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Memphis Depot
Dunn Field

Remedial Design Investigation Work Plan

September 2005 (Rev. 1)

CH2MHILL

U.S. Army Engineering
and Support Center, Huntsville

U.S. Army Engineering and Support Center, Huntsville
Contract No. DACA87-02-D-0006
Task Order No. 6

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September 1, 2005

MEMORANDUM FOR TURPIN BALLARD (USEPA – Region 4) and
EVAN SPANN (TDEC)

SUBJECT: Final Dunn Field Remedial Design Investigation Workplan

The Final Dunn Field Disposal Sites Remedial Design Investigation Workplan is attached. Field activities for the Remedial Design Investigation are scheduled to begin on September 26, 2005.

For more information, please don't hesitate to contact David D. Nelson, Project Manager for CH2M HILL at (770) 604-9182 (x 394) or me at (717) 770-6950.

MICHAEL A. DOBBS
Environmental Program Manager

Attachment on CD ROM:
Final Dunn Field Remedial Design Investigation Workplan

Distribution:
- DDMT (2 copies)
- U.S. EPA (3 copies)
- TDEC (3 copies)
- DDC (New Cumberland) (3 copies)
- AFCEE (3 copies)
- MACTEC (2 copies)

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Acronyms

ASTM	American Society for Testing and Materials
BCT	BRAC Cleanup Team
bgs	below ground surface
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, and xylene
CEHNC	U.S. Army Engineering and Support Center, Huntsville, Alabama
cis-1,2-DCE	cis-1,2-dichloroethene
cm/sec	centimeters per second
COC	contaminant of concern
CSM	conceptual site model
CT	carbon tetrachloride
CVOC	chlorinated volatile organic compound
DCE	dichloroethene
DLA	Defense Logistics Agency
DO	dissolved oxygen
DPT	direct push technology
DQOs	data quality objectives
DRC	Depot Redevelopment Corporation
EB	equipment blank
ECD	electron capture detector
EDMS	Environmental Data Management System
EISOPQAM	*Environmental Investigation Standard Operating Procedures and Quality Assurance Manual*
EPA	Environmental Protection Agency
FID	flame ionization detector
FB	field blank
FTL	field team leader
GC	gas chromatograph
gpm	gallons per minute
GPS	Global Positioning System
HASP	Health and Safety Plan
IDW	investigative-derived waste
lbs/gal	Pounds per gallon
MIP	membrane interface probe
MS/MSD	matrix spike/matrix spike duplicates
mS/m	microsiemens per meter
MW	monitoring well
NTU	nephelometric turbidity units
ORP	oxidation-reduction potential
OVA	organic vapor analyzer
PCA	tetrachloroethane
PCE	tetrachloroethene

PID	photoionization detector
PRB	permeable reactive barrier
PVC	polyvinyl chloride
QA	quality assurance
RA	Remedial Action
RAB	Restoration Advisory Board
RD	Remedial Design
RDI	Remedial Design Investigation
RG	Remedial Goal
RI	Remediation Investigation
SVE	soil vapor extraction
TAL	Target Analyte List
TB	trip blank
TCA	trichloroethane
TCE	trichloroethylene
TDEC	Tennessee Department of Environment and Conservation
TCL	Target Compound List
TM	Technical memorandum
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
ZVI	zero-valent iron
μg/kg	micrograms per kilogram
μg/L	micrograms per liter
μV	microvolts

1.0 Introduction

As part of the Remedial Design (RD) effort for Dunn Field of the Defense Distribution Center (Memphis) (hereafter referred to as the Memphis Depot), additional soil and groundwater samples will be collected onsite and offsite (west of Dunn Field; also referred to as Off-Depot). Specifically, this work will include installation of additional monitoring wells (MWs), membrane interface probe (MIP) and direct-push technology (DPT) points, and soil borings in support of the Source Area RD, Off-Depot groundwater model for the Off-Depot Groundwater RD, the long-term Soil Vapor Extraction (SVE) Treatability Study, and the design and final placement of the offsite zero-valent iron (ZVI) permeable reactive barrier (PRB).

The objectives for the activities described in this work plan are as follows:

- Increase soil data density for the four treatment areas of the onsite soil remedy to refine the limits of soil contaminated with chlorinated volatile organic compounds (CVOCs) down to a depth of approximately 30 feet (within the loess deposits only).
- Further delineate the CVOC groundwater plumes and provide additional monitoring locations for the full-scale groundwater remedy.
- Collect additional data from the fluvial and intermediate aquifers to support the groundwater model that is being developed to estimate the effect of natural attenuation on the CVOC plumes as well as potential points of compliance for Dunn Field.
- Collect additional lithological and hydrogeological data along the proposed PRB alignment.

In addition, surface soil samples will be collected in the northern half of the Disposal Area of Dunn Field to delineate iron and antimony contamination that may impact the City of Memphis' recreational reuse plan.

This work plan has been developed by CH2M HILL for the U.S. Army Engineering and Support Center, Huntsville, Alabama (CEHNC) and the Defense Logistics Agency (DLA). Once approved by the Memphis Depot Base Realignment and Closure (BRAC) Cleanup Team (BCT), which consists of personnel from DLA, the U.S. Environmental Protection Agency (EPA), and the State of Tennessee Department of Environment and Conservation (TDEC), the activities described herein will be implemented by CH2M HILL and its subcontractors.

The data collected by this effort will be documented within a technical memorandum (TM). The TM will include, as a minimum:

- Description of the investigation procedures
- Field measurement methods and data collected
- Summary of field and laboratory analytical data presented in graphs, tables, and/or figures
- Variances to field procedures performed

- Overall impact on the Dunn Field Source Area and Off-Depot RDs

The TM will also contain a section that covers data quality and validation.

This work plan is organized into the following sections:

- **Section 1 Introduction** includes a discussion of the work plan structure, objectives, and organization.
- **Section 2 Background Information** presents information on the operational history and current status of Dunn Field.
- **Section 3 Remedial Design Investigation Activities** describes the activities and procedures required to complete the Dunn Field Remedial Design Investigation (RDI).
- **Section 4 Sampling and Analysis** describes how field sampling, waste characterization, and sampling and analysis activities will be conducted in support of the Dunn Field RDI.
- **Section 5 Data Management, Analysis, and Interpretation** describes procedures for recording observations and raw data in the field or laboratory and procedures that will be used to analyze and interpret data from the Dunn Field RDI.
- **Section 6 Community Relations** describes community relations activities performed in conjunction with the Dunn Field RDI.
- **Section 7 Reporting** describes preparation of the TM documenting the results of the Dunn Field RDI.
- **Section 8 Schedule** indicates the planned starting and ending dates for the tasks outlined in the work assignment.
- **Section 9 References** lists all documents cited in this work plan.

2.0 Background Information

This section presents information on the hydrogeologic setting and the current status of Dunn Field as related to the RD process. A thorough description of the operational and regulatory history of Dunn Field is provided in both the *Dunn Field Remedial Investigation Report* (CH2M HILL, 2002a), *Dunn Field Five –Year Review* (CH2M HILL, 2003a) and the *Dunn Field Feasibility Study* (CH2M HILL, 2003b).

2.1 Hydrogeologic Setting

2.1.1 Geology

The impacted vadose zone at Dunn Field consists of two distinct geological units: a shallow, relatively low-permeability loess, and the deep, relatively high-permeability alluvium (fluvial sands). The loess, a semi-cohesive eolian deposit composed of silt, silty clay, silty fine sand, and mixtures thereof, is positioned from immediately below ground surface (bgs) to, on average, 30 feet bgs. To the west of Dunn Field, the loess deposits are approximately 20 feet thick. Because it is a critical component of the SVE system design, the loess is the focal point of the MIP and DPT investigation.

Underlying the loess are several feet of sandy clay, followed by 30 to 75 feet of the fluvial sands, silt, and gravel. Additional site geology details are presented in the *Dunn Field Remedial Investigation Report* (CH2M HILL, 2002a).

2.1.2 Hydrogeology

Groundwater occurs within a predominantly medium- to fine-grained sand geological unit referred to as the fluvial aquifer. Recharge to the unconfined fluvial aquifer is primarily from the infiltration of rainfall. Continuous cores obtained from previous soil borings at Dunn Field indicate perched groundwater exists seasonally in the loess. However, these perched water zones are limited in areal extent and cannot serve as a water supply. Notably, because of its impact on the SVE design and strategy, the vertical permeability of the loess equals or exceeds its horizontal permeability. Based on falling head laboratory permeameter analysis conducted in March 2002 (American Society for Testing and Materials [ASTM] Method D5084; Shelby tube soil samples were collected during installation of the monitoring probes), the horizontal hydraulic conductivity of the loess ranges from 9.4×10^{-7} cm/s to 1.1×10^{-5} cm/s and the vertical hydraulic conductivity ranges from 6.0×10^{-6} cm/s to 1.6×10^{-5} cm/s.

The base of the fluvial aquifer is the uppermost clay in the Jackson Formation/Upper Claiborne Group. The saturated thickness of the fluvial aquifer is variable across Dunn Field and is controlled by the configuration of the basal clay. Depth to water is approximately 75 feet bgs. Maximum saturated thickness ranges between 10 and 30 feet above the clay. In general, the groundwater in the fluvial aquifer flows in a western direction, which is also the direction of the local dip of the clay confining unit.

Aquifer tests conducted at Dunn Field indicate the average hydraulic conductivity for the fluvial aquifer is 7.8×10^{-3} centimeters per second (cm/sec). The groundwater velocity in the fluvial aquifer is estimated to range from 0.13 ft/day to 1.7 ft/day based on a hydraulic gradient that ranges from 0.0017 ft/ft to 0.023 ft/ft along the western boundary of Dunn Field and an effective porosity of 0.3. Additional site hydrogeology details are presented in the *Dunn Field Remedial Investigation Report* (CH2M HILL, 2002a).

2.2 Current Status of Dunn Field

The Dunn Field remedial investigation and remedial design have been completed in several stages and have included the following key activities:

- **Remedial Investigation.** The RI, which began in 1996, has included soil, soil gas, and long-term groundwater sampling, in addition to aquifer testing (CH2M HILL, 2002a).
- **Disposal Sites Pre-Design Investigation.** The investigation, which included a geophysical survey, trenching through disposal sites, and sampling, was conducted in September and October 2003 to supplement existing chemical and physical data on 17 former disposal sites on Dunn Field (CH2M HILL, 2004a).
- **Off-Depot Design-Related Investigation.** This investigation was conducted from June through December 2004 by MACTEC to evaluate site hydrogeology and contaminant concentrations in the area of MW-54 so that appropriate Off-Depot remedial actions (RAs) could be designed and implemented. The objective of the Off-Depot Design-Related Investigation was expanded to identify the area(s) to be included in the early implementation of remedial action, to provide baseline groundwater data for comparison to post-injection monitoring results, and to assess the hydrogeology downgradient of the remediated area (MACTEC, 2005a).

Based on the various investigation findings, the following response actions have already been completed at Dunn Field:

- **Interim Groundwater Remedial Action.** A groundwater extraction system consisting of 11 recovery wells was installed along the western Dunn Field boundary and began operation in November 1998. The objectives of the hydraulic containment system were to: 1) prevent further contaminant plume migration; and 2) reduce contaminant mass in groundwater.
- **Chemical Warfare Materiel Removal Action.** A non-time critical removal action was conducted to reduce or eliminate the potential risk posed by chemical warfare materiel wastes at Sites 1, 24-A, and 24-B. The removal action was completed in March 2001 and documented in the *Final Chemical Warfare Materiel Investigation/Removal Action Report* (U.S. Army Corps of Engineers [USACE], 2001).
- **Soil Removal Action at Site 60, Former Pistol Range.** A non-time critical removal action to address lead-contaminated surface soil at Site 60, a former pistol range in the Northeast Open Area, was completed in March 2003. Approximately 930 cubic yards of lead-contaminated surface soil was excavated, transported, and disposed offsite at an approved, permitted landfill (CH2M HILL, 2002b and 2002c).

- **Disposal Sites Remedial Action.** As the first of three components of the Dunn Field RA, surface soil and waste materials from the Disposal Area were excavated, transported, and disposed of based on the findings of the *Disposal Sites Pre-Design Investigation* (CH2M HILL, 2004a). The RA was conducted in spring 2005.

- **Early Implementation of Selected Remedy.** Based on the results of groundwater sampling conducted from June through October 2004, ZVI was injected into the fluvial aquifer to address the concentrations of CVOCs at the leading edge of the high concentration portion of the plume (within the 500 micrograms per liter [μg/L] isopleth for total CVOCs). The targeted area is 800 to 1,000 feet downgradient (west) of Dunn Field (MACTEC, 2005b).

Finally, in support of the overall Dunn Field RD, two field-scale treatability studies have been conducted:

- **Soil Vapor Extraction Treatability Study.** The objective of the SVE treatability study, which has been conducted in four phases from December 2001 to February 2005, was to collect site-specific data to design a full-scale SVE system (CH2M HILL, 2003c [Phase I]; Phases II to IV results to be reported in the Source Areas RD).

- **ZVI Treatability Study.** The ZVI treatability study (CH2M HILL, 2004b), which included pressurized pneumatic injection of ZVI powder into the saturated zone (fluvial aquifer) at Dunn Field, was conducted from October 29 to November 14, 2003, to collect site-specific data to design the full-scale source area groundwater remedy.

Ongoing Dunn Field design and development activities include the following:

- Design of the Source Area subsurface soil (SVE) and groundwater (ZVI injection) RAs
- Design and placement of the Off-Depot ZVI PRB
- Development of the Off-Depot groundwater model

2.3 Remedial Design Investigation Justification

Several data gaps that must be addressed for the selected remedy to be designed and cost-effectively implemented were identified during the Dunn Field RD process. These data gaps include the following:

- **Subsurface Soil Source Delineation.** The source areas targeted for SVE are based on a relatively low density of soil sample locations. Additional investigation is recommended to increase soil data density in the four treatment areas to be involved in the onsite soil remedy to better define the limits of soil contaminated with CVOCs above remedial goals (RGs).

- **Onsite Groundwater Plume Delineation.** The groundwater plume has not been adequately defined around the proposed ZVI injection areas. Additional groundwater investigation, particularly adjacent to and upgradient of the targeted treatment areas, will provide plume delineation and provide additional monitoring locations for full-scale implementation.

- **Off-Depot Groundwater Plume Delineation.** Additional CVOC data will be used to effectively position the Off-Depot ZVI PRB. Furthermore, more data are necessary for enhancing the conceptual site model for the fluvial, intermediate, and Memphis Sand aquifers in the western and northwestern Off-Depot areas, as well as to support the groundwater model being developed to evaluate the effect of natural attenuation on the CVOC plumes and estimate potential points of compliance for Dunn Field.
- **Off-Depot Aquifer Lithology and Hydrogeology.** Additional data, including groundwater flow direction, saturated thickness, and top of clay elevation along the proposed alignment, are required to effectively design and construct the ZVI PRB.
- **Distribution of Iron and Antimony in Onsite Surface Soils.** Additional iron and antimony data will be collected from site surface soils to complete the revised risk assessment that now reflects a recreational reuse scenario[1] for the northern portion of the Disposal Area.

