the urine and feces (ATSDR,1987) (USEPA,1987).

Acute Toxicity:

Acute toxicity studies of carbon tetrachloride for humans have shown a range of variation depending on the person involved and that acute toxicity is low in contrast to that with repeated exposure. Prior exposure to alcohol, phenobarbital, and some pesticides have been shown to increase the effects of carbon tetrachloride. Single exposures to low concentrations may cause symptoms such as irritation of the eyes, moderate dizziness, and headache which disappear quickly once the exposure is discontinued. Exposure to higher concentrations will cause the same symptoms as above, but additional symptoms of nausea, loss of appetite, mental confusion, agitation and the feeling of suffocation may also be seen. At these higher levels, liver damage as well as central nervous system depression may occur. The kidneys and lungs may also be affected, but only at doses which are well above the threshold for hepatotoxicity. By the oral route, single doses of 59 mg/kg are generally without effect in humans, although some individuals may be affected by doses of 30 mg/kg (ATSDR,1987).

Chronic Toxicity:

The symptoms of chronic exposure to carbon tetrachloride include fatigue, lassitude, giddiness, anxiety, headache, muscle twitching, and increased reflex excitability. Persons exposed may complain of lack of appetite, nausea, and occasionally of diarrhea. Sometimes blood pressure is lowered and accompanied by pain in the cardiac region and mild anemia. Organ damage is usually restricted to the liver, although there have been cases of kidney damage. After chronic exposure there is usually regeneration in these organs (ATSDR,1987).

Carbon tetrachloride is carcinogenic in animals, producing mainly hepatic neoplasms. The increased incidence of tumors is generally observed at doses high enough to cause clear liver injury. No strong evidence of carcinogenicity in humans has been reported (ATSDR,1987).

Regulatory Standards:

Occupational exposures:

OSHA PEL	10 ppm	TWA
	25 ppm	Ceiling
ACGIH	5 ppm	TWA

Safe Drinking Water Act:
MCL: 0.005 mg/L
MCLG: 0.0 mg/L

Clean Water Act:
Ambient Water Quality Criteria, Human Health
Water and Fish Ingestion: 0.0004 mg/L
Fish Consumption Only: 0.00000048 mg/L
Ambient Water Quality Criteria, Aquatic Organisms
Freshwater: Acute- 35 mg/L
Saltwater: Acute- 50 mg/L

Carbon tetrachloride is listed under RCRA for ground water monitoring. The reportable quantity for release into the environment under CERCLA is 10 pounds (proposed) (ACGIH,1988) (USEPA,1988).

Environmental effects:

Although carbon tetrachloride is poorly soluble in water, both freshwater and saltwater organisms may be affected. The 96-hour LC50 for freshwater fish is about 27 mg/L and acute toxicity has been noted in both fresh and saltwater organisms at concentrations of 5 to 50 mg.L (USEPA,1986).

References:

ACGIH.1988. American Conference of Governmental Industrial Hygienists. Threshold Limit Values and Biological Exposure Indices for 1988-1989. Cincinnati, Ohio: ACGIH.

ATSDR. 1987. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Carbon Tetrachloride. Atlanta: US Public Health Service.

USEPA. 1986. US Environmental Protection Agency. Quality Criteria for Water.

USEPA. 1987. US Environmental Protection Agency. Health Advisory for Carbon Tetrachloride.

USEPA.1988. US Environmental Protection Agency. Iris Chemical File on Carbon Tetrachloride;CASRN 56-23-5 (5/24/89). Cincinnati, Ohio: USEPA, Env. Criteria & Assessment Office.

1,1,2,2-TETRACHLOROETHANE

Introduction:

1,1,2,2-Tetrachloroethane is a man-made, colorless dense liquid with a penetrating, sweet, chloroform-like odor that does not burn easily. It is currently produced by only one company in the United States. It had been used extensively as a substance to produce other chemicals and as an industrial solvent. Additionally 1,1,2,2-tetrachloroethane was used as a chemical to separate other substances, for cleaning and degreasing metals, and in paints and pesticides. Its present use appears to be limited (ATSDR,1989).

Most of the 1,1,2,2-tetrachloroethane released into the environment eventually moves in the atmosphere or groundwater. Breakdown of this chemical in both the atmosphere and groundwater is slow. Half of the chemical is expected to disappear from groundwater in 1-3 months and from air in about 2 months (ATSDR,1989).

Low levels of 1,1,2,2-tetrachloroethane can be present in both indoor and outdoor air. It appears that the source of the indoor concentrations may be products used in the home. Low levels have also been detected in several drinking water supplies, but exposure from contaminated drinking water are rare. 1,1,2,2-tetrachloroethane has not been reported in food or soil. It is also not expected to accumulate in the food chain (ATSDR,1989).

Metabolism:

1,1,2,2-Tetrachloroethane can enter the body when a person breathes air containing the chemical or when a person's skin come into contact with the chemical. It if were to occur in the drinking water, or if it was accidentally ingested, 1,1,2,2-tetrachloroethane would be absorbed into the body. Most of it leaves the body fairly quickly (within a few days) through the breath or through the urine (ATSDR,1989).

Acute Toxicity:

Inhalation of large concentrations (116 ppm) of 1,1,2,2-tetrachloroethane by humans have been reported to cause mucosal irritation, fatigue, vomiting and dizziness. Several instances of deaths from 1,1,2,2-tetrachloroethane have been reported, but the concentration was unknown. The studies of high oral doses of 1,1,1,2-tetrachloroethane have occurred as the result of accidents. Ingestion of doses >285 mg/kg/day humans have been reported as resulting in death. Autopsies showed severe liver destruction and fatty degeneration of the liver. Doses of 100 mg/kg/day have been reported to cause a loss of consciousness. Jaundice and enlarged livers have also been noted in persons exposed to high concentrations of 1,1,2,2-tetrachloroethane (ATSDR,1989).

Chronic Toxicity:

The human health effects from long term exposure to relatively low concentrations of 1,1,2,2-tetrachloroethane are not known. Hepatocellular carcinomas have been reported in studies with mice and rats, but there are no conclusive reports of cancer in humans (ATSDR,1989).

Regulatory Standards:

Occupational exposure:

OSHA PEL	5 ppm	TWA
OSHA PEL (Proposed)	1 ppm	TWA
ACGIH TLV	1 ppm	TWA

Safe Drinking Water Act:
No data available

Clean Water Act:

Ambient Water Quality Criteria, Human Health
- Water and Fish Ingestion: 1.7E-04 mg/L
  Fish Consumption Only: 1.1E-02 mg/L

Ambient Water Quality Criteria, Aquatic Organisms
  Freshwater: 2.4 mg/L (LOEL)
  Saltwater: 9.0 mg/L (LOEL)

1,1,2,2-Tetrachloroethane is listed under RCRA for ground water monitoring. The reportable quantity for release into the environment under CERCLA is 100 pounds (proposed) (ACGIH,1988) (USEPA,1988).

<u>References:</u>

ACGIH.1988. American Conference of Governmental Industrial Hygienists. Threshold Limit Values and Biological Exposure Indices for 1988 to 1989. Cincinnati, Ohio: ACGIH.

ATSDR. 1989. Agency for Toxic Substances and Disease Registry. Toxicological Profile for 1,1,2,2-Tetrachloroethane. Atlanta, Georgia: US Public Health Service.

USEPA.1988. US Environmental Protection Agency. Iris Chemical File on 1,1,2,2-Tetrachloroethane; CASRN 79-34-5 (5/24/89). Cincinnati, Ohio: USEPA, Env. Criteria & Assessment Office.

TETRACHLOROETHENE

Introduction:

Tetrachloroethene or tetrachloroethylene is a nonflammable liquid solvent used for dry cleaning fabrics for metal degreasing. It is also used in the production of other chemicals. Tetrachloroethene is liquid at room temperature but vaporizes easily in an open environment (ATSDR, 1987).

Metabolism:

Tetrachloroethene is readily absorbed after ingestion or inhalation exposures. Dermal absorption is poor. A large portion of the absorbed dose is distributed to the fatty tissues. Tetrachloroethene's primary urinary metabolites are trichloroacetic acid and trichlorethanol. Urinary excretion accounts for only a small percentage of the absorbed dose as the main excretion pathway is through exhalation of the unmetabolized compound (ATSDR, 1987).

Acute and Chronic Toxic Effects:

Tetrachloroethene is thought to be relatively nontoxic by the inhalation and oral routes. An acute LC_{50} for mice of 5,200 ppm was reported. A single dose LD_{50} for rats of 3,005 mg/kg was also given in the literature. When tetrachloroethene was used as an antihelminthic drug in humans, a dose of 60 to 80 mg/kg was nonlethal (ATSDR, 1987).

Chronic inhalation exposure to mice have shown hepatic effects at concentrations of 9 ppm and above. Central nervous system effects in gerbils were noted at 60 ppm. The human threshold for CNS effects is 100 to 200 ppm. Tetrachloroethene is regarded as a hepatotoxin and renal toxin in humans by the ingestion and inhalation routes.

Developmental studies in rat and mice indicate that tetrachlorethene is fetotoxic but not teratogenic at concentrations which were also maternally toxic. Tetrachloroethene is believed to be a potential transplacental neurotoxicant. It is also thought to cause sperm abnormalities (ATSDR, 1987).

Carcinogenic Effects:

Occupationally exposed cohort studies have not demonstrated a clear increase in cancer risk for workers exposed to tetrachloroethene. These studies are complicated by exposures to multiple chemical compounds. Chronic inhalation studies in mice and rats show an increased incidence of mononuclear cell leukemia, renal tubular cell adenomas or adenocarcinomas as well as hepatocellular carcinomas. Chronic ingestion studies show an increased risk of hepatocellular carcinomas in mice but not in rats. The toxicity of tetrachloroethene increases in the presence of compounds, such as PCBs, which induce increased metabolism of tetrachloroethene (ATSDR, 1987).

Regulatory Levels of Concern:

Safe Drinking Water Act:
MCLG: 0 ug/L

Clean Water Act:
Ambient Water Quality Criteria, Protection of Human Health:
Water & Fish Consumption:8.0E-01 ug/L
Fish Consumption: 8.85 ug/L
Ambient Water Quality Criteria, Aquatic Organisms:
Freshwater:Acute-5.28E+03 ug/L;Chronic-8.4E+02 ug/L
Marine: Acute-1.02E+04 ug/L;Chronic-4.5E+02 ug/L

Oral Reference Dose: 1.0E-02 mg/kg/day

Environmental Concerns:

Acute toxicity of tetrachlorethene to aquatic organisms was tested with two invertebrate and three fish species. The acute values range from 4.8 to 30.8 mg/L. Chronic toxicity data for the fathead minnow is 0.084 mg/L. A freshwater alga species was more resistant than the animal species with no observed effects at concentrations as high as 816 mg/L. A bioconcentration factor of 49 was determined for the bluegill and a factor of 39 was estimated for the rainbow trout (Callahan, 1979).

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1987. Draft Toxicological Profile for Tetrachloroethylene. US Public Health Service.

Integrated Risk Information Service (IRIS), 1989. USEPA, Environmental Assessment and Criteria Office, Cincinnati, Ohio.

Callahan et al., 1979. Water-Related Environmental Fate of 129 Priority Pollutants. USEPA, Office of Water and Waste Management. Washington, D.C.

TRICHLOROETHENE

Introduction:

Trichloroethene or trichloroethylene is a colorless liquid at room temperature with an odor similar to ether. The major use of this man-made chemical is as a solvent for degreasing metal parts. It is also used in making more complex chemical compounds (ATSDR, 1988).

Metabolism:

Trichloroethene is metabolized within the body to trichloroethanol, trichloroethylene-glucoronide and trichloroacetic acid and, possibly, the hypnotic agent chloral hydrate. Forty to seventy-five percent of an inhaled dose is metabolized. The liver removes trichloroethene from the blood.

The glutathione conjugate of trichloroethene is transported from the liver to the kidneys where the kidney enzymes product a metabolite which covalently binds to DNA and is the most probable mechanism for the induction of carcinogenicity (ATSDR, 1989).

In humans, most of the metabolized dose is execreted in the urine. Elimination of trichloroethene from adipose tissue has a relatively long half-life (ATSDR, 1988).

Acute and Chronic Toxic Effects:

Trichloroethene is not acutely toxic by the inhalation or oral routes. A human LC_{10} of 2,900 ppm for humans is reported. A dose of 70 mg/kg is thought to be fatal for humans. The bone marrow, central nervous system, liver and kidney are the principals target organs. Oral and inhalation effects noted included narcosis, enlargement of the liver and kidney, impaired heme synthesis and immunosuppression. Trichloroethene is fetotoxic to animals, but is thought to be teratogenic.

Carcinogenic Effects:

Genotoxicity assays have been equivocal with most positive associated with in vitro assays using liver enzyme metabolism systems. Human epidemiological studies have not shown a clear connection between exposure to trichloroethene and increased cancer risk. Experimental animals exposed by inhalation developed cancers in the lung and liver, while animals exposed orally had increased incidence of hepatocellular and renal carcinomas (ATSDR, 1988).

Quantitative Estimate of Carcinogenic Risk:

The USEPA has calculated a quantitative estimate of carcinogenic risk (hepatocellular carcinoma) for the oral exposure route. The Oral Slope factor is set at 1.2E-02 mg/kg/day (based on Arochlor 1260). The slope factor is the cancer risk (proportion effected) per unit of dose and can be used to compare the relative potency of different substances on the basis of chemical weight. The drinking water unit risk is the increased risk of cancer associated with a lifetime daily exposure of 1 ug/L and is set at 3.2E-07. The drinking water concentration associated with an estimated excess risk of 1E-06 is 3.0 ug/L per day (IRIS, 1989).

Regulatory levels of concern:

Safe Drinking Water Act:
    MCLG:0 mg/L
    MCL: 5 ug/L

Clean Water Act:
    Ambient Water Quality Criteria, Protection of Human Health:
        Water & Fish Consumption:2.7 ug/L
        Fish Consumption: 8.07E+01 ug/L
    Ambient Water Quality Criteria, Aquatic Organisms:
        Freshwater:Acute-4.5E+04 ug/L;Chronic-None

Marine: Acute-2.0E+03 ug/L;Chronic-None

Reference Dose, Oral or Inhalation: Not available

Environmental Concerns:

Trichloroethene volatilizes rapidly from water. It is highly mobile in soil and quickly leaches to the groundwater. Its' high vapor pressure suggests that trichloroethene exists predominantly in the vapor phase with some removal from the atmosphere via wet deposition. Trichloroethene is believed to have a low bioaccumulation potential in fish and other aquatic creatures. LC_{50} of approximately 50 mg/L was found for three species tested (ATSDR, 1988).

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1988. Toxicological Profile for Trichloroethylene. US Public Health Service.

Integrated Risk Information System (IRIS), 1988. Trichloroethylene. USEPA, Environmental Criteria and Assessment Office. Cincinnati, Ohio.

METHYLENE CHLORIDE

Introduction:

Methylene chloride is a colorless, odorless solvent found in insecticides, metal cleaners, paints, and paint removers. Methylene chloride is also known as dichloromethane and is commonly included in a chemical category called the halomethanes.

Metabolism:

Methylene chloride is lipophilic and easily absorbed via inhalation or ingestion. Once absorbed, it is quickly distributed throughout the body, but is most common to adipose tissues, the brian and the liver. Most absorbed methylene chloride is excreted via the lungs or the kidneys.

At low doses, methylene chloride is primarily metabolized by the MFO pathway to CO and CO_2. Some of the CO is exhaled, but a significant portion is involved in the formation carboxyhemoglobin (CoHb).

Acute Toxicity:

The formation of CoHb interferences with oxygen transport by the blood and results in cardiorespiratory stress. Acute exposures (<300 ppm) are associated with impairment of the central nervous system as well as liver and kidney effects.

Acute inhalation exposures to 500 ppm for 10 days resulted in mild liver damage in rats. Above 500 PPM, methylene chloride induces sluggishness, nausea and headaches. If trapped against the skin, methylene chloride can produce a chemical burn. It is also an eye and throat irritant. Inhalation exposures of 11,000 to 16,000 PPM are fatal for most species, while 1,000 to 4,000 mg/kg is the oral or fatal dose range. NIOSH gives 5,000 PPM as the level which is immediately dangerous to human life and health.

Chronic Toxicity:

Human studies have not shown any evidence of liver and kidney damage after 30 years of occupational exposure to 30-125 PPM methylene chloride or to 140-475 PPM over a three-month period.

Animal studies demonstrate mild liver damage after 100 days of inhalation exposure to 100 PPM methylene chloride in air. Chronic ingestion by rats of 50 MG/KG/DAY in water also showed slight liver damage.

Carcinogenicity:

Liver and lung tumors are demonstrated in methylene chloride - exposed mice and rats, but only after two years of chronic inhalation and ingestion exposures. Epidemiological evidence shows no association between human exposure and an increased incidence in liver or lung tumors.

Levels of Concern:

OSHA PELs: 500 PPM TWA
1,000 PPM Ceiling
2,000 PPM Peak
ACGIH TLV: 50 PPM TWA
NIOSH REL: lowest feasibility limit

Ambient Water Quality Criteria, Human Health:
Fish and Water Consumption: 0.19 UG/L
Fish Consumption: 15.7 UG/L
Ambient Water Quality Criteria, Aquatic Life:
Freshwater: Acute - 11,000 UG/L; Chronic - none
Marine: Acute - 12,000 UG/L; Chronic - 8,400 UG/L

Environmental Fate:

Atmospheric methylene chloride is easily dispersed and transported. The compound's lifetime in the troposphere ranges from a few months to 1.4 years. Phosgene is a possible degradation product.

Volatilization is the most common fate processes in surface waters. Biodegradation is also important in aquatic systems. Volatilization, leaching and biodegradation are all important processes in the soil environment. Methylene chloride has a low log octanol/water partition coefficient and is not expected to bioaccumulate. It's estimated BCF is 2.3.

References:

ATSDR, 1987. Toxicological Profile for Methylene Chloride. Department of Health and Human Services. Atlanta, GA.

USEPA, 1980. Ambient Water Quality Criteria for Halomethanes. Office of Water Regulation and Standards, Washington, DC. EPA 440/5-80-051.

USEPA, 1988. Dichloromethane. IRIS Data Base. Cincinnati, Ohio.

TRANS-1,2-DICHLOROETHYLENE

126 280

Introduction:

Trans-1,2-dichloroethylene (trans-1,2-DCE) is a colorless, low-boiling liquid. It is flammable and is considered a dangerous fire hazard. Its use is as a general solvent for organic materials, dye extraction, perfumes, lacquers, and thermoplastics.

Metabolism:

Trans-1,2-DCE should be readily absorbed through oral, inhalation or dermal routes during a contamination incident.

Alcohols and carboxylic acids are the predominant metabolic end products of trans-1,2-DCE. EPA's health advisory on this chemical notes that trans-1,2-DCE transforms to 2,2-dichloroethanol and 2,2-dichloroacetic acid in a study of rat liver microsomal preparations supplemented with NADPH. Trans-1,2-DCE is metabolized at a slower rate than cis-1,2-dichloroethylene in an *in vitro* hepatic microsomal system. No data on the excretion of trans-1,2-dichloethylene are available (USEPA 1987).

Acute and Chronic Toxicity:

DCE is considered moderately toxic when ingested, inhaled or contacted dermally. The principal toxic effects of trans-1,2-dichloroethylene (DCE) following acute oral exposure are upon the liver and kidney (Jenkins et al., 1972, Freundt et al., 1977). A single 400 mg/kg oral dose of trans-1,2-DCE produced a significant increase in glucose-6-phosphatase in adult female Holtzman rats when compared to controls, and a dose of 1,500 mg/kg significantly decreased the level of liver tyrosine transaminase. Trans-1,2-DCE appeared to be less potent than the cis-isomer and both were less potent than 1,1-DCE.

Freundt et al., (1977) reported on the effects of trans-1,2-DCE following inhalation in mature female Wistar rats. A brief (8-hour) or prolonged exposure (8 hours/day, 5 days/week for 1, 2, or 16 weeks) of 200 to 3,000 ppm yielded an increased incidence of slight to severe fatty degeneration of the hepatic lobules and lipid accumulation by the Kupffer cells. Damage became more noticeable in higher percentage of the animals as the length of exposure increased to 8 or 16 weeks. Eight-hour exposures to the 200 to 1,000 ppm concentrations caused a significant decrease in the number of erythrocytes, and exposure to 1,000 ppm for 8 hours also resulted in significant reductions in serum albumin, urea nitrogen and alkaline phosphatase levels.

General anesthetic and narcotic effects can occur at exposure levels above those at which liver and kidney effects are observed. It appears that the trans-isomer is about twice as potent as the cis-isomer in depressing the central nervous system.

Carcinogenic Effects:

No data on teratogenicity or carcinogenicity following oral ingestion were found. Trans-1,2-DCE was not mutagenic in bacterial assays (USEPA 1987).

Regulatory Levels of Concern:

Time Weighted Average
790 mg/m^3

Environmental Concerns:

Limited data are available on the aquatic toxicity of trans-1,2-DCE. The LC_{50} reported for the bluegill is 135 mg/L. No data on the chronic toxicity to aquatic organisms were found in the literature.

References:

Freundt KJ, Leibaldt DP, Lieberwirth R. 1977. Toxicity studies on trans-1,2-DCE. Toxicology 10:131-139.

Jenkins LJ, Andersen ME. 1972. 1,1-DCE nephrotoxicity in the rat. Toxicol. Appl. Pharmacol. 46:131-141.

USEPA. 1987. US Environmental Protection Agency. Trans-1,2-DCE health advisory. Washington, DC: US Environmental Protection Agency, Office of Drinking Water.

ACETONE

Introduction:

Acetone is used as a solvent for fats, oils, waxes, resins and cements. It is used in the manufacture of many products such as explosives, plastics and synthetic fibers. It is flammable and explosive in a closed environment.

Metabolism:

Acetone is easily absorbed via the lungs to the blood stream. It is also absorbed through the skin. Acetone is metabolized in the body to glucaric acid and mercapturic acids which are primary excreted in urine. Acetone is rapidly excreted after absoption with only a fraction of the original dose present in the body after sixteen hours.

Acute and Chronic Toxicity:

Acetone is not toxic to humans except in high doses. A blood concentration of 200 to 300 ug/L is considered toxic and 550 ug/L is considered lethal. Pretreatment with acetone prior to exposure to other toxicants increases the observed toxic effects in animal species. Symptoms of acute acetone poisoning include restlessness, headache, vomiting, lowered blood pressure and irregular respiration. Direct contact with the eyes produces corneal irritation. Extended contact with skin defats the skin and produces dermatitis.

Chronic inhalation and ingestion exposures to animals are associated with granular degeneration and necrosis of the kidney tubules. Exposures ranged as high as 5 mg/L by gavage and 3,000 ppm by inhalation. Workers chronically exposed to 1,000 ppm over seven to fifteen years complained of inflamation of the airways, stomach and duodenum.

Carcincogenicity:

No specific evidence links acetone exposure to the development of tumors in animals. Genotoxicity and mutagenicity testing results are largely negative.

Regulatory Levels of Concern:

The Reference Dose for Acetone is 1E-01 mg/kg/day. No drinking water or ambient water quality criteria have been established. The Time-Weighted Average for inhalation exposures is 750 ppm (ACGIH, 1990).

Environmental Concerns:

Acetone is released into the environment from stack emissions, volcanic eruptions and waste water. It is also a metabolic product released by plants and animals. When released on soil, acetone will both volatilize and leach into the ground where it is usually biodegraded. In water, acetone will probably biodegrade and be released into the atmosphere. In the atmosphere, acetone is lost by photolysis and reaction with hydroxyl radicals. Bioconcentration and adsorption to sediments are not expected.

References:

Hazardous Substances Data Base, 1989. National Library of Medicine. Bethesda, Maryland.

HEPTACHLOR

126 285

Introduction:

The pesticide Heptachlor is no longer manufactured in the United States. It used in the control of termites and is a impurity in the pesticide chlordane. Heptochlor epoxide is an oxidation product which is formed by many plants and animals after exposure to heptachlor.

Acute and Chronic Toxicity:

Heptachlor is readily absorbed from the gastrointestinal tract and the skin. It is slowly eliminated via the bile duct to the feces. Heptachlor epoxide is often detected in human milk, blood and other body tissues.

Heptachlor is acutely toxic via the oral and dermal routes. In rats, the oral LD_{50}s is approximately 71 mg/kg and the dermal LD_{50} is 195 to 250 mg/kg. Human death is reported after inhalation exposures to technical grade chlordane which is approximately 10% heptachlor. Hepatotoxicity is the most sensitive noncancer endpoint with animal acute and chronic studies describing evidence of severe liver damage, increased liver weight, and increased levels of serum liver enzymes. The neurotoxicological signs include hypoactivity, tremors, convulsions, ataxia and changes in EEG patterns. Long-term oral exposures in animals are also associated with renal, adrenal and blood defects. Heptochlor is also fetotoxic and caused reduced fertility in laboratory rodents.

