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THE MEMPHIS DEPOT
TENNESSEE

ADMINISTRATIVE RECORD
COVER SHEET

AR File Number 19

FINAL FEASIBILITY STUDY REPORT

DEFENSE DEPOT MEMPHIS, TENNESSEE (DDMT)

Contract Number DACA87-88-C-0082
LEGS Job Number 11-8531-02

Prepared for:

United States Army Corps of Engineers
Huntsville Division
106 Wynn Drive
Huntsville, Alabama 35807

Submitted by:

Law Environmental, Inc.
Government Services Division
114 TownPark Drive
Kennesaw, Georgia 30144

SEPTEMBER 1990

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LAW ENVIRONMENTAL, INC.

GOVERNMENT SERVICES DIVISION
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404-499-6800

October 31, 1990

Department of the Army
Corps of Engineers, Huntsville Division
P.O. Box 1600
Huntsville, AL 35807-4301

Attention: Mr. David Hasley
Project Manager

Subject: Revisions to Final Feasibility Study
RI/FS at Defense Depot Memphis, Tennessee (DDMT)
Contract No. DACA87-88-C-0092
LEGS Job No. 11-8531-01

Dear Mr. Hasley,

LAW Environmental, Inc. is pleased to submit a revision to the Final Feasibility Study. Please insert the enclosed pages into your Final FS Report, and discard the existing pages.

Should you have any questions concerning these revisions or other aspects of the project, please do not hesitate to call.

Sincerely,

Frank W. Thomas, P.G.
Project Manager

Thomas L. Richardson, P.E.
Project Principal

LAW ENVIRONMENTAL, INC.

GOVERNMENT SERVICES DIVISION
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September 24, 1990

U.S. Army Corps of Engineers
Huntsville Division
P.O. Box 1600
Huntsville, AL 35807-4301

Attention: Mr. David Hasley
Project Manager

Subject: Draft Final Feasibility Study Report
Defense Depot Memphis (DDMT)
Project No: 11-8531-02
Contract No. DACA87-88-C-0082

Dear Mr. Hasley:

Law Environmental, Inc. is pleased to submit the Final Feasibility Study Report for the DDMT project. The report is distributed in accordance with the project Scope of Work. The distribution is repeated on the following page for your convience.

If you have any questions regarding the Final Report, please do not hesitate to call us at 404/499/6800.

Sincerely,

Frank W. Thomas

Frank W. Thomas, P.G.
Project Geologist

Thomas L. Richardson, P.E.
Project Principal

Encl.

FT/tc

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1.0 INTRODUCTION

Defense Depot Memphis, Tennessee (DDMT) is a major field installation of the Defense Logistics Agency (DLA), U.S. Department of Defense (DOD). Due to the requirements of its primary mission, providing material to support all U.S. military services and some civil agencies, DDMT has been engaged in a variety of operations dealing with hazardous substance transportation, shipment and disposal.

DOD developed the Installation Restoration Program (IRP) in 1981 to evaluate and remediate the effects of past hazardous waste management and disposal practices at its facilities and to comply with provisions of the Comprehensive Environmental Response, Compensation and Liability Act, as amended. All DOD facilities will be examined under the IRP.

This Feasibility Study (FS) is based primarily on information obtained in the Remedial Investigation (RI) including the Risk Assessment. These two studies are a continuing part of the RI/FS process. The RI/FS effort is managed and contracted on behalf of DLA by the Huntsville Division, U.S. Army Corps of Engineers (CEHND). CEHND retained Law Environmental, Inc. Government Services Division (LEGS) to perform the DDMT RI/FS.

1.1 PURPOSE AND ORGANIZATION OF REPORT

This Feasibility Study report presents a range of feasible remedial action alternatives that, if implemented, will protect human health and the environment as far as practical and reasonable within the applicable or relevant and appropriate requirements (ARARs). An array of feasible alternatives have been evaluated and are presented in this report. Section 4 describes the recommended remedial actions for each of the areas investigated.

The report organization adheres to the report format suggested in Chapter 6 of the EPA Document: Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, October, 1988. Briefly, the report is presented in the following sequence:

1. Description of the environmental situation at DDMT based on information collected during the Remedial Investigation (RI).
2. Selection of sites to be investigated for the development of remedial action alternatives.
3. Identification and screening of applicable technologies.
4. Assembly of applicable technologies into remedial action alternatives.
5. Screening of remedial action alternatives.
6. Detailed analyses of the screened alternatives.
7. Recommendations.

1.2 BACKGROUND INFORMATION

1.2.1 Site Description

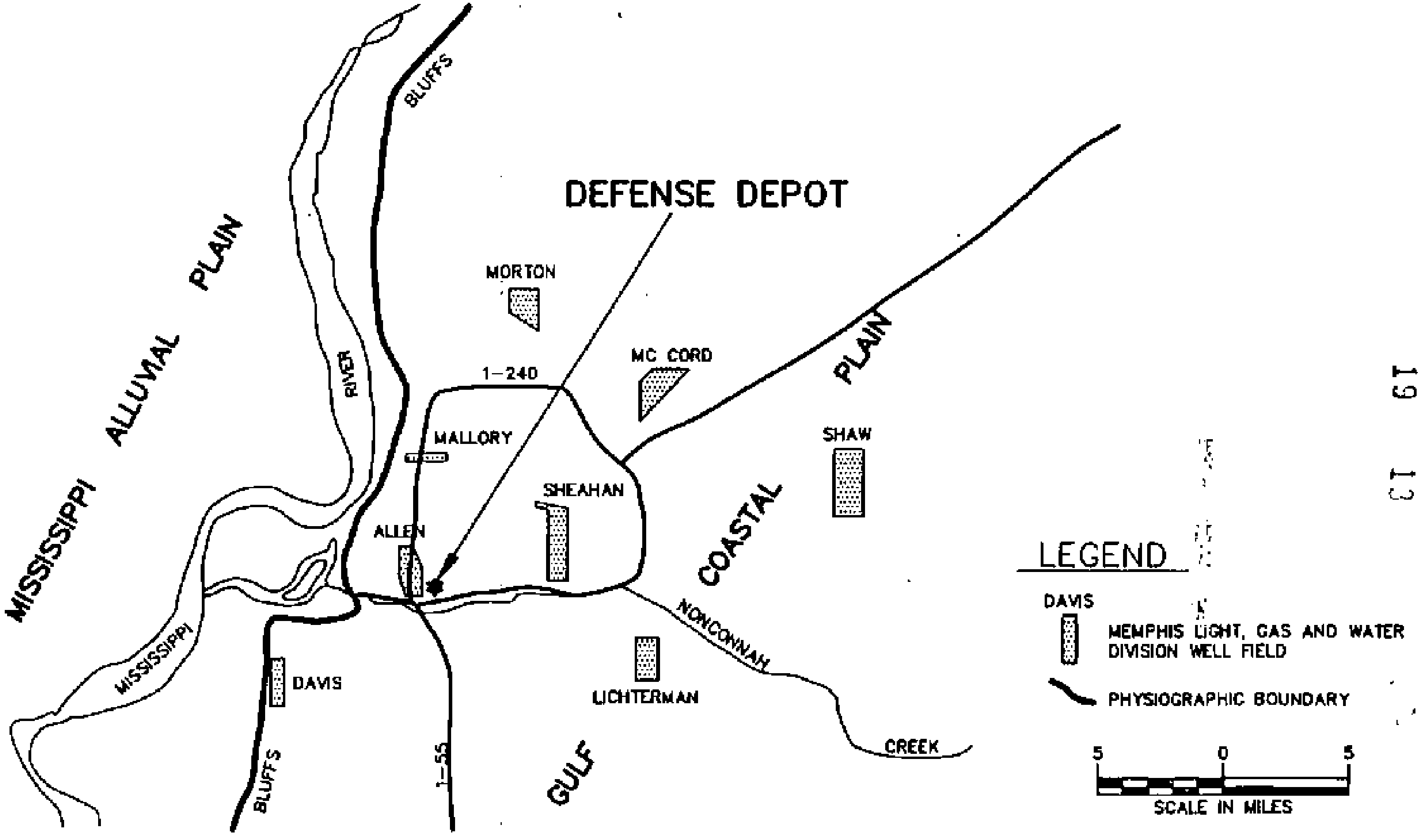
Defense Depot Memphis, Tennessee is situated on 642 acres of federal land in the City of Memphis, Shelby County, Tennessee. The Depot lies in the south central section of Memphis, four miles southeast of the Central Business District and one mile north of Memphis International Airport. DDMT is set in a mixed residential, commercial and industrial land use areas (Figure 1-1). DDMT consists of two sections: Dunn Field, an open storage area about sixty acres in size, and the main installation, which is intensely developed.

19 13

FIGURE 1-1

MAJOR PHYSIOGRAPHIC SUBDIVISIONS IN THE MEMPHIS AREA AND LOCATIONS OF MEMPHIS LIGHT, GAS AND WATER DIVISION WELL FIELDS

DEFENSE DEPOT MEMPHIS, TENNESSEE



SOURCE: (MODIFIED FROM BRAHANA AND OTHERS, 1987).
(U.S.G.S. OPEN-FILE REPORT 88-485).

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As a major field installation of the Defense Logistics Agency, DDMT warehouses and distributes an extensive inventory of supplies utilized by U.S. military services and federal agencies. These supplies span a broad range of commodities including clothing, food, medical supplies, electronic equipment, petroleum products and industrial chemicals. Due to the nature of its mission and the large supply volumes handled, some items were spilled, leaked or disposed within installation boundaries during the last forty-eight years.

A review of installation file data and other records suggest that as many as 75 sites of potential environmental concern exist at the facility. These include: waste disposal sites, spill locations and material storage. In past years, much of DDMT's waste disposal has been conducted at Dunn Field. Thirty-five of the 75 sites are located in Dunn Field. Figure 1-2 and Table 1-1 show the known locations in Dunn Field and types of material.

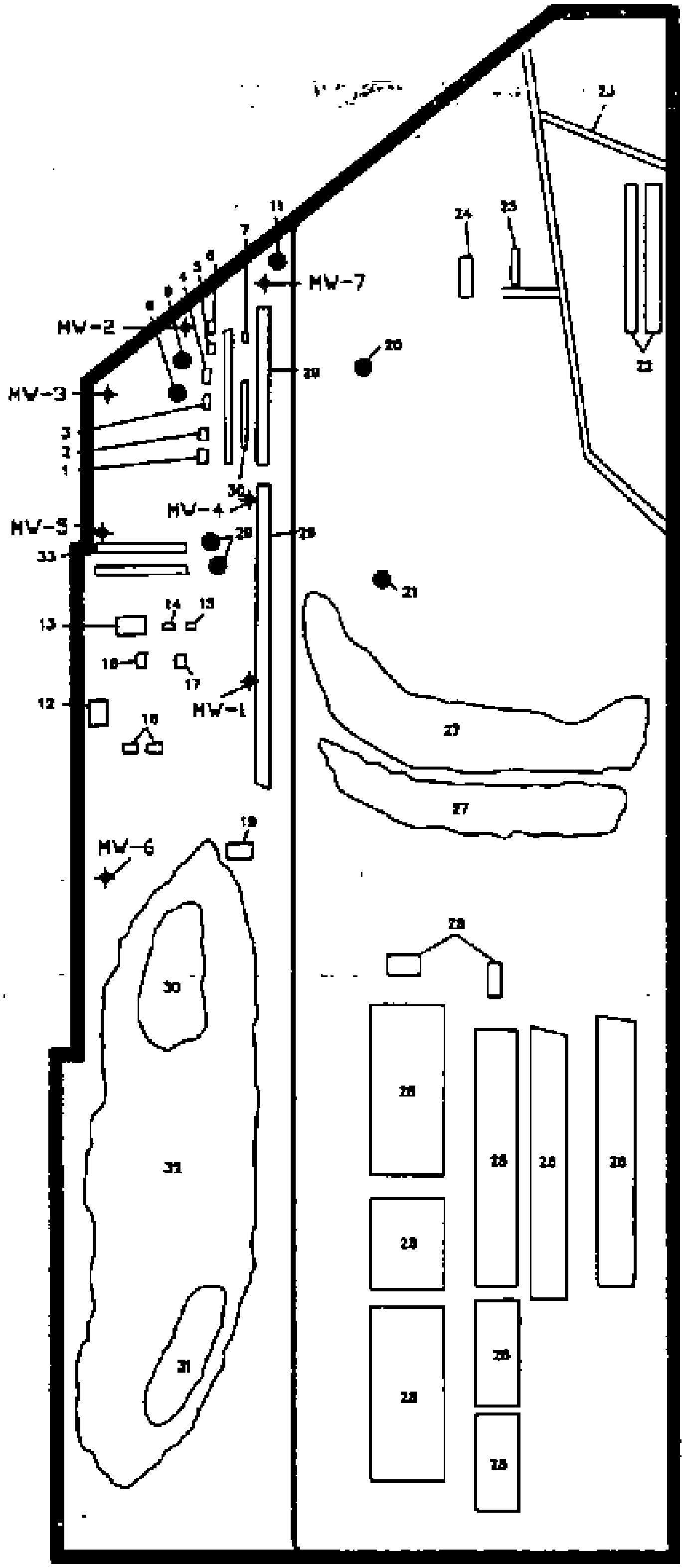
1.2.2 Previous Investigations

Prior to Law Environmental's Remedial Investigation, numerous technical studies were performed at DDMT to assist DLA in its continuing mission requirements. The technical studies reviewed and utilized in support of the RI include the following general categories:

1. Industrial Hygiene
2. Facility Planning
3. Regulatory Compliance Consultation
4. Surface Water Quality
5. Ground Water Quality
6. Waste Management Assessment
7. Hazardous Waste Remediation

FIGURE 1-2

DUNN FIELD DISPOSAL & STORAGE SITES



NUMBERS CORRESPOND TO
HAZARDOUS MATERIAL STORAGE
OR DISPOSAL SITES LISTED
ON TABLE 1-1.

LEGEND

✦ MONITORING WELLS INSTALLED BY AEHA

SCALE: 1"~350'

SOURCE: US ARMY ENVIRONMENTAL HYGIENE AGENCY, 1982.
GEOHYDROLOGIC STUDY NO. 38-26-0195-83.

TABLE 1-1
DEFENSE DEPOT MEMPHIS TENNESSEE
DUNN FIELD SITES
SUMMARY OF HAZARDOUS MATERIAL USE, STORAGE AND DISPOSAL SITES
SITE LOCATIONS ARE ILLUSTRATED ON FIGURE 4-1

MAP NO.	LOCATION	MATERIALS/WASTE	QUANTITY, DIMENSIONS OR SIZE	REMARKS
1	NW QUADRANT	MUSTARD AND LEWISITE	NINE TRAINING SETS	DISPOSED IN 1955
2	NW QUADRANT	AMMONIUM HYDROXIDE & GLACIAL ACETIC ACID	7 POUNDS SOLID, 1 GAL. LIQUID	DISPOSED IN 1955
3	NW QUADRANT	VARIOUS CHEMICAL; ORTHO-TOLIDINE DIHYDROCHLORIDE	3,000 QUARTS/5 CU.FT OTD	DISPOSED IN 1955
4	NW QUADRANT	POL AND PAINT	13-55 GAL. DRUMS	---
5	NW QUADRANT	POL AND THINNER	32-55 GAL. DRUMS	DISPOSED IN 1955
6	NW QUADRANT	METHYL BROMIDE	3 CUBIC FEET	DISPOSED IN 1955
7	NW QUADRANT	EYE OINTMENT	40,037 UNITS	DISPOSED IN 1955
8	NW QUADRANT	FUMING NITRIC ACID	1,700 BOTTLES	DISPOSED IN 1954
9	NW QUADRANT	METHYL BROMIDE	3,768 ONE-GALLON CANS	DISPOSED IN 1954
10	NW QUADRANT	ASHES AND METAL WASTE	UNCERTAIN	DISPOSED IN 1955 - (not shown on figure)
11	NW QUADRANT	TRICHLOROACETIC ACID	1,433 ONE-OUNCE BOTTLES	DISPOSED IN 1965
12	NW QUADRANT	SULPHURIC AND HYDROCHLORIC ACIDS	30 PALLETS	DISPOSED IN 1967
13	NW QUADRANT	MIXED CHEMICAL & ACID, DETERGENT, ALUMINUM SULPHATE & SODIUM	32 CUBIC YARDS MIXED CHEMICALS & ACID, 8,100 POUNDS SOLIDS	---
14	NW QUADRANT	SODIUM	ONE PALLET	---
15	NW QUADRANT	SODIUM PHOSPHATE	ONE PALLET	DISPOSED IN 1968
16	NW QUADRANT	ACID	ONE PALLET	DISPOSED IN 1969
17	NW QUADRANT	HERBICIDE, MEDICAL SUPPLIES & CLEANING COMPOUND	UNCERTAIN	DISPOSED IN 1969
18	NW QUADRANT	ACID	UNCERTAIN	---
19	NW QUADRANT	HARDWARE (NUTS & BOLTS)	UNCERTAIN	---
20	NE QUADRANT	ASPHALT	UNCERTAIN	---
21	NE QUADRANT	SANITARY WASTE, CN CANISTERS, & SMOKE POTS	UNCERTAIN	UTILIZED FROM 1955-60
22	NE QUADRANT	XXCC-3 IMPREGNITE	UNCERTAIN	---
23	NE QUADRANT	DRAINAGE DITCHES	---	MAY HAVE REC'D RUNOFF FROM STORAGE & DISPOSAL AREAS
24	PISTOL RANGE	UNKNOWN	UNCERTAIN	LEACHATE OBSERVED APRIL, 1989
25	BUILDING 1184	PESTICIDES & HERBICIDES	UNCERTAIN	CURRENTLY IN USE
26	NE QUADRANT	DRAIN PIPE	UNCERTAIN	--- (not shown on figure)

- continued -

TABLE 1-1
DEFENSE DEPOT MEMPHIS TENNESSEE
DUNN FIELD SITES
SUMMARY OF HAZARDOUS MATERIAL USE, STORAGE AND DISPOSAL SITES
SITE LOCATIONS ARE ILLUSTRATED ON FIGURE 4-1

MAP NO.	LOCATION	MATERIALS/WASTE	QUANTITY, DIMENSIONS OR SIZE	REMARKS
27	NE QUADRANT	BAUXITE	TWO SEMI-CONTAINED PILES	---
28	SE QUADRANT	FLUORSPAR	TEN BINS	---
29	NW QUADRANT	FOOD SUPPLIES	UNCERTAIN	---
30	SW QUADRANT	FOODS, BURNED CONSTRUCTION DEBRIS	UNCERTAIN	DISPOSED IN 1948
31	SW QUADRANT	VARIOUS COMBUSTIBLES	UNCERTAIN	UTILIZED IN 1946
32	SW QUADRANT	BAUXITE	ONE SEMI-CONTAINED PILE	UTILIZED FROM 1942-72
33	NW QUADRANT	SODIUM, SODIUM PHOSPHATE, ACID, CHLORINATED LIME & MEDICAL SUPPLIES	UNCERTAIN	DISPOSED IN 1970
74	NW QUADRANT	MIXED SOLID WASTE	UNCERTAIN	WASTE ZONE 3.5 TO 10 FEET BELOW GRADE, ENCOUNTERED AT WELL MW-10
75	NW QUADRANT	MUNICIPAL WASTE	UNCERTAIN	WASTE ZONE 6 TO 18 FEET BELOW GRADE, ENCOUNTERED AT WELL MW-12

Most of the studies at the site were performed internally by the U.S. Army Environmental Hygiene Agency (USAEHA) or the U. S. Army Toxic and Hazardous Materials Agency (USATHAMA). A few were projects conducted by consultants or Architect - Engineering (AE) firms under contract to DLA. The specific previous investigations utilized in support of the RI/FS are listed in Section 1 of the RI report.

1.2.3 Remedial Investigation Activities

The Remedial Investigation included the collection of regional and study area information. This information was used to characterize the surface and subsurface environments at DDMT. The following is a brief review of RI activities.

The study area's surface features were investigated by on-site visual reconnaissance, by reviewing U.S Army Corps of Engineers historical aerial imagery, U.S. Geological Survey 7.5 Minute Series Topographic Quadrangle maps and installation topographic maps.

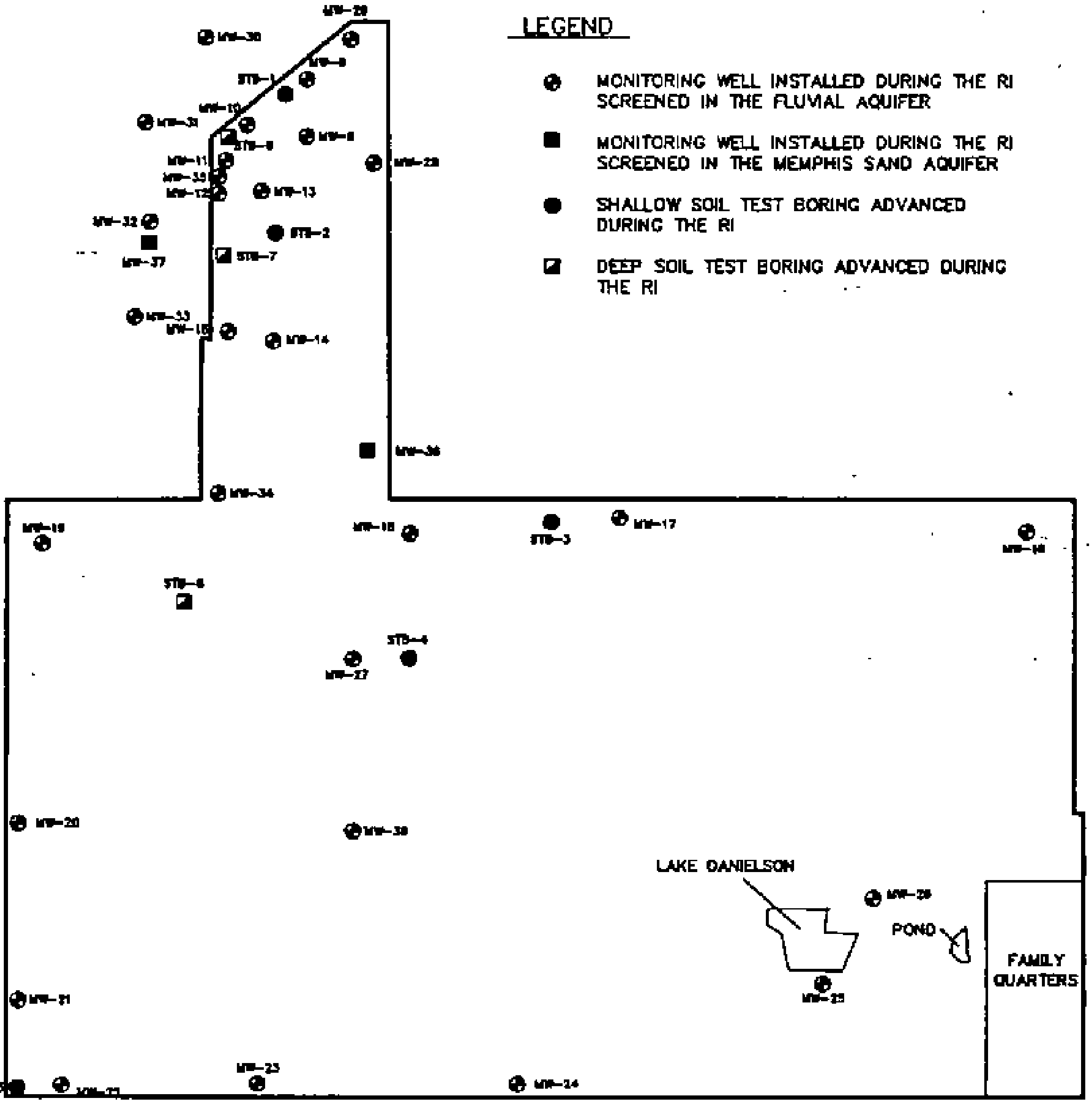
LEGS investigated the suspected contaminant sources by visual reconnaissance, interviews with DDMT personnel and a review of installation files, internal technical studies and previous consultations.

The geology, hydrogeology, ground-water and subsurface soil contamination were investigated at the main installation and in Dunn Field by installing and sampling thirty shallow monitoring wells into the Fluvial deposits. The location of the wells screened in the Fluvial aquifer, MW-8 through MW-35 and MW-38 and MW-39, are shown on Figure 1-3. In addition to the wells installed during the RI, monitoring wells MW-2 through MW-7 (installed by USAEHA) were sampled. The AEHA wells are shown on Figure 1-2.

FIGURE 1-3

RI MONITORING WELL AND SOIL TEST BORING LOCATIONS

DEFENSE DEPOT MEMPHIS, TENNESSEE



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◉	MONITORING WELL INSTALLED DURING THE RI SCREENED IN THE FLUVIAL AQUIFER
■	MONITORING WELL INSTALLED DURING THE RI SCREENED IN THE MEMPHIS SAND AQUIFER
●	SHALLOW SOIL TEST BORING ADVANCED DURING THE RI
◪	DEEP SOIL TEST BORING ADVANCED DURING THE RI

SCALE: 1" ~ 1000'

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GOVERNMENT SERVICES DIVISION

Five soil borings were advanced into the Fluvial deposits to help characterize the subsurface stratigraphy and to collect soil samples for analysis. The locations of STB-1 through STB-5 are shown on Figure 1-3.

The confining unit between the Fluvial aquifer and the Memphis Sand aquifer was investigated by advancing three 220-foot stratigraphic test borings (STB-6, STB-7 and STB-8) and by installing two deep monitoring wells (MW-36 and MW-37). Soil samples were collected from each boring for analysis from within the confining unit and at the top of the Memphis Sand aquifer. The water quality of the Memphis Sand aquifer was investigated by sampling the two wells screened into this aquifer. The soil test borings and deep monitoring well locations are shown on Figure 1-3.

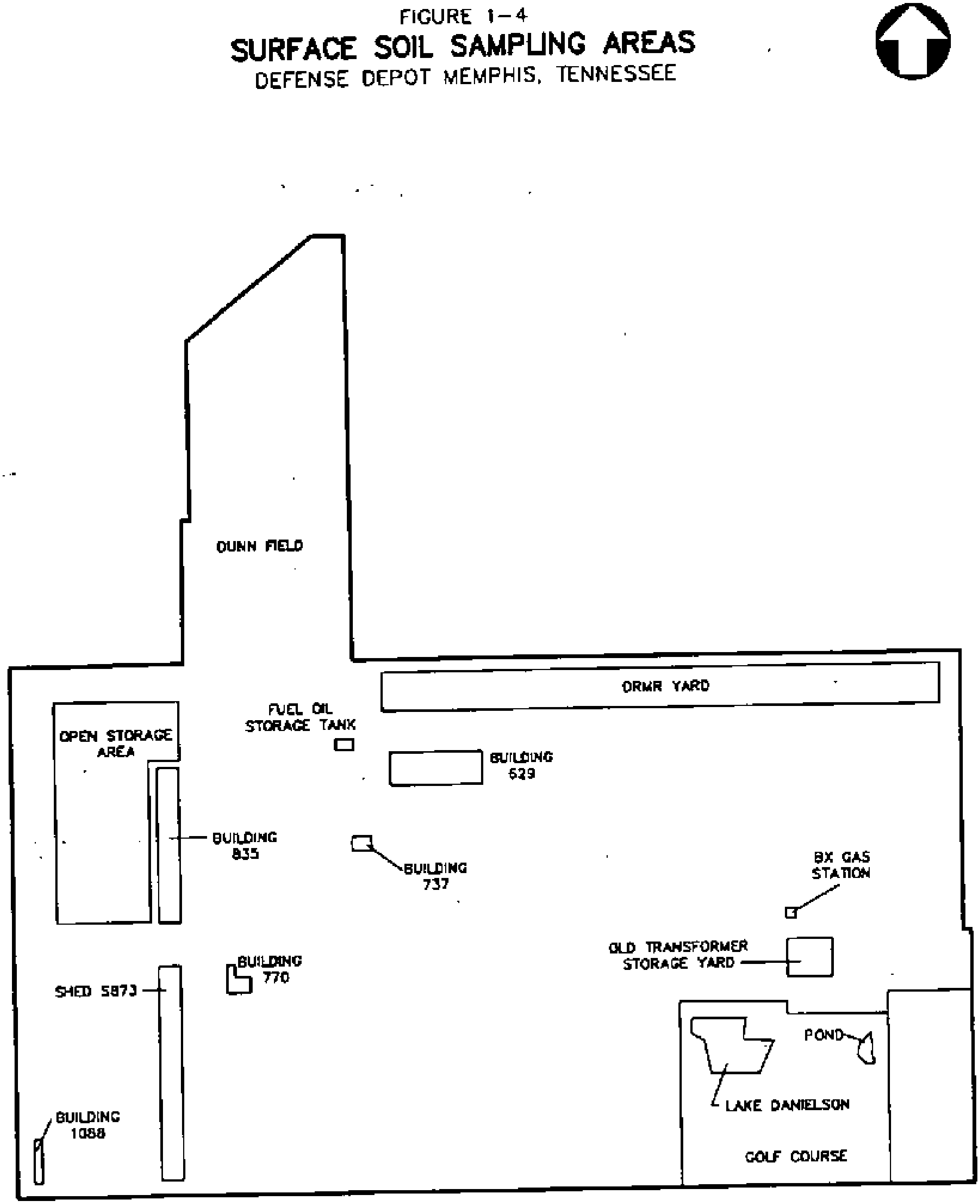
Twelve areas of potential surface soil contamination were investigated by collecting surface soil samples. A total of fifty soil samples were collected (SS-1 through SS-50). The surface soil investigation focused on probable or known "hot spots". The twelve sampling areas are shown on Figure 1-4. Each of the sampling locations are shown on Figure 2-1 and 2-2a through 2-2d in the RI report. The areas selected for development of remedial action alternatives will be discussed later in this section and will be shown on Figures 1-6 through 1-11.

Installation surface waters were sampled at points of discharge off of DDMT property and, from Lake Danielson and the golf course pond. Sediment samples were collected from Lake Danielson and the golf course pond.

FIGURE 1-4

SURFACE SOIL SAMPLING AREAS

DEFENSE DEPOT MEMPHIS, TENNESSEE



1.3 SELECTION OF AREAS FOR DEVELOPMENT OF REMEDIAL ALTERNATIVES

Based on the information obtained during the RI, remedial action alternatives were developed for three separate media at DDMT. The three media considered in this FS are: (1) ground water in the Dunn Field area; (2) surface water and sediments in Lake Danielson and the golf course pond and (3) surface soils on the main installation. A summary of each area is presented below, including suspected contaminant source, physical conditions, extent of contamination, apparent risk to human health and/or the environment and data gaps.

1.3.1 Dunn Field Ground-Water Investigation

The Fluvial aquifer's geologic and hydrogeologic characteristics and the quality of the ground water in the Dunn Field area were investigated by installing and sampling fifteen monitoring wells during the RI. In addition to these fifteen wells, the five of the seven wells installed by AEHA were sampled. All monitoring wells (except MW-34) screened in the Fluvial aquifer in Dunn Field are shown on Figure 1-3.

To help characterize the Dunn Field subsurface environment (both physically and chemically), two stratigraphic soil test borings were advanced into the Fluvial deposits (STB-1 and STB-2). Three soil samples were collected from within the Fluvial deposits from each boring. The location of each boring is shown in Figure 1-3.

The possibility for vertical migration of ground-water contamination in Dunn Field was investigated during the RI by collecting soil samples from within the confining unit and the top of the Memphis Sand aquifer from STB-6 and STB-7. Water samples were collected from the Memphis Sand aquifer from MW-36 and MW-37.

1.3.1.1 Physical Conditions - Information obtained during installation of the monitoring wells and soil test borings demonstrated that the Fluvial aquifer, within Dunn Field, consists of clayey sand, sand and gravelly sand. The saturated thickness of the Fluvial aquifer ranges from eight feet at MW-14 to approximately 23 feet at MW-28. Recharge to this unit is primarily from the infiltration of rainfall (Graham and Parks, 1986). A comparison of ground-water surface levels suggests that the Fluvial aquifer does not discharge to local streams. Discharge from the Fluvial aquifer is probably directed toward underlying units in hydraulic communication with the aquifer.

Water level data collected in the Dunn Field area was utilized to prepare a water table surface map of the Fluvial aquifer. Figure 1-5 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. From this information a westerly ground-water flow direction was determined.

A ground-water velocity of 303 ft/year was calculated using the following method:

$V = Ki/p$ where: V = velocity
K = hydraulic conductivity
i = gradient
p = effective porosity

An average hydraulic conductivity (K) was obtained using slug-test results from each monitoring well in Dunn Field (7.5×10^{-3} ft/min or 3.8×10^{-3} cm/sec). The gradient (i) was measured between various wells in the Dunn Field area and an average value of 0.02 was used. The porosity was not measured and an average value of 26% was used for a silty sandy gravelly soil.

Using the information listed above, the following calculations were used to determine the ground-water velocity:

$$V = \frac{(7.5 \times 10^{-3}\ \text{ft/min})\ (0.02)}{0.26}\ \frac{(60\ \text{min})}{\text{hr}}\ \frac{(24\ \text{hr})}{\text{day}}\ \frac{(365\ \text{days})}{\text{year}}$$

V = 303 feet/year.

It should be noted that this velocity was calculated using parameters measured over a very limited range and may not be indicative of areas not covered in this investigation. This value should also be used cautiously in estimating the rate and extent of ground-water contamination since no values for attenuation, retardation, dispersion or degradation were obtained.

The Jackson/upper Claiborne confining unit was found to be primarily a lean to fat lignitic montmorillonite clay. This formation is approximately ninety feet thick in the northwestern Dunn Field area. Monitoring well MW-37, located approximately 350 feet west of Dunn Field, was the most western location at which the confining unit was investigated during the RI. The continuity of the confining unit west of MW-37 was investigated only by reviewing boring logs from the Allen Well Field (located approximately 1 mile west of DDMT). From these records it appears that the confining unit is variable both in thickness and elevation throughout the area.

The water levels measured in the Fluvial aquifer were approximately ninety feet higher in elevation than those encountered in the Memphis Sand aquifer (MW-36 and MW-37). The difference in the hydraulic head between the two aquifers indicates that downward vertical migration from the Fluvial aquifer to the Memphis Sand aquifer is possible, despite the clayey nature of the confining unit.

The upper portion of the Memphis Sand aquifer was encountered in Dunn Field during the installation of MW-36, MW-37, STB-6 and STB-7. Samples collected for physical properties analysis indicate this formation is composed of gray, very fine grained, silty sand. The water levels encountered in the wells screened into the Memphis Sand aquifer were approximately 19 feet above the top of the aquifer. This rise in water level (hydraulic head) is indicative of artesian conditions. The top of the Memphis Sand aquifer (bottom of the confining unit) was encountered at an elevation of 125 NGVD. The potentiometric water level in MW-36 and MW-37 was encountered at approximately 144 feet NGVD.

1.3.1.2 <u>Extent of Ground-Water Contamination</u> - The analytical results indicate that a plume of contaminated ground water exists in the Fluvial aquifer in the west and northwest portions of Dunn Field and extending past the western boundary of the installation. Chlorinated volatile organic compounds and metals were detected in the Dunn Field Fluvial aquifer. The levels of contamination found in the ground water varied within the sampled area. The levels near the edge of the plume were near detection limits. In the central portion of the plume (around MW-12), the level of contamination was found to exceed ARARs by several orders of magnitude. Table 1-2 lists the constituents detected in the Fluvial aquifer ground water. This table also includes the results from MW-16, which was used to determine background levels. ARARs have been included for reference. A full description of project ARARs is given in Section 6.0 of the RI report.