[1] Only industrial reuses were considered during the original Disposal Area risk assessment.

3.0 Remedial Design Investigation Activities

This section describes the activities and procedures required to complete the Dunn Field RDI. References to other appropriate documents or attachments are included. The activities described below, which will be conducted to complete the Dunn Field investigation, include land surveying, MIP investigation with DPT soil confirmation sampling, onsite and Off-Depot MW installation and sampling, and soil coring to gather lithologic and hydrogeologic data along the proposed ZVI PRB alignment.

3.1 Preliminary Activities

Preliminary study activities associated with the implementation of the Dunn Field RDI include:

- Submission of applications for any required local drilling permits
- Survey of targeted treatment areas and development of MIP sampling grid
- Coordination with Memphis Depot personnel on the location of utilities in the area
- Designation of areas for temporary storage of equipment and material
- Site-specific security and safety concerns

3.1.1 Logistics

Equipment, supplies, and personnel required to complete the pre-design data collection at Dunn Field will be mobilized after approval of this plan and the Site Health and Safety Plan (HASP). The Site HASP must be reviewed and approved by CEHNC.

A site coordination meeting will be held after the final work plan has been submitted and before mobilization of the field effort. Participation may include personnel from DLA, EPA, TDEC, CEHNC, CH2M HILL, the Depot Redevelopment Corporation (DRC), and subcontractor personnel. The meeting will include discussions of Depot regulations, data quality objectives, field procedures, field schedules, and review of the Site HASP.

3.1.2 Land Surveying

Available maps describing the location of the proposed soil treatment areas and the proposed MIP locations (Figure 3-1) will be provided to Allen-Hoshell, a professional land surveyor registered in the State of Tennessee. The surveyor will translate this information and stake the locations on Dunn Field based on the known northing and easting coordinates. The stakes or flags will be positioned at a sufficient height to be visible to persons mowing the grass at Dunn Field. Revised and/or additional MIP and soil confirmation sample locations will be clearly marked in the field with stakes or pinflags so that their positions can be surveyed at the completion of the investigation.

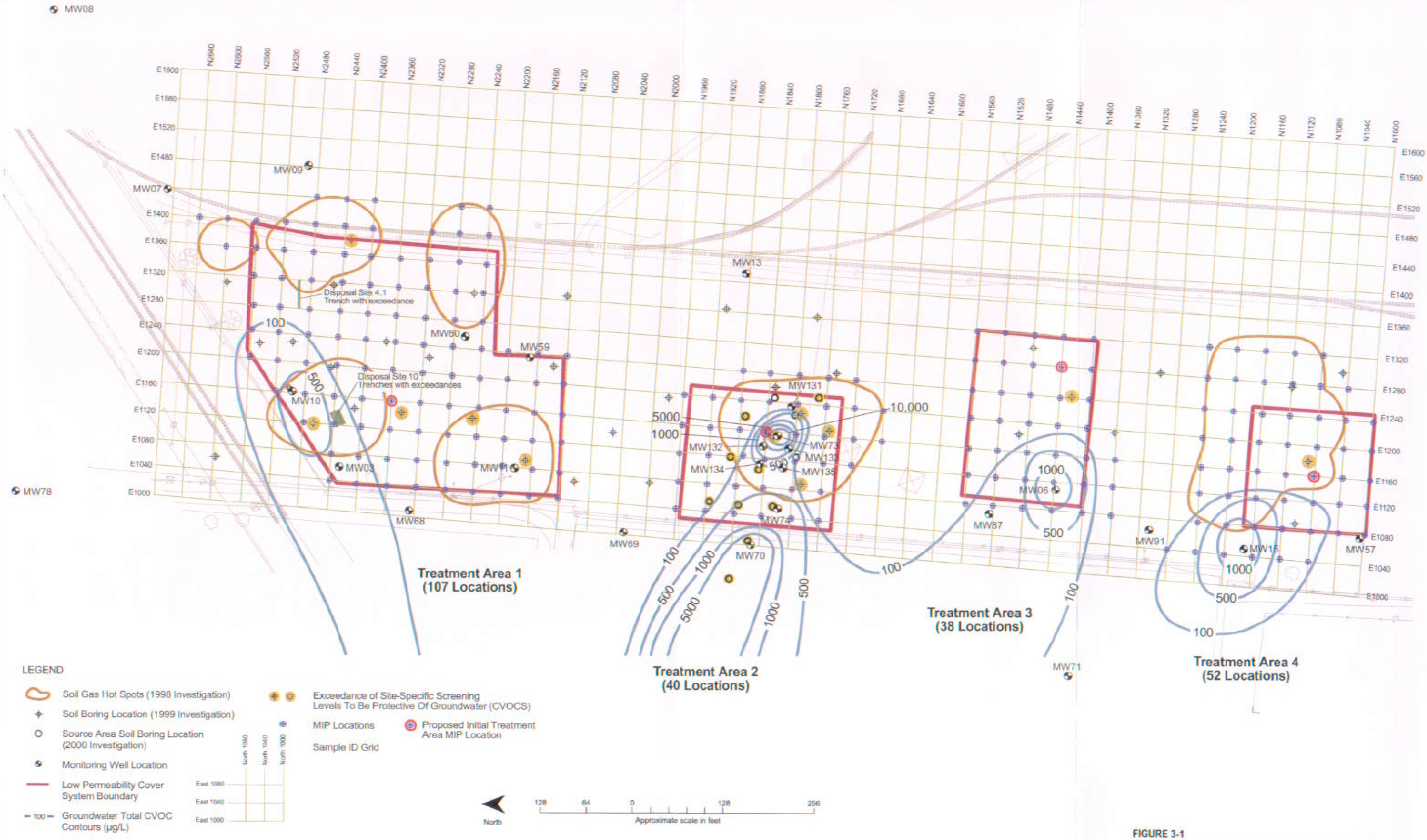


FIGURE 3-1
Proposed MIP Sample Locations and Sampling Grid
Memphis Depot Dunn Field Remedial Design Investigation

3.1.3 Utility Locating

Field personnel will mark locations of the proposed MIP sampling grid and MW and soil boring locations at least 2 weeks prior to commencement of the activity. All locations will be approved by Memphis Depot and DRC representatives, and all utilities will be marked by a professional utilities locating service prior to the start of drilling. The preliminary MIP, MW, and soil boring locations are depicted on Figures 3-1, 3-2, and 3-3, but final locations will be based on the utility locations and conditions encountered in the field.

3.2 Membrane Interface Investigation

To better delineate the areas requiring soil remediation at Dunn Field, an MIP investigation will be conducted within the four proposed treatment areas (Figure 3-1). The MIP is a screening tool with semi-quantitative capabilities acting as an interface between the CVOCs in the subsurface and gas phase detectors at the surface. The MIP points will be completed by Fugro GeoSciences (Fugro) of Houston, Texas.

The MIP uses a direct push probing system to advance a sensor through a soil column while collecting continuous data on temperature, electrical conductivity, and CVOC concentrations in gas phase. The MIP system comprises a down-hole heating element that raises subsurface temperatures and volatilizes organic contaminants. The volatilized CVOCs permeate across a membrane at the probe tip and are brought to the surface in an inert carrier gas stream for analysis.

MIP rigs are typically equipped with a flame ionization detector (FID), photoionization detector (PID), electron capture detector (ECD), and a gas chromatograph (GC). The FID measures the mass of total combustible compounds in the gas stream. The PID measures only those ionizable compounds with ionization potentials less than the PID bulb energy; thus, the PID response is a subset of the FID response. The PID is best used for the detection of aromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylene [BTEX] compounds), and the FID is best used for straight chained hydrocarbons (methane, butane).

The ECD analyzes the mass of a smaller set of organic chemicals that generally represent the CVOCs. PID, FID, and ECD data, as well as the response from the soil conductivity detector, are collected continuously during advancement. The three detectors will be used to simultaneously evaluate and correlate the results obtained from each detector. The ECD and PID response (in microvolts [μV]) will be plotted versus depth to evaluate the concentration of CVOCs at each location. Soil conductivity (microsiemens per meter [mS/m]) will also be plotted versus depth at each location. The Geoprobe MIP standard operating procedures are provided as Appendix A.

As shown on Figure 3-1, a 40-foot by 40-foot grid will be used to locate and identify the MIP locations in each of the four treatment areas identified in the Source Areas RD. A total of 237 proposed MIP locations are identified on Figure 3-1; to complete the loess CVOC delineation, up to 260 MIP locations may be required. Each MIP point will be advanced from the ground surface to approximately 30 feet bgs (top of the fluvial sands). Borings will be terminated at the base of the loess (20 to 30 feet bgs) as previously determined through drilling (Figure 3-4) or when the electrical conductivity readings suggest that the MIP has begun to penetrate the underlying fluvial sands.

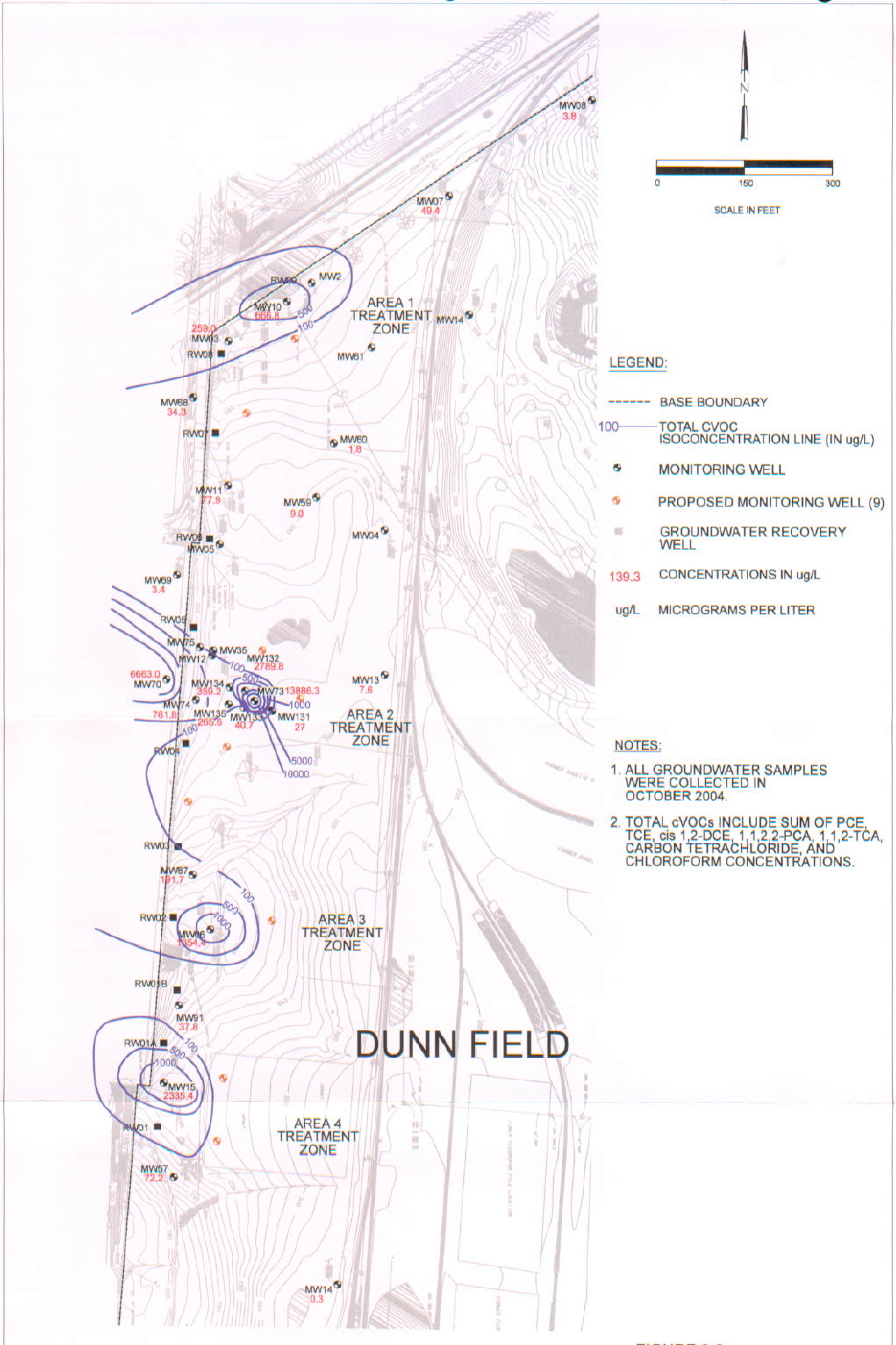
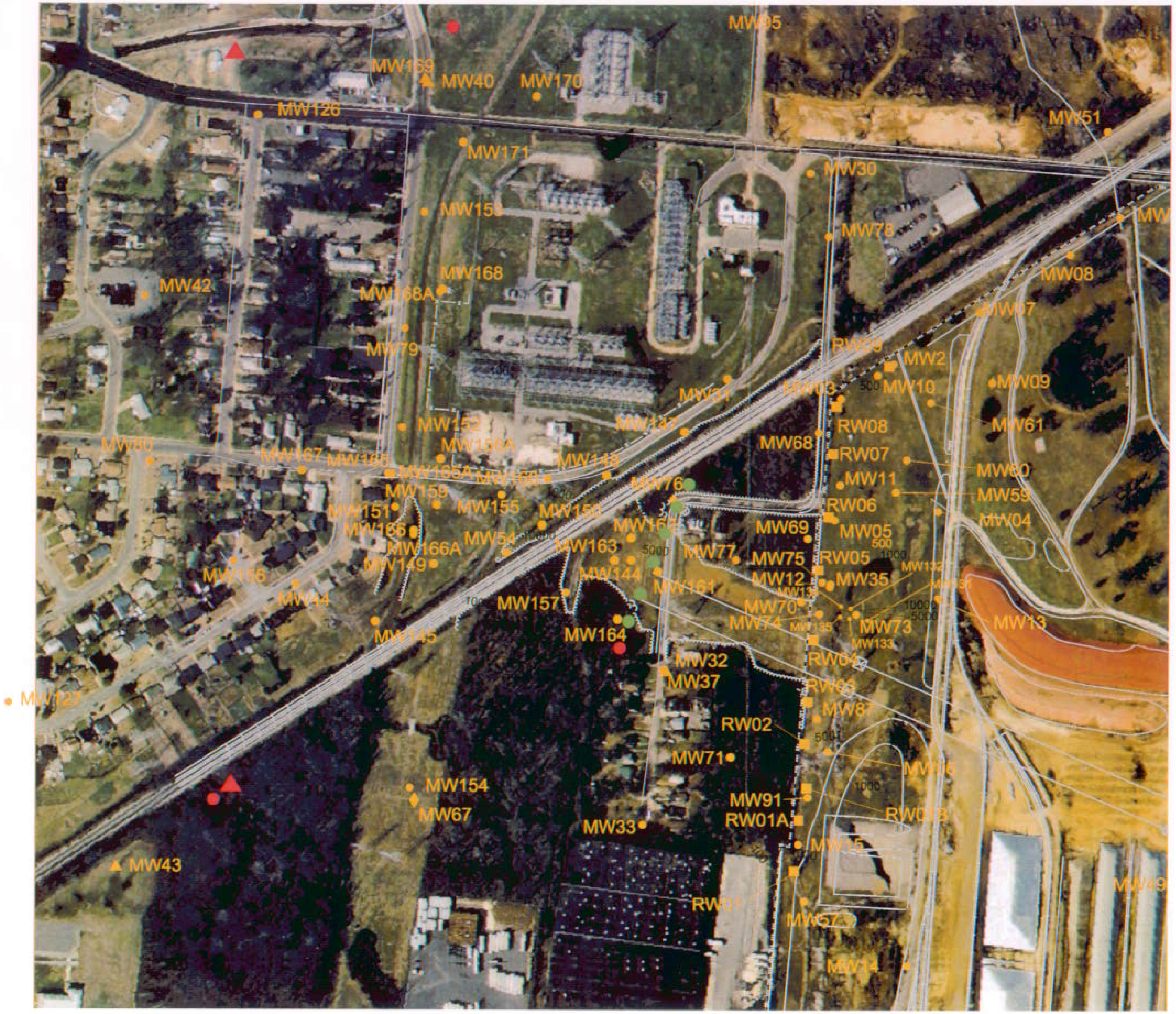


