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US Army Corps of Engineers Baltimore District

VINT HILL FARMS STATION

Further Delineation of VOC Contamination in Overburden at AREE 34 – Summary Report

FINAL DOCUMENT

FEBRUARY 2004

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The former U.S. Army Vint Hill Farms	Station (VHFS) closed in Se	otember, 1997, pu	rsuant to the Base Realignment and
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former VHES has been identified as a lo	DA) or Fauquier County. Are	a Requiring Envirol	nmental Evaluation (AREE) 34 at the
is present in the saturated overburde	n material and underlying b	edrock aquifer. A	Remedial Investigation (RI) and a
Supplemental RI have been conducted	I at AREE 34. Based on the	results of these in	nvestigations, it was determined that
further investigation was required to be	tter define the upgradient exte	ent of the groundwa	ater contamination in the overburden
material and to refine the conceptual	site model (CSM). The Fur	her Delineation of	VOC Contamination in Overburden
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VINT HILL FARMS STATION

FURTHER DELINEATION OF VOC CONTAMINATION IN OVERBURDEN AT AREE 34 – SUMMARY REPORT

FINAL DOCUMENT

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°C	degrees Celsius
04 D	
/0 T	
μg/kg	
μg/L	
μ∟	microliters
μν	
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1- trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethene
AAFES	Army, Air Force Exchange System
Accutest	Accutest Laboratories, Inc.
amsl	above mean sea level
AREE	Area Requiring Environmental Evaluation
ASTM	American Society for Testing and Materials
bgs	below ground surface
BRAC	Base Realignment and Closure
CCC	continuing calibration check
CCl ₄	carbon tetrachloride
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHCl ₃ + TCA	chloroform plus trichloroethane
cis-1,2-DCE	cis-1,2-dichloroethene
CLP	Contract Laboratory Program
COC	chain-of-custody
Columbia	Columbia Technologies
CSM	conceptual site model
decon	decontamination
DCE	dichloroethene
DO	dissolved oxvgen
DOD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
DSITMS	Direct Sampling Ion Trap Mass Spectrometer
FC	electrical conductivity
FCD	electron-capture detector
FST	Fastern Standard Time
eV	
FDVCO	Further Delineation of VOC Contamination in Overburden at AREE 34
FDVCO-SR	Further Delineation of VOC Contamination in Overburden at AREE 34 – Summary Report
FDVCO-WP	Further Delineation of VOC Contamination in Overburden at AREE 34 – Work Plan
FID	flame-ionization detector
FOI	Field Operation Leader
FST	Field Sampling Team
ft	feet
ft/min	feet ner minute

g.....gram GAC.....granular activated carbon GC/MS.....gas chromatograph/mass spectrometer GPS.....global positioning system HCIhydrochloric acid I.D....inside diameter IDWinvestigation-derived wastes LCSlaboratory control sample MCL.....Maximum Contaminant Level MDL.....method detection limit MIPMembrane Interface Probe mLmilliliters MRDMissouri River Division MS.....matrix spike mS/M.....milliSiemens per meter MS/MSDmatrix spike/matrix spike duplicate NEPA.....National Environmental Policy Act NFG.....National Functional Guideline ng.....nanogram NPLNational Priority List O.D.outside diameter PCEtetrachloroethene PDBpassive diffusion bag PEC.....performance evaluation check PIDphotoionization detector ppbparts per billion ppbVparts per billion vapor PPE.....personal protective equipment ppmparts per million PT.....performance test PVC.....polyvinyl chloride QA.....quality assurance QAP.....Quality Assurance Plan QA/QCquality assurance/quality control QC.....quality control RI.....Remedial Investigation RL....reporting limit RPD.....relative percent difference RRFRelative Response Factor SARA.....Superfund Amendments and Reauthorization Act SDG.....Sample Delivery Group Shaw.....Shaw Environmental. Inc. SOP.....Standard Operating Procedure SRISupplemental Remedial Investigation TCEtrichloroethene TCL.....Target Compound List TDI.....thermal desorption interface Tri-CordersTri-Corders Environmental, Inc. USACEU.S. Army Corps of Engineers USATHAMA......U.S. Army Toxic and Hazardous Materials Agency USCS.....Unified Soil Classification System USEPAU.S. Environmental Protection Agency VDEQVirginia Department of Environmental Quality VHEDAVint Hill Economic Development Authority DACA31-01-F-0142 vii GSA1-130-03 February 2004