Figure 1-5 shows the known extent of chlorinated ground-water contamination. The area of the plume shown on this figure covers approximately 46 acres. An estimated 75 million gallons of contaminated ground water has been calculated for this known area using an average aquifer thickness of 14 feet. The western most

TABLE 1-2
POSITIVE RESULTS IN GROUND WATER
DUNN FIELD AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER		Background Well			DUNN FIELD																	OFF-BASE			
		MW18	MCL	STATE OF TN	MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13	MW14	MW15	MW28	MW29	MW34	MW35	MW30	MW31	MW32	MW33
Depth of well in feet		75.0			74.8	79.9	77.5	69.4	73.4	69.1	82.5	71.0	85.3	86.8	83.0	78.9	80.8	75.0	54.3	156.9	89.7	59.1	79.2	67.8	59.7
HALOGENATED VOLATILES (ug/l)																									
1,1,1-Trichloroethane	PHASE I	--	200	200	3J	--	--	--	5J	5	--	9	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--			4J	--	--	--	4J	5	--	10	--	--	--	--	--	--	9	--	--	--	5	--	
1,1,2,2-Tetrachloroethane	PHASE I	--	--	1.7	--	--	--	150	--	--	--	10	73	340D	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--			--	--	--	68	--	--	--	9	11	1600D	2J	--	--	--	--	--	--	--	2600	110	
1,1,2-Trichloroethane	PHASE I	--	--	0.6	--	--	--	7	--	--	--	--	2J	1J	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--			--	--	--	4J	--	--	--	--	--	7	--	--	--	--	--	--	--	--	12	6	--
1,1-Dichloroethane	PHASE I	--	--	NA	--	--	--	--	3J	3J	--	3J	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--			--	--	--	--	2J	4J	--	4J	--	--	--	--	--	--	5	--	--	--	--	--	
1,1-Dichloroethylene	PHASE I	--	7	7	36	--	--	--	61	60	3J	130	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--			47	--	--	--	58	60	2J	160	--	--	--	--	--	--	56	--	--	--	91	--	
1,2-Dichloroethane	PHASE I	--	5	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--			--	--	--	--	--	--	--	3J	--	--	--	--	--	--	--	--	--	--	--	--	
1,2-Dichloroethylene	PHASE I	--	100/70(a)	350	--	--	3J	270D	--	--	--	6J	520D	190D	--	--	--	--	--	--	--	--	--	--	
	PHASE II	--			--	--	--	160	--	--	--	160	81	610D	--	--	2J	--	--	--	1J	--	1100D	110	--
Carbon Tetrachloride	PHASE I	--	5	5	--	5J	4J	77	--	--	17	--	4J	1J	--	1J	10J	--	--	--	--	--	--	--	--
	PHASE II	--			--	10	--	40	--	--	5	3J	6	3J	--	--	17	--	--	--	--	--	11	52	
Chloroform	PHASE I	--	100(c)	0.19	3J	2J	11	15	6	--	3J	--	6	3J	--	--	4J	--	--	--	--	--	--	--	--
	PHASE II	--			--	7	2J	10	6	--	--	6	11	10	--	--	18	--	--	--	--	--	33	12	
Methylene chloride	PHASE I	--	--	1500	--	--	--	--	48J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
	PHASE II	--			2J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Tetrachloroethene	PHASE I	--	5	0.8	49	100	210	3	68	58	6	190	--	--	3J	--	--	--	--	--	--	--	--	--	
	PHASE II	--			74	2000	48	2J	47	64	6	240D	18	33	9	--	--	--	87	--	--	--	96	2J	
Trichloroethene	PHASE I	--	5	5	25	4J	28	180D	19	21	17	140	380D	1700D	--	--	2J	--	--	--	--	--	--	--	
	PHASE II	--			35	9	5	120	18	21	4J	3900	61	5100D	--	--	8	--	24	--	61	--	15000	110	

-continued-

TABLE 1-2
POSITIVE RESULTS IN GROUND WATER
DUNN FIELD AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER		Background Well	MCL	STATE OF TN	DUNN FIELD																	OFF-BASE			
		MW16			MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13	MW14	MW15	MW28	MW29	MW34	MW35	MW30	MW31	MW32	MW33
Depth of well in feet		76.0			74.6	79.9	77.5	69.4	73.4	69.1	82.5	71.0	85.3	86.8	83.0	78.8	80.8	75.0	54.3	156.9	69.7	59.1	79.2	67.8	59.7
NONHALOGENATED VOLATILES (ug/l)																									
Acetone	PHASE I	3J	--	NA	--	--	--	34B	3J	--	--	--	1JB	1JB	1JB	2JB	--	--	--	--	--	--	--	--	
	PHASE II	--			6J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
NONHALOGENATED SEMIVOLATILES (ug/l)																									
Benzoic acid	PHASE I	--	--	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
	PHASE II	--			3J	3J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Di-n-butyl phthalate	PHASE I	--	--	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
	PHASE II	--			--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	42	--	--	--	
N-Nitrosodiphenylamine	PHASE I	2J	--	0.049	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
	PHASE II	--			4BJ	19B	6BJ	5BJ	3BJ	4BJ	3BJ	6BJ	4BJ	7BJ	6BJ	--	5BJ	3BJ	6BJ	--	3BJ	--	--	--	
bis(2-Ethylhexyl) phthalate	PHASE I	6J	--	1500	8J	7J	6J	5J	6J	5J	8J	13	--	6J	5J	8J	8J	--	--	--	--	--	--	--	
	PHASE II	3J			7BJ	--	--	--	--	--	--	--	3BJ	--	--	--	--	--	--	--	11J	--	--	--	
VOLATILE METALS (ug/l)																									
Arsenic	PHASE I	55	50	50	--	--	--	--	--	--	82	85	--	--	--	--	--	--	--	--	--	--	--	--	
	PHASE II	40			--	--	--	--	--	--	--	160	--	--	--	210	--	--	60	--	--	60	180	--	80
Lead	PHASE I	79	50	50	238N	257N	84N	395N	390N	166N	171N	653N	353N	417N	150N	507N	255N	--	--	--	--	--	--	--	
	PHASE II	80			90	130	40	70	260	70	--	1000	140	70	40	200	120	80	90	--	--	60	290	120	100
Mercury	PHASE I	--	2	2	1.8	1.1	.6	3.6	1.4	1.7	.8	.7	1.4	.5	1.4	1.9	3.1	--	--	--	--	--	--	--	
	PHASE II	--			--	--	--	1	--	1	--	1	--	--	--	2	1	--	--	--	--	--	1	1	

-continued-

TABLE 1-2
POSITIVE RESULTS IN GROUND WATER
DUNN FIELD AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER		Background Well MW16	MCL	STATE OF TN	DUNN FIELD MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13	MW14	MW15	MW28	MW29	MW34	MW35	OFF-BASE MW30	MW31	MW32	MW3
Depth of well in feet		75.0			74.6	79.9	77.5	69.4	73.4	69.1	62.5	71.0	85.3	66.8	83.0	78.9	80.8	75.0	64.3	156.9	69.7	59.1	79.2	67.6	59
NONVOLATILE METALS (ug/l)																									
Antimony	PHASE I	--	--	NA	45BN	59BN	--	142N	170N	113N	61N	81N	54BN	--	--	--	--	--	--	--	--	--	--	--	--
	PHASE II	--			--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Barium	PHASE I	216	1000	1000	659N	696N	224N	117N	1090N	694N	416N	1510N	3300N	2010N	416N	3740N	999N	--	--	--	--	--	--	--	--
	PHASE II	410			310	280	200	630	540	350	130	1900	1200	660	220	1500	550	860	410	120	120	600	880	1000	460
Cadmium	PHASE I	--	10	0.0037	--	--	--	8N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
	PHASE II	--			--	--	--	--	--	--	--	--	--	--	--	--	--	8	9	--	--	--	--	--	
Chromium (b)	PHASE I	66	50	50	643N	623N	170N	386N	1240N	471N	182N	286N	530N	517N	184N	500N	393N	--	--	--	--	--	--	--	--
	PHASE II	50			160	120	50	40	340	100	10	310	120	40	20	190	110	130	170	--	--	60	260	140	100
Copper	PHASE I	198	1300	1000	345N	438N	78N	213N	856N	304N	138N	613N	643N	454N	190N	592N	400N	--	--	--	--	--	--	--	--
	PHASE II	180			60	80	40	40	210	180	20	910	520	60	50	180	110	80	80	--	--	50	100	50	70
Nickel	PHASE I	29	--	13.4	324N	301N	57N	145N	602N	170N	67N	142N	225N	380N	79N	421N	170N	--	--	--	--	--	--	--	
	PHASE II	40			40	50	20	80	170	60	--	170	60	40	20	100	60	70	60	--	--	30	130	80	60
Silver	PHASE I	--	50	50	--	--	--	20	--	--	--	--	--	42	11	13	68	--	--	--	--	--	--	--	
	PHASE II	--			--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Zinc	PHASE I	116	5000	5000	114N	115N	311N	517N	1910N	745N	304N	1120N	872N	1300N	407N	1840N	662N	--	--	--	--	--	--	--	
	PHASE II	180			160	170	91	63	450	180	14	1300	230	110	79	430	140	250	210	24	38	160	490	220	210

Shaded numbers indicate levels equal to or above MCL or State of TN guidelines.
MCL - SDWA Maximum Containment Level
STATE OF TN - State of Tennessee Guidance Levels (Non-enforceable)
(a) Trans Isomer/Cis Isomer
(b) No distinction between Chromium (III) and Chromium (VI)
(c) Total trihalomethanes

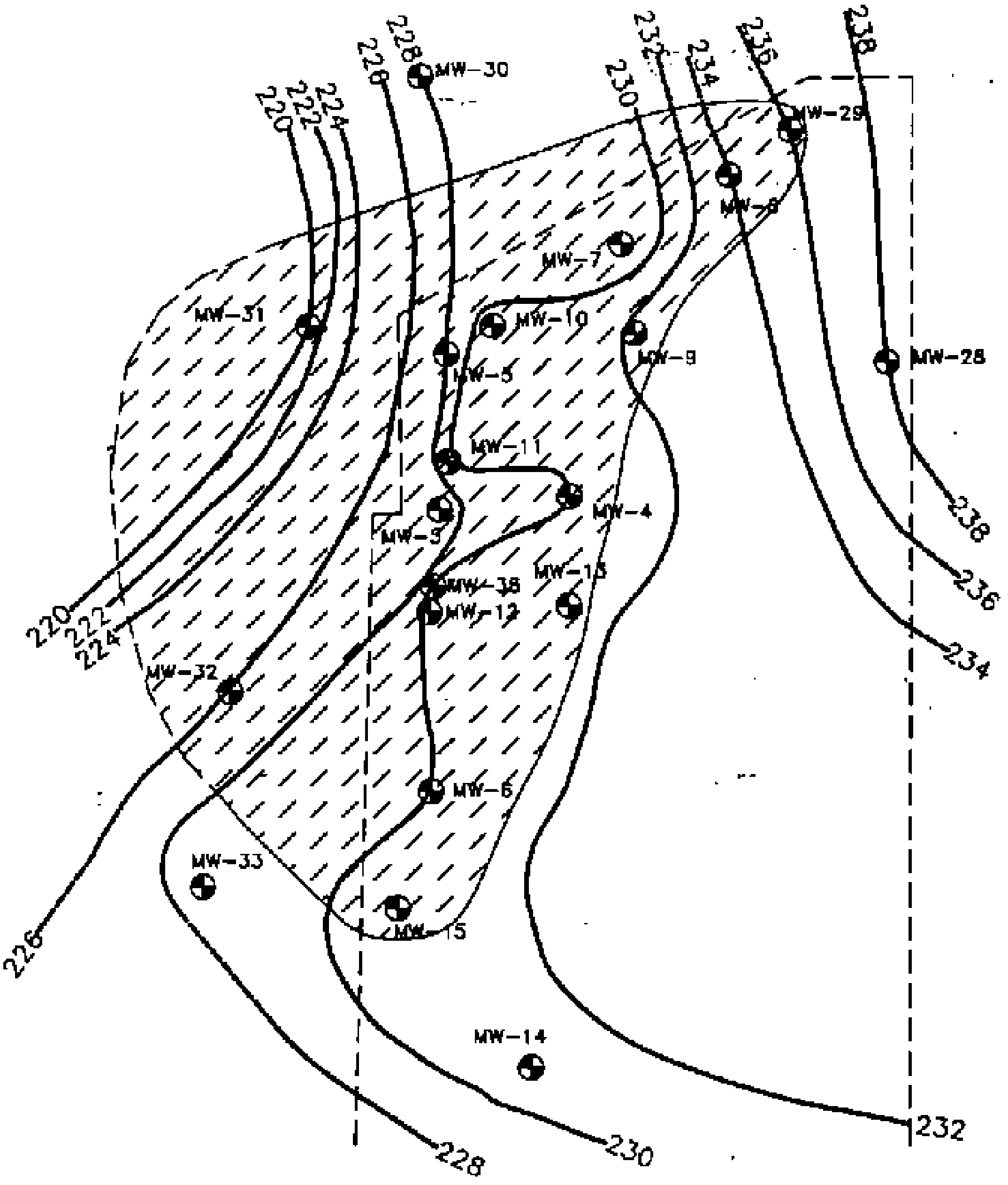
B (Inorganic) – Value less than the Contract Required Detection Limit (CRDL) but greater than the Instrument Detection Limit (IDL).
B (Organic) – Found in method blank.
D = Identified in an analysis at a secondary dilution factor.
J = Estimated value less than the sample quantitation limit but greater than zero.

N = Spiked sample recovery not within control limits.
-- = Not detected.
NA = Not Available.

FIGURE 1-5

WATER TABLE SURFACE OF FLUVIAL DEPOSITS AT DUNN FIELD JANUARY, 1990

DEFENSE DEPOT MEMPHIS, TENNESSEE



•• 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.

POSITIVE RESULTS FOR ALL CONSTITUENTS DETECTED IN THE FLUVIAL AQUIFER GROUND WATER ARE GIVEN IN TABLE 1-2.

LEGEND

◕	MONITORING WELL LOCATION
———	ISOPLETHS OF EQUAL ELEVATIONS
– – –	INFERRED ELEVATIONS

375 0 375

SCALE IN FEET

location at which the ground-water contamination was investigated was at MW-31 and MW-32. These two wells contained appreciable levels of contamination; therefore, it is expected that the contamination has migrated further west than these locations. The western extent of the contaminant plume was not identified during the RI.

Four stratigraphic soil test borings were advanced in Dunn Field. Samples were collected to provide information concerning the amount of contamination within the subsurface soil matrix. The analytical results for these samples are given in Table 1-3.

STB-1 is located in the northern portion of Dunn Field in a contaminated area of the Fluvial aquifer. However, no significant contamination was detected in the soil samples collected from this boring.

STB-2 is located in the central portion of Dunn Field in an area where only low levels of ground-water contamination were detected. Analysis of soil samples collected from this boring indicated low levels of Polynuclear Aromatic Hydrocarbon (PAH) contamination. As expected (due to the insolubility), PAH contamination was not detected in any of the ground-water samples. However, it is uncommon for these contaminants to be detected at these depths (68 feet) due to their immobility.

STB-6 is located in the northwest corner of Dunn Field in an area of significant ground-water contamination. Low levels of chlorinated volatile organic contamination was detected in the samples collected from within the confining unit and from the top of the Memphis Sand aquifer. This suggests the possibility that the contaminants have migrated through the confining unit and have entered the Memphis Sand aquifer. However, it is possible that the contaminants were introduced during drilling operations and may not indicate actual contamination of the Memphis Sand aquifer.

TABLE I-3
POSITIVE RESULTS IN SUBSURFACE SOILS
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I														
		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:		25.5'	62.5'	73.5'	10.0'	17.5'	67.5'	21.0'	28.0'	93.5'	18.0'	26.0'	102.0'	16.0'	78.0'	83.0'
HALOGENATED VOLATILES ug/kg																
Chloroform	70	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--
Methylene chloride	5800	16B	19B	10B	7B	8B	12B	3J	3J	3J	2J	16B	19B	13B	21B	12B
NONHALOGENATED VOLATILES ug/kg																
2-Butanone	7200	--	--	--	--	--	--	--	--	--	18	--	--	--	--	--
Acetone	690	57	43	20	24B	12B	13B	--	--	30	3J	8J	17	18	14B	14
Toluene	14,400	--	--	--	--	--	--	--	--	--	1J	--	--	--	--	--
NONHALOGENATED SEMIVOLATILES ug/kg																
Benzoic acid	na	--	--	--	--	--	58J	--	--	--	--	--	--	--	--	--
bis(2-Ethylhexyl) phthalate	15,000	1200	1200	760J	1100	1800	1600	2000B	670B	810B	610B	1500B	560BJ	450B	440B	320BJ
Di-n-butyl phthalate	na	--	--	--	--	210BJ	100BJ	140BJ	170BJ	120BJ	--	--	--	--	--	--
N-Nitrosodiphenylamine	12.8 - 38	--	--	--	45JB	--	--	--	--	--	--	44J	--	--	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)																
Fluoranthene		--	--	--	--	51J	47J	--	--	--	--	--	--	--	--	--
Pyrene		--	--	--	--	40J	40J	--	--	--	--	--	--	--	--	--
TOTAL PAHs	0.0028	--	--	--	--	91	87	--	--	--	--	--	--	--	--	--
NONVOLATILE METALS	EPTOX Standard															
Barium (EPTOX in ug/l)	100,000	15	25	58	--	--	--	16	18	49	--	--	25	--	10	--
Cadmium (EPTOX in ug/l)	1000	--	12	5	20	6	--	7	--	--	--	--	--	--	--	--

TABLE 1-3
POSITIVE RESULTS IN SUBSURFACE SOILS
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE II											
		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'	81.0'	170.0'	92.0'	97.0'	127.0'	217.0'
HALOGENATED VOLATILES ug/kg													
1,1,2,2-Tetrachloroethane	1300	240E	12	4J	13	--	--	--	--	--	--	--	--
1,2-Dichloroethane	40	--	--	--	--	--	--	--	--	--	--	--	11
1,2-Dichloroethylene	350	26	--	13	7	--	--	--	--	--	--	--	--
Methylene chloride	6600	21B	16B	6BJ	5JB	5BJ	11B	6B	8	10B	7B	5BJ	5BJ
Trichloroethene	70	4J	--	1J	--	--	--	--	--	--	--	--	--
NONHALOGENATED VOLATILES ug/kg													
2-Butanone	7200	--	--	15	--	--	--	--	--	3BJ	2BJ	2J	--
Acetone	590	210	80	1100D	74	250	86	31	9J	60B	40B	45	28
Toluene	14,400	1J	1J	5J	--	--	6J	--	--	--	3J	--	2J
NONHALOGENATED SEMIVOLATILES ug/kg													
bis(2-Ethylhexyl) phthalate	15,000	500B	280BJ	6400B	590B	1800B	160BJ	1900B	230BJ	520B	250BJ	350BJ	270BJ
Di-n-butyl phthalate	na	--	--	--	--	--	--	78J	--	--	--	--	--
N-Nitrosodiphenylamine	12.8 - 32	--	--	--	--	--	--	--	--	105BJ	53BJ	38J	98BJ
PESTICIDES ug/kg													
beta-BHC	2.4 - 6.1	--	--	14Z	--	--	--	--	--	--	--	--	18Z
VOLATILE METALS mg/kg													
Lead	[illegible] - 5	6	7	5	9	11	9	7	--	--	6	--	7

TABLE 1-3
POSITIVE RESULTS IN SUBSURFACE SOILS
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE II											
		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'	181.0'	71.0'	76.0'	91.0'	170.0'	92.0'	97.0'	127.0'	217.0'

NONVOLATILE METALS mg/kg

Barium	100	20.7	39.1	42.5	72.7	39.1	51.6	68.6	10.6	3.6	26.1	2.9	14.2
Cadmium	1	--	--	--	--	--	--	--	0.8	--	--	--	--
Chromium (a)	6	9	11	4	16	12	11	8	4	1	6	2	8
Copper	na	3	3	4	5	2	6	6	2	3	5	3	6
Nickel	20	2	--	5	3	3	3	7	3	--	6	--	4
Zinc	na	15.7	11.4	31.2	47.2	12.1	41.3	31	11.8	14	20.5	3.8	11.6

Shaded areas are values that are equal to or exceed the State of Tennessee soil criteria guidelines.

na = Not Available

State of TN values are only To Be Considered (TBC) guidelines. These are not enforceable clean up levels.

EPTOX Standard - Source: 40 CFR 261 (Appendix 2)

(a) No distinction between Chromium (III) and Chromium (VI).

B (Organic) = Found in method blank.

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

E = Concentration exceeds the calibration range of the GC/MS instrument for this specific analysis.

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

Z = Matrix interference; compound not positively identifiable.

-- = Not detected.

STB-7 is located along the western boundary of Dunn Field near the southern extent of the known ground-water contaminant plume. No significant contamination was detected in any of the samples collected from this boring.

The quality of the Memphis Sand aquifer was investigated by installing two monitoring wells into the aquifer (MW-36 and MW-37). MW-36 is located upgradient from the Fluvial aquifer contaminant plume. MW-37 is located west of Dunn Field, within the known extent of the contamination. The only contaminant detected was acetone, found in MW-37. None of the contaminants that were detected in the Fluvial aquifer were found in either of the wells. This suggests that the contaminants detected in the Fluvial aquifer have not migrated through the confining unit as of the time of sampling.

1.3.1.3 Contamination Source - Based on the analytical results and the ground-water flow direction, it appears that the source of the Dunn Field ground-water contamination is the burial trenches located within Dunn Field. Typically, landfilled solid waste materials, such as those reportedly located in Dunn Field, are buried in the dry state. Liquid wastes were containerized and the documented fluid spills, involving small quantities, were local in nature. Contamination, in the form of leachate, is produced by the water saturation of dry solid wastes (USEPA, 1980), by the leakage of corroding liquid waste containers or by the spillage of fluids at ground surface. Continued saturation will mobilize the contaminants. The chief source of water at the disposal site is precipitation, a prime component of a site's water balance. A calculation of the study area's net precipitation (the amount of rainfall potentially available for infiltration and waste saturation) was nine inches annually. This value is adequate to both generate and mobilize waste-related contamination at DDMT.

1.3.1.4 Risk Assessment - The potential environmental exposure pathways associated with any off-site ground-water contamination include ingestion, inhalation and dermal absorption. A vital pathway which is included in the exposure evaluation is the possibility that the Fluvial aquifer is interconnected with the Memphis Sand aquifer, which is the source of drinking water for the entire Memphis area. Table 1-4 lists the contaminants of concern that were identified in DDMT monitoring wells screened in the Fluvial aquifer. None of the constituents listed on this table were detected in the wells screened in the Memphis Sand aquifer (MW-36 and MW-37).

An unacceptable health risk was not associated with the contaminated Fluvial aquifer ground water because this water is not used for drinking or irrigation. However, an unacceptably high risk could be associated with drinking water from the Memphis Sand aquifer in the vicinity of Dunn Field. This estimate is based on the potential migration of contaminated ground water into the Memphis Sand aquifer and the conservative exposure scenario assumed for this estimate. This scenario assumes that contaminant levels below standard sensitive detection limits are entering the Allen Well Field and that the population ingests contaminated drinking water from this single source for a lifespan of seventy years. This scenario assumes that wells will no longer be pumped after contamination is detected by current sensitive gas chromatography methods. As drinking water comes from multiple sources in the Memphis area, the excess cancer risk estimates are overestimated. Thus, actual health risk associated with drinking water exposures is expected to be acceptable. However, long-term environmental and economic factors associated with potential negative impacts on the Allen Well Field must be considered.

TABLE 1-4
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-Dichloroethylene	X		
1,1,2,2-Tetrachlorethane	X		
Tetrachloroethene	X		
Trichloroethene	X	X	
Methylene chloride		X	
BASE/NEUTRAL/ACID EXTRACTABLES:			
Anthracene		X	
Benzo(a)anthracene		X	
Benzo(a)pyrene		X	
Benzo(b)fluoranthene		X	
Benzo(k)fluoranthene		X	
Chrysene		X	
Fluoranthene		X	
Indeno(1,2,3-cd)pyrene		X	
Phenanthrene		X	
Pyrene		X	
PESTICIDES & 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		

1.3.1.5 Data Gaps - The major data gap associated with the Dunn Field ground-water contamination is the definition of the contaminant plume, particularly in the west and northwest direction. This is significant because the confining unit west of Dunn Field may be less consistent, and thus, less effective in retardation of ground-water movement downward to the Memphis Sand aquifer. Further study of the plume should also include investigation of the confining unit in that area.

A second major data gap is an accurate determination of the location of burial areas and waste characterization. Although a plan is available indicating burial areas, personal accounts and the unplanned penetration of buried waste indicate that other areas also exist. Location of these areas, using a non-invasive method, such as surface geophysics, would be a cost-effective alternative to remediation of large areas in Dunn Field.

1.3.2 Surface Soils

Surface soil contamination was investigated at twelve areas during the RI. A limited number of samples were collected from each site. The sampling locations were targeted to areas based on soil discoloration and/or known areas where spillage or burial had occurred due to past site utilization. Moderate to high levels of metals, pesticides, PCBs, volatile organics and semi-volatile organics, which exceeded ARARs, were detected in surface soil samples from six of the twelve areas.

1.3.2.1 Nature of Contamination - The contaminants detected have been broken down into the following waste groups as specified in the Technology Screening Guide for Treatment of CERCLA Soils and Sludges (USEPA, 1988):

1. Halogenated Volatiles
2. Nonhalogenated Volatiles
3. Nonhalogenated Semi-volatiles
4. PCBs
5. Pesticides
6. Volatile Metals
7. Nonvolatile Metals

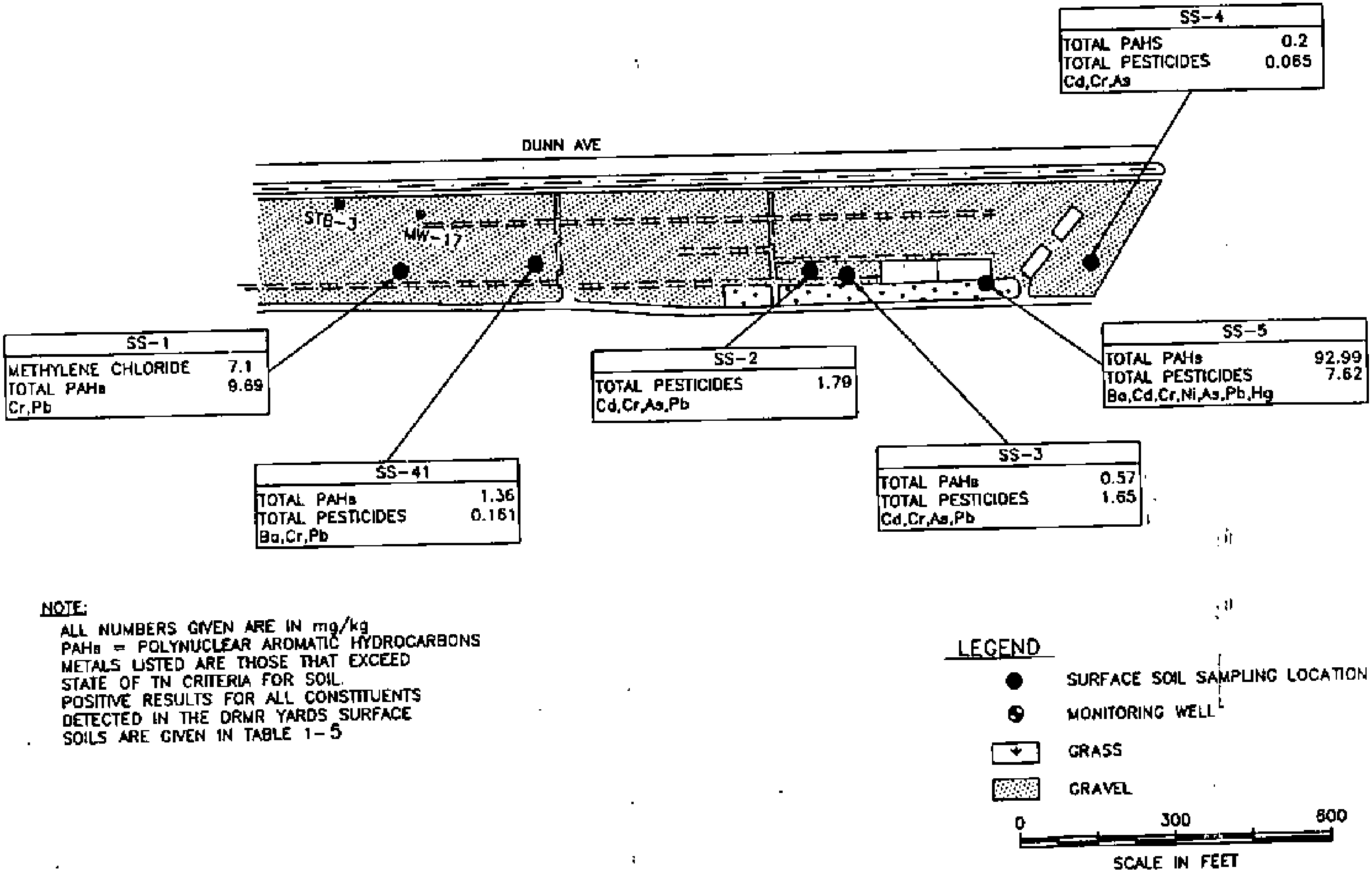
The positive results detected during the RI are given for each waste group in Tables 1-5 through 1-10. Concentrations are compared to Tennessee Superfund Hazardous Substance guidelines. The sites are listed below and are shown on Figures 1-6 through 1-11:

1. DRMR Yard
2. Building 629
3. Golf Course
4. Building 1088
5. Open Storage Area
6. Building 770

FIGURE 1-6

SITE LOCATION MAP FOR SURFACE SOILS COLLECTED IN THE DRMR YARD WITH POSITIVE RESULTS EXCEEDING ARARs

DEFENSE DEPOT MEMPHIS, TN



NOTE:

ALL NUMBERS GIVEN ARE IN mg/kg
PAHs = POLYNUCLEAR AROMATIC HYDROCARBONS
METALS LISTED ARE THOSE THAT EXCEED STATE OF TN CRITERIA FOR SOIL.
POSITIVE RESULTS FOR ALL CONSTITUENTS DETECTED IN THE DRMR YARDS SURFACE SOILS ARE GIVEN IN TABLE 1-5

LAW ENVIRONMENTAL INC.
GOVERNMENT SERVICES DIVISION

TABLE 1-5
POSITIVE RESULTS IN SURFACE SOILS
DRMR YARD
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I					PHASE II
		SS1	SS2	SS3	SS4	SS5	SS41
HALOGENATED VOLATILES ug/kg							
Methylene chloride	8600	7100B	9B	14B	16B	41B	15B
NONHALOGENATED VOLATILES ug/kg							
Acetone	590	--	--	8J	8J	4J	12
Toluene	14,400	--	8	17	--	2J	13
Total xylenes	150	--	4J	11	--	--	--
NONHALOGENATED SEMIVOLATILES ug/kg							
Benzoic acid	na	840J	--	--	--	230J	--
bis(2-Ethylhexyl) phthalate	15,000	630J	--	--	420J	2900	290BJ
Butyl benzyl phthalate	na	--	--	--	--	4700	--
Dibenzofuran	na	--	--	--	--	290J	--
N-Nitrosodiphenylamine	12.8 - 32	--	--	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	0.0028	9,690	--	570	200	92,990	1,360

TABLE 1-5
POSITIVE RESULTS IN SURFACE SOILS
DRMR YARD
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I					PHASE II
		SS1	SS2	SS3	SS4	SS5	SS41
PESTICIDES ug/kg							
4,4'-DDD	na	--	--	--	--	260	--
4,4'-DDE	na	--	290D	250	--	1100D	21
4,4'-DDT	.23 - .58	--	1500D	1400D	--	5900D	130D
beta-BHC	2.4 - 6.1	--	--	--	--	--	10Z
Dieldrin	0048 - .012	--	--	--	65D	--	--
Endosulfan sulfate	na	--	--	--	--	360	--
VOLATILE METALS mg/kg							
Arsenic	5	4*	18*	26*	33	20	--
Lead	5	66N	96N	129N	22	2420	878
Mercury	0.2	--	0.030	0.030	0.050	0.460	--
NONVOLATILE METALS mg/kg							
Antimony	na	--	--	--	--	22	--
Barium	100	5.8B	43.4	19.2B	97.8	273	311
Cadmium	1	--	4	1.6	1.0	159	0.8
Chromium **	5	15	19	17	14	296	144
Copper	na	246*G	25*G	34*G	26	1590	42
Nickel	20	3.0B	6.0B	3.0B	14	146	6.0
Silver	5	--	--	--	--	2.5	--
Zinc	na	22*	130*	92.4*	80.7	2160	265

Shaded areas are values that are equal to or exceed the State of Tennessee soil criteria guidelines.

na = Not Available

State of TN values are only To Be Considered (TBC) guidelines. These are not enforceable clean up levels.

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.

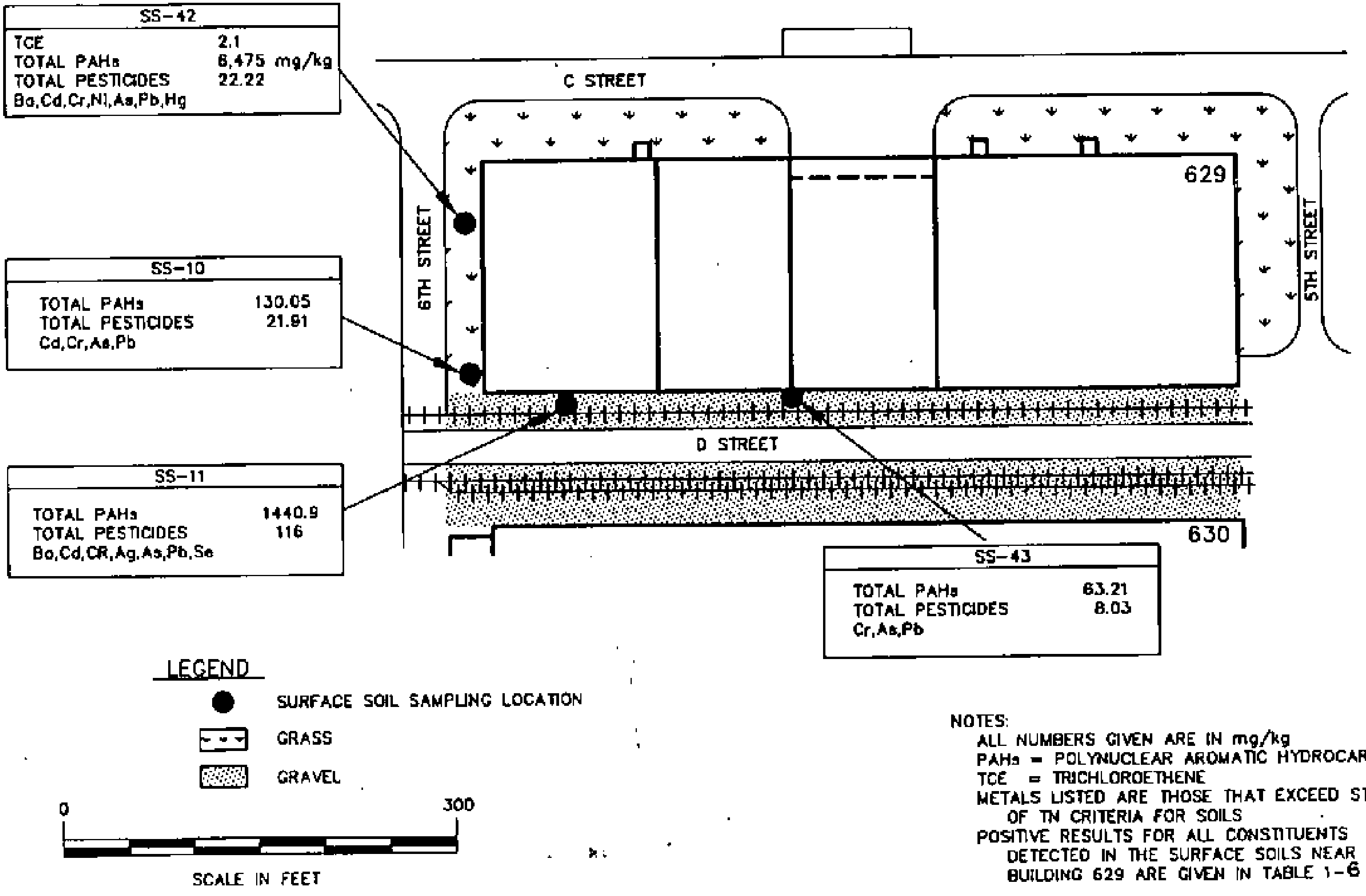
** = No distinction between Chromium (III) and Chromium (VI).

-- = Not detected.

FIGURE 1-7

SITE LOCATION MAP FOR SURFACE SOILS COLLECTED NEAR BUILDING 629 WITH POSITIVE RESULTS EXCEEDING ARARs

DEFENSE DEPOT MEMPHIS, TENNESSEE



NOTES:
ALL NUMBERS GIVEN ARE IN mg/kg
PAHs = POLYNUCLEAR AROMATIC HYDROCARBONS
TCE = TRICHLOROETHENE
METALS LISTED ARE THOSE THAT EXCEED STATE OF TN CRITERIA FOR SOILS
POSITIVE RESULTS FOR ALL CONSTITUENTS DETECTED IN THE SURFACE SOILS NEAR BUILDING 629 ARE GIVEN IN TABLE 1-6

LAW ENVIRONMENTAL INC.
GOVERNMENT SERVICES DIVISION

TABLE 1-6
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 629
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I		PHASE II	
		SS10	SS11	SS42	SS43
HALOGENATED VOLATILES ug/kg					
1,1,2-Trichloroethane	1200	--	--	11	--
Methylene chloride	8600	18B	13B	8B	7B
Tetrachloroethene	100	--	--	3J	--
Trichloroethene	70	--	--	2100E	--
NONHALOGENATED VOLATILES ug/kg					
Acetone	590	67	95	24	21
Carbon disulfide	14,400	2J	8	--	--
Toluene	14,400	6J	18	4J	7
HALOGENATED SEMIVOLATILES ug/kg					
Pentachlorophenol	3600	--	--	--	270J
NONHALOGENATED SEMIVOLATILES ug/kg					
bis(2-Ethylhexyl) phthalate	15,000	500J	--	--	1300BJ
Dibenzofuran	na	1300J	9700	24000J	340J
N-Nitrosodiphenylamine	12.8 - 32	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	0.0028	130,050	1,429,300	6,475,000	63,210

TABLE 1-6
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 629
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I		PHASE II	
		SS10	SS11	SS42	SS43
PESTICIDES ug/kg					
4,4'-DDD	na	2100X	3600	1400JX	320DJ
4,4'-DDE	na	4500D	39000D	9000DJ	2500DJ
4,4'-DDT	.23 - .58	6700D	59000D	7900DJ	710DJ
alpha-Chlordane	na	4000D	--	--	--
beta-BHC	2.4 - 6.1	--	--	1800XZ	--
Dieldrin	.0048 - .012	240	--	--	4500D
Endrin ketone	na	--	12000D	--	--
gamma-Chlordane	30	4000D	2400J	620J	--
Heptachlor	1	120	--	--	--
Heptachlor epoxide	na	250	--	--	--
Methoxychlor	na	--	--	1500J	--
VOLATILE METALS mg/kg					
Arsenic	5	12	20	12	26
Lead	5	81	1680	1120	126
Mercury	0.2	0.080	0.84	1.3	--
NONVOLATILE METALS mg/kg					
Antimony	na	--	88	--	--
Barium	100	57.6	343	108	70.8
Cadmium	1	1.1	6.0	11.8	--
Chromium **	5	24	135	39	15
Copper	na	16	135	705	15
Nickel	20	--	--	367	5.0
Silver	5	3.0	9.0	--	--
Zinc	na	63.4	960	10400	94.8

Shaded areas are values that are equal to or exceed the State of Tennessee soil criteria guidelines.

na = Not Available

State of TN values are only To Be Considered (TBC) guidelines. These are not enforceable clean up levels.

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.

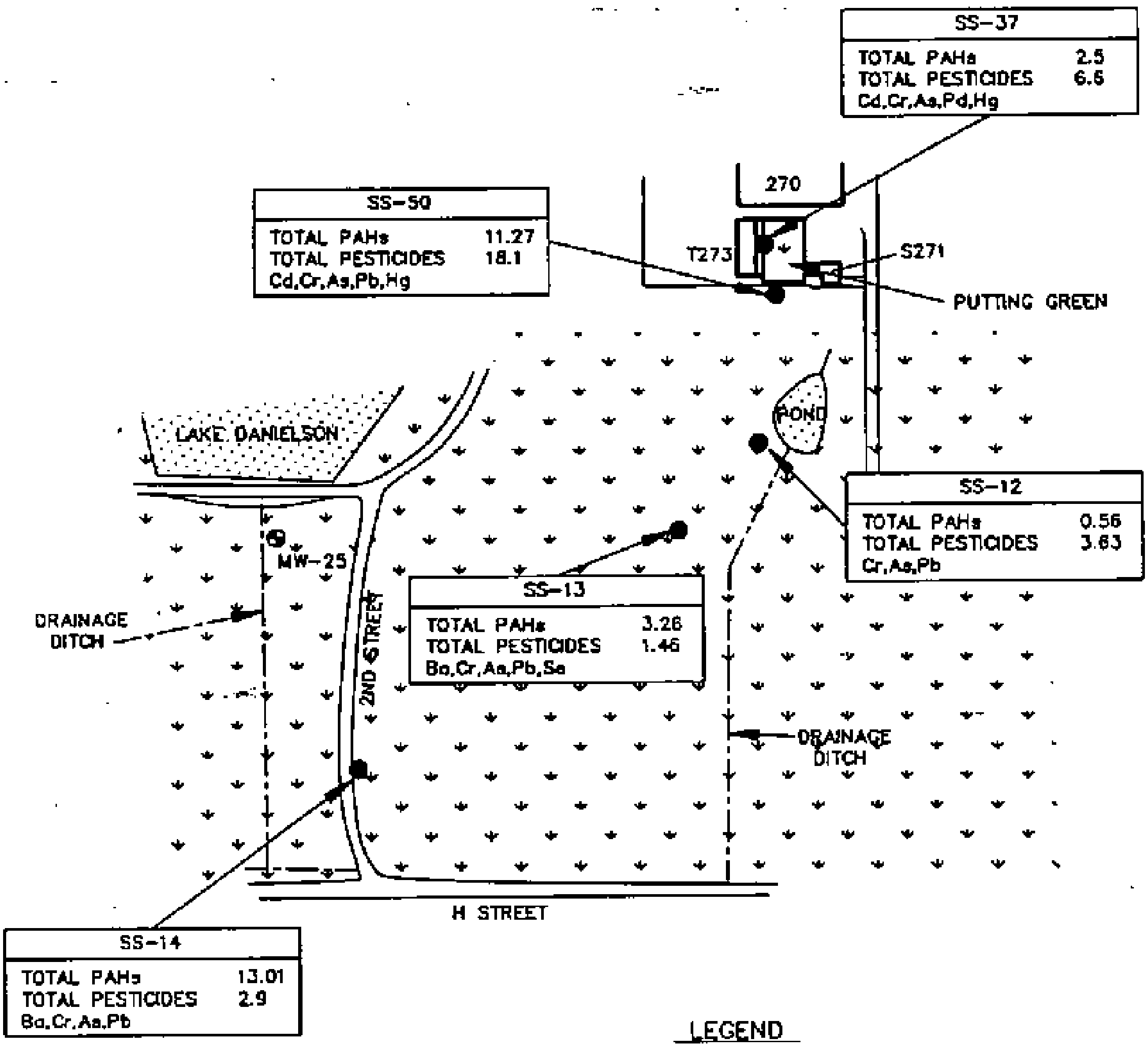
** = No distinction between Chromium (III) and Chromium (VI).

-- = Not detected.