Carcinogenicity:

Chronic oral exposure to heptachlor or heptachlor epoxide increased the incidence of liver carcinomas in several species of mice. Heptachlor is considered a probable human carcinogen (B2) because human evidence of carcinogenicity is not adequate to establish a relationship. Studies of pesticide applicators indicate a slight increased incidence in cancers of the lung, skin and bladder.

Regulatory Concerns:

ACGIH 8 hr-TWA TLV:0.5 mg/m^3 with skin absorption

NIOSH PEL:0.5 mg/m^3 with 100 mg/m^3 being immediately dangerous to life or health

Drinking Water Health Advisories: 10 day-10 ug/L
Lifetime-17.5 ug/L (hepatchlor)
Lifetime-0.4 ug/L (h.epoxide)

National Ambient Water Quality: 0.28 ppb

Maximum Contaminant Level Goal of zero in drinking water.

Environmental Concerns:

Heptachlor and its epoxide are persistent in soil with half-lives of two and fourteen years, respectively. Heptachlor tends to partition to sediments from water. Both heptachlor and heptachlor epoxide bioaccumulate in aquatic organisms, especially fish and mollusks.

References:

ATSDR, 1989. Toxicological profile for Heptachlor/Heptachlor epoxide. Public Health Service, Atlanta, Ga.

1,1-DICHLOROETHYLENE

126 287

Introduction:

1,1-Dichloroethylene (1,1-DCE) is used in the production of organic chemicals and polyvinylidene chloride copolymers. These copolymers are used in packing materials, as flame retardants, as adhesives and as coatings in pipes. 1,1-DCE is present in food wraps.

Metabolism:

1,1-DCE is readily penetrates the lungs and rapidly enters the blood stream following inhalation exposures. Oral doses up to 100 mg/kg of body weight are readily absorbed from the gastrointestinal tract of rats and mice. It is expected that 1,1-DCE would also readily penetrate the skin because of its lipophillic properties. 1,1-DCE appears to accumulate preferentially in the kidney, liver and lung. 1,1-DCE undergoes complex biotransformation processes. The main pathway for 1,1-DCE involve conjugation with glutathione. As glutathione is depleted, increasing amounts of reactive DCE intermediates become bound to liver and kidney tissue. 1,1-DCE is quickly excreted with the bulk of the metabolites exiting the body via expired air and urine.

Acute Toxicity:

Acute inhalation exposures in rodents (10,000 ppm or greater) are associated with irritation of the upper respiratory tract, depression of the central nervous system and arrhythmias of the heart. In rats, four-hour inhalation exposures to 200-250 ppm resulted in increased liver weight, hepatic enzyme induction and massive histologic injury to liver cells. Acute exposures as low as 10 ppm produced lesions in the nephritic tissues of mice. In humans, inhaled exposures to 4,000 ppm produced convulsions, spasm and unconsciousness. Maternal and developmental toxicity is associated with inhalation exposures in rodents.

The oral LD50 in fasted rats is 1,500 mg DCE/kg body weight, while mice are more sensitive with an LD50 of 200 mg/kg. Oral administered 1,1-DCE mainly targets the liver and kidneys, but also effects the lungs and digestive tract.

Chronic Toxicity:

Longer-term inhalation exposures to 1,1-DCE is also associated with irritation of the respiratory tract. The liver and kidneys are the major target organs of DCE toxicity following chronic inhalation exposures. Continuous inhalation exposure to experimental animals is more damaging than intermittent chronic exposures (i.e., 48 ppm for 90 days as opposed to 100 ppm for 8 hr/day, 5 days/week for 43 days) Damage to the central nervous system, lungs and heart have also been noted in animal studies.

Chronic ingestion studies with rats over a two year period showed few treatment-related changes. Cytoplasmic vacuolation of hepatocytes and increased fatty deposits were noted with doses ranging from 10 to 20 mg/kg.

Carcinogenicity:

Inhalation studies in mice and rats have shown an increased incidence of mammary carcinomas in females and lung tumors in both sexes. High dose males (25 ppm) had an increased incidence of renal adenocarcinomas (Maltoni, 1985). These results were not statistically significant. Long-term oral animal testing has not provided statistically significant evidence. 1,1-DCE is considered to be a tumor-initiating agent when dermally administered (Van Duuren et al, 1979). 1,1-DCE is considered a possible human carcinogen (EPA Class C).

Regulatory Concerns:

Maximum Contaminant Level:0.007 mg/L

NIOSH REL TWA:4 mg/m3

ACGIH TWA TLV:5 ppm or 20 mg/m3

Ambient Water Quality Criteria to Protect Human Health:

Ingestion of Fish and Water:	0.033 ug/L
Ingestion of Fish:	1.85 ug/L

Environmental Concerns:

Because of its high volatility, 1,1-DCE mainly partitions to the atmosphere. It is water soluble and is often found in surface and groundwater. 1,1-DCE has a low propensity to bind to organic or particulate matter. It is transformed in the atmosphere by reaction with radicals and undergoes biodegradation in soil or water.

References:

ATSDR, 1988. Toxicological Profile for 1,1-Dichlorethene. Public Health Service. Atlanta, Ga.

Maltoni, C. et al, 1985. Experimental research on vinylidene chloride carcinogenesis. Archives of Research on Industrial Carcinogenesis. Vol. 3, Princeton, NJ: Princeton Scientific Publishers.

Van Duuren, B.L. et al., 1979. Carcinogenicity of halogenated olefinic and aliphatic hydrocarbons in mice. J. Natl. Cancer Inst. 63(6): 1433-1439.

CHLORDANE

Introduction:

Chlordane is a man-made substance used as a pesticide from 1948 to 1988. After mixing with water, the chemical was used to stop termites and to treat corn and other crops.

Metabolism:

Data on humans exposed by inhalation suggest that chlordane levels in blood and milk fat increase with increased duration of exposure. Inhaled doses distribute primarily to the lungs and liver. Oral doses distribute to adipose tissue, spleen, brain, kidney and liver, in that order of primacy. The primary metabolites identified in human tissues are oxychlordane, trans-nonachlor and heptachlor epoxide. Chlordane metabolites are excreted in the milk of lactating mothers. Seventy to 90% of an oral dose is excreted within seven days with most eliminated in the feces (70-90%) and 2 to 8% in urine.

Acute and Chronic Toxicity:

Absorption following ingestion of or skin contact with chlordane can be fatal. An acute oral dose as low as 25 mg/kg can result in death. While the human dermal LD50 is not known, the dermal LD50 in animals is quite low. Inhalation exposures are unlikely to cause death. Rats repeatedly exposed to chlordane aerosols do not suffer respiratory defects.

Gastrointestinal distress such as nausea, vomiting, diarrhea and cramps are associated with oral exposures. Chlordane, like other organochlorine insecticides, functions as a potent inducer of hepatic microsomal enzymes. Animal studies suggest that subtle hepatic effects occur which would influence the metabolism of other substances in the body rather than damage hepatocytes directly.

Kidney congestion has been observed in rats and hamsters given large acute oral doses of 200 and 1200 mg/kg, respectively. Skin contact may cause burning sensations, development of rash and pruitis. Eye contact can cause conjunctivitis.

Neurological effects are the primary effects noted after acute oral, inhalation or dermal exposures and include headache, dizziness, tremors, confusion, convulsions and coma. These effects are not associated with occupational exposures.

Male mice exposed to chlordane had testicular degeneration after chronic oral exposures for 30 days. Reduced fertility has also been reported in animal studies. Exposure to chlordane is believed to affect metabolism and circulating levels of steroid hormones. Chlordane has induced mitotic gene conversions and sister chromatid exchange in genotoxicity assays.

Carcinogenicity:

Chronic oral treatment resulted in significant increases in hepatocellular carcinomas in mice. Some researchers suggest that chlordane acts as a promoter of liver tumors.

Regulatory Concerns:

OSHA PEL: 0.5 mg/m3

ACGIH TWA-TLV: 0.5 mg/m3

Ambient Water Quality Criteria for the protection of human health:

Ingestion of Water and Organisms:	0.46 ng/L
Ingestion of Fish:	0.48 ng/L

Environmental Concerns:

Chlordane in water will both adsorb to sediments and volatilize. Chlordane will bioconcentrate in both marine and fresh water species as well as bacteria. In soil, chlordane will adsorb to the organic mater and volatilize slowly over time. It will leach significantly and is usually found only in the top 20 centimeters of soil. Chordane can persists in soils as long as twenty years.

References:

ATSDR, 1988. Toxicological Profile for Chlordane. Public Health Service. Atlanta, Ga.

BETA-BHC
(HEXACHLOROCYCLOHEXANE)

Introduction:

Benzene hexachloride (BHC), also known as hexachlorocyclohexane, exists as eight isomers. Alpha-, beta-, delta- and gamma-BHC (lindane) are often found in mixtures at hazardous wastes sites. While lindane is still available in some household products, technical grade BHC, which contains all four isomers, is no longer used as a pesticide in the United States.

Metabolism:

BHC is readily absorbed via inhalation, ingestion or dermal contact. BHC has been found in adipose tissue and the blood following inhalation exposures. Following ingestion, BHC is deposited primarily to fat, the kidneys, the lungs and the liver. BHC has also been detected in the brain, human milk and can cross the placenta. Chlorophenols and chlorobenzenes are the primary metabolites excreted in urine by lindane-exposed workers. Metabolites are also found in milk and semen.

Acute and Chronic Toxicity:

The toxicity of BHC is often dependent on the solubility and viscosity of its carriers. Exposure to excessive amounts by inhalation or ingestion has lead to death in humans. The central nervous system is strongly affected with convulsions and coma preceding death. Blood disorders have been reported in humans after inhalation exposures. Liver toxicity is believed to be associated with an inhibition of Mg^{2+}-ATPase activity. Nephritic effects have been noted in animals, but not in humans. Immune system changes have been noted in animals.

In humans, neurotoxic effects include paresthesia of the face and extremities, headaches, vertigo, seizures and convulsions.

Alterations in reproductive hormones and spontaneous abortions have been observed in women with detectable levels of BHC in their blood. BHC has produced mitotic disturbances in mammalian and plant cells, but is not mutagenic in bacteria, yeast or algae.

Carcinogenicity:

Alpha-, beta-, gamma- and technical grade BHC have all shown carcinogenic effects following long-term exposures. Hepatocellular carcinoma is the most frequent reported tumor type. Metabolites, such as 2,4,6-trichlorophenol, are also carcinogenic.

Regulatory Concerns:

OSHA PEL TWA:0.5 mg/m^3 with skin absorption (Lindane)

MCL: 0.004 mg/L (Lindane)

Lifetime Health Advisory: 0.2 ug/L

Ambient Water Quality Criteria to protect human health:

Ingestion of Water and Aquatic Organisms:	Ingestion of Fish:
A-BHC:9.2 ng/L	31 ng/L
B-BHC:18.6 ng/L	54.7 ng/L
G-BHC:12.3 ng/L	62.5 ng/L

All isomers either Class B2 or C carcinogens.

Environmental Concerns:

BHC in soil can leach to groundwater, sorb to soil particles or volatilize to the atmosphere. Leaching is dependent on the amount of organic material in the soil. Gamma-BHC released in water has a tendency to dissolve and remain in the water column. In surface water, it may adsorb to sediments or partition to aquatic organisms where the chemical accumulates in the foodchain.

Biodegradation is the major degradation process in water. Biotransformation is also important in soils.

References:

ATSDR, 1988. Toxicological Profile for Alpha-,Beta-, Gamma- and Delta-Hexachlorocyclohexane. Public Health Service.

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TAB

Appendix C Reports Review for DDMT RI/FS

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Appendix C

Reports Reviewed for DDMT RI/FS

Reports Reviewed for DDMT RI/FS

- Harland Bartholomew & Associates, Inc., July 1988, Master Plan, Defense Depot Memphis, Tennessee.
- O.H. Materials Company, Summary Report: On-site Remedial Activities at Defense Depot Memphis, Feb. 1986.
- Phoenix Environmental Consultants, Inc., January, 1984, Environmental Assessment for Hazardous Materials Mission Expansion.
- Defense Depot Memphis, Tennessee, 1982. Draft Spill Prevention Control and Countermeasures Plan, Facilities Engineering Division, DDMT.
- U.S. Army Environmental Hygiene Agency, December 1986, Ground-Water Consultation No. 39-26-0815-87, Defense Depot Memphis, Tennessee.
- Defense Logistics Agency, 1 October 1980. Defense Depot Memphis, Master Plan Component Analysis of Existing Facilities.
- U.S. Army Environmental Hygiene Agency, August 1977. Environmental Impact Assessment. Consultation visit No. 21-1443-78, Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, August 1975. Environmental Survey No. 99-012-76, Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, January 1978. Environmental Assessments of Existing Operations at DLA Installations, Survey No. 24-1443-78.
- Defense Supply Agency, 1978. Defense Depot Memphis. Safety & Health Office (DDMT-GE) Industrial Hygiene Survey No. 78-002: Asbestos Rebagging & Rewarehousing by Kennedy Contracting Company.
- U.S. Army Environmental Hygiene Agency, August 1977, Waste Management Consultation No. 26-1443-78, Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, May 1977, Hazardous Waste Management Survey No. 26-0020-78, Defense Depot Memphis, Tennessee.

- U.S. Army Environmental Hygiene Agency, September 1977 Industrial Hygiene Special Study Survey No. 556-35-0127-80, Evaluation of Hazardous Material Warehouse, Defense Depot Memphis, Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, August 1977, Waste Management Consultation No. 26-1443-78, Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, May 1977, Hazardous Waste Management Survey No. 26-0020-78, Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, May 1980. Hazardous Waste Management Consultation No. 37-26-0113- 81, Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, June 1977. Industrial Hygiene Survey No. 23-022-70. Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, October 1969. Industrial Hygiene Survey No. 23-022-70. Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, June 1973. Industrial Hygiene Survey No. 35-049-73/74. Defense Depot Memphis, Tennessee. Aberdeen Proving Ground, MD 21010.
- U.S. Army Environmental Hygiene Agency, June 1977, Radiation Protection Survey No. 62-0431-77. Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, October 1974. Entomological Survey No. 44-P09-75. Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, October 1979. Installation Pest Management Program Review No. 16-62- 0589-90. Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, November 1978. Installation Pest Management Program Review No. 16-62- 0541-79. Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, September 1977. Installation Pest Management Program Review No. 62-0577-78. Defense Depot Memphis, Tennessee.

- U.S. Army Environmental Hygiene Agency, November 1978, Installation Pest Resistance Study (ES) No. 18-62-0542-79, Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, November 1973. Entomological Survey No. 44-015-74, Defense Depot Memphis, Tennessee.
- U.S. Army Environmental Hygiene Agency, September 1976. Installation Pest Management Program Review No. 62-0544- 77. Defense Depot Memphis, Tennessee.

TAB

Appendix D - Previous Sampling Locations and Data

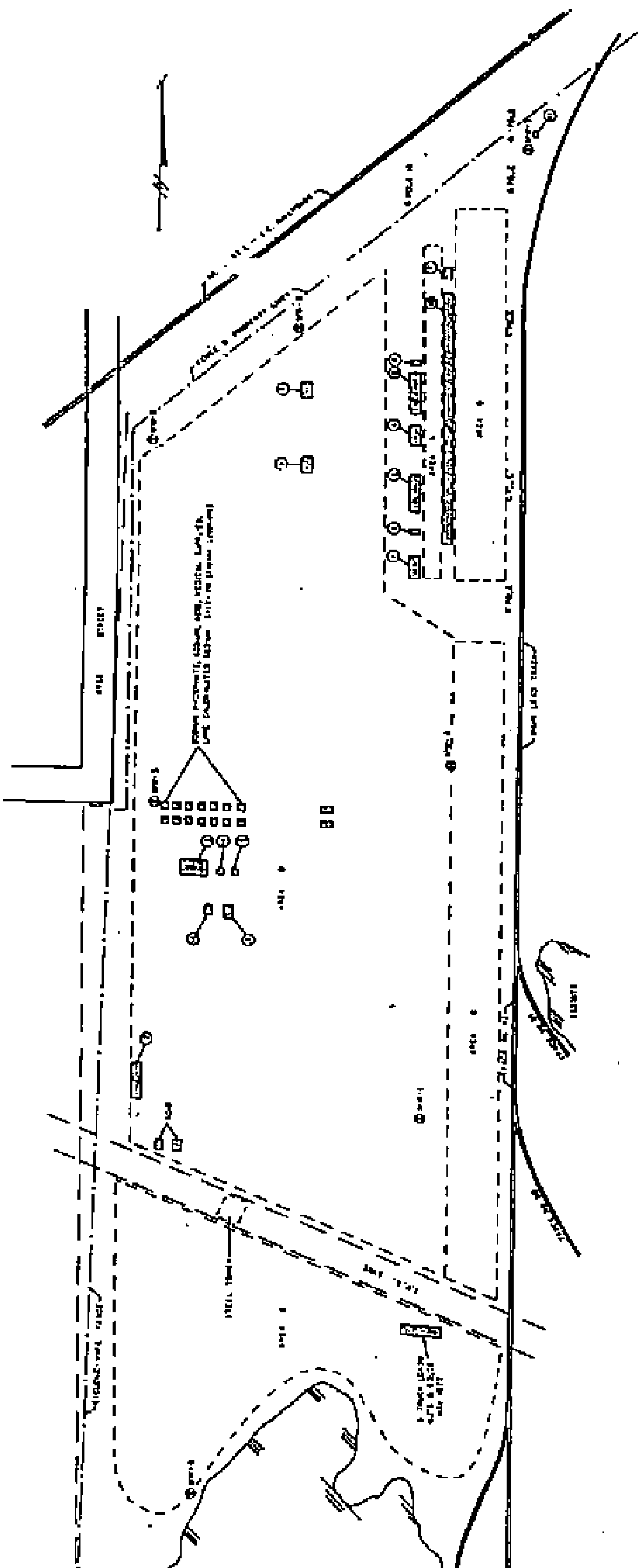
Appendix D

Previous Sampling Locations and Data

Appendix D—Table of Contents
Summary of Previous Investigations
Defense Depot Memphis, Tennessee

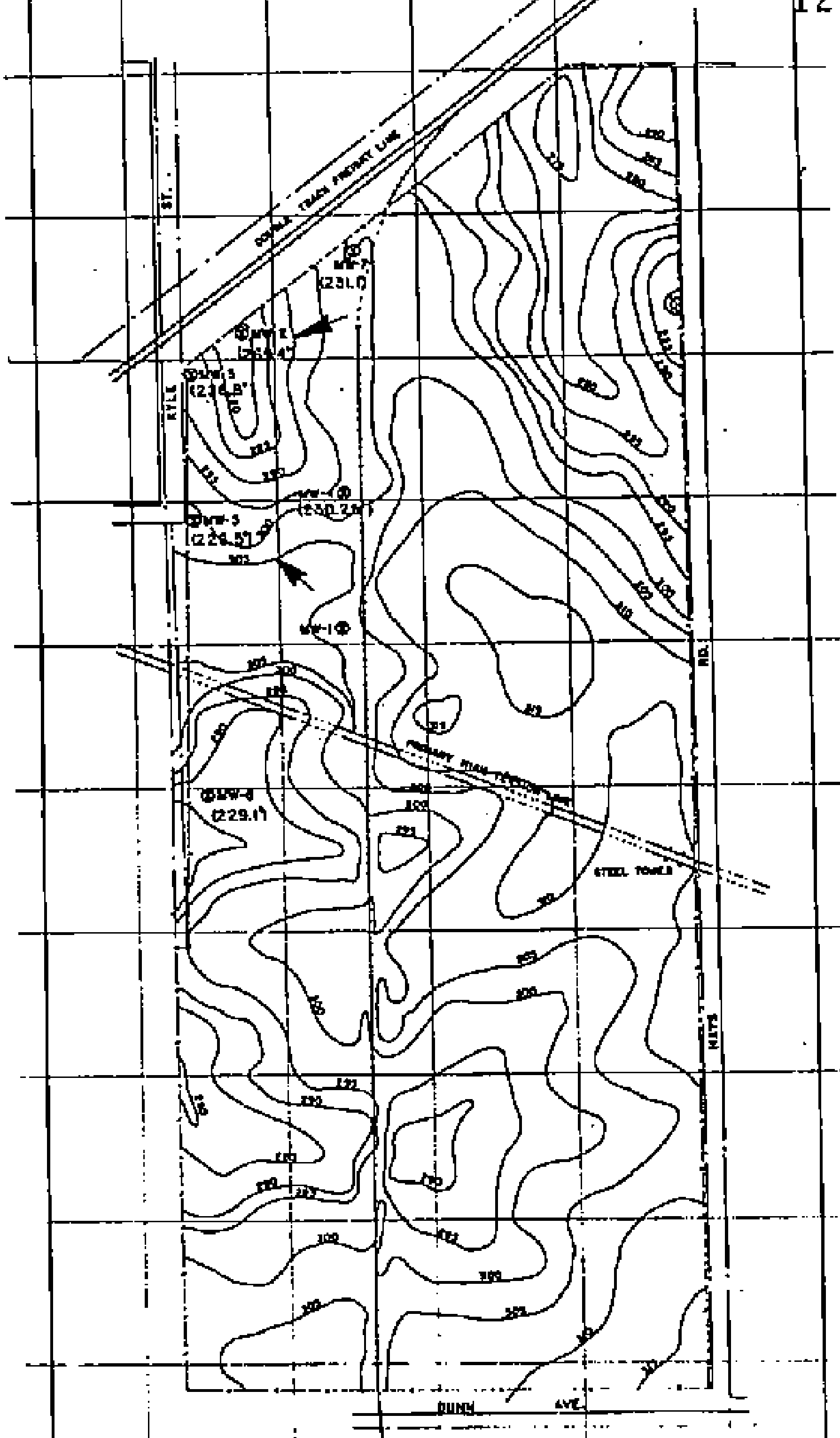
*Some of the location maps and figures excerpted from these reports, which were previously in this appendix, have been transferred to Section 3 in response to regulatory agency comments.

Geohydrologic Study
Number 38-26-0195-83
United States Army Environmental Hygiene Agency (USAEHA)
July 1982



LOCATION MAP for MONITORING WELLS
DUNN FIELD AREA DEFENSE DEPOT MEMPHIS
MEMPHIS, TN

Scale: [illegible]



TOPOGRAPHY and MONITORING WELL LOCATIONS DUNN FIELD AREA

GROUND WATER FLOW DIRECTION ⟶

DDMT

SCALE: 1" = 200'

0 200

N

Geohydrologic Study No. 38-26-0195-83, DDM, Memphis, TN, 21 Jun-2 Jul 82

TABLE 5. ANALYTICAL RESULTS, DEFENSE DEPOT MEMPHIS

Monitoring Well	NO_2NO_3 mg/L	COD mg/L	Cl mg/L	SO_4 mg/L	SpC umhos	Phenol mg/L	F mg/L	pH -
MW-2	0.10	75.0	6.4	35.0	570	<0.04	0.67	6.4
MW-3	1.2	11.0	9.8	41.0	300	<0.04	0.22	6.0
MW-4	2.2	11.0	16.0	17.0	234	<0.04	0.27	6.0
MW-5	2.0	<5.0	24.0	16.0	224	<0.04	0.23	6.2
MW-6	1.9	13	70.0	16.0	431	<0.04	0.30	6.1
MW-7	0.82	11	16.0	21.0	229	<0.04	0.28	6.1

ROGER E. BOLDT, Ph.D.
Chief, Non-Metals Analysis Branch
Radiological and Inorganic Chemistry
Division

LABORATORY ANALYSIS OF SOILS

The proponent of this form is HSE-ES.

PROJECT NO. 38-26-0195-82

LOCATION DEFENSE DEPOT MEMPHIS, MEMPHIS, TN.