FIGURE 3-2
PROPOSED NEW ONSITE MONITORING WELL LOCATIONS
Memphis Depot Dunn Field
Remedial Design Investigation

CH2MHILL



LEGEND:

-------	DEPOT BOUNDARY
———	BASE BOUNDARY
● MW	MONITORING WELL SCREENED IN FLUVIAL AQUIFER
▲ MW	MONITORING WELL SCREENED IN INTERMEDIATE AQUIFER
■ RW	GROUNDWATER EXTRACTION WELL
◆ MW	MONITORING WELL SCREENED IN MEMPHIS AQUIFER
●	PROPOSED FLUVIAL AQUIFER MONITORING WELL (3)
▲	PROPOSED INTERMEDIATE AQUIFER MONITORING WELL (2)
●	PROPOSED SOIL BORING (6)
ug/L	MICROGRAMS PER LITER

NOTES:

1. ALL SAMPLES WERE COLLECTED IN OCTOBER 2004, EXCEPT THOSE INDICATED BELOW.
2. MW-145, MW-149, MW-153, MW-154 AND MW-156 WERE COLLECTED IN AUGUST 2004.
3. MW-165, MW-166, MW-167, MW-168A WERE COLLECTED IN NOVEMBER 2004.
4. MW-169, MW-170, AND MW-171 WERE COLLECTED IN DECEMBER 2004.
5. MW-7, -8, -9, -29, -30, -33, -40, -42, -43, -44, -51, -54, -68, -69, -70, -76, -77, -79, -80, -95, -126, -127, -129, AND -130 WERE COLLECTED USING DIFFUSION SAMPLERS.
6. ALL OTHER MONITORING WELLS WERE SAMPLED USING LOW-FLOW TECHNIQUES.
7. CVOCS INCLUDE SUM OF PCE, TCE, cis 1,2-DCE, 1,1,2,2-PCA, 1,1,2-TCA, CARBON TETRACHLORIDE, AND CHLOROFORM CONCENTRATIONS.

FIGURE 3-3
PROPOSED NEW OFF-DEPOT MONITORING WELL AND SOIL BORING LOCATIONS
MEMPHIS DEPOT DUNN FIELD REMEDIAL DESIGN INVESTIGATION

CH2MHILL

ATL/CAD1/PROJECTS/148071 DDMT/PRD 2004/GRDWATER 13-JULY-2005

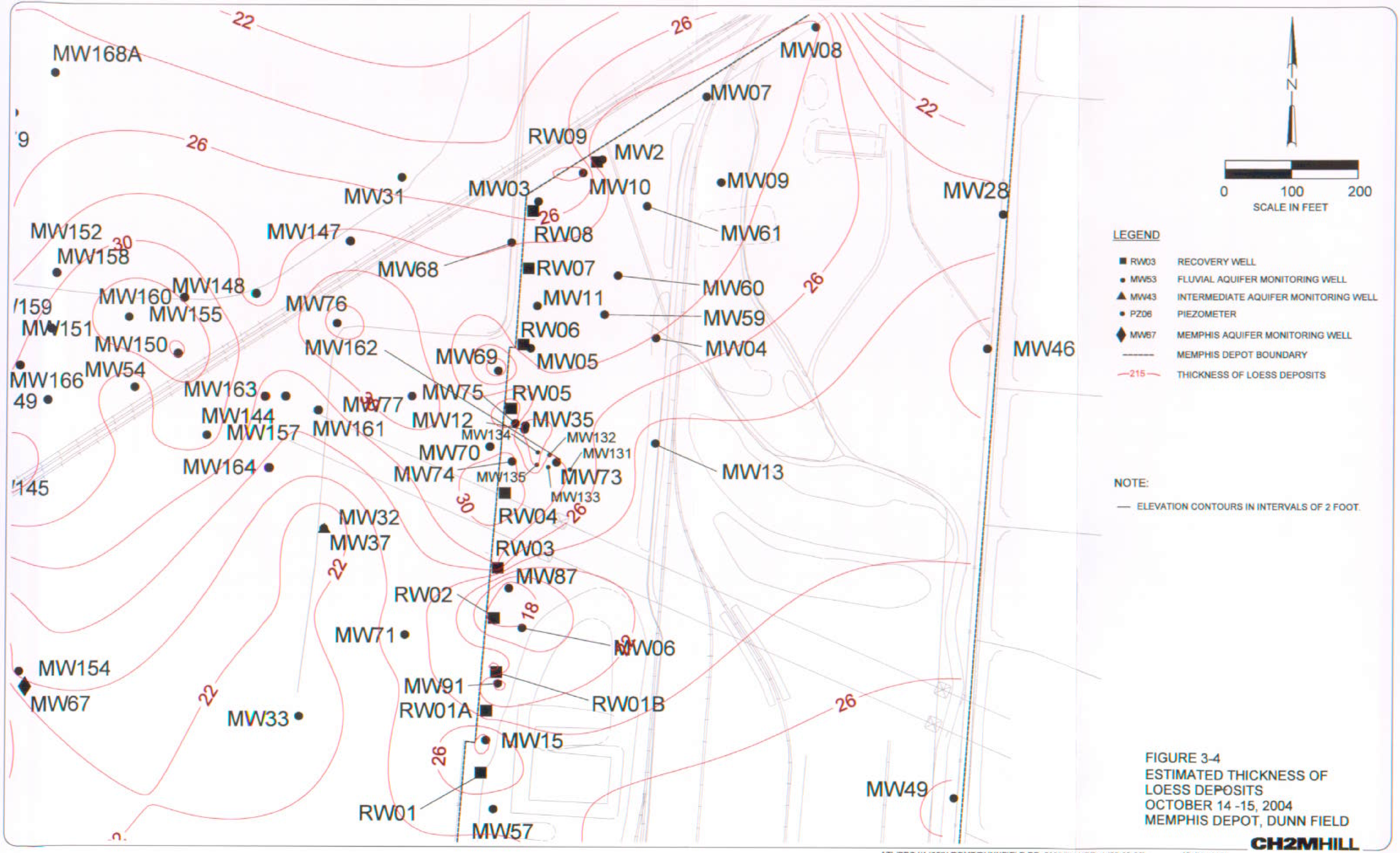


FIGURE 3-4
ESTIMATED THICKNESS OF LOESS DEPOSITS
OCTOBER 14 -15, 2004
MEMPHIS DEPOT, DUNN FIELD

CH2MHILL

ATL/PROJ/148071/DDMT/DUNNFIELD RD_2003/FIGURE_4 (03-23-05) 12-JUL-2005

The overall strategy for the investigation will be to characterize the magnitude and extent of elevated CVOCs (i.e., tetrachloroethene [PCE], trichloroethene [TCE], 1,1,2,2-tetrachloroethane [PCA], 1,1,2-trichloroethane [TCA], carbon tetrachloride [CT], chloroform, and *cis*-1,2-dichloroethene [DCE]) in soil by using the semi-quantitative MIP instrument. Maximum soil concentrations in the loess and relevant physical characteristics for the contaminants of concern (COCs) are listed in Table 3-1. In general, the CVOC concentrations that have influenced the preliminary Source Area RD are considerably higher than the MIP detection limit. Although many of the site-specific loess screening levels to be protective of groundwater are below the ECD detection limit (250 micrograms per kilogram [μg/kg]), the detection limit is sufficiently low to make SVE system design decisions. As needed, soil samples will be collected to adequately delineate the areas with CVOCs above remedial goals, as described in Section 3.2.1.

Also, as listed in Table 3-1, the 1,1,2,2-PCA boiling point is above the approximate maximum membrane temperature. This indicates a possible poor correlation between the MIP results and the conventional laboratory analysis due to incomplete 1,1,2,2-PCA diffusion through the membrane. However, because the 1,1,2,2-PCA is generally collocated with other MIP-detectable CVOCs at relatively elevated concentrations, this should not impact the effectiveness of this investigation approach to delineate the areas requiring SVE. In addition, 1,1,2,2-PCA degrades into other CVOCs such as TCE and cis-1,2-DCE, which are readily detectable by the MIP. The 1,1,2,2-PCA degradation products can be used to help infer locations where 1,1,2,2-PCA may be present. Select soil samples (see below) will be collected and analyzed for 1,1,2,2-PCA where it is suspected based on the MIP results and the underlying groundwater plume.

The MIP investigation will begin in areas of known soil contamination to allow the MIP operator to understand the relative detector responses (each of the three detectors will respond differently: PID is best for aromatics; ECD is best for chlorinated compounds; and FID is best for aliphatic compounds). Responses from the initial borings will help develop a "fingerprint" for the CVOCs of interest and identify spatial variations. Borings will proceed outward from the areas of known contamination until the MIP response indicates that CVOC concentrations have decreased to *de minimis* levels, based on total CVOC readings on the FID, PID, ECD, and GC signals. Once the borings along one transect reach these levels, DPT borings will proceed along another transect, starting near the postulated "source area" and continuing until *de minimis* levels are reached in that transect. It is estimated that 8 to 10 borings will be completed per day.

3.2.1 Confirmation Soil Sampling

As part of the MIP investigation, up to 80 discrete soil samples, no more than 18 inches from select MIP points (low to high responses), will be collected using a standard DPT; confirmation samples will be collected and analyzed by the laboratory during the MIP investigation so decisions can be made while the subcontractor is mobilized. The soil samples will be located using the same 40-foot grid used for the MIP investigation. This distance is comparable to the proposed loess air injection well spacing (50 feet).

TABLE 3-1
Key Physical Characteristics for Dunn Field Contaminants of Concern
Memphis Depot Dunn Field Remedial Design Investigation

Parameter	Maximum Concentration in Loess (µg/kg) (1)				Site-Specific Loess Screening Levels to be Protective of Groundwater (µg/kg) (1)	Boiling Point (°C)(2)
	TA1	TA2	TA3	TA4		
Carbon Tetrachloride	6,800	BRG	BRG	570	215*	76.7
Chloroform	14,000	BRG	BRG	2,400	917	62
Dichloroethane, 1,2-	46	BRG	BRG	BRG	32.9*	83.5
Dichloroethene, *cis*-1,2-	190,000(3)	BRG	BRG	BRG	755	60
Dichloroethene, *trans*-1,2-	190,000(3)	BRG	BRG	BRG	1,520	48
Methylene chloride	39	BRG	BRG	BRG	30.5*	42
Tetrachloroethane, 1,1,2,2-	160,000	33,000	55	BRG	11.2*	146.4**
Tetrachloroethene	4,400	1,900	BRG	140	180.6*	121.4
Trichloroethane, 1,1,2	2,200	100	BRG	BRG	62.7*	113.7
Trichloroethene	460,000	18,000	BRG	470	182*	86.7
Vinyl chloride	7,000	47	66	BRG	29.4*	-13.9

Notes:
(1) Electron Capture Detector (ECD) has a total CVOC detection limit of 250 µg/kg.
(2) Source: Verschuren, K. (1983). *Handbook of Environmental Data on Organic Chemicals*, Second Edition.
(3) Total 1,2-dichloroethene
* indicates parameters with remedial goals below MIP detection limit.
** indicates parameters with boiling point above maximum membrane temperature (125°C).
(TA1, 2, 3, and 4) refer to the four treatment areas in the sources areas RD.
BRG = below remedial goal

The MIP data will be compared to the soil data to correlate the data sets and, ultimately, to use the entire MIP data set to delineate the source areas requiring soil remediation. In addition to MIP detection confirmation, some of the soil sample locations will be selected to adequately delineate the areas with CVOCs concentrations that are below the MIP detection limit, but above the established Dunn Field RGs. This will ensure that areas requiring remedial action are addressed during the RD.

Correlative soil sample intervals will be selected based on MIP response. The MIP operator will be directed by CH2M HILL field personnel during the investigation to advance the DPT at the desired location(s) and collect confirmatory samples at the desired elevation(s). The objective is to collect the confirmatory samples at locations representing the full range of CVOC responses (based on the ECD, PID, and FID results) and expected soil concentrations. If the MIP response is unreliable, especially around the perimeter of the suspected contaminated area, then the density of confirmation soil samples will be biased or increased to promote adequate delineation.

Soil sample intervals on the perimeter of MIP detection effectiveness will be biased toward the bottom of the loess since the goal of the soil remedy to be protective of groundwater. The relatively high vertical permeability of the loess and the age of the release(s) suggest that the contaminant mass may be present near the bottom of the matrix (if remediation were required). One or more vertical intervals will be sampled at each location based on the

MIP response and the goal of the sample (correlation vs. delineation). Final decisions regarding the sampling location will be made by the field team leader (FTL) and the offsite technical team. The completed MIP and DPT points will be filled to ground surface with bentonite-grout slurry.

3.2.2 Communication

Communication between field and technical team members is critical for MIP investigation effectiveness. The decision logic, as presented on Figure 3-5, outlines contingencies in which team members may need to reach a decision during the field effort. The FTL will be responsible for frequent communication with technical team members through electronic data transfer. For field activities to be adaptive to the changing conceptual site model (CSM), weekly field summaries will be made available to the project team and a teleconference will be held weekly, as necessary.

3.3 Monitoring Well Installation

Additional onsite and Off-Depot monitoring wells are proposed to 1) provide plume delineation and provide additional monitoring locations for full-scale implementation, 2) effectively position the Off-Depot ZVI PRB, and 3) enhance the understanding of the CSM in the western and northwestern portion Off-Depot areas and to support the groundwater model. The proposed wells are discussed below.