FIGURE 1-8

SITE LOCATION MAP FOR SURFACE SOILS COLLECTED FROM THE GOLF COURSE WITH POSITIVE RESULTS EXCEEDING ARARs

DEFENSE DEPOT MEMPHIS, TENNESSEE



LEGEND

- ● SURFACE SOIL SAMPLING LOCATION
- ⊕ MONITORING WELL LOCATION
- ⁝ GRASS

NOTES:
ALL NUMBERS GIVEN ARE IN mg/kg
PAHs = POLYNUCLEAR AROMATIC HYDROCARBONS
TCE = TRICHLOROETHENE
METALS LISTED ARE THOSE THAT EXCEED STATE OF TN CRITERIA FOR SOILS
POSITIVE RESULTS FOR ALL CONSTITUENTS DETECTED IN THE SURFACE SOILS NEAR THE GOLF COURSE ARE GIVEN IN TABLE 1-7

0 300 600
SCALE IN FEET

TABLE 1-7
POSITIVE RESULTS IN SURFACE SOILS
GOLF COURSE
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I				PHASE II
		SS12	SS13	SS14	SS37	SS50
HALOGENATED VOLATILES ug/kg						
Chloroform	70	--	--	2J	--	--
Methylene chloride	8600	14B	21B	15B	13B	16B
Tetrachlorethene	100	--	--	--	2J	--
Trichloroethene	70	--	--	--	4J	--
NONHALOGENATED VOLATILES ug/kg						
Acetone	590	9J	38	24	15	22
Toluene	14,400	17	9J	6J	3J	--
Total xylenes	150	--	--	--	8J	--
NONHALOGENATED SEMIVOLATILES ug/kg						
bis(2-Ethylhexyl) phthalate	15,000	1500BJ	2200BJ	2700B	710BJ	1700B
N-Nitrosodiphenylamine	12.8 - 32	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	0.0028	560	3,260	13,010	2,500	11,270

TABLE 1-7
POSITIVE RESULTS IN SURFACE SOILS
GOLF COURSE
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN.	PHASE I				PHASE II
		SS12	SS13	SS14	SS37	SS50
PESTICIDES ug/kg						
4,4'-DDE	na	2000D	340D	--	1200D	4300D
4,4'-DDT	.23 - .58	870	290	--	4000D	3000DJ
Dieldrin	.0048 - .012	760D	830D	2900D	1400D	3800D
Heptachlor	1.0	--	--	--	--	1100Z
Heptachlor epoxide	na	--	--	--	--	340Z
beta-BHC	2.4 - 6.1	--	--	--	--	2500
VOLATILE METALS mg/kg						
Arsanic	5	33	22	41	42	12
Lead	5	80G*	50G*	80G*	71	157
Mercury	0.2	0.15N	0.1N	0.8N	0.32	0.5
NONVOLATILE METALS mg/kg						
Antimony	na	--	--	5.0B	5.0	--
Barium	100	95.8	118	117	76.9	76.4
Cadmium	1	--	--	--	2.0	1.9
Chromium **	6	20G	13G	16G	13	17
Copper	na	34*	21*	26*	18	15
Nickel	20	13*	12*	12*	11	8
Zinc	na	81.2G	89.3G	82.3G	80.4	290

Shaded areas are values that are equal to or exceed the State of Tennessee soil criteria guidelines.

na = Not Available

State of TN values are only To Be Considered (TBC) guidelines. These are not enforceable clean up levels.

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.

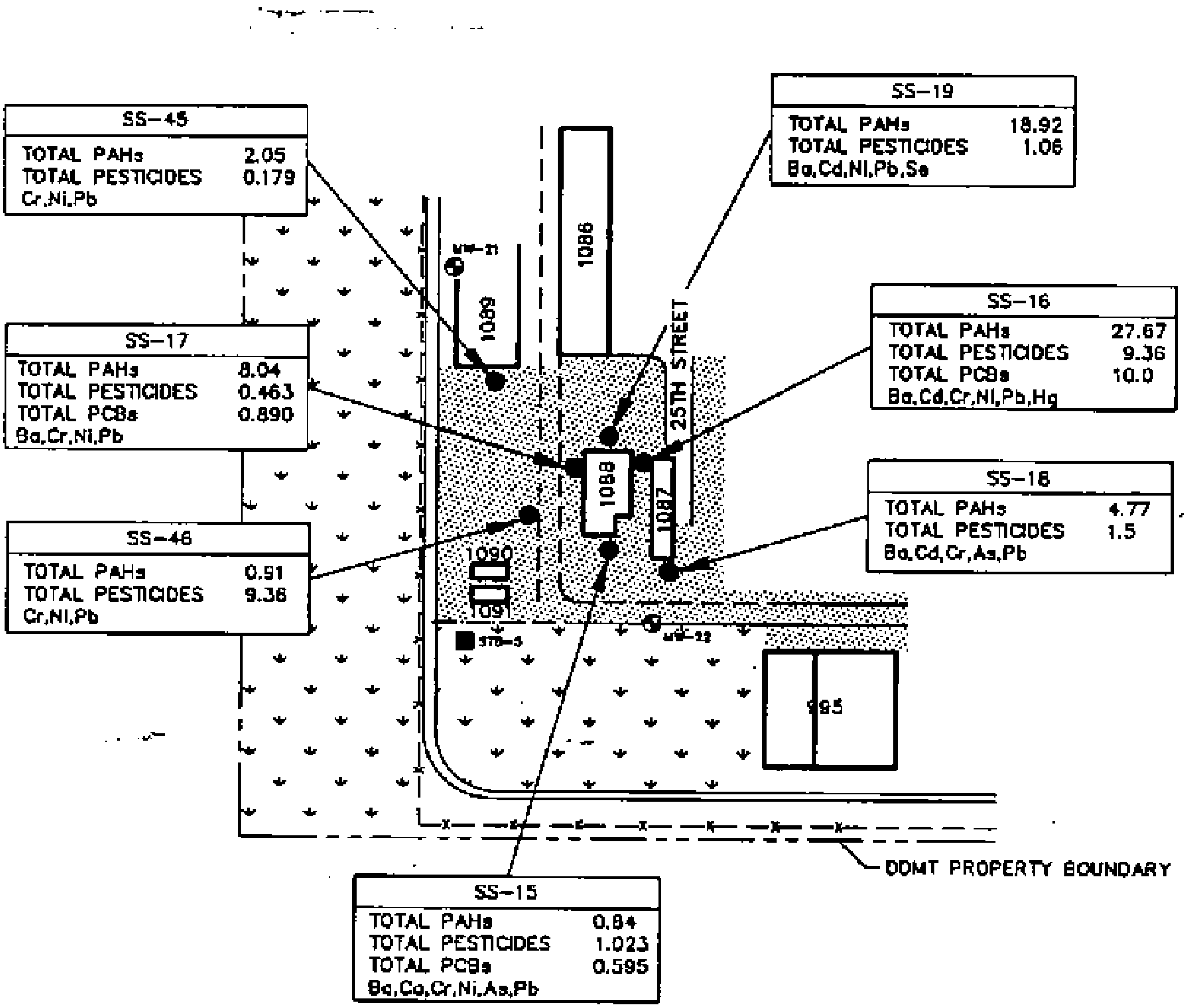
** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

FIGURE 1-9

SITE LOCATION MAP FOR SURFACE SOILS COLLECTED NEAR BUILDING 1088 WITH POSITIVE RESULTS EXCEEDING ARARs

DEFENSE DEPOT MEMPHIS, TENNESSEE



NOTES:
- ALL NUMBERS GIVEN ARE IN mg/kg
- PAHs = POLYNUCLEAR AROMATIC HYDROCARBONS
- METALS LISTED ARE THOSE THAT EXCEED STATE OF TN CRITERIA FOR SOILS
- POSITIVE RESULTS FOR ALL CONSTITUENTS DETECTED IN THE SURFACE SOILS NEAR BUILDING 1088 ARE GIVEN IN TABLE 1-8

LEGEND

●	SURFACE SOIL SAMPLING LOCATION
■	SOIL TEST BORING LOCATION
⊕	MONITORING WELL LOCATION
☐	GRASS
▨	GRAVEL

0 300
SCALE IN FEET

LAW ENVIRONMENTAL INC.
GOVERNMENT SERVICES DIVISION

TABLE 1-8
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 1088
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I					PHASE II	
		SS15	SS16	SS17	SS18	SS19	SS45	SS46
HALOGENATED VOLATILES ug/kg								
Methylene chloride	8600	16B	29B	11B	9B	11B	11B	8B
NONHALOGENATED VOLATILES ug/kg								
Acetone	590	15	17	12B	6BJ	11BJ	13	9J
Toluene	14,400	5J	4J	--	2J	6	2J	--
NONHALOGENATED SEMIVOLATILES ug/kg								
2,4-Dimethylphenol	na	--	--	--	--	720J	--	--
2-Methylphenol	na	--	--	--	--	1100J	--	--
4-Methylphenol	na	--	--	--	--	500J	--	--
Benzoic acid	na	--	--	--	--	320J	--	--
Benzyl alcohol	na	--	--	--	1000J	--	--	--
bis(2-Ethylhexyl) phthalate	15,000	1700B	4300B	600BJ	8100B	--	1200B	1400B
Butyl benzyl phthalate	na	96J	370J	--	--	--	--	--
Dibenzofuran	na	--	--	--	--	210J	--	--
Dimethyl phthalate	na	--	--	--	--	--	180J	--
Di-n-butyl phthalate	na	160J	470J	--	950J	--	--	--
N-Nitrosodiphenylamine	12.8 - 32	150J	590J	--	--	--	--	--
Phenol	na	--	--	--	--	550J	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)								
Acenaphthene	.	--	--	--	--	250J	--	--
Anthracene	.	--	670J	200J	--	260J	--	--
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	160J
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	760J	780J	2500	210J	120J
Pyrene	.	160J	4700	1100J	860J	2600	440J	250J
Total PAHs	0.0028	840	27,670	8,040	4,770	18,920	2,050	910

19 50

TABLE 1-8
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 1088
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I					PHASE II	
		SS15	SS16	SS17	SS18	SS19	SS45	SS46
PESTICIDES ug/kg								
4,4'-DDD	na	45D	250	52D	--	--	--	13J
4,4'-DDE	na	110D	1300D	97D	400D	180	33	27
4,4'-DDT	0.58	450D	7400D	260D	1100D	660	90D	110D
alpha-BHC	1.4-3.5	12Z	--	--	--	--	--	--
alpha-Chlordane	30	--	--	--	--	--	25J	--
beta-BHC	2.4-6.1	26Z	--	43Z	--	--	--	--
delta-BHC	na	--	--	11Z	--	--	--	--
Dieldrin	na	110Z	410Z	--	--	220	--	--
Endosulfan-I	74	19Z	--	--	--	--	--	--
gamma-BHC (Lindane)	0.06	11Z	--	--	--	--	--	--
gamma-Chlordane	30	--	--	--	--	--	31J	--
Heptachlor epoxide	1	69Z	--	--	--	--	--	--
PCBs ug/kg								
Aroclor-1016	na	100Z	--	140Z	--	--	--	--
Aroclor-1221	na	95Z	--	--	--	--	--	--
Aroclor-1232	na	270Z	--	550Z	--	--	--	--
Aroclor-1242	na	130Z	--	200Z	--	--	--	--
Aroclor-1254	na	--	10000D	--	--	--	--	--
Total PCBs	10000	595	10,000	890	--	--	--	--
TOTAL VOLATILE METALS mg/kg								
Arsenic	5	6	--	--	15	--	--	--
Lead	5	2670G'	17500	247	2060	10300	312	166
Mercury	0.2	0.04N	0.26	--	0.06	0.18	--	--
Selenium	1	--	--	--	9	--	--	--
TOTAL NONVOLATILE METALS mg/kg								
Antimony	na	88	30	--	26	48	--	--
Barium	100	216	313	109	409	148	85.2	91.8
Cadmium	1	1.9N	23.4	0.7	4.7	4.4	--	--
Chromium **	5	714G	6710	109	8660	2230	138	78
Copper	na	124*	240	72	52	148	116	76
Nickel	20	37*	53	23	16	32	29	24
Silver	5	--	0.8B	--	--	--	--	--
Zinc	na	996G	21000	270	22100	4600	202	146

TABLE 1-6
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 1088
DEFENSE DEPOT MEMPHIS TENNESSEE

Shaded areas are values that are equal to or exceed the State of Tennessee soil criteria guidelines.

na = Not Available

State of TN values are only To Be Considered (TBC) guidelines. These are not enforceable clean up levels.

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.

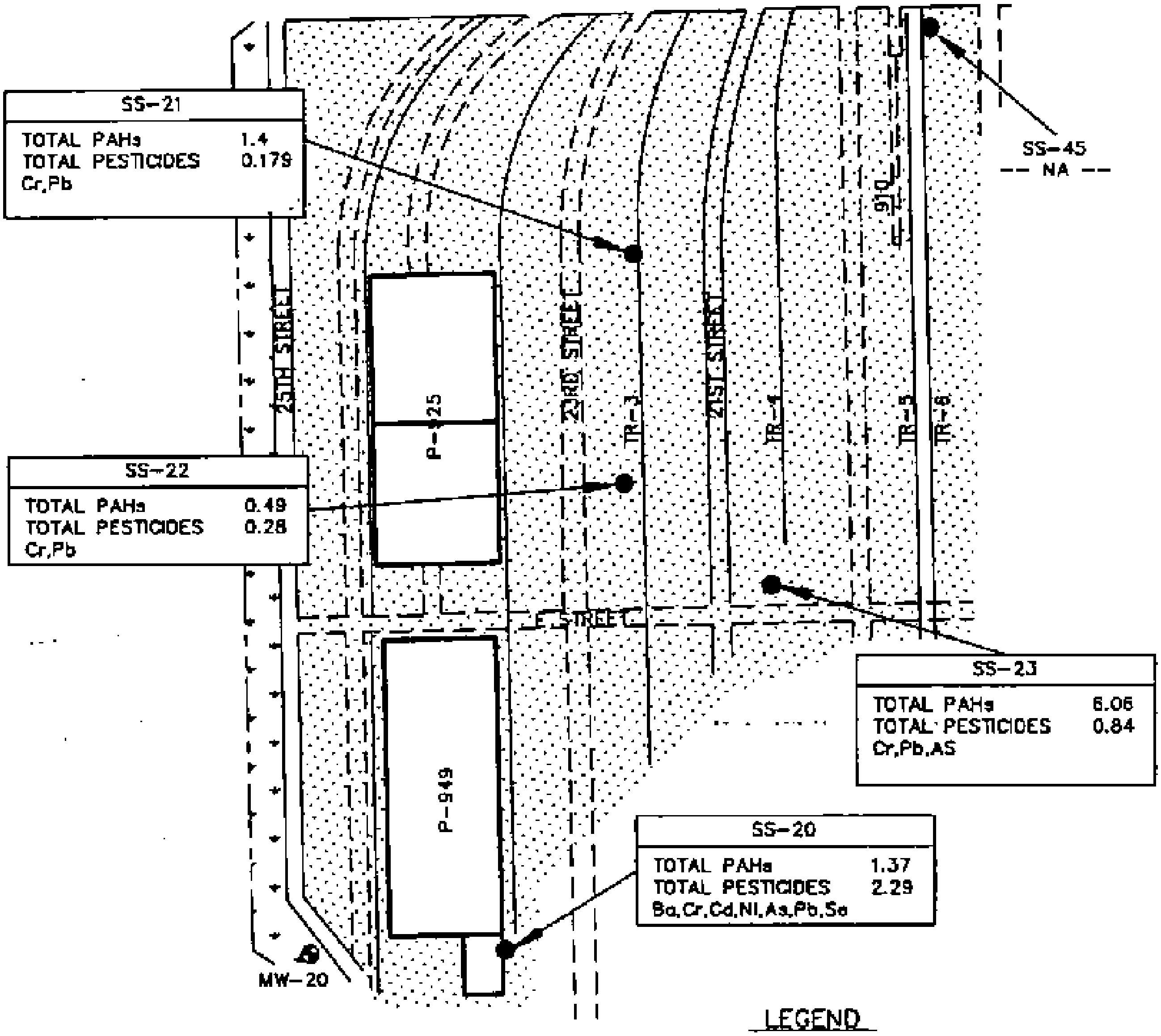
** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

FIGURE 1-10

SITE LOCATION MAP FOR SURFACE SOILS COLLECTED FROM THE OPEN STORAGE AREA WITH POSITIVE RESULTS EXCEEDING ARARs

DEFENSE DEPOT MEMPHIS, TENNESSEE



LEGEND

●	SURFACE SOIL SAMPLING LOCATION
⊕	MONITORING WELL LOCATION
☐	GRASS
▨	GRAVEL

NOTES:
ALL NUMBERS GIVEN ARE IN mg/kg
PAHs = POLYNUCLEAR AROMATIC HYDROCARBONS
TCE = TRICHLOROETHENE
METALS LISTED ARE THOSE THAT EXCEED STATE OF TN CRITERIA FOR SOILS
POSITIVE RESULTS FOR ALL CONSTITUENTS DETECTED IN THE SURFACE SOILS NEAR THE HARDSTAND AREA ARE GIVEN IN TABLE 1-9

0 300 600
SCALE IN FEET

TABLE 1-9
POSITIVE RESULTS IN SURFACE SOILS
OPEN STORAGE AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I									
		SS20	SS21	SS22	SS23	SS32	SS33	SS34	SS35	SS36	SS40
HALOGENATED VOLATILES (ug/kg)											
1,1,2,2-Tetrachloroethane	1300	--	--	--	19	--	--	--	--	--	--
Methylene chloride	8600	18B	20B	20B	50B	6B	8B	11B	6B	13B	9B
Trichloroethene	70	--	--	--	2J	--	--	--	--	--	4J
NONHALOGENATED VOLATILES (ug/kg)											
2-Butanone	7200	--	--	--	--	--	--	--	--	8J	--
Acetone	590	8BJ	6JB	6JB	22	7JB	10JB	13B	11B	23B	31
Benzene	70	--	--	--	4J	--	--	--	--	--	--
Ethylbenzene	154,000	--	--	--	--	--	--	--	--	--	4J
Toluene	14,400	17	12	20	33	3J	2J	6	--	4J	34
Total xylenes	150	1J	--	3J	--	--	--	--	--	--	9
HALOGENATED SEMIVOLATILES (ug/kg)											
Pentachlorophenol	3600	--	310J	--	--	--	--	--	--	--	--

TABLE 1-9
POSITIVE RESULTS IN SURFACE SOILS
OPEN STORAGE AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I									
		SS20	SS21	SS22	SS23	SS32	SS33	SS34	SS35	SS36	SS40
NONHALOGENATED SEMIVOLATILES (ug/kg)											
2-Methylnaphthalene	na	2600	--	--	--	--	--	--	--	--	--
bis(2-Ethylhexyl) phthalate	15,000	2300B	--	470BJ	410BJ	350BJ	320BJ	340BJ	390B	440BJ	--
Benzoic acid	na	--	--	--	--	--	--	--	43J	--	--
N-Nitrosodiphenylamine	12.8 - 32	--	--	--	--	--	49BJ	35BJ	63BJ	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)											
Benzo(a)anthracene	.	--	--	--	230J	--	--	--	--	--	--
Benzo(b)fluoranthene	.	350J	500J	290J	600J	--	--	--	--	--	--
Benzo(g,h,i)perylene	.	--	--	--	2100J	--	--	--	--	--	--
Chrysene	.	360J	260J	--	270J	--	--	--	--	--	--
Dibenzo(a,h)anthracene	.	--	--	--	2100J	--	--	--	--	--	--
Fluoranthene	.	--	350J	--	400J	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	.	--	--	--	230J	--	--	--	--	--	--
Pyrene	.	660J	290J	200J	360J	--	--	--	--	--	--
Total PAHs	0.002B	776	1,400	490	6,060	--	--	--	--	--	--

TABLE 1-9
POSITIVE RESULTS IN SURFACE SOILS
OPEN STORAGE AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I									
		SS20	SS21	SS22	SS23	SS32	SS33	SS34	SS35	SS36	SS40
PESTICIDES (ug/kg)											
4,4'-DDD	na	--	24	--	--	--	--	--	--	--	--
4,4'-DDE	na	490D	150D	50D	85D	--	--	--	--	--	--
4,4'-DDT	.23 - .58	1800D	250D	120D	210D	--	--	--	--	--	--
beta-BHC	2.4 - 6.1	--	53Z	32Z	--	--	--	--	--	--	--
Dieldrin	0048 - .01	--	120D	78D	160D	--	--	--	--	--	--
Endosulfan-I	na	--	--	--	16Z	--	--	--	--	--	--
Toxaphene	70	--	--	--	370Z	--	--	--	--	--	--
PCBs (ug/kg)											
Aroclor-1016	.	--	100Z	--	--	--	--	--	--	--	--
Aroclor-1232	.	--	400Z	--	--	--	--	--	--	--	--
Aroclor-1242	.	--	150Z	--	--	--	--	--	--	--	--
Aroclor-1254	.	--	--	--	220Z	--	--	--	--	--	--
Aroclor-1260	.	--	--	--	320Z	--	--	--	--	--	--
Total PCBs	10000	--	650	--	550	--	--	--	--	--	--
VOLATILE METALS (mg/kg)											
Arsenic	5	15	--	--	23	6	26	8	30	25	21
Lead	5	7680	137	43	112	4	12	4	12	21	19
Mercury	0.2	0.16	0.04	--	0.04	--	0.04	--	0.04	0.04	--
Selenium	1	12	--	--	--	--	--	--	--	--	--

TABLE 1-9
POSITIVE RESULTS IN SURFACE SOILS
OPEN STORAGE AREA
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I									
		SS20	SS21	SS22	SS23	SS32	SS33	SS34	SS35	SS36	SS40
NONVOLATILE METALS (mg/kg)											
Antimony	na	27	6B	--	12	--	4	--	4	--	--
Barium	100	6540	45.2	25.9B	96.9	16.6	80.5	12	126	69.9	22.8
Cadmium	1	5.4	--	--	--	--	--	--	--	--	1
Chromium **	5	16200	115	30	34	10	13	10	13	15	32
Copper	na	41	21	10	30	5	15	4	20	16	10
Nickel	20	24	4B	3B	9	4	14	4	17	14	4
Silver	5	1.3B	--	--	--	--	--	--	--	--	--
Zinc	na	26200	266	75	167	9.4	46.8	6.9	59.8	53	132

Shaded areas are values that are equal to or exceed the State of Tennessee soil criteria guidelines.

na = Not Available

State of TN values are only To Be Considered (TBC) guidelines. These are not enforceable clean up levels.

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.

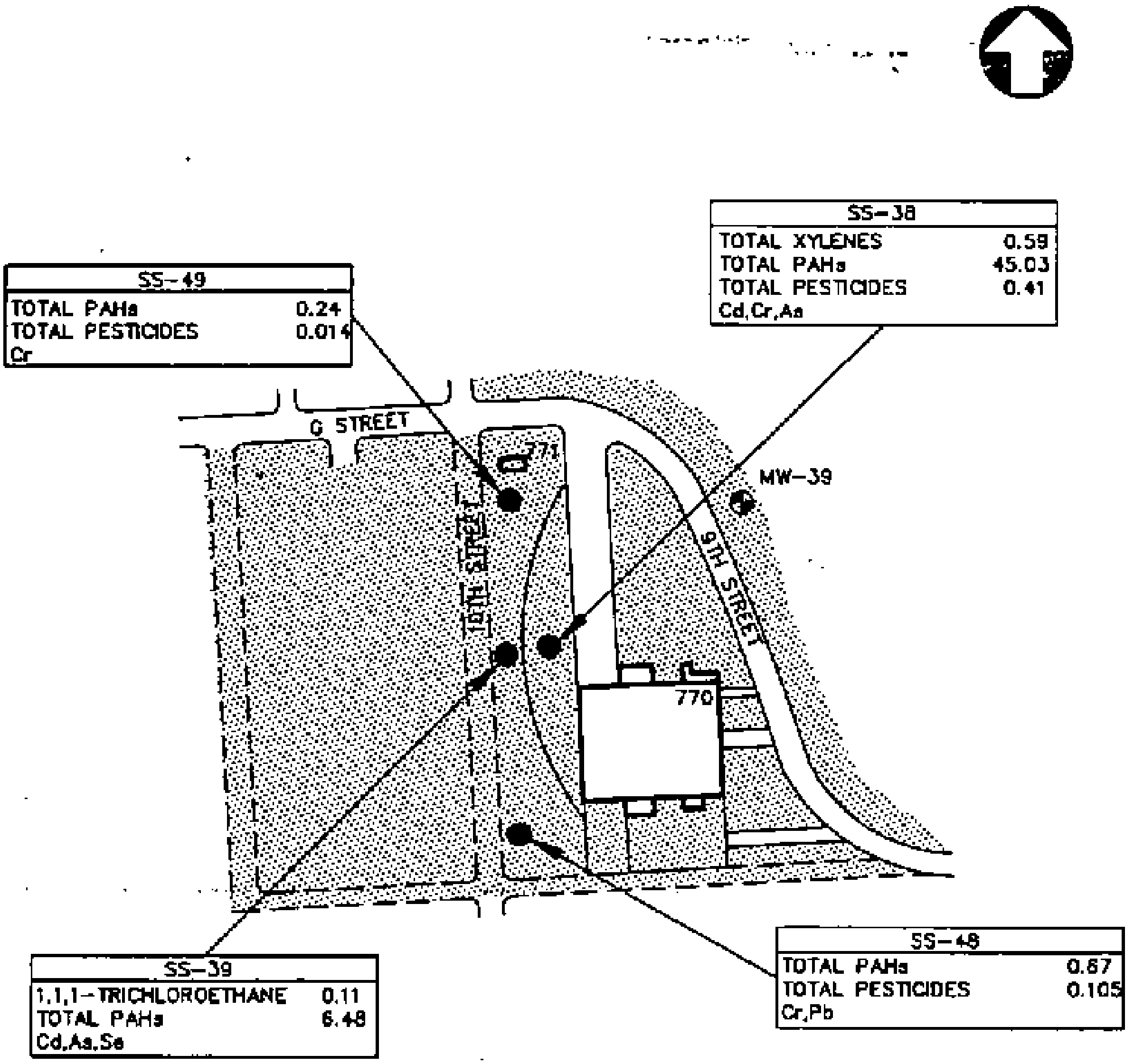
** = No distinction between Chromium (III) and Chromium (VI)

-- = Not detected.

FIGURE 1-11

SITE LOCATION MAP FOR SURFACE SOILS COLLECTED NEAR BUILDING 770 WITH POSITIVE RESULTS EXCEEDING ARARs

DEFENSE DEPOT MEMPHIS, TENNESSEE



NOTES:
- ALL NUMBERS GIVEN ARE IN mg/kg
- PAHs = POLYNUCLEAR AROMATIC HYDROCARBONS
- TCE = TRICHLOROETHENE
- METALS LISTED ARE THOSE THAT EXCEED STATE OF TN CRITERIA FOR SOILS
- POSITIVE RESULTS FOR ALL CONSTITUENTS DETECTED IN THE SURFACE SOILS NEAR BUILDING 770 ARE GIVEN IN TABLE 1-10

LEGEND

●	SURFACE SOIL SAMPLING LOCATION
⊕	MONITORING WELL LOCATION
▨	GRAVEL

0 300 600

SCALE IN FEET

TABLE 1-10
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 770
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I		PHASE II	
		SS38	SS39	SS48	SS49
HALOGENATED VOLATILES ug/kg					
1,1,1-Trichloroethane	30,000	110	--	--	--
Methylene chloride	8600	36B	8B	5BJ	6B
Tetrachlorethene	100	31	--	--	--
Trichloroethene	70	--	--	1J	2J
NONHALOGENATED VOLATILES ug/kg					
4-Methyl-2-pentanone	na	--	6J	--	--
Acetone	590	47J	200	51	22
Ethylbenzene	154,000	9J	6	--	--
Toluene	14,400	43	16	13	32
Total xylenes	150	590	53	1J	2J
NONHALOGENATED SEMIVOLATILES ug/kg					
2-Methylnaphthalene	na	610J	4000	--	--
bis(2-Ethylhexyl) phthalate	15,000	4800B	--	340B	160BJ
Dibenzofuran	na	--	350J	--	--
Butyl benzyl phthalate	na	--	1300J	--	--
Di-n-butyl phthalate	na	--	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	880J	170J	150J
Total PAHs	0.0028	45,030	6,480	670	240

TABLE 1-10
POSITIVE RESULTS IN SURFACE SOILS
BUILDING 770
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I		PHASE II	
		SS38	SS39	SS48	SS49
PESTICIDES ug/kg					
4,4'-DDD	na	--	--	10J	--
4,4'-DDE	na	--	--	17X	--
4,4'-DDT	.23 - .58	--	--	52	--
beta-BHC	2.4 - 6.1	290Z	--	26Z	14Z
gamma-BHC (Lindane)	60	120Z	--	--	--
VOLATILE METALS mg/kg					
Arsenic	5	9	13	--	--
Lead	5	48	24	90	4
Selenium	1	--	15	--	--
NONVOLATILE METALS mg/kg					
Antimony	na	--	17	--	--
Barium	100	20.9B	15.8	19.3	11.7
Cadmium	1	1	3	0.5	0.8
Chromium **	5	10	--	19	6
Copper	na	13	18	10	4
Nickel	20	3	7	6	5
Zinc	na	411	122	55.2	59.4

Shaded areas are values that are equal to or exceed the State of Tennessee soil criteria guidelines.

na = Not Available

State of TN values are only To Be Considered (TBC) guidelines. These are not enforceable clean up levels.

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.

1.3.2.2 Source of Contamination - The suspected source of contamination at each site is as follows:

Site	Suspected Source of Contamination
1. DRMR Yard	Leaking drums
2. Building 629	Spills swept or hosed out of doors at Building 629
3. Building T-273 at Golf Course	Cleaning of pesticide application equipment
4. Building 1088	General spillage from paint shop and/or cleaning operations
5. Open Storage Area	Leakage from railroad tank cars on Tracks #3 and #4
6. Building 770	General spillage from maintenance shop and waste oil storage drums

In addition to the above-mentioned sources, PAH contamination could have occurred in the past from spraying oils onto the soils for dust control.

1.3.2.3 Risk Assessment - Table 1-4 lists 21 constituents of concern in surface soils. Pesticides and PAH compounds were associated with most of the potential health risk estimated for soil exposures. Nonhalogenated semi-volatiles or PAH contamination was found at levels greatly exceeding health-based values at every location. Pesticides were detected at levels above the health-based values at each site except at Building 770.

The detected levels of halogenated and nonhalogenated volatile contaminants was found to be generally below health-based values and are not considered contaminants of concern. Both volatile and nonvolatile metal contamination was detected at all sites.

1.3.2.3.1 Calculation of Target Soil Cleanup Concentrations - Health-based risk estimates for potential subchronic, chronic and lifetime exposures to soils at DDMT were calculated in the Remedial Investigation Report. Unacceptable levels of risk were associated with subchronic and chronic scenarios via the incidental ingestion, dermal absorption and dust inhalation pathways. Using this scenario, "acceptable" soil constituent levels were back calculated. These "acceptable" levels are herein referred to as "target" levels, and could conceivably be used as clean-up levels. However, these are not referred to as clean-up levels because this determination also requires regulatory interaction. Target levels are calculated in the following sections for non-carcinogens and carcinogens, and summarized in the succeeding section.

1.3.2.3.2 Target Levels Based on Exposure to Systematic Toxicants (Non-Carcinogens) - Unacceptable levels of adverse health risk associated with exposure to systematic toxicants (non-carcinogens) is primarily attributed to the presence of pesticides and PAH compounds in site surface soils. To derive target goals based on the subchronic and chronic exposure scenarios for dermal absorption, the chemical-specific hazard index is divided by the cumulative hazard index to give a target hazard index value. The target hazard index value is then multiplied by the dermal absorbed reference dose (RfD) value (subchronic or chronic as appropriate) to predict an acceptable dermal dose. The acceptable dermal dose is then divided by the dermal absorption intake factor to find the Target Soil Concentration. Tables 1-11 and 1-12 show Target Soil Concentrations based on the subchronic and chronic soil exposures described in the RI report.

TABLE 1-11

Target Soil Concentrations
Based on Subchronic Soil Exposures

Constituents of Concern	Subchronic Target Hazard Index Value	Subchronic Acceptable Dermal Dose	Target Soil Concentration (mg/kg)	Maximum Surface Soil Concentration (mg/kg)
Acetone	1.4E-05	1.28E-06	0.006	1.1
Trichloroethene	--	--	--	2.1
Methylene Chloride	--	--	--	7.1
Anthracene	2.2E-03	1.52E-04	0.71	130
Benzo(a)anthracene	1.6E-02	1.13E-03	5.32	970
Benzo(a)pyrene	7.5E-03	5.26E-04	2.47	450
Benzo(b)fluoranthene	9.0E-03	6.31E-04	2.96	540
Benzo(k)fluoranthene	7.5E-03	5.26E-04	2.47	450
Chrysene	1.0E-02	7.24E-04	3.40	620
Fluoranthene	1.4E-02	1.00E-03	4.72	860
Indeno(1,2,3-cd)pyrene	5.2E-03	3.62E-04	1.70	310
Phenanthrene	3.3E-03	2.34E-04	1.10	200
Pyrene	1.5E-02	1.02E-03	4.77	870
4,4-DDT	1.7E-01	6.89E-05	0.32	59
4,4-DDD	--	--	--	3.6
4,4-DDE	--	--	--	39
beta-BHC	1.1E-03	2.92E-06	0.014	2.5
Dieldrin	6.8E-01	3.39E-06	0.016	2.9
Arsenic	5.2E-02	4.91E-05	0.230	42
Chromium	7.6E-03	1.89E-02	89	16200
Lead	--	--	--	17500

-- Subchronic RfD not available for these compounds.

TABLE 1-12

Target Soil Concentrations
Based on Chronic Soil Exposures

Constituents of Concern	Target Chronic Hazard Indices Dermal Abs.	Acceptable Dermal Dose	Target Soil Concentrations (mg/kg)	Maximum Surface Soil Concentration (mg/kg)
Acetone	2.33E-06	2.21E-07	0.0010	1.1
Trichloroethene	--	--	--	2.1
Methylene Chloride	3.91E-05	1.46E-06	0.0068	7.1
Anthracene (a)	6.64E-04	4.65E-05	0.22	130
Benzo(a)anthracene	3.34E-03	2.34E-04	1.10	970
Benzo(a)pyrene	1.85E-03	1.30E-04	0.61	450
Benzo(b)fluoranthene	2.14E-03	1.50E-04	0.70	540
Benzo(k)fluoranthene	1.50E-03	1.05E-04	0.49	450
Chrysene	2.42E-03	1.69E-04	0.80	620
Fluoranthene	3.98E-03	2.78E-04	1.31	860
Indeno(1,2,3-cd)pyrene	1.13E-03	7.93E-05	0.37	310
Phenanthrene	2.91E-03	2.04E-04	0.96	200
Pyrene	3.53E-03	2.47E-04	1.16	870
4,4-DDT	5.03E-02	2.01E-05	0.094	59
4,4-DDD	--	--	--	3.6
4,4-DDE	--	--	--	39
beta-BHC	5.57E-03	1.52E-06	0.0071	2.5
Dieldrin	7.28E-01	3.64E-06	0.017	2.9
Arsenic	1.65E-01	1.57E-04	0.74	42
Chromium	2.79E-02	6.96E-03	33	16200
Lead	--	--	--	17500

(a) Minimum Risk Level for PAHs in food (ATSDR, 1990) used for Oral Reference Dose of PAH compounds.

-- Chronic Reference Dose Values were not available.

1.3.2.3.3 Target Levels Based on Exposure to Carcinogens - An unacceptable excess cancer risk was associated with current soil exposures via incidental ingestion, dermal contact and inhalation. Several constituents, primarily pesticides and PAHs contribute to the overall excess cancer risk. To calculate acceptable target risk levels, the chemical-specific risk was divided by the total excess cancer risk to find the percentage of excess cancer risk contributed by that constituent. The chemical-specific percentage of risk contributed was multiplied by 1×10^{-6} to find the acceptable target risk level of each constituent of concern.

The chemical-specific target risk level was then divided by the chemical-specific slope factor to give an acceptable intake for the constituent. The chemical-specific acceptable intake for each pathway was then divided by the pathway-specific intake factor for the constituent to give the chemical- and site-specific soil health-based clean-up goal. Table 1-13 shows the stepwise procedure used to calculate health-based clean-up goals for surface soils based on excess cancer risk.

1.3.2.3.4 Target Levels-Summary - Table 1-14 summarizes all the target levels. The most stringent target requirements are based on carcinogenic exposures. A required reduction efficiency for remedial action was calculated by comparing health-based clean-up levels to the arithmetic mean soil concentrations for each constituent. Based on the potentially highly toxic nature of the carcinogens and the conservative scenario assumed in the risk assessment, very low target levels have been estimated. These levels may be impossible to achieve. Hazardous Substances Guidelines for the State of Tennessee and proposed RCRA Action Levels for soils are also given. Clean up goals will have to adjust to the Best Demonstrated Available Technology (BDAT) for remediation of the constituents of concern.

TABLE 1-13

Target Soil Concentrations
Based on Lifetime Excess Cancer Risks

Constituents of Concern	Target Excess Cancer Risks			Acceptable Intakes			Target Soil Concentration			Lowest Target Concentrations (mg/kg)
	Ingestion	Dermal Absorption	Inhalation	Ingestion	Dermal Absorption	Inhalation	Ingestion	Dermal Absorption	Inhalation	
Trichloroethene	6.29E-11	2.18E-10	2.37E-14	5.72E-09	2.08E-08	1.39E-12	4.09E-02	2.28E-04	6.62E-06	6.62E-06
Methylene Chloride	1.51E-10	3.29E-10		2.01E-08	7.32E-08		1.44E-01	8.01E-04		8.01E-04
Anthracene			3.44E-10			1.56E-10			7.43E-04	7.43E-04
Benzo(a)anthracene			1.73E-09			7.85E-10			3.74E-03	3.74E-03
Benzo(a)pyrene			9.60E-10			4.35E-10			2.07E-03	2.07E-03
Benzo(b)fluoranthene			1.11E-09			5.04E-10			2.40E-03	2.40E-03
Benzo(k)fluoranthene			7.79E-10			3.53E-10			1.68E-03	1.68E-03
Chrysene			1.25E-09			5.69E-10			2.71E-03	2.71E-03
Fluoranthene			2.06E-09			9.35E-10			4.45E-03	4.45E-03
Indeno(1,2,3-cd)pyrene			5.87E-10			2.66E-10			1.27E-03	1.27E-03
Phenanthrene			1.51E-09			6.84E-10			3.26E-03	3.26E-03
Pyrene			1.51E-09			6.86E-10			3.26E-03	3.26E-03
4,4-DDT	9.46E-08	2.75E-07	2.30E-11	2.78E-07	1.01E-06	6.77E-11	1.99E+00	1.11E-02	3.23E-04	3.23E-04
4,4-DDD	6.33E-09	1.84E-08		2.64E-08	9.60E-08		1.88E-01	1.05E-03		1.05E-03
4,4-DDE	5.66E-08	1.65E-07		1.66E-07	6.06E-07		1.19E+00	6.63E-03		6.63E-03
beta-BHC	3.78E-08	2.48E-07	9.22E-12	2.10E-08	7.65E-08	5.12E-12	1.50E-01	8.37E-04	2.44E-05	2.44E-05
Dieldrin	8.04E-07	2.93E-07	1.96E-10	5.03E-08	1.83E-07	1.22E-11	3.59E-01	2.00E-03	5.83E-05	5.83E-05
Arsenic			2.85E-08			5.28E-10			2.51E-03	2.51E-03
Chromium			9.61E-07			2.34E-08			1.12E-01	1.12E-01
Lead										ND

NOTE: Cancer Slope Factor values not available for all constituents and exposure routes

ND No Data

TABLE 1-14

Remediation Efficiency Estimates
Based on Health-based Clean-up Values

Constituents of Concern	Excess Cancer Risk Target Soil Concentration (mg/kg)	Subchronic Target Soil Concentration (mg/kg)	Chronic Target Soil Concentrations (mg/kg)	Overall Target Soil Concentrations (a) (mg/kg)	Arithmetic Mean for Surface Soils (mg/kg)	Reduction Efficiency Required	Tennessee Dept. of Superfund Hazardous Substances Guidelines (b) (mg/kg)	Proposed RCRA Action Levels for Soils (c) (mg/kg)
Acetone	--	0.006	0.0010	6.03E-03	0.02	74.23%	0.59	8000
Trichloroethene	6.62E-06	--	--	6.62E-06	0.04	99.98%	0.07	60
Methylene Chloride	8.01E-04	--	0.0068	8.01E-04	0.15	99.48%	8.6	90
Anthracene	7.43E-04	0.71	0.22	7.43E-04	4.9	99.98%	0.0000028	NA
Benzo(a)anthracene	3.74E-03	5.32	1.10	3.74E-03	24.7	99.98%	0.0000028	NA
Benzo(a)pyrene	2.07E-03	2.47	0.61	2.07E-03	13.7	99.98%	0.0000028	NA
Benzo(b)fluoranthene	2.40E-03	2.96	0.70	2.40E-03	15.9	99.98%	0.0000028	NA
Benzo(k)fluoranthene	1.68E-03	2.47	0.49	1.68E-03	11.1	99.98%	0.0000028	NA
Chrysene	2.71E-03	3.40	0.80	2.71E-03	17.9	99.98%	0.0000028	NA
Fluoranthene	4.45E-03	4.72	1.31	4.45E-03	29.5	99.98%	63.6-159.6	NA
Indeno(1,2,3-cd)pyrene	1.27E-03	1.70	0.37	1.27E-03	8.4	99.98%	0.0000028	NA
Phenanthrene	3.26E-03	1.10	0.96	3.26E-03	21.6	99.98%	0.0000028	NA
Pyrene	3.96E-03	4.77	1.16	3.96E-03	26.2	95.56%	0.0000028	NA
4,4-DDT	3.23E-04	0.32	0.094	3.23E-04	2.1	99.98%	0.00023-0.00058	2
4,4-DDD	1.05E-03	--	--	1.05E-03	0.2	99.48%	NA	3
4,4-DDE	6.63E-03	--	--	6.63E-03	1.3	99.48%	NA	2
beta-BHC	2.44E-05	0.014	0.0071	2.44E-05	0.2	99.98%	0.0024-0.0061	4
Dieldrin	5.83E-05	0.016	0.017	5.83E-05	0.4	99.98%	0.0000048-0.000012	0.04
Arsenic	2.51E-03	0.230	0.74	2.51E-03	16.6	99.98%	5	80
Chromium	1.12E-01	89	33	1.12E-01	737.0	99.98%	5	400
Lead	--	--	--	ND	903.0	ND	5	NA

(a) Based primarily on dermal exposure to carcinogens in soils; acetone is exception.