BORE HOLE NO	1	1	1	1	1	1	1	1	1	3	3	3
DEPTH OF SAMPLE	4.5-6.5'	9.0-10.0'	19.0-21.0'	29.0-31.0'	38.0-38.6'	0-2.5'	23-24'	45-50'	55-60'	4-5'	28-30'	41-45'
SAMPLE TYPE	ST	ST	ST	ST	ST	BS	BS	BS	BS	BS	BS	BS
GRAIN SIZE ANALYSIS					½-87.8				¾-94.6			
% PASSING NO. 4 (SIEVE)	100.0	100.0	100.0	100.0	79.7	98.6	99.9	100.0	84.8	99.0	99.8	99.5
% PASSING NO. 10 (SIEVE)	100.0	100.0	99.9	100.0	75.7	98.0	99.8	99.9	81.3	97.2	99.6	99.0
% PASSING NO. 20 (SIEVE)	100.0	99.9	99.7	99.9	73.1	97.5	99.6	98.8	77.6	93.9	99.1	95.6
% PASSING NO. 40 (SIEVE)	99.9	99.7	99.2	99.7	62.6	96.2	99.1	88.8	64.8	90.3	96.3	74.2
% PASSING NO. 100 (SIEVE)	99.6	99.0	79.3	25.8	7.9	95.4	83.6	56.3	7.6	84.8	75.7	9.8
% PASSING NO. 200 (SIEVE)	99.2	98.3	75.4	21.4	7.4	95.1	80.6	33.1	6.7	83.3	73.9	9.0
% PASSING NO. 0.02 (HYDROMETER)												
% PASSING NO. 0.002 (HYDROMETER)												
% PASSING NO. 0.001 (HYDROMETER)												
ATTERBERG LIMITS												
LIQUID LIMIT W_L	27.5	25.8	22.0	27.5	NON	32.0	28.9	21.3	NON	33.0	28.2	NON
PLASTIC LIMIT W_P	21.9	21.7	13.2	20.8	PLASTIC	21.5	20.2	16.7	PLASTIC	24.5	21.6	PLASTIC
PLASTIC INDEX I_P	5.6	4.1	8.8	6.7		10.5	8.7	4.6		8.5	6.6	
UNIFIED SOIL CLASSIFICATION	ML-CL	ML-CL	CL	SM-SC	GW-GC	CL	CL	SM-SC	GW-GM	ML	ML-CL	GW-GM
STANDARD PROCTOR DENSITY												
gm/cm³												
lb/ft³												
OPTIMUM MOISTURE CONTENT (OMC%)												
NATURAL MOISTURE CONTENT %												
PERMEABILITY Cm/sc (k)												
"IN SITU" (SHELBY TUBE/SPLIT SPOON)												
PROCTOR DENSITY - COMPACTION MOLD												
PROCTOR DENSITY - HAND REMOLDED	7.2×10^{-7}	8.15×10^{-6}	4.21×10^{-8}	1.14×10^{-4}	8.19×10^{-7}		3.57×10^{-6}					
3-VOID								6.89×10^{-5}	4.27×10^{-5}		4.14×10^{-5}	5.92×10^{-5}
VOID RATIO (k)	0.761	0.727	0.500	0.410	0.605		0.590	0.789	0.620		0.875	0.669
% SATURATION (k)	100.37	95.85	94.53	139.73	94.18		97.07	94.84	89.21		97.17	94.00
POROSITY (k)	43.2	42.1	33.3	29.1	37.7		37.1	44.1	38.3		46.7	40.1
DRY DENSITY (k)	1.53	1.56	1.80	1.93	1.68		1.70	1.51	1.67		1.44	1.62
MOISTURE CONTENT (k)	28.3%	25.8%	17.5%	21.2%	21.1%		21.2%	27.7%	20.5%		31.5%	23.3%
SPECIFIC GRAVITY	2.7	2.7	2.7	2.7	2.7		2.7	2.7	2.7		2.7	2.7
CATION EXCHANGE CAPACITY (CEC)												
% BASE SATURATION												

COMPLETED BY

DATE 9-3-82

APPROVED BY

DATE 9 Sept 82

AEHA Form 92, 1 Dec 81

Richard M. Carnevale
RICHARD M. CARNEVALE
1LT, MSC
Sanitary Engineer
Waste Disposal Engineering
Division

LABORATORY ANALYSIS OF SOILS

The proponent of this form is HSE-ES.

PROJECT NO. 38-26-0195-B2

LOCATION DEFENSE DEPOT MEMPHIS, MEMPHIS, TN.

BORE HOLE NO	5											
DEPTH OF SAMPLE	35-46'											
SAMPLE TYPE	BS											
GRAIN SIZE ANALYSIS												
% PASSING NO. 4 (SIEVE)	99.1											
% PASSING NO.10 (SIEVE)	97.3											
% PASSING NO 20 (SIEVE)	95.8											
% PASSING NO 40 (SIEVE)	89.2											
% PASSING NO.100 (SIEVE)	35.1											
% PASSING NO 200 (SIEVE)	30.1											
% PASSING NO 0.02 (HYDROMETER)												
% PASSING NO. 0.002 (HYDROMETER)												
% PASSING NO. 0.001 (HYDROMETER)												
ATTERBERG LIMITS												
LIQUID LIMIT w_L	19.0											
PLASTIC LIMIT w_P	17.8											
PLASTIC INDEX I_P	1.2											
UNIFIED SOIL CLASSIFICATION	SM											
STANDARD PROCTOR DENSITY												
gm/cm^3												
lb/ft^3												
OPTIMUM MOISTURE CONTENT (OMC %)												
NATURAL MOISTURE CONTENT %												
PERMEABILITY Cm/sc (k)												
"IN SITU" (SHELBY TUBE/SPLIT SPOON)												
PROCTOR DENSITY-COMPACTION MOLD												
PROCTOR DENSITY- HAND REMOLDED												
3-VOID	6.57×10^{-4}											
VOID RATIO (k)	0.789											
% SATURATION (k)	92.79											
POROSITY (k)	44.1											
DRY DENSITY (k)	1.51											
MOISTURE CONTENT (k)	27.1%											
SPECIFIC GRAVITY	2.7											
CATION EXCHANGE CAPACITY (CEC)												
% BASE SATURATION												

COMPLETED BY

DATE

APPROVED BY

DATE 7 Sept 92

AEHA Form 92, 1 Oct 81

Richard M. Carnevale

RICHARD M. CARNEVALE
1LT, MSC
Sanitary Engineer
Waste Disposal Engineering

Water Quality Biological Study Number
32-24-0733-86
USAEHA
March 1986

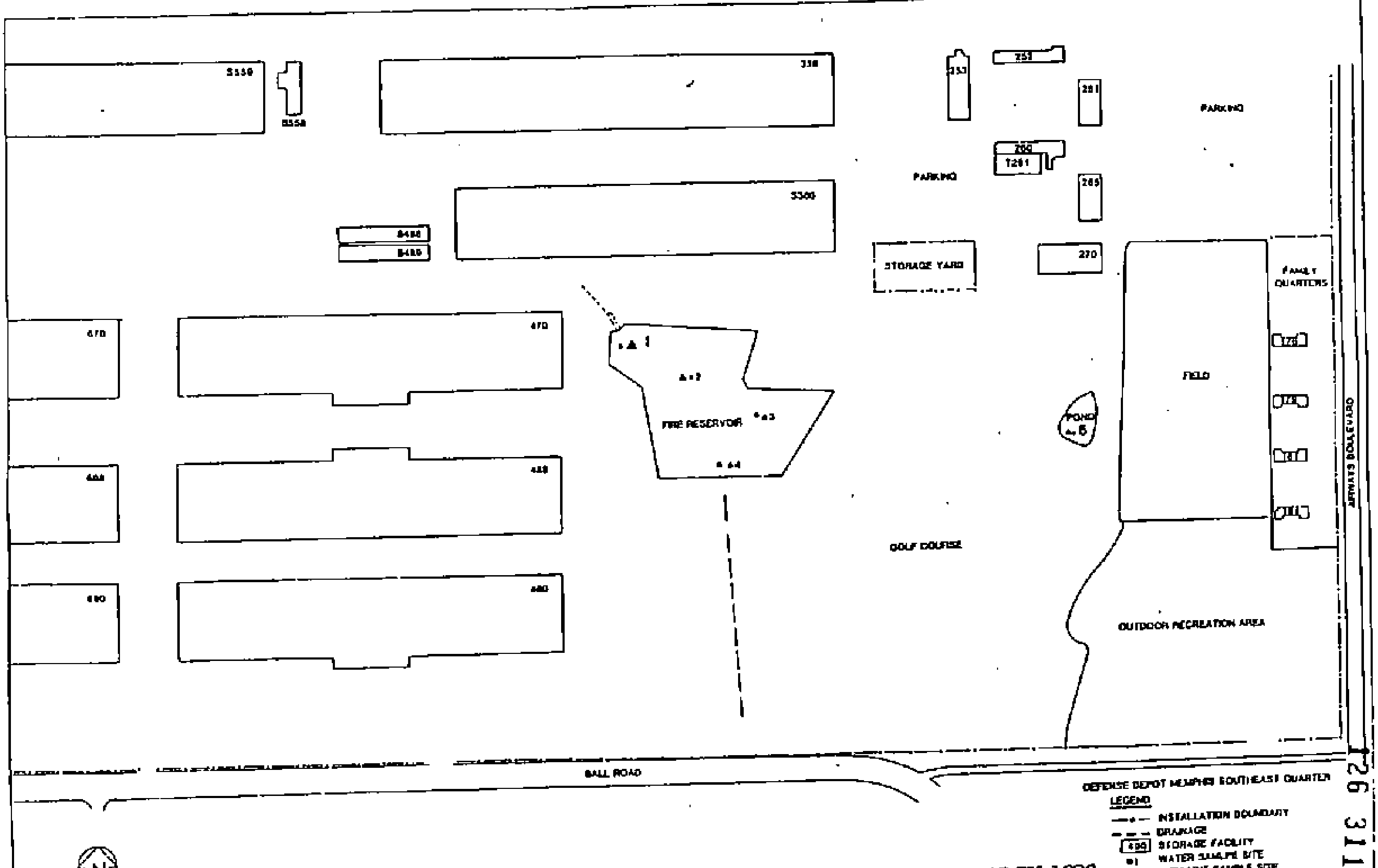


FIGURE SAMPLE SITE LOCATIONS ON DEFENSE DEPOT MEMPHIS. 10-14 MARCH 1988

METALS IN FISH TISSUE (FILLETS) FROM FIRE RESERVOIR AND SMALL POND, DDMT, 10-14 MARCH 1986

	Sample					
	Catfish from Fire Reservoir				Goldfish from Pond	
Metal (mg/kg)	A	B	C	D	A	B
Antimony	<0.992	<0.954	<1.05	<1.00	<0.992	<0.978
Arsenic	<0.992	<0.954	<1.05	<1.00	<0.992	<0.978
Beryllium	<0.198	<0.191	<0.209	<0.200	<0.198	<0.196
Cadmium	<0.099	<0.095	<0.105	<0.100	<0.099	<0.098
Chromium	<2.98	<2.86	<3.14	<3.00	<2.98	<2.94
Copper	<3.97	50.8	<4.18	<4.00	<3.97	<3.91
Lead	0.794	1.15	0.628	<0.200	0.397	<0.196
Mercury	<0.039	<0.038	<0.042	<0.040	0.238	0.333
Nickel	<9.92	<9.54	<10.5	<10.0	<9.92	<9.78
Selenium	<0.198	<0.191	<0.209	<0.200	<0.198	<0.196
Thallium	<0.198	<0.191	<0.209	<0.200	<0.198	<0.196
Zinc	3.57	19.8	3.97	3.80	15.9	10.8

PESTICIDE RESIDUES IN SEDIMENT FROM FIRE RESERVOIR AND SMALL POND, DDMT, 10-14 MARCH 1986

Pesticide	Detection Limit mg/kg	Sample Site* 1	2	3	4	5
Aldrin	0.050	BDL	BDL	BDL	BDL	BDL
BHC (Alpha)	0.020	BDL	BDL	BDL	BDL	BDL
BHC (Beta)	0.060	BDL	BDL	BDL	BDL	BDL
BHC (Delta)	0.060	BDL	BDL	BDL	BDL	BDL
Chlordane	0.400	BDL	BDL	BDL	BDL	BDL
Chlordane (Metab)†	0.400	1.11	2.52	1.64	2.09	BDL
O,P'-DDD	0.120	0.95	1.34	0.77	0.97	BDL
P,P'-DDD	0.100	3.45	3.75	2.32	3.93	0.21
O,P'-DDE	0.120	BDL	BDL	BDL	BDL	BDL
P,P'-DDE	0.100	2.71	5.31	4.22	4.75	0.22
O,P'-DDT	0.120	0.18	0.24	0.18	0.21	BDL
P,P'-DDT	0.150	0.77	0.81	0.59	0.75	0.15
Diazinon	0.052	BDL	BDL	BDL	BDL	BDL
Dieldrin	0.070	BDL	BDL	BDL	BDL	BDL
Endrin	0.130	BDL	BDL	BDL	BDL	BDL
HCB	0.020	BDL	BDL	BDL	BDL	BDL
Heptachlor Epoxide	0.050	BDL	BDL	BDL	BDL	BDL
Lindane	0.024	BDL	BDL	BDL	BDL	BDL
Malathion	0.010	BDL	BDL	BDL	BDL	BDL
Methoxychlor	0.500	BDL	BDL	BDL	BDL	BDL
Methyl Parathion	0.030	BDL	BDL	BDL	BDL	BDL
Mirex	0.120	BDL	BDL	BDL	BDL	BDL
Oxychlordane	0.050	BDL	BDL	BDL	BDL	BDL
Parathion	0.020	BDL	BDL	BDL	BDL	BDL
PCB (Aroclor 1242, 1248, 1254 & 1260)	0.100	BDL	BDL	BDL	BDL	BDL
Toxaphene	4.00	BDL	BDL	BDL	BDL	BDL

† Metabolized total constituents chlordane that includes cis and trans chlordane.
BDL - Below detectable limit

PESTICIDE RESIDUES IN FISH TISSUE (FILLETS) FROM FIRE RESERVOIR AND SMALL POND, ODMT, 10-14 MARCH 1986

Pesticide	Detection Limit mg/kg	Catfish from Fire Reservoir				Goldfish From Pond	
		A	B	C	D	A	B
Aldrin	0.004	BDL*	BDL	BDL	BDL	BDL	BDL
BHC (Alpha)	0.003	BDL*	BDL	BDL	BDL	BDL	BDL
BHC (Beta)	0.005	BDL*	BDL	BDL	BDL	BDL	BDL
BHC (Delta)	0.005	BDL*	BDL	BDL	BDL	BDL	BDL
Chlordane	0.030	BDL*	BDL	BDL	BDL	BDL	BDL
Chlordane (Metab)†	0.030	2.13	2.13	2.01	1.82	0.14	0.60
Chlorpyrifos	0.004	0.012	0.008	0.023	0.006	BDL	BDL
O,P'-DDD	0.010	0.51	0.57	0.55	0.43	0.02	0.07
P,P'-DDD	0.010	4.06	4.76	3.66	3.68	0.18	1.02
O,P'-DDE	0.010	‡	‡	‡	‡	‡	‡
P,P'-DDE	0.010	15.55	15.65	8.44	11.82	1.25	3.61
O,P'-DDT	0.015	0.59	0.63	0.29	0.47	BDL	BDL
P,P'-DDT	0.020	2.16	2.03	1.38	1.66	BDL	BDL
Diazinon	0.003	BDL	BDL	BDL	BDL	BDL	BDL
Dieldrin	0.008	0.31	0.19	0.16	0.16	0.03	0.17
Endrin	0.012	BDL	BDL	BDL	BDL	BDL	BDL
HCB	0.003	BDL	BDL	BDL	BDL	BDL	BDL
Heptachlor	0.003	BDL	BDL	BDL	BDL	BDL	BDL
Heptachlor Epoxide	0.005	‡	‡	‡	‡	‡	‡
Lindane	0.003	BDL	BDL	BDL	BDL	BDL	BDL
Malathion	0.005	BDL	BDL	BDL	BDL	BDL	BDL
Methoxychlor	0.040	BDL	BDL	BDL	BDL	BDL	BDL
Methyl Parathion	0.004	BDL	BDL	BDL	BDL	BDL	BDL
Mirex	0.020	BDL	BDL	BDL	BDL	BDL	BDL
Oxychlordane	0.005	‡	‡	‡	‡	‡	‡
Parathion	0.004	BDL	BDL	BDL	BDL	BDL	BDL
PCB (Aroclor 1242	0.200	BDL	BDL	BDL	BDL	BDL	BDL
PCB (Aroclor 1248 & 1254)	1.00	BDL	BDL	BDL	BDL	BDL	BDL
PCB (Aroclor 1260)	0.200	0.45	0.48	0.34	0.44	1.13	2.84
Ronnel	0.004	BDL	BDL	BDL	BDL	BDL	BDL
Toxaphene	0.400	BDL	BDL	BDL	BDL	BDL	BDL

* BDL Below Detection Limit

† Metabolized/total constituents chlordane that includes cis and trans chlordane

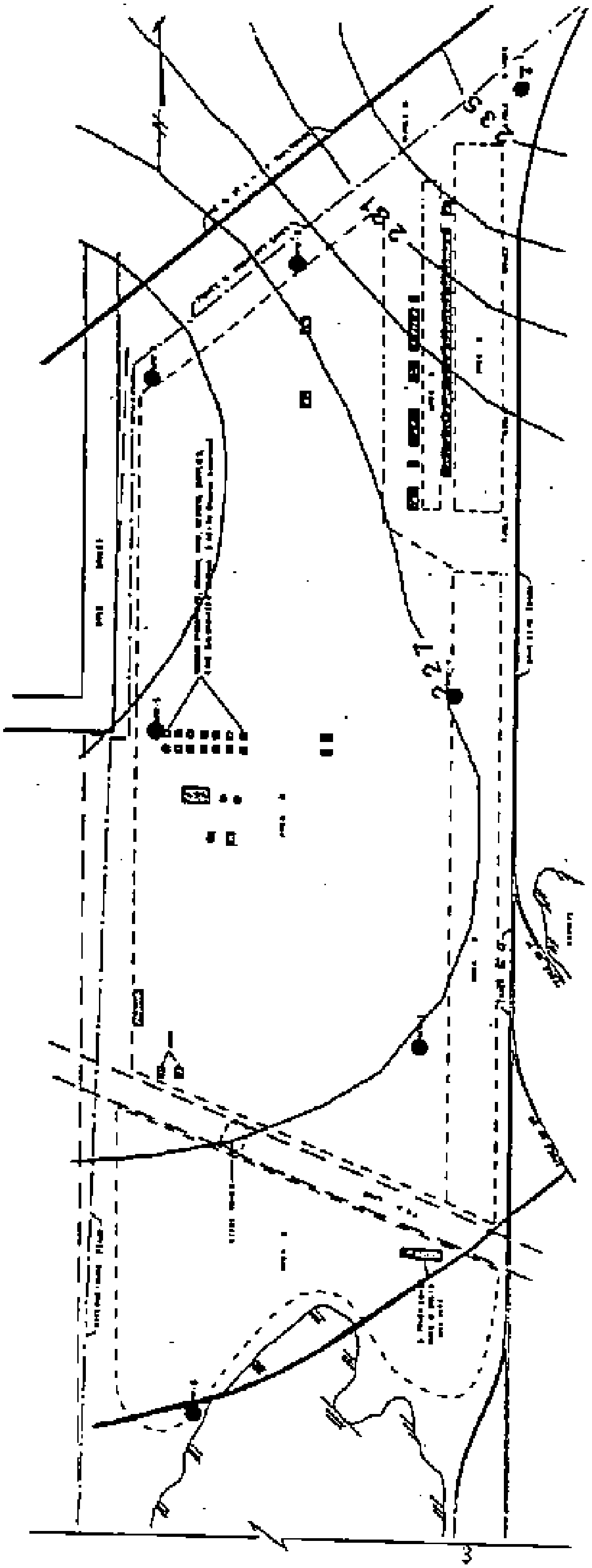
‡ Unable to separate

GENERAL CHEMICAL AND PHYSICAL WATER QUALITY DATA FROM FIRE RESERVOIR AND SMALL POND, DDMT, 10-14 MARCH 1986

Characteristic Unit	Sample Date (March)	Sample Site* 1	2	3	4	5
Dissolved Oxygen	11	10.4	10.9	11.0	11.5	15.6
mg/L	12	9.8	10.1	10.3	10.0	7.6
Temperature	11	14.0	14.2	13.7	13.9	17.1
°C	12	14.0	13.7	13.7	13.7	14.9
pH	11	6.8	7.6	8.2	8.2	9.6
Standard Units	12	8.0	8.6	8.5	8.6	8.5
Conductivity	11	77	77	77	77	97
µmhos/cm	12	83	74	75	74	60
Chlorides	11	1.3	1.5	1.6	1.3	2.0
mg/L	12	1.5	1.2	1.9	1.1	1.5
Cyanide	11	<0.01	<0.01	<0.01	<0.01	<0.01
mg/L	12	<0.01	<0.01	<0.01	<0.01	<0.01
Sulfates	11	11.5	11.2	11.6	11.0	7.7
mg/L	12	11.1	11.0	12.1	11.2	6.4
Biochemical Oxygen Demand	11	3.6	3.9	3.5	3.6	10.3
mg/L	12	3.1	3.6	4.2	3.9	16.0
Total Organic Carbon	11	19.4	16.8	17.1	17.3	16.8
mg/L	12	18.9	17.0	15.8	17.3	23.4
Ammonia Nitrogen	11	0.023	0.22	0.23	0.26	0.32
mg/L	12	0.33	0.63	0.51	0.58	0.11
Total Kjeldahl-Nitrogen	11	0.51	0.89	0.81	1.6	0.90
mg/L	12	1.6	0.51	0.50	0.54	4.2
Nitrate Nitrite Nitrogen	11	0.16	0.16	0.19	0.15	0.08
mg/L	12	0.97	0.26	0.25	0.25	0.30
Total Phosphate Phosphorus	11	0.047	0.035	0.045	0.067	0.61
mg/L	12	0.12	0.086	0.096	0.085	0.46
Grease and Oil	11	<5.0	<5.0	33	10.9	<5.0
mg/L	12	<5.0	48	23.2	13.9	<5.0
Alkalinity (as $CaCO_3$)	11	26.0	25.1	28.0	27.0	23.1
mg/L	12	24.1	23.1	25.1	23.1	23.1
Hardness (as $CaCO_3$)	11	31.3	29.3	31.3	29.3	21.2
mg/L	12	39.4	32.3	27.3	29.3	24.3

Groundwater Consultation Study Number
38-26-0815-87
USAEHA
December 1986

Ground-Water Consultation No. 38-26-0815-87, DDMT, TN, 8-10 Dec 86



Contour Interval = 2 Ft.

FIGURE. DUNN FIELD: Well locations and ground-water contours.

CHEMICAL ANALYSIS

TABLE B-1. WATER LEVEL INFORMATION (MEASURED FROM THE TOP OF THE WELL CASING)

	MW2	MW3	MW4	MW5	MW6	MW7
Depth to Water	DRY	62'11"	70'5"	74'11"	58'4"	64'3"

TABLE B-2. GENERAL CHARACTERISTIC DATA

	MW3	MW4	MW5	MW6	MW7
Conductivity (μmhos/cm)	318	247	290	2481	261
TDS (mg/L)	289	208	245	1670	222
pH	5.1	5.2	6.2	5.6	6.3

TABLE B-3. TOTAL METALS (ppm). ALL SAMPLES WERE PREPARED FOLLOWING EPA METHOD 200.0

	EPA Method	Detection Limits	MW3	MW4	MW5	MW6	MW7
Ba	200.7	0.010	0.135	0.129	0.155	0.674	0.107
Cr	200.7	0.020	BDL	BDL	0.022	0.027	BDL
Fe	200.7	0.100	2.03	2.40	11.4	1.13	0.760
Mn	200.7	0.030	BDL	BDL	0.082	9.110	BDL
Hg	245.2	0.0002	0.0004	0.0002	BDL	BDL	0.0002
Na	200.7	0.500	20.7	24.3	23.8	34.2	16.2
Pb	239.2	0.001	0.006	0.003	0.012	BDL	0.004
Se	270.2	0.001	0.001	BDL	0.001	BDL	0.001
Zn	200.7	0.010	0.048	0.074	0.079	0.079	0.043

BDL = Below detectable limit

Ground-Water Consultation No. 38-26-0815-87, DDMT, TN, 8-10 Dec 86

TABLE B-4. PURGEABLE ORGANICS (ppm). ALL SAMPLES WERE ANALYZED FOLLOWING EPA METHOD 624

	Detection Limits	MW3	MW4	MW5	MW6	MW7
1,1-Dichloroethene	0.003	0.027	BDL	BDL	BDL	0.075
1,1-Dichloroethane	0.003	BDL	BDL	BDL	BDL	0.003
1,1,1-Trichloroethane	0.003	0.004	BDL	BDL	BDL	0.009
Trichloroethene	0.003	0.018	0.004	0.007	0.150	0.015
Tetrachloroethene	0.003	0.029	0.081	0.027	0.003	0.039
Chloroform	0.003	BDL	0.006	BDL	0.019	0.003
Carbon Tetrachloride	0.003	BDL	0.004	BDL	0.078	BDL
Trans-1,2-Dichloroethene	0.003	BDL	BDL	BDL	0.200	BDL
1,1,2,2-Tetrachloroethane	0.003	BDL	BDL	BDL	0.082	BDL
1,1,2-Trichloroethane	0.003	BDL	BDL	BDL	0.004	BDL

NOTE: No other purgeable organics were detected.
BDL - Below detectable limit.