Proposed Onsite Monitoring Wells

As shown on Figure 3-2, 8 to 10 new MWs will be installed on Dunn Field to further delineate the CVOC groundwater plumes and provide additional monitoring locations for the groundwater remedy. MWs completed on Dunn Field will consist of 2-inch diameter polyvinyl chloride (PVC) and will range from 90 to 105 feet bgs. All MWs will be installed using rotasonic drilling methods as conducted by ProSonic Corporation of Aiken, South Carolina.

Continuous soil sampling will be conducted at each of the well locations using the Rotasonic soil coring system. The sampling interval will not be greater than 10 feet. Each location targeted for the fluvial aquifer will be drilled 10 feet into the underlying clay unit for verification. The sampling technique must provide samples representative of the interval sampled and be relatively undisturbed. Select soil cores from below the water table will be archived for future reference.

Proposed Off-Depot Monitoring Wells

As shown on Figure 3-3, four Off-Depot MWs will be installed to enhance the conceptual site model for the fluvial, intermediate, and Memphis Sand aquifers in the western and northwestern Off-Depot areas, as well as to collect additional data to support the groundwater model. One deep (no deeper than 200 feet bgs) and one shallow MW (no deeper than 130 feet bgs) will be installed near MW-43 and also near MW-169/MW-40 to address data gaps in these areas.

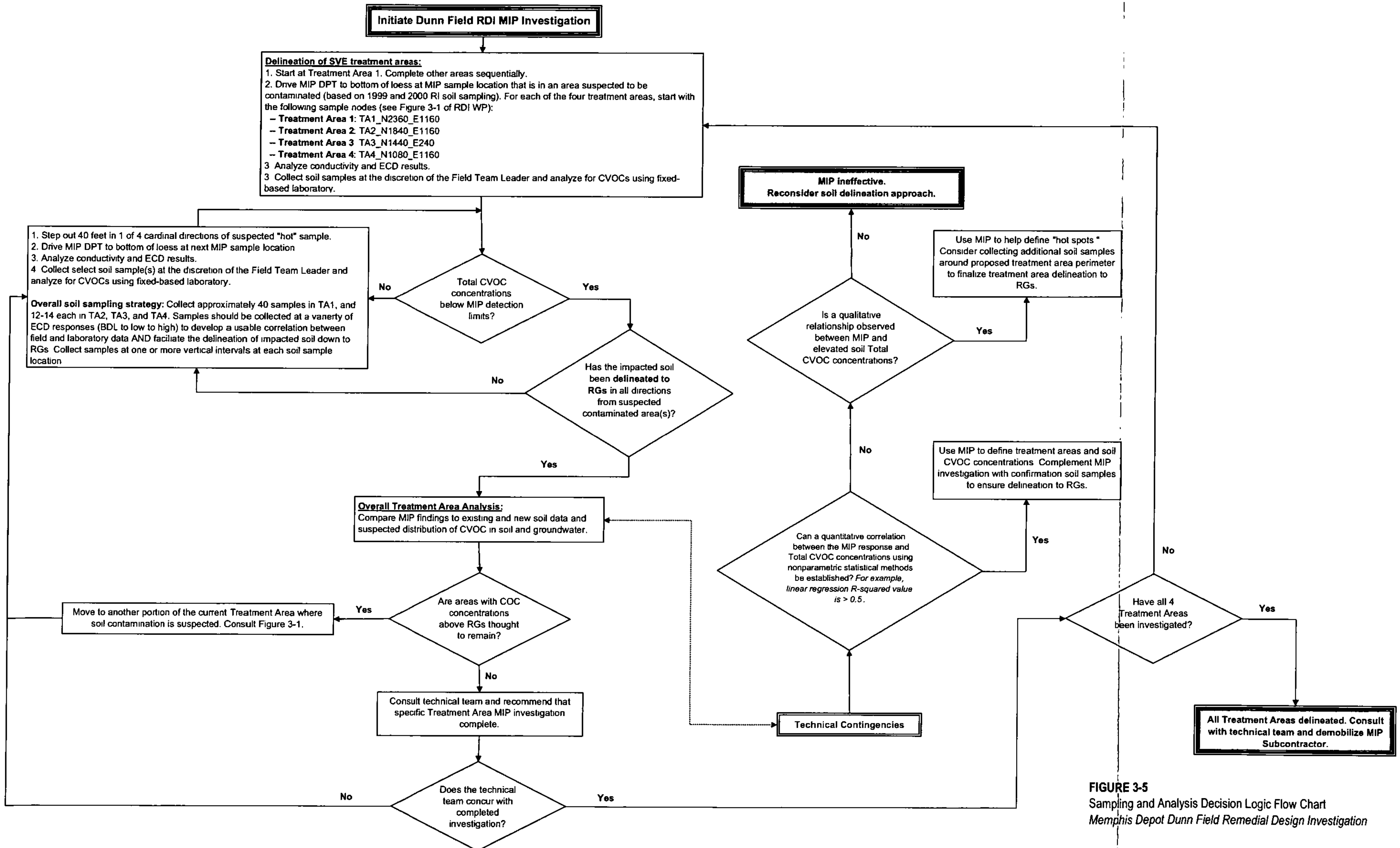


FIGURE 3-5
Sampling and Analysis Decision Logic Flow Chart
Memphis Depot Dunn Field Remedial Design Investigation

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The shallow MW screen intervals will be positioned above the confining clay layer that underlies the fluvial aquifer; the deep MWs are expected to be completed below the confining clay. If the confining clay layer is not directly below the fluvial deposits, the drilling casing will be advanced until clay is encountered within the intermediate aquifer or to a depth of 200 feet bgs where a deep MW will be installed. No more than 10 feet of screen will be used in each well. The FTL will contact the project manager to discuss the location of the second shallow well.

The primary objective of the deeper well near MW-169/MW-40 will be to assess the clay layer thickness at the top of the intermediate aquifer (assuming that the clay layer is present) and position with respect to local stratigraphy. Its final placement will be a function of site access, lithologic findings at the new nearby fluvial aquifer boring and monitoring well, estimates of the potentiometric surface, and hydrogeologic and other field conditions.

The fifth off-Depot MW will be installed at the southern end of the proposed PRB (Figure 3-3). This well will be installed no deeper than 130 feet bgs or until the first confining clay unit is reached and will be completed within the fluvial aquifer. This datum, along with data from existing MWs, is critical to define the lateral extent of the proposed PRB.

Continuous soil sampling will be conducted using the Rotasonic soil coring system. The sampling interval will not be greater than 10 feet. The sampling technique must provide samples representative of the interval sampled and be relatively undisturbed. Select soil cores from below the water table will be archived for future reference. Each location targeted for the fluvial aquifer will be drilled 10 feet into the underlying clay unit for verification.

3.3.1 Well Installation

The wells casing and screen will be constructed within the rotasonic drill casing (minimum 6¼-inch inner diameter) as the casing is withdrawn from the boring. The annular space will be filled with well material consisting of the filter pack, bentonite seal, and grout as the rotasonic casing is withdrawn from the borehole. The depth of placement of the screen and well material will be as directed by the FTL.

Well Casing and Screen

Well casings will be new, unused, decontaminated, 2-inch inside diameter schedule 40 PVC pipe with internal flush joined threaded joints that conform to ASTM Standard F-480-88A or the National Sanitation Foundation Standard 14 (Plastic Pipe System). Screens will be factory slotted to 0.010 inch. A threaded PVC cap or point will be placed at the bottom of the screen.

Filter Pack

Filter Seal No. 2 or equivalent will be used as the filter pack, which will extend from the bottom of the hole to at least 5 feet above the top of the well screen. The filter pack will be installed with a bottom-discharge tremie pipe. The tremie pipe will be lifted from the bottom of the hole at the same rate the filter pack is set. The contractor will record the volume of the filter pack emplaced in the well. Potable water may be used, with the approval of FTL, to emplace the filter pack so long as no contaminants are introduced.

Bentonite Seal

Following filter pack placement, a minimum 6-foot-thick bentonite seal will be placed above the filter pack. The 100 percent sodium bentonite seal will consist of 1/4-inch or 3/8-inch diameter dry bentonite pellets or chips. The bentonite seal will be installed by gravity methods. The bentonite seal will be allowed to hydrate for a minimum of 4 hours prior to the installation of the cement grout.

Cement Grout

Cement grout will be placed in the annular space above the bentonite seal to ground surface. The grout will be pumped through a side-discharge tremie pipe and the length will be no more than 5 feet from the top of the level of grout at all times. The greatest lift thickness per event will be no more than 60 feet. Grouting events will be separated 12 hours minimum. No method will be permitted that does not force grout from the bottom of the borehole to the surface. The grout seal will be Type II Portland cement or American Petroleum Institute Class A cement with no more than 4 percent bentonite. The grout will be mixed in the following proportions: 94 pounds of neat cement, not more than 4 lbs. of 100 percent sodium bentonite powder, and not more than 8 gallons of potable water. The grout will have a mixed minimum specific density of 9.4 pounds per gallon (lb/gal) or the manufacturer's recommended density. A mud balance will be used to ensure the density of the mixture conforms to the manufacturer's standards. Prior to installation of the surface completions, the boreholes will be topped off with grout to approximately 1 to 2 feet bgs.

3.3.2 Well Completion

All MWs will be completed with flush-mount wellhead protection pads and properly developed. For those wells on Dunn Field (total of nine), four bollards will be placed at each corner of the pad. The 3-inch diameter, galvanized steel bollards will be recessed approximately 2 feet into the ground, set in concrete, and painted with high visibility yellow paint. The inner annulus of the pipe will be filled with grout.

The top-of-casing and wellhead protection pad will be surveyed for each new MW and added to the existing Memphis Defense Depot horizontal and vertical coordinate system. After the new MWs are installed, a site-wide groundwater level gauging event will take place across Dunn Field that will include existing MWs as well. Depth-to-water data will be used to develop a potentiometric surface map for use in the Off-Depot groundwater RD.

3.3.3 Well Development

The wells will be developed with a surge block in conjunction with a pump and/or bailers. No air, detergents, soaps, acids, bleaches, or additives will be used during well development. Well development will be initiated no sooner than 24 hours following grout installation.

Development will start once the pump or other water-removal device is set within the water in the well and will continue until clear, sand-free formation water is produced from the well and until pH, conductivity, turbidity, and temperature measurements have stabilized.

Stabilization is defined when the pH is within ±0.1, the conductivity is + or – 3 percent, and the turbidity remains less than 10 nephelometric turbidity units (NTUs) for at least 30 minutes. The FTL will determine when development is complete. Water from development will be contained and disposed in accordance with Section 3.6.

After each new MW is developed, CH2M HILL will collect groundwater samples from each of the newly installed MWs and from up to three nearby, existing MWs. This information will be critical for updating the groundwater plume on Dunn Field as well as providing essential confirmation data for the groundwater modeling effort currently underway. The samples will be analyzed for VOCs by Kemron Environmental of Marietta, Ohio. All samples will be shipped from the site for laboratory analysis via overnight courier. All data will be validated by an internal CH2M HILL chemist. A data quality evaluation report will be attached to the TM describing the sample results.

3.4 Lithology and Hydrogeologic Investigation

A ZVI PRB is currently proposed near MW-76, MW-161, and MW-164. Six soil borings and the previously mentioned MW will be installed to collect additional lithological and hydrogeological data in that area. Each soil boring will be advanced no deeper than 130 feet bgs or until a confining clay is reached. The lithology will be continuously collected and recorded in a field logbook. Like the MWs, soil cores will be collected using Rotasonic drilling methods and the lithology at each location will be recorded in a field logbook. Select soil cores from below the water table will be archived for future reference. Each location will be drilled 10 feet into the underlying clay unit for verification. The data generated from this effort will be presented within the TM describing this field effort. Each of the soil borings will be abandoned using a bentonite/grout mixture.

3.5 Surface Soil Investigation

As requested by the DLA during the April 2005 BRAC Cleanup Team Meeting in Memphis, Tennessee, the potential risks associated with the proposed recreational[2] use of the Dunn Field Disposal Area were considered using previously collected soil data. The reuse designation is based on the Dunn Field Public-Conveyance map.

The risks for a future recreational adult, youth, or child exposed to surface soil and groundwater fall within the acceptable risk range of 1 to 100 in a million. Although the hazard indices (HI) are below the target level of 1.0 for an adult and a youth, the HI is slightly above 1.0 for a child, due to antimony and iron levels in surface soil (reference).

In response and, based upon a request by the Defense Logistics Agency (DLA) during the July 2005 BRAC Cleanup Team Meeting in Memphis, Tennessee, additional iron and antimony surface soil data will be collected to verify previously detected concentrations,

[2] Only industrial reuses were considered during the original Disposal Area risk assessment.

further evaluate the distribution of iron and antinomy in the northern half of the Disposal Area (Figure 3-6), and assess the absorption availability of antimony[3].

As shown on Figure 3-6, using the same sampling grid established for the MIP investigation, approximately 53 surface soil (0 to 1 ft bgs) composite samples, will be collected and analyzed for Target Analyte List (TAL) metals. Sampling methods are discussed in Section 4.

3.6 Decontamination

3.6.1 Personnel Decontamination

Onsite activities will require decontamination of personnel exiting the work area, especially in cases where a release of contaminants has been detected by the monitoring instruments. Decontamination procedures are defined within Section 4 of the November 2001, EPA Science and Ecosystem Services Division *Environmental Investigation Standard Operating Procedures and Quality Assurance Manual* (EISOPQAM).

3.6.2 Equipment Decontamination

All downhole drilling equipment as well as other equipment will be decontaminated according to procedures presented in Appendix B of the EISOPQAM (EPA, 2001). Decontamination of the DPT rig, drill rig, rotasonic drilling equipment, pipes, bits, tools, and all downhole equipment will be conducted between each sample location or well installation. Decontamination of development equipment will be performed between each well developed and will consist of the following steps:

1. High pressure, low volume steam-cleaning.
2. Wash and scrub with non-phosphate detergent (Liquinox®) and potable water.
3. Rinse with potable water.
4. Rinse with deionized (or analyte free) water.
5. Rinse with laboratory grade isopropyl alcohol (PVC or plastic material will not be rinsed with solvent).
6. Rinse with potable water.
7. Air dry to the extent practical.
8. Wrap in plastic sheeting or aluminum foil.

Decontamination activities will be conducted on a concrete or asphalt decontamination pad on Dunn Field. A minimum 3 feet high splashguard will be constructed by the selected subcontractor around three sides of the decontamination pad using plywood and plastic sheeting.

All wash and decontamination water will be managed in accordance with Section 3.6. All personnel protection clothing and articles will be contained in drums and disposed of separately.