(b) Draft Guidelines from State of Tennessee (12/14/87)

(c) Federal Register 55 (145):30865-30873; revision to 40 CFR Section 264.521(a)(2)(i-iv)

1.3.2.4 Data Gaps - The lateral and vertical extent of contamination has not been determined at any of the sites. A field screening method (such as thin layer chromatography conducted on-site) would be an economical method for estimating contamination extent, with confirmation provided by selected samples submitted for laboratory analysis.

1.3.3 Lake Danielson and the Golf Course Pond

Two permanent surface waters exist at DDMT (Figure 1-12). The largest body of water is Lake Danielson, about four acres in size. Lake Danielson receives a significant amount of installation warehouse district 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 to a concrete-lined channel, to the culvert extending beneath N Street and Ball Road. Storm water flow is then directed to Nonconnah Creek via unnamed tributaries.

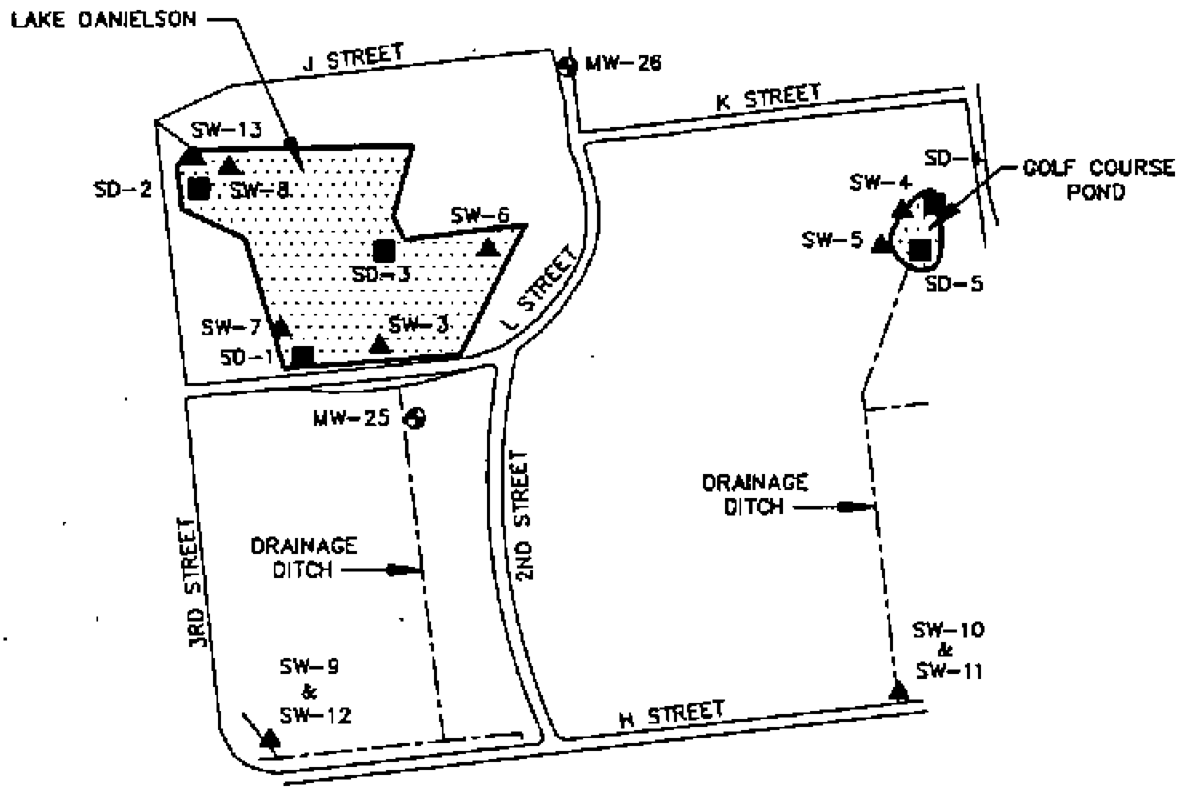
The smaller surface water is the golf course pond. It receives runoff from the surrounding golf course, Buildings 249, 250, 251, 265, 270, 271 and the south parking lot. Pond overflow is directed to a culvert extending beneath N Street and Ball Road.

1.3.3.1 Nature of Contamination - Previous investigations of the surface waters and sediments from these two bodies of water indicate a history of contamination from surface runoff from areas of transformer storage and biocide application. In a study conducted by AEHA in 1986, pesticides were detected in the sediments and in fish tissue (USAEHA Water Quality Biological Study No. 32-24-0733-86, March, 1986). The contaminants included 4,4'-DDT, dieldrin, chlordane and chlorpyrifos. Questionably high levels of PCBs were also detected in these matrices. Following the

FIGURE 1–12

SITE LOCATION MAP FOR SURFACE WATER AND SEDIMENT SAMPLES COLLECTED IN THE LAKE DANIELSON/GOLF COURSE POND AREA

DEFENSE DEPOT MEMPHIS, TENNESSEE



NOTES:

POSITIVE RESULTS FOR SURFACE WATER ARE GIVEN IN TABLE 1-15

POSITIVE RESULTS FOR SEDIMENTS ARE GIVEN IN TABLE 1-16

LEGEND

▲ SURFACE WATER SAMPLE LOCATION

■ SEDIMENT SAMPLE LOCATION

● MONITORING WELL LOCATION

0 300 600

SCALE IN FEET

LAW ENVIRONMENTAL INC.

GOVERNMENT SERVICES DIVISION

1986 investigation, fishing and recreational use was discontinued at Lake Danielson. Recreational use of these two bodies of water remain under these restrictions.

The only significant contaminant detected in the Lake Danielson water column exceeding Ambient Water Quality Criteria (AWQC) was copper. This constituent was not selected as a contaminant of concern in performing the risk assessment (Table 1-4). Low levels of arsenic and DDE were also detected, but at levels not exceeding AWQC. No significant contamination was detected in the sample collected at the inlet to Lake Danielson. The samples collected from the golf course pond had similar results to those collected in the lake. Copper was the only constituent detected that exceeded AWQC. No pesticides were detected in the pond's water column. However, samples collected from the pond's outflow drainage ditches had levels of DDT, lead, copper and zinc exceeding AWQC. Analytical results from the RI for surface water are given in Table 1-15.

Sediment samples were collected during the RI from Lake Danielson and the pond. Metals, pesticides and PAH contamination were detected at significant levels. All contaminant levels were greater in the pond sediments than in the lake. Since no contaminants were detected in the water column, it would appear that the sediments are acting as a contaminant "sink". Sampling was done on a clear day, turbulence (storms) may cause disturbance of the sediments, thus releasing contaminants back into the water. The sediments analytical results from the RI are given in Table 1-16.

19 70

TABLE 1-15
POSITIVE RESULTS IN SURFACE WATER
LAKE DANIELSON & GOLF COURSE POND
DEFENSE DEPOT MEMPHIS TENNESSEE

	Ambient Water Quality Criteria Aquatic Life (fresh)		PHASE I					PHASE II		
			GOLF COURSE POND		LAKE DANIELSON			GOLF COURSE POND DISCHARGE		LAKE DAN. INLET
PARAMETER	Acute	Chronic	SW4	SW5	SW6	SW7	SW8	SW10	SW11	SW13
HALOGENATED VOLATILES ug/l										
Methylene chloride	11,000	na	--	--	--	2BJ	1BJ	--	--	--
NONHALOGENATED VOLATILES ug/l										
Acetone	na	na	2BJ	2BJ	--	2BJ	2BJ	1BJ	4J	--
Total xylenes	na	na	--	--	--	--	--	--	1J	--
HALOGENATED SEMIVOLATILES ug/l										
Benzoic acid	na	na	--	--	--	--	--	--	--	5BJ
bis(2-Ethylhexyl) phthalate	940	3	3BJ	5BJ	--	2BJ	3BJ	7BJ	3J	6BJ
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	--	--
Pyrene	na	na	--	--	--	--	--	3J	3J	--
PESTICIDES ug/l										
4,4'-DDE	1050	na	--	--	.21	--	--	.14	.88D	--
4,4'-DDT	1.1	0.001	--	--	--	--	--	.27	1.9D	--
VOLATILE METALS ug/l										
Arsenic	360	190	--	--	48	41	37	--	--	--
Lead	82	3.2	--	--	--	--	--	--	50	--
NONVOLATILE METALS ug/l										
m	na	na	14B	14B	17B	15B	15B	26B	55	60
opper	18	12	46	30	24B	20B	19B	25	30	--
Zinc	120	110	22	22	41	32	37	81	110	54

TABLE 1-15
POSITIVE RESULTS IN SURFACE WATER
LAKE DANIELSON & GOLF COURSE POND
DEFENSE DEPOT MEMPHIS TENNESSEE

Shaded areas are values that are equal to or exceed either the acute or chronic Ambient Water Quality Criteria guidelines.

na = 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.

-- = Not detected.

TABLE 1-16
POSITIVE RESULTS IN SEDIMENTS
DEFENSE DEPOT MEMPHIS TENNESSEE

		PHASE I									
		LAKE DANIELSON						GOLF COURSE POND			
PARAMETER	STATE OF TN	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	8600	42B	38B	22B	22B	28B	22B	27B	29B	14B	25B
NONHALOGENATED VOLATILES (ug/kg)											
Acetone	590	71B	75B	46B	51B	43B	36B	170	140	21	24
2-Butanone	7200	--	3BJ	1BJ	--	--	--	6J	5J	--	--
Toluene	14,400	--	--	--	--	--	--	--	--	--	2J
HALOGENATED SEMIVOLATILES (ug/kg)											
Pentachlorophenol	3600	--	--	--	--	--	--	--	--	270J	--
NONHALOGENATED SEMIVOLATILES (ug/kg)											
bis(2-Ethylhexyl) phthalate	15,000	550	570	580J	530J	760J	640J	710J	630J	710J	710J
Benzoic acid	na	460J	490J	300J	590J	160J	470J	680J	450J	1200J	970J
N-Nitrosodiphenylamine	12.8 - 32	100BJ	--	170BJ	--	270BJ	100BJ	190BJ	--	280BJ	190BJ

(continued on next page)

TABLE 1-16
POSITIVE RESULTS IN SEDIMENTS
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I									
		LAKE DANIELSON						GOLF COURSE POND			
		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	0.0028	74	71	100	--	3,460	--	330	--	16,500	8,980

PESTICIDES (ug/kg)

4,4'-DDD	na	47	--	--	--	45	--	190D	280D	3000D	960D
4,4'-DDE	na	36	--	--	--	110D	--	68D	64D	460Z	--
4,4'-DDT	.23 - .58	--	--	--	--	--	--	--	--	2900D	620D
Endosulfan-I	.74	--	--	--	--	--	--	--	--	200Z	--

TABLE 1-16
POSITIVE RESULTS IN SEDIMENTS
DEFENSE DEPOT MEMPHIS TENNESSEE

PARAMETER	STATE OF TN	PHASE I									
		LAKE DANIELSON						GOLF COURSE POND			
		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	--	--	--	--	--	--	5	6	91	55
Mercury	0.2	0.04	0.05	0.05	0.05	--	--	0.05	0.04	0.06	0.04
NONVOLATILE METALS (mg/kg)											
Barium	100	76	86.4	122	110	89.7	99	96	95.2	101	104
Cadmium	1	0.78	--	--	--	--	--	--	--	0.98	--
Chromium **	5	13	13	12	10	12	9	13	11	28	21
Copper	na	20	23	18	17	15	16	15	16	28	26
Nickel	20	11	14	14	12	14	13	13	13	14	14
Zinc	na	44.5N	47.8N	50.9N	47.6N	48.8N	45.4N	44.7N	43.2N	80.9N	66.8N

Shaded areas are values that are equal to or exceed the State of Tennessee soil criteria guidelines.

na = Not Available

State of TN values are only To Be Considered (TBC) guidelines. These are not enforceable clean up levels.

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.

1.3.3.2 Source of Contamination - The source of contamination in Lake Danielson and the golf course pond is thought to be from runoff into these surface water bodies from the warehouse areas via the base storm water system. Overland runoff of pesticides applied to the golf course may have contributed. Although installation operations have been improved to reduce this source of contamination, past operations still may be contributing to the problem.

1.3.3.3 Risk Assessment - The potential routes of exposure associated with contaminated surface water and sediments include the following:

1. Off-site ingestion of fish and other aquatic life from contaminated lakes and creeks.

2. Dermal absorption of contaminants present in off-site surface waters.

Ingestion of fish potentially presents an unacceptable level of risk for off-site fisherman, but no excessive risk is associated with dermal absorption of contaminants present in off-site drainage canals or creeks.

1.3.3.4 Data Gaps - The source of the sediment contamination and the cause of fish kills cannot be evaluated from the available data. Of particular interest is water quality, at the points of storm water discharge and in the lake and pond, after large rain events which may tend to wash additional contamination into the lake. In addition, rainfall events may stir up pesticides retained in the lake or pond sediments. Coordination of sampling with a fish kill or during a major rainfall period would be useful.

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 INTRODUCTION

Contaminated ground water, surface water, sediments and surface soils were detected during the Remedial Investigation activities. These environmental media were considered individually in evaluating potentially applicable remedial alternatives. Several process options within each remedial technology type were evaluated for each contaminated media. Potentially applicable technologies were identified on the basis of experience and using various published references. These references included journals, standard engineering text books and USEPA publications (References 1 through 10).

The following guidelines have been considered to develop the remedial action objectives for each of the environmental settings:

1. compliance with ARARs
2. eliminate or reduce the need for long-term management
3. reduce toxicity, mobility or volume of waste
4. reduce potential risk of exposure or direct contact with waste (long-term, short-term and during remediation activities)

The contaminants of interest and the preliminary ARARs for ground water, surface soils and Lake Danielson were discussed in Section 1.0. Prior to actual clean up, the actual allowable exposure limits (clean up levels) for all of the constituents of concern must be established.

General response actions were developed considering the following:

- Contaminants of interest
- Allowable exposure levels based on the Risk Assessment and ARARs
- Compliance with regulations (RCRA and CERCLA)
- The USEPA Guidance for Conducting RI/FS under CERCLA (1988)
- Site conditions
- Volume of waste and the time required for remediation using potentially applicable technologies
- Volume of waste and capacity of off-site disposal treatment facilities, duration of haul time and distance required for waste transportation
- Availability of technologies, field demonstration capabilities and uncertainties for the specific technologies
- Effectiveness and implementability of technology
- Cost
- Probability of acceptance by the public
- Likelihood of acceptance by regulation agencies (USEPA, Tennessee Division of Solid and Hazardous Waste and Memphis/Shelby County Health Department).

During the screening process of each technology the following criteria were evaluated per EPA guidance for:

A) Effectiveness:	1) Overall Protection of Human Health and Environment
	2) Compliance with ARAR's
	3) Long-term Effectiveness and Performance
	4) Reduction in Toxicity, Mobility or Volume Through Treatment
	5) Short-term Effectiveness
B) Implementability	6) Implementability
C) Cost	7) Cost
D) Other	8) State Acceptance
	9) Community Acceptance

The screening process is an ongoing process and should be reevaluated prior to design and construction of any remedial action technology. During screening, emphasis was placed on the effectiveness and implementability of each technology. Cost was considered to be the least important factor in developing a remedial action alternative. The actual cost for each technology can only be determined on a unit basis, since the actual volume of contamination is unknown. The cost shown on the screening tables are relative values based on these unit costs.

The following sections describe applicable technologies for remediation of ground water, soil and Lake Danielson at DDMT. Included in the discussion is an evaluation of each technology. Following the screening and evaluation of each technology, remedial action alternatives will be developed. These alternatives will then be ranked based on their effectiveness and implementability. A detailed analysis of the selected remedial action alternatives is given in Section 3.

2.2 GROUND WATER

2.2.1 Remedial Action Objectives for Ground Water

The overall objective for ground water remediation in the Dunn Field area is for the protection of human health. Specifically, these goals are to remediate ground-water contamination in the Fluvial aquifer, minimize the possibility of contaminant migration to the Memphis Sand aquifer and to adequately mitigate the source of contamination.

Ground water from the Fluvial aquifer is not currently (or expected to be in the future) used for drinking water, industry or agriculture. This aquifer is separated from the Memphis Sand aquifer (primary source of drinking water for Memphis, TN) by approximately 90-feet of lean to fat clay within the Dunn Field area. However, it has been reported that the two aquifers are hydraulically connected in some areas. Although no contamination was detected in ground-water samples collected from the Memphis Sand aquifer (MW-36 & MW-37), the potential exists for contaminants to migrate from the Fluvial aquifer.

Two areas must be examined in developing the ground water remedial alternatives. These two areas are: 1) the source areas where the contamination is being generated and 2) the contaminated portion of the Fluvial aquifer. The information obtained in performing the RI indicates that the contaminant source area is located within Dunn Field. However, the location of the trench, or trenches, contributing the contamination was not identified. Although the areal extent of ground-water contamination was not fully determined, remedial action alternatives may still be evaluated.

Due to technology limitations, no currently available remedial action will remove 100% of the contamination from the Fluvial aquifer. Ground-water clean-up levels will be determined based on information obtained during treatability studies using the Best Demonstrated Available Technology (BDAT). The State of Tennessee broadly proposes that clean-up levels will be set to Maximum Containment Levels (MCLs) for all ground water. However, the State agrees that actual levels will be negotiated on a site by site basis.

2.2.2 General Response Actions for Ground Water

General response actions were developed to address the remedial action objectives for the ground water and contaminant source(s) in the Dunn Field area. Six potentially applicable general response actions were evaluated and screened based on the criteria discussed in Section 2.1. These actions include:

- No Action
- Institutional Controls
- Plume Containment
- Source Containment
- Pump and Treat Technologies
- In Situ Treatment

Since the lateral and vertical extent of ground water contamination was not fully determined, the volume of contaminated ground water that must be treated can only be estimated. The areal extent of the known contaminant plume covers approximately 46 acres (Figure 1-5). An estimated 75 million gallons of contaminated ground water is contained within the known extent of the plume area.

2.2.3 Identification and Screening of Technologies

Potentially applicable technologies for ground water remediation at Dunn Field are listed on Table 2-1. A process option that satisfies the remedial action objective was selected from each general response action. Each technology and the related process options were evaluated and screened based on their effectiveness, implementability and costs. The technologies are discussed and evaluated in the following sections. These options were then evaluated and ranked to determine the appropriate remedial action alternatives.

2.2.3.1 Institutional Control

2.2.3.1.1 Description - The institutional control alternative is not considered a technology but has been included in this section as a possible alternative. In selecting this alternative for consideration, the horizontal and vertical extent of ground water contamination must be defined. This alternative consists of the following components:

1. Notification of property owners within the zone of contamination as to deed restrictions on present and future use of ground water from the Fluvial aquifer.

2. Establishment of a periodic ground water monitoring program to determine changes in the levels of contamination and plume migration into more sensitive areas.

TABLE 2-1
TECHNOLOGY SCREENING FOR REMEDIAL ACTION APPLICABLE TO GROUND WATER DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
No Action	None	None	Leave ground water as is. No further monitoring or investigation.	Contamination is not mitigated. Does not comply with ARARs. (MCLs until clean-up levels are determined)	Not Effective	NA	NA	Yes
Institutional Control	Deed Restrictions	None	All deeds for property within contaminated area would include restrictions on use. Notification of contaminants to State of TN and Memphis, Light, Gas and Water—Establish joint monitoring program. May include source control (see "contaminant" below)	Same as above. Regulatory personnel will be needed for implementation	Effective only in preventing well installation into the shallow aquifer.	Easily implemented by DDMT personnel.	NA	Yes
	Continued Monitoring	Natural Attenuation	Same as above. Continued monitoring and source containment (see below) contamination will naturally degrade and dilute given enough time.	Same as above. Additional plume investigation is necessary. In time, contaminants may migrate to the Memphis Sand aquifer. Breakdown products of the contaminants are more carcinogenic than are contaminants present. This action will require that the full extent of contamination be determined and may require the addition of down-gradient wells in the future as the contaminants continue to migrate.	Effective only in gauging plume migration and natural attenuation.	Easily Implemented Long-Term Maintenance	Low	Yes
Plume Containment	Gradient Control	Injection Wells	Injection wells used to create area with higher hydraulic head to change direction and speed of plume migration. Desirable if short-term natural attenuation can alleviate contaminant concentrations.	Same as above. Installation, operations and maintenance of injection wells required.	Not Generally Effective	May be readily implemented	Moderate	No
		Hydraulic Barrier	Line of extraction wells with overlapping radius of influence, thus not allowing any contamination to pass downgradient of the selected boundary (either DDMT's western boundary or any further west)	May be used for barrier or treatment of extracted ground water. Further definition of plume is required. Continued monitoring and maintenance required.	Effective in limiting further off-site migration, does not remediate on-site or off-site contamination.	May be readily implemented	Moderate to High	Yes

TABLE 2-1 (Continued)
TECHNOLOGY SCREENING FOR REMEDIAL ACTION APPLICABLE TO GROUND WATER
DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
Plume Containment (Continued)	Vertical Barriers	Slurry Walls	Low permeability cut-off walls are installed below ground to contain, capture or redirect ground-water flow. Leachate recovery system must be included.	Full extent of plume must be defined. Does not mitigate contamination.	Have proven to be ineffective due to inability to construct a truly impervious wall.	The depth of construction at this site may be very difficult to implement. Proven to be very difficult to construct.	Moderate to High	No
Source Containment	Capping	Low Permeability Caps and/or liners	Burial sites capped with low permeability clays or synthetic covers to prevent surface water from infiltration and creation of leachate.	Burial sites must be identified/located. Direct sampling from within waste sites could be used to locate specific "problem" areas.	Generally effective in limiting further waste migration; waste remains in place requiring on-going monitoring.	Easily Implemented	Moderate	Yes
	Removal	Evaluation of Waste	Removal of the waste material would require excavation, treatment and/or transporting to a RCRA disposal facility.	Same as Above.	Most effective source control.	May be difficult and dangerous to implement.	High	No
Pump and Treat	Extraction Wells	Wellpoints	Good for soils with low to high hydraulic conductivities and for heterogeneous materials.	Used for wells less than 20 feet in depth. Capacity 0.1-25 gpm, spacing 5-10 feet.	Not effective for depths at DDMT	Should not be considered as an action	-	No

TABLE 2-1 (Continued)
TECHNOLOGY SCREENING FOR REMEDIAL ACTION APPLICABLE TO GROUND WATER DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
Pump and Treat (Continued)	Extraction Wells (Continued)	Ejector Wells	Good for soils with low hydraulic conductivities and for heterogeneous materials.	Used for wells greater than 20 feet. Capacity of 0.1-40 gpm, spacing 20-40 feet.	Potentially Effective	Fairly easily implemented and maintained	Moderate	No
		Deep Wells	Good for soils with high hydraulic conductivities.	Used at depths greater than 20 feet. Capacity of 25-3000 gpm, spacing greater than 50 feet.	Effective	Same as above	Moderate	Yes
Post Extraction Treatment	Physical Treatment	Air Stripping	Removal of relatively volatile dissolved organic contaminants using air as the gas for mass transfer.	May need to combine with carbon treatment and/or filtration. Emission of volatiles to atmosphere may be unacceptable.	Has proven very effective for removal of volatile organics.	Easily implemented in conjunction with other technologies	Moderate	Yes
		Activated Carbon Treatment	Extracted ground water allowed to flow through a series of packed bed reactors. Organic molecules are absorbed into the internal pores of the carbon granules.	Upon saturation the carbon granules must be treated or disposed at a RCRA facility. May or may not aid in metal remediation as suspended solids may "clog" the system. Pretreatment may be required.	Same as Above	Same as Above	Moderate	Yes
		Filtration	Suspended solids are removed from solution by forcing the fluid through a porous medium.	Requires backflushing to unclog filter. This wastewater must be treated.	Has proven very effective for removal of undissolved solids (i.e., metals).	Same as Above	Low	Yes
		Precipitation/ Flocculation	Removal of metals as hydroxides or sulfides is the most common precipitation application. Lime or sodium sulfide is added in a rapid mixing tank. Mixture flows to a flocculation chamber and precipitation occurs, followed by filtration.	Selection of suitable precipitate or of flocculant and dosage determined in the laboratory. Generates a large volume of sludge which must be disposed of.	Has proven very effective for removal of dissolved metals.	Same as above	Low	Yes

TABLE 2-1 (Continued)
TECHNOLOGY SCREENING FOR REMEDIAL ACTION APPLICABLE TO GROUND WATER DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
Post Extraction Treatment (Continued)	Physical Treatment (Continued)	Sedimentation	Relies upon gravity to remove suspended solids.	Collection of sediments in a tank or pond. A sediment removal system must be incorporated. Generates a large volume of sludge which must be disposed of. Requires more time than other available technologies. Tanks would have to remain covered and air treated to remove volatiles	Same as Above	More difficult to implement than other technologies.	Low	No
		Reverse Osmosis	The application of sufficient pressure to concentrated solution to overcome osmotic pressure and force the net flow through the membrane toward the dilute phase.	Pretreatment for removal of solids.	Very effective for removal of organics and dissolved inorganics.	Same as Above	Moderate to High	No
	Chemical Treatment	Ultraviolet Catalyzed Oxidation With Hydrogen Peroxide	Contaminated ground water is mixed with hydrogen peroxide in a reactor and exposed to ultraviolet light. Hydrogen peroxide is an oxidizer and reacts with chlorine to produce chloride ions.	No effect on metals. No vapor or emissions. No wastewater or sludge created for disposal or further treatment.	Very effective for destroying organics, not effective on inorganics	Same as Above	Moderate	Yes
Discharge of Ground Water	--	Reinjection	Reinject treated ground water to aquifer.	Will aid in contaminant migration, can be used as hydraulic gradient control, could help in cleaning subsurface soils and decreases extraction time.	Effective	Fairly easy to implement. Moderately easy to maintain. Difficult to permit.	Moderate	No
		Deep Well Injection	Discharge treated or untreated ground water to regulated deep well injection system.	Contaminated water would have to be transported long distance to locations where the state of TN has regulated an aquifer for injection purposes.	Does not Mitigate Contamination	Difficult to implement and permit.	Moderate to High	No
		Surface Water	Discharge treated ground water to onsite surface water.	Continual analysis of treated water prior to discharge.	Effective	Requires NPDES Permit	Added Expense to Treatment	Yes

TABLE 2-1 (Continued)

TECHNOLOGY SCREENING FOR REMEDIAL ACTION APPLICABLE TO GROUND WATER DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
Discharge of Ground Water (Continued)		POTW (Publicly Owned Treatment Works)	Discharge treated or untreated ground water to local POTW.	Same as Above	Effective	Requires Approval from Local Sewage Treatment Authority	Added Expense to Extraction, possible discharge fees	Yes
		Water Supply	Discharge treated ground water to water supply system.	Analysis of treated water and permission with MLG&W.	Effective	Problems with Public Perception	Added Expense to Treatment	No
In Situ Treatment	In Situ Biological Treatment	Biodegradation/ Biorestoration	Biological modification or destruction. Nutrients are injected to enhance native microorganisms to biodegrade contamination.	Chlorinated solvent not easily degraded, toxic intermediate breakdown products.	Not Currently Proven Effective, Potentially Very Effective	Proper Evaluation and Design Required for Implementation	Moderate Cost	Yes
	In Situ Chemical Treatment	Precipitation Chelation Polymerization	Of the three methods, precipitation is the most developed technology. Divalent metals may be precipitated and thus immobilizing them sulfides, phosphates, hydroxides or carbonates to the ground water.	Care must be taken that more pollution is not created. Metals can become resolubile. May clog soils and hinder other remedial technologies.	No long-term effectiveness. Not effective for organics.	Readily Available	Moderate	No
		Soil Flushing	Applying a liquid flushing agent (water or surfactants) to the soil and allowing it to percolate down to the ground water where it can be extracted and treated by methods listed above.	Solvents are selected based on their ability to solubilize the contaminants.	Effective removal of low levels of contamination from subsurface soils. Will decrease time required for extraction.	May be difficult to implement if sites of waste burial are unknown.	Moderate	No
		Oxidation	Ozone, hypochlorite, or hydrogen peroxide are injected into ground water to increase the oxidation state of compounds. The contaminants are detoxified, mobility is increased, or made more amenable to biological degradation.	Only contaminant detected at DDMT that would be affected by treatment is arsenic. May create more contamination.	Not effective for organics and metals other than arsenic.	Readily Available	Moderate	No

TABLE 2-1 (Continued)
TECHNOLOGY SCREENING FOR REMEDIAL ACTION APPLICABLE TO GROUND WATER
DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
In Situ Treatment (Continued)		Reduction	Same as above only reducing agents are introduced into ground water.	Only contaminants at DDMT that would be affected by treatment is chromium and selenium.	Not effective for organics and metals other than chromium and selenium.	Same as Above	Same as Above	No
		Hydrolysis	Water with lime or NaOH is injected into ground water. The mixture causes an attack of a nucleophile on an electrophile resulting in a bond cleavage and displacement of the leaving group.	Not applicable to contaminants detected at DDMT.	Not Effective	NA	NA	No
		Neutralization	Neutralization involves injecting dilute acids or bases into the ground water to adjust the pH. This may serve as a pretreatment prior to oxidation precipitation, or reduction.	Same as Above	Not Effective	NA	NA	No

2.2.3.1.2 Evaluation - The institutional control alternative does little to reduce the risk to exposure since the contamination is not mitigated. Most of the chlorinated volatile organics detected in the ground water at Dunn Field will take a considerable amount of time to naturally degrade. The half-lives for the types of contaminants detected at DDMT is unknown. Reported values have ranged from weeks to years (Howard, 1990). In addition to the lengthy half-lives, the majority of the organic contaminants break-down to form vinyl chloride. This constituent was not detected in samples collected during the RI. During the degradation period the contaminants can be expected to migrate both laterally and vertically, thus potentially increasing the risk associated with this site.

Although the capital cost for this alternative is relatively inexpensive, the future cost of liabilities associated with the exposure risks may be unacceptable. This is because contamination could possibly, or already has (Section 1.0), penetrated the confining unit and entered the drinking water supply for the Memphis area.

Even though Institutional Control does not meet the remedial action objectives it has been retained in the screening of technologies. This is because as a first step towards effective ground water remediation, the plume definition and the further monitoring portion of this alternative must be incorporated.

2.2.3.2 Plume Containment

2.2.3.2.1 Description - Plume containment could be used to prevent further lateral off-site migration of the contamination. However, as migration past the installation boundary has already occurred, this action could only be partially effective. Plume containment could be achieved by several technologies as discussed below.

Injection Wells - Plume containment could be achieved by using injection wells to change both the direction and speed of the plume's migration. By creating an area with a higher hydraulic head, the plume can be forced to change direction. This technique has been effective at some sites for short term diversions. This technology does not mitigate contamination and has no effect on vertical contamination migration. Since this technology does not meet the remedial action objective it will not be retained for future consideration.

Hydraulic Barriers - Extraction Wells - A line of extraction wells (Section 2.2.3.4 discusses the types of wells) could be used to halt the advance of the leading edge of a contaminant plume. The wells are placed at a sufficiently close spacing to capture all ground water moving off-site. Depending on natural gradients, the wells will eventually recover contamination from up-gradient where contaminants are miscible and move readily with water. The wells will also have an effect down-gradient, capturing some of that contamination. This technology was retained during screening since its incorporation into a pump and treat alternative (Section 2.2.3.4) is important.

Slurry Walls - Slurry walls are subsurface barriers used to reduce lateral ground-water flow. The term slurry wall can be applied to a variety of barriers all having one thing in common: they are all constructed in a vertical trench that is excavated under a slurry. The slurry, usually a mixture of bentonite and water, hydraulically shores the trench to prevent collapse and at the same time forms a filter cake on the trench walls to prevent high fluid losses into the surrounding ground. The wall itself can be constructed of a combination of cement, bentonite and native soil. Slurry walls have proven to be difficult to construct, maintain and to be ineffectual at preventing contaminant migration.

Due to the sandy-gravelly soil conditions, depth to the Fluvial aquifer, and the possibility of disturbing the burial trenches in Dunn Field, slurry walls would be extremely difficult to construct. Since this technology is ineffective, difficult to implement, and relatively expensive it was not retained during the screening process.

2.2.3.2.2 Evaluation - The three plume containment technologies were evaluated to be ineffective at addressing the remedial action objective. This evaluation was based, in part, on the fact that contamination has already migrated past the installation boundaries. Plume containment would also have little positive effect on potential vertical migration to the Memphis Sand aquifer. However, extraction wells forming a hydraulic barrier and associated treatment system eventually incorporated into a full pump and treat system may prove to be very effective.

2.2.3.3 Source Containment

2.2.3.3.1 Description - Source containment is necessary to limit continued contamination of the Fluvial aquifer. The burial sites should be located prior to final design of source containment. The most effective source containment would be excavation of the waste and transportation to a RCRA hazardous waste disposal site. However, because of the heterogeneous and potentially dangerous nature of the burial pit contents, this technology would be difficult to implement. In lieu of excavating the waste, a low permeability cap could be placed over each burial trench. The cap should be composed of a lean clay and/or a synthetic membrane. The capping of these sites would prevent surface water from percolating through the waste, thus slowing the leaching of contaminants to the ground water.

2.2.3.3.2 Evaluation - The two technologies (removal and capping) evaluated for control of the suspected contaminant source in Dunn Field should be considered as part of any remedial action alternative undertaken at DDMT. The first technology, excavation of waste, would provide the most effective means of source control. Even though this technology would provide long-term effectiveness, a high risk to the personnel involved may be associated with the execution of this option. In the process of excavation, more contamination may be released to the subsurface environment than would naturally occur. The cost of excavating and transporting the wastes may also prove inhibitive.

The second technology, capping of the burial waste sites would greatly reduce infiltration of surface water into the waste areas, thus reducing the generation and migration of leachate to the ground water. This technology would be an effective, easily implemented and relatively inexpensive method of controlling the contaminant source.

2.2.3.4 Pump and Treat Technologies - The most accepted ground water remedial alternatives include four technologies: 1) the extraction of ground water (pumping), 2) treatment, 3) the discharge of the treated water and 4) disposal of treatment residuals. Several options for each technology have been evaluated to determine appropriate remedial action alternatives for the type of conditions found at DDMT. Each of the options are briefly discussed in the following paragraphs.

2.2.3.4.1 Ground-Water Extraction Wells - Three types of extraction wells are in common use at sites where ground/water remediation is being undertaken. The following gives a brief description of the three types:

1. Wellpoints - Wellpoint systems consist of a group of closely spaced wells connected to a header pipe and pumped by a suction pump. Wellpoints are best suited for ground-water extraction in stratified soils where total lift or drawdown will not exceed 22 feet. A suction (vacuum) pump is typically used in wellpoint systems to lift water.

2. Ejector Wells - Ejector systems consist of closely spaced wells connected to a header pipe. The lift principal is as follows: high pressure supply water moves down the supply pipe through ports in the ejector body to the tapered nozzle where the pressure head is converted to water velocity; supply water exits the nozzle at less than atmospheric pressure creating a vacuum in the suction chamber; ground water is drawn into the chamber through the foot valve because of the pressure differential; supply water and ground water are mixed in the suction chamber. The mixed water enters the venturi where the velocity decreases because of divergence resulting in increased pressure; the increase in pressure develops sufficient head to return the combined flow to the surface. This type of well system has proven to be very inefficient (less than 15 percent).

3. Deep Wells - Deep well systems can be installed to any depth and can be spaced at greater distances than wellpoints or ejector wells. The major components of a deep well include; casing, screen, filter pack and seal and pump. A submersible electric pump is typically used in conjunction with deep wells. The pump selection must be made based on the total capacity, operating conditions (pumping cycle, load) and total head.

Additional information will be required before an economical design of the extraction well system can be made. Design of an integrated pumping system will involve calculating the well spacing, pumping rate and draw-down. A conceptual level design can be performed based on the data obtained to date. The final design must be based on more detailed pilot level studies.

2.2.3.4.2 Ground Water Treatment Technologies - Two appropriate remedial technologies, physical and chemical treatment, were evaluated for post-extraction treatment of ground water at DDMT. The variable characteristics of the contaminants (organic and inorganic) detected during the Remedial Investigation indicates that a combination of process options would be the most effective method for ground water remediation. The following is a brief description of the process options.

2.2.3.4.2.1 Physical Treatment - The first remedial technology presented and screened involves the physical treatment of ground water. The following sections describe each of the process options that are feasible for this type of technology.

Air Stripping - Air stripping is a mass transfer process in which volatile contaminants dissolved in the water are transferred to a gas phase. The tendency for a dissolved constituent to be removed by air stripping can be determined by the constituent's Henry's Law constant. A general rule of thumb is that components with Henry's Law constants of greater than approximately the constant for TCE can be effectively removed by air stripping. Several of the organic constituents detected in the ground water at DDMT are significantly less than that criteria.

Air stripping is generally accomplished in a packed tower equipped with an air blower. The water stream flows down through the packing while the air flows upward, and is exhausted through the top. Volatile, soluble components have an affinity for the gas phase and tend to leave the aqueous stream.

The feed stream must be low in suspended solids (i.e., some sort of filtration device prior to air stripping) and may require pH adjustment to reduce solubility and improve transfer to the gas phase. Air stripping would only be partially effective and must be followed by another process such as carbon adsorption (see below).

The equipment for air stripping is relatively simple, start-up and shut-down time can be accomplished quickly, and the modular design makes air stripping well suited for temporary applications.

Another factor in the consideration of whether to utilize air stripping technology for the removal of volatile contaminants is the air pollution implications. The gas stream generated during treatment may require collection and subsequent treatment or incineration. Air stripping has been retained in the screening process since it can be easily incorporated with other technologies to develop an effective remedial action alternative.

Activated Carbon Treatment - The process of adsorption onto activated carbon involves contacting a waste stream with the carbon, usually by flow through a series of packed bed reactors. The activated carbon selectively adsorbs constituents by a surface attraction phenomenon in which organic molecules are attracted to the internal pores of the carbon granules.

Adsorption depends on the strength of the molecular attraction between adsorbent and adsorbate, molecular weight, type and characteristic of adsorbent, electrokinetic charge, pH and surface area.

As in air stripping, pretreatment is required to lower the suspended solids to 50 ppm or less. Air stripping can be applied prior to carbon adsorption in order to remove a portion of the volatile contaminants, thereby reducing the organic load to the column. Using the air stripping first would also minimize carbon regeneration costs.

Carbon treatment is well suited to mobile treatment systems as space requirements are small. Start-up and shut-down are rapid. The main consideration associated with activated carbon treatment is the regeneration of spent carbon. Regeneration must be performed for each column at the conclusion of its bed-life, the spent carbon may be restored to its original condition for reuse; otherwise, the carbon must be disposed. For the types (and levels) of contamination detected in the ground water at DDMT the bed-life of the carbon would be relatively short (weeks). For this time period it would be more economical to incorporate a carbon regeneration unit on-site than to dispose of the spent carbon.

Activated carbon treatment has been retained in the screening process since it can be readily implemented in conjunction with other technologies, and an effective remedial action alternative may be developed.

<u>Multi-Media Filtration</u> - Multi-Media Filtration is a physical process whereby suspended solids are removed from solution by forcing the fluid through a porus medium. The filter media consists of a bed of granular particles (sand or sand with anthracite or coal). The bed is contained within a basin and is supported by an underdrain system which allows the filtered liquid to be drawn off while retaining the filter media in place. As water laden with suspended solids passes through the bed of filter medium, the particles become trapped on top of, or within, the bed. This either reduces the filtration rate at a constant pressure or increases the amount of pressure needed to force the water through

the filter. In order to prevent plugging, the filter is backflushed at a high velocity to dislodge the particles. The backwash water contains high concentrations of solids and requires further treatment.