TABLE B-5. ACID EXTRACTABLE ORGANICS (ppm). ALL SAMPLES WERE ANALYZED FOLLOWING EPA METHOD 625

	Detection Limits	MW3	MW4	MW5	MW6	MW7
4,6-Dinitro-O-Cresol	0.250	BDL	TRC	BDL	BDL	BDL
4-Nitrophenol	0.025	BDL	TRC	BDL	BDL	BDL
P-Chloro-M-Cresol	0.025	BDL	TRC	BDL	BDL	BDL
Pentachlorophenol	0.025	BDL	TRC	BDL	BDL	BDL
2,4,6-Trichlorophenol	0.025	BDL	TRC	BDL	BDL	BDL

NOTE: No other acid extractable organics were detected.
TRC = Trace amount detected.
BDL = Below detectable limit.

TABLE B-6. BASE/NEUTRAL EXTRACTABLE ORGANICS (EPA METHOD 625)

No base/neutral extractable organics were detected in any sample.

TABLE B-7. PESTICIDES AND PCBs (EPA Method 608)

No pesticides or PCBs were detected in any sample.

Remedial Investigation/Feasibility Study
Law Environmental
August 1990

TABLE D-1
POSITIVE RESULTS IN GROUND WATER
DUNN FIELD AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

HALOGENATED VOLATILES (ug/l)

PARAMETER		Background Well MW18	MCL	MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13	MW14	MW15	MW28	MW29	MW34	MW35	MW30	MW31	MW32	MW33
1,1,1-Trichloroethane	PHASE I	--	200	3J	--	--	--	5J	5	--	9	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		4J	--	--	--	4J	5	--	10	--	--	--	--	--	--	9	--	--	--	5	--	--
	AEHA-1987	--		4	--	--	--	9	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1,1,2,2-Tetrachloroethane	PHASE I	--	--	--	--	--	150	--	--	--	10	73	340D	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	65	--	--	--	8	11	1900D	2J	--	--	--	--	--	--	--	280D	110	--
	AEHA-1987	--		--	--	--	82	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1,1,2-Trichloroethane	PHASE I	--	--	--	--	--	7	--	--	--	--	2J	1J	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	4J	--	--	--	--	--	7	--	--	--	--	--	--	--	--	12	5	--
	AEHA-1987	--		--	--	--	4	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1,1-Dichloroethane	PHASE I	--	--	--	--	--	--	3J	3J	--	3J	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	--	2J	4J	--	4J	--	--	--	--	--	--	5	--	--	--	--	--	--
	AEHA-1987	--		--	--	--	--	3	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1,1-Dichloroethylene	PHASE I	--	7	36	--	--	--	81	66	3J	130	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		47	--	--	--	56	68	2J	160	--	--	--	--	--	--	58	--	--	--	61	--	--
	AEHA-1987	--		27	--	--	--	75	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1,2-Dichlorethane	PHASE I	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	--	--	--	--	3J	--	--	--	--	--	--	--	--	--	--	--	--	--
	AEHA-1987	--		--	--	--	--	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1,2-Dichloroethylene	PHASE I	--	100/70(c)	--	--	3J	270D	--	--	--	6J	520D	190D	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	160	--	--	--	160	81	510D	--	--	2J	--	--	--	1J	--	1100D	110	--
	AEHA-1987	--		--	--	--	200	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Carbon Tetrachloride	PHASE I	--	5	--	5J	4J	77	--	--	7	--	4J	1J	--	1J	10J	--	--	--	--	--	--	--	--
	PHASE II	--		--	10	--	40	--	--	5	3J	5	3J	--	--	17	--	--	--	--	--	11	52	--
	AEHA-1987	--		--	4	--	78	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Chloroform	PHASE I	--	100(c)	3J	2J	11	15	8	--	3J	--	8	3J	--	--	4J	--	--	--	--	--	--	--	--
	PHASE II	--		--	7	2J	10	6	--	--	8	11	10	--	--	18	--	--	--	--	--	33	12	--
	AEHA-1987	--		--	6	--	19	3	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Methylene chloride	PHASE I	--	5	--	--	--	--	48J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		2J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	AEHA-1987	--		--	--	--	--	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Tetrachlorethene	PHASE I	--	5	49	100	210	3	59	58	6	180	--	--	3J	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		74	200D	46	2J	47	54	5	240D	18	33	9	--	--	--	67	--	--	--	96	2J	--
	AEHA-1987	--		29	81	27	3	39	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Trichloroethene	PHASE I	--	5	25	4J	28	190D	19	21	7	140	380D	1700D	--	--	2J	--	--	--	--	--	--	--	--
	PHASE II	--		35	9	5	120	16	21	4J	390D	81	5100D	--	--	6	--	24	--	61	--	1500D	110	--
	AEHA-1987	--		18	4	7	150	15	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

TABLE D-1
POSITIVE RESULTS IN GROUND WATER
DUNN FIELD AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER		Background Well MW18	MCL	MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13	MW14	MW15	MW28	MW20	MW34	MW35	MW30	MW31	MW32	MW33
NONHALOGENATED VOLATILES (ug/l)																								
Acetone	PHASE I	3J	--	--	--	--	34B	3J	--	--	--	1JB	1JB	1JB	2JB	--	--	--	--	--	--	--	--	--
	PHASE II	--		0J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NONHALOGENATED SEMIVOLATILES (ug/l)																								
Benzoic acid	PHASE I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		3J	3J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Di-n-butyl phthalate	PHASE I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	42	--	--	--	--
N-Nitrosodiphenylamine	PHASE I	2J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		4BJ	19B	8BJ	5BJ	3BJ	4BJ	3BJ	8BJ	4BJ	7BJ	6BJ	--	5BJ	3BJ	6BJ	--	3BJ	--	--	--	--
bis(2-Ethylhexyl) phthalate	PHASE I	5J	--	8J	7J	6J	5J	5J	5J	8J	13	--	5J	3J	8J	8J	--	--	--	--	--	--	--	--
	PHASE II	3J		7BJ	--	--	--	--	--	--	--	3BJ	--	--	--	--	--	--	--	11J	--	--	--	--
VOLATILE METALS (ug/l)																								
Arsenic	PHASE I	55	60	--	--	--	--	--	--	62	65	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	40		--	--	--	--	--	--	--	150	--	--	--	210	--	--	50	--	--	50	160	--	60
	AEHA-1987			--	--	--	--	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Lead	PHASE I	79	50/15(l)	238N	257N	84N	395N	390N	165N	171N	653N	353N	417N	150N	507N	255N	--	--	--	--	--	--	--	--
	PHASE II	80		90	130	40	70	260	70	--	1000	140	70	40	200	120	80	90	--	--	50	280	120	100
	AEHA-1987			6	3	12	--	4	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Mercury	PHASE I	--	2	1.8	1.1	.6	3.8	1.4	1.7	.8	.7	1.4	.5	1.4	1.9	3.1	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	1	--	1	--	1	--	--	--	2	1	--	--	--	--	--	1	1	--
	AEHA-1987			0.4	0.2	--	--	0.2	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

TABLE D-1
POSITIVE RESULTS IN GROUND WATER
DUNN FIELD AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

NONVOLATILE METALS (ug/l)

PARAMETER		Background Well MW16	MCL	MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13	MW14	MW15	MW28	MW29	MW34	MW35	MW30	MW31	MW32	MW33
Antimony	PHASE I	--	6	458N	598N	--	142N	170N	113N	81N	81N	546N	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	AEHA-1987			NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Barium	PHASE I	218	2000	659N	695N	224N	117N	1030N	994N	418N	1310N	3390N	2010N	416N	3740N	999N	--	--	--	--	--	--	--	--
	PHASE II	410		310	280	200	630	540	350	130	1900	1200	560	220	1500	550	980	410	120	120	600	880	1000	460
	AEHA-1987	--		135	129	155	674	107	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Cadmium	PHASE I	--	5	--	--	--	8N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	--	--	--	--	--	--	--	--	--	--	9	9	--	--	--	--	--	--
	AEHA-1987			--	--	--	--	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Chromium (d)	PHASE I	55	100	643N	823N	170N	386N	1240N	471N	182N	288N	530N	517N	184N	600N	393N	--	--	--	--	--	--	--	--
	PHASE II	50		80	120	50	40	340	100	10	310	120	40	20	190	110	130	170	--	--	50	280	140	100
	AEHA-1987			--	--	22	27	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Copper	PHASE I	198	1300(g)	345N	438N	76N	213N	856N	304N	138N	613N	843N	454N	190N	592N	400N	--	--	--	--	--	--	--	--
	PHASE II	180		50	80	40	40	210	180	20	810	520	80	50	180	110	80	80	--	--	50	100	50	70
	AEHA-1987			--	--	--	--	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Nickel	PHASE I	29	100	324N	301N	57N	145N	602N	170N	87N	142N	225N	350N	79N	421N	170N	--	--	--	--	--	--	--	--
	PHASE II	40		40	50	20	30	170	50	--	170	60	40	20	100	60	70	80	--	--	30	130	60	50
	AEHA-1987			--	--	--	--	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Silver	PHASE I	--	100(h)	--	--	--	20	--	--	--	--	--	42	11	13	68	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	AEHA-1987			--	--	--	--	--	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Zinc	PHASE I	116	5000(h)	114N	115N	311N	517N	1810N	745N	304N	1120N	872N	1300N	407N	1840N	882N	--	--	--	--	--	--	--	--
	PHASE II	180		160	170	91	63	450	160	14	1300	230	110	79	430	140	250	210	24	36	160	490	220	230
	AEHA-1987			48	74	79	79	43	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

(c) Trans Isomer/Cis Isomer
(d) No distinction between Chromium (III) and Chromium (VI)
(e) Total trihalomethanes
(f) MCL/Action Level
(g) MCLG. Primary MCL is a Treatment Technique
(h) Secondary MCL
NT = Well not tested for this parameter due to one of following reasons:
 (1) Well not constructed yet
 (2) Well constructed but sample not analyzed for this parameter
AEHA 1987 – Groundwater samples analyzed using EPA Methods 624, 625, 608, 200.7, 245.2, 239.2, and 270.2

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL) but greater than the Instrument Detection Limit (IDL).
B (Organic) = Found in method blank.
D = Identified in an analysis at a secondary dilution factor.
J = Estimated value less than the sample quantitation limit but greater than zero.
N = Spiked sample recovery not within control limits.
-- = Not detected.
NA = Not Available

TABLE D-1.1
POSITIVE RESULTS IN GROUND WATER DUNN FIELD – PERCHED WATER TABLE DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	MCL	PHASE I MW2
NONHALOGENATED VOLATILES (ug/l)		
Acetone	--	3J
NONHALOGENATED SEMIVOLATILES (ug/l)		
bis(2-Ethylhexyl) phthalate	--	5J
VOLATILE METALS (ug/l)		
Arsenic	50	100
Lead	50/15 (b)	186N
Mercury	2	.5
Selenium	50	90
NONVOLATILE METALS (ug/l)		
Antimony	6	90N
Barium	2000	475N
Cadmium	5	12N
Chromium (c)	100	118N
Copper	1300 (d)	127N
Nickel	100	48N
Zinc	5000 (h)	299N

Reference – RI Report (1990)

(b) MCL/ Action Level

(c) No distinction between Chromium III and Chromium VI.

(d) MCLG. Primary MCL is Treatment Technique.

(h) Secondary MCL

J = Estimated value less than the sample quantitation limit, but greater than zero.

N = Spiked sample recovery not within control limits.

NA = Not Available

TABLE D-1.2
POSITIVE RESULTS IN GROUND WATER
MAIN INSTALLATION – FLUVIAL AQUIFER
DEFENSE DEPOT MEMPHIS TENNESSEE

		BACKGROUND WELL												
PARAMETER (UG/L)	DATE	MW16	MCL	MW17	MW19	MW20	MW21	MW22	MW23	MW24	MW25	MW26	MW38	MW39
HALOGENATED VOLATILES (ug/l)														
Carbon Tetrachloride	PHASE I	--	5	--	--	--	--	--	--	--	2J	5J	--	--
	PHASE II	--		--	--	--	--	--	--	--	--	5	--	--
Chloroform	PHASE I	--	100(c)	--	--	--	--	--	--	--	--	1J	--	--
	PHASE II	--		--	--	--	--	--	--	--	--	2J	--	--
Methylene chloride	PHASE I	--	5	--	--	--	--	--	--	--	--	1BJ	--	--
	PHASE II	--		--	--	--	--	--	--	--	--	--	--	--
Tetrachlorethene	PHASE I	--	5	--	--	--	39	--	--	--	8	10	--	--
	PHASE II	--		--	--	--	15	2J	--	--	7	5	--	1J
Trichloroethene	PHASE I	--	5	--	--	--	--	5J	--	--	--	3J	--	--
	PHASE II	--		--	--	--	2J	11	--	--	--	3J	--	9
NONHALOGENATED VOLATILES (ug/l)														
Acetone	PHASE I	3J	--	3J	--	4J	2J	3J	3J	3J	2BJ	4J	--	--
	PHASE II	--		--	--	--	--	--	--	--	--	--	--	--
NONHALOGENATED SEMIVOLATILES (ug/l)														
Di-n-butyl phthalate	PHASE I	--	--	--	--	3J	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	--	--	--	--	--	--	--	--
Di-n-octyl phthalate	PHASE I	2J	--	--	--	7J	--	--	4J	--	--	3J	--	--
N-Nitrosodiphenylamine	PHASE I	2J	--	--	--	--	3J	3J	--	2J	5J	--	--	--
Phenol	PHASE II	--	--	--	--	--	--	--	--	--	--	--	--	3J
bis(2-Ethylhexyl) phthalate	PHASE I	5J	--	3J	5J	12J	--	4J	8J	5J	--	9J	--	--
	PHASE II	3J		--	2J	--	--	--	--	--	--	--	--	54
VOLATILE METALS (ug/l)														
Arsenic	PHASE I	55	50	324	38	--	--	--	--	--	--	--	--	--
	PHASE II	40		--	--	70	60	200	120	--	--	50	--	--
Lead	PHASE I	79	50/15 (e)	205	42	79*	97*	201*	334*	152*	128	--	--	--
	PHASE II	80		--	--	50	110	220	140	--	70	50	--	70
Mercury	PHASE I	--	2	6.8	--	.9N	1N	1.4N	1.6N	.4N	1.7	.4N	--	--
	PHASE II	--		--	--	--	1	5	1	--	--	--	--	--

TABLE D-1.2
POSITIVE RESULTS IN GROUND WATER
MAIN INSTALLATION – FLUVIAL AQUIFER
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER (UG/L)	DATE	BACKGROUND WELL MW16	MCL	MW17	MW19	MW20	MW21	MW22	MW23	MW24	MW25	MW28	MW38	MW39
NONVOLATILE METALS (ug/l)														
Antimony	PHASE I	--	6	47B	--	--	--	--	--	--	--	--	--	--
	PHASE II	--		--	--	--	--	--	--	--	60	50	--	--
Barium	PHASE I	216	2000	603	296	247	229	343	567	167	1960	808	--	--
	PHASE II	410		190	310	290	240	380	390	81	410	380	80	130
Cadmium	PHASE I	--	5	8	6	11N*	7N*	14N*	15N*	16N*	--	--	--	--
	PHASE II	--		--	--	--	--	7	8	--	--	--	--	--
Chromium (d)	PHASE I	55	100	406	17	100	171	616	306	31	337	150	--	--
	PHASE II	50		10	20	90	110	560	150	--	40	30	--	20
Copper	PHASE I	196	1300 (f)	322	106	242	146	326	1570	86	209	268	--	--
	PHASE II	160		60	80	130	90	160	230	50	20	40	--	30
Nickel	PHASE I	29	100	238	--	35	49	110	73	26	125	58	--	--
	PHASE II	40		--	--	40	40	100	40	--	--	--	--	--
Zinc	PHASE I	116	5000 (h)	910	59	150	242	594	413	193	408	400	--	--
	PHASE II	180		180	53	140	190	750	290	170	120	120	23	86

Reference – RI Report (1990)
MCL – SDWA Maximum Containment Level
(c) Total trihalomethanes
(d) No distinction between Chromium III and Chromium VI.
(e) MCL/ Action Level
(f) MCLG. Primary MCL is Treatment Technique.
(h) Secondary MCL
B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL) but greater than the Instrument Detection Limit (IDL).
B (Organic) = Found in method blank.
J = Estimated value less than the sample quantitation limit but greater than zero.
N = Spiked sample recovery not within control limits.
* = Duplicate analysis not within control limits.
-- = Not detected.
NA = Not Available.

TABLE D-1.3
POSITIVE RESULTS IN GROUNDWATER MEMPHIS SAND AQUIFER DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	DATE	MCL	MW36	MW37
NONHALOGENATED VOLATILES (ug/l)				
Acetone	PHASE II	--	--	3500D
2-Butanone	PHASE II		4J	--
4-Methyl-2-pentanone	PHASE II		--	8J
NONHALOGENATED SEMIVOLATILES (ug/l)				
N-Nitrosodiphenylamine	PHASE II	--	3BJ	--
NONVOLATILE METALS (ug/l)				
Barium	PHASE II	2000	410	380
Chromium (c)	PHASE II	100	--	20
Copper	PHASE II	1300 (d)	10	20
Nickel	PHASE II	100	--	20
Zinc	PHASE II	5000 (e)	73	150

Reference RI Reoprt (1990)
MCL – SDWA Maximum Containment Level
(c) No distinction between Chromium III and Chromium VI.
(d) MCLG. Primary MCL is Treatment Technique.
(e) Secondary MCL
D = Identified in an analysis at a secondary dilution factor.
J = Estimated value less than the sample quantitation limit, but greater than zero.
-- = Not detected.
NA = Not Available.

TABLE D-2.1

SURFACE SOIL SAMPLING LOCATIONS

SAMPLE TYPE AND NUMBER	LOCATION	DEPTH
SS-I	PDO YARD 150' south of MW-17	1-2"
SS-2	PDO YARD	surface
SS-3	PDO YARD hazardous material storage Post # Y-50-29-67-AA Drums of cleaning compound solvent	surface
SS-4	PDO YARD north of B street; south of Post # Y-50-34-67-AA In drainage ditch	surface
SS-5	PDO YARD southern most cement bin; west of Bldg. S209; east of Bldg. 308	surface
SS-6	DUNN FIELD junction of drainage pipe and and concrete ditch; east of Bldg. 1184	surface
SS-7	DUNN FIELD burn area; north of road north of Bauxite storage	1.0'
SS-8	DUNN FIELD 100' south of gate on Dunn Ave.; 20' west of rr track # 15; beneath oil drums	surface
SS-9	DUNN FIELD 75' west of western fence; 500' north of Dunn Ave.	surface
SS-IO	HAZARDOUS MATERIAL STORAGE southwest corner of Bldg. 629; along ramp on 6th street	0.5'
SS-11	HAZARDOUS MATERIAL STORAGE west end of Bldg. 629; below door # 11	0.5'

SS-12	GOLF COURSE south end of fish pond; 3' south of water-edge	0.2'
SS-13	GOLF COURSE 200' southwest of fish pond	surface
SS-14	GOLF COURSE 3' east of 2nd street; 300' north of N street	surface
SS-15	PAINT AREA west side of Bldg. 1088 beneath metal dust collector	0.2'
SS-16	PAINT AREA north end of Bldg. 1087 east side of driveway and doorway	0.2'
SS-17	PAINT AREA/SAND BLAST AREA northwest corner of Bldg. 1088 just west of emergency exit door	0.2'
SS-18	PAINT AREA south end of Bldg. 1087 east side of driveway	0.2'
SS-19	PAINT AREA northwest corner of Bldg. 1087	0.2'
SS-20	P-949 AREA south end of new fabric structure; 5' east of concrete slab	
SS-21	HARDSTAND OPEN AREA 300' south of B street; 2' east of rr track # 3	0.5'
SS-22	HARDSTAND OPEN AREA 600' south of B street; 2' west of rr track # 3	0.5'
SS-23	HARDSTAND OPEN AREA 2' east of rr track # 4	0.5'
SS-24	FUEL OIL STORAGE TANK west of Bldg. 720; beneath diesel fuel tank	0.5'

SS-25	MOGAS STATION southeast corner of G and 2nd street; 2' west of tank valves	1.0'
SS-26	RECOUPMENT AREA 20' east of Bldg. 873; south end of bin # 6	1.0'
SS-27	RECOUPMENT AREA 20' east of Bldg. 873; north end of bin # 6	1.0'
SS-28	RECOUPMENT AREA 150' east of Bldg. 873; centered on bin # 7	1.0'
SS-29	RECOUPMENT AREA 125' east of Bldg. 873; 20' south of rr track # 3	1.0'
SS-30	NEW CREDIT UNION BLDG. OLD TRANSFORMER STORAGE YARD 3' southwest of southwest corner	1.0'
SS-31	NEW CREDIT UNION BLDG. OLD TRANSFORMER STORAGE YARD 2' north of north end of Bldg.; very center of building	1.0'
SS-32	HARDSTAND OPEN AREA 30' south of B street; centered between rr track # 11 & 12	1.0'
SS-33	HARDSTAND OPEN AREA 75' north of the northwest corner of new hazardous material storage building	1.0'
SS-34	HARDSTAND OPEN AREA 20' south of B street; directly south of 804	1.0'
SS-35	HARDSTAND OPEN AREA northwest corner of the new hazardous material storage building	1.0'
SS-36	HARDSTAND OPEN AREA 300' south of B street; 3' east of rr track # 8	1.0'

SS-37	OLD PESTICIDE STORAGE AREA in flower bed between putting green and Bldg. T-273	1.0'
SS-38	BLDG. 770 50'north of south end of Bldg. 770; 10' west of building at inlet to underground tank	surface
SS-39	BLDG. 770 50'north of south end of Bldg. 770; 55' west of building; beneath two garbage bins filled with oil filters, cans of hydraulic fluid, and anti-freeze	surface
SS-40	HARDSTAND OPEN AREA 100' south of B street; central between 17th street and rr track # 7; transformer storage area	0.2'
SS-41	PDO YARD Due South of Gate 19; 10' North of gravel Road	surface
SS-42	HAZARDOUS MATERIAL STORAGE west end of Bldg. 629	surface
SS-43	HAZARDOUS MATERIAL STORAGE South side of Bldg. 629 200' East of SS-11	surface
SS-44	DUNN FIELD	surface
SS-45	PAINT AREA South east corner of Bldg. S:089	surface
SS-46	PAINT AREA just north of S1090 and just west of Bldg. 880	surface
SS-47	BLDG. 737 North west corner of bldg. in the gravel	surface
SS-48	BLDG. 770 North east corner of J & 10th St. intersection	surface

SS-49	BLDG. 770 North west corner of bldg. 2'from storm drain	surface
SS-50	OLD PESTICIDE STORAGE AREA beside storm drain at southeast corner of bldg. T-273	surface

TABLE D-2.2

SOIL TEST BORINGS

SAMPLE NUMBER	LOCATION	SAMPLING DEPTHS
STB-1 #1	DUNN FIELD	25.5′
#2		62.5′
#3		73.5′
STB-2 #1	DUNN FIELD	10.0′
#2		17.5′
#3		67.5
STB-3 #1	PDO YARD	21.0′
#2		26.0′
#3		93.5′
STB-4 #1	OLD DIP VAT DRIP AREA	19.0′
#2		26.0′
#3		102.0′
STB-5 #1	NORTHWEST CORNER OF MAIN INSTALLATION	16.0′
#2		78.0′
#3		83.0′
STB-6 #1	NORTHWEST CORNER OF DUNN FIELD	71.5′
#2		76.0′
#3		86.0′
#4		181.0′
STB-7 #1	WEST EDGE OF DUNN FIELD	71.0′
#2		76.0′
#3		91.0′
#4		170.0′
STB-8 #1	MAIN INSTALLATION NORTH OF BUILDING 835	92.0′
#2		97.0′
#3		127.0′
#4		212.0′

TABLE D-3
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 629
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I		PHASE II	
PARAMETER	SS10	SS11	SS42	SS43
HALOGENATED VOLATILES ug/kg				
1,1,2-Trichloroethane	--	--	11	--
Methylene chloride	18B	13B	8B	7B
Tetrachloroethene	--	--	3J	--
Trichloroethene	--	--	2100E	--
NONHALOGENATED VOLATILES ug/kg				
Acetone	67	95	24	21
Carbon disulfide	2J	8	--	--
Toluene	6J	18	4J	7
HALOGENATED SEMIVOLATILES ug/kg				
Pentachlorophenol	--	--	--	270J
NONHALOGENATED SEMIVOLATILES ug/kg				
bis(2-Ethylhexyl) phthalate	500J	--	--	1300BJ
Dibenzofuran	1300J	9700	24000J	340J
N-Nitrosodiphenylamine	510JB	1900JB	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)				
2-Methylnaphthalene	500J	2000J	--	--
Acenaphthene	2300	20000	64000J	1100J
Acenaphthylene	550J	1900J	--	--
Anthracene	4400	26000	130000J	1800
Benzo(a)anthracene	9500	110000D	970000	5300
Benzo(a)pyrene	8300	100000D	450000	5200
Benzo(b)fluoranthene	9500	110000D	540000	9300
Benzo(g,h,i)perylene	5300	85000D	360000	2900
Benzo(k)fluoranthene	10000	92000D	450000	--
Chrysene	8900	120000D	620000	6800
Dibenzo(a,h)anthracene	1400J	9800	160000	1400
Fluoranthene	23000	280000D	860000	9300
Fluorene	2600	16000	47000J	880J
Indeno(1,2,3-cd)pyrene	4900	72000D	310000	2800
Naphthalene	1900	4600	--	130J
Phenanthrene	19000	200000D	620000	7000
Pyrene	18000	180000D	870000	9300
TOTAL PAHs	130,050	1,429,300	6,475,000	63,210

TABLE D-3
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 629
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I		PHASE II	
PARAMETER	SS10	SS11	SS42	SS43
PESTICIDES ug/kg				
4,4'-DDD	2100X	3600	1400JX	320DJ
4,4'-DDE	4500D	39000D	9000DJ	2500DJ
4,4'-DDT	6700D	59000D	7900DJ	710DJ
alpha-Chlordane	4000D	--	--	--
beta-BHC	--	--	1600XZ	--
Dieldrin	240	--	--	4500D
Endrin ketone	--	12000D	--	--
gamma-Chlordane	4000D	2400J	620J	--
Heptachlor	120	--	--	--
Heptachlor epoxide	250	--	--	--
Methoxychlor	--	--	1500J	--
VOLATILE METALS mg/kg				
Arsenic	12	20	12	26
Lead	81	1580	1120	126
Mercury	0.080	0.84	1.3	--
NONVOLATILE METALS mg/kg				
Antimony	--	8B	--	--
Barium	57.5	343	108	70.8
Cadmium	1.1	6.0	11.8	--
Chromium **	24	135	39	15
Copper	16	135	705	15
Nickel	--	--	367	5.0
Silver	3.0	9.0	--	--
Zinc	63.4	960	10400	94.8

Reference – RI Report (1990)

na = Not Available

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL). B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

E = Concentration exceeded the calibration range of the GC/MS instrument.