VHFS.....Vint Hill Farms Station VOA.....volatile organic analysis VOC.....volatile organic compound WG.....Work Group WSRT....western South Run tributary

1.0 INTRODUCTION

This Further Delineation of Volatile Organic Compound (VOC) Contamination in Overburden at Area Requiring Environmental Evaluation (AREE) 34 – Summary Report (FDVCO-SR) has been prepared to better define the nature and extent of the VOC contamination detected in the saturated overburden material at AREE 34 at the former Vint Hill Farms Station (VHFS) in Warrenton, Virginia.

The former VHFS is located approximately 40 miles southwest of Washington, D.C., in Fauquier County, Virginia, and approximately 11 miles northeast of Warrenton, Virginia. The general location of the former VHFS is shown on Figure 11. VHFS, while active, primarily functioned as an Army installation engaged in communications intelligence. VHFS closed in September, 1997, pursuant to the Base Realignment and Closure (BRAC) program. All of the former VHFS property has been transferred to the Vint Hill Economic Development Authority (VHEDA) or to Fauquier County as part of a public benefit conveyance. The former VHFS property was transferred in three pieces, with the final transfer occurring on May 22, 2003.

Although the former VHFS is not a National Priority List (NPL) site, the field work and data evaluation generally followed U.S. Environmental Protection Agency (USEPA) guidance documents developed for activities performed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). In addition, the FDVCO investigation was conducted in compliance with U.S. Army Corps of Engineers (USACE) technical guidance and quality assurance (QA) requirements (USACE, 1994a; 1994b); the National Environmental Policy Act of 1969 (NEPA); and the President's Council on Environmental Quality (CEQ) regulations (40 National Code of Federal Regulations [CFR] 1500-1508). The procedures that were used in the investigation were consistent with the Department of the Army's environmental policy toward integrating the NEPA and CERCLA/SARA process.

The FDVCO investigation utilized the USEPA Triad approach to manage decision uncertainty (i.e., to increase confidence that project decisions about contaminant presence, location, fate, exposure, and risk reduction are made correctly and cost-effectively). A primary product of the Triad approach is an accurate conceptual site model (CSM) that is the foundation for decisions that are both correct and optimized from a cost-benefit standpoint. The Triad approach achieves this by actively identifying and managing decision uncertainties and data uncertainties, and by incorporating advanced science and technology tools. The Triad approach consists of three major elements:

- Systematic project planning;
- Dynamic work strategies; and
- Real-time measurement systems.

Systematic project planning, the most important element of the Triad, ensures high decision confidence by developing: a consensus on the desired outcome for the site; a preliminary CSM from existing data; scientific, engineering, and regulatory decisions required to achieve the desired outcome; a list of the unknowns that impede making those decisions; strategies to eliminate or "manage around" those unknowns; and explicit control over the greatest sources of uncertainty in the environmental data (i.e., sampling-related variables). Dynamic work strategies is the element that allows the project to adapt in real time (i.e., while the work crew is still in the field) to new information as it becomes available. Preliminary CSMs can be tested and sufficiently evolved in the field to the desired level of decision confidence required to complete the project. Real-time measurement systems using advanced science and technology tools, such as field analytical instrumentation, in situ sensing systems, and computerized data management/visualization tools, allow data to be gathered, interpreted, and shared sufficiently fast to support real-time decisions.

This study was performed under the purview of the U.S. Army and the Virginia Department of Environmental Quality (VDEQ). A Field Sampling Team (FST) that included a senior hydrogeologist from Shaw Environmental, Inc. (Shaw), a senior person from Columbia Technologies (Columbia) for the Membrane Interface Probe (MIP) operation, a senior person from Tri-Corders Environmental, Inc.