Filtration equipment is relatively simple, readily available in a wide range of sizes and easy to operate and control. Filtration technology has been retained since it is also easily integrated with other treatment options.

Precipitation/Flocculation - Precipitation is a physiochemical process whereby some or all of a substance in solution is transformed into a solid phase. It is based on alteration of the chemical equilibrium relationships affecting the solubility of inorganic species. Removal of metals as hydroxides or sulfides is the most common precipitation application. Generally, lime or sodium sulfide is added to the waste-water in a rapid mixing tank along with flocculating agent. The waste-water flows to a flocculation chamber in which adequate mixing and retention time is provided for agglomeration of precipitate particles. Agglomerated particles are separated from the liquid phase by settling in a sedimentation chamber, and/or by other physical processes such as filtration.

The processes require chemical pumps, metering devices and mixing and settling tanks. The equipment is readily available and easy to operate. Precipitation and flocculation can be easily integrated into more complex treatment systems. Precipitation/Flocculation can be used to effectively remove heavy metals prior to using other technologies for organic removal. This option has been retained in the event that further ground-water analysis indicate a significant metal contamination. It should be noted that the high levels of metals detected during the RI (Table 1-2) are total metals, not dissolved metals. Thus, Precipitation/Flocculation may, or may not, be a necessary component of a remedial action alternative.

Sedimentation - Sedimentation is a process that relies upon gravity to remove suspended solids in an aqueous waste stream. The fundamentals of a sedimentation process include: 1) a basin or container of sufficient size to maintain the liquid, 2) a means of directing the liquid into the basin in a manner conducive to settling and 3) a means of physically removing the settled particles from the liquid.

Sedimentation is typically used as a pretreatment for carbon adsorption, air stripping, reverse osmosis and filtration.

Sedimentation employs readily available equipment and is relatively easy to operate. The process is versatile in that it can be applied to almost any liquid containing suspended solids. It can also be easily integrated into a more complex treatment system as a pre- or post-treatment option. Since the sedimentation process is nondestructive, results in a large volume of sludge that may require further treatment and/or disposal and is slower than filtration, it was not retained as the most effective technology for the type of conditions at DDMT.

Reverse Osmosis - Osmosis is the spontaneous flow of solvent (water) from a dilute solution through a semipermeable membrane to a more concentrated solution. Reverse osmosis is the application of sufficient pressure to the concentrated solution to overcome the osmotic pressure and force the net flow of water through the membrane toward the dilute phase. This allows the concentration of solute to be built up in a circulating system on one side of the membrane while relatively pure water is transported through the membrane.

Reverse osmosis is primarily limited to polishing low flow streams containing highly toxic contaminants. Although this technology would be effective at DDMT, its high initial and operating costs tend to be inhibitive.

2.2.3.4.2.2 Chemical Treatment Technology - Chemical treatment technologies involve the chemical alteration of the ground water. Only one process option was evaluated and is discussed below.

Ultraviolet Catalyzed Oxidation With Hydrogen Peroxide (UV/H_2O_2) - In the UV/H_2O_2 process the ground water is treated in a batch or continuous mode in which hydrogen peroxide is initially added. The solution is then exposed to UV light. The unit is operated until analysis of the water shows that the contaminants have been destroyed.

UV light catalyzes the chemical oxidation of organic contaminants in water by its combined effect upon the organic contaminant and its reaction with hydrogen peroxide. Many organic contaminants absorb UV light and may undergo a change in their chemical structure or simply become more reactive to chemical oxidants.

Ultraviolet light reacts with hydrogen peroxide molecules to form hydroxyl radicals. These very powerful chemical oxidants then react with the organic contaminants in the water. If carried to completion, the end products of hydrocarbon oxidation with the UV/H_2O_2 process are carbon dioxide, water and chlorine.

The UV/H_2O_2 process provides one of the most effective alternatives for ground-water remediation at DDMT. Since this technology allows for total destruction of organic contamination at a reasonable cost, it has been retained for incorporation into a remedial action alternative.

2.2.3.4.2.3 Evaluation - All of the process options discussed in the above sections are effective technologies for some, but not all, of the contaminants at DDMT. The diverse characteristics of the contamination (organic and inorganic) necessitate the combination of technologies to provide an effective remedial action alternative that will treat all contaminants effectively.

For example, an effective remedial action alternative would be the combined use of Precipitation/Flocculation to remove the metals, Filtration to remove the suspended solids, and Carbon Adsorption Air Stripping to remove the non-volatile organics. However, this alternative does not completely eliminate the contamination. A concentrated sludge is produced in the precipitation stage and the organics removed by Air Stripping are merely transferred from the water to the air. In addition, organic contaminants are transferred from the water to the carbon through adsorption. The spent carbon has to be regenerated or disposed of as a hazardous waste.

A second, but very effective, remedial alternative would include UV/H_2O_2 to remove organic constituents and Filtration to remove solids and possibly (if determined necessary) Precipitation/Flocculation to remove metals. This alternative may be more expensive to operate than the previously described alternative, but less in overall cost since most of the contamination is eliminated and wastes generated during remediation will need no further treatment.

2.2.3.4.3 Description of Discharge of Treated Water

Following extraction and treatment of the contaminated ground water an appropriate method of discharge must be incorporated into the remedial action alternative. Four methods have been investigated; (1) reinjection (or Deep Well Injection), (2) discharge to surface water through DDMTs NPDES permit, (3) discharge via the Publicly Owned Treatment Works (POTW) and (4) discharge into the public drinking water supply.

It should be noted that the discharge method selected will be a factor in determining ground-water clean-up levels. The following is a brief discussion of each option.

Reinjection - After the ground water has been extracted and treated, it could be reinjected into the Fluvial aquifer upgradient of extraction wells. As previously discussed, this could be done to increase hydraulic gradients and increase the velocity of the contaminated ground water. Injection permits are typically very difficult to obtain. Therefore, this option was not considered for incorporation into a remedial action alternative.

Deep Well Injection - The State of Tennessee has classified all aquifers for either drinking water or injection purposes. The only aquifers currently being used for injection are located in the central portion of the state. Therefore, if this method were to be used, the ground water extracted at DDMT would have to be transported long distances and injected into the state operated wells. Due to logistical problems and the high cost associated with this method no further consideration was given.

Surface Water - The extracted ground water could be sufficiently treated to meet NPDES permit requirements and then discharged to surface waters on site. DDMT's NPDES permit currently allows for storm water run-off only. This type of discharge will require treatment of the effluent to meet the State of Tennessee ambient water criteria (Section 6.0 of the RI report).

Publicly Owned Treatment Works (POTW) - Treated or partially treated ground water can be discharged to the POTW. This option is generally used when the sewage treatment facility is designed for the same type contaminants that are being treated, and sufficient treatment capacity exists at the facility. DDMT's sewage is discharged to the City of Memphis - South treatment facility. A system discharge agreement can be established with the City of Memphis based on negotiated levels of effluent concentrations. A copy of the system discharge agreement has been included in Appendix C of this document.

Water Supply - This option entails discharging the treated ground water to Memphis Light, Gas and Water (MLG & W) for reuse as a water supply. This option is typically not utilized due to public objections, and the potential liability. For these reasons this type of discharge was not included in any of the remedial action alternatives.

Evaluation - Discharge of the treated water to the surface waters or the POTW offers the most reasonable alternative. Both options will require continual monitoring of the effluent prior to discharge to meet discharge requirements. Discharge to the surface waters would require a NPDES permit and effluent to meet the ambient water criteria. POTW discharge would allow higher limits, but could require a discharge fee.

2.2.3.4.4 Summary of Pump and Treat - Based on the previous discussion, an applicable pump and treat system would consist of the following items:

a. An extraction system consisting of deep wells. The wells could initially be installed as a hydraulic barrier to limit off-site migration, and later expanded to remediate both on-site and off-site contamination.

b. Treatment of contaminated ground water.

c. Disposal of treated ground water to either a POTW or surface waters utilizing a NPDES permit.

A pump and treat system would remove a considerable amount of contaminated ground water and significantly reduce contamination levels. However, due to the tendency of constituents to adsorb to the soil matrix, a pump and treat system cannot typically remove a portion of the contamination, thus preventing the achievement of low clean-up goals. Pulsed pumping (alternating periods of pumping and non-pumping) can be utilized to improve recovery. However, achieving very low clean-up goals may still not be obtainable.

A pump and treat system can be combined with other technologies. For example, the initial extraction wells could be established at the downgradient property (i.e. to form a hydraulic barrier). Additional extraction wells, both downgradient and upgradient, could be established later.

2.2.3.5 In Situ Treatment - An alternative to pump and treat methods is to treat the contaminated ground water in situ.

2.2.3.5.1 Description - In situ treatment entails the use of chemical or biological agents, or physical manipulations which degrade, remove or immobilize contaminants. In situ technologies also include methods for delivering solutions to the subsurface and methods for controlling the spread of contaminants and treatment reagents beyond the treatment zone. In situ biodegradation or bioreclamation, is based on the concept of stimulating microflora to decompose the contaminants of concern. In situ chemical treatment involves the injection of a specific chemical or chemicals into the subsurface in order to degrade, immobilize or flush the contaminants.

Each of these methods have been evaluated for feasible remedial action at DDMT and are discussed below.

In Situ Biological Treatment - In situ biological treatment, or bioremediation, is a technology for treating zones of contamination by microbial degradation. The basic concept involves altering environmental conditions to enhance microbial metabolism or cometabolism of organic contaminants, resulting in the breakdown and detoxification of contaminants.

Microbial metabolic activity can be classified into three main categories: aerobic respiration, in which oxygen is required as a terminal electron acceptor; anaerobic respiration, in which sulfate or nitrate serves as a terminal electron acceptor; and fermentation, in which the microorganism rids itself of excess electrons by exuding reduced organic compounds.

Bioremediation shows great potential for completely, or almost completely, degrading contamination. Actual application, however, is controlled by the specific contaminants and hydrogeologic conditions. The chlorinated solvents present in the ground water at Dunn Field are not easily biodegraded compared to some other classes of constituents. In addition, the intermediate breakdown products can be more hazardous than the original constituents (e.g., under some biodegradation conditions TCE breaks down to vinyl chloride, a known carcinogen). Hydrogeologic conditions govern the delivery of nutrients to the system. Thus, these conditions must be evaluated in detail and the delivery system properly engineered to achieve proper results. Bioremediation could potentially be applied to the ground-water contamination at Dunn Field but would be difficult to implement and this technology has not been proven to be as effective as pump and treat.

In Situ Chemical Immobilization - Immobilization methods are designed to render contaminants insoluble and prevent leaching of the contaminants from the soil matrix and their movement from the area of contamination. Technologies considered under this category include: precipitation, chelation and polymerization. In situ treatment of a leachate plume using any of the immobilization techniques has limited application. The problems associated with this technique include the following:

- Need for numerous, closely-spaced injection wells
- Contaminants are not removed from the aquifer

- Injection of a potential ground water pollutant or the formation of toxic byproducts.

Since this technology does not meet the remedial action objective no further consideration was given.

In Situ Chemical Mobilization - Organic and inorganic contaminants can be washed from contaminated soils by means of an extraction process termed "soil flushing". Water or an aqueous solution is injected into the area of contamination, and the contaminated elutriate is pumped to the surface for treatment. During elutriation, sorbed contaminants are mobilized into solution by reason of solubility, formation of an emulsion or by a chemical reaction with the flushing solution.

Soil flushing is generally used as an alternative to the excavation and treatment of the contaminant waste. Although removal of the contaminant source from Dunn Field is not recommended (Section 2.2.3.3), soil flushing is not applicable to the conditions at DDMT. If the contaminant source is located and capped no further generation of leachate should occur. Leachates existing within the unsaturated soil matrix at the time of capping will naturally migrate to the water table and be recovered by whatever remedial technology is incorporated.

In Situ Chemical Detoxification - In situ detoxification techniques are those which serve to destroy, degrade or otherwise reduce the toxicity of contaminants and include hydrolysis, oxidation, reduction and neutralization. These methods are applicable to specific chemical contaminants. The only contaminants detected in the ground water at DDMT that are applicable to this type of treatment are arsenic, chromium and selenium. The problems associated with this technology are the same as those for in situ chemical immobilization.

2.2.3.5.2 Evaluation - Bioremediation shows potential as an in situ technique for ground water remediation at Dunn Field but has not been included for detailed evaluation for the reasons previously discussed. However, this technology is currently in a state of active development and should be reconsidered for use when site remediation goals have been more completely defined.

2.2.4 Development of Alternatives

The screened technologies were combined to develop site-specific remedial action alternatives to address human health and environmental concerns associated with ground-water contamination at DDMT. The potential exposure pathways, receptors and risk of exposure were considered, on the basis of the RI report. The screened technologies were also combined to develop feasible alternative actions that could mitigate the potential exposure risks identified in the Risk Assessment (Section 6.0 of the RI Report).

Five alternatives were developed to address the remedial action objectives described in Section 2.2.1 of this report. All of the alternatives listed below (except No Action) will require further assessment to determine the full extent of ground-water contamination. In addition to plume definition, each alternative includes the location, definition and containment of the contaminant source. The most reasonable alternative for containment is capping the burial trenches in Dunn Field with an impermeable membrane and/or clay seal. The alternatives range from No Action to Pump and Treat as presented below:

1. No action
2. Institutional control
3. Containment of ground-water contamination - Hydraulic Barriers

4. Pump and Treat
    4a. Filtration, Air Stripping and Precipitation/Flocculation
    4b. Filtration, Carbon Adsorption and Precipitation/Flocculation
    4c. Filtration, UV/H_2O_2 and Precipitation/Flocculation
5. In situ Biorestoration

2.2.5 Screening of Alternatives

The assessment of each alternative was based on the same evaluation criteria (Effectiveness and Implementability) as used for screening the technologies described previously in Section 2.2.3. The selected alternatives can be implemented with the understanding that comprehensive design studies and remediation planning will be required to comply with the ARAR's and address public health and safety.

2.2.5.1 Evaluation of Alternative 1 (No Action) - Remedial action alternative number 1 was selected for a detailed analysis (Section 3.0) so that it may be used as a baseline for comparative analysis of the risk and cost associated with other alternatives. Although there is no capital cost for this alternative, the future cost of liabilities associated with the exposure risks are unknown.

2.2.5.2 Evaluation of Alternative 2 (Institutional Control) - Institutional controls, such as further monitoring and deed restrictions do not mitigate the contamination or comply with ARARs. However, this alternative was selected for a detailed analysis because if further assessment at DDMT indicates that the contamination within the Fluvial aquifer is adequately contained, then monitoring may prove to be a viable alternative to remediation.

2.2.5.3 Evaluation of Alternative 3 (Hydraulic Barriers) - A Hydraulic Barrier could be established along the western and northern perimeters of Dunn Field by installing extraction wells. However, since the contaminant plume has already migrated west and north of DDMT boundaries this would not be an effective alternative. Therefore, as a remedial action alternative, a Hydraulic Barrier will not be considered in a detailed analysis (Section 3.0). However, a hydraulic barrier could be considered as a subset of a pump-and-treat system.

2.2.5.4 Evaluation of Alternative 4 (Pump and Treat) - The pumping of contaminated ground water will require using Deep Wells as discussed in Section 2.2.3.4.1. Three post-extraction treatment alternatives have been developed for the type of contaminants detected at DDMT. The treatment technologies include Air Stripping, Activated Carbon Adsorption and UV/H_2O_2.

Each treatment technology requires the removal of suspended solids prior to treatment. Filtration of the ground water was selected as the most effective technology since it will produce the least amount of treatment waste (sludge). Analysis of ground water for the dissolved metal component will determine if a Precipitation/Flocculation pretreatment will be necessary.

Even though the selected treatment technologies will not fully remediate the subsurface environment in Dunn Field, they provide the most effective means available. Of the three technologies selected, only the UV/H_2O_2 method will destroy the organic contaminants. Although Air Stripping and Carbon Adsorption technologies are less expensive to install and operate than UV/H_2O_2, and are as effective in reducing organic contaminant levels, they produce wastes that must be further treated. These additional treatment costs can equal or exceed the operating costs of UV/H_2O_2 technology. Therefore, Air Stripping and Carbon Adsorption have not been selected for a detailed analysis.

2.2.5.5 Evaluation of Alternative 5 (In Situ Biorestoration) - The contaminants detected at DDMT (chlorinated volatile organics) are not currently well suited for this technology. However, considering the rapid advancements in the technology, it may need to be reconsidered for use when site remediation goals have been more thoroughly defined.

2.2.5.6 Selection of Alternatives

Based on the information presented in the screening and evaluation of the remedial action alternatives, the following have been selected for detailed analysis (Section 3.0):

1) No Action
2) Institutional Control
3) Source Containment (Capping)
4) Pump and Treat
    Filtration-Precipitation/Flocculation -
    UV/H_2O_2

2.3 SURFACE SOILS

2.3.1 Remedial Action Objectives for Surface Soils

The primary remedial action objective for surface soils is the protection of human health and the environment. This requires the prevention of ingestion and direct contact with soils having contaminant levels exceeding the target levels that were determined in the risk assessment (Section 1.0). A secondary remedial action objective is to limit the potential effect that surface soil contamination might have on surface water run-off. A third remedial action objective is to prevent migration of contaminants from the surface soils to the ground water.

2.3.2 General Response Actions for Surface Soils

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

- No action
- Institutional controls
- Excavation and on-site treatment
- In situ treatment
- Excavation and off-site treatment/disposal
- Excavation and off-site disposal

Excavation of contaminated soils at DDMT may require compliance with RCRA's Land Disposal Restrictions (LDR) regulations. These regulations apply to soils transported off-site for disposal, and may apply to some forms of on-site treatment and replacement. The regulations are generally based on the generation process for each contaminant. Contaminated soils which 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. In order to categorize the waste at DDMT as "Listed Wastes", a thorough and time consuming examination of the records (waste manifests) would have to be performed by base personnel. If the contaminants detected in the RI can be identified from any of these records the wastes will be considered as "Listed".

Contaminated soils which can not be "Listed" are evaluated on the basis of their "Characteristics" (ignitability, corrosivity, reactivity and toxicity). For soils, this basically means their toxicity, as currently defined by the EP-toxicity and soon to be redefined by the TCLP tests (September, 1990). Soils which are above the toxicity standards are defined as "Characteristic Waste". These soils would have to be treated to below their characteristic level before land disposal.

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 (HOC's). These soils would have to be treated to below the California List for total HOC's (1,000 mg/kg) before land disposal. Clean-up levels should be negotiated between DDMT, the Regional and State RCRA office, and the Superfund Enforcement Personnel. As previously discussed, health based target levels may be impossible to reach. Moreover, regulatory based levels may be more applicable at DDMT.

2.3.3 Identification and Screening of Technologies - Surface Soils

The technologies that are potentially applicable to soil and sediment remediation DDMT are listed on Table 2-2. Each technology, and the related process options, were evaluated and screened using the criteria listed in Section 2.1.

2.3.3.1 Institutional Controls

2.3.3.1.1 Description - Using institutional controls as a remedial technology at DDMT could involve the following actions:

1) Installation of fences around the areas of contamination
2) Posting of potential health hazards
3) Controlling the access to each site through security measures
4) Worker training on potential health hazards and safety procedures

TABLE 2-2
SCREENING TECHNOLOGIES FOR REMEDIAL ACTION APPLICABLE TO SOILS AND SEDIMENTS
DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
No Action	None	None	Leave site as is.	Contamination is not mitigated.	Does not comply with ARARs	NA	NA	Yes
Institutional Actions	Access Control	Site Restrictions	Install fences, monitor site conditions, control access through security measures. Seeding grass to prevent fugitive dust.	Contamination is not mitigated.	Only partially effective, remediation may be required later. Does not comply with ARARs.	Fairly Easily Implemented	Low	Yes
Remove and Backfill	None	Off-Site Treatment and Disposal	Excavate and containerize contaminated soil. Transport to a RCRA level C disposal site. Contaminants must be either listed or characterized prior to transport.	Pretreatment of soils to prevent fugitive dust. Further sampling to define limits of contamination.	Very effective	Easily Implemented	High	Yes
		Off-Site Disposal (No Treatment)	Same as above.	Same as above, can only landfill if no characteristics are determined	Effective based on compliance with LDR	May not be possible due to Land-Ban Restrictions	Moderate	Yes
On Site or In Situ Treatment	Thermal Destruction	Fluidized Bed Incineration	Combustion in a bed of highly agitated inert material with solids injected directly into the bed. Soils can act as the bed. Requires excavation and transport of soil unless done on site. Requires fuel supply and electricity.	Metal contamination may result in toxic air pollutants. Applicable to organic compounds.	Highly effective on organic materials only. Not effective for metals.	Implementation May Not Be Possible Due to Urban Setting	Moderate to High	No
		Rotary Kiln Incineration	Slightly inclined refractory line cylinders with soils injected into the high end and passed through the combustion chamber as the cylinder rotates.	Same as Above	Same as Above	Same as Above	Same as Above	No
		Infrared Thermal Treatment	Uses silicon carbide elements to generate thermal radiation. Materials for treatment are exposed on a conveyor.	Same as Above	Same as Above	Same as Above	Same as Above	No

TABLE 2-2 (Continued)
SCREENING TECHNOLOGIES FOR REMEDIAL ACTION APPLICABLE TO SOILS AND SEDIMENTS
DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
		Pyrolysis Incineration	High temperature destruction in an oxygen reduced or oxygen free atmosphere to separate organic fractions as gas and inorganic fractions as solids.	Applicable to organics but not to metals. Requires high voltage.	Same as above	Same as Above	Same as Above	No
		Vitrification Plant	Thermal destruction to transform physical and chemical characteristics of material. Some containments would volatilize and must be trapped, others would become immobilized in a vitreous or glass-like solid.	Complete stabilization of contaminants is possible. Requires a lot of power at high voltage on site.	Immobilizes Contamination	Same as Above	High	No
		In Situ Vitrification	Melting of wastes: low moisture soils, in place to bind the material in a vitreous or glass-like solid.	Contamination is not disturbed. Requires high voltage.	Same as Above	Fairly Easy to Implement	High	No
	Physical Treatment	Low Temperature Thermal Stripping	Contaminated soils are passed through a pug mill equipped with heat transfer surfaces. An induced airflow conveys the desorbed volatile organic/air mixture through a carbon absorption unit.	Does not destroy contamination, only volatilizes organics.	Effective for volatile organics. Not effective on metals or low volatility metals.	Fairly easy to implement	Moderate	No
		Critical Fluid Solvent Extraction	Same as above but liquefied gases at high pressures are used as the extraction agent.	Same as above	Same as Above	Same as Above	Same as Above	No
		Soil Washing	Extracts contaminants from soils using a liquid medium such as water, water/surfactant, acid or bases as the washing solution.	Can handle all contaminants, method modified to suit constituents and soil types.	Generally Effective, May not achieve low cleanup levels.	Fairly easy to Implement	Moderate	Yes

TABLE 2-2 (Continued)
SCREENING TECHNOLOGIES FOR REMEDIAL ACTION APPLICABLE TO SOILS AND SEDIMENTS
DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
		In Situ Soil Flushing	Injection of solvents or surfactant solution to enhance contaminant solubility. Ground water extraction/reinjection is then utilized to recover and treat dissolved contaminants.	Same as above generally used for subsurface soil remediation Does not achieve remediation goals.	Not effective for surfacesoils at DDMT.	Can be implemented in conjunction with ground water remediation if subsurface soil contamination is targeted for remediation.	Moderate	No
	Chemical	Chemical Extraction (Best basic extraction sludge treatment)	Separates contaminant wastes into respective phase fractions by extracting organics absorbed on the particles and filtering or centrifuging resulting mixtures.	Solid waste must be pretreated generally increasing volume. Does not achieve remediation goals.	Is not effective for heavy metals.	May Be Very Difficult to Implement	Moderate	No
		In Situ Chemical Treatment	Treatment of soils in place, remediation agents are added to and mixed with soils	Not effective for non-halogenated semi-volatiles.	Not effective for the contaminants of concern.	Same as Above	Same as Above	No
		In Situ Stabilization Solidification	Stabilization agents are added to and mixed with soils using drilling techniques to precipitate, neutralize, and stabilize the contaminants.	Need additional contamination characterization but is potentially applicable	Potentially effective to immobilize waste.	May Be Difficult to Implement	Moderate	No
		Above ground stabilization/ solidification	Same as above except soil is excavated and stabilized in a vessel. After stabilizin may be transported to landfill.	Organics may cause poor stabilization.	Very Effective for Metal	Easily Implemented	Low	Yes
	Bioreclamation	In situ Bioreclamation	Injection of nutrients into soils to promote biological breakdown of soils.	Chlorinated compounds difficult to breakdown, range of constituents presents additional problems. TCLP of stabilized blocks must be performed and no leachate criteria exceeded prior to landfilling	Effective only for some of the contaminants	Difficult to Implement	Moderate	No

TABLE 2-2 (Continued)
SCREENING TECHNOLOGIES FOR REMEDIAL ACTION APPLICABLE TO SOILS AND SEDIMENTS
DEFENSE DEPOT, MEMPHIS, TENNESSEE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments	Effectiveness	Implementability	Cost	Retain For Further Consideration
		Composting	Stacking compost (highly biodegradable material + 10% soil into elongated piles).	Potentially applicable, leachate needs to be collected and treated, requires excavation. Odor nuisance, requires excavation. Solute fraction of metals may kill bugs.	Effective only for some of the contaminants	Easily Implemented	Moderate	No
		Slurry-Phase Treatment	Treating soil in large mobile bioreactor using aerobic or anaerobic microorganisms.	Heavy metals and chloride inhibit the operation.	May be very effective or contaminants other than metals	Fairly Easily Implemented	Moderate	Yes
		Solid-Phase Treatment	Treatment in above-grade, lined beds with overhead irrigation of Nutrients.	Not applicable to inorganics found at site, leachate needs to be contained and treated. Requires air emission collection and treatment.	Same as Above	Not Readily Implementable	Moderate	No
		Landfarming	Spreading soils on grade-level parcel (unlined).	Potentially applicable, leachate may seep into ground water.	Same as Above	Leachate Requires Management	Low to Moderate	No

5) Seeding the contaminated areas with grass to prevent fugitive dust.

2.3.3.1.2 Evaluation - Based on the health risk determined for each site the use of the actions listed above may prove to be an effective way of addressing the remedial action objective. For example, some of the areas (DRMR Yard) where contamination was detected could be fenced off and access limited.

This technology would not comply with ARAR's or other applicable clean-up goals. However, it could be an effective method of meeting the remedial action objective of limiting worker contact with contaminated soils.

2.3.3.2 Excavation and Off-Site Treatment and Disposal

2.3.3.2.1 Description - This technology involves excavation of site soils and transportation to an appropriate RCRA disposal facility. Based on constituent make up, the facility may be able to either dispose of the material directly, or treat the soil prior to disposal.

2.3.3.2.2 Evaluation - This technology effectively removes site contamination and transports it to a secure disposal facility. The cost of the option is determined by what treatment is required. Due to final implementation of the RCRA Land Disposal Restrictions, these costs are escalating. Thus, this technology is applicable for small remediations, but could lead to prohibitive costs for larger removals. This technology has been retained for incorporation into a remedial action alternative since the volume of contaminated soil is unknown.

2.3.3.3 On-Site or In Situ Thermal Treatment Technologies

All of the on-site thermal technologies included on Table 2-2 would provide some level of remediation for the contaminated soils at DDMT. However, the high levels of metal contamination would not be reduced by thermal treatment. In some cases the metals may cause toxic emissions to be generated during treatments. In addition to the emission problems, permitting would be a problem since DDMT is located in an urban area. Following treatment, the metals and ash will have to be stabilized prior to landfilling. None of the on-site thermal technologies will be retained for further incorporation into remedial action alternatives due to the problems associated with each process option and the types of contamination detected in the soils at DDMT. A brief description of each option has been included for reference. After further characterization of soil contamination this technology may need to be investigated.

2.3.3.3.1 Description - Each of the readily available and potentially applicable thermal treatment technologies are presented in the following paragraphs.

Fluidized-Bed Incineration - There are two types of fluidized-bed incinerators: circulatory bed and bubbling bed. In a bubbling bed, the flow of fluidizing gases is kept low to minimize entrainment of solids. In a circulatory bed, the flow of fluidizing gases is high enough to cause some entrainment of bed materials back to the bed. The soil is stirred, or fluidized, by passing an oxidizer up through the bed. The oxidizer is usually air, although it can be pure oxygen or nitric oxide depending on the type of combustion required. As the unit operates, solids are added to the volume of the bed then bled down to maintain a constant volume and consistency. In a unit primarily handling liquid, additional bed material would be required to maintain the proper bed characteristics. During a treatability study air emissions would have to be monitored since acidic exhaust is often associated with this option. Limestone, added to the bed, has been shown to effectively control acid gas emissions.

Operating temperatures are in the range of 840° F to 1800° F. To achieve temperatures above 1550° F, the waste must have a minimum heating value of 4500 Btu/lb or additional fuel must be supplemented.

Fluidized-bed technology has several primary advantages. The combustion design is fairly simple, compact, efficient and its maintenance cost is low. Comparatively low gas temperatures and air requirements minimize the formation of nitric oxide. In some cases, the bed can contain lime or other material to chemically react with the products of combustion and reduce acid gases. The bed mass provides a large surface area for reaction and combustion with relatively uniform temperatures.

Inorganic wastes cannot be treated by this technology and certain organic wastes will cause the bed to agglomerate.

Rotary Kiln Incineration - Rotary Kiln Incinerators can process solids that have no heating value. Solids may be fed in compacted or loose by either a bucket elevator or a conveyor system. The temperature of operation can range from approximately 1500° F to 2000° F. The temperature of operation is based upon the characteristics of the wastes, and the time the material and its offgases remain in the incinerator.

There are two options for the application of this technology. They are co-current flow or counter-current flow. The choice of flow direction is based upon the waste characteristics.

A secondary combustion system operating at 2000° F or greater is placed in sequence after the rotary kiln incinerator to finalize waste destruction. Rotary kilns are capable of being operated in a pyrolytic or low oxygen mode if needed. Ash and residue can be discharged either directly from the drum of the kiln or after being passed to the secondary combustion chamber. Acid gases and combustion end-products can be treated by the injection of lime or caustic soda with the feed or in the air pollution control system. Inorganic hazardous constituents must be further treated after passing through the incinerator, since this system will not detoxify them.

The advantages of rotary kiln incineration are its ability to handle varieties of waste simultaneously, to achieve a high operating temperature, and to achieve a gentle and continuous mixing of wastes.

Infrared Treatment - Infrared thermal treatment involves the introduction of waste at one end of a long chamber for processing by high temperatures generated through electricity. The infrared radiation comes from silicon carbide elements positioned over a conveyor. The waste is stirred by moving past stationary paddles and subjected to high energy radiation which causes breakdown of organic materials. While similar to incineration, the gas evolution is low compared with other incinerators due to the lack of a supplemental fuel supply. The resulting gases are burned in a secondary combustion chamber similar to that used for the rotary kiln process.

Pyrolytic Incineration - Pyrolysis involves the destruction of organic material in the absence of oxygen at a high temperature to reduce toxic organic constituents to elemental gas and water. The absence of oxygen allows separation of the waste into an organic fraction (gas) and an inorganic fraction (salts, metals and particulates) as char material. The process conditions range from pure heating (thermolysis) to conditions in which only slightly less than the theoretical (stoichiometric) air quantity is supplied. Gases and ashes are the principle products generated by the pyrolytic reaction.

The pyrolytic incineration process is a two-step process. In the first step, waste material is decomposed at 1000° to 1400° F into an organic gaseous fraction and an inorganic solid fraction in the absence of air. In the second step, the organic fraction is fed into a high-temperature, direct-fired incinerator operated at 2200° F, where hazardous elements from the organic fraction are destroyed and the clean, decontaminated gases are sent to an energy recovery device.

Plant Vitrification - This process converts waste into inert, glass-like material. While primarily intended to dispose of inorganic, non-combustible wastes, the vitrification process can handle some wastes with organic constituents.

The process equipment system consists of a long enclosed chamber with a pool of glass kept at above 2300° F by use of electrical heaters immersed in the glass. Inorganic and non-combustible solids enter the feed end and fall into the pool of glass; the waste then vitrifies and becomes part of the glass. As waste material is fed in, vitrified material is drawn off at the other end to maintain the internal liquid glass levels. In some cases, glass must be introduced with the waste to control the composition of the vitrified material.

Sufficient oxygen is kept over the pool of glass so that any combustible material can be completely burned. If the waste feed contains any combustible liquid, it evaporates and burns over the pool. Residues that do no exit with the combustion gases fall into the pool. Water contained in the waste feed evaporates and leaves the glass chamber with the gaseous combustion products. These gases are treated using air pollution control equipment for acid gas and particulates such as a bag house and scrubber.

Drawn off material can be molded into blocks or made into granular form as it exits from the equipment. The resultant glass-like material is stable and practically inert.

The advantages of plant vitrification are 1) waste toxicity and mobility can be reduced significantly, specifically metals which are not treated with other thermal methods are immobilized; and 2) the residual waste might be disposed of as non-hazardous material or recycled.

In Situ Vitrification - In situ vitrification is similar to the plant vitrification technology discussed above, except that the waste is not excavated. Operating temperatures are produced by placing electrodes in the ground and running high voltage currents through the waste material. Electrode spacing and depths are adjusted for the required temperatures and desired coverage. During processing, a hood is placed over the treated area and off-gases treated with appropriate equipment. The process starts with a bed of conductive material on the ground surface that is started vitrifying by the electrodes. The reactive layer moves downward and slightly outward during processing until the desired depth is achieved. The end-product is a vitreous or glass-like material in the ground. The in situ vitrification process typically offers less control of the generated gases and final composition of the glass. Also, while the plant vitrification is a continuous process, in situ vitrification can be a batch process involving set-up and placing of electrodes and processing.

2.3.3.3.2 Evaluation - The advantages of thermal technologies are 1) their ability to remediate heterogenous waste in a relatively short time, and 2) their effectiveness at destroying volatiles, semi-volatiles and pesticides.

The disadvantages to the incineration technologies are their ineffectiveness at treating metals, the difficulty associated with obtaining a permit for on-site use, the contaminated ash must be stabilized prior to disposing of (landfilled) and toxic air pollutants must be avoided. In addition, the high set-up cost involved with most operations requires a large volume of soil to be economical. Because DDMT is in an urban setting, and because metals contamination is present at most sites, these treatment options are not considered applicable.

2.3.3.4 On-Site or In Situ Physical/Chemical Technologies

2.3.3.4.1 Description - This section describes the applications and restrictions of physical/chemical treatment technologies for the remediation of contaminated soils at DDMT. Physical treatment processes separate the waste stream by either applying physical force or changing the physical form of the waste. Thus, they typically result in concentrating the waste into a small volume of highly concentrated constituents rather than the original large volume of low concentration material. Chemical treatment is often used to aid the physical processes. The chemical treatment processes may also alter the chemical structure of the constituents to produce a waste residue that is less hazardous than the original waste. Thus, physical and chemical processes are discussed together.

Treatment sludges from any of the chemical/physical processes may require additional treatment either on site or off site prior to disposal. Treatment needed may include dewatering (and subsequent treatment of water) and immobilization. Solid residuals must be disposed of off-site at a RCRA Facility.

The following paragraphs contain information on individual process options.

Chemical Extraction - Chemical extraction processes are used to separate contaminated soils into their respective phase fractions: organics, water and particulate solids. One demonstrated process, Basic Extraction Sludge Treatment (BEST), has been used primarily to treat oily sludges containing hydrocarbons and organics of high molecular weight. Generally, this process is suited for wastes containing greater than 200 ppm of organics and oil concentration up to 40%, but is not appropriate for materials containing heavy metals.

In Situ Chemical Treatment - In situ chemical treatment allows treatment of contaminated soils and waste deposits in place. By using this treatment method a wide range of treatment agents, including solvents, precipitating, neutralizing, oxidizing and reducing chemicals, and stabilizing agents. These processes involve dispensing of remediation agents to the desired depth. These treatments can selectively treat metal and organic contamination. However, the processes are difficult to control and would be difficult to implement due to the variety of constituents present at DDMT. In situ treatment would also contribute to ground-water contamination at the site. For these reasons this option is not included as a remedial alternative.

Soil Washing - The soil washing process extracts contaminants from the soil matrix using a liquid medium such as water as the washing solution. This process is used on excavated soils that are fed into a washing unit. The washing fluid may be composed of water, organic solvents, water/chelating agents, water/surfactants, acids or bases, depending on the contaminant to be removed.

A typical soil washing system operates in the following way: Contaminated soil enters the system on either a batch or a continuous basis, and is fed through a feeder, where oversized non-soil material and debris that cannot be treated are removed with a coarse screen. The waste passes into a soil scrubber, where it is sprayed with washing fluid. Soil particles greater than approximately 2 mm in diameter are sorted and rinsed, leave the scrubber, and are dewatered. The remaining soil enters a countercurrent chemical extractor, where additional washing fluid is passed countercurrent to the soil flow, removing the contaminants. The treated solids are then dewatered. The remainder of the process is a multistep treatment for removal of contaminants from the washing fluid prior to its recycling. Treatment is generally accomplished by conventional waste-water treatment systems depending on the types of contamination.

The advantage of a soil washing system is that it can remove all types of contamination. Fine soil particles and highly adsorptive constituents require additional washing solutions and effort. A batch system can be mobilized economically to handle small to moderate volumes of soil. For larger volumes a continuous system can be installed. Soil washing has been retained as a viable option for on-site soil remediation at DDMT.

In Situ Soil Flushing - In-situ soil flushing is a process applied to unexcavated soils using a ground water reinjection/extraction system. In situ soil flushing consists of injection of a solvent or surfactant solution (or water) to enhance the contaminant solubility, which results in increased recovery of contaminants in the leachate or ground water. In EPA test studies, the system has not shown to be effective. In addition, because it involves injecting other constituents into the ground, further ground-water contamination is likely. Based on this information in situ soil flushing has not been retained for further investigation.

Low Temperature Thermal Stripping - The low temperature thermal stripping system employs a process in which solids with organic contamination are heated in the presence of water, driving off the water and organic contaminants and producing a dry solid containing trace amounts of the organic residue. The contaminated solids are fed by auger or pump into the dryer and heated to 500-800° F. An inert nitrogen carrier gas transports the volatilized water and organics to the off-gas handling system, a three-stage cooling and condensing rain which condenses organics of low, intermediate and high volatility in a step-wise fashion. This system is particularly applicable for high to moderate volatile constituents, such as petroleum products. Since only low levels of volatile compounds were detected in the soils at DDMT, this is not an effective option.

<u>Stabilization/Solidification</u> - Stabilization can be performed in situ or in tanks. In situ stabilization allows direct application of stabilizing agents, mixing paddles and augers can be utilized for deep soils. Common construction equipment such as a backhoe or front end loader can be used to mix shallow soils with reagents. At the end of the treatment, a treated block of soil or a continuous stabilized mass is left behind.

The equipment used for tank stabilization is similar to that used for cement mixing and handling. It includes a feed system, mixing vessels, and a curing area.

Whether in ground or in tanks, stabilization facilitates a chemical and/or physical reduction of the mobility of hazardous constituents. Heavy metals, semi-volatiles, pesticides, PCBs and nonvolatile organics may be treated successfully. Mobility is reduced through the binding of hazardous constituents into a solid mass with low permeability that resists leaching. The actual mechanism of binding depends on the type of stabilization process. The processes can be categorized by the primary stabilizing agent used: cement-based, pozzolanic-based or silicate-based, thermoplastic-based, or organic polymer-based.

Critical parameters in stabilization treatment include selection of stabilizing agents and other additives, the waste-to-additive ratio, mixing and curing conditions. All of these parameters are dependent on the chemical and physical characteristics of the waste. Bench-scale treatability tests should be conducted to select the proper additives and their ratios and to determine the curing time required to set the waste adequately. Leaching tests (TCLP) and compressive strength tests should be conducted to determine the integrity of the solid end product.

The advantage of a stabilization system, in addition to its economy, is its applicability to a wide range of wastes. It is used primarily to reduce leachability.

Due to implementation problems and cost, in situ stabilization is not the most viable remedial option. However, surface stabilization provides an effective, easily implemented and relatively inexpensive method for remediation. The post-stabilization material must pass the TCLP test for the type of wastes contained ("Listed" or "Characterized") prior to landfilling.