J = Estimated value less than the sample quantitation limit, but greater than zero.

X = Estimated value due to a confirmed compound which is off-scale in both columns.

** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

TABLE D-4
POSITIVE RESULTS IN SURFACE SOILS
FUEL OIL STORAGE TANK
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	PHASE I
	SS24

HALOGENATED VOLATILES (ug/kg)

Methylene chloride	13B

NONHALOGENATED VOLATILES (ug/kg)

Acetone	58J
Toluene	5J

NONHALOGENATED SEMIVOLATILES (ug/kg)

bis(2-Ethylhexyl) phthalate	470B
N-Nitrosodiphenylamine	53BJ
Polynuclear Aromatic Hydrocarbons (PAHs)	
Benzo(a)anthracene	74J
Benzo(a)pyrene	71J
Benzo(b)fluoranthene	100J
Benzo(k)fluoranthene	80J
Chrysene	77J
Fluoranthene	200J
Phenanthrene	120J
Pyrene	140J
Total PAHs	862

PESTICIDES (ug/kg)

4,4'-DDT	51
Dieldrin	130D
Endosulfan-I	41Z

VOLATILE METALS (mg/kg)

Arsenic	30
Lead	98
Mercury	0.06

TABLE D-4
POSITIVE RESULTS IN SURFACE SOILS
FUEL OIL STORAGE TANK
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	PHASE I SS24
NONVOLATILE METALS (mg/kg)	
Barium	67.5
Chromium **	26
Copper	16
Nickel	12
Zinc	48.6

Reference – RI Report (1990)

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

J = Estimated value less than the sample quantitation limit,
but greater than zero.

Z = Matrix interference; compound not positively identifiable.

** = No distinction between Chromium (III) and Chromium (VI).

TABLE D-5
POSITIVE RESULTS IN SURFACE SOILS
GOLF COURSE
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I				PHASE II
PARAMETER	SS12	SS13	SS14	SS37	SS50
HALOGENATED VOLATILES ug/kg					
Chloroform	--	--	2J	--	--
Methylene chloride	14B	21B	15B	13B	16B
Tetrachlorethene	--	--	--	2J	--
Trichloroethene	--	--	--	4J	--
NONHALOGENATED VOLATILES ug/kg					
Acetone	9J	38	24	15	22
Toluene	17	9J	6J	3J	--
Total xylenes	--	--	--	8J	--
NONHALOGENATED SEMIVOLATILES ug/kg					
bis(2-Ethylhexyl) phthalate	1500BJ	2200BJ	2700B	710BJ	1700B
N-Nitrosodiphenylamine	260J	280J	340J	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)					
Acenaphthene	--	--	--	--	200J
Anthracene	--	--	280J	--	330J
Benzo(a)anthracene	--	270J	920J	--	810J
Benzo(a)pyrene	--	340J	930J	--	610J
Benzo(b)fluoranthene	--	420J	1100J	620J	1100J
Benzo(g,h,i)perylene	--	--	780J	--	--
Benzo(k)fluoranthene	--	340J	1100J	--	--
Chrysene	--	390J	1200J	--	990J
Fluoranthene	330J	630J	2700	780J	2200
Fluorene	--	--	--	--	160J
Indeno(1,2,3-cd)pyrene	--	--	700J	--	370J
Phenanthrene	--	310J	1600J	520J	2000
Pyrene	230J	560J	1700J	580J	2500
Total PAHs	560	3,260	13,010	2,500	11,270

TABLE D-5
POSITIVE RESULTS IN SURFACE SOILS
GOLF COURSE
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I				PHASE II
PARAMETER	SS12	SS13	SS14	SS37	SS50
PESTICIDES ug/kg					
4,4'-DDE	2000D	340D	--	1200D	4300D
4,4'-DDT	870	290	--	4000D	3000DJ
Dieldrin	760D	830D	2900D	1400D	3800D
Heptachlor	--	--	--	--	1100Z
Heptachlor epoxide	--	--	--	--	340Z
beta-BHC	--	--	--	--	2500
VOLATILE METALS mg/kg					
Arsenic	33	22	41	42	12
Lead	80G*	50G*	80G*	71	157
Mercury	0.15N	0.1N	0.8N	0.32	0.5
NONVOLATILE METALS mg/kg					
Antimony	--	--	5.0B	5.0	--
Barium	95.8	118	117	76.9	78.4
Cadmium	--	--	--	2.0	1.9
Chromium **	20G	13G	16G	13	17
Copper	34*	21*	26*	18	15
Nickel	13*	12*	12*	11	8
Zinc	81.2G	89.3G	82.3G	80.4	290

Reference - RI Report (1990)

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL).

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

G = Native analyte > 4 times spike added, therefore acceptance criteria do not apply.

J = Estimated value less than the sample quantitation limit, but greater than zero.

N = Spiked sample recovery not within control limits.

Z = Matrix interference; compound not positively identifiable.

* = Duplicate analysis not within control limits.

** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

TABLE D-6
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 1088
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	PHASE I					PHASE II	
	SS15	SS16	SS17	SS18	SS19	SS45	SS46
HALOGENATED VOLATILES ug/kg							
Methylene chloride	16B	29B	11B	9B	11B	11B	8B
NONHALOGENATED VOLATILES ug/kg							
Acetone	15	17	12B	6BJ	11BJ	13	9J
Toluene	5J	4J	--	2J	6	2J	--
NONHALOGENATED SEMIVOLATILES ug/kg							
2,4-Dimethylphenol	--	--	--	--	720J	--	--
2-Methylphenol	--	--	--	--	1100J	--	--
4-Methylphenol	--	--	--	--	500J	--	--
Benzoic acid	--	--	--	--	320J	--	--
Benzyl alcohol	--	--	--	1000J	--	--	--
bis(2-Ethylhexyl) phthalate	1700B	4300B	600BJ	8100B	--	1200B	1400B
Butyl benzyl phthalate	96J	370J	--	--	--	--	--
Dibenzofuran	--	--	--	--	210J	--	--
Dimethyl phthalate	--	--	--	--	--	180J	--
Di-n-butyl phthalate	180J	470J	--	950J	--	--	--
N-Nitrosodiphenylamine	150J	590J	--	--	--	--	--
Phenol	--	--	--	--	550J	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)							
Acenaphthene	--	--	--	--	250J	--	--
Anthracene	--	670J	200J	--	280J	--	--
Benzo(a)anthracene	--	2100J	620J	--	2200	160J	90J
Benzo(a)pyrene	--	1700J	--	370J	1500J	140J	84J
Benzo(b)fluoranthene	120J	2400J	1300J	830J	4600	160J	180J
Benzo(g,h,i)perylene	--	1400J	840J	--	--	--	--
Benzo(k)fluoranthene	100J	2200J	--	--	--	--	--
Chrysene	110J	2500J	790J	1000J	2500	220J	130J
Fluoranthene	220J	5800	1800J	1300J	3200	340J	210J
Fluorene	--	--	--	--	310J	--	--
Indeno(1,2,3-cd)pyrene	--	1200J	630J	--	1500J	120J	--
Naphthalene	--	--	--	--	480J	--	--
Phenanthrene	130J	3000J	780J	780J	2500	210J	120J
Pyrene	160J	4700	1100J	880J	2600	440J	250J
Total PAHs	840	27,670	8,040	4,770	18,920	2,050	910

TABLE D-6
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 1088
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I					PHASE II	
PARAMETER	SS15	SS16	SS17	SS18	SS19	SS45	SS46
PESTICIDES ug/kg							
4,4'-DDD	45D	250	52D	--	--	--	13J
4,4'-DDE	110D	1300D	970	400D	180	33	27
4,4'-DDT	450D	7400D	260D	1100D	880	90D	110D
alpha-BHC	12Z	--	--	--	--	--	--
alpha-Chlordane	--	--	--	--	--	25J	--
beta-BHC	26Z	--	43Z	--	--	--	--
delta-BHC	--	--	11Z	--	--	--	--
Dieldrin	110Z	410Z	--	--	220	--	--
Endosulfan-I	19Z	--	--	--	--	--	--
gamma-BHC (Lindane)	11Z	--	--	--	--	--	--
gamma-Chlordane	--	--	--	--	--	31J	--
Heptachlor epoxide	69Z	--	--	--	--	--	--
PCBs ug/kg							
Aroclor-1016	100Z	--	140Z	--	--	--	--
Aroclor-1221	95Z	--	--	--	--	--	--
Aroclor-1232	270Z	--	550Z	--	--	--	--
Aroclor-1242	130Z	--	200Z	--	--	--	--
Aroclor-1254	--	10000D	--	--	--	--	--
Total PCBs	595	10,000	890	--	--	--	--
TOTAL VOLATILE METALS mg/kg							
Arsenic	6	--	--	15	--	--	--
Lead	2670G*	17500	247	2060	10300	312	169
Mercury	0.04N	0.26	--	0.08	0.18	--	--
Selenium	--	--	--	9	--	--	--
TOTAL NONVOLATILE METALS mg/kg							
Antimony	68	30	--	26	48	--	--
Barium	216	313	109	409	148	85.2	91.6
Cadmium	1.9N	23.4	0.7	4.7	4.4	--	--
Chromium **	714G	6710	109	8880	2230	138	76
Copper	124*	240	72	52	146	116	76
Nickel	37*	63	23	16	32	29	24
Silver	--	0.8B	--	--	--	--	--
Zinc	996G	21000	279	22100	4500	202	146

Reference – RI Report (1990)

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL).

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

G = Native analyte > 4 times spike added, therefore acceptance criteria do not apply.

J = Estimated value less than the sample quantitation limit, but greater than zero.

N = Spiked sample recovery not within control limits.

Z = Matrix interference; compound not positively identifiable.

* = Duplicate analysis not within control limits.

** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

TABLE D-7
POSITIVE RESULTS IN SURFACE SOILS
OPEN STORAGE AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	PHASE I									
	SS20	SS21	SS22	SS23	SS32	SS33	SS34	SS35	SS36	SS40
HALOGENATED VOLATILES ug/kg										
1,1,2,2-Tetrachloroethane	--	--	--	19	--	--	--	--	--	--
Methylene chloride	18B	20B	20B	50B	8B	8B	11B	8B	13B	9B
Trichloroethene	--	--	--	2J	--	--	--	--	--	4J
NONHALOGENATED VOLATILES ug/kg										
2-Butanone	--	--	--	--	--	--	--	--	8J	--
Acetone	8BJ	6JB	8JB	22	7JB	10JB	13B	11B	23B	31
Benzene	--	--	--	4J	--	--	--	--	--	--
Ethylbenzene	--	--	--	--	--	--	--	--	--	4J
Toluene	17	12	20	33	3J	2J	6	--	4J	34
Total xylenes	1J	--	3J	--	--	--	--	--	--	9
HALOGENATED SEMIVOLATILES ug/kg										
Pentachlorophenol	--	310J	--	--	--	--	--	--	--	--
NONHALOGENATED SEMIVOLATILES ug/kg										
2-Methylnaphthalene	2600	--	--	--	--	--	--	--	--	--
bis(2-Ethylhexyl) phthalate	2300B	--	470BJ	410BJ	350BJ	320BJ	340BJ	380B	440BJ	--
Benzoic acid	--	--	--	--	--	--	--	43J	--	--
N-Nitrosodiphenylamine	--	--	--	--	--	46BJ	35BJ	63BJ	--	--

(continued on next page)

TABLE D−7
POSITIVE RESULTS IN SURFACE SOILS
OPEN STORAGE AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I									
PARAMETER	SS20	SS21	SS22	SS23	SS32	SS33	SS34	SS35	SS36	SS40
Polynuclear Aromatic Hydrocarbons (PAHs)										
Benzo(a)anthracene	--	--	--	230J	--	--	--	--	--	--
Benzo(b)fluoranthene	350J	500J	290J	600J	--	--	--	--	--	--
Benzo(g,h,i)perylene	--	--	--	2100J	--	--	--	--	--	--
Chrysene	360J	280J	--	270J	--	--	--	--	--	--
Dibenzo(a,h)anthracene	--	--	--	2100J	--	--	--	--	--	--
Fluoranthene	--	350J	--	400J	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	--	--	--	230J	--	--	--	--	--	--
Pyrene	660J	290J	200J	360J	--	--	--	--	--	--
Total PAHs	776	1,400	490	6,060	--	--	--	--	--	--

PESTICIDES ug/kg

4,4'-DDD	--	24	--	--	--	--	--	--	--	--
4,4'-DDE	490D	150D	50D	65D	--	--	--	--	--	--
4,4'-DDT	1600D	250D	120D	210D	--	--	--	--	--	--
beta-BHC	--	53Z	32Z	--	--	--	--	--	--	--
Dieldrin	--	120D	76D	160D	--	--	--	--	--	--
Endosulfan-I	--	--	--	16Z	--	--	--	--	--	--
Toxaphene	--	--	--	370Z	--	--	--	--	--	--

TABLE D-7
POSITIVE RESULTS IN SURFACE SOILS
OPEN STORAGE AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I									
PARAMETER	SS20	SS21	SS22	SS23	SS32	SS33	SS34	SS35	SS36	SS40
PCBs ug/kg										
Aroclor-1016	--	100Z	--	--	--	--	--	--	--	--
Aroclor-1232	--	400Z	--	--	--	--	--	--	--	--
Aroclor-1242	--	150Z	--	--	--	--	--	--	--	--
Aroclor-1254	--	--	--	220Z	--	--	--	--	--	--
Aroclor-1260	--	--	--	320Z	--	--	--	--	--	--
Total PCBs	--	650	--	550	--	--	--	--	--	--
VOLATILE METALS mg/kg										
Arsenic	15	--	--	23	6	26	8	30	25	21
Lead	7680	137	43	112	4	12	4	12	21	19
Mercury	0.18	0.04	--	0.04	--	0.04	--	0.04	0.04	--
Selenium	12	--	--	--	--	--	--	--	--	--
NONVOLATILE METALS mg/kg										
Antimony	27	8B	--	12	--	4	--	4	--	--
Barium	6540	45.2	25.9B	96.9	16.6	80.5	12	128	69.9	22.8
Cadmium	5.4	--	--	--	--	--	--	--	--	1
Chromium **	16200	115	30	34	10	13	10	13	15	32
Copper	41	21	10	30	5	15	4	20	16	10
Nickel	24	48	38	9	4	14	4	17	14	4
Silver	1.3B	--	--	--	--	--	--	--	--	--
Zinc	26200	266	75	167	9.4	46.8	6.9	59.8	63	132

Reference RI Report (1990)

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL).

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

J = Estimated value less then the sample quantitation limit, but greater than zero.

Z = Matrix interference; compound not positively identifiable.

** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

TABLE D-8
POSITIVE RESULTS IN SURFACE SOILS
GRAVEL AREA EAST OF S873
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	PHASE I			
	SS25	SS27	SS28	SS29
HALOGENATED VOLATILES (ug/kg)				
Methylene chloride	23B	12B	4J	4J
NONHALOGENATED VOLATILES (ug/kg)				
Acetone	5BJ	3JB	9J	5J
Toluene	3J	4J	33	1J
Total xylenes	--	--	2J	--
NONHALOGENATED SEMIVOLATILES (ug/kg)				
bis(2-Ethylhexyl) phthalate	440B	320BJ	380BJ	340BJ
Diethyl phthalate	77J	--	--	--
Di-n-butyl phthalate	44J	--	--	--
N-Nitrosodiphenylamine	--	49BJ	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)				
Benzo(a)anthracene	45J	--	--	--
Benzo(b)fluoranthene	70J	--	--	--
Chrysene	44J	--	--	--
Fluoranthene	75J	--	--	--
Phenanthrene	55J	--	--	--
Pyrene	55J	--	--	--
Total PAHs	344	--	--	--
VOLATILE METALS (mg/kg)				
Arsenic	28	36	17	23
Lead	17	13	15	11
Mercury	0.03	--	0.02	0.03
NONVOLATILE METALS (mg/kg)				
Antimony	7	8	5	6
Barium	143	105	18.3	18.5
Chromium **	16	17	6	10
Copper	22	22	5	6
Nickel	20	18	5	6
Zinc	70.5	67	9	--

Reference – RI Report (1990)

B (Organic) = Found in method blank.

J = Estimated value less than the sample quantitation limit, but greater than zero.

-- = Not detected.

** = Not distinction between Chromium (III) and Chromium (VI).

TABLE D-9
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 770
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	PHASE I		PHASE II	
	SS38	SS39	SS48	SS49
HALOGENATED VOLATILES ug/kg				
1,1,1-Trichloroethane	110	--	--	--
Methylene chloride	36B	8B	5BJ	6B
Tetrachlorethene	31	--	--	--
Trichloroethene	--	--	1J	2J
NONHALOGENATED VOLATILES ug/kg				
4-Methyl-2-pentanone	--	6J	--	--
Acetone	47J	200	51	22
Ethylbenzene	9J	6	--	--
Toluene	43	16	13	32
Total xylenes	590	53	1J	2J
NONHALOGENATED SEMIVOLATILES ug/kg				
2-Methylnaphthalene	610J	4000	--	--
bis(2-Ethylhexyl) phthalate	4800B	--	340B	160BJ
Dibenzofuran	--	350J	--	--
Butyl benzyl phthalate	--	1300J	--	--
Di-n-butyl phthalate	--	480J	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)				
3-Nitroaniline	--	--	--	36J
Benzo(a)anthracene	7800	--	80J	--
Benzo(a)pyrene	3600J	--	62J	--
Benzo(b)fluoranthene	2800J	--	150J	90J
Benzo(k)fluoranthene	4600	--	--	--
Chrysene	2200J	--	110J	--
Fluoranthene	12000	--	160J	66J
Fluorene	620J	--	--	--
Indeno(1,2,3-cd)pyrene	--	--	53J	--
Naphthalene	--	1600J	--	--
Phenanthrene	18000	1100J	85J	37J
Pyrene	13000	680J	170J	150J
Total PAHs	45,030	6,480	670	240

TABLE D-9
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 770
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I		PHASE II	
PARAMETER	SS38	SS39	SS48	SS49
PESTICIDES ug/kg				
4,4'-DDD	--	--	10J	--
4,4'-DDE	--	--	17X	--
4,4'-DDT	--	--	52	--
beta-BHC	290Z	--	26Z	14Z
gamma-BHC (Lindane)	120Z	--	--	--
VOLATILE METALS mg/kg				
Arsenic	9	13	--	--
Lead	48	24	90	4
Selenium	--	15	--	--
NONVOLATILE METALS mg/kg				
Antimony	--	17	--	--
Barium	20.9B	15.8	19.3	11.7
Cadmium	1	3	0.5	0.8
Chromium **	10	--	19	6
Copper	13	18	10	4
Nickel	3	7	6	5
Zinc	411	122	55.2	59.4

Reference - RI Report (1990)

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL).

B (Organic) = Found in method blank.

J = Estimated value less than the sample quantitation limit, but greater than zero.

X = Estimated value due to a confirmed compound which is off-scale in both columns.

Z = Matrix interference; compound not positively identifiable.

** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

TABLE D-10
POSITIVE RESULTS IN SURFACE SOILS OLD TRANSFORMER STORAGE YARD DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I	
PARAMETER	SS30	SS31

HALOGENATED VOLATILES (ug/kg)

Methylene chloride	3J	7B

NONHALOGENATED VOLATILES (ug/kg)

Acetone	4J	7JB
Toluene	3J	--

NONHALOGENATED SEMIVOLATILES (ug/kg)

bis(2-Ethylhexyl) phthalate	350BJ	460B
Polynuclear Aromatic Hydrocarbons (PAHs)		
Benzo(a)anthracene	240J	--
Benzo(a)pyrene	190J	--
Benzo(b)fluoranthene	320J	--
Benzo(g,h,i)perylene	230J	--
Chrysene	230J	--
Fluoranthene	390J	--
Indeno(1,2,3-cd)pyrene	180J	--
Phenanthrene	210J	--
Pyrene	340J	--
Total PAHs	2330	--

PESTICIDES (ug/kg)

4,4'-DDE	78D	18
4,4'-DDT	1900D	190D

VOLATILE METALS (mg/kg)

Arsenic	19	12
Lead	81	5
Mercury	0.04	0.02

TABLE D-10
POSITIVE RESULTS IN SURFACE SOILS
OLD TRANSFORMER STORAGE YARD
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I	
PARAMETER	SS30	SS31

NONVOLATILE METALS (mg/kg)

Antimony	4	--
Barium	78.1	21.9
Cadmium	1	--
Chromium **	14	10
Copper	22	6
Nickel	13	3
Silver	0.6	--
Zinc	69	11

Reference – RI Report (1990)

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

J = Estimated value less than the sample quantitation limit, but greater than zero.

-- = Not detected.

** = No distinction between Chromium (III) and Chromium (VI).

TABLE D-11
POSITIVE RESULTS IN SURFACE SOILS
BX GAS STATION
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I
PARAMETER	SS25

HALOGENATED VOLATILES (ug/kg)

Methylene chloride	25B

NONHALOGENATED SEMIVOLATILES (ug/kg)

bis(2-Ethylhexyl) phthalate	510B
N-Nitrosodiphenylamine	56BJ
Polynuclear Aromatic Hydrocarbons (PAHs)	
Benzo(a)anthracene	54J
Benzo(a)pyrene	53J
Benzo(b)fluoranthene	62J
Benzo(g,h,i)perylene	58J
Benzo(k)fluoranthene	93J
Chrysene	76J
Fluoranthene	140J
Indeno(1,2,3-cd)pyrene	47J
Phenanthrene	76J
Pyrene	110J
Total PAHs	769

PESTICIDES (ug/kg)

Dieldrin	36D

VOLATILE METALS (mg/kg)

Arsenic	25
Lead	16
Mercury	0.03

NONVOLATILE METALS (mg/kg)

Antimony	4
Barium	130
Chromium **	14
Copper	20
Nickel	19
Zinc	57.9

Reference - RI Report (1990)

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

J = Estimated value less than the sample quantitation limit, but greater than zero.

** = No distinction between Chromium (III) and Chromium (VI).

TABLE D-12
POSITIVE RESULTS IN SURFACE SOILS PESTICIDE STORAGE AREA – BUILDING 737 DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE II
PARAMETER	SS47

HALOGENATED VOLATILES (ug/kg)

Methylene chloride	6B
Trichloroethene	1J

NONHALOGENATED VOLATILES (ug/kg)

Acetone	74
Toluene	5J

NONHALOGENATED SEMIVOLATILES (ug/kg)

bis(2-Ethylhexyl) phthalate	330BJ
Polynuclear Aromatic Hydrocarbons (PAHs)	
Chrysene	78J
Benzo(a)anthracene	57J
Benzo(a)pyrene	48J
Benzo(b)fluoranthene	90J
Fluoranthene	130J
Indeno(1,2,3-cd)pyrene	84J
Phenanthrene	72J
Pyrene	130J
Total PAHs	687

PESTICIDES (ug/kg)

4,4'-DDE	14J
4,4'-DDT	79DJ
alpha-Chlordane	33DJ
beta-BHC	33XZ
gamma-Chlordane	53DJ
Heptachlor epoxide	9.1Z

VOLATILE METALS (mg/kg)

Arsenic	19
Lead	4

NONVOLATILE METALS (mg/kg)

Barium	30.8
Chromium **	9
Copper	12
Nickel	3
Zinc	67

Reference – RI Report (1990)

** = No distinction between Chromium (III) and Chromium (VI).

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

J = Estimated value less than the sample quantitation limit, but greater than zero.