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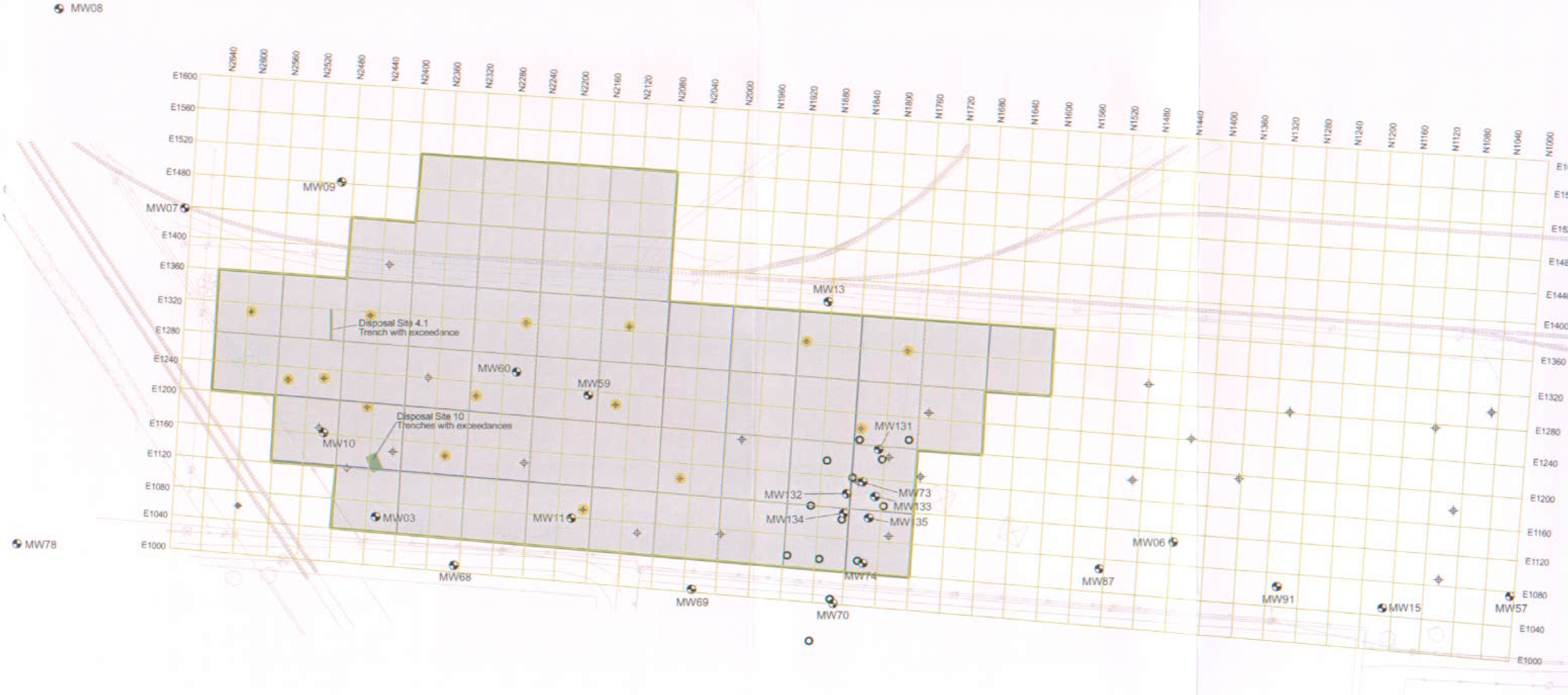
[3] Antimony may be in a metallic form that is not readily available for absorption; therefore, it would not present an exposure concern.



LEGEND

- Soil Boring Location (1999 Investigation)
- Source Area Soil Boring Location (2000 Investigation)
- Monitoring Well Location
- Exceedance of Risk Assessment Threshold for Recreational Reuse Scenario
- Surface Soil Sampling Area (Based on Dunn Field Public Benefit Conveyance Map)
- 80-Foot x 80-Foot Composite Sample Boundary (53 Samples)
- Sample ID Grid

North 1080 North 1040 North 1000
East 1080 East 1040 East 1000

North

128 64 0 128 256
Approximate scale in feet

FIGURE 3-6
Proposed Surface Soil Sampling Grid
Memphis Depot Dunn Field Remedial Design Investigation

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3.7 Waste Management

All soil cuttings will placed in roll-off boxes or drums located in a central staging area on Dunn Field. Soil cuttings may be staged temporarily at drill locations and stored in drums or covered by plastic sheeting prior to placement in roll-off boxes or drums. Drilling fluids, development water, and wastewater from equipment decontamination produced during the drilling operation will be containerized in 55-gallon drums approved by the Department of Transportation. The drums will be permanently marked with a weatherproof label provided by the FTL, signifying the date, site number, and well number. Soil, wastewater and sediment generated from equipment and personnel decontamination activities will also be stored at the site prior to removal from Dunn Field.

Per Section 4, representative samples of the investigative derived waste (IDW) will be collected for chemical characterization for offsite disposal. Once analytical results of the IDW are available, all IDW will be managed and disposed of in accordance with federal, state, and local regulations. The IDW will be removed from the site within 60 days following of the receipt of analytical results. During past investigation activities at Dunn Field, IDW water was disposed of in the City of Memphis sewer system after a temporary permit had been obtained from the City of Memphis Public Works Department. The permit provided an explanation that the water contained concentrations of contaminants similar to the effluent from the operating Dunn Field groundwater extraction system, which discharges into the City's sewer system.

Non-investigative waste, such as litter and household garbage, will be collected on an as-needed basis to maintain the site in a clean and orderly manner. This waste will be containerized and transported to the designated sanitary landfill or collection bin. Acceptable containers will be sealed containers or plastic garbage bags.

3.8 Health and Safety

A site-specific HASP will be developed and submitted to CEHNC for review and approval prior to mobilization. Issues particular to the groundwater and soil investigation are discussed in the HASP. These issues may include, but not be limited to, the following:

- **Groundwater Sampling: Use of Pumping Equipment.** The use of equipment to obtain samples includes air-operated bladder-type pumps, electrical generators, tubing, diffusion bags, and portable direct-reading instruments. The work will require effort around potentially hazardous environments and will require controls on ambient air hazards.
- **Monitoring Well Installation: Drilling.** The installation of wells at Dunn Field will require the use of rotasonic equipped drill rigs. The use of this equipment has inherent hazards, including rotating mechanical equipment, potential hazardous atmospheres, noise, and potential slips, trips, and fall possibilities.
- **Soil Sampling.** Soil from the loess deposits may potentially contain levels of VOCs hazardous to personnel exposed to the vapors. Screening with field equipment will be necessary to keep the hazards below action levels.

3.9 Site Security/Erosion Control

Access controls (i.e., orange safety fencing) and erosion control measures will be maintained around all drilling, stockpiles, or other areas disturbed by their operations. Open holes will be barricaded with orange safety fence. All work areas will be kept clean and neat.

4.0 Sampling and Analysis

Sampling and analysis procedures associated with the activities required for the Dunn Field RDI are outlined below. This section includes information regarding locations, frequency, and analyses for soil and groundwater to be collected during the investigation, as well as analyses required for disposal characterization for IDW.

4.1 Data Quality Objectives

The data quality objectives (DQOs) detailed in Table 4-1 are established to achieve the objectives outlined in Section 1.

TABLE 4-1
Data Quality Objectives
Memphis Depot Dunn Field Remedial Design Investigation

Objective	Data Quality Level	Qualitative DQO	Quantitative DQO
Land surveying of sample and well locations	Screening (initial) and definitive (post investigation)	Conduct initial land survey to layout MIP sampling grid, and locate soil boring and MW locations. Post investigation survey will be conducted to establish coordinates of additional or revised sampling locations.	Use a professional land surveyor to conduct a survey and provide specific geographical coordinates in a northing and easting format.
Update CVOC distribution in loess deposits soil	Screening (MIP) and definitive (Level III) (soil samples)	Develop profile of CVOC distribution within loess deposits soil.	Conduct grid-based MIP investigation in proposed SVE treatment areas. Measure PID, FID, and ECD response and soil conductivity. Collect and analyze co-located soil samples for target compound list (TCL) VOCs (Method 5035/8260B) in offsite laboratory to correlate MIP response.
Update CVOC distribution in groundwater	Definitive (Level III) (groundwater samples)	Collect groundwater samples to revise groundwater CVOC plume maps. Revise source area groundwater remedial strategy based on results.	Install additional MWs and collect groundwater samples from select existing and new MWs during supplemental groundwater investigation. MWs will also be sampled before, during, and after source areas groundwater remedy is implemented. Analyze groundwater samples by SW-846 Method 8260B.

TABLE 4-1
Data Quality Objectives
Memphis Depot Dunn Field Remedial Design Investigation

Objective	Data Quality Level	Qualitative DQO	Quantitative DQO
Enhance groundwater model data set	Screening (hydrogeologic and lithologic) and definitive (Level III) (groundwater samples)	Collect additional lithologic, hydrogeologic, and contaminant data from new MWs installed in the fluvial and intermediate aquifers to support the groundwater model.	Install additional MWs and collect groundwater samples from select existing and new MWs. MWs will also be sampled before, during, and after Off-Depot groundwater remedy is implemented. Analyze groundwater samples by SW-846 Method 8260B.
Assess lithology and hydrogeology of fluvial aquifer along proposed PRB alignment	Screening (hydrogeologic and lithologic) and definitive (Level III) (groundwater samples)	Collect additional lithologic, hydrogeologic, and contaminant data from soil borings and new MW installed in the fluvial aquifer to support the PRB design.	Complete multiple soil borings and install additional MW.
Complete re-evaluation of Disposal Areas risk assessment	Definitive (soil samples)	Measure iron and antimony concentrations in surface soil in the portion of the Disposal Area designated for recreational reuse to support the site risk assessment.	Collect five surface soil aliquots from 0 to 1 ft bgs in each 80-ft- by 80-ft grid cell identified on Figure 3-1. Blend aliquots into one composite sample and analyze for TAL metals by SW-846 Method 6020.

The following methods will be used to assess the quality of the data obtained by the MIP detectors, or define the uncertainty of the MIP data:

- If a sufficient non-parametric correlation, or other appropriate statistical method, between the confirmation soil sample results (Section 4.2) and the MIP response can be made, then a "source concentration" and the lower detection limits in the MIP will be defined.
- If a direct quantitative correlation cannot be defined but the MIP provides an elevated response at locations with high concentrations[4] so that a qualitative assessment can be made, the MIP will still be used to define the areas requiring remedial action.
- If the MIP is unresponsive in an area where contamination has been previous reported, then it is assumed that the CVOC levels are below the MIP threshold. The ECD data may therefore be unusable other than defining that concentrations are above/below a certain concentration range. Nevertheless, the MIP data will still be useful for refining site stratigraphy and potential migration pathways in the loess.

  As discussed previously, soil samples will be collected at selected locations to help define the MIP threshold. If the MIP response is determined to be unreliable, especially around the perimeter of the suspected contaminated area, then the density of confirmation soil samples will be biased or increased to promote adequate delineation.

[4] Based on existing soil data or corresponding DPT soil samples.

4.2 Soil Sampling

4.2.1 Soil Core Sampling

During the drilling of each soil boring and MW, soil cores will be collected in continuous sampling mode from land surface to the bottom of each boring. The core samples will be collected in plastic tube bags placed at the end of the core barrel subsequent to drilling each 10- to 20-foot length. The core samples will be cut open and examined for geologic characteristics immediately upon return to the surface.

Lithologic descriptions of unconsolidated materials encountered in the boreholes will be described in accordance with the 1990 ASTM D-2488-90, *Standard Practice for Description and Identification of Soils* (Visual-Manual Procedure). Descriptive information to be recorded in the field will include:

- Identification of the predominant particles size and range of particle sizes
- Percent of gravel, sand, fines, or all three
- Description of grading and sorting of coarse particles
- Particle angularity and shape
- Maximum particle size or dimension

Plasticity of fines description includes:

- Color using Munsell Color System
- Moisture (dry, wet, or moist)
- Consistency of fine grained soils
- Structure of consolidated materials
- Cementation (weak, moderate, or strong)

Identification of the Unified Soil Classification System (USCS) group symbol will be used. Additional information to be recorded is: depth to the water table, caving or sloughing of the borehole, changes in drilling rate, depths of laboratory sample collection, presence of organic materials, presence of fractures or voids in consolidated materials, and other noteworthy observations or conditions, such as the locations of geologic boundaries.

Headspace field screening (see the field screening Standard Operating Procedure in TM SA.01 – *Data Collection Plan for Long-Term Operational Areas, Main Installation, Memphis Depot*) will be conducted over each core using an organic vapor analyzer (OVA)/FID until the last core is removed from the boring. No samples will be collected for laboratory analysis.

4.2.2 DPT Sampling

As part of the MIP investigation, approximately 35 to 40 discrete soil samples, approximately 12 to 18 inches from select MIP points (low to high responses), will be collected using a standard DPT rig. These soil samples will be delivered by CH2M HILL to an offsite laboratory where they will be analyzed for CVOCs (SW-846 Method 8260B) on a rapid turnaround time (i.e., 24 to 72 hours). The soil sample collection approach is discussed in Section 3.2.1.

4.2.3 Surface Soil Sampling

The portion of the Disposal Area designated for recreational reuse (based on the Dunn Field Public-Conveyance map) will be divided into 80-ft by 80-ft grid cells as shown on Figure 3-6. Five random surface soil aliquots will be collected from 0 to 1 ft bgs from each of the 53 grid cells using stainless steel spoons or hand-augers that will be appropriately decontaminated between samples. The five aliquots will then be composited in a stainless steel bowl; one sample will be submitted from each grid cell for laboratory analysis SW-846 Methods 6010/6020.

Sampling methods and equipment have been selected to minimize decontamination requirements and the possibility of cross-contamination. Reusable sampling equipment will be decontaminated between locations by following these steps:

1. Scrubbing with brushes in Liqinox® solution
2. Two rinses with potable water
3. Analyte-free water rinse
4. Isopropanol (pesticide-grade) rinse
5. Analyte-free water rinse
6. Air drying

4.3 Groundwater Sampling

Groundwater sampling will be performed following the installation of the new MWs; samples will be collected from 14 new (Figures 3-2 and 3-3) and approximately 45 existing onsite and Off-Depot MWs. In addition to CVOC analysis, groundwater samples will be analyzed for the field parameters summarized in Table 4-2. Groundwater sampling and sampling equipment decontamination will be performed in accordance with this work plan, the *Final Generic Quality Assurance Project Plan* (CH2M HILL, 1995; amended in 2002), the EPA Region 4 Science and Ecosystems Services Division *EISOPQAM*, dated November 2001 and the USACE Engineer Manual 200-1-3, dated February 2001.

TABLE 4-2
Groundwater Monitoring Parameter Summary
Memphis Depot Dunn Field Remedial Design Investigation

Parameter	Laboratory Method
CVOC – Laboratory	
Volatile Organics	Fixed Based Laboratory – SW846 Method 8260B
Geochemical Parameters – Field	
Color	Field/Visual
Visible particulate	Field/Visual
Turbidity	Field Direct Reading Instrument – YSI 6820 Multimeter
Dissolved oxygen (DO)	Field Direct Reading Instrument – YSI 6820 Multimeter
Oxygen Reduction Potential (ORP)	Field Direct Reading Instrument – YSI 6820 Multimeter
pH	Field Direct Reading Instrument – YSI 6820 Multimeter
Temperature	Field Direct Reading Instrument – YSI 6820 Multimeter

Groundwater levels will be measured in MWs prior to and during each sampling event. Water levels will be measured using an electronic sensor with tape graduated in 0.01 feet. Measurements will be recorded as depth to water from the mark on the top of the well casing. Well number, date and time of measurement, and depth to water will be recorded in the field logbook.