2.3.3.4.2 Evaluation - An evaluation of each of the physical/chemical options discussed above result in the selection of solidification as the most applicable remedial technology. Both in situ and tank solidification options have been proven to be effective for the type of contaminants detected at DDMT.

Solidification is an effective and economic option that will meet the remedial action objectives (protect health and environment, reduce mobility and prevent leachate). Mobile systems are readily available and can be easily implemented at DDMT.

2.3.3.5 Biological Treatment Technologies

2.3.3.5.1 Description - Waste utilized by microorganisms as a food source to sustain growth is the basis of biodegradation (or biorestoration). Biodegradation can be an effective way of reducing toxic constituents to harmless basic elements. Contaminated soils can be biologically treated in situ or excavated and treated by solid-phase and slurry-phase bioremediation processes.

For in situ use, naturally occurring organisms are typically used. For above ground, controlled application such as in a reactor, acclimated genetically engineered microorganisms can be used. Biorestoration is accomplished by adding a supply of nutrients to the soil to promote microorganism growth. Each of the process options are discussed below.

In Situ Biodegradation - In situ biodegradation uses indigenous, introduced aerobic or anaerobic bacteria to biodegrade organic compounds in soils. The technology involves enhancing the natural biodegradation process by injecting nutrients (i.e., phosphorus, nitrogen, etc.), oxygen and/or cultured bacterial strains. In some cases it may be necessary to adjust environmental parameters such as soil pH and temperature. A major limitation of an in situ system is the difficulty in delivery of nutrients. The nutrient carrying matrix (such as water or air) may preferentially travel through more previous zones while the contamination may remain locked in the less pervious zones.

In situ biodegradation is predominantly used for subsurface soil remediation in conjunction with ground water pumping and reinjection systems to circulate nutrients and oxygen through a contaminated aquifer and associated soils. This technology is not suitable for remediation of surface soils and/or soils contaminated with heavy metals. Heavy metal contamination will destroy the microorganisms before biodegradation can take place.

Composting - Composting involves the storage of highly biodegradable and structurally firm material (e.g., chopped hay, wood chips, etc.) with a small percentage (<10%) of biodegradable waste. Adequate aeration, optimum temperature, moisture and nutrient content and the presence of an appropriate microbial population are necessary to enhance decomposition of organic compounds.

There are three basic types of composting: open windrow systems, static windrow systems and in-vessel (reactor) systems. The open windrow system consists of stacking the compost into elongated piles. Aeration is accomplished by tearing down and rebuilding the piles. The static windrow system also involves long piles of compost. However, the piles are aerated by a forced air system; i.e., the piles are built on top of a grid of perforated pipes. Finally, the in-vessel system involves placing the compost into an enclosed reactor. Aeration is accomplished by tumbling, stirring and forced aeration.

When treating wastes, it is necessary to collect and treat leachate and runoff water from the composting beds. As mentioned previously the heavy metal contamination will destroy the microorganisms. Pretreatment of the soils (fixation of metals) can be done to increase the effectiveness. In addition to the metals, pesticides have not been successfully reduced in biorestoration studies.

Slurry-Phase Treatment - The slurry-phase technology involves the treatment of contaminated soil in a large mobile bioreactor. This system maintains intimate mixing and contact of microorganisms with the hazardous compounds and creates the appropriate environmental conditions for optimizing microbial biodegradation of target contaminants.

The first step in the treatment process is to create the aqueous slurry. During this step stones and rubble are physically separated from the waste, and the waste is mixed with water if necessary to obtain the appropriate slurry density. A typical soil slurry contains about 50% solids by weight. The actual percentage of solids is determined ~~in the laboratory~~ based on the concentration of contaminants, the rate of biodegradation, and the physical nature of the waste. The slurry is mechanically agitated in a reactor vessel to keep the solids suspended and maintain the appropriate environmental conditions. Inorganic and organic nutrients, oxygen and acid or alkali for pH control may be added to maintain optimum conditions. Microorganisms may be added initially to seed the bioreactor or added continuously to maintain the correct concentration of biomass. The residence time in the bioreactor varies with the nature of soil and the contaminants involved. Once biodegradation of the contaminants is completed, the treated slurry is dewatered. The residual water may require further treatment prior to disposal.

An advantage of treatment in a contained process is that a remediation system can be designed to pretreat waste contaminated with heavy metals as well as biodegradable semi-volatile and volatile compounds. Soil washing and extraction of metals using weak acids and chelating agents can be combined with biological treatment by coupling two separate slurry-phase reactors in series.

<u>Solid-Phase Treatment</u> - Solid-phase soil bioremediation is a process that treats soils in an above grade system using conventional soil management practices to enhance the microbial degradation of contaminants. The system can be designed to contain and treat soil leachate and volatile organic compounds.

The system consists of a treatment bed lined with a high-density liner and covered with clean sand. The contaminated soils are placed on the treatment bed. Lateral perforated drainage pipe is placed on top of the liner to collect soil leachate. Leachate draining from the soil is transported by the drain pipes and collected in a gravity-flow lined sump and then pumped to an on-site bioreactor for treatment. Treated leachate can then be used as a source of microbial inocula and reapplied to the soil treatment bed through an overhead irrigation system, after adjusting for nutrients and other environmental parameters.

As in the slurry-phase treatment the soils must be pretreated to stabilize or remove the heavy metals.

Landfarming - Landfarming as a biological treatment technology is similar to the solid-phase treatment except that contaminated soils or waste are placed on the ground instead of a lined surface. Landfarming can be performed at different depths in order to obtain the maximum reduction of contaminants by the available soil microorganisms. The potential for soil and ground-water contamination could be created by not using a liner.

2.3.3.5.2 Evaluation - Biorestoration can be an effective remediation method for contaminated soils if used in conjunction with other process options. Pretreatment of DDMT soils will be required to remove or fix the heavy metals. This option could be utilized if bench or pilot scale soil washing tests show it capable of obtaining site clean-up goals.

2.3.4 Development of Alternatives

The screened technologies were combined to develop site-specific remedial action alternatives that address the remedial action objectives (protection of human health and environment and reduce the potential transport of contaminants to other media). The exposure pathways (inhalation and dermal contact) and receptors (employees working at DDMT and surrounding residents) were considered in developing the remedial alternatives. Alternatives were selected that could mitigate the potential risks identified in the Risk Assessment (Section 6.0 of the RI Report).

Four alternatives were developed that could potentially fulfill the remedial action objects. All of the alternatives listed below (except No Action) will require further assessment to determine the full extent of surface soil contamination. RCRA Land Disposal Regulations will become an ARAR if excavation of the soils at DDMT occurs (Section 2.3.2). If the contaminants cannot be traced to a "Listed" waste they must be "Characterized" (TPCL) before clean-up levels or disposal levels can be established. The following alternatives have been assembled for screening:

1. No action
2. Institution control
3. Excavation / on-site treatment / off-site disposal
    - 3a. soil washing/slurry-phase bioreactor
    - 3b. stabilization
4. Excavation / off-site treatment / off-site disposal

2.3.5 Screening of Alternatives

The assessment of each alternative was based on the same evaluation criteria (Effectiveness and Implementability) as was used for screening the technologies described in Section 2.3.3. The selected alternatives can be implemented with the understanding that comprehensive treatability and pilot scale studies will be required to comply with ARARs and address public health and safety.

2.3.5.1 Evaluation of Alternative 1 (No Action) - A no action alternative is selected for detailed analysis (Section 3.0) so that it may be used as a baseline for comparative analysis of the risk and cost associated with other alternatives. Although there is no capital cost involved with this alternative, the future costs of liabilities associated with exposure risks are unknown.

2.3.5.2 Evaluation of Alternative 2 (Institutional Control) - Institutional controls, such as limiting access and seeding areas with grass, do not mitigate the contamination. This alternative was selected for a detailed analysis since it could potentially reduce health risk associated with soil contamination. However, this alternative will do little to reduce environmental risks or hinder contaminant migration to surface water and ground water.

2.3.5.3 Evaluation of Alternative 3 (Excavation/On-site Treatment) To fully address the remedial action objectives the contaminated soils will have to be excavated and treated. This alternative contains two technologies that could be conducted on-site. The technologies selected are: (1) Soil washing combined with a bioreactor and (2) Stabilization. Both technologies have potential to successfully address the remedial action objectives.

Using either of the technologies, treatment wastes will be produced which will require further disposal. Stabilization will produce a larger volume resultant than soil washing. However, if the stabilized material can be shown, through TCLP methods, not to produce a leachate it can be disposed of in a sanitary landfill. The soils washing residue must be disposed of at a Level C, RCRA Facility (hazardous waste landfill).

Soil washing, although potentially effective, would be difficult to implement. This process will require the following steps:

1. Excavation of soil
2. Crushing and coarse screening of the soil
3. Washing the soils (the numerous contaminants and fine-grained nature of the DDMT soils could require numerous washing steps and various washing additives)
4. Mixing in bioreactor for a determined period of time

5. Analyzing the product to determine if reduction in contamination is sufficient
6. Treatment of waste sludge
7. Off-site disposal of treatment products to a Level C, RCRA Facility.

Stabilization would reduce the mobility and provide an effective, easily implemented and cost effective alternative for soil remediation. The stabilization process requires the following steps:

1. Excavation of soil
2. Crushing and mixing of soil
3. Mixing with stabilizers
4. Analyzing the product for leachate
5. Off-site disposal to a sanitary landfill

Since both technologies would be effective, the implementability of each becomes the deciding criteria. As can be seen from the above discussion, the Stabilization process is much easier to implement than Soil Washing. For this reason, Stabilization was selected for a detailed evaluation (Section 3.0).

2.3.5.4 Evaluation of Alternative 4 (Excavation/Off-site Treatment) - This alternative provides an effective and easily implemented option for remediation of soil contamination. However, the complicated contaminants detected at DDMT may make this alternative cost-prohibitive if large volumes of soils are involved. However, the final decision as to the viability of this alternative will depend on the amount of soil that must be treated. For this reason this alternative has been selected for a detailed analysis (Section 3.0).

2.3.5.5 Selection of Alternatives - Based on the information provided in the screening and evaluation of alternatives the following have been selected for detailed analysis (Section 3.0):

1. No Action
2. Institutional Control
3. Excavation/On-Site Treatment/Off-Site Disposal
4. Excavation/Off-Site Treatment/Off-Site Disposal

2.4 LAKE DANIELSON

2.4.1 Remedial Action Objectives for Lake Danielson

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 ecology (particularly the fish) within the Lake. Lake Danielson is currently under restricted access (no fishing). The installation wishes to increase the utility of these two surface water bodies, specifically by allowing activities such as picnicking, and potentially fishing. No significant contamination was detected in the surface water within the lake and pond or from storm water entering the lake. However, water quality could be affected by short-term increases in contaminant levels as the result of peak storm events. Although surface water contamination was not detected, its condition during storm events could be a key element in remediation of the lake and pond.

Sediment contamination was detected in Lake Danielson and the golf course pond. PAH, pesticide and metal contamination was significantly higher in the pond than levels detected in the lake.

Three general areas of attainment must be addressed in developing remediation alternatives for the Lake Danielson area. These include: 1) surface water, 2) sediments and 3) the present storm water drainage system that supplies the lake and pond.

2.4.2 General Response Actions for Lake Danielson

General response actions were developed for the three areas in developing remedial alternatives for the Lake Danielson area. These actions include:

- No Action
- Institutional Control
- Storm Water Drainage Diversion or Treatment
- Establish Aquatic Vegetation for Sediment
- Lake Abandonment with Contaminated Sediment Removed

2.4.3 Applicable Technologies for Lake Danielson

The restrictions currently in force at the lake and pond constitute institutional control. These include fishing, swimming and boating restrictions. An additional institutional control measure which could be implemented is continued water quality monitoring, particularly of storm water entering the lake. Samples should be collected at the inlet drain to Lake Danielson during and immediately after a rain has occurred. Water samples should also be collected within the lake itself at these times. If possible, water samples collected immediately after a fish kill would also be useful. This data could be utilized in a further ecological study of the lake to determine the cause of the "fish kills" that have occurred.

An alternative that was considered was to divert storm water to the ground-water treatment system in Dunn Field (Section 2.2.3.4).

However, due to the different type of contaminants in the two media (ground water vs. surface water) this alternative may not be an effective remedial action.

Another alternative would be to plant appropriate aquatic vegetation to stabilize the sediments in the lake, thus reducing the potential for release of contamination from the sediments into the water column.

The lake and pond act as sedimentation ponds for a portion of the base drainage system. As such, contamination released from those drainage areas may tend to accumulate in the lake and pond. Based on this, another alternative is to abandon these facilities. This could be done by breaching the dams land cleaning out contaminated sediments. After removal of the sediments a natural drainage system could be established (no backfilling). However, if abandoned, all contaminated storm water run-off would be discharged directly to Nonconnah Creek via open ditches.

A final alternative is to dredge the contaminated sediments from the lake and pond, leaving the bodies of water intact. After the sediments have been removed they could be sent to an off-site disposal treatment facility. The effective utilization of this alternative would rely on determining and mitigating the contaminant source. The lake/pond could then either be reestablished (if storm water is determined to be free of contamination), or backfilled with clean soil.

2.4.4. Selection of Remedial Alternatives - Three remedial alternatives have been selected for detailed evaluation. They are:

1. No Action
2. No Action with continued restrictions on fishing and additional monitoring of storm water entering the lake and pond
3. Dredge Sediments/Landfill

A detailed analysis of each alternative is given in Section 3.0.

3.0 DETAILED ANALYSIS OF CORRECTIVE ACTION ALTERNATIVES

3.1 INTRODUCTION

This section of the report presents the detailed analysis of alternatives developed in Section 2.0 of this report. Alternatives are discussed for application in three separate areas. The first area of discussion is remediation of ground water in Dunn Field, the second is surface soils on the main installation and the third is the surface water and sediments of Lake Danielson and the small golf course pond. The discussion of each area is then subdivided with detailed analyses of remedial alternatives developed for that area. Detailed analyses of each remedial action alternative (RAA) is presented using the seven evaluation criteria presented in the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (OSWER 9355.3-01 USEPA, 1988). The criteria are as follows.

3.1.1 Short-Term Effectiveness

This criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation period.

3.1.2 Long-Term Effectiveness

The assessment of alternatives against this criterion evaluates the long-term effectiveness of alternatives in protecting human health and the environment.

3.1.3 Reduction of Toxicity, Mobility, and Volume

This criterion evaluates the anticipated performance of the specific treatment technologies.

3.1.4 Implementability

This assessment evaluates the technical and administrative feasibility of alternatives and the availability of required resources.

3.1.5 Regulatory Compliance

This criterion describes how the alternative complies with Applicable, Relevant, and Appropriate Requirements (ARARs).

3.1.6 Overall Protection

The assessment against this criterion describes how the alternative, as a whole, protects and maintains protection of human health and the environment.

3.1.7 Cost

The evaluation of cost for each alternative is done with available data and information. Costs are determined using estimated values of volume and ground-water flow. The estimates are expected to have an accuracy range of +50 percent to -30 percent as outlined in the RI/FS Guidance Document (EPA, 1988). Additional data will be necessary to further define remedial alternative characteristics and cost.

3.2 REMEDIAL ACTION ALTERNATIVES FOR DUNN FIELD

The Remedial Action Alternatives (RAAs) for Dunn Field focus on the ~~ground~~-water (GW) contamination at the site. Results of ground-water sampling at Dunn Field have shown significant levels of chlorinated compounds and concentrations of metals from total metals analyses above the MCL's. A total of four GW-RAA's are evaluated for this area. Detailed cost analysis is for each of GW-RAAs are given in Appendix A. These alternatives include:

- GW-RAA-1 No Action
- GW-RAA-2 Institutional Control
- GW-RAA-3 Capping of Burial Sites
- GW-RAA-4 Pumping and Treatment of Ground Water

3.2.1 Remedial Action Alternative - 1 (GW-RAA-1) - No Action

The No Action alternative assumes no further action at the site and is used as a baseline to measure the other alternatives.

3.2.1.1 (GW-RAA-1) Technologies Incorporated - None.

3.2.1.2 (GW-RAA-1) Key Design Assumptions - None.

3.2.1.3 (GW-RAA-1) Short-Term Effectiveness - Because no action is taken, there is no short-term exposure to the community or workers due to the remediation.

3.2.1.4 (GW-RAA-1) Long-Term Effectiveness - Because the source of contamination would remain at the site, the potential risk of exposure would continue to exist with this alternative.

3.2.1.5 (GW-RAA-1) Reduction of Toxicity, Mobility and Volume - The ground water would not be treated to reduce toxicity, mobility or volume under this alternative. The ground-water contaminant plume would be expected to migrate and natural attenuation of the organic constituents would occur.

3.2.1.6 (GW-RAA-1) Implementability - There are no implementation concerns since no action would be taken.

3.2.1.7 (GW-RAA-1) Regulatory Compliance - The No Action alternative would not comply with applicable standards due to exceedences of ARARs by constituents in the ground water.

3.2.1.8 (GW-RAA-1) Overall Protection - Since no remedial action is taken under this alternative, potential risks remain at the site. In addition, contributions from the source areas to the existing ground-water contaminant plume would continue over time.

3.2.1.9 (GW-RAA-1) Cost - Implementation of the No Action alternative incurs no cost.

3.2.2 Remedial Action Alternative - 2 (GW-RAA-2) - Institutional Control

Implementation of GW-RAA-2, Institutional Control, would consist of continued monitoring of the on and off-site ground-water monitoring wells. A restriction on the drilling of water supply wells and removal of ground water from the Fluvial aquifer in the contaminated area would have to be implemented. Monitoring of existing wells would be periodical, as negotiated with the appropriate regulatory agencies. Restrictions of ground-water use in the area would be regulated by Shelby County and the State of Tennessee.

3.2.2.1 (GW-RAA-2) Technologies Incorporated - None.

3.2.2.2 (GW-RAA-2) Key Design Assumptions - None.

3.2.2.3 (GW-RAA-2) Short Term Effectiveness - Because there is no actual remediation of the source, there would be no short term exposure to the community. There is potential exposure to the persons sampling ground-water wells at the site. This concern could be adequately addressed by the use of the proper protective clothing, air monitoring equipment and decontamination procedures.

3.2.2.4 (GW-RAA-2) Long Term Effectiveness - Because the source of ground-water contamination and the contaminated ground water itself continues to exist at the site, future potential exposure would also continue. Ground-water monitoring would aid in tracking contaminant levels and plume movements. At present the full extent of ground-water contamination is not known. Additional study would be necessary to fully characterize and delineate the contaminated plume. Regulation of the Fluvial aquifer's use would only provide protection from direct exposure of ground water from the Fluvial aquifer. In addition to monitoring the Fluvial aquifer it will be necessary to monitor the Memphis Sand drinking water aquifer to determine if contaminants are migrating through the confining unit. Monitoring of the drinking water is currently being done by Memphis Light, Gas and Water (MLG&W) at the Allen Well Field, located approximately one mile west of DDMT. The Institutional Control alternative must address the possibility of contamination from DDMT reaching the drinking water supply for the City of Memphis.

If results of ground-water monitoring indicate any of the following, additional remedial alternatives would have to be implemented.

1. Rising contaminant levels in the Fluvial aquifer

2. Contaminant plume migration into a more sensitive area; such as in the Allen Well Field area

3. Detection of contaminants in the Memphis Sand aquifer

3.2.2.5 (GW-RAA-2) Reduction of Toxicity, Mobility and Volume - Neither the waste in the burial areas nor the contaminated ground water is treated to reduce the toxicity, mobility or volume.

3.2.2.6 (GW-RAA-2) Implementability - This alternative would be easy to implement. By sampling ground water from the Fluvial aquifer and the Memphis Sand aquifer contaminant levels could be monitored and additional remedial alternatives evaluated if necessary. All equipment and materials necessary for this alternative are readily available.

3.2.2.7 (GW-RAA-2) Regulatory Compliance - This requirement does not comply with CERCLA closure requirements of a regulated unit. It does, however, give a level of confidence concerning risk through the monitoring of contaminant levels and movements.

3.2.2.8 (GW-RAA-2) Overall Protection - This alternative does not offer protection from potential exposure through monitoring of the ground water. It does, however, offer a level of protection through the regulation of the drilling of water supply wells and removal of ground water from the Fluvial aquifer. By limiting or excluding use of ground water from the Fluvial aquifer, the potential for exposure is reduced. It does not offer protection from contaminants potentially reaching the Memphis Sand aquifer.

3.2.2.9 (GW-RAA-2) Cost - Cost of this alternative would be the installation of monitoring wells and the actual sampling and analysis expenses incurred. Results could be evaluated in a brief ground-water quality report and submitted to the appropriate agency. Costs of this alternative have been summarized on Table 3-1. Detailed cost are provided in Appendix A-1.

3.2.3 Remedial Action Alternative (GW-RAA-3) - Multi-Layer Cap and Monitoring

Capping of the burial sites would help contain and isolate the buried waste. The conditions in Dunn Field are very suitable for capping to be an effective alternative for contaminant source control. It has been estimated that approximately 50 feet of soil exists between the bottom of the burial trenches and the top of the water table. Installing a multi-layer cap over the burial sites would reduce water percolating through the landfill, thus, minimizing the amount of contamination contributed to the ground water.

3.2.3.1 (GW-RAA-3) Technologies Incorporated - The multi-layer cap would consist of the following components, from top to bottom:

- Loam layer, two feet thick
- Gravel/Sand drainage layer, one foot thick

TABLE 3-1

COST ESTIMATE SUMMARY
DUNN FIELD

RAA-2 Institutional Control

Component	Cost
Capital Costs	
(1) None	0
Annual Operation and Maintenance Costs	
(1) Monitoring	$200,000
Total Annual O & M Costs	$200,000
Total Present Worth (30 years)	$1,315,000

* See Appendix A-1 for Detailed Cost Analysis.

- 30 mil synthetic membrane
- Clay, low permeability, compacted to two feet thick
- Fabric, geotextile
- Sand, drainage layer one foot thick

This cap meets the minimum RCRA requirements as set forth in EPA document 625/4-89-022.

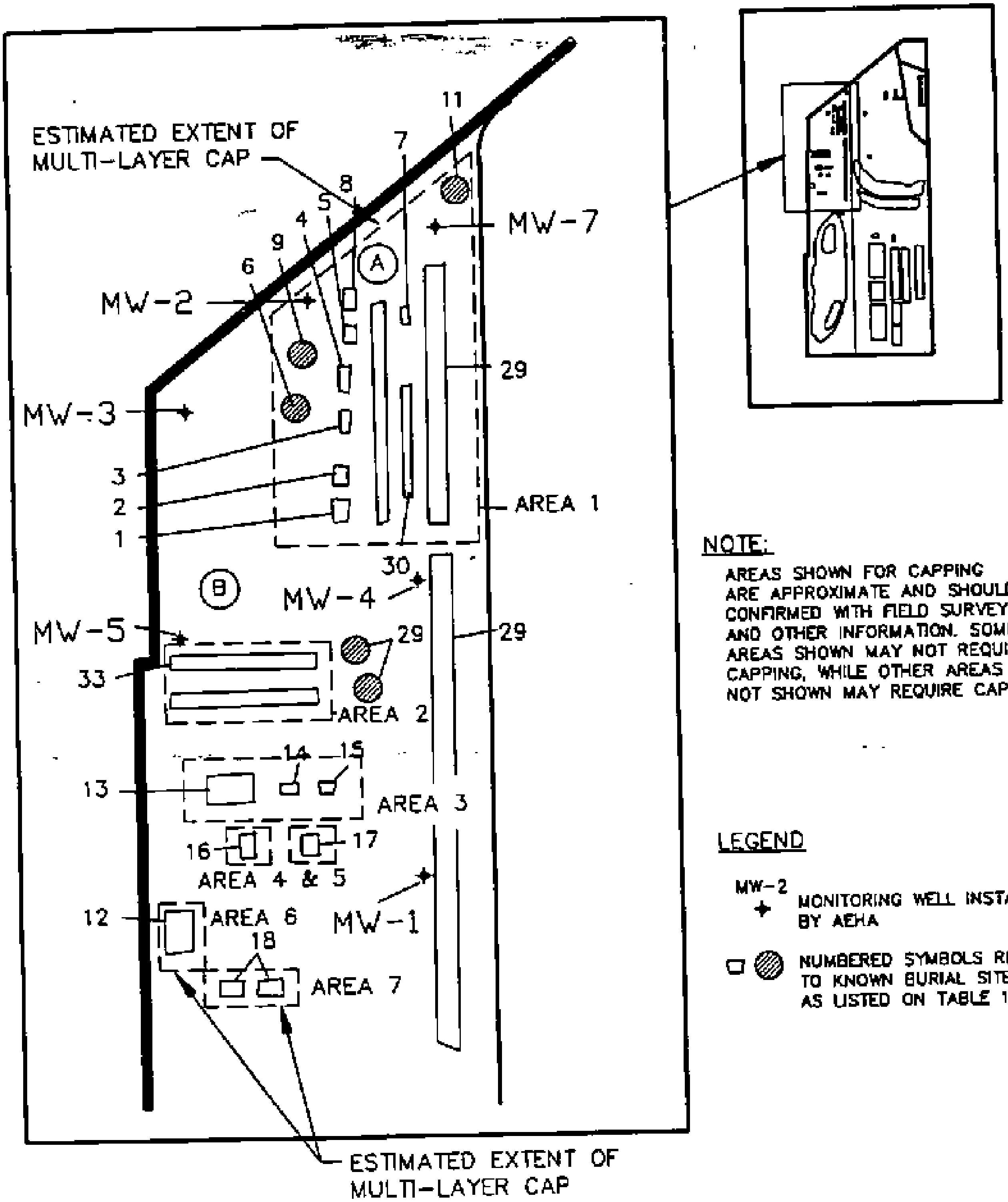
3.2.3.2 <u>(GW-RAA-3) Key Design Assumptions</u> - The following design assumptions were made regarding the implementation of this alternative.

- The estimated area of burial sites identified in Figures 3-1 and 3-2 was used for cost estimating purposes. Actual areas required for capping should be evaluated by further field studies.
- The design life of the cap is estimated at 30 years. After 30 years, the membrane and other cap elements may need to be replaced.
- A 30 mil reinforced polyvinyl chloride (PVC) liner would be used as the synthetic membrane material. The PVC liner was chosen due to its relative low cost and ease of installation. The 30 mil membrane should have adequate tear strength and chemical resistance for the Dunn Field site.
- A low maintenance shallow rooting grass cover would be placed over the loam to control erosion.

FIGURE 3-1

DUNN FIELD DISPOSAL & STORAGE SITES

APPROXIMATE AREAS FOR MULTI-LAYER CAP (SEE NOTE)



NOTE:

AREAS SHOWN FOR CAPPING ARE APPROXIMATE AND SHOULD BE CONFIRMED WITH FIELD SURVEY AND OTHER INFORMATION. SOME AREAS SHOWN MAY NOT REQUIRE CAPPING, WHILE OTHER AREAS NOT SHOWN MAY REQUIRE CAPPING.

LEGEND

MW-2 ✦ MONITORING WELL INSTALLED BY AEHA

□ ▨ NUMBERED SYMBOLS REFER TO KNOWN BURIAL SITES AS LISTED ON TABLE 1-1.

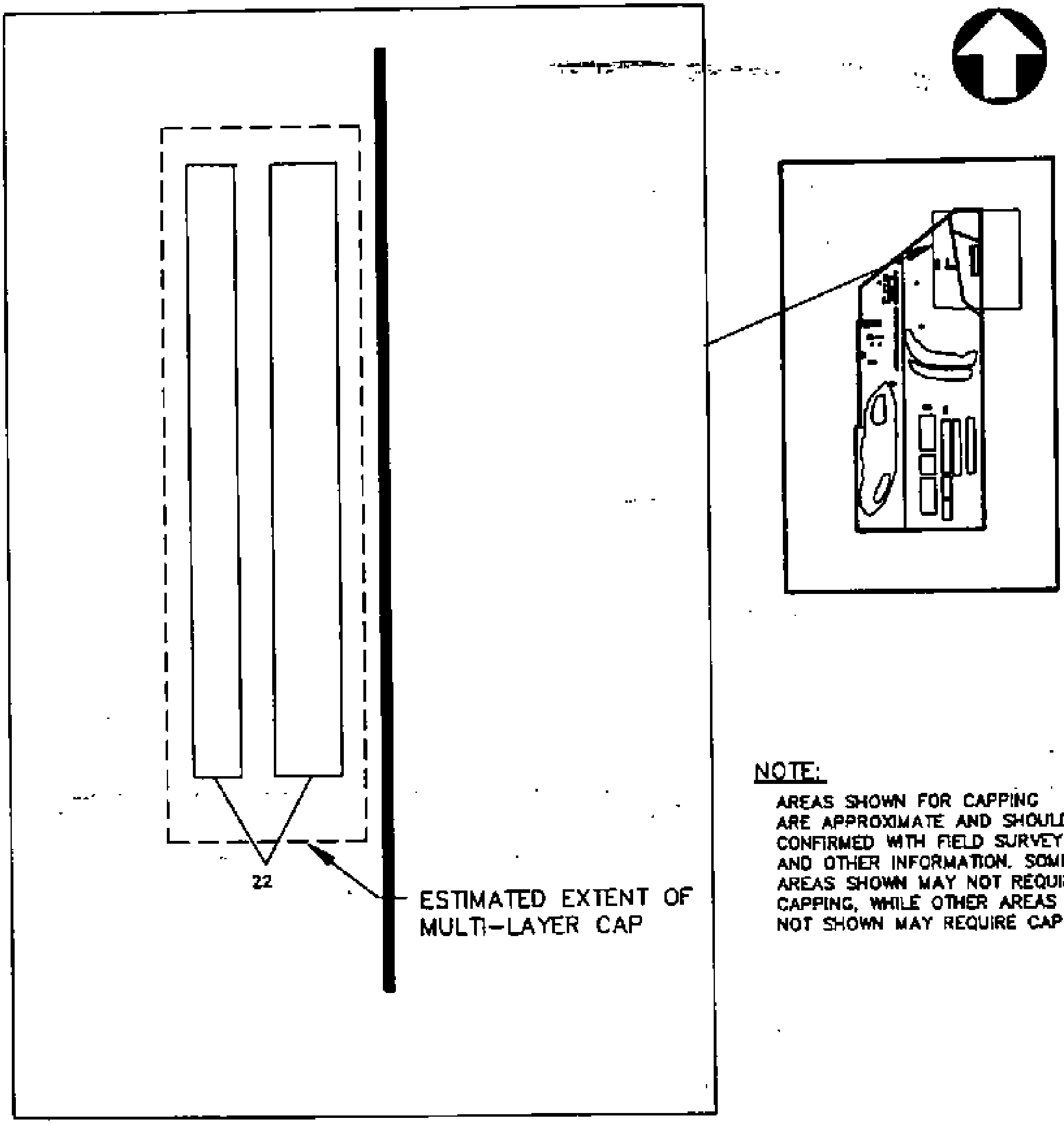
SOURCE: US ARMY ENVIRONMENTAL HYGIENE AGENCY, 1982. GEOHYDROLOGIC STUDY NO. 38-26-0195-83.

SCALE: 1" ~ 175'

FIGURE 3-2

DUNN FIELD DISPOSAL & STORAGE SITES

APPROXIMATE AREA FOR MULTI-LAYER CAP (SEE NOTE)



NOTE:
AREAS SHOWN FOR CAPPING ARE APPROXIMATE AND SHOULD BE CONFIRMED WITH FIELD SURVEY AND OTHER INFORMATION. SOME AREAS SHOWN MAY NOT REQUIRE CAPPING, WHILE OTHER AREAS NOT SHOWN MAY REQUIRE CAPPING.

SCALE: 1" ~ 70'

SOURCE: US ARMY ENVIRONMENTAL HYGIENE AGENCY, 1982. GEOHYDROLOGIC STUDY NO. 38-26-0195-83.

- This alternative would also include the institutional control measures (monitoring and regulation) of GW-RAA-2 to monitor contaminant levels and movements and provide protection from potential exposure.

3.2.3.3 <u>(GW-RAA-3) Short-Term Effectiveness</u> - Installation of a multi-layer cap over the burial sites would immediately isolate the sites from surface exposure. A reduction in the percolation of water to the burial areas would occur quickly. However, a reduction in the volume of leachate generated from infiltration may require more time, allowing the source areas to dewater.

3.2.3.4 <u>(GW-RAA-3) Long-Term Effectiveness</u> - Because the source of contamination would remain at the site, the potential risk of future exposure would continue to exist. The long-term risks would be reduced with this alternative. The cap will require long-term management and maintenance, including inspection on a regular basis for signs of erosion, settlement, subsidence or the presence of burrowing animals. Maintenance activities should include periodic mowing and weed control to prevent invasion by deep-rooted vegetation. Any signs of settling or subsidence will require immediate repair. In addition, the monitoring program as described in GW-RAA-2 will remain for the 30 year life of the cap instead of two years, as required by RCRA. It was assumed for the cost analysis in this report that the synthetic liner would have to be replaced after 30 years.

3.2.3.5 <u>(GW-RAA-3) Reduction of Toxicity, Mobility and Volume</u> - Waste is not treated to reduce toxicity or volume with this alternative. Mobility will be significantly reduced.

3.2.3.6 <u>(GW-RAA-3) Implementability</u> - This alternative would be relatively easy to implement using standard construction equipment. Multi-layer caps similar to the one proposed for this alternative have been proven reliable in the field under similar conditions. The monitoring program will provide an added level of confidence concerning risks associate with leaving the contaminants on-site. By sampling ground water from the Fluvial aquifer and the Memphis Sand aquifer, the contaminant migration pathways at the site could be monitored. All equipment and materials necessary for this alternative are readily available.

3.2.3.7 <u>(GW-RAA-3) Regulatory Compliance</u> - The multi-layer capping of the burial trenches complies with applicable standards and with the existing exposure pathways. The monitoring portion of this alternative may not comply, depending on the current extent of contamination.

3.2.3.8 <u>(GW-RAA-3) Overall Protection</u> - This alternative accomplishes the remedial action objective of providing containment of the contaminant source and thereby reducing surface water infiltration. The alternative does not eliminate the source of contamination, so the potential risk of exposure via contaminated ground water still exists. However, the monitoring program would provide information regarding contaminant levels and movements so that if contaminant levels increase or become more mobile in the subsurface, additional remedial alternatives could be employed.

3.2.3.9 <u>(GW-RAA-3) Cost</u> - Cost of this alternative would be the capitol cost of installation and design plus the annual operation and maintenance cost. These costs are summarized on Table 3-2. The detailed cost calculation sheets are presented in Appendix A-2.

TABLE 3-2

COST ESTIMATE SUMMARY
DUNN FIELD

RAA-3 Multi-Layer Cap and Monitoring

Component	Cost
Capital Costs	
(1) Multi-Layer Cap	$ 490,471
Indirect Capital Costs	
(2) Engineering Design (6%)	29,429
Total Capital Costs	$ 519,899
Annual Operation and Maintenance Costs	
(1) Multi-Layer Cap O & M	5,000
(2) Monitoring	99,808
Total Annual O & M Costs	$ 104,808
Total Present Worth	$1,508,000

* Detailed cost analysis are presented in Appendix A-2.

3.2.4 Remedial Action Alternative - 4 (GW-RAA-4) - Pump and Treat

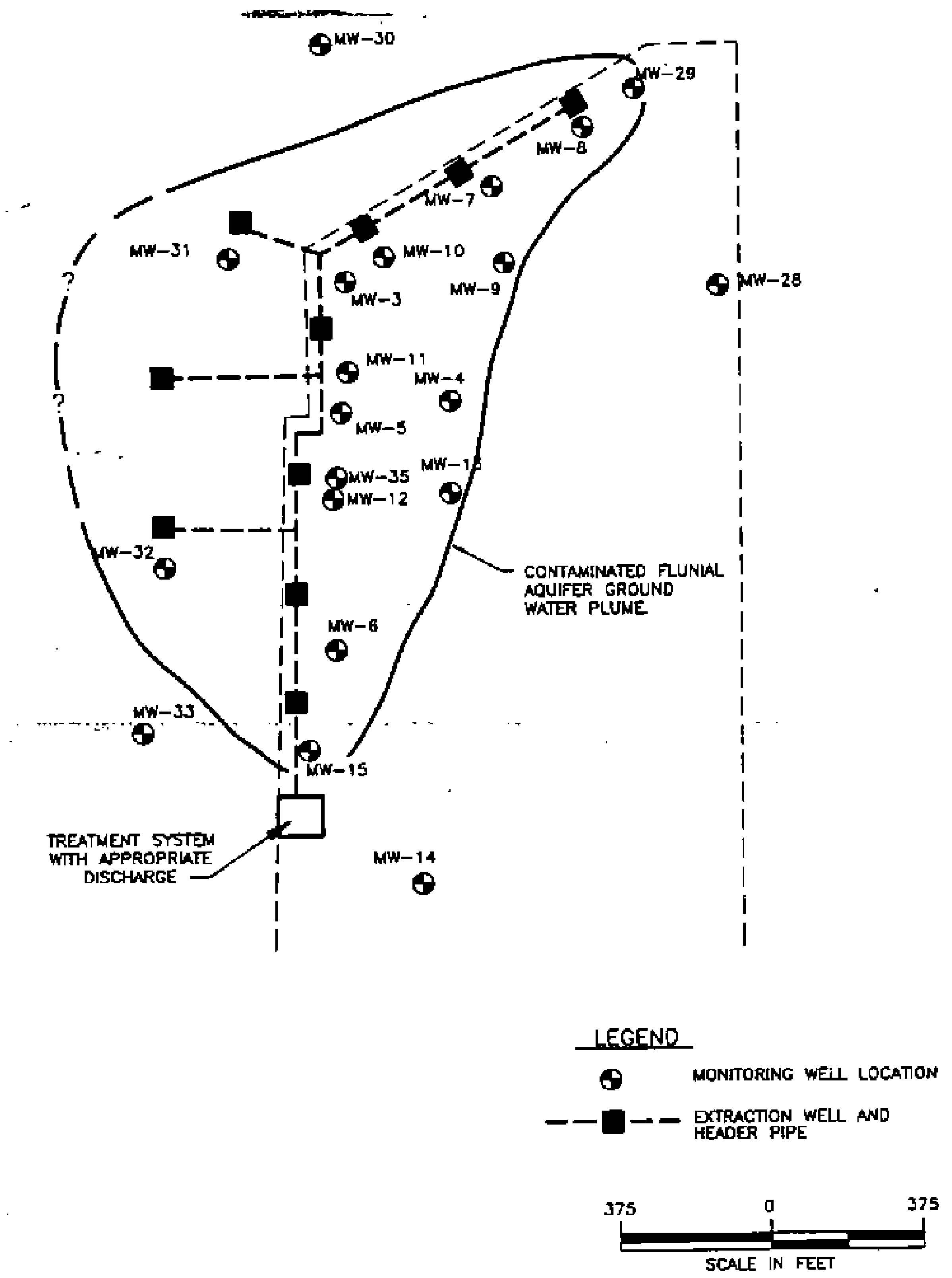
The fourth remedial action alternative employs the extraction and treatment of contaminated ground water. This alternative could be used to achieve two objectives: (1) reduce contamination in the ground water and (2) use the pumping effect of the extraction wells to form a hydraulic barrier to limit further off-site migration. Additional study would be necessary to fully characterize the heterogeneous nature of the Fluvial aquifer deposits, delineate the aquifer geometry and preferred flow routes and define the contaminant plume. The data needed to effectively design a workable pump and treat system could be gathered through performance of an aquifer test, additional soil test borings, geophysics and a small scale pilot study. In addition, this alternative could be combined with GW-RAA-3 (Multi-Layer Cap and Monitoring) to provide for containment of the source areas.

3.2.4.1 (GW-RAA-4) Technologies Incorporated - A pump and treat system for ground water would incorporate the use of a series of large diameter (approximately 6-inch) extraction wells into which submersible or pneumatic pumps would be installed. A conceptual-level design for the extraction well system is shown on Figure 3-3. It should be noted that the final design of the system should be based on site specific information obtained from fully defining the extent of contamination and from a pump test. Ground water collected from the extraction wells would be diverted to a treatment system designed for filtration of solids, the treatment of organic contaminants by the use of hydrogen peroxide and ultraviolet light and possibly the treatment of metals by a precipitation and flocculation system. Treated water could then be diverted to a nearby surface water feature or storm drainage system as negotiated with the appropriate regulatory agency.