X = Estimated value due to a confirmed compound which is off-scale in both columns.

Z = Matrix interference; compound not positively identifiable.

TABLE D-13
POSITIVE RESULTS IN SURFACE WATER
MAIN INSTALLATION
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	Ambient Water Quality Criteria Aquatic Life (ug/l)(a) Acute	Chronic	PHASE I SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	PHASE II SW10	SW11	SW12	SW13	SW14
HALOGENATED VOLATILES (ug/l)															
Methylene chloride	11,000	na	1BJ	1BJ	--	--	--	2BJ	1BJ	1BJ	--	--	--	--	--
NONHALOGENATED VOLATILES (ug/l)															
2-Butanone			--	--	--	--	--	--	--	--	--	--	--	--	4J
Acetone	na	na	5BJ	3BJ	2BJ	2BJ	--	2BJ	2BJ	18B	10J	4J	4J	--	110
Total xylenes	na	na	--	--	--	--	--	--	--	--	--	1J	--	--	--
NONHALOGENATED SEMIVOLATILES (ug/l)															
Benzoic acid	na	na	--	--	--	--	--	--	--	--	--	--	5BJ	5BJ	3BJ
bis(2-Ethylhexyl) phthalate	940	3	--	3BJ	3BJ	5BJ	--	2BJ	3BJ	12BJ	7BJ	3J	3BJ	6BJ	3BJ
Butyl benzyl phthalate	940	3	--	--	--	--	--	--	--	--	--	3J	--	--	--
Di-n-butyl phthalate	940	3	--	--	--	--	--	--	--	--	3J	--	--	--	--
Di-n-octyl phthalate	940	3	--	--	--	--	--	--	--	--	3BJ	--	--	--	--
Fluoranthene	na	na	--	--	--	--	--	--	--	--	--	2J	--	--	--
N-Nitrosodiphenylamine	na	na	--	--	--	3J	--	3J	--	--	2J	--	7BJ	--	--
Pyrene	na	na	--	--	--	--	--	--	--	--	3J	3J	--	--	--
PESTICIDES (ug/l)															
4,4'-DDE	1050	na	--	--	--	--	.21	--	--	--	.14	.060	.050	--	--
4,4'-DDT	1.1	0.001	--	--	--	--	--	--	--	.16	.27	1.00	2.20	--	--
Endosulfan-I			.102	--	--	--	--	--	--	--	--	--	--	--	--
VOLATILE METALS (ug/l)															
Arsenic	360	190	--	--	--	--	48	41	37	47	--	--	30	--	--
Lead	82	3.2	--	--	--	--	--	--	--	295	--	50	100	--	--
NONVOLATILE METALS (ug/l)															
Barium	na	na	78B	15B	14B	14B	170	15B	15B	60B	26B	55	98	60	42
Cadmium			--	--	--	--	--	--	--	5	--	--	10	--	--
Chromium			20	--	--	--	--	--	--	--	--	--	20	--	10
Copper	18	12	23B	27	46	30	24B	20B	19B	66	25	30	20	--	--
Silver			--	--	--	--	--	--	--	13	--	--	--	--	--
Zinc	120	110	29	88	22	22	41	32	37	400	81	110	150	54	38

Reference – RI Report (1990)

NA – Not Available

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL) but greater than the Instrument Detection Limit (IDL).

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

J = Estimated value less than the sample quantitation limit but greater than zero.

Z = Matrix interference; compound not positively identifiable.

-- = Not detected

TABLE D-14
POSITIVE RESULTS IN SURFACE WATER
DUNN FIELD
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	Ambient Water Quality Criteria Aquatic Life (fresh) Acute	Chronic	PHASE I SW1	PHASE II SW15	SW16
HALOGENATED VOLATILES (ug/l)					
Methylene chloride	11,000	na	1BJ	--	--
NONHALOGENATED VOLATILES (ug/l)					
Acetone	na	na	7BJ	18	2J
NONHALOGENATED SEMIVOLATILES (ug/l)					
Benzoic acid	na	na	--	--	3BJ
bis(2-Ethylhexyl) phthalate	940	3	--	--	10BJ
N-Nitrosodiphenylamine	na	na	--	--	5BJ
PESTICIDES (ug/l)					
Dieldrin			.13	.11	--
VOLATILE METALS (ug/l)					
Lead	82	3.2	--	40	--
NONVOLATILE METALS (ug/l)					
Barium	na	na	91B	77	56
Cadmium			6	--	--
Copper	18	12	18B	10	--
Zinc	120	110	57	110	140

Reference — RI Report (1990)

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL).

B (Organic) = Found in method blank.

J = Estimated value less than the sample quantitation limit, but greater than zero.

-- = Not detected.

TABLE D-15
POSITIVE RESULTS IN SEDIMENTS
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I									
	LAKE DANIELSON						GOLF COURSE POND			
PARAMETER	SD-1-SS	SD-1-9	SD-2-SS	SD-2-9	SD-3-SS	SD-3-9	SD-4-SS	SD-4-9	SD-5-SS	SD-5-9
Polynuclear Aromatic Hydrocarbons (PAHs)										
Acenaphthene	--	--	--	--	--	--	--	--	110J	140J
Anthracene	--	--	--	--	--	--	--	--	200J	200J
Benzo(a)anthracene	--	--	--	--	230J	--	--	--	1100	680J
Benzo(a)pyrene	--	--	--	--	230J	--	--	--	1300	500J
Benzo(b)fluoranthene	--	--	--	--	380J	--	--	--	1800	690J
Benzo(g,h,i)perylene	--	--	--	--	200J	--	--	--	940	390J
Benzo(k)fluoranthene	--	--	--	--	290J	--	--	--	1600	690J
Chrysene	--	--	--	--	300J	--	--	--	1400	750J
Dibenzo(a,h)anthracene	--	--	--	--	--	--	--	--	330J	140J
Fluoranthene	74J	71J	100J	--	700J	--	130J	--	3000	1700
Fluorene	--	--	--	--	--	--	--	--	120J	150J
Indeno(1,2,3-cd)pyrene	--	--	--	--	210J	--	--	--	900	350J
Phenanthrene	--	--	--	--	330J	--	100J	--	1300	1200
Pyrene	--	--	--	--	610J	--	100J	--	2400	1400
Total PAHs	74	71	100	--	3,480	--	330	--	16,500	8,980

PESTICIDES ug/kg

4,4'-DDD	47	--	--	--	45	--	190D	280D	3000D	960D
4,4'-DDE	36	--	--	--	110D	--	68D	64D	460Z	--
4,4'-DDT	--	--	--	--	--	--	--	--	2900D	620D
Endosulfan-I	--	--	--	--	--	--	--	--	200Z	--

TABLE D-15
POSITIVE RESULTS IN SEDIMENTS
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I									
	LAKE DANIELSON						GOLF COURSE POND			
PARAMETER	SD-1-SS	SD-1-9	SD-2-SS	SD-2-9	SD-3-SS	SD-3-9	SD-4-SS	SD-4-9	SD-5-SS	SD-5-9
HALOGENATED VOLATILES ug/kg										
Methylene chloride	42B	38B	22B	22B	26B	22B	27B	29B	14B	25B
NONHALOGENATED VOLATILES ug/kg										
Acetone	71B	75B	46B	51B	43B	36B	170	140	21	24
2-Butanone	--	3BJ	1BJ	--	--	--	6J	5J	--	--
Toluene	--	--	--	--	--	--	--	--	--	2J
HALOGENATED SEMIVOLATILES ug/kg										
Pentachlorophenol	--	--	--	--	--	--	--	--	270J	--
NONHALOGENATED SEMIVOLATILES ug/kg										
bis(2-Ethylhexyl) phthalate	550	570	580J	530J	760J	640J	710J	630J	710J	710J
Benzoic acid	460J	490J	300J	590J	160J	470J	660J	450J	1200J	970J
N-Nitrosodiphenylamine	100BJ	--	170BJ	--	270BJ	100BJ	190BJ	--	280BJ	190BJ

(continued on next page)

TABLE D-15
POSITIVE RESULTS IN SEDIMENTS
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I									
	LAKE DANIELSON						GOLF COURSE POND			
PARAMETER	SD-1-SS	SD-1-9	SD-2-SS	SD-2-9	SD-3-SS	SD-3-9	SD-4-SS	SD-4-9	SD-5-SS	SD-5-9
VOLATILE METALS mg/kg										
Lead	--	--	--	--	--	--	5	6	91	55
Mercury	0.04	0.05	0.05	0.05	--	--	0.05	0.04	0.06	0.04
NONVOLATILE METALS mg/kg										
Barium	78	88.4	122	110	89.7	89	96	95.2	101	104
Cadmium	0.7B	--	--	--	--	--	--	--	0.9B	--
Chromium **	13	13	12	10	12	9	13	11	28	21
Copper	20	23	18	17	15	16	15	16	28	26
Nickel	11	14	14	12	14	13	13	13	14	14
Zinc	44.5N	47.8N	50.9N	47.5N	46.8N	45.4N	44.7N	43.2N	80.9N	66.8N

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL). B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

J = Estimated value less than the sample quantitation limit, but greater than zero.

N = Spiked sample recovery not within control limits.

Z = Matrix interference; compound not positively identifiable.

** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

TABLE D-16
POSITIVE RESULTS IN SUBSURFACE SOILS
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I														
PARAMETER	STB-1-1	STB-1-2	STB-1-3	STB-2-1	STB-2-2	STB-2-3	STB-3-1	STB-3-2	STB-3-3	STB-4-1	STB-4-2	STB-4-3	STB-5-1	STB-5-2	STB-5-3
Depth of Sample:	25.8'	62.5'	73.5'	10.0'	17.5'	67.5'	21.0'	26.0	93.5'	19.0'	20.0'	102.0'	16.0'	75.0'	83.0
HALOGENATED VOLATILES ug/kg															
Chloroform	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--
Methylene chloride	10B	19B	10B	7B	6B	12B	3J	3J	3J	2J	16B	19B	13B	21B	12B
NONHALOGENATED VOLATILES ug/kg															
2-Butanone	--	--	--	--	--	--	--	--	--	18	--	--	--	--	--
Acetone	57	43	20	24B	12B	13B	--	--	30	31	6J	17	16	14B	14
Toluene	--	--	--	--	--	--	--	--	--	1J	--	--	--	--	--
NONHALOGENATED SEMIVOLATILES ug/kg															
Benzoic acid	--	--	--	--	--	58J	--	--	--	--	--	--	--	--	--
bis(2-Ethylhexyl) phthalate	1200	1200	760J	1100	1800	1600	2000B	670B	910B	610B	1500B	560BJ	450B	440B	320BJ
Di-n-butyl phthalate	--	--	--	--	210BJ	100BJ	140BJ	170BJ	120BJ	--	--	--	--	--	--
N-Nitrosodiphenylamine	--	--	--	43JB	--	--	--	--	--	--	44J	--	--	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)															
Fluoranthene	--	--	--	--	51J	47J	--	--	--	--	--	--	--	--	--
Pyrene	--	--	--	--	40J	40J	--	--	--	--	--	--	--	--	--
TOTAL PAHs	--	--	--	--	91	87	--	--	--	--	--	--	--	--	--
NONVOLATILE METALS															
Barium (EPTOX in ug/l)	15	25	58	--	--	--	10	16	49	--	--	25	--	10	--
Cadmium (EPTOX in ug/l)	--	12	5	20	6	--	7	--	--	--	--	--	--	--	--

Reference -- RI Report (1990)

B (Organic) = Found in method blank.

J = Estimated value less than the sample quantitation limit, but greater than zero.

-- = Not detected

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TABLE D-17
POSITIVE RESULTS IN SUBSURFACE SOILS
DEFENSE DEPOT MEMPHIS TENNESSEE

	Phase II											
PARAMETER	STB-6-1	STB-6-2	STB-6-3	STB-6-4	STB-7-1	STB-7-2	STB-7-3	STB-7-4	STB-8-1	STB-8-2	STB-8-3	STB-8-4
Depth of Sample:	71.5'	76.0'	86.0'	161.0'	71.0'	76.0'	91.0'	170.0'	92.0'	97.0'	127.0'	217.0'
HALOGENATED VOLATILES ug/kg												
1,1,2,2-Tetrachloroethane	240E	12	4J	13	--	--	--	--	--	--	--	--
1,2-Dichloroethane	--	--	--	--	--	--	--	--	--	--	--	11
1,2-Dichloroethylene	26	--	13	7	--	--	--	--	--	--	--	--
Methylene chloride	21B	16B	6BJ	5JB	6BJ	11B	8B	8	10B	7B	5BJ	5BJ
Trichloroethene	4J	--	1J	--	--	--	--	--	--	--	--	--
NONHALOGENATED VOLATILES ug/kg												
2-Butanone	--	--	13	--	--	--	--	--	3BJ	2BJ	2J	--
Acetone	210	90	1100D	74	250	95	31	9J	60B	40B	45	28
Toluene	1J	1J	5J	--	--	5J	--	--	--	3J	--	2J
NONHALOGENATED SEMIVOLATILES ug/kg												
bis(2-Ethylhexyl) phthalate	500B	250BJ	6400B	590B	1600B	160BJ	1900B	230BJ	520B	250BJ	350BJ	270BJ
Di-n-butyl phthalate	--	--	--	--	--	--	76J	--	--	--	--	--
N-Nitrosodiphenylamine	--	--	--	--	--	--	--	--	65BJ	53BJ	39J	98BJ
PESTICIDES ug/kg												
beta-BHC	--	--	14Z	--	--	--	--	--	--	--	--	19Z
VOLATILE METALS mg/kg												
Lead	6	7	5	9	11	9	7	--	--	8	--	7
NONVOLATILE METALS mg/kg												
Barium	20.7	39.1	42.6	72.7	30.1	51.6	55.6	10.6	3.6	20.1	2.9	14.2
Cadmium	--	--	--	--	--	--	--	0.8	--	--	--	--
Chromium **	9	11	4	5	12	11	6	4	1	5	2	6
Copper	3	3	4	5	2	6	6	2	3	5	3	6
Nickel	2	--	5	8	3	3	7	3	--	8	--	4
Zinc	15.7	11.4	31.2	47.2	12.1	41.3	31	11.9	14	20.5	3.8	11.6

Reference – RI Report (1990)

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

J = Estimated value less than the sample quantitation limit, but greater than zero.

E = Concentration exceeds the calibration range of the GC/MS instrument for this specific analysis.

Z = Matrix interference; compound not positively identifiable.

** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

TABLE D-18
POSITIVE RESULTS IN SURFACE SOILS
DRMR YARD
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	PHASE I					PHASE II
	SS1	SS2	SS3	SS4	SS5	SS41
HALOGENATED VOLATILES ug/kg						
Methylene chloride	7100B	9B	14B	16B	41B	15B
NONHALOGENATED VOLATILES ug/kg						
Acetone	--	--	6J	8J	4J	12
Toluene	--	6	17	--	2J	13
Total xylenes	--	4J	11	--	--	--
NONHALOGENATED SEMIVOLATILES ug/kg						
Benzoic acid	840J	--	--	--	230J	--
bis(2-Ethylhexyl) phthalate	630J	--	--	420J	2900	290BJ
Butyl benzyl phthalate	--	--	--	--	4700	--
Dibenzofuran	--	--	--	--	290J	--
N-Nitrosodiphenylamine	--	--	580J	--	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)						
Acenaphthene	--	--	--	--	650J	--
Acenaphthylene	--	--	--	--	350J	--
Anthracene	6100	--	--	--	2000	--
Benzo(a)anthracene	--	--	--	--	8600	120J
Benzo(a)pyrene	--	--	--	--	6200	--
Benzo(b)fluoranthene	--	--	--	--	8200	210J
Benzo(g,h,i)perylene	--	--	--	--	5000	--
Benzo(k)fluoranthene	--	--	--	--	7600	--
Chrysene	490J	--	--	--	7400	170J
Dibenzo(a,h)anthracene	--	--	--	--	2600	--
Fluoranthene	--	--	--	100J	15000	370J
Fluorene	--	--	--	--	690J	--
Indeno(1,2,3-cd)pyrene	--	--	--	--	4000	--
Phenanthrene	--	--	--	100J	7700	200J
Pyrene	3100	--	570J	--	17000	290J
TOTAL PAHs	9,690	--	570	200	92,990	1,360

TABLE D-18
POSITIVE RESULTS IN SURFACE SOILS
DRMR YARD
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I					PHASE II
PARAMETER	SS1	SS2	SS3	SS4	SS5	SS41
PESTICIDES ug/kg						
4,4'-DDD	--	--	--	--	260	--
4,4'-DDE	--	290D	250	--	1100D	21
4,4'-DDT	--	1500D	1400D	--	5900D	130D
beta-BHC	--	--	--	--	--	10Z
Dieldrin	--	--	--	650	--	--
Endosulfan sulfate	--	--	--	--	360	--
VOLATILE METALS mg/kg						
Arsenic	4*	18*	26*	33	20	--
Lead	66N	96N	129N	22	2420	878
Mercury	--	0.030	0.030	0.050	0.460	--
NONVOLATILE METALS mg/kg						
Antimony	--	--	--	--	22	--
Barium	5.6B	43.4	19.2B	97.8	273	311
Cadmium	--	4	1.6	1.0	159	0.8
Chromium **	15	19	17	14	296	144
Copper	246*G	25*G	34*G	26	1590	42
Nickel	3.0B	6.0B	3.0B	14	146	6.0
Silver	--	--	--	--	2.5	--
Zinc	22*	130*	92.4*	60.7	2160	265

Reference – RI Report (1990)

B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL).

B (Organic) = Found in method blank.

D = Identified in an analysis at a secondary dilution factor.

G = Native analyte > 4 times spike added, therefore acceptance criteria do not apply.

J = Estimated value less than the sample quantitation limit, but greater than zero.

N = Spiked sample recovery not within control limits.

Z = Matrix interference; compound not positively identifiable.

* = Duplicate analysis not within control limits.

** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected

TABLE D-19
POSITIVE RESULTS IN SURFACE SOILS
DUNN FIELD
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I				PHASE II
PARAMETER	SS6	SS7	SS8	SS9	SS44
HALOGENATED VOLATILES (ug/kg)					
Carbon Tetrachloride	--	--	--	--	4J
Methylene chloride	44B	45B	10B	8B	8B
NONHALOGENATED VOLATILES (ug/kg)					
2-Butanone	--	--	19	--	--
2-Hexanone	--	--	2J	--	--
4-Methyl-2-pentanone	--	--	62	--	--
Acetone	8J	7J	120	19	20
Ethylbenzene	--	--	2J	--	--
Toluene	1J	2J	6	--	1J
Total xylenes	--	3J	14	--	--
NONHALOGENATED SEMIVOLATILES (ug/kg)					
2-Methylnaphthalene	--	2600	3600J	--	--
4-Methylphenol	--	300J	--	--	--
Benzoic acid	--	250J	--	--	--
bis(2-Ethylhexyl) phthalate	940J	--	--	910	1900B
Dibenzofuran	--	11000	--	--	--
N-Nitrosodiphenylamine	--	1400J	3200J	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)					
Acenaphthene	--	19000	--	--	--
Acenaphthylene	--	2000J	--	--	--
Anthracene	--	21000	--	--	--
Benzo(a)anthracene	--	81000D	--	150J	200J
Benzo(a)pyrene	--	68000D	--	130J	150J
Benzo(b)fluoranthene	--	68000D	--	300J	300J
Benzo(g,h,i)perylene	--	48000D	--	150J	--
Benzo(k)fluoranthene	--	28000	--	--	--
Chrysene	--	87000D	--	210J	250J
Dibenzo(a,h)anthracene	--	26000	--	--	--
Fluoranthene	--	220000D	--	340J	510J
Fluorene	--	18000	--	--	--
Indeno(1,2,3-cd)pyrene	--	44000D	--	120J	--
Naphthalene	--	4800	--	--	--
Phenanthrene	--	160000D	--	180J	300J
Pyrene	--	160000D	2600J	270J	510J
Total PAHs	--	1,054,800	2600	1850	2220

TABLE D-19
POSITIVE RESULTS IN SURFACE SOILS
DUNN FIELD
DEFENSE DEPOT MEMPHIS TENNESSEE

	PHASE I				PHASE II
PARAMETER	SS6	SS7	SS8	SS9	SS44
PESTICIDES (ug/kg)					
4,4'-DDE	160D	--	--	--	--
4,4'-DDT	170D	--	--	--	--
alpha-Chlordane	--	1500J	--	--	--
Dieldrin	330D	--	480D	64D	--
VOLATILE METALS (mg/kg)					
Arsenic	21	35	23	21	--
Lead	51	122	459	19	2
Mercury	0.04	0.06	0.06	0.04	--
NONVOLATILE METALS (mg/kg)					
Barium	99.2	105	64.5	70.3	65.2
Cadmium	1.6	1	1.1	--	--
Chromium **	12	32	--	10	27
Copper	32	54	24	18	6
Nickel	12	14	9	10	7
Sodium	--	--	82B	--	--
Zinc	102	114	300	45.1	30.2

Reference – RI Report (1990)
B (Inorganic) = Value less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit
B (Organic) = Found in method blank.
D = Identified in an analysis at a secondary dilution factor.
J = Estimated value less than the sample quantitation limit, but greater than zero.
** = No distinction between Chromium III and Chromium VI.
-- = Not detected.