Before sampling, each well will be purged using a low-flow bladder pump to minimize both agitation of the groundwater and sample turbidity. The following methods are consistent with the Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures (EPA, 1996). The intent of this procedure is to remove stagnant water from the well and introduce fresh groundwater into the well at a rate that does not produce significant drawdown of the water level in the well being sampled. This procedure reduces both the time required to purge the wells and the quantity of water removed (IDW). The field team will keep the pumping rate as low as possible, taking care not to lower the water level in the well. The anticipated pumping rate is 0.15 to 0.25 gallons per minute (gpm) so that water levels do not decline more than 1.2 inches (0.1 feet). Water level measurements will be made concurrently with the water quality parameter measurements. Field measurements of dissolved oxygen (DO), oxidation-reduction potential (ORP), turbidity, pH, temperature, and specific conductance will be made at the beginning of the procedure and at 5-minute intervals during purging. The water quality parameters will be measured using an airtight flow-through cell. Measurement data will be recorded in the field logbook. Purging will continue until field measurements are stable to within ±10 percent over three successive measurements. The above parameters will be documented and the wells will then be sampled using the same low-flow pump rate.

Samples will be collected from MWs using the low-flow bladder pump and Teflon®-lined tubing once the field parameters have stabilized. Headspace in the volatiles sample container must be minimized by filling the sample jar until a positive meniscus is present.

Containers will be quickly and adequately sealed; container rims and threads will be clean before tightening lids. Unless otherwise specified, Teflon®-lined screw lids will be used to seal the jar. Sample containers will be properly labeled and will be immediately cooled to 4°C ±2°C, and this temperature will be maintained through delivery to the laboratory until the samples are analyzed. New tubing will be used and the pump decontaminated for each well.

4.4 Investigation-Derived Waste

Representative samples of the IDW will be collected for chemical characterization needed for offsite disposal. IDW samples will be analyzed for the list of parameters described within Table 4-3.

4.4.1 Sediment

Sediment will be removed from the decontamination area and placed in drums. Sediment samples will be collected from the drums and analyzed for the same parameters as soil samples to assess final disposition of IDW materials.

TABLE 4-3
Sampling and An[illegible]ummary
Memphis Depot Dunn Field Remedial Design Investigation

Sample Task	Sample Point	Matrix	Sampling Frequency	Approx. Sample No	Sampling Method	Sampling Equipment	TAT	DQO Level/Data Package Requirement	Required Analysis	Analytical Methods	Holding Time	Sample Preservation	Containers
Groundwater Sampling													
Groundwater Sampling Event	45 existing and 14 new monitoring wells	Water	Once	59 plus 6 dup (10%) and 3 MS/MSD (5%)	Grab, Low flow technique	Flow-thru cell, bladder pump, Teflon-lined tubing	14 days	DQO Level III	TCL Volatiles	8260B	14 days	HCl pH<2; Cool to 4°C	(2) 40 mL vial
	Equipment Rinsate Blank		1 per 10 samples (10%)	6	Prepared in Field	Analyte-free water, SS funnel							
	Trip Blank		1 per cooler containing volatile samples	6	Prepared by Lab	N/A							
Soil Sampling													
MIP Confirmation Sampling	Treatment areas in conjunction with MIP investigation	Soil	At or near 15-20% of MIP locations	40 plus 4 dup (10%) and 2 MS/MSD (5%)	Grab	DPT, SS spoon	24 to 72 hrs	DQO Level III	TCL Volatiles	5035/8260B	14 days	Cool to 4°C	(2) 40 mL vials
Surface soil	Grid-based sample locations in northern portion of the Disposal Area	Soil	One composite sample per 80-ft by 80-ft grid cell	53 plus 5 dup (10%) and 2 MS/MSD (5%)	Grab	SS Auger, SS Spoons, SS Bowl	14 days	DQO Level III	TAL Metals	6010/6020	14 days	Cool to 4°C	(1) 8 oz glass
IDW Disposal Characterization Sampling													
Disposal to POTW	Well development, purge water, decon fluids, and surface water (as necessary)	Water	One Representative Sample to comply with the Memphis Depot Industrial Discharge Agreement with the City of Memphis	One	Grab	Drum thief or dip jar	14 days	DQO Level III	TCL Volatiles	8260B	14 days	HCl pH<2, Cool to 4°C	(3) 40 ml vial
									TAL Metals	6010B/7470A	6 months, Hg = 28 days	HNO_3, pH<2, Cool to 4°C	(1) 500 mL HDPE
									TCL Semivolatiles	8270C	7 day extr; 40 day analysis	Cool to 4°C	(1) Amber Liter Glass Jar
Soil	Soil cuttings, decon residuals	Soil	Every 250 CY for soil	Variable	Composite comprising 5 aliquots (except for VOCs, which is a grab)	SS Auger, SS Spoons, SS Bowl	14 days	DQO Level III	TCLP Volatiles	1311/8260B	14 day TCLP extr; 14 day analysis	Cool to 4°C	(1) 4 oz glass
									TCLP Semivolatiles	1311/8270C	14 day TCLP extr; 7 day extr; 40 day analysis	Cool to 4°C	(2) 8 oz glass
									TCLP Pesticides	1311/8081A	14 day TCLP extr; 7 day extr; 40 day analysis		
									TCLP Herbicides	1311/8151A	14 day TCLP extr; 7 day extr; 40 day analysis		
									TCLP Metals	1311/6010B, 7470A	6 month TCLP extr; 6 month analysis, Hg 28 day TCLP extr; 28 day analysis	Cool to 4°C	(2) 8 oz glass
									Ignitability	1030	ASAP		
									Corrosivity	9045A	ASAP		
									Reactivity	Chapter 7 3	ASAP		

Notes:
1 - Wells will be purged with QED or equivalent low-flow device Samples will be collected using teflon tubing and pump.
TAT = Turnaround time
VOCs = Volatile organic compounds
SVOCs = Semi-volatile organic compounds
C = degrees celcius
ml = milliliter
NA- Not Applicable

4.4.2 Water

Water derived from decontamination activities will be collected and drummed. Water samples will be collected from the drums and analyzed for CVOC content, reactivity, corrosivity, flammability, and explosivity. Results will be used to determine final disposition of the water.

4.4.3 Personnel IDW

IDW from personnel, including Tyvek® or Saranex® coveralls, nitrile gloves, rubber booties, duct tape, spent jars from field screening, etc., will be placed into separate drums for waste collection purposes. Analytical results from the soil samples will help determine whether there is need to sample the IDW, and, if so, what analyses should be performed. Two IDW samples are estimated for this effort.

5.0 Data Management, Analysis, and Interpretation

5.1 Data Description

Information generated from the Dunn Field RDI will include land survey, geologic, hydrogeologic, and geochemical data:

- Land survey data will be derived from the locating of the soil sample locations (MIP, DPT, and conventional soil borings locations), new groundwater MWs, and perimeter of the preliminary SVE treatment area. MIP and soil confirmation sample locations will be clearly marked in the field with stakes or pin flags so that their positions can be identified using global positioning system (GPS) or conventional land survey (Allen-Hoshell) when the investigation is complete.
- Geologic data will be derived from the installation of monitoring wells and soil borings and will include: 1) lithologic and stratigraphic characteristics of the loess and fluvial deposits that overlie the fluvial aquifer; and 2) lithologic and stratigraphic characteristics of the fluvial aquifer.
- Hydrogeologic data will derive from collection and analysis of water level measurements, and soil and groundwater samples.
- Geochemical information from this study will derive from analysis of all groundwater samples collected for CVOC, soil samples collected for metals, and field geochemistry. These data are critical for the completion of the revised Dunn Field Risk Assessment and Source Areas and Off-Depot Groundwater RDs (for example, placement of the source area ZVI injection locations, and orientation of the Off-Depot ZVI PRB and ZVI injection locations).

5.2 Data Management

Data management for the Dunn Field RDI will match the requirements of the DQOs presented in Section 4.1. Much of the field data will be obtained through the efforts of field screening, which includes use of direct-reading instruments, and laboratory analysis of samples. The information presented in this section is considered supplemental to the *Final Generic Quality Assurance Project Plan* (CH2M HILL, 1995) for the Memphis Depot activities.

5.2.1 Sample Numbering System

During sampling events conducted for the Dunn Field RDI, nomenclature will be used to distinguish between categories of sampling events, sample locations, and, where appropriate, depth of sample collection. Sample numbering protocol will be as shown in Table 5-1.

TABLE 5-1
Sample Numbering Summary
Memphis Depot Dunn Field Remedial Design Investigation

Sample Event	Type of Sample(s) and Location	Sample Number Description	Example Sample Number
MIP Investigation	MIP conductivity and CVOC response	Samples numbers consider treatment area (1-4) and grid location (see Figure 3-1).	TA4_N1080_E1120
	Soil confirmation sample	Samples numbers consider treatment area (1-4), grid location (see Figure 3-1), and discrete sample depth.	TA4_N1080_E1120_16-18
Surface soil	Soil	Samples will reflect grid location (center coordinate) and depth of sample collection.	N1800_E1320_0-1
Groundwater Sampling for VOCs and Geochemistry	Groundwater onsite and Off-Depot	Sample location and depth to pump. Note: for samples collected with a diffusion bag (optional), sample numbers will reflect depth of diffusion bag sampler located in each well.	MW-73_75 **If diffusion bags are used:** MW-73_75-78
Aquifer lithology	Soil along proposed PRB alignment	Samples will reflect location and depth of sample collection.	SB180_100-110

Note: For duplicate soil samples, a double blind sample number will be used for the duplicate sample. Matrix spike/matrix spike duplicates will be denoted with an "MS/MSD" at the end of the sample number. Equipment, field, and trip blanks will be designated with "EB", "FB", and "TB", respectively.

5.2.2 Soil and Water Sample Labels

All soil and water samples obtained at the site will be placed in an appropriate sample container, as identified in Table 4-3, for shipment to the laboratory. Each sample container will be identified with a separate identification label. Labeling will be done in indelible/waterproof ink. Errors will be crossed out with a single line, dated, and initialed. Each securely affixed label will include the following information:

- Project identification
- Sample identification
- Sampler's name or initials
- Preservatives added
- Date of collection
- Time of collection
- Required analytical method numbers

5.2.3 Field Screening Data Management

Field screening efforts will include ambient air screening around MWs and soil borings with an OVA/FID and screening of groundwater during purging procedures with portable direct-reading instruments. The data collected from these instruments will require the full attention of the operator to ensure that reported values are not misinterpreted or misunderstood. Data that will be recorded with each measurement include the following:

- Date and time
- Elapsed time since test began, as necessary
- Location of measurement/location where the sample was collected, as necessary
- Instrument measurement

Each measurement will be handwritten into a bound field logbook and, after the entire test has been completed, the data will be transferred into an electronic file for use within the Dunn Field RDI TM.

Other field notes to be collected during the Dunn Field RDI and written in the field logbook(s) include: weather information, personnel present during onsite activities, subcontractor names and activities, notes on the proximity of the activities to established features within Dunn Field, and all other pertinent information that may impact data analysis. This information will be included in the Dunn Field RDI TM, as necessary.

5.2.4 Analytical Laboratory Data Management

Multiple samples will be submitted to an analytical laboratory for CVOC and metals analysis and reporting. During collection of groundwater and soil samples, the date, time, location of sample collection, and sample number will be recorded in the field notebook. This information will be transferred, as required, to the Chain-of-Custody documents. Copies of the Chain-of-Custody documents will be kept at the site until the study is complete and will then be transferred to the site files for record keeping.

After the analytical data have been received from the laboratory, the data will be stored electronically, summarized, and reproduced for the Dunn Field RDI TM. Prior to this, however, the data will be reviewed by a project chemist for quality assurance (QA). If there are any differences between the chemist's and the laboratory's review of the data, a letter report will be issued describing the differences and any potential results from the study. Electronic Deliverable Data will be delivered according to Environmental Data Management System (EDMS) version 4.11 or higher. Information on EDMS is available at the following Web site:
http://www.aee.faa.gov/emissions/edms/edms_Updates/Updates.htm

5.3 Data Analysis and Interpretation

The data collected during the Dunn Field RDI will be tabulated and graphed to assess soil metals and groundwater CVOC spatial trends. All data and the resulting interpretation will be presented and described within the Dunn Field RDI TM and relevant RD documents. The data will be used as a basis for the design of the Dunn Field groundwater and soil remedy and to complete the Dunn Field risk assessment.

6.0 Community Relations

The Memphis Depot has an active community involvement program that monitors events that occur at the Memphis Depot site, especially for Dunn Field. This investigation will occur with the knowledge of members of the community, many of whom live just beyond the perimeter of Dunn Field. It is imperative that this investigation be conducted according to the specifications presented herein and that if any changes are necessary, proper notification is followed and discussions are held with all stakeholders.

Prior to initiation of field activities, fact sheets describing the investigation and duration of the fieldwork will be distributed to the local community members in the area adjacent to Dunn Field. The findings from the study will also be presented to the RAB members once they are finalized.

7.0 Reports

A Dunn Field RDI TM will provide the necessary documentation of the completed investigation process. CH2M HILL will complete the TM according to the schedule presented in Section 8. The TM will include, but not be limited to the following:

- Description of the investigation procedures
- Field measurement methods and data collected
- Summary of field and laboratory analytical data presented in graphs, tables, and/or figures
- Variances to field procedures performed
- Overall impact on the Dunn Field RD

The TM will also contain a separate section that covers the data quality and validation. At a minimum, the following information will be included in this section:

- Assessment of measurement data precision, accuracy, and completeness
- System and performance audit results
- Potential QA problems and corrective actions implemented
- Copies of documentation, such as memos and reports

The TM will be submitted to the BCT for review and comment. The final TM will be presented within the Source Area and Off-Depot Groundwater RD documents.

8.0 Schedule

The schedule is presented in Table 8-1 for the completion of the RDI work plan, the proposed fieldwork, and the preparation of the final TM.