FIGURE 3-3

CONCEPTUAL DESIGN OF GROUND WATER EXTRACTION SYSTEM

DEFENSE DEPOT MEMPHIS, TENNESSEE



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GOVERNMENT SERVICES DIVISION

3.2.4.2 <u>(GW-RAA-4) Key Design Assumptions</u> - Implementation of this alternative would require additional information and data as discussed above. Design assumptions such as ground-water flow characteristics, well spacing~~, and~~ volumes of contaminated ground water to be treated cannot be adequately addressed at the present. For the purposes of estimation, however, the following gross assumptions have been made.

- Contaminants to be removed from ground water include chlorinated solvents and metals.
- Ground-water flow is estimated to be 10 to 50 gallons per minute (gpm) from a six-inch diameter extraction well, 90 feet deep, screened into the Fluvial aquifer.
- The spacing of extraction wells is estimated as approximately 300 feet. For the purposes of costing, ten extraction wells have been assumed.
- The ground-water treatment system will be built on-site. A chemical oxidation treatment system consisting of a hydrogen peroxide and ultraviolet light degradation process in series with filtration and precipitation/flocculation system.
- Treated water can be disposed of to a surface water feature or a local storm/sanitary sewer line (POTW).
- A minimum of ten years operation is estimated for this alternative.

An overall permit would be required to operate the system (such as a RCRA Part B permit if the facility falls under RCRA guidance). Specific permits (NPDES and/or POTW) would also be required to discharge the water.

3.2.4.3 (GW-RAA-4) Short-Term Effectiveness - This alternative would reduce the levels of ground-water contamination fairly rapidly. The installation of an extraction system would prevent further lateral contaminant migration. A potential for exposure to workers implementing this alternative could be adequately addressed with protective clothing, monitoring equipment and decontamination procedures. There is little potential for exposure to the immediate community.

3.2.4.4 (GW-RAA-4) Long-Term Effectiveness - This alternative should be effective in long-term reduction of contaminated ground-water levels and associated health risk. The pump and treat technology will not treat all residual contamination, although pulsed pumping could be effective in further reduction of contaminant levels. An estimated duration of this alternative is ten to twenty years. Additional characterization will refine this figure to an acceptable degree of confidence. The addition of an extended monitoring plan will be necessary to provide the necessary information necessary to evaluate the long-term effectiveness.

This treatment alternative will require long-term operation and maintenance. If used in conjunction with a multi-layer cap (GW-RAA-3), the cap will require long-term maintenance and inspection as well.

3.2.4.5 (GW-RAA-4) Reduction of Toxicity, Mobility and Volume - Treatment of the contaminated ground water will accomplish reduction in toxicity, mobility and volume. Toxicity and volume could be reduced by the treatment system itself. Mobility of the contaminant plume is contained by the physical forces of extraction which should form a barrier to the lateral movement of the contaminated ground water.

3.2.4.6 <u>(GW-RAA-4) Implementability</u> - This alternative should be relatively simple to implement. The technology and processes have been reliably demonstrated. Equipment and materials are readily available. However, as stated previously, additional characterization and a pilot study will be necessary prior to successfully implementing this alternative.

3.2.4.7 <u>(GW-RAA-4) Regulatory Compliance</u> - Successful treatment of the contaminated ground water will meet regulatory requirements and provide protection of human health and the environment.

3.2.4.8 <u>(GW-RAA-4) Overall Protection</u> - Remedial alternative GW-RAA-4 would provide the overall protection to human health and the environment by reducing the potential for exposure to contamination either from the Fluvial aquifer or the Memphis Sand aquifer. The source areas should be addressed in conjunction with the pump and treat alternative (GW-RAA-3).

3.2.4.9 <u>(GW-RAA-4) Cost</u> - Cost of implementing this remedial alternative is estimated using the gross assumptions discussed in Section 3.2.4.2. Development of more confident cost estimates must be performed following completion of additional site characterization. Estimated costs are summarized on Table 3-3. Detailed cost worksheets are presented in Appendix A-3.

3.3 <u>REMEDIAL ACTION ALTERNATIVES FOR SURFACE SOILS</u>

The detailed remedial alternative analysis for surface soils (SS) focuses on surface soils around the main installation of DDMT. Soils were found to be contaminated with significant levels of polynuclear aromatic hydrocarbons (PAHs), pesticides and metals. The purpose of this sampling was to confirm/deny the existence of

TABLE 3-3

COST ESTIMATE SUMMARY
DUNN FIELD

GW-RAA-4 Pump & Treatment of Ground Water with Quarterly Monitoring

Component	Cost
Capital Costs	
(1) Extraction Well Installation (10,6-inch wells)	$ 155,000
(2) Initial Treatment Set-up (Chemical Oxidation)	15,000
(3) Treatment Set-up (Precipitation/Flocculation)	200,000
Indirect Capital Costs	
(4) Engineering Design (6%)	22,200
Total Capital Costs	$ 392,200
Annual Operation and Maintenance Costs	
(1) Quarterly Sampling	199,616
(2) Treatment (Chemical Oxidation)	2,365,200
(3) Treatment (Flocculation/Precipitation)	99,864
Total Annual O & M Costs	$2,664,680
Total Present Worth	$16,765,000

* Detailed cost analysis are presented in Appendix A-3.

contamination at probable source areas. The limited number of the soil samples are inadequate for determining volumes of the contaminated areas. However, based on the surface soil contamination encountered at six separate areas of the installation, four remedial action alternatives have been prepared and are discussed in the following section. Due to the lack of information concerning the volume of the contaminated media, a detailed cost analysis has not been included. The alternatives include:

- (SS-RAA-1) No Action
- (SS-RAA-2) Site Restrictions
- (SS-RAA-3) Excavation On Site/Solidification/Landfill
- (SS-RAA-4) Excavate/Off-Site Treatment/Landfill

3.3.1 Remedial Action Alternative - 1 (SS-RAA-1) - No Action

The No Action Alternative assumes no further action at the site and is used as a baseline to measure the other alternatives.

3.3.1.1 Technologies Incorporated - None.

3.3.1.2 Key Design Assumptions - None.

3.3.1.3 (SS-RAA-1) Short-Term Effectiveness - Because no action is taken, there is no short-term exposure to the community or workers due to remediation.

3.3.1.4 (SS-RAA-1) Long-Term Effectiveness - Because the source of contamination would remain at the site, the risk of exposure would continue to exist with this alternative.

3.3.1.5 (SS-RAA-1) Reduction of Toxicity, Mobility and Volume - The contaminated surface soils would not be treated to reduce toxicity, mobility or volume under this alternative.

3.3.1.6 (SS-RAA-1) Implementability - There are no implementation concerns since no action would be taken.

3.3.1.7 (SS-RAA-1) Regulatory Compliance - The No Action alternative would not comply with applicable standards due to exceedances of ARARs.

3.3.1.8 (SS-RAA-1) Overall Protection - Since no remedial action is taken under this alternative, potential risks remain at the site providing no overall protection to human health and the environment.

3.3.1.9 (SS-RAA-1) Cost - Implementation of the No Action alternative incurs no cost.

3.3.2 Remedial Action Alternative - 2 (SS-RAA-2) - Site Restrictions

Implementation of SS-RAA-2, Site Restrictions, would consist of: setting up boundaries around the contaminated areas to limit access; personnel using protective clothing when working in a contaminated area; posting warning signs; annual training for personnel working in or around the contaminated areas; and seeding the areas with grass to reduce fugitive dust. These protective measures could be implemented by DDMT environmental staff.

3.3.2.1 (SS-RAA-2) Technologies Incorporated - None.

3.3.2.2 (SS-RAA-2) Key Design Assumptions - The only assumption necessary with this alternative is how much of an area to label "contaminated". Additional sampling will be necessary to accurately delineate full extent of contamination.

3.3.2.3 (SS-RAA-2) Short-Term Effectiveness - Because there is no remediation of contaminated soils, there is a continued risk of exposure to personnel working in or around the contaminated areas. Direct exposure could be addressed with the restrictive measures of this alternative. There is little potential for exposure to the community surrounding DDMT from the contamination present in the soils.

3.3.2.4 (SS-RAA-2) Long-Term Effectiveness - This alternative could potentially provide long-term effectiveness, provided that the institutional controls are in place.

3.3.2.5 (SS-RAA-2) Reduction of Toxicity, Mobility and Volume - There is no reduction of toxicity or volume of contaminants in surface soils with this alternative. Mobility of the contaminants can be reduced by seeding the areas with grass.

3.3.2.6 (SS-RAA-2) Implementability - This alternative would place limitations on the use of certain areas by the depot.

3.3.2.7 (SS-RAA-2) Regulatory Compliance - This alternative does not remediate the surface contamination and would not comply with ARARs.

3.3.2.8 (SS-RAA-2) Overall Protection - Site restrictions would effectively address exposure for workers at DDMT. This protection would rely on the diligence of depot personnel in enforcement of institutional controls. The potential effect on surface water run-off and migration of contaminants to the ground water is not addressed.

3.3.2.9 (SS-RAA-2) Cost - There would be minimal cost incurred with implementation of this alternative. Implementation of this alternative could be managed by DDMT.

3.3.3 Remedial Action Alternative - 3 (SS-RAA-3) - Excavation/Solidify/Landfill

This alternative consists of excavating contaminated soils and binding-up the contaminates using a solidification process. The solidified soil could then be disposed in a landfill. This technology would be particularly effective if the soils are classed as a "Characteristic waste" based on their potential metals leaching toxicity. As explained previously a more complete characterization of soils at DDMT is necessary prior to the design and implementation of an extensive remedial action. Additional work would: (1) delineate the horizontal and vertical extent of contamination, (2) define the organic and chemical properties of the soil and (3) determine the applicability of using a solidification process. Given these limitations, the following detailed analysis is presented.

3.3.3.1 (SS-RAA-3) Technologies Incorporated - This alternative uses standard excavation practices to remove contaminated soil. The soil is then mixed with cement and other additives using a "pug mill." The treated mass is tested to confirm that its leaching potential has been reduced. Depending on its classification as a RCRA waste (i.e. either a "Listed" waste or a "Characteristic" waste) it would be disposed in a Level C, RCRA Facility or Level D, RCRA landfill. The excavated area would then be backfilled with new gravel.

3.3.3.2 (SS-RAA-3) Key Design Assumptions - Key design assumptions must be made following further characterization in order to more accurately design the remedial alternative assumptions.

3.3.3.3 (SS-RAA-3) Short-Term Effectiveness - This alternative does involve potential for exposure during remediation. This concern can be adequately addressed by the use of site restrictions, protective clothing, monitoring equipment and decontamination procedures.

3.3.3.4 (SS-RAA-3) Long-Term Effectiveness - Implementation of the Solidify/Landfill remedial action would have positive long-term effects since the contaminants are effectively bound to the solidified soil and placed in a secure RCRA facility.

3.3.3.5 (SS-RAA-3) Reduction of Toxicity, Mobility and Volume - This alternative effectively reduces the toxicity and mobility of the waste, volume is significantly increased. Proper design and remediation techniques would adequately address this criteria.

3.3.3.6 (SS-RAA-3) Implementability - Depending on results from additional characterization study, this alternative could be readily implemented. Excavation could be accomplished using standard construction equipment and materials. The solidification treatment system would be designed specifically for the site conditions (i.e., contaminants, soil types, special situations) allowing for greater success of the remediation action. The availability of solidification units are relatively widespread. This alternative involves excavation of relatively shallow areas of soil.

3.3.3.7 (SS-RAA-3) Regulatory Compliance - The acceptance of this alternative by regulatory agencies will be based on analysis of the solidification material. Soil above clean-up levels would be removed and disposed in compliance with Land Disposal Regulations.

3.3.3.8 (SS-RAA-3) Overall Protection - Implementation of this remedial action could provide overall protection to the depot personnel and the immediate community. Moreover, the source of contamination would be removed, thus effectively preventing additional migration of contaminants.

3.3.3.9 (SS-RAA-3) Cost - Given the uncertainties associated with the design and implementation of this alternative at the present, an accurate cost estimate is not feasible. Vendor quotes have indicated solidification costs range from $50 to $100/ton of soil material. Landfilling costs could vary significantly based on the classification of the soil and the type landfill required.

3.3.4 Remedial Action Alternative - 4 (SS-RAA-4) - Excavation/Off-Site Disposal

This remedial action consists of the excavation and off-site treatment and disposal of contaminated soils. This is a relatively simple alternative to implement, however, the costs can be high. The full extent of contamination must be known to provide data for an accurate cost estimate. Depending on the applicability of the Land Disposal Restrictions the soils may need treatment prior to disposal. This treatment (such as incineration) could be performed at the disposal facility. This would be an additional cost which cannot be addressed at this time. A detailed alternative analysis has been prepared using available data.

3.3.4.1 <u>(SS-RAA-4) Technologies Incorporated</u> - Standard excavation and disposal technologies would be necessary for implementation of this alternative. Treatment technologies may be necessary should the contaminants to be disposed of invoke Land Disposal Restrictions. The treatment methods that would be selected and utilized by the disposal facility are not discussed herein.

3.3.4.2 <u>(SS-RAA-4) Key Design Assumptions</u> - Due to the nature of the uncertainties associated with implementation of this alternative, key design assumptions cannot be addressed at this time.

3.3.4.3 <u>(SS-RAA-4) Short-Term Effectiveness</u> - Short-term exposure potential does exist for personnel performing remediation activities on site as well as those involved with the transportation and disposal activities. Exposure can be reduced with the use of protective clothing, monitoring equipment, decontamination procedures and adherence to waste handling and transporting requirements.

3.3.4.4 <u>(SS-RAA-4) Long-Term Effectiveness</u> - This alternative offers long-term effectiveness since contamination is removed from the site, reducing exposure to DDMT personnel.

3.3.4.5 <u>(SS-RAA-4) Reduction of Toxicity, Mobility and Volume</u> - Excavation and off-site disposal effectively reduces toxicity, mobility and volume of contamination at the site to acceptable levels.

3.3.4.6 <u>(SS-RAA-4) Implementability</u> - This alternative can be readily implemented using standard excavation, waste handling and waste transportation methods.

3.3.4.7 <u>(SS-RAA-4) Regulatory Compliance</u> - Regulatory acceptance of this alternative could be received as it actively addresses the contaminated soils reducing both exposure potential and concentrations of contaminants to acceptable levels. However, prior to acceptance compliance with LDR will require either "Listing" or "Characterizing" the wastes.

3.3.4.8 <u>(SS-RAA-4) Overall Protection</u> - Removal and off-site disposal of contaminated soils would provide overall protection for on and off-site personnel.

3.3.4.9 <u>(SS-RAA-4) Cost</u> - Implementation of this alternative has high costs associated with it in comparison with the other alternatives. Treatment of soils prior to disposal for compliance with LDR would add to the cost. Due to the uncertainties associated with implementation of this remedial action alternative, it was not possible to prepare an accurate cost estimate.

3.4 REMEDIAL ACTION ALTERNATIVES FOR LAKE DANIELSON

The detailed remedial action alternative analysis for Lake Danielson also includes the golf course pond. No significant contamination was detected in both surface water (SW) bodies. Pesticide contamination was detected in the sediments. Both bodies of water receive surface runoff and directed storm drainage from the surrounding areas. In addition, Lake Danielson also receives drainage from the warehouse district portion of the depot. Occurrence of the fish kills in the lake has not been explained.

Based on the results at these surface water bodies, continued restrictions may provide an adequate short-term alternative to remediation. Prior to selecting a long-term, effective remedial action alternatives, the contaminant source must be determined. Since only low levels of contaminants were detected in the surface water at the lake/pond it can not be determined if the contaminant source is intermittent (storm surges) or no longer exists. However, three remedial action alternatives have been addressed for the lake/pond. A detailed cost analysis for each alternative is presented in Appendix B. The alternatives discussed in the section include:

- (SW-RAA-1) No Action
- (SW-RAA-2) Site Analysis and Restrictions
- (SW-RAA-3) Dredge and Landfill

3.4.1 Remedial Action Alternative - 1 (SW-RAA-1) - No Action

The No Action alternative assumes no further action at either the lake or the pond and is used as a base line to measure other alternatives.

3.4.1.1 <u>(SW-RAA-1) Technologies Incorporated</u> - None.

3.4.1.2 <u>(SW-RAA-1) Key Design Assumptions</u> - None.

3.4.1.3 (SW-RAA-1) Short-Term Effectiveness - Because no action is taken, there is no short-term exposure to workers or the community from remedial action.

3.4.1.4 (SW-RAA-1) Long-Term Effectiveness - Because the source of contamination would continue to exist at the site, the potential for exposure would continue to exist with this alternative.

3.4.1.5 (SW-RAA-1) Reduction of Toxicity, Mobility and Volume - There would be no reduction of toxicity, mobility or volume of wastes under this alternative.

3.4.1.6 (SW-RAA-1) Implementability - There are no implementation concerns under this alternative.

3.4.1.7 (SW-RAA-1) Regulatory Compliance - This alternative would not meet regulatory requirements due to exceedances of ARARs in the lake and pond sediments.

3.4.1.8 (SW-RAA-1) Overall Protection - The No Action alternative would provide no overall protection to human health or the environment.

3.4.1.9 (SW-RAA-1) Cost - There would be no cost incurred under this alternative.

3.4.2 Remedial Action Alternative - 2 (SW-RAA-2) - Site Analysis and Restrictions

Remedial Action SW-RAA-2, Site Analysis, consist of a variety of steps in an effort to control and study the pesticide contamination problem in Lake Danielson and the small golf course pond. These steps include:

1) Site Restrictions
2) Monitoring Surface Water and Sediments
3) Review of In-Place Drainage Systems
4) Spill Control
5) Review of Pesticide Application Procedures

The remedial objective of implementing this alternative is to characterize the site and determine the cause of fish kills at the depot. Should the cause of the fish kills be determined, additional remedial alternatives could be implemented.

3.4.2.1 (SW-RAA-2) Technologies Incorporated - The Site Analysis alternative does not require specialized technologies to perform its objective.

3.4.2.2 (SW-RAA-2) Key Design Assumptions - Because this alternative is mostly a data gathering exercise, there are no key design assumptions.

3.4.2.3 (SW-RAA-2) Short-Term Effectiveness - Short-term exposure potential would be most probable during sampling activities. This exposure potential could be addressed by the use of protective clothing, monitoring equipment and decontamination procedures. The current access restrictions for depot employees and golfers should remain in effect to reduce the exposure potential.

3.4.2.4 (SW-RAA-2) Long-Term Effectiveness - This alternative has no long-term exposure benefits. However, results obtained during implementation of this alternative could be used in the design and implementation of remedial alternatives that would offer long-term exposure protection.

3.4.2.5 (SW-RAA-2) Reduction of Toxicity, Mobility and Volume - Because waste is not treated under this alternative, there are no reductions in toxicity or mobility. If contamination is determined to be caused via storm water runoff into the lake and pond, DDMT could innate practices to mitigate the source. Once the contaminant source has been stopped this alternative could provide time for natural degradation of the contaminants to occur.

3.4.2.6 (SW-RAA-2) Implementability - The Site Analysis alternative could be readily implemented using available information from the depot and standard sampling protocol.

3.4.2.7 (SW-RAA-2) Regulatory Compliance - This alternative in itself would not meet regulatory requirements for the protection of human health and the environment. Of particular concern are the fish kills in Lake Danielson. The determination of the contaminant source will be necessary prior to the design and implementation of additional remedial action alternatives.

3.4.2.8 (SW-RAA-2) Overall Protection - This alternative does not offer any means of overall protection to human health or the environment.

3.4.2.9 (SW-RAA-2) Cost - Cost of implementing this alternative is minimal. DDMT has presently implemented site restriction measures. A review of available information on drainage systems, pesticide application history and chemical/pesticide spill history would be beneficial. Cost incurred during this alternative would be the time spent reviewing available data and site characterization. A detailed cost analysis is included in Appendix B-1.

3.4.3 Remedial Action Alternative - 3 (SW-RAA-3) - Dredge and Landfill

This remedial action alternative focuses on the actual remediation of pesticide contaminated sediments from both Lake Danielson and the small golf course pond. Remediation under this alternative would consist of partial drainage of the surface waters (assumed to be clean) and the dredging of sediments from both the lake and the golf course pond. Following collection, the material would require off-site disposal. Implementation of this alternative could be used with SW-RAA-2, Site Analysis, to delineate site geometry and volumes of contaminated media. Therefore, due to the uncertainties associated with this alternative, the following detailed analysis is presented in a general discussion.

3.4.3.1 <u>(SW-RAA-3) Technologies Incorporated</u> - Dredging of contaminated sediments could be accomplished using standard remediation technologies. Equipment and materials are readily available to complete this alternative. The excavated sediment would be sent to a landfill, where it may or may not require treatment prior to disposal.

3.4.3.2 <u>(SW-RAA-3) Key Design Assumptions</u> - Gross volume calculations give the following results for the volume of contaminated sediment. Surface water does not require treatment.

Sediments:

Assume Lake Danielson is 6 acres and the Golf Course Pond 1 acre:
7 acres X 43,560 ft^2/acre = 304,920 ft^2

Assume 2 feet of contaminated sediments:
304,920 ft^2 X 2 ft = 609,840 ft^3 = 22,587 cubic yards of sediments

It is assumed that the water in the pond will not require treatment and can be pumped or released to a drainage feature, sanitary sewer or storm drainage system.

3.4.3.3 (SW-RAA-3) Short-Term Effectiveness - This alternative does have potential exposure to workers implementing the remedial construction and treatment activities. Exposure could be minimized however, with the use of protective clothing, monitoring equipment and decontamination procedures. In addition, the site should have restricted access to depot employees and unauthorized personnel during remedial activities.

3.4.3.4 (SW-RAA-3) Long-Term Effectiveness - The dredging and off-site disposal alternative offers long-term effectiveness for depot employees and the immediate community. Moreover, since the sediments are remediated to safe levels the site can be eliminated from future environmental consideration. However, this should not be implemented until the contaminant source has been identified and eliminated.

3.4.3.5 (SW-RAA-3) Reduction of Toxicity, Mobility and Volume - Since wastes are only removed from the site to environmentally safe levels, there is no reduction in toxicity, mobility or volume.

3.4.3.6 <u>(SW-RAA-3) Implementability</u> - This alternative can be readily implemented using standard equipment and materials. Remediation can be accomplished using accepted waste handling and treatment procedures.

3.4.3.7 <u>(SW-RAA-3) Regulatory Compliance</u> - Because the contaminated sediments/water are disposed of at environmentally safe facilities, regulatory acceptance could be obtained for this remediation alternative.

3.4.3.8 <u>(SW-RAA-3) Overall Protection</u> - Since wastes are removed from the site, there would be overall protection for human health and the environment. Following remediation, the site could be removed from further environmental consideration.

3.4.3.9 <u>(SW-RAA-3) Cost</u> - The cost associated with the implementation of this alternative are based on the estimated volume calculations given in Section 3.4.3.2, Key Design Assumptions. As stated previously, additional study is necessary to fully define the volume of contaminated sediments and therefore refine costing efforts. Costs have been estimated using available data and should be used as a rough comparison value. These cost do not include reclamation of areas in the form of a lake/pond, or the backfilling with clean soils. These costs are presented on Table 3-4. Detailed cost estimated are presented in Appendix B-2.

TABLE 3-4

COST ESTIMATE SUMMARY
LAKE DANIELSON

SW-RAA-3 Dredge and Off-Site Disposal

Component	Cost
Capital Costs	
(1) Dewatering & Surface Water Diversion	$52,140
(2) Dredging of Sediments	61,175
(3) Off-Site Disposal	4,291,530
(4) Trucking	1,129,350
Indirect Capital Costs	
(1) Engineering & Design	332,051
Total Capital Costs	$5,866,401
Annual Operation and Maintenance Costs	
None	0
Total Present Worth	$5,866,401

* Detailed cost analysis are presented in Appendix B-2.

4.0 RECOMMENDATIONS

The purpose of this section is to present a recommended course of action for each of the three areas under consideration. Each area is discussed separately in the following sections.

4.1 DUNN FIELD GROUND WATER

The contaminated ground water at Dunn Field presents a potential health risk. The risk is not currently high because the Fluvial aquifer is not used as a drinking water supply, nor does future use appear as a likely possibility. The Fluvial aquifer in Dunn Field is separated from the Memphis Sand drinking water aquifer by approximately 90-feet of clay. Despite the presence of this confining unit, the large downward differential head between the aquifers will cause eventual downward migration of the contaminants. A serious concern that was not addressed in the RI is if the western extent of the contaminated plume (currently undefined) extends to an area not underlain by a significant confining unit thickness. Prior to any remedial action it is recommended that the full extent of the plume be defined. The confining unit should be investigated in the area of the plume to determine its continuity and consistency. Finally, the contaminant source should be identified and corrective actions taken to mitigate further ground-water contamination.

Final remedial action recommendations concerning the Dunn Field ground water should be deferred until the extent of contamination has been determined and treatability studies have been performed to determine the most effective technology. However, based on information to date, the following preliminary recommendations are made:

1. Define the burial areas in Dunn Field which are the probable source of ground-water contamination. This process should include: interviews with people who were actually involved in the burials, the use of surface geophysical surveys to locate the burial sites; and the comparison of results to define which areas need remediation.

2. Install an impervious cap over the burial areas to limit ground-water infiltration and thus significantly reduce the amount of leachate seeping from the burial trenches.

3. Perform analysis of representative ground-water samples to determine dissolved metals concentrations, suspended solids, hardness, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and silica levels for use in the design of treatment studies.

4. Perform treatability studies using the UV/H_2O_2 process to determine effectiveness (see Section 3.2.4 for complete discussion of this alternative).

5. Perform pump test studies to provide adequate information to design and install a ground-water extraction system.

6. Install a ground-water extraction system in areas where contaminant levels exceed ARARs. Based on clean-up levels obtained in the treatability study, dispose treated water to POTW or to surface water in accordance with DDMT's NPDES permit.

4.2 SURFACE SOILS

A total of twelve potentially contaminated surface soil areas were investigated at DDMT. The sampling was targeted at the most likely areas of contamination (obvious spills, etc.). Highly elevated levels of contamination were detected in six areas. However, the sampling was insufficient to determine the extent of this contamination, either horizontally or with depth. Thus, it is not possible to estimate quantities of contamination with any confidence. This affects the estimate of total cost. It also affects the selection of a remedial technology because some technologies are more cost-effective when large quantities are involved.

Based on the current understanding of site conditions and on the health based clean-up levels calculated in the risk assessment the following recommendations can be made:

1. Additional investigation should be performed to determine the extent of contamination both horizontally and with depth. A field screening method should be used to reduce costs, with selected confirmation from laboratory analysis. Sampling should be sufficient to allow a more accurate determination of quantities so that a clean-up contract can be prepared.

2. If soils are to be excavated RCRA Land Disposal Regulations require soil contaminants to either be "Listed" or "Characterized". DDMT records will have to be searched and comparisons made between the hazardous material stored/spilled on-site and the contaminants in the soils. If contaminants can not be "Listed" then TCLP analysis must be performed to "Characterize" the contaminants.

3. If possible, all areas requiring clean-up should be approached at one time so that a large quantity of contaminated soil is produced. This large quantity would allow an on-site technology to be utilized economically.

4. Treatability studies should be performed to determine the most effective technology (soil washing or stabilization).

5. If it is necessary to treat localized areas, off-site disposal and treatment could be considered. Land Disposal Regulations will be considered an ARAR and these regulations will have to be complied with. The cost of this alternative should also be thoroughly reviewed prior to implementation.

4.3 LAKE DANIELSON/GOLF COURSE POND

Low levels of contamination were detected within the surface waters of both Lake Danielson and the golf course pond. Pesticides and metals were encountered in the sediments of both bodies of water. The RI results did not provide information concerning the cause of fish kills within Lake Danielson. The most likely hypothesis is that large rainfalls bring additional contamination from the drainage basins into both impoundments. This hypothesis is supported by the reports that fish kills occur after heavy rainfalls. Based on these understandings, the following recommendations are presented:

1. Perform additional surface water sampling of both Lake Danielson and the golf course pond. The sampling should be performed after a heavy rainfall, and ideally after a fish kill. The water entering the lake from the storm water system, and the water within the lake and pond

should be sampled. The additional sampling results should be combined with existing results to formulate a course of action.

2. If the contaminated water is observed to be entering the lake, consider either treatment or diversion of the water.

3. After the above surface water questions have been resolved, consider treatment of the sediment in both surface water bodies. This could be done by dredging the lake and disposing of the sediments off-site. The actual dredging could also be performed by draining the lakes and excavating with a front-end loader. The introduction of aquatic plant life could be considered to reduce turbidity in the water (i.e., prevent sediments from intermittently mixing with the water).

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USEPA, 1989b. Superfund LDR Guide #5 "Determining When Land Disposal Restrictions (LDRs) are Applicable to CERCLA Response Actions". Directive 9347 3-05FS.

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Federal Register/Vol 54, No. 224, Page 48372. Proposed Third Ruling of "LAND-BAN" Restrictions.

APPENDIX A

APPENDIX A-1
[illegible]

APPENDIX A-1

Detailed Cost Analysis
Ground Water
Remedial Action Alternative 2
Institutional Control

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JOB No.: 11-8531-01 PAGE: 1 OF 4
JOB NAME: DDMT
BY: GPM DATE: 4-12-90
CHECKED BY: TLR DATE: 4-17-90

BASIS OF CAPITAL COSTS ESTIMATE

COST ITEM RAA-2 COST COMPONENT INSTITUTIONAL CONTROL

BASIS: MONITORING OF OFF AND ON-SITE WELLS AND REGULATION OF FLUVIAL AQUIFER USE

CALCULATION/SOURCE:
IN-HOUSE PROJECT FILES

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JOB No.: 11-8531-01 PAGE: 2 OF 4
JOB No.: DDMT
BY: GPM DATE: 4-12-90
CHECKED BY: TLR DATE: 4-17-90

ANNUAL OPERATING COSTS ESTIMATE

SITE: DDMT - DUNN FIELD ALTERNATIVE: INSTITUTIONAL CONTROL RAA-2

COST COMPONENT	ESTIMATE ($)	BASIS OF ESTIMATE	FREQUENCY	YEAR/PERIOD
O & M COSTS 1. OPERATING LABOR a. ____ b. ____ c. ____				
2. MAINTENANCE MATERIAL & LABOR a. ____ b. ____ c. ____				
3. AUXILIARY MATERIAL & LABOR a. MONITORING b. ____ c. ____	199,616	PER MONITORING COST BREAKDOWN ESTIMATE x 4	QUARTERLY	1 - 2
4. AUXILIARY a. ____ b. ____ c. ____	99,808	PER MONITORING COST ESTIMATE x 2	SEMI-ANNUAL	3 - 30
5. ADMINISTRATION				
6. INSURANCE, TAXES, LICENSES a. ____ b. ____ c. ____				
7. MAINTENANCE RESERVE & CONTINGENCY COST				
8. OTHER				

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JOB No.: 11-8531-01 PAGE: 3 OF 4
JOB NAME: DDMT
BY: GPM DATE: 4-12-90
CHECKED BY: TLR DATE: 4-17-90

COSTS ANALYSIS

SITE: DDMT - DUNN FIELD
ALTERNATIVE: INSTITUTIONAL CONTROLS RAA-2

COST COMPONENT	COST/YEAR COST OCCURS (THOUSANDS OF DOLLARS)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. CAPITAL COSTS																
2. O & M COSTS	200	200	200	100	→											
3. ANNUAL EXPENDITURES, X_t (SUM OF LINES 1 AND 2)	200	200	200	100	→											
4. DISCOUNT FACTORS ANNUAL DISCOUNT RATE = 10 %	1.0	.909	.826	.751	.683	.621	.564	.513	.467	.424	.386	.35	.319	.29	.263	.239
5. PRESENT WORTH (PRODUCT OF LINES 3 AND 4)	200	182	165	75	68	62	56	51	47	42	39	35	32	29	26	24

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL PRESENT WORTH ($1000)
1. CAPITAL COSTS																
2. O & M COSTS	100	→														
3. ANNUAL EXPENDITURES, X_t (SUM OF LINES 1 AND 2)	100	→														
4. DISCOUNT FACTORS ANNUAL DISCOUNT RATE = %	.218	.198	.180	.164	.149	.135	.123	.112	.101	.092	.084	.076	.069	.063	.057	
5. PRESENT WORTH (PRODUCT OF LINES 3 AND 4)	22	20	18	16	15	14	12	11	10	9	8	8	7	6	6	1315

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JOB No.: 11-8531-01 PAGE: 4 OF 4
JOB NAME: DDMT
BY: GPM DATE: 4-11-90
CHECKED BY: TLR DATE: 4-17-90

GROUND-WATER MONITORING COST ESTIMATE DUNN FIELD (ON AND OFF-SITE)

INSTITUTIONAL CONTROLS RAA-2

(1) TOTAL - 24 GW MONITORING WELLS

(2) WELLS SAMPLED FOR: VOC'S, SEMI-VOLATIES, PEST./PCB's-DISSOLVED METALS COST EA. $1,500/WELL

(3) ANALYSIS 24 WELLS x $1,500/WELL	$ 36,000
(4) LABOR - P4 LEVEL 4 PERSONS x 3 DAYS x 10 HRS/DAY x $68/HR	8,160
(5) TRAVEL - ROUND TRIP MEMPHIS $475 x 4 PERSONS	1,900
(6) AUTO - 2 VEHICLES x $55/DAY x 2 DAYS	220
(7) PER DIEM 4 PERSONS x 3 DAYS x $77/DAY	924
(8) MISC. OTHER DIRECT COST (i.e. TAPE, ICE, BAGS, ACIDS, DECON EQUIPMENT)	450
SUBTOTAL	$ 47,654
REPORT PREPARATION	
(9) LABOR P4 24 HRS x $68/HR	1,632
P6 (REVIEW) 4 HRS x $107/HR	428
C3-4 (CLERICAL) 6 HRS x $30/HR	190
SUBTOTAL	$2,250
SAMPLE EFFORT TOTAL PER EVENT	$49,904

APPENDIX A-2
GW/RAA-8

APPENDIX A-2

Detailed Cost Analysis
Ground Water
Remedial Action Alternative 3
Source Containment

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JOB No.: 11-8531-01 PAGE: 1 OF 5
JOB NAME: DDMT
BY: GPM DATE: 4-12-90
CHECKED BY: TLR DATE: 4-17-90

BASIS OF CAPITAL COSTS ESTIMATE

COST ITEM RAA-3 COST COMPONENT SOURCE CONTAINMENT

BASIS: INSTALLATION OF MULTI-LAYER CAP ABOVE BURIAL SITES AND SEMI-ANNUAL SAMPLING

CALCULATION/SOURCE:

(1) IN-HOUSE PROJECT FILES

(2) REMEDIAL ACTION AT WASTE DISPOSAL SITES
EPA/625/6-85/006

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JOB No.: 11-8531-01 PAGE: 2 OF 5
JOB NAME: DDMT
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CHECKED BY: TLR DATE: 4-17-90

CAPITAL COSTS ESTIMATE

SITE: DDMT - DUNN FIELD ALTERNATIVE: SOURCE CONTAINMENT RAA-3

COST COMPONENT	COST ESTIMATE	BASIS OF ESTIMATE	YEAR INCURRED
DIRECT CAPITAL COST 1. CONSTRUCTION COSTS a. EQUIPMENT 11% b. LABOR 25% c. MATERIALS 64%	53,952 122,618 313,901	SOURCE #'S 1 & 2	1
SUBTOTAL	490,471		
2. EQUIPMENT COSTS _____ INSTALLED _____ PURCHASED			
3. LAND & SITE DEVELOPMENT a. EQUIPMENT b. LABOR c. MATERIALS			
SUBTOTAL			
4. BUILDINGS & SERVICES a. EQUIPMENT b. LABOR c. MATERIALS			
SUBTOTAL			
5. RELOCATION COSTS			
SUBTOTAL			
6. DISPOSAL COSTS			
SUBTOTAL			
TOTAL DIRECT COST	490,471		
INDIRECT CAPITAL COST 1. ENGINEERING & DESIGN	29,429	6% OF DIRECT COST	
2. CONTINGENCY ALLOWANCE			
3. OTHER INDIRECT COSTS a. LEGAL FEES b. LICENSE/PERMIT COSTS c. START-UP & SHAKE-DOWN			
SUBTOTAL			
TOTAL INDIRECT COST	29,429		
TOTAL CAPITAL COSTS	519,899		

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ANNUAL OPERATING COSTS ESTIMATE

SITE: DDMT - DUNN FIELD ALTERNATIVE: SOURCE CONTAINMENT RAA-3

COST COMPONENT	ESTIMATE ($)	BASIS OF ESTIMATE	FREQUENCY	YEAR/PERIOD
O & M COSTS 1. OPERATING LABOR a. ______ b. ______ c. ______				
2. MAINTENANCE MATERIAL & LABOR a. COP O & M b. ______ c. ______	5,000			
3. AUXILIARY MATERIAL & LABOR a. MONITORING b. ______ c. ______	99,808	COST BREAKDOWN ESTIMATE	SEMI-ANNUAL	1 - 30
4. PURCHASED SERVICES a. ______ b. ______ c. ______				
5. ADMINISTRATION				
6. INSURANCE, TAXES, LICENSES a. ______ b. ______ c. ______				
7. MAINTENANCE RESERVE & CONTINGENCY COST				
8. OTHER				

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JOB No.: 11-8531-01 PAGE: 4 OF 5
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COSTS ANALYSIS

SITE: DDMT - DUNN FIELD
ALTERNATIVE: SOURCE CONTAINMENT RAA-3

COST COMPONENT	COST/YEAR COST OCCURS (THOUSANDS OF DOLLARS)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. CAPITAL COSTS	519															
2. O & M COSTS	/	104.8														→
3. ANNUAL EXPENDITURES, Xt (SUM OF LINES 1 AND 2)	519	104.8														→
4. DISCOUNT FACTORS ANNUAL DISCOUNT RATE = 10 %	1.0	.909	.826	.751	.683	.621	.564	.513	.467	.424	.386	.35	.319	.29	.263	.239
5. PRESENT WORTH (PRODUCT OF LINES 3 AND 4)	519	95.3	86.6	78.7	71.6	65.1	59.1	53.8	48.9	44.4	40.5	36.7	33.4	30.4	27.6	25.0

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL PRESENT WORTH ($1000)
1. CAPITAL COSTS																
2. O & M COSTS																
3. ANNUAL EXPENDITURES, Xt (SUM OF LINES 1 AND 2)																
4. DISCOUNT FACTORS ANNUAL DISCOUNT RATE = 10 %	.218	.198	.180	.164	.149	.135	.123	.112	.101	.092	.084	.076	.069	.063	.057	
5. PRESENT WORTH (PRODUCT OF LINES 3 AND 4)	22.8	20.8	18.9	17.2	15.6	14.1	12.9	11.7	10.6	9.64	8.80	7.96	7.23	6.60	5.97	1,508

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MULTI-LAYER CAP COST ESTIMATE

SOURCE CONTAINMENT RAA-3

(A) CLEANING AND GRUBBING \$1198/ACRE x 3.65	\$ 4373
(B) SOIL IMPORT (3.65 ACRES x 43.56ft^2 x 2ft) ÷ 27ft^3 = 11,777 yd^3	
(1) CLAY \$3.38/yd^3 x 11,777 yd^3	39,806
(2) SAND/GRAVEL \$11.44/yd^3 x 5,889 yd^3 (1 FT LAYER)	19,903
(3) LOAM \$3.38/yd^3 x 11,777 yd^3	39,806
(C) SOIL PLACEMENT \$1.09/yd^3 x (11,777 + 5,889 + 11,777)	32,093
(D) VEGETATION, MULCH & HYDROSEED \$1198/ACRE x 3.65 ACRES	4,373
(E) 30 mil PVC LINER 0.38/ft^2 x 158,800	60,344
(F) CAP INSTALLATION (INCL. EARTH WORK) 51.31/ft^2 x 158,800ft^2	208,028
SUBTOTAL	\$408,726
+ 20% LEVEL C	81,745
MULTI-LAYER CAP ESTIMATE	\$490,471

APPENDIX A-3
GW-RAA-4

APPENDIX A-3

Detailed Cost Analysis
Ground Water
Remedial Action Alternative 4
Pump and Treat

LAW ENVIRONMENTAL, INC.
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JOB No.: 11-8531-01 PAGE: 1 OF 5
JOB NAME: DDMT
BY: GPM DATE: 4-12-90
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BASIS OF CAPITAL COSTS ESTIMATE

COST ITEM RAA-4 COST COMPONENT PUMP AND TREAT

BASIS: (1) REMOVAL AND TREATMENT OF CONTAMINATED GROUND WATER BY

- (a) CHEMICAL OXIDATION
- (b) PRECIPITATION / FLOCCULATION

(2) QUARTERLY MONITORING

CALCULATION/SOURCE:

(1) GROSS SUBSURFACE ASSUMPTIONS
(2) VENDOR COMMUNICATION

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JOB No.: 11-8531-01 PAGE: 2 OF 5
JOB NAME: DDMT
BY: GPM DATE: 4-12-90
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CAPITAL COSTS ESTIMATE

SITE: DDMT - DUNN FIELD ALTERNATIVE: PUMP AND TREAT RAA-4

COST COMPONENT	COST ESTIMATE	BASIS OF ESTIMATE	YEAR INCURRED
DIRECT CAPITAL COST 1. CONSTRUCTION COSTS a. EQUIPMENT b. LABOR c. MATERIALS	17,050 38,750 99,200	DETAILED COST BREAKDOWN $15,500 / WELL x 10 WELLS	1
SUBTOTAL	155,000		
2. EQUIPMENT COSTS [✓ INSTALLED] PURCHASED	15,000	INITIAL SET-UP & 5-DAY TRAINING FOR CHEMICAL OXIDATION SYSTEM	1
3. LAND & SITE DEVELOPMENT a. EQUIPMENT b. LABOR c. MATERIALS			
SUBTOTAL			
4. BUILDINGS & SERVICES a. EQUIPMENT b. LABOR c. MATERIALS		SET UP FOR FLOCCULATION / PRECIPITATION SYSTEM FOR METAL TREATMENT	1
SUBTOTAL	200,000		
5. RELOCATION COSTS			
SUBTOTAL			
6. DISPOSAL COSTS			
SUBTOTAL			
TOTAL DIRECT COST	370,000		
INDIRECT CAPITAL COST 1. ENGINEERING & DESIGN	22,200	6% OF DIRECT COST	
2. CONTINGENCY ALLOWANCE			
3. OTHER INDIRECT COSTS a. LEGAL FEES b. LICENSE/PERMIT COSTS c. START-UP & SHAKE-DOWN			
SUBTOTAL			
TOTAL INDIRECT COST	22,200		
TOTAL CAPITAL COSTS	392,200		

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JOB No.: 11-8531-01 PAGE: 3 OF 5
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ANNUAL OPERATING COSTS ESTIMATE

SITE: DDMT - DUNN FIELD ALTERNATIVE: PUMP AND TREAT RAA-4

COST COMPONENT	ESTIMATE ($)	BASIS OF ESTIMATE	FREQUENCY	YEAR/PERIOD
O & M COSTS 1. OPERATING LABOR a. ______ b. ______ c. ______				
2. MAINTENANCE MATERIAL & LABOR a. ______ b. ______ c. ______				
3. AUXILIARY MATERIAL & LABOR a. MONITORING b. ______ c. ______	199,616	COST BREAKDOWN ESTIMATE	QUARTERLY	1 - 10
4. PURCHASED SERVICES a. CHEMICAL - OX		365 DAYS / YEAR 500 gpm		1 - 10
b. TREATMENT	2,365,200	$9.00/1000 GALLONS		
c. METALS FLOCL	99,864	$0.38/1000 GALLONS		
5. ADMINISTRATION				
6. INSURANCE, TAXES, LICENSES a. ______ b. ______ c. ______				
7. MAINTENANCE RESERVE & CONTINGENCY COST				
8. OTHER				

ANNUAL TOTAL $2,664,680.00

LAW ENVIRONMENTAL, INC.
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JOB No.: 11-8531-01 PAGE: 4 OF 5
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COSTS ANALYSIS

SITE: DDMT - DUNN FIELD
ALTERNATIVE: PUMP AND TREAT RAA-4--

COST COMPONENT	COST/YEAR COST OCCURS (THOUSANDS OF DOLLARS)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. CAPITAL COSTS	392	/	→	→	→	→	→	→	→	→	→					
2. O & M COSTS	0	2,665	→	→	→	→	→	→	→	→	→					
3. ANNUAL EXPENDITURES, X_i (SUM OF LINES 1 AND 2)	0	2,665	→	→	→	→	→	→	→	→	→					
4. DISCOUNT FACTORS ANNUAL DISCOUNT RATE = 10 %	1.0	.909	.826	.751	.683	.621	.564	.513	.467	.424	.386					
5. PRESENT WORTH (PRODUCT OF LINES 3 AND 4)	392	2,422	2,201	2,001	1,820	1,655	1,503	1,367	1,245	1,130	1,029					

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL PRESENT WORTH ($1000)
1. CAPITAL COSTS																
2. O & M COSTS																
3. ANNUAL EXPENDITURES, X_i (SUM OF LINES 1 AND 2)																
4. DISCOUNT FACTORS ANNUAL DISCOUNT RATE = %																
5. PRESENT WORTH (PRODUCT OF LINES 3 AND 4)																16,765

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COST ESTIMATE - 90' RECOVERY WELL (6" DIA.)