Groundwater Monitoring Results for DDMT
Environmental Science and Engineering, Inc.
September 1993

Table DOMT Analytical Results for Parameters Above Detection Limits (MW-3 through MW-15)

SAMPLE ID'S PARAMETERS UNITS	STORET METHOD	MW3 CODMTW 3	MW4 CODMTW 4	MW5 CODMTW 5	MW6 CODMTW 6	MW7 CODMTW 7	MW8 CODMTW 8	MW9 CODMTW 9	MW10SP CODMTW 10	MW11 CODMTW 11	MW12SP CODMTW 12	MW13 CODMTW 13	MW14 CODMTW 14	MW15 CODMTW 15	State and Federal MCLs* Tennessee MCL	Federal MCL
DATE TIME		11/12/93 15:00	11/15/93 15:00	11/16/93 13:00	11/18/93 09:00	11/15/93 18:50	11/17/93 12:20	11/15/93 17:11	11/11/93 18:00	11/13/93 09:30	11/11/93 15:30	11/15/93 15:30	11/17/93 15:45	11/18/93 12:00		
CARBON TETRACHLORIDE UG/L	32102 8010-G	--	--	--	43.7	--	--	1.07	1.32	--	--	--	--	38.3	5	5
CHLOROFORM UG/L	32106 8010-G	3.75	--	1.85	14.3	13.8	--	1.78	4.22	2.22	1.93	--	--	59.2	--	100
1,1-DICHLOROETHANE UG/L	34496 8010-G	1.06	--	--	--	1.49	1.83	--	3.36	--	--	--	--	--	--	--
1,2-DICHLOROETHANE UG/L	34531 8010-G	--	--	--	--	--	--	--	3.56	--	--	--	--	--	5	5
1,1-DICHLOROETHYLENE UG/L	34501 8010-G	38.5	--	-	--	36.5	34.4	7.90	88.6	--	--	--	--	--	7	7
TRANS-1,2-DICHLORO ETHENE UG/L	34546 8010-G	--	--	--	20.8	--	--	--	118	11.7	19.4	--	--	7.05	100	100
METHYLENE CHLORIDE UG/L	34423 8010-G	--	--	--	--	--	--	--	124	--	--	--	--	--	--	5
1,1,2,2-TETRACHLORO ETHANE UG/L	34516 8010-G	--	--	--	219	--	--	--	33.5	3.58	262	--	--	3.71	--	--
TETRACHLOROETHENE UG/L	34475 8010-G	183	32.6	18.8	3.06	35.0	35.3	22.3	143	21.1	14.0	2.01	--	4.29	5	5
1,1,1-TRICHL'ETHANE UG/L	34506 8010-G	3.06	--	--	--	1.63	1.96	--	5.46	--	--	--	--	--	200	200
1,1,2-TRICHL'ETHANE UG/L	34511 8010-G	--	--	--	9.10	--	--	--	4.14	--	--	--	--	--	--	5
TRICHLOROETHENE UG/L	39180 8010-G	55.5	--	1.33	138	13.7	15.3	9.70	1020	49.3	1500	--	--	48.4	5	5
TOLUENE UG/L	34010 8020-G	--	--	--	--	--	--	1.89	10.7	--	--	--	--	--	1000	1000
BIS(2-ETHYLHEXYL) PHTHALATE UG/L	39100 8270/3520-G	1.4	--		--	--	4.0	3.6	5.2	2.8	--	-	6.9	--	--	6
DI-N-BUTYLPHTHALATE UG/L	39110 8270/3520-G	--	--	--	--	-	1.7	--	--	--	--	--	--	--	--	--
FLUORANTHENE UG/L	34376 8270/3520-G	--	--	--	1.5	--	--	--	--	--	--	--	--	--	--	--
PHENOL UG/L	34694 8270/3520-G	--	--	-	--	--	--	--	4.1	--	--	--	--	--	--	--
ACENAPHTHENE UG/L	34205 8310/3520-G	--	--	--	10.1	--	--	--	--	--	--	19.0	--	--	--	--
ANTHRACENE UG/L	34220 8310/3520-G	--	1.59	1.23	6.04	4.84	1.65	--	--	--	--	38.5	5.77	--	--	--
BENZO(A)ANTHRACENE UG/L	34526 8310/3520-G	0.022	0.053	0.034	0.784	0.128	0.043	0.004	0.015	0.010	--	1.05	0.131	0.004	--	0.1*
BENZO(A)PYRENE UG/L	34247 8310/3520-G	0.025	0.048	0.037	0.826	0.165	0.053	0.008	0.023	0.017	--	1.37	0.136	0.003	--	0.2
BENZO(B)FLUORANTHENE UG/L	34230 8310/3520-G	0.020	0.057	0.041	0.915	0.144	0.055	0.010	0.071	--	--	1.43	0.135	0.003	--	0.2*
BENZO(GHI)PERYLENE UG/L	34521 8310/3520-G	0.021	0.098	0.068	1.61	0.325	0.089	--	0.026	0.010	--	2.20	0.225	--	--	--
BENZO(K)FLUORANTHENE UG/L	34242 8310/3520-G	0.012	0.025	0.019	0.423	0.066	0.027	0.005	0.011	0.006	--	0.897	0.068	0.002	--	0.2*
CHRYSENE UG/L	34320 8310/3520-G	--	--	--	2.04	0.179	1.56	--	--	--	--	2.69	2.82	--	--	0.2*
DIBENZ(A,H)ANTHRACENE UG/L	34556 8310/3520-G	--	0.008	0.004	0.533	0.017	0.008	--	--	0.034	--	0.150	0.006	--	--	0.3*
FLUORANTHENE UG/L	34376 8310/3520-G	0.057	0.105	0.089	3.31	0.334	0.113	0.015	0.050	--	--	2.70	0.323	0.018	--	--
INDENO(1,2,3-CD) PYRENE UG/L	34403 8310/3520-G	0.016	0.015	0.005	1.37	0.060	0.014	--	0.030	0.027	0.005	0.360	0.061	0.010	--	0.4*
NAPHTHALENE UG/L	34696 8310/3520-G	--	--	--	1.88	--	--	--	--	--	--	3.90	--	--	--	--
PHENANTHRENE UG/L	34461 8310/3520-G	--	0.150	0.146	3.03	0.939	0.165	--	--	--	--	4.59	0.784	--	--	--
PYRENE UG/L	34469 8310/3520-G	0.130	0.287	0.208	6.91	3.54	0.275	--	--	1.15	--	11.7	1.35	--	--	--
ALDRIN UG/L	39330 8080/3520-G	-	--		-	-	-	--	--	-	--	0.027	--	-	--	--
DDD,PP' UG/L	39310 8080/3520-G	--	--	--	--	--	--	--	0.093	--	--	--	--	--	--	--
DDE,PP' UG/L	39320 8080/3520-G	--	--	-	-	--	--		0.023	--	--	--		--	--	-
DDT,PP' UG/L	39300 8080/3520-G	--	--	-	--	--	--	--	0.041	0.015	--	--	--	--	--	--
DIELDRIN UG/L	39380 8080/3520-G	--	0.007	--	--	--	0.057	0.044	0.011	--	--	--	--	--	--	-

Table DOMT Analytical Results for Parameters Above Detection Limits (MW-1 through MW-15) (Continued, Page 2 of 2)

SAMPLE ID'S PARAMETERS UNITS	STORET METHOD	MW3 COUNTY 3	MW4 COUNTY 4	MW5 COUNTY 5	MW6 COUNTY 6	MW7 COUNTY 7	MW8 COUNTY 8	MW9 COUNTY 9	MW10SP COUNTY 10	MW11 COUNTY 11	MW12BP COUNTY 12	MW13 COUNTY 13	MW14 COUNTY 14	MW15 COUNTY 15	State and Federal MCLs¹	
DATE TIME		11/13/93 15:00	11/15/93 15:00	11/16/93 13:00	11/18/93 09:00	11/15/93 18:50	11/17/93 12:20	11/15/93 17:13	11/11/93 18:00	11/13/93 09:30	11/11/93 15:30	11/15/93 15:30	11/17/93 15:45	11/18/93 12:00	Tennessee MCL	Federal MCL
ALUMINUM, TOTAL UG/L	1105 6010-G	18200	33600	59400	42900	26900	167000	61100	119000	137000	51200	36100	103000	134000	--	--
ARSENIC, TOTAL UG/L	1002 7060-G	--	6.5	13.5	3.0	7.6	--	4.3	17.4	4.6	7.1	--	138	19.4	50	50
BARIUM, TOTAL UG/L	1007 6010-G	155	120	218	610	147	573	260	1020	1330	354	140	1570	508	2000	2000
CHROMIUM, TOTAL UG/L	1034 6010-G	59.3	233	134	77.9	76.7	284	304	263	309	88.9	66.6	208	308	100	100
COBALT, TOTAL UG/L	1037 6010-G	30.4	98.6	53.1	189	94.3	132	61.9	90.7	344	223	42.1	329	385	--	--
COPPER, TOTAL UG/L	1042 6010-G	33.3	87.1	63.8	38.5	47.8	376	138	171	313	83.4	115	189	387	--	1300
LEAD, TOTAL UG/L	1051 7421-G	18.3	127	30.3	44.1	36.7	89.9	63.7	477	363	53.4	57.5	109	53.2	5	15
MERCURY, TOTAL UG/L	71900 7470-G	--	0.87	0.43	0.57	--	0.73	--	0.73	0.74	0.23	0.33	1.52	1.00	2	2
ZINC, TOTAL UG/L	1092 6010-G	132	195	232	138	171	467	365	735	475	151	160	452	454	--	--
RESIDUE, DISS (TDS) MG/L	70300 160.1-G	270	169	177	760	288	405	222	302	280	302	186	350	223	--	--
ALUMINUM, DISS UG/L	1106 6010-G	--	--	--	--	--	--	--	43.5	--	--	--	292	--	--	--
BARIUM, DISS UG/L	1005 6010-G	97.0	49.4	38.0	377	63.2	58.1	54.9	76.9	82.6	87.4	36.0	85.2	39.4	--	--
LEAD, DISS UG/L	1049 7421-G	--	--	--	--	--	--	--	--	--	--	--	--	10.3	--	--
ZINC, DISS UG/L	1090 6010-G	--	--	-	24.7	--	--	-	--	--	--	--	--	--	--	--

¹All units in micrograms per liter (ug/L).
²Proposed value.

Table DOMT Analytical Results for Parameters Above Detection Limits (MW-16 through MW-31)

SAMPLE ID'S PARAMETERS UNITS	STORET METHOD	MW16 COOMTW 16	MW19 COOMTW 19	MW20 COOMTW 20	MW21 COOMTW 21	MW22SP COOMTW 22	MW23 COOMTW 23	MW24 COOMTW 24	MW25 COOMTW 25	MW26 COOMTW 26	MW28 COOMTW 28	MW29 COOMTW 29	MW30 COOMTW 30	MW31 COOMTW 31	State and Federal MCLs* Tennessee MCL	 Federal MCL
DATE TIME		11/09/93 14:05	11/19/93 18:00	11/15/93 14:30	11/18/93 17:00	11/17/93 15:00	11/15/93 09:10	11/14/93 17:00	11/13/93 08:20	11/09/93 19:30	11/19/93 18:30	11/17/93 09:45	11/19/93 15:45	11/19/93 17:10		
CARBON TETRACHLORIDE UG/L	32102 8010-G	--	--	--	--	--	--	--	--	3.16	--	--	--	4.81	5	5
CHLOROFORM UG/L	32106 8010-G	--	--	--	--	--	--	--	--	--	--	4.26	--	21.3	--	100
1,1-DICHLOROETHANE UG/L	34496 8010-G	--	--	--	--	--	--	--	--	--	--	2.69	--	1.66	--	--
1,2-DICHLOROETHANE UG/L	34531 8010-G	--	--	--	--	--	--	--	--	--	--	--	--	1.50	5	5
1,1-DICHLOROETHYLENE UG/L	34501 8010-G	--	--	--	--	--	--	--	--	--	--	33.1	--	52.4	7	7
TRANS-1,2-DICHLORO ETHENE UG/L	34546 8010-G	--	--	--	--	--	--	--	--	--	--	--	--	164	100	100
1,1,2,2-TETRACHLORO ETHANE UG/L	34516 8010-G	--	--	--	--	--	--	--	--	--	--	--	--	96.0	--	--
TETRACHLOROETHENE UG/L	34475 8010-G	--	--	--	49.1	--	--	--	11.3	6.50	--	43.1	--	95.4	5	5
1,1,1-TRICHL'ETHANE UG/L	34506 8010-G	--	--	--	--	--	--	--	--	--	--	--	--	2.37	200	200
1,1,2-TRICHL'ETHANE UG/L	34511 8010-G	--	--	--	--	--	--	--	--	--	--	--	--	6.48	--	5
TRICHLOROETHENE UG/L	39180 8010-G	1.10	--	--	4.47	1.74	--	--	--	1.79	--	14.9	--	5110	5	5
BIS(2-ETHYLHEXYL) PHTHALATEUG/L	39100 8270/3520-G	1.9	--	5.6	2.4	--	--	9.6	4.0	5.8	--	3.4	11	2.1	--	6
PHENOL UG/L	34694 8270/3520-G	2.8	--	3.5	--	--	--	--	--	--	--	--	--	--	--	--
ANTHRACENE UG/L	34220 8310/3520-G	--	--	--	--	--	--	--	--	--	--	0.261	--	--	--	--
BENZO(A)ANTHRACENE UG/L	34526 8310/3520-G	--	--	--	--	0.008	0.003	0.003	--	--	0.035	0.013	--	--	--	0.1*
BENZO(A)PYRENE UG/L	34247 8310/3520-G	--	--	0.005	0.002	0.010	0.005	0.004	--	--	0.006	0.008	0.007	0.003	--	0.2
BENZO(B)FLUORANTHENE UG/L	34230 8310/3520-G	--	0.007	0.006	0.003	0.015	0.008	0.005	--	0.007	0.008	0.008	0.009	0.005	--	0.2*
BENZO(K)FLUORANTHENE UG/L	34242 8310/3520-G	--	--	0.003	0.001	0.005	0.003	0.007	--	--	0.004	0.004	0.004	0.033	--	0.2*
CHRYSENE UG/L	34320 8310/3520-G	--	--	--	--	--	--	--	--	--	--	1.60	0.183	--	--	0.2*
DIBENZ(A,H)ANTHRACENE UG/L	34556 8310/3520-G					0.005			--	--	0.004	--	--	--	--	0.3*
FLUORANTHENE UG/L	34376 8310/3520-G	0.007	0.005	0.012	0.009	0.022	0.011	0.009	--	0.007	0.017	0.019	0.018	0.019	--	--
INDENO(1,2,3-CD) PYRENE UG/L	34403 8310/3520-G	0.007	--	--	--	0.020	--	--	--	--	--	--	--	--	--	0.4*
NAPHTHALENE UG/L	34696 8310/3520-G	--	1.20	1.11	--	--	--	--	--	--	1.20	--	--	--	--	--
ALUMINUM, TOTAL UG/L	1105 6010-G	17800	15100	120000	105000	176000	195000	49900	33400	23400	141000	129000	75500	78900	--	--
ARSENIC, TOTAL UG/L	1002 7060-G	6.2	--	3.0	4.9	6.0	67.5	--	--	--	98.5	44.5	8.4	17.0	50	50
BARIUM, TOTAL UG/L	1007 6010-G	167	567	413	259	462	566	358	599	360	3550	379	316	381	2000	2000
CADMIUM, TOTAL UG/L	1027 6010-G	--	--	--	--	--	13.8	--	--	--	--	--	--	--	10	5
CHROMIUM, TOTAL UG/L	1034 6010-G	27.4	85.8	191	772	824	438	118	109	49.3	370	909	337	168	100	100
COBALT, TOTAL UG/L	1037 6010-G	--	37.5	61.2	42.7	79.8	66.7	156	103	33.1	571	36.5	--	67.3	--	--
COPPER, TOTAL UG/L	1042 6010-G	84.8	122	314	142	179	210	71.6	90.1	93.3	396	99.6	49.7	76.6	--	1300
LEAD, TOTAL UG/L	1051 7421-G	30.9	3030	85.2	73.3	93.3	444	24.4	33.8	17.9	119	34.5	30.7	81.3	5	15
MERCURY, TOTAL UG/L	71900 7470-G	--	0.28	0.66	0.47	1.86	1.65	0.31	0.26	0.26	1.11	0.33	--	0.61	2	2
ZINC, TOTAL UG/L	1092 6010-G	71.6	136	321	389	841	1530	768	140	107	657	281	136	264	--	--
RESIDUE, DISS (TDS) MG/L	70300 160.1-G	406	287	335	166	288	398	181	373	260	172	428	325	243	--	--
ALUMINUM, DISS UG/L	1106 6010-G	--	--	--	--	--	--	--	--	454	--	--	--	--	--	--
BARIUM, DISS UG/L	1005 6010-G	55.1	112	61.0	29.8	91.0	27.1	38.8	44.9	171	79.0	82.8	--	84.8	--	--
COPPER, DISS UG/L	1040 6010-G	--	--	--	--	--	--	--	--	--	--	11.4	--	--	--	--

*All units in micrograms per liter (ug/L)
*Proposed value.

Table CDMT Analytical Results for Parameters Above Detection Limits (MW-32 through MW-39, Duplicate Samples, and Equipment Blanks)

SAMPLE ID'S PARAMETERS UNITS	STORET METHOD	MW32 COOMTW 32	MW33 COOMTW 33	MW34 COOMTW 34	MW35 COOMTW 35	MW36 COOMTW 36	MW37SP COOMTW 37	MW38 COOMTW 38	MW39 COOMTW 39	MW40DUP COOMTW 40	MW41DUP COOMTW 41	MW42DUP COOMTW 42	MW43DUP COOMTW 43	MW44EBLK COOMTW 44	State and Federal MCLs* Tennessee MCL	 Federal MCL
DATE TIME		11/18/93 17:00	11/19/93 09:20	11/19/93 10:30	11/14/93 17:10	11/12/93 17:15	11/18/93 11:30	11/15/93 18:15	11/15/93 13:40	11/16/93	11/11/93	11/11/93	11/11/93	11/14/93 16:30		
CARBON TETRACHLORIDE UG/L	32102 8010-G	31.5	--	--	--	--	--	--	--	--	1.12	--	--	--	5	5
CHLOROBENZENE UG/L	34301 8010-G	--	--	--	1.38	--	--	--	--	--	--	--	--	--	--	100
CHLOROFORM UG/L	32106 8010-G	11.3	--	2.17	1.34	--	--	--	--	--	4.18	2.97	--	1.06	--	--
1,1-DICHLOROETHANE UG/L	34496 8010-G	--	--	--	--	--	--	--	--	--	3.38	--	--	--	--	--
1,2-DICHLOROETHANE UG/L	34531 8010-G	--	--	--	6.48	--	--	--	--	--	3.73	1.32	--	--	5	5
1,1-DICHLOROETHYLENE UG/L	34501 8010-G	--	--	--	--	--	--	--	--	--	99.1	--	--	--	7	7
TRANS-1,2-DICHLORO ETHENE UG/L	34546 8010-G	10.4	--	--	28.1	--	--	--	--	--	339	33.2	--	--	100	100
METHYLENE CHLORIDE UG/L	34423 8010-G	--	--	--	--	--	--	--	--	--	228	--	--	2.47	--	5
1,1,2,2-TETRACHLORO ETHANE UG/L	34516 8010-G	162	2.28	--	63.8	--	--	--	--	--	43.6	333	--	--	--	--
TETRACHLOROETHENE UG/L	34475 8010-G	2.00	--	--	14.2	--	--	--	2.35	--	361	39.6	--	--	5	5
1,1,1-TRICHL ETHANE UG/L	34506 8010-G	--	--	--	--	--	--	--	--	--	6.63	--	--	--	200	200
1,1,2-TRICHL ETHANE UG/L	34511 8010-G	7.69	--	--	--	--	--	--	--	--	4.66	1.64	--	--	--	5
TRICHLOROETHENE UG/L	39180 8010-G	137	--	--	961	--	--	1.55	3.53	--	1310	1730	--	--	5	5
TOLUENE UG/L	34010 8020-G	--	--	--	--	--	--	--	--	--	33.1	--	--	--	1000	1000
BIS(2-ETHYLHEXYL) PHTHALATE UG/L	39100 8270/3520-G	46	4.7	2.5	--	9.2	13	7.8	1.9	13	2.4	1.9	3.5	--	--	6
PHENOL UG/L	34694 8270/3520-G	2.3	3.4	--	--	--	2.3	5.9	2.2	3.4	5.5	--	2.4	--	--	--
ANTHRACENE UG/L	34220 8310/3520-G	--	--	--	0.462	--	--	--	1.84	--	0.805	--	0.293	--	--	--
BENZO(A)ANTHRACENE UG/L	34526 8310/3520-G	--	--	--	0.035	0.008	--	0.002	0.035	--	0.334	--	0.021	--	--	0.1*
BENZO(A)PYRENE UG/L	34247 8310/3520-G	--	0.006	0.008	0.032	0.011	--	0.007	0.046	--	0.140	--	0.010	--	--	0.2
BENZO(B)FLUORANTHENE UG/L	34230 8310/3520-G	--	0.006	0.008	0.013	0.014	--	0.002	0.063	--	0.167	--	0.013	--	--	0.2*
BENZO(GHI)PERYLENE UG/L	34521 8310/3520-G	--		-	0.318	--	--	--	0.093	--	0.319	--	0.033	--	--	--
BENZO(K)FLUORANTHENE UG/L	34242 8310/3520-G	--	0.001	0.005	0.007	0.012	--	0.001	0.029	--	0.063	--	0.006	--	--	0.2*
CHRYSENE UG/L	34320 8310/3520-G	--	--	--	--	0.130	0.189	--	0.327	0.333	0.318	--	--	--	--	0.2*
DIBENZ(A,H)ANTHRACENE UG/L	34556 8310/3520-G	--	--	--	--	--	--	--	0.005	--	0.014	--	--	--	--	0.3*
FLUORANTHENE UG/L	34376 8310/3520-G	0.004	0.020	0.025	0.037	0.025	--	0.003	0.015	0.004	0.248	--	0.026	--	--	--
INDENO(1,2,3-CD) PYRENE UG/L	34403 8310/3520-G	--	--	--	--	0.013	0.007	--	0.030	--	0.114	0.004	--	--	--	0.4*
PHENANTHRENE UG/L	34461 8310/3520-G	--	--	--	--	--	--	--	0.158	--	0.098	--	--	--	--	--
PYRENE UG/L	34469 8310/3520-G	--	--	--	0.055	--	--	--	0.166	--	1.02	--	--	3.98	--	--
DDD, PP' UG/L	39310 8080/3520-G	--	--	--	--	--	--	--	--	--	0.035	--	--	--	--	--
DDT, PP' UG/L	39300 8080/3520-G	--	--	--	--	--	--	--	--	--	0.013	--	--	--	--	--
DIELDRIN UG/L	39380 8080/3520-G	--	--	--	0.008	--	--	0.063	--	--	--	0.006	--	--	--	--
HEPTACHLOR EPOXIDE UG/L	39420 8080/3520-G	--	--	--	--	--	--	--	--	--	--	0.005	--	--	0.2	0.2

Table BDMT Analytical Results for Parameters Above Detection Limits (MW-12 through MW-39, Duplicate Samples, and Equipment Blanks) (Continued, Page 2 of 3)

SAMPLE ID'S PARAMETERS UNITS	STORET METHOD	MW12 COOMTW 12	MW13 COOMTW 13	MW14 COOMTW 14	MW15 COOMTW 15	MW16 COOMTW 16	MW17SD COOMTW 17	MW18 COOMTW 18	MW19 COOMTW 19	MW40DUP COOMTW 40	MW41DUP COOMTW 41	MW42DUP COOMTW 42	MW43DUP COOMTW 43	MW44EQBK COOMTW 44	State and Federal MCLs*	
DATE TIME		11/18/93 17:00	11/19/93 09:20	11/19/93 10:30	11/14/93 17:30	11/17/93 17:15	11/18/93 11:30	11/15/93 18:15	11/15/93 13:40	11/18/93	11/11/93	11/11/93	11/17/93	11/16/93 16:30	Tennessee MCL	Federal MCL
ALUMINUM, TOTAL UG/L	1105 6010-G	127000	63200	3730	17800	765	3210	4990	3550	3480	174000	53100	179000	--	--	--
ARSENIC, TOTAL UG/L	1002 7060-G	20.6	39.4	--	4.6	--	--	--	4.7	--	4.6	--	22.5	--	50	50
BARIUM, TOTAL UG/L	1007 6010-G	1450	435	142	387	176	588	91.7	122	574	3030	326	450	--	2000	2000
CHROMIUM, TOTAL UG/L	1034 6010-G	231	116	13.9	81.4	10.3	--	20.8	31.7	--	382	83.1	895	--	100	100
COBALT, TOTAL UG/L	1037 6010-G	117	32.5	--	72.1	--	--	--	--	--	80.1	188	57.9	--	--	--
COPPER, TOTAL UG/L	1042 6010-G	183	64.9	7.6	63.7	6.4	6.5	16.5	33.2	5.4	372	59.4	180	--	--	1300
LEAD, TOTAL UG/L	1051 7421-G	98.1	46.1	6.7	36.0	8.2	7.5	6.7	27.5	--	421	28.1	94.0	--	5	15
MERCURY, TOTAL UG/L	71900 7470-C	1.96	0.36	--	--	--	--	--	--	--	0.74	0.36	1.96	--	2	2
ZINC, TOTAL UG/L	1092 6010-G	107	374	21.1	161	15.0	--	40.0	37.1	--	731	374	845	--	--	--
RESIDUE, DISS (TDS) MG/L	70300 160.1-G	872	202	127	196	196	216	166	198	214	379	193	279	0.0	--	--
ALUMINUM, DISS UG/L	1106 6010-G	--	--	--	325	--	--	--	--	--	44.0	--	--		--	--
BARIUM, DISS UG/L	1005 6010-G	262	58.2	17.8	72.6	344	464	--	40.5	456	73.1	41.8	90.3		--	--
LEAD, DISS UG/L	1049 7421-G	--	--	--	--	--	--	--	2.3	--	--	--	3.0		-	--
ZINC, DISS UG/L	1090 6010-G	--	--	66.5	--	20.5	--	--	--	--	33.3	--	--		--	--

*All units in micrograms per liter (ug/L)
-Proposed value

Table DDMT Analytical Results for Parameters Above Detection Limits (Equipment and Trip Blanks)

SAMPLE ID'S PARAMETERS UNITS	STORET METHOD	MW45EBLK CDDMTW 45	MW46EBLK CDDMTW 46	MW47EBLK CDDMTW 47	MW48TS CDDMTW 48	MW49TS CDDMTW 49	MW50TS CDDMTW 50	MW51TS CDDMTW 51	MW52TBLK CDDMTW 52	MW53TBLK CDDMTW 53	MW55TBLK CDDMTW 55	MW56TBLK CDDMTW 56	MW57TBLK CDDMTW 57	MW58TBLK CDDMTW 58	State and Federal MCLs[a] Tennessee MCL	 Federal MCL
DATE TIME		11/18/91 15:00	11/18/91 16:30	11/18/91 16:30	11/19/91 17:15	11/19/91 15:15	11/19/91 17:45	11/20/91 18:30	11/15/91 21:10	11/11/91 21:00	11/14/91 17:30	11/13/91 13:30	11/09/91 14:00	11/10/91 22:00		
CHLOROFORM UG/L	32106 8010-C	3.63	--	1.35	--	--	--	--	--	--	--	--	--	--	--	--
METHYLENE CHLORIDE UG/L	34423 8010-C	--	--	--	--	--	--	--	--	--	--	--	3.32	--	--	5
1,1,2,2-TETRACHLORO ETHANE UG/L	34516 8010-C	--	--	--	--	--	--	--	--	3.09	--	--	--	--	--	--
TRICHLOROETHENE UG/L	39180 8010-C	--	--	--	--	--	--	--	--	1.27	--	--	--	--	5	5
BARIUM, TOTAL UG/L	1007 6010-C	--		--	38.4	31.6	35.4	36.3							2000	2000
LEAD, TOTAL UG/L	1051 7421-C	--	--	--	7.9	5.7	2.4	3.4							5	15
ZINC, TOTAL UG/L	1092 6010-C	--	--	--	705	7330	545	428							--	--
RESIDUE, DISS (TDS) MG/L	70300 160.1-C	--	--	--	350	272	257	248							--	--
BARIUM, DISS UG/L	1005 6010-C				36.5	30.7	37.8	33.6							--	--
LEAD, DISS UG/L	1049 7421-C				2.1	5.9	7.5	2.8							--	--
ZINC, DISS UG/L	1090 4010-C				707	2790	546	431								