TABLE 8-1
Schedule of Activities
Memphis Depot Dunn Field Remedial Design Investigation

Task	Estimated Completion Date
Submit Draft (Rev. 0) Dunn Field RDI Work Plan to Internal Reviewers	July 8, 2005 (complete)
Receive Comments from Internal Reviewers	July 22, 2005 (complete)
Submit Draft (Rev. 0) Dunn Field RDI Work Plan to BCT	August 1, 2005 (complete)
Receive Comments from BCT	August 17, 2005 (complete)
Respond to BCT comments	August 31, 2005 (complete)
Submit Final (Rev. 1) Dunn Field RDI Work Plan	September 7, 2005
Mobilize for Investigation Effort	September 26, 2005
Onsite Investigation Activities and Laboratory Analyses Complete	November 15, 2005
Submit Draft (Rev. 0) Dunn Field RDI TM to Internal Reviewers	November 28, 2005
Receive Comments from Internal Reviewers	December 9, 2005
Submit Draft (Rev. 0) Dunn Field RDI TM to BCT	December 16, 2005
Receive Comments from BCT	January 7, 2005
Submit Final (Rev. 1) Dunn Field RDI TM	January 21, 2005

9.0 References

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APPENDIX A

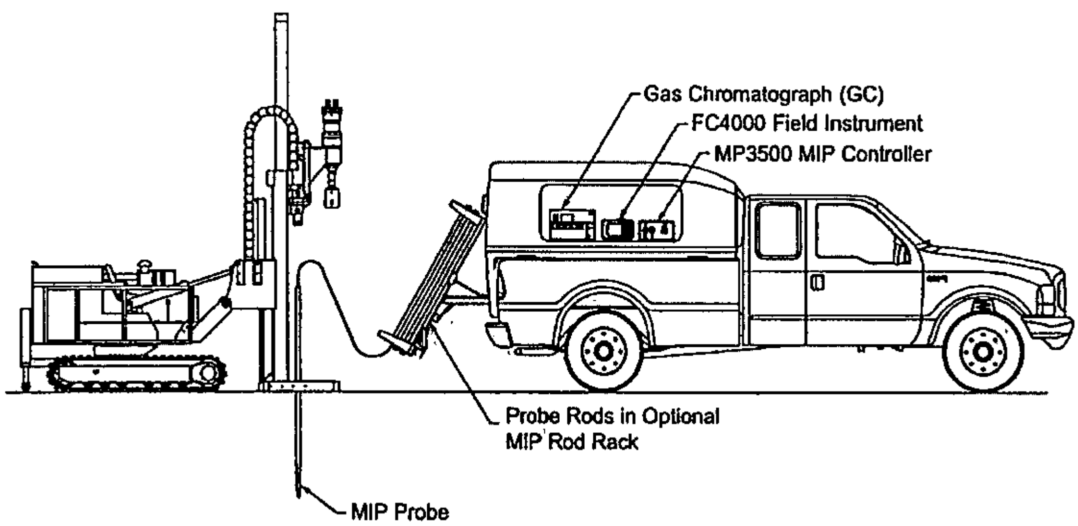
Geoprobe MIP Standard Operating Procedure

Geoprobe® Membrane Interface Probe (MIP)

Standard Operating Procedure

Technical Bulletin No. MK3010

PREPARED: May, 2003



THE MIP SYSTEM MAY BE DEDICATED TO A SINGLE CARRIER VEHICLE FOR USE IN TANDEM WITH MULTIPLE GEOPROBE® DIRECT PUSH MACHINE MODELS

Geoprobe Systems®

A DIVISION OF KEJR, INC.

Geoprobe Systems®

Geoprobe® and Geoprobe Systems®, Macro-Core® and Direct Image®
are Registered Trademarks of Kejr, Inc., Salina, Kansas

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.

1.0 OBJECTIVE

This document serves as the standard operating procedure for use of the Geoprobe Systems® Membrane Interface Probe (MIP) to detect volatile organic compounds (VOCs) at depth in the subsurface.

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and testing, soil conductivity and contaminant logging, grouting, and materials injection.
**Geoprobe® is a registered trademark of Kejr, Inc., Salina, Kansas.*

Membrane Interface Probe (MIP): A system manufactured by Geoprobe Systems® for the detection and measurement of volatile organic compounds (VOCs) in the subsurface. A heated probe carrying a permeable membrane is advanced to depth in the soil. VOCs in the subsurface cross the membrane, enter into a carrier gas stream, and are swept to gas phase detectors at ground surface for measurement.

2.2 Discussion

The MIP is an interface between contaminates in the soil and the detectors at ground surface. It is a screening tool used to find the depth at which the contamination is located, but is not used to determine concentration of the compound. Two advantages of using the MIP are that it detects contamination in situ and can be used in all types of soil conditions.

Refer to Figure 2.1. The MIP is a logging tool used to make continuous measurements of VOCs in soil. Volatile compounds outside the probe diffuse across a membrane and are swept from the probe to a gas phase detector at ground surface. A log is made of detector response with probe depth. In order to speed diffusion, the probe membrane is heated to approximately 100° C (212° F).

Along with the detection of VOCs in the soil, the MIP also measures the electrical conductivity of the soil to give a probable lithology of the subsurface. This is accomplished by using a dipole measurement arrangement at the end of the MIP probe so that both conductivity and detector readings may be taken simultaneously. A simultaneous log of soil conductivity is recorded with the detector response.

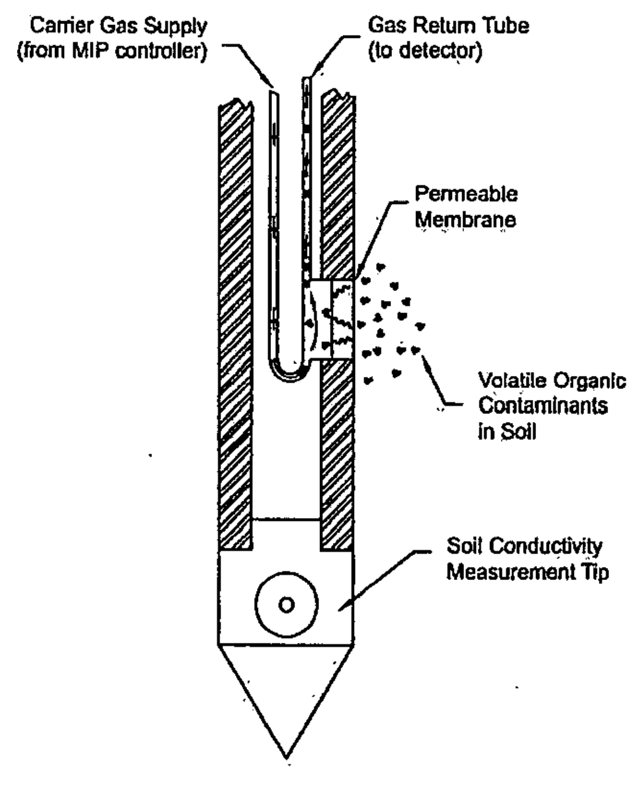


Figure 2.1
Schematic drawing of the MIP probe

3.0 Tools and Equipment

The following equipment is needed to perform and record an MIP log. Basic MIP system components are listed in this section and illustrated in Figure 3.1. Refer also to Appendix I for more required tools as determined by your specific model of Geoprobe® direct push machine.

3.1 Basic MIP System Components

Description	Quantity	Part Number
Field Instrument	(1)	FC4000
MIP Controller	(1)	MP3500
MIP/EC Acquisition Software	(1)	MP3517
MIP Probe	(1)	MP4510
Replacement Membrane	(1)	MP3512
Membrane Wrench	(1)	16172
LB Sample Tube	(1)	AT6621
Stringpot (linear position transducer)	(1)	SC160
Stringpot Cordset	(1)	SC161
MIP O-ring and Service Kit	(1)	MP2515
MIP Trunkline, 100-ft (30 m) length	(1)	MP2550
Extension Cord, 25-ft (8 m) length	(1)	SC153
Needle Valve	(1)	13700
24-in. Nafion Dryer Tube	(1)	12457

3.2 Anchoring Equipment

Description	Quantity	Part Number
Soil Anchor, 4.0-in. OD flight	(3)	10245
Anchor Foot Bridge	(1)	10824
Anchor Plate	(3)	10167
GH60 Hex Adapter (if applicable)	(1)	10809
Chain Vise	(3)	10075

3.3 Optional Accessories

Description	Quantity	Part Number
MIP Trunkline, 150-ft (46 m) length	(1)	13999
MIP Trunkline, 200-ft (61 m) length	(1)	15698
FID Compressed Air System	(1)	AT1004
Hydrogen Gas Regulator	(1)	10344
Nitrogen Gas Regulator	(1)	13940
Cable Rod Rack, for 48-in. rods	(1)	18355
Rod Cart Assembly, for 1.25-in. OD rods	(1)	SC610
Rod Cart Hitch Rack, for SC610	(1)	SC650K
Rod Cart Carrier, for SC610	(1)	SC675
Rod Wiper, for 5400 Series foot	(1)	AT1255
Rod Wiper, for 66 Series foot	(1)	18181
Rod Grip Pull Handle, for GH40 hammer	(1)	GH1255
Rod Grip Pull Handle, for GH60 hammer	(1)	9641
Water Transport System	(1)	19011

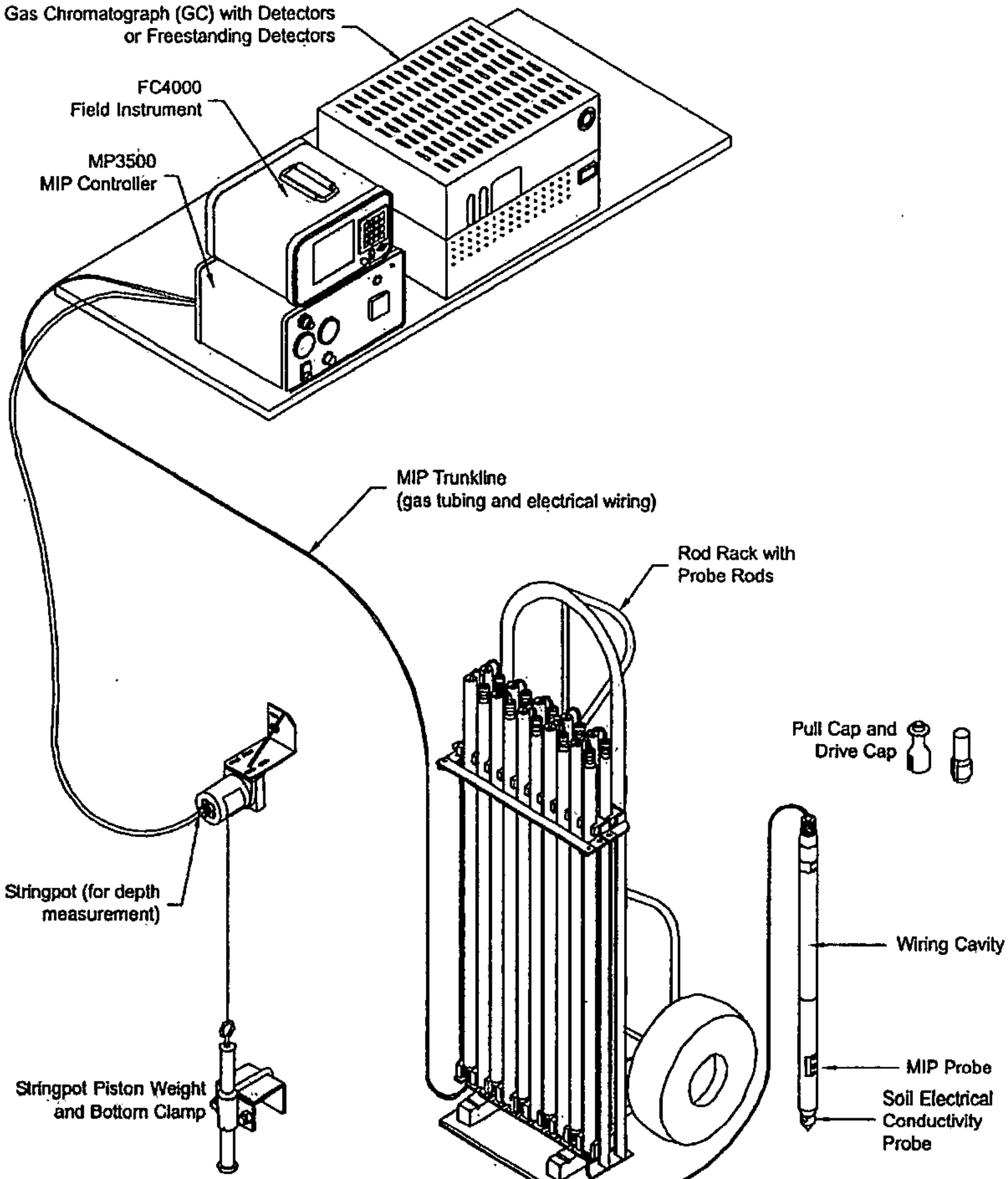


Figure 3.1
MIP system components

4.0: Quality Control - Response Testing

Response testing is an important quality control measure used to validate each log by proving that the integrity of the system is intact. Without running a response test, the operator will not know if the system is detecting the correct compounds or even if the system is working.

4.1 Preparation for Response Testing

Response testing is a necessary part of the MIP logging process because it ensures that the entire system is working correctly and also enables the operator to measure the trip time. Trip time is the time it takes for the contaminant to go from the probe, through the trunk line, and to the detectors. This time will need to be entered into the MIP software for depth calculations as described later in this document.

The following items are required to perform response testing:

- Neat sample of the analyte of interest (i.e.: benzene, TCE, PCE, etc.) purchased from chemical vendor
- Microliter syringes
- 25- or 50-mL Graduated cylinder
- Several 40-mL VOC vials with labels
- Testing cylinder made from a nominal 2-in. PVC pipe with a length of 24 in.
- 0.5 L plastic beaker or pitcher
- 25 mL Methanol
- Supply of fresh water, 0.5 L needed per test
- 5-gallon bucket filled with fine sand and water
- Stopwatch

Preparation of the stock standard is critical to the final outcome of the concentration to be placed into the testing cylinder.

1. Pour methanol into graduated cylinder to the 25 mL mark.

2. Pour 25 mL of methanol from graduated cylinder into 40-mL VOC vial.

3. Mix appropriate volume of desired neat analyte into 40-mL VOC vial containing 25 mL of methanol. The required volume of neat analyte for five common compounds is listed in Column 3 of Table 4.1. Use the equation at the then of this section to calculate the appropriate neat analyte volume for other compounds of interest.

4. Label the vial with name of standard (i.e. TCE, PCE, Benzene), concentration (50 mg/mL), date created, and created by (your name). This is the Stock Standard.

The equation used for making a stock standard is shown on the following page.

Table 4.1
Density and required volumes of neat compounds used to make a 50 mg/mL working standard into 25 ml of methanol

Compound	Density (mg/uL)	Volume of Neat Analyte Required to Prepare a Working Standard (uL)
Benzene	0.8765	1426
Toluene	0.8669	1442
Carbon Tetrachloride	1.594	784
PCE	1.6227	770
TCE	1.4642	854

25 mL (methanol) x 50 mg/mL = 1250 mg
1250 mg x 1/density of analyte = amount of neat material to be placed into 25 mL of Methanol

Example: Preparation of 50 mg/mL Benzene standard.
1250 mg x 1/0.8765 mg/uL = 1426 uL
Use 1426 uL of neat Benzene in 25 mL of Methanol to get a 50 mg/mL standard.

4.2 Response Test Procedure

With the standard prepared, the operator is ready to test the response of the probe as described below.