PUMP AND TREAT RAA-4

1) MOBILIZATION	$ 500	
2) MUD-ROTARY DRILLING (10" DIA. BOREHOLE) $11/FT x 90FT	990	
3) STANDARD PENETRATION TEST $ 22/SAMPLE x 18 SAMPLES	396	
4) TYPE II SCHEDULE 40 PVC WATER WELL		
0 - 30FT - $45/FT x 30FT	1,350	
30 - 100FT - $35/FT x 60FT	2,100	
5) STEAM CLEANING $130/HR x 4HRS	520	
6) WATER HAULING $130/HR x 6HRS	780	
7) EQUIPMENT CHARGES		
- WATER TRUCK PER DAY $80 x 3 DAYS	240	
- STEAM CLEANER PER DAY $50 x 3 DAYS	150	
8) PROTECTIVE COVER 8" x 5' COVER WITH LOCK	180	
9) CONCRETE WELL PAD 6' x 6' x 6"	300	
10) PER DIEM (3 - MAN CREW) $72/MAN/DAY x 3 DAYS	648	
11) GEOLOGIST - P4 - $60/HR x 24 HRS	1,440	
PER DIEM 3 DAYS $72/DAY	216	
TRAVEL AND CAR	635	
SUBTOTAL	$10,445	/PER WELL
SUBMERSIBLE PUMP		
1) GROUND MOVER $755 45 TO 95 gpm (STAINLESS SUBMERSIBLE PUMP WITH LEADS, MOTOR, PUMP & CONTROL FOR EACH)	$1,163	
2) OTHER DIRECT COSTS (WIRE, TUBING FOR DISCHARGE, ETC)	500	
LABOR GEOLOGIST P4 $60/HR x 20 HRS (INCL. TRAVEL)	1,200	
P1 $45/HR x 20 HRS (INCL. TRAVEL)	900	
PER DIEM 2 x 2 DAYS x $72/DAY	288	
TRAVEL 2 x $470 ROUND TRIP	940	
CAR 1 x 2 DAYS x $55/DAY	110	
SUBTOTAL	$5,101	/PER PUMP INSTALLATION
TOTAL WELL INSTALLATION & PUMP INSTALLATION	$15,546	/PER WELL

APPENDIX B

APPENDIX B-1
SW - RAA #2

APPENDIX B-1

Detailed Cost Analysis
Lake Danielson
Remedial Action Alternative 2
Site Analysis

LAW ENVIRONMENTAL, INC.
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JOB No.: 11-8531-01 PAGE: 1 OF 2
JOB NAME: DDMT
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BASIS OF CAPITAL COSTS ESTIMATE

COST ITEM RAA-2 COST COMPONENT SITE ANALYSIS - LAKE DANIELSON

BASIS: PROVIDE RECORD REVIEW OF PESTICIDE APPLICATION HISTORY, DRAINAGE SYSTEMS, SPILL CONTROL HISTORY AND SITE CHARACTERIZATION

CALCULATION/SOURCE:

IN-HOUSE COST ESTIMATE $58,000 (SEE ATTACHED)

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LAKE DANIELSON (RAA-2) - SITE ANALYSIS

RECORDS AND SYSTEM REVIEW

1) LABOR P4 GEOLOGIST $60/HR x 60 HRS	$ 3,600
P6 GEOTECH ENG. $97/HR x 10 HRS	970
2) TRAVEL $475/ROUND TRIP x 2 PERSONS	950
3) PER DIEM $77/DAY x 2 DAYS x 2 PERSONS	308
4) CAR RENTAL $55/DAY x 2 DAYS	110
5) MISC. ODC'S	100
TOTAL	$6038

LAKE AND POND SAMPLING

1) ANALYSIS $1500 PER SAMPLE x 25 SEDIMENT SAMPLES	$37,500
$1500 PER SAMPLE x 6 WATER SAMPLES	9,000
2) LABOR P3 CHEMIST $40/HR x 24 HRS x 2 PERSONS	1,920
3) REVIEW DATA & REPORT P3 $40/HR x 16 HRS	640
P6 $97/HR x 3 HRS	291
4) TRAVEL $475/ROUND TRIP x 2 PERSONS	950
5) PER DEMI $77/DAY x 3 DAYS x 2 PERSONS	462
6) CAR RENTAL $55/DAY x 3 DAYS	165
7) MISC. ODC'S (ACIDS, STRIPPERS, SAFETY EQUIP, GAS, ETC.)	500
TOTAL	$51,428
RAA-2 TOTAL	$57,466

APPENDIX B-4
SW-RAA-3

APPENDIX B-2

Detailed Cost Analysis
Lake Danielson
Remedial Action Alternative 3
Dredge/Treatment

LAW ENVIRONMENTAL, INC.
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BASIS OF CAPITAL COSTS ESTIMATE

COST ITEM RAA-3 COST COMPONENT DREDGE TREATMENT-LAKE DANIELSON POND

BASIS: REMOVAL AND OFF-SITE DISPOSAL OF CONTAMINATED SEDIMENTS

CALCULATION/SOURCE:

1) REMEDIAL ACTION AT WASTE DISPOSAL SITES EPA/625/6-85/006

2) LAW ENVIRONMENTAL IN-HOUSE FILES

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CAPITAL COSTS ESTIMATE

SITE: LAKE DANIELSON ALTERNATIVE: RAA-3

COST COMPONENT	COST ESTIMATE	BASIS OF ESTIMATE	YEAR INCURRED
DIRECT CAPITAL COST			
1. CONSTRUCTION COSTS	6,729	DREDGING OF SEDIMENTS	1
a. EQUIPMENT	15,294		
b. LABOR	39,152		
c. MATERIALS			
SUBTOTAL	61,175		
2. EQUIPMENT COSTS ____ INSTALLED ____ PURCHASED			
3. LAND & SITE DEVELOPMENT	5,735	TEMPORARY DEWATERING PONDS AND SURFACE WATER DIVERSION	1
a. EQUIPMENT	13,035		
b. LABOR	33,370		
c. MATERIALS			
SUBTOTAL	52,140		
4. BUILDINGS & SERVICES			
a. EQUIPMENT			
b. LABOR			
c. MATERIALS			
SUBTOTAL			
5. TRUCKING COSTS			1
SUBTOTAL	1,129,350		
6. DISPOSAL COSTS		OFF0SITE DISPOSAL IN RCRA "C" LANDFILL	1
SUBTOTAL	4,291,530		
TOTAL DIRECT COST	5,534,195		
INDIRECT CAPITAL COST			
1. ENGINEERING & DESIGN	332,051	6% OF DIRECT COST	
2. CONTINGENCY ALLOWANCE			
3. OTHER INDIRECT COSTS			
a. LEGAL FEES			
b. LICENSE/PERMIT COSTS			
c. START-UP & SHAKE-DOWN			
SUBTOTAL			
TOTAL INDIRECT COST	332,051		
TOTAL CAPITAL COSTS	5,866,246		

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ANNUAL OPERATING COSTS ESTIMATE

SITE: LAKE DANIELSON ALTERNATIVE: RAA-3 DREDGING & SOIL WASH

COST COMPONENT	ESTIMATE ($)	BASIS OF ESTIMATE	FREQUENCY	YEAR/PERIOD
O & M COSTS 1. OPERATING LABOR a. ___ b. ___ c. ___	0			
2. MAINTENANCE MATERIAL & LABOR a. ___ b. ___ c. ___				
3. AUXILIARY MATERIAL & LABOR a. ___ b. ___ c. ___				
4. PURCHASED SERVICES a. ___ b. ___ c. ___				
5. ADMINISTRATION				
6. INSURANCE, TAXES, LICENSES a. ___ b. ___ c. ___				
7. MAINTENANCE RESERVE & CONTINGENCY COST				
8. OTHER				

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JOB No.: 11-8531-01 PAGE: 4 OF 6
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COSTS ANALYSIS

SITE: LAKE DANIELSON/ GOLF COURSE POND

ALTERNATIVE: RAA-3 DREDGE AND LANDFILL

COST COMPONENT	COST/YEAR COST OCCURS (THOUSANDS OF DOLLARS)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. CAPITAL COSTS	5534															
2. O & M COSTS	/															
3. ANNUAL EXPENDITURES, X_t (SUM OF LINES 1 AND 2)	5534															
4. DISCOUNT FACTORS ANNUAL DISCOUNT RATE = 10 %	1.0															
5. PRESENT WORTH (PRODUCT OF LINES 3 AND 4)	5534															

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL PRESENT WORTH ($1000)
1. CAPITAL COSTS																
2. O & M COSTS																
3. ANNUAL EXPENDITURES, X_t (SUM OF LINES 1 AND 2)																
4. DISCOUNT FACTORS ANNUAL DISCOUNT RATE = %																
5. PRESENT WORTH (PRODUCT OF LINES 3 AND 4)																5,534

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RAA-3 DREDGE AND OFF-SITE DISPOSAL

DEWATER PONDS

1) PUMPS $150/WEEK/PUMP x 2 WEEKS x 4 PUMPS	$ 1,200
2) LABOR $60/HR x 80 HRS x 2 PERSONS	9,600
3) TRAVEL $475/ROUND TRIP x 2 PERSONS	950
4) PER DIEM $77/DAY x 10 DAYS x 2 PERSONS	1,540
5) CAR RENTAL $55/DAY x 2 DAYS	550
6) MISC. ODC'S (i.e. HOSE, PLUMBING PARTS, TOOLS, PIPING)	1,000
SUB TOTAL	$14,840

SURFACE WATER DIVERSION

1) GRADING: EXCAVATE, HAUL 2-MILES, SPREAD: $7.46 yd^3 x 5000 yd^3 (GRADER WITH FRONT END LOADER; LABOR, MATERIAL & EQUIP.)	$37,300

DREDGING (NO DE-WATERING/STABILIZATION REQUIRED)

1) DREDGING: CRAWLER - HYDRAULIC CRAWLER, 1 cy CAPACITY DRY EXCAVATION $2.71/yd^3 x 22,587 yd^3	$61,175

OFF-SITE DISPOSAL

1) DISPOSAL IN RCRA SUBTITLE C FACILITY WITH NO ADDITIONAL TREATMENT @ $190/yd^3 $190/yd^3 x 22,587yd^3	$4,291,530
2) TRUCKING @ $50/yd^3 $50/yd^3 x 22,587yd^3	$1,129,350
RAA-3 TOTAL	$5,534,194

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LANDFILL QUOTE FOR DISPOSAL IN RCRA SUBTITLE "C" LANDFILL

TAX $10-20/TON

TIPPING COST $110-120/TON

SAY TOTAL $140/TON

@ 100#SOIL/c.y. 1 c.y. = 1.35 TONS

ADJUST TOTAL BY 1.35

DISPOSAL COST $140/TON (1.35) = $190/c.y.

TRUCKING COST $35/TON
x 1.35
$46/c.y.

SAY $50/c.y.

APPENDIX C

APPENDIX C

System Discharge Agreement
City of Memphis

PERMIT NUMBER ____

19 216

City of Memphis

Division of Public Works

System Discharge Agreement made by and between the City of Memphis and

____

on ________ ________ , ________ .

PERMIT NUMBER ______

19 217

SEWER USE AGREEMENT

INTENT AND PURPOSE

THE CITY OF MEMPHIS IN ENACTING THE REVISED SEWER USE ORDINANCE DEEMED IT NECESSARY TO IDENTIFY CERTAIN SIGNIFICANT CONTRIBUTORS TO THE MUNICIPAL SEWER SYSTEM AND AGREE WITH THESE SIGNIFICANT CONTRIBUTORS ON THE DISCHARGE QUANTITY AND CHARACTERISTICS WHICH WOULD BE PERMITTED IN THE MUNICIPAL SYSTEM. THE BASIS FOR THE VALUES SHOWN AND MUTUALLY AGREED UPON IN THE FOLLOWING PAGES ARE PRIMARILY TO COMPLY WITH THE STATE OF TENNESSEE AND ENVIRONMENTAL PROTECTION AGENCY REGULATIONS AND TO PRESERVE THE INTEGRITY OF THE PUBLIC OWNED TREATMENT WORKS.

THE AGREEMENT WHICH IS MUTUALLY REACHED BY THIS DOCUMENT SERVES AS A FIRM UNDERSTANDING BETWEEN THE USER AND THE CITY FOR A SPECIFIED PERIOD OF TIME. THE PARAMETERS WHICH HAVE BEEN IDENTIFIED IN THIS DOCUMENT REFLECT THE BEST ESTIMATE OF THE USER AS TO THE CHARACTERISTICS OF HIS DISCHARGE AND WILL REMAIN IN EFFECT UNTIL MODIFIED BY AMENDMENTS TO THE DISCHARGE AGREEMENT. THE ALLOWABLE LEVELS FOR EACH PARAMETER WHICH HAVE BEEN MUTUALLY AGREED UPON ARE DETERMINED BY ONE OR MORE FACTORS. PRIMARY IN THE DETERMINATION IS THE PROTECTION TO THE INTEGRITY OF THE PUBLIC OWNED TREATMENT WORKS. ACCORDINGLY, A TABLE OF GUIDANCE FOR CRITERIA INFLUENT LEVELS FOR SPECIFIC INCOMPATIBLE WASTES HAS BEEN DEVELOPED AND IS PART OF THE SEWER USE ORDINANCE. THE VALUES IN THIS TABLE WERE DERIVED CONSIDERING THE WORSE OF THREE CASES: TOXICITY OR INTERFERENCE TO THE UNIT PROCESSES IN THE TREATMENT PLANT, "PASS THROUGH" THE PLANT IN VIOLATION OF EFFLUENT STANDARDS, OR SIGNIFICANT CONTAMINATION OF THE WASTE SLUDGE TO RENDER A PROBLEM. IN MOST CASES, THE PARAMETERS WERE LIMITED BY THE ANTICIPATED "PASS THROUGH" THE PLANT IN VIOLATION OF EFFLUENT STANDARDS. WHERE THE EFFLUENT STANDARDS DO NOT LIST THOSE INCOMPATIBLE WASTES, THE MAXIMUM ALLOWABLE LEVEL ENTERING THE PLANT WAS BASED UPON ESTABLISHED TOXICITY DATA FOR THE VARIOUS UNIT PROCESSES IN THE MEMPHIS PLANTS.

PERMIT NUMBER 19 218

WILLFULL FAILURE OF AN INDUSTRIAL USER TO REPORT SIGNIFICANT CHANGES IN OPERATIONS WHICH AFFECT WASTEWATER CONSTITUENTS AND CHARACTERISTICS CAN RESULT IN THE REVOKING OF HIS DISCHARGE AGREEMENT. IF A PUBLIC SEWER BECOMES OBSTRUCTED OR DAMAGED BECAUSE OF ANY SUBSTANCES IMPROPERLY DISCHARGED INTO IT, ______________________________ IF RESPONSIBLE FOR SUCH DISCHARGE SHALL BE BILLED AND SHALL PAY FOR THE EXPENSES INCURRED BY THE CITY IN CLEANING OUT, REPAIRING, OR REBUILDING THE SEWER.

EACH INDUSTRIAL USER DISCHARGING INCOMPATIBLES IDENTIFIED BY THE ENVIRONMENTAL PROTECTION AGENCY MUST ALSO PRETREAT TO THE POINT AS REQUIRED BY THE EPA. IN ADDITION TO THIS, THE STATE OF TENNESSEE HAS IDENTIFIED CERTAIN ALLOWABLE LEVELS FOR INCOMPATIBLES ENTERING A PUBLICLY OWNED TREATMENT WORKS. THE PRETREATMENT VALUES SET BY THE CITY ARE LISED IN TABLE I OF THE APPROVED SEWER USE ORDINANCE. USERS WILL PRETREAT OR OTHERWISE MODIFY THEIR DISCHARGE TO THE MUNICIPAL SYSTEM TO BE COMPATIBLE WITH THE VALUES IN TABLE I OR THE LATEST EPA REGULATIONS FOR PRETREATMENT, WHICHEVER IS MORE RIGID AND RESTRICTIVE.

WHEREAS, SECTION 35 1/2 OF THE CODE OF ORDINANCES OF THE CITY OF MEMPHIS REQUIRES THAT "DISCHARGERS TO THE MUNICIPAL WASTEWATER TREATMENT FACILITIES DESIGNATED BY THE APPROVING AUTHORITY AS REQUIRING AGREEMENTS SHALL NOT DISCHARGE TO THE SYSTEM WITHOUT SAID AGREEMENT"; AND

WHEREAS, ______________________ LOCATED AT ____________________ DESIRES TO DISCHARGE TO THE MEMPHIS SEWER SYSTEM; AND

WHEREAS, ______________________ AGREES TO COMPLY WITH ALL REQUIREMENTS SPECIFIED IN SECTION 35 1/2 OF THE CODE OF ORDINANCES AND ANY REVISIONS THEREOF.

NOW THEREFORE, ________________, ____________________________ IS GRANTED THE RIGHT TO DISCHARGE THE WASTEWATER OF SUCH CHARACTERISTICS AND VOLUME AS DESCRIBED IN APPENDIX A INTO THE CITY OF MEMPHIS SEWER SYSTEM FROM ____________________ TO ____________________________

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______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

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APPENDIX "A"

INDUSTRIAL WASTE DISCHARGE AGREEMENT

1. NAME OF INDUSTRY:
2. ADDRESS:
3. SIC #:
4. REPRESENTATIVE: TITLE: PHONE:
5. BRIEF DESCRIPTION OF MANUFACTURING OR SERVICE ACTIVITY ON PREMISES:
6. PRINCIPAL RAW MATERIALS USED:
7. CATALYSTS, INTERMEDIATES:
8. PRINCIPAL PRODUCTS OR SERVICE:
9. HOURS OF OPERATION/DAY: DAYS OF OPERATION/WEEK:
10. PRESENT NUMBER OF EMPLOYEES:
    "NORMAL" NUMBER OF EMPLOYEES:
11. TYPE OF PROCESS: CONTINUOUS: BATCH:
12. IS THERE A SCHEDULED SHUTDOWN?
    WHEN?
13. IS PRODUCTION SEASONAL?
    IF YES, EXPLAIN INDICATING MONTH(S) OF PEAK PRODUCTION:
14. MLG&W BILLING ADDRESS (IF DIFFERENT FROM ITEM 2):
15. MLG&W ACCOUNT NUMBER (OR NUMBERS):
16. ESTIMATED ANNUAL WATER USAGE: MILLION GALLONS
17. WATER USAGE BY SOURCE: MUNICIPAL: PRIVATE:

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______________________	______________________
______________________	______________________
______________________	______________________

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18. LIST WATER CONSUMPTION IN PLANT

COOLING WATER ____________ GALLONS PER DAY

BOILER FEED ____________ GALLONS PER DAY

PROCESS WATER ____________ GALLONS PER DAY

SANITARY SYSTEM ____________ GALLONS PER DAY

CONTAINED IN PRODUCT ____________ GALLONS PER DAY

OTHER ____________ GALLONS PER DAY

19. LIST AVERAGE VOLUME OF DISCHARGE OR WATER LOSS TO

CITY WASTEWATER SEWER ____________ GALLONS PER DAY

STORM SEWER ____________ GALLONS PER DAY

WASTE HAULER ____________ GALLONS PER DAY

EVAPORATION ____________ GALLONS PER DAY

CONTAINED IN PRODUCT ____________ GALLONS PER DAY

20. PRETREATMENT? IF SO, DESCRIPTION OF FACILITIES:

21. ANY BATCH DISCHARGES? TYPE, TIME, VOLUME AND STRENGTH OF FLOW:

22. TYPE AND DESCRIPTION OF METERING AND SAMPLING FACILITIES FOR SEWAGE DISCHARGE:

23. AREA OF PLANT SITE IN ACRES:

24. LIST PLANT SEWER OUTLETS, SIZE, FLOW (ATTACH AND REFER TO MAP):

25. PERSON OR LABORATORY RESPONSIBLE FOR DISCHARGE SAMPLING AND ANALYSIS:

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____________	____________
____________	____________
____________	____________

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26. VARIATIONS IN FLOW RATE TO SANITARY SEWER? EXPLAIN, IF ANY:

27. FUTURE PLANS FOR PLANT EXPANSION, WATER REUSE, INCREASE OR DECREASE IN DISCHARGE QUANTITY OR STRENGTH, PRETREATMENT FACILITIES, OR OTHERS: (USE EXTRA SHEETS AS NECESSARY)

28. IS THERE A SPILL PREVENTION CONTROL AND COUNTER-MEASURE PLAN IN EFFECT FOR THIS PLANT?

________ YES ________ NO

29. THE DAILY AVERAGE MAXIMUM LEVEL IS A MAXIMUM AVERAGE FOR A WEEK OF OPERATION FOR A YEAR'S DURATION. REDUCED OPERATION TIMES, FOR EXAMPLE WEEKEND REDUCTION IN PRODUCTION, ARE NOT TO BE INCLUDED.

THE INSTANTANEOUS MAXIMUM LEVEL FOR POLLUTANTS WE CLASSIFY AS COMPATIBLE IS THE MAXIMUM DAILY AVERAGE CONCENTRATION FOR A YEAR'S DURATION OF A 24 HOUR PERIOD OR DAILY OPERATING PERIOD FOR A FLOW PROPORTIONATE SAMPLE OR IF FLOW PROPORTIONATE SAMPLES ARE NOT ATTAINABLE, THEN A TIME PROPORTIONATE SAMPLE DURING HOURS OF OPERATION.

THE INSTANTANEOUS MAXIMUM LEVEL FOR POLLUTANTS WE CLASSIFY AS INCOMPATIBLE IS THE MAXIMUM LEVEL AT ANY POINT IN TIME AND IS DETERMINED BY A GRAB SAMPLE AT THE TIME OF MAXIMUM DISCHARGE OF A PARAMETER. ALL PRIORITY POLLUTANTS ARE CONSIDERED AS INCOMPATIBLE.

THE FOLLOWING TABLE (TABLE A-1) SPECIFIES THE DESIRED METHOD OF SAMPLING FOR DETERMINING THE INSTANTANEOUS MAXIMUM CONCENTRATION FOR THE VARIOUS PARAMETERS AND DENOTES WHICH PARAMETERS WE CONSIDER COMPATIBLE AND WHICH WE CONSIDER INCOMPATIBLE.

THE MINIMUM LIMIT FOR PH OF 5.5 AS SPECIFIED IN THE SEWER USE ORDINANCE IS AN INSTANTANEOUS MINIMUM OR A "AT NO TIME TO FALL BELOW" LIMIT AND IS NOT A DAILY AVERAGE DETERMINED FROM A COMPOSITED SAMPLE.

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TABLE A-1

METHOD OF SAMPLE COLLECTION FOR DETERMINATION OF INSTANTANEOUS MAXIMUM LEVEL CONCENTRATIONS

(1) 24 HOUR FLOW PROPORTIONATE COMPOSITE SAMPLE, OR IF NECESSARY TIME COMPOSITE SAMPLE

(2) GRAB SAMPLE

PARAMETER	TYPE SAMPLE REQUIRED	CLASSIFICATION
BOD_5	1	COMPATIBLE
BOD_{20}	1	COMPATIBLE
SUSPENDED SOLIDS	1	COMPATIBLE
SETTLEABLE SOLIDS	1	COMPATIBLE
TOTAL SOLIDS	1	COMPATIBLE
TEMPERATURE -MAY NEVER BE ABOVE 150° F	2	INCOMPATIBLE ABOVE 150° F
PH -MAY NEVER BE BELOW 5.5 -	2	INCOMPATIBLE BELOW 5.5
COD	1	COMPATIBLE
OIL & GREASE (HYDROCARBON ORIGIN)	2	INCOMPATIBLE ABOVE 100 PPM
OIL & GREASE (TOTAL)	1	COMPATIBLE
CYANIDES	2	INCOMPATIBLE
PESTICIDES	2	INCOMPATIBLE
VOLATILE COMPOUNDS	2	INCOMPATIBLE
SULFIDES	2	INCOMPATIBLE
SULFATES	1	COMPATIBLE
CHLORIDES	1	COMPATIBLE
COLOR	1	COMPATIBLE
TOC	1	COMPATIBLE
RADIOACTIVE MATERIAL	2	INCOMPATIBLE
CHLORINE DEMAND	2	INCOMPATIBLE
ACIDITY	1	COMPATIBLE
ALKALINITY	1	COMPATIBLE
ARSENIC	2	INCOMPATIBLE
PHOSPHATE	1	COMPATIBLE
AMMONIA NITROGEN	2	INCOMPATIBLE
MERCURY	2	INCOMPATIBLE
CHROMIUM, HEXV.	2	INCOMPATIBLE
CHROMIUM TOTAL	2	INCOMPATIBLE
CADMIUM	2	INCOMPATIBLE
ZINC	2	INCOMPATIBLE
PHENOLS	2	INCOMPATIBLE
LEAD	2	INCOMPATIBLE
NICKEL	2	INCOMPATIBLE
COPPER	2	INCOMPATIBLE
IRON	2	INCOMPATIBLE
SILVER	2	INCOMPATIBLE
BARIUM	2	INCOMPATIBLE
PRIORITY POLLUTANTS	2	INCOMPATIBLE

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29. (continued)

ARE ANY OF THE PRIORITY POLLUTANTS LISTED IN THE FOLLOWING TABLE (TABLE A-2) BEING USED AT THIS FACILITY IN MANUFACTURING OF THE PRODUCT OR IS A BY-PRODUCT WHICH MAY BE DISCHARGED? IF SO, INDICATE BY A CHECK MARK ON TABLE A-2 ANY PRIORITY POLLUTANT PRESENT AND QUANTIFY ANY OF THESE POLLUTANTS PRESENT IN YOUR DISCHARGE IN MORE THAN TRACE AMOUNTS BY THE DAILY AVERAGE MAXIMUM LEVEL AND INSTANTANEOUS MAXIMUM LEVEL IN CONCENTRATION AND POUND PER DAY DISCHARGED.

TABLE A-2

PRIORITY POLLUTANT	DAILY AVERAGE MAXIMUM LEVEL*		INSTANTANEOUS MAXIMUM LEVEL	
	mg/l	#/day	mg/l	#/day
1. ACENAPHTHENE				
2. ACROLEIN				
3. ACRYLONITRILE				
4. BENZENE				
5. BENZIDINE				
6. CARBON TETRACHLORIDE (TETRACHLOROMETHANE)				
7. CHLOROBENZENE				
8. 1,2,4-TRICHLOROBENZENE				
9. HEXACHLOROBENZENE				
10. 1,2-DICHLOROETHANE				
11. 1,1,1,TRICHLOROETHANE				
12. HEXACHLOROETHANE				
13. 1,1,-DICHLOROETHANE				
14. 1,1,2-TRICHLOROETHANE				

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29. (Continued) TABLE A-2 (CONTINUED)

PRIORITY POLLUTANT	DAILY AVERAGE MAXIMUM LEVEL*		INSTANTANEOUS MAXIMUM LEVEL	
	mg/l	#/day	mg/l	#/day
15. 1,1,2,2-TETRACHLOROETHANE				
16. CHLOROETHANE				
17. BIS(CHLOROMETHYL) ETHER				
18. BIS(2-CHLOROETHYL)ETHER				
19. 2-CHLOROETHYL VINYL ETHER (MIXED)				
20. 2-CHLORONAPHTHALENE				
21. 2,4,6-TRICHLOROPHENOL				
22. PARACHLOROMETA CRESOL				
23. CHLOROFORM(TRICHLOROMETHANE)				
24. 2-CHLOROPHENOL				
25. 1,2-DICHLOROBENZENE				
26. 1,3-DICHLOROBENZENE				
27. 1,4-DICHLOROBENZENE				
28. 3,3-DICHLOROBENZIDINE				
29. 1,1-DICHLOROETHYLENE				
30. 1,2-TRANS-DICHLOROETHYLENE				
31. 2,4-DICHLOROPHENOL				
32. 1,2-DICHLOROPROPANE				
33. 1,3-DICHLOROPROPYLENE				
34. 2,4-DIMETHYLPHENOL				
35. 2,4-DINITROTOLUENE				
36. 2,6-DINITROTOLUENE				
37. 1,2-DIPHENYLHYDRAZINE				

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29. (continued) TABLE A-2 (CONTINUED)

PRIORITY POLLUTANT	DAILY AVERAGE MAXIMUM LEVEL*		INSTANTANEOUS MAXIMUM LEVEL	
	mg/l	#/day	mg/l	#/day
38. ETHYLBENZENE				
39. FLUORANTHENE				
40. 4-CHLOROPHENYL PHENYL ETHER				
41. 4-BROMOPHENYL PHENYL ETHER				
42. BIS(2-CHLOROISOPROPYL) ETHER				
43. BIS(2-CHLOROETHOXY) METHANE				
44. METHYLENE CHLORIDE (DICHLOROMETHANE)				
45. METHYL CHLORIDE (CHLOROMETHANE)				
46. METHYL BROMIDE (BROMOMETHANE)				
47. BROMOFORM (TRIBROMOMETHANE)				
48. DICHLOROBROMOMETHANE				
49. TRICHLOROFLUOROMETHANE				
50. DICHLORODIFLUOROMETHANE				
51. CHLORODIBROMOMETHANE				
52. HEXACHLOROBUTADIENE				
53. HEXACHLOROCYCLOPENTADIENE				
54. ISOPHORONE				
55. NAPHTHALENE				
56. NITROBENZENE				
57. 2-NITROPHENOL				
58. 4-NITROPHENOL				
59. 2,4-DINITROPHENOL				
60. 4,6-DINITRO-O-CRESOL				
61. N-NITROSODIMETHYLAMINE				
62. N-NITROSODIPHENYLAMINE				

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29. (continued)

TABLE A-2 (CONTINUED)

PRIORITY POLLUTANT	DAILY AVERAGE MAXIMUM LEVEL*		INSTANTANEOUS MAXIMUM LEVEL	
	mg/1	#/day	mg/1	#/day
63. N-NITROSODI-N-PROPYLAMINE				
64. PENTACHLOROPHENOL				
65. PHENOL (4APP)				
66. BIS(2-ETHYLHEXYL) PHTHALATE				
67 BUTYL BENZYL PHTHALATE				
68. DI-N-BUTYL PHTHALATE				
69. DI-N-OCTYL PHTHALATE				
70. DIETHYL PHTHALATE				
71. DIMETHYL PHTHALATE				
72. BENZO(A)ANTHRACENE (1,2 BENZANTHRACENE)				
73. BENZO(A)PYRENE (3,4-BENZOPYRENE)				
74. 3,4-BENZOFLUORANTHENE				
75. BENZO(K)FLUORANTHANE(11, 12-BENZOFLUORANTHENE				
76. CHRYSENE				
77. ACENAPHTHYLENE				
78. ANTHRACENE				
79. BENZO(GHI)PERYLENE(1,12-BENZOPERYLENE)				
80. FLUORENE				
81. PHENANTHRENE				
82. 1,2,5,6-DIBENZANTHRACENE				
83. INDENO (1,2,3-CD) PYRENE				
84. PYRENE				
85. TETRACHLOROETHYLENE				
86. TOLUENE				
87. TRICHLOROETHYLENE				
88. VINYL CHLORIDE (CHLOROETHYLENE)				
89. ALDRIN				

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29. (continued) TABLE A-2 (CONTINUED)

PRIORITY POLLUTANT	DAILY AVERAGE MAXIMUM LEVEL*		INSTANTANEOUS MAXIMUM LEVEL	
	mg/l	#/day	mg/l	#/day
90. DIELDRIN				
91 CHLORDANE(TECH. MIXTURE & METABOLITES)				
92 4,4'DDT				
93. 4,4'-DDE(P,P'DDX)				
94. 4',4'-DDD (P,P'-TDE)				
95. ALPHA-ENDOSULFAN				
96. BETA-ENDOSULFAN				
97. ENDOSULFAN SULFATE				
98. ENDRIN				
99. ENDRIN ALDEHYDE				
100. HEPTACHLOR				
101. HEPTACHLOR EPOXIDE				
102. ALPHA-BHC				
103. BETA-BHC				
104. GAMMA-BHC (LINDANE)				
105. DELTA-BHC				
106. PCB-1242(AROCHLOR 1242)				
107. PCB-1254(AROCHLOR 1254)				
108. PCB-1221(AROCHLOR 1221)				
109. PCB-1232(AROCHLOR 1232)				
110. PCB-1248(AROCHLOR 1248)				
111. PCB-1260(AROCHLOR 1260)				
112. PCB-1016(AROCHLOR 1016)				
113. TOXAPHENE				
114. ANTIMONY (TOTAL)				
115. ARSENIC (TOTAL)				
116. ASBESTOS (FIBROUS)				
117. BERYLLIUM (TOTAL)				

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29. (continued)

TABLE A-2 (CONTINUED)

PRIORITY POLLUTANT	DAILY AVERAGE MAXIMUM LEVEL*		INSTANTANEOUS MAXIMUM LEVEL	
	mg/l	#/day	mg/l	#/day
118. CADMIUM (TOTAL)				
119. CHROMIUM (TOTAL)				
120. COPPER (TOTAL)				
121. CYANIDE (TOTAL)				
122. LEAD (TOTAL)				
123. MERCURY (TOTAL)				
124. NICKEL (TOTAL)				
125. SELENIUM (TOTAL)				
126. SILVER (TOTAL)				
127. THALLIUM (TOTAL)				
128. ZINC (TOTAL)				
129. 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN (TCDD)				

30. CHEMICAL ANALYSIS: + QUANTIFY FOR BOTH DAILY AVERAGE MAXIMUM LEVEL AND INSTANTANEOUS MAXIMUM LEVEL IN CONCENTRATIONS AND POUNDS PER DAY THE PARAMETERS THAT ARE SIGNIFICANT IN YOUR WASTEWATER DISCHARGE.

	DAILY AVERAGE* MAXIMUM LEVEL		INSTANTANEOUS MAXIMUM LEVEL	
	mg/l	#/day	mg/l	#/day
BOD_5				
BOD_{20}				
SUSPENDED SOLIDS				
SETTLEABLE SOLIDS				
TOTAL SOLIDS				
TEMPERATURE				
pH				

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10. continued	DAILY AVERAGE* MAXIMUM LEVEL		INSTANTANEOUS MAXIMUM LEVEL	
	mg/l	#/day	mg/l	#/day
COD				
OIL & GREASE (HYDROCARBON ORIGIN)				
OIL & GREASE(TOTAL)				
CYANIDES (OXIDIZABLE)				
CYANIDES (TOTAL)				
PESTICIDES**				
SURFACTANTS				
VOLATILE COMPOUNDS				
SULFIDES				
SULFATES				
CHLORIDES				
COLOR				
TOC				
RADIOACTIVE MATERIAL				
CHLORINE DEMAND				
ACIDITY				
ALKALINITY				
ARSENIC				
PHOSPHATE				
AMMONIA NITROGEN				
MERCURY				
CHROMIUM, HEXV.				
CHROMIUM, TOTAL				
CADMIUM				
ZINC				
PHENOLS				

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30. continued

	DAILY AVERAGE* MAXIMUM LEVEL		INSTANTANEOUS MAXIMUM LEVEL	
	mg/1	#/day	mg/1	#/day
LEAD				
NICKEL				
COPPER				
IRON				
SILVER				
BARIUM				
OTHER CHARACTERISTICS				
OTHER MATTER				

\+ PARAMETERS TO BE THOSE IDENTIFIED BY EPA (AS A MINIMUM) FOR EACH SIC CODE

* BASED ON 24-HOUR FLOW PROPORTIONATE COMPOSITE SAMPLE

** IDENTIFY INDIVIDUAL COMPOUNDS

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ADDENDUM I

MONITORING SCHEDULE

CITY OF MEMPHIS	NAME OF INDUSTRY

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ADDENDUM II

COMPLIANCE SCHEDULE

CITY OF MEMPHIS	NAME OF INDUSTRY

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ADDENDUM III

PERMITTED STORMWATER AREAS

CITY OF MEMPHIS	NAME OF INDUSTRY

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