[a] All units in micrograms per liter (ug/L).
[b] Proposed value

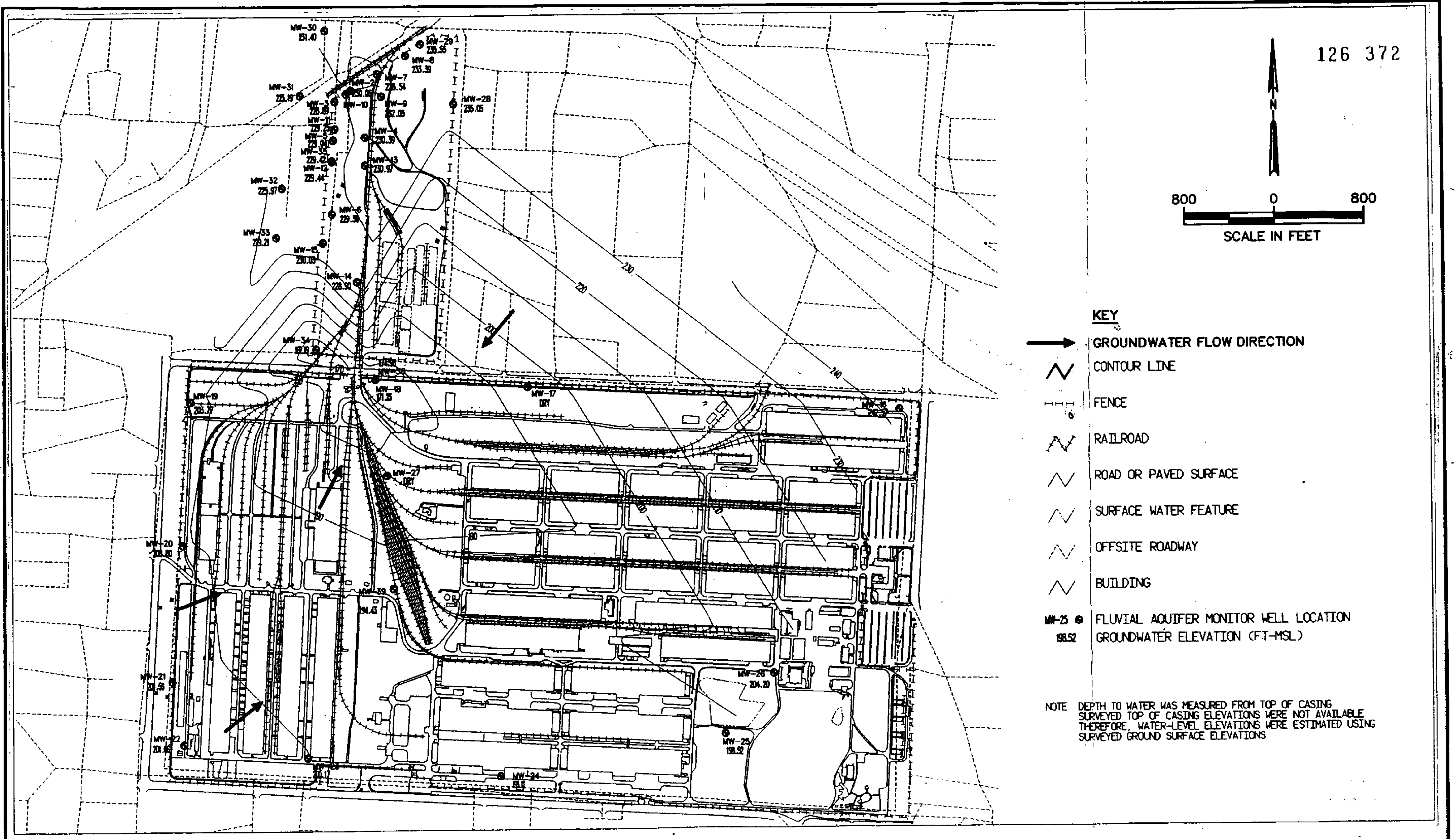
Table Analytical Results for Parameters Above Detection Limits (Trip Blanks)

SAMPLE ID'S PARAMETERS UNITS	STORET METHOD	MW60TUCK COONTW 60	MW61TUCK COONTW 61	MW62TUCK COONTW 62	MW64TUCK COONTW 64	MW76 COONTWO 1	MW77 COONTWO 7	MW78 COONTWO 3	State and Federal MCLs*	
DATE TIME		11/12/93 15:00	11/17/93 15:00	11/19/93 22:00	11/18/93 20:00	11/10/93 11:15	11/10/93 13:30	11/10/93 15:15	Tennessee MCL	Federal MCL
BROMODICHLOROMETHANE UG/L	32101 8010-G	--	--	--	--	--	18.6		--	100
DIBROMOCHLOROMETHANE UG/L	32105 8010-G	--	--	--	-	--	15.5		--	100
1,2-DICHLOROETHANE UG/L	34531 8010-G	--				--	17.6		--	--
TRANS-1,2-DICHLORO ETHENE UG/L	34546 8010-G	-	--	--	--	--	17.8		100	100
CIS-1,3-DICHLORO PROPENE UG/L	34704 8010-G				-	--	15.8		--	--
TRANS-1,3-DICHLORO PROPENE UG/L	34699 8010-G						18.4			--
METHYLENE CHLORIDE UG/L	34423 8010-G		15.4				14.9		--	-
1,1,2,2-TETRACHLORO ETHANE UG/L	34516 8010-G	2.72			-	--	--		5	5
TETRACHLOROETHENE UG/L	34475 8010-G	--	--	-	--	--	15.3		200	200
1,1,1-TRICHL'ETHANE UG/L	34506 8010-G	--	-	--	--	--	15.3		5	5
TRICHLOROETHENE UG/L	39180 8010-G	1.25	--	--	-	--	--		2	2
VINYL CHLORIDE UG/L	39175 8010-G	--	--	--	--	--	20.0		--	--
ACENAPHTHENE UG/L	34205 8270/3520-G					--	39		--	0.2•
BENZO(B)FLUORANTHENE UG/L	34230 8270/3520-G					--	8.0		--	0.2•
BENZO(K)FLUORANTHENE UG/L	34242 8270/3520-G					--	6.3		--	--
DI-N-BUTYLPHTHALATE UG/L	39110 8270/3520-G					--	33		--	--
2,4-DIMETHYLPHENOL UG/L	34606 8270/3520-G						87		--	--
2,6-DINITROTOLUENE UG/L	34626 8270/3520-G					--	13		-	--
FLUORENE UG/L	34381 8270/3520-G					--	18		--	--
ISOPHORONE UG/L	34408 8270/3520-G					--	18		--	--
PENTACHLOROPHENOL UG/L	39032 8270/3520-G					--	77		--	1
PHENANTHRENE UG/L	34461 8270/3520-G					--	37		--	--
PHENOL UG/L	34694 8270/3520-G					--	72		--	--
PYRENE UG/L	34469 8270/3520-G					--	18		--	--
2,4,6-TRICHL'PHENOL UG/L	34621 8270/3520-G					--	71		--	--
2,4,5-TRICHL'PHENOL UG/L	77687 8270/3520-G					--	69		--	--
ALUMINUM, TOTAL UG/L	1105 6010-G					--	5510	74200	--	--
ARSENIC, TOTAL UG/L	1002 7060-G					--	37.9	--	50	50
BARIUM, TOTAL UG/L	1007 6010-G					--	458	--	2000	2000
CADMIUM, TOTAL UG/L	1027 6010-G					--	48.4	--	10	5
CHROMIUM, TOTAL UG/L	1034 6010-G					--	48.3	--	100	100
COBALT, TOTAL UG/L	1037 6010-G					--	101	--	--	--
COPPER, TOTAL UG/L	1042 6010-G					--	45.3	--	--	1300
LEAD, TOTAL UG/L	1051 7421-G						20.7		5	15
MERCURY, TOTAL UG/L	71900 7470-G					-	0.28	-	2	2
SELENIUM, TOTAL UG/L	1147 7740-G						17.5	--	--	--
ZINC, TOTAL UG/L	1092 6010-G					--	28.0	-	--	--

*All units in micrograms per liter (ug/L)
•Proposed value.

126 371

126 372



NOTE DEPTH TO WATER WAS MEASURED FROM TOP OF CASING. SURVEYED TOP OF CASING ELEVATIONS WERE NOT AVAILABLE THEREFORE, WATER-LEVEL ELEVATIONS WERE ESTIMATED USING SURVEYED GROUND SURFACE ELEVATIONS

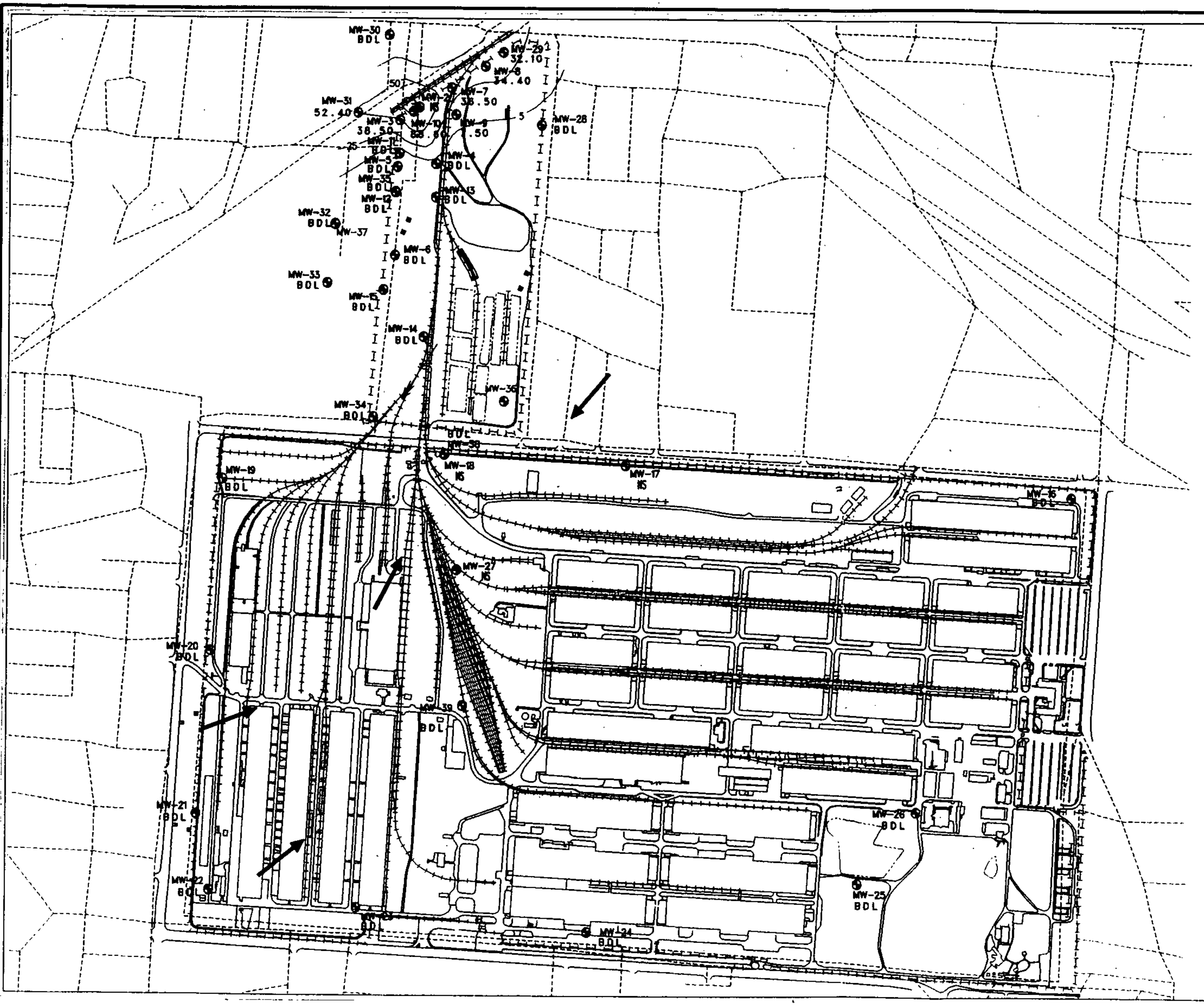
Source: ESE, Inc., 1994

FIGURE D-1
POTENTIOMETRIC GROUNDWATER CONTOURS FOR THE FLUVIAL AQUIFER - NOVEMBER 1993
Defense Depot Memphis, Tennessee

CH2M HILL

MW-0008.DWG 28-Feb-1995

126 373



KEY

GROUNDWATER FLOW DIRECTION

CONTOUR LINE

FENCE

RAILROAD

ROAD OR PAVED SURFACE

SURFACE WATER FEATURE

OFFSITE ROADWAY

BUILDING

MW-25 FLUVIAL MONITOR WELL LOCATION
BDL 1,1-DICHLOROETHYLENE CONCENTRATION (PPB)

MW-36 MEMPHIS SAND AQUIFER MONITOR WELL LOCATION

BDL BELOW DETECTION LIMIT

NS NOT SAMPLED

NOTE:

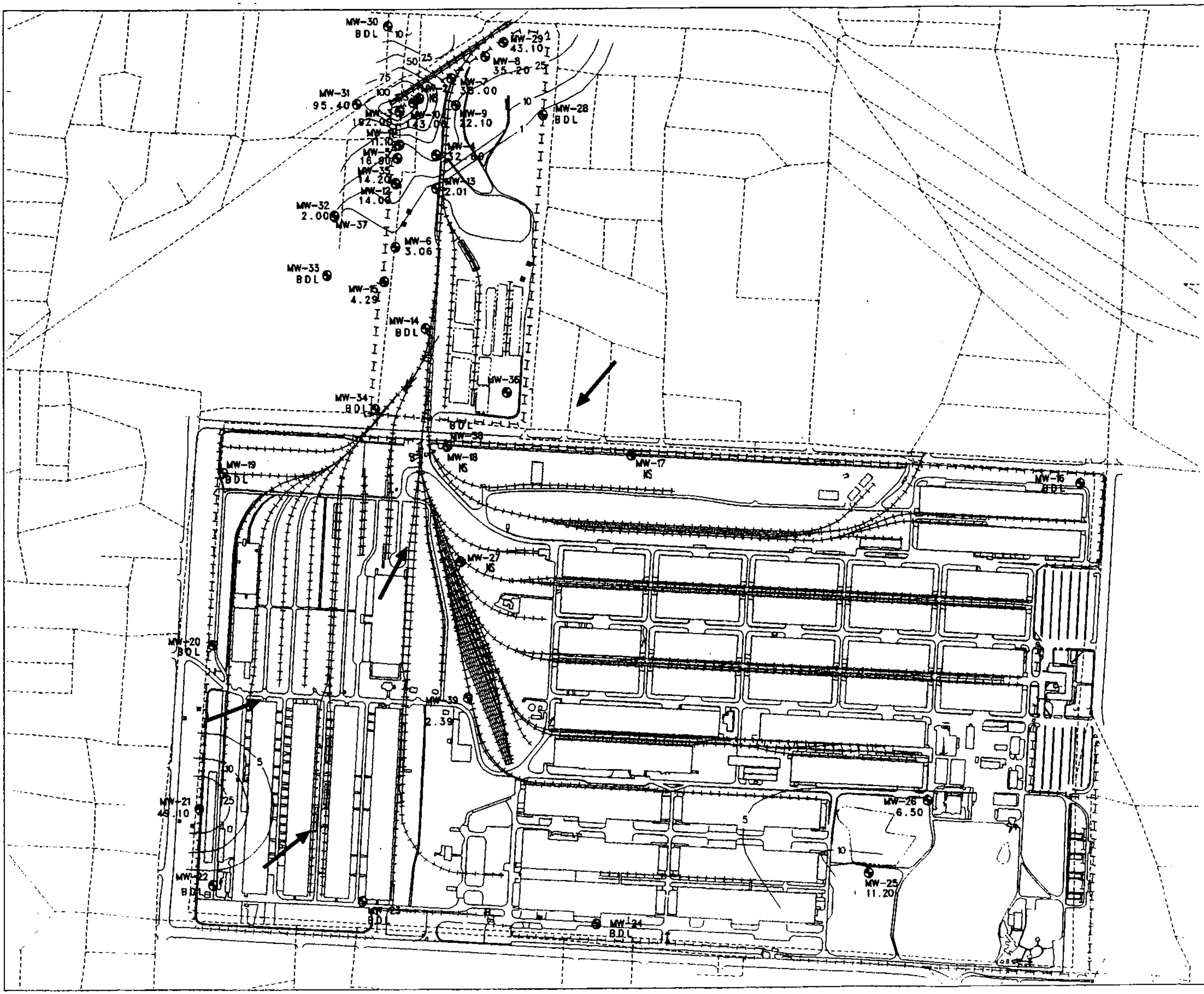
MW-32 AND MW-37 ARE CLUSTER WELLS WITH MW-32 SCREENED IN THE FLUVIAL AQUIFER AND MW-37 SCREENED IN THE MEMPHIS SAND AQUIFER.

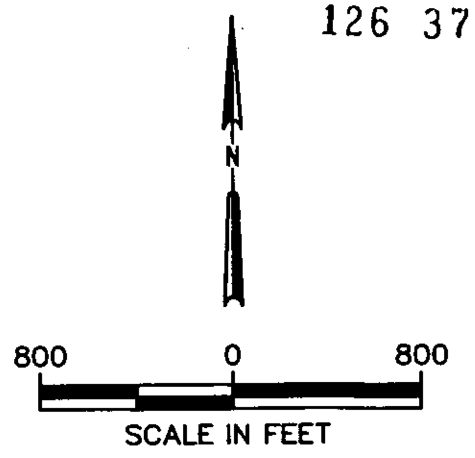
Source: ESE, Inc., 1994

FIGURE D-2
1,1-DICHLOROETHYLENE CONCENTRATIONS IN GROUNDWATER FOR THE FLUVIAL AQUIFER - NOVEMBER 1993
Defense Depot Memphis, Tennessee

MWP-0008.DWG 03-Mar-1995

126 374





KEY

→ GROUNDWATER FLOW DIRECTION

CONTOUR LINE

FENCE

RAILROAD

ROAD OR PAVED SURFACE

SURFACE WATER FEATURE

OFFSITE ROADWAY

BUILDING

MW-25 ⊕ FLUVIAL AQUIFER MONITOR WELL LOCATION
11.20 TETRACHLOROETHENE CONCENTRATION (PPB)

MW-36 ⊕ MEMPHIS SAND AQUIFER MONITOR WELL LOCATION

BDL BELOW DETECTION LIMIT

NS NOT SAMPLED

NOTE:

MW-32 AND MW-37 ARE CLUSTER WELLS WITH MW-32 SCREENED IN THE FLUVIAL AQUIFER AND MW-37 SCREENED IN THE MEMPHIS SAND AQUIFER.

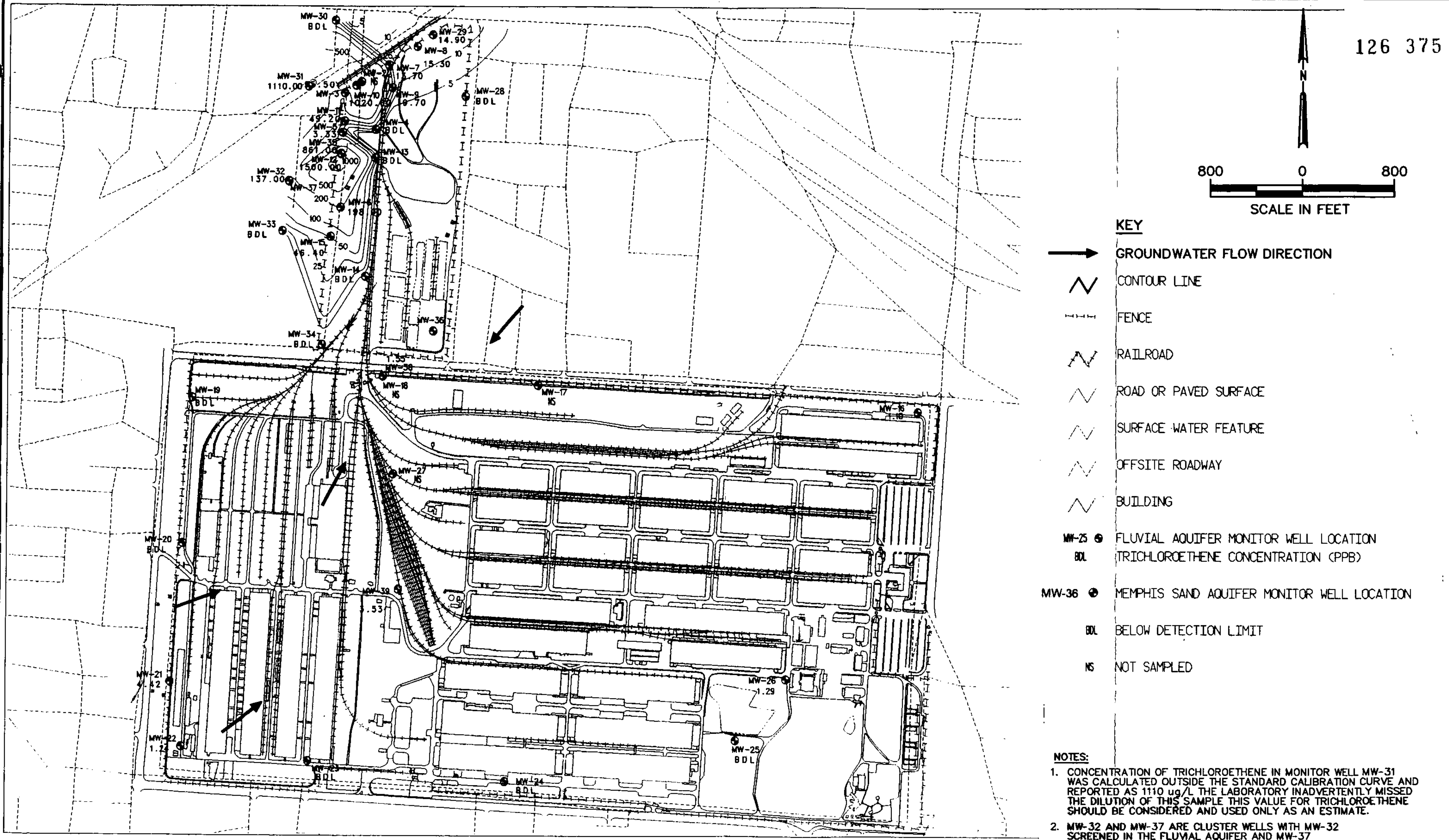
FIGURE D-3
TETRACHLOROETHENE CONCENTRATIONS IN GROUNDWATER FOR THE FLUVIAL AQUIFER - NOVEMBER 1993
Defense Depot Memphis, Tennessee

CH2M HILL

Source: ESE, Inc., 1994

MWP-0009.DWG 28-Feb-1995

126 375



NOTES:

1. CONCENTRATION OF TRICHLOROETHENE IN MONITOR WELL MW-31 WAS CALCULATED OUTSIDE THE STANDARD CALIBRATION CURVE AND REPORTED AS 1110 ug/L THE LABORATORY INADVERTENTLY MISSED THE DILUTION OF THIS SAMPLE THIS VALUE FOR TRICHLOROETHENE SHOULD BE CONSIDERED AND USED ONLY AS AN ESTIMATE.
2. MW-32 AND MW-37 ARE CLUSTER WELLS WITH MW-32 SCREENED IN THE FLUVIAL AQUIFER AND MW-37 SCREENED IN THE MEMPHIS SAND AQUIFER.

Source: ESE, Inc.,1994

MWP-0010.DWG 28-Feb-1995

FIGURE D-4
TRICHLOROETHENE CONCENTRATIONS IN GROUNDWATER
FOR THE FLUVIAL AQUIFER - NOVEMBER 1993
Defense Depot Memphis, Tennessee

CH2M HILL

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE

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