(Tri-Corders) for the Direct Sampling Ion Trap Mass Spectrometer (DSITMS) analysis, and field technical support from each of the three firms conducted the field activities. The senior hydrogeologist from Shaw acted as the Field Operation Leader (FOL). The FST interacted with the Work Group (WG), which consisted of personnel from the USACE Baltimore, Department of Defense (DOD) BRAC Office, VDEQ, USEPA Innovative Technology Office, and USACE Seattle.

1.1 PHYSICAL SETTING OF AREE 34

This section provides information describing the physical setting of AREE 34. The reader is referred to the AREE 34 Remedial Investigation (RI) Report (USACE, 2003a) for information regarding the past, current, and future uses of AREE 34 and the surrounding buildings.

1.1.1 Site Location and Topography

AREE 34 is located due east of Building 2400 in the southern central portion of the former VHFS property (see Figure 1-2). AREE 34 consists of approximately one-third acre based on the results of the AREE 34 RI (USACE, 2003a), and is primarily covered by an asphalt parking lot in a previously industrial area of the former VHFS. This area has been paved since 1966 based on a review of historical building drawings.

The topography in the vicinity of AREE 34 is fairly flat with surface elevations ranging from 406.84 to 411.61 feet (ft) above mean sea level (amsl).

1.1.2 Surface Water Hydrology

The former VHFS property is located in the Occoquan watershed. Most of the property drains to South Run (located along the northwestern boundary of the former VHFS property, see Figure 1-2) via intermittent tributaries and drainage ditches. South Run is a small Class III Virginia stream which discharges into Lake Manassas, a recreation and drinking water reservoir built on Broad Run for the City of Manassas. The most prominent tributary located on the former VHFS property that drains to South Run is western South Run tributary (WSRT) show on Figure 1-2. The headwaters of WSRT are located approximately 900 ft to the north-northwest of AREE 34.

1.1.3 Geology/Hydrogeology

The central portion of VHFS is underlain by folded sedimentary rocks of the Catharpin Creek Member which consists of sandstone, arkosic sandstone, siltstone, shale, and claystone. These units strike north-northeast and dip approximately 40 degrees west-northwest (USATHAMA, 1981). Intrusions of basalt, oriented northeast to southwest, cut the bedrock in the central portion of the former VHFS property close to where AREE 34 resides.

Previous geological investigations performed as part of the AREE 34 Supplemental Remedial Investigation (SRI) (USACE, 2003b) have shown that bedrock is present at approximately 23 to 30 ft below ground surface (bgs), becoming shallower from west to east (see Figure 1-3). Based on previous hydrogeologic studies at the former VHFS, the bedrock encountered in well borings was massive and sporadically fractured (USACE, 1999). The bedrock is overlain by reddish-brown clay and silt overlying a brown, saprolitic, silt and fine sand (a chemical and physical weathering product of the underlying bedrock) which increases in density with depth.

Groundwater at the former VHFS property occurs in fractured bedrock and to a lesser extent in the overburden. Although most portions of the bedrock in the region have low porosity and permeability, particularly the basalt and diabase dikes, groundwater is found in zones of fractured bedrock. These fracture zones trend parallel and perpendicular to the trench axes (northeast-southwest). Because groundwater flow is primarily restricted to fracture zones, permeability and storage capacity in bedrock may be variable and limited. The bedrock aquifer is semi-confined, with the unfractured bedrock and saprolite acting as confining units. Recharge to the fractured bedrock aquifer occurs at outcrop areas and from percolation from the overburden along fractures.

The overburden at AREE 34, which consists primarily of clay and silt overlying saprolite, also contains groundwater. Much like the bedrock, saprolite is relatively dry and impermeable where it is DACA31-01-F-0142 1-2 Further Delineation of VOC Contam. In Overburden - SR GSA1-130-03 February 2004 Farms Station unfractured, so the quantity of groundwater the overburden contains is limited mostly by its thickness and the extent of fracturing. The quantity of groundwater stored in the clay and silt overlying the saprolite is limited by the thickness of the soil. The overburden serves as a reservoir for slow recharge to the bedrock along fractures. The saturated overburden material is unconfined.