1. Immerse the probe into the 5-gallon bucket of fine sand and water to stabilize the baseline. This is necessary due to the sensitivity of the photoionization detector (PID) and the electron capture detector (ECD) to water.

2. Access the MIP Time software and view the detector vs. time data. The detector signals should be stable before proceeding.

3. Obtain 500 mL of water (either tap water or distilled) in a suitable measuring container.

Table 4.2
Volume of 50 mg/mL working standard and final concentration in 0.5 L test sample volume

Volume of 50 mg/mL Standard	Final Concentration of 0.5 L Sample (mg/L or ppm)
1000 uL	100
100 uL	10
10 uL	1

4. Use a standard volume specified in Table 4.2 to mix the desired test concentration. This is the Working Standard.

5. Pour the working standard into a nominal 2-inch x 24-inch PVC pipe and immediately insert the MIP into the solution (Fig. 4.1). Leave the probe in the test solution for 45 seconds. At the end of 45 seconds, place the probe back in the 5-gallon bucket of sand and water.

6. From the results on the MIP Time software the trip time and response time can both be measured (Fig. 4.2).

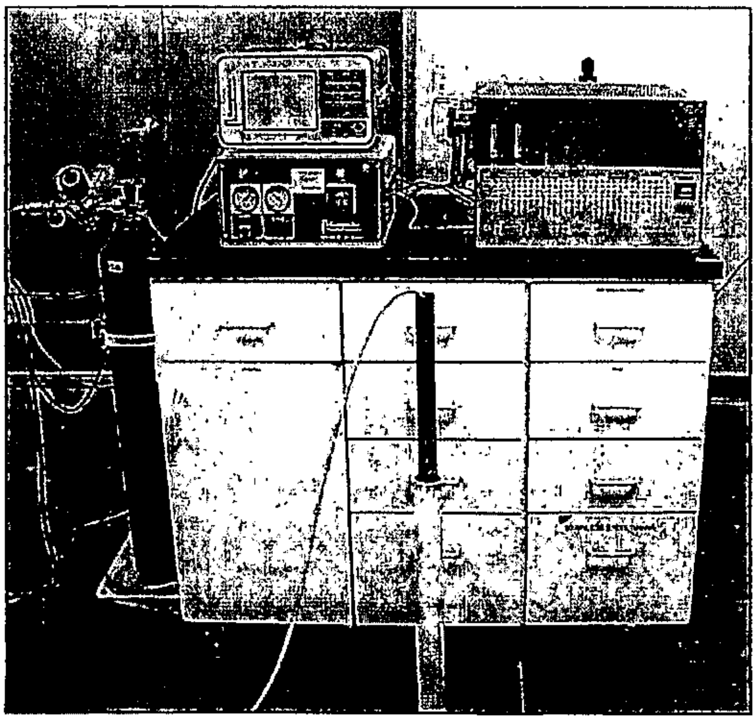


Figure 4.1
The MIP probe is placed in a PVC pipe containing the standard solution.

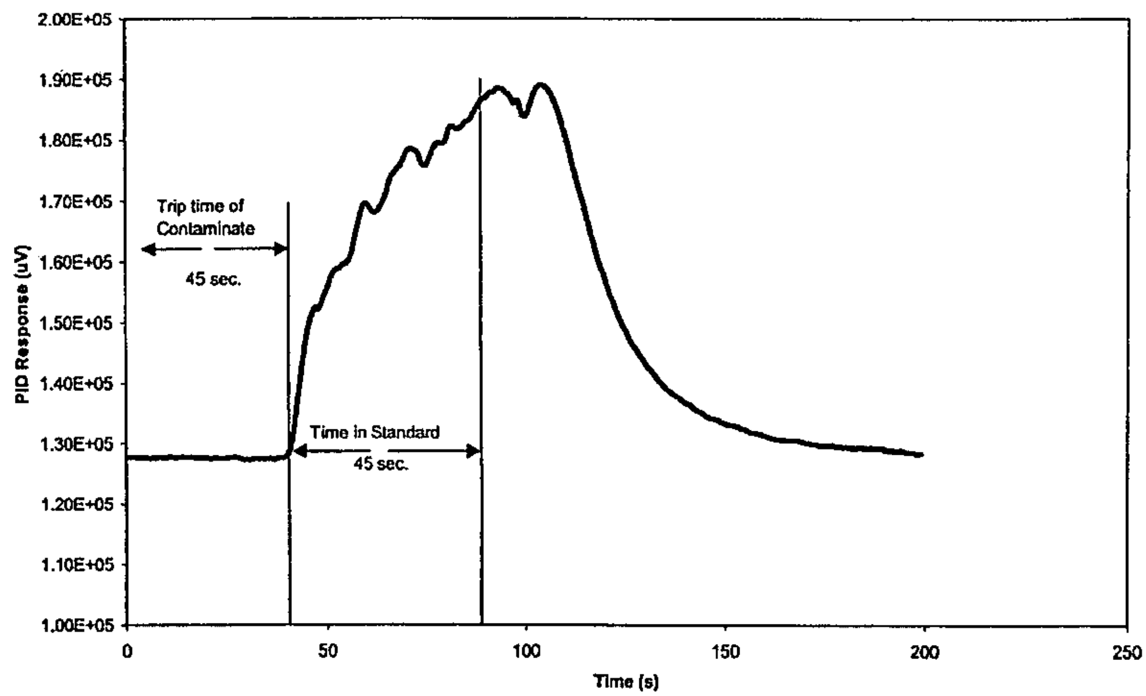


Figure 4.2
SRI PID Response Test - 10 ppm Benzene

5.0 Field Operation

1. Power on the generator.

2. Turn on any gases that will be used for the MIP system (i.e. nitrogen carrier gas, hydrogen for the FID, etc.). Check the flow rate of the system and psi on the mass flow controller. Compare these numbers to previous work.

3. Power on the detector or detectors and allow to warm up to set temperature (approximately 30 minutes).

4. Power on the MP2500 or MP3500 MIP Controller.

5. Power on the computer or the FC4000 Field Instrument.

6. Advance a pre-probe 3 to 4 feet into the subsurface at the location to be logged.

7. Remove the pre-probe and raise the probe foot of the direct push machine.

8. If advancing the MIP with percussion, raise the probe foot enough to slide the rod wiper plate underneath.

9. If pushing only, turn the desired amount of anchors into the subsurface and return the probe foot to the position from which the pre-probe was advanced. Leave the probe foot raised sufficiently to allow sliding the rod wiper underneath.

10. Place the rod wiper plate under the foot such that the opening is directly over the pre-probed hole. Lower the foot firmly onto the rod wiper.

11. If pushing only, position the anchoring bridge over the foot of the machine such that the anchors extend through the holes in the bridge (fig. 5.1). Install a chain vise at each anchor to secure the bridge.

12. With the software loaded, run a response test (Section 4.0) and record the height of the peak response and the trip time into a field notebook. Refer to Figure 4.2.

13. If the trip time is different than what was placed into the software, restart the software and enter the correct trip time.

14. Attach a slotted drive cap to the MIP drive head.

15. Insert the MIP point into rod wiper opening and drive it into the soil until the membrane of the probe is at ground level.

16. Connect the stringpot cable to the stringpot weight located on the probe foot and pull keeper pin so the weight drops to the ground.

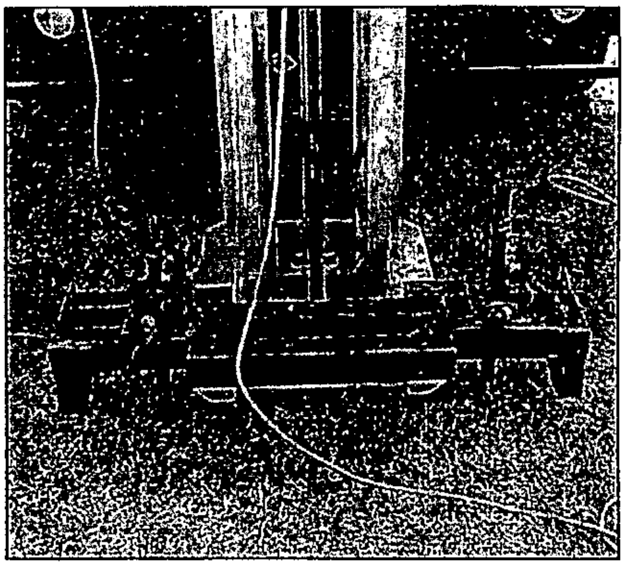


Figure 5.1
Anchor the probe foot to allow advancement of MIP probe by push only (no percussion).

NOTE: **Do not allow the stringpot cable to retract into the stringpot housing at a high rate. This will ultimately damage the stringpot.**

17. Record the system parameters in a field notebook at this time (i.e.. mass flow, trip time).

NOTE: **If the mass flow reading drops or rises more than one psi, turn off the flow at the primary controller and remove the probe from the ground. If the temperature monitor quits heating or gives an error, remove the probe from the ground.**

18. Place the trigger switch in the "ON" position.

19. Advance the probe at a rate of 1 ft/min to the predetermined log depth or until refusal is attained.

NOTE: **Refusal is attained when it takes longer than 1.5 minutes of continuous hammering to advance the probe one foot. This is the maximum time to reach one foot of probe travel.**

20. When the MIP log is complete, turn the trigger off and slowly return the stringpot cable into the stringpot housing.

21. Pull the probe rod string using either the Geoprobe® rod grip pull system or a slotted pull cap.

22. When the MIP reaches the surface, clean the face with water and run a response test. This response test should be written down in the field notes and compared to the initial test. This system check ensures the data for that log is valid.

23. Save the data to a 3.5-inch floppy disk and exit the MIP software.

24. Data from the MIP can now be graphed with Direct Image® MIP Display Log or imported into any spreadsheet for graphing.

6.0 Replacing a Membrane on the MIP Probe

A probe membrane is considered in good working condition as long as two requirements are met: 1) The butane sanity test result is greater than 1.0E+06 uV response, 2) Flow of the system has not varied more than 3 mL/min from the original flow of the system (a flow meter or bubble flow meter should be kept with the system at all times). If either one of these requirements are not met, a new face must be installed as follows.

1. Turn the heater off and allow the block to cool to less than 50° C on the control panel readout.

2. Clean the entire heating block with water and a clean rag to remove any debris.

3. Dry the block completely before proceeding.

4. Remove the membrane using the membrane wrench (Fig. 6.1). Keep the wrench parallel to the probe while removing the membrane to ensure proper engagement with socket head cap screw.

NOTE: Do Not leave the membrane cavity open for extended periods. Debris can become lodged in the gas openings in the plug.

5. Remove and discard the copper washer as shown in Figure 6.2. Each new membrane is accompanied by a new copper washer. **Do not reuse the copper washer.**

6. Inspect the open cavity for any foreign objects. Remove any objects present and clean the inside of cavity of any soil that was deposited on the wall of the block.

7. Insert the new copper washer around the brass plug making sure that it sits flat on the surface of the block.

8. Install the new membrane by threading it into the socket. Use the membrane wrench to tighten the membrane to a snug fit. Do not overtighten.

9. Turn the gas on and leave the heater off. Apply water to the membrane and surrounding area to check for leaks. If a leak is detected (bubbles are formed in the water), use the membrane wrench to further tighten the membrane.

10. Use a flow meter/bubble flow meter to check flow to the detectors. Record this value in a field notebook.

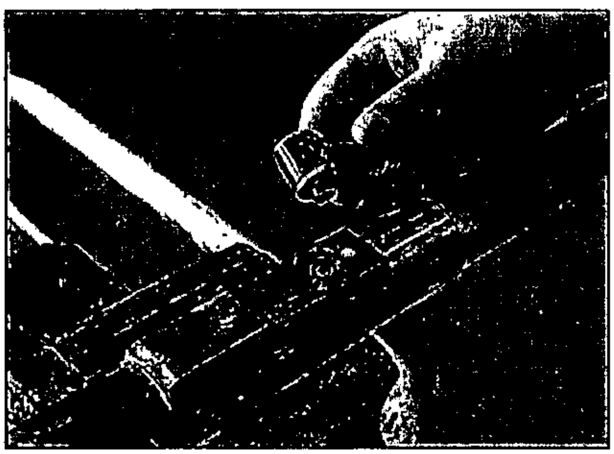


Figure 6.1
Unthread the membrane from the probe block.

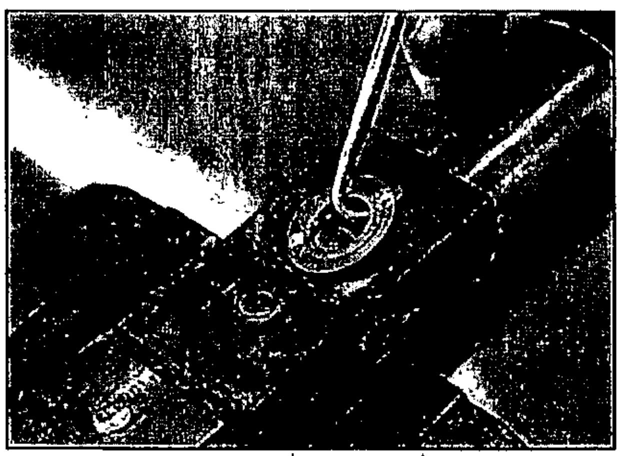


Figure 6.2
Remove and discard the copper washer.

Appendix I: Tools for Various Direct Push Machines

Model 5400 and 54DT Direct Push Machines

Description	*Part Number*
Stringpot Mounting Bracket	SC110
Stringpot Bottom Clamp	SC111
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.25-in. rods	AT1202
Slotted Pull Cap, for 1.25-in. rods	AT1203
MIP Drive Adapter, for 1.25-in. rods	MP2512
MIP Drive Head	GW1516
Probe Rod, 1.25-in. x 48-in.	AT1248

Model 54LT Direct Push Machine

Description	*Part Number*
Stringpot Mounting Bracket	11433
Stringpot Bottom Clamp	SC111
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.25-in. rods	AT1202
Slotted Pull Cap, for 1.25-in. rods	AT1203
MIP Drive Adapter, for 1.25-in. rods	MP2512
MIP Drive Head	GW1516
Probe Rod, 1.25-in. x 48-in.	AT1248

Model 5410 Direct Push Machine

Description	*Part Number*
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.25-in. rods	AT1202
Slotted Pull Cap, for 1.25-in. rods	AT1203
MIP Drive Adapter, for 1.25-in. rods	MP2512
MIP Drive Head	GW1516
Probe Rod, 1.25-in. x 48-in.	AT1248

Model 6600, 66DT and 6610DT Direct Push Machines

Description	*Part Number*
Stringpot Mounting Bracket	16971
Stringpot Bottom Clamp	11751
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.5-in. rods	15607
Slotted Pull Cap, for 1.5-in. rods	15164
Drive Cap Adapter, for GH60 and 1.25-in. rods	15498
MIP Drive Adapter, for 1.5-in. rods	18563
MIP Friction Reducer	18564
Probe Rod, 1.5-in. x 48-in.	13359

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