Water level surveys conducted at AREE 34 during the SRI (USACE, 2003b) showed that: 1) the water table ranges between 4.9 and 11.8 ft bgs in the contaminated portion of the saturated overburden; 2) the direction of horizontal groundwater flow in the saturated overburden is north-northwest to west-northwest (see Figure 1-4); and 3) the direction of horizontal groundwater flow in the fractured bedrock aquifer varies between east-southeast and due east (see Figure 1-5). The general direction of horizontal groundwater flow in the bedrock aquifer is approximately opposite of the direction of horizontal groundwater flow in the saturated overburden material. The closest drinking water supply source is Production Well No. 1 which is located 400 ft to the south-southeast of AREE 34 (see Figure 1-2). Production Well No. 1 is hydraulically downgradient of AREE 34 with respect to the general direction of groundwater flow in the saturated overburden material.

1.2 OVERVIEW OF THE AREE 34 RI AND SRI

For discussion of the identification of AREE 34 and investigation activities that occurred in the vicinity of AREE 34 prior to the AREE 34 RI, the reader is referred to Section 1 of the AREE 34 RI Report (USACE, 2003a).

As part of the AREE 34 RI performed from March to July, 2001 (USACE, 2003a), the following investigation activities were performed:

- 26 temporary monitoring wells were installed;
- Groundwater samples were collected from the temporary monitoring wells as well as preexisting monitoring well NP-PZ2 and analyzed for tetrachloroethene (PCE) and trichloroethene (TCE) (see Figure 1-6);
- Three new permanent saturated overburden monitoring wells (MW34-1, MW34-2, and MW34-3) were installed;
- Groundwater samples were collected from the three new monitoring wells and four pre-existing saturated overburden monitoring wells and analyzed for Target Compound List (TCL) VOCs (see Figure 1-7); and
- Four soil borings were advanced from which a total of 32 soil samples were collected and analyzed for TCL VOCs.

Based on the temporary monitoring well program and the permanent monitoring well sampling conducted during the RI, the VOC contaminant plume in the saturated overburden at AREE 34 was presumed to impact an area of approximately one-third acre. The impacted area appeared to begin at approximately the center of the existing parking lot and move due west toward the former photo neutralization pit site and Building 2400. Four VOCs were detected above their corresponding Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (USEPA, 1996a) (see Figure 1-7). These four VOCs are: carbon tetrachloride (CCl₄) (maximum detection = 6.6 micrograms per liter [μ g/L]; MCL = 5 μ g/L); 1,1-dichloroethene (1,1-DCE) (maximum detection = 32 μ g/L; MCL = 7 μ g/L); PCE (maximum detection = 29 μ g/L; MCL = 5 μ g/L); and TCE (maximum detection = 37 μ g/L; MCL = 5 μ g/L). The MCL exceedences are sporadic (see Figure 1-6) indicating no discernible "point" source, but rather the impact of possibly one or more small spills of solvent. This conclusion is supported by the results of subsurface soil sampling which identified nondetectable concentrations of the VOCs (i.e., no ongoing source) except for a trace level of carbon disulfide at 10 – 12 ft bgs below the center of the parking lot.

As part of the AREE 34 SRI performed from October, 2002, through January, 2003 (USACE, 2003b), the following investigation activities were performed:

One new permanent saturated overburden monitoring well was installed;

- Three new permanent bedrock aquifer monitoring wells were installed; and
- Groundwater samples were collected from the four new monitoring wells and seven pre-existing saturated overburden monitoring wells and analyzed for TCL VOCs (Figures 1-8 and 1-9).

Based on the saturated overburden monitoring well sampling conducted during the AREE 34 SRI (USACE, 2003b), the VOC contaminant plume in the saturated overburden material at AREE 34 is more extensive than initially determined during the AREE 34 RI (see Figure 1-8). The impacted area extends further to the south-southeast to at least the location of saturated overburden monitoring well MW34-4. The highest detected individual VOC concentrations (primarily), as well as total VOC concentrations (736.46 μ g/L), detected during the AREE 34 SRI were detected in the groundwater sample from saturated overburden monitoring well MW34-4. Four VOCs were detected above their corresponding MCLs as follows: CCl₄ (maximum detection = 280 μ g/L; MCL = 5 μ g/L); 1,1-DCE (maximum detection = 171 μ g/L; MCL = 7 μ g/L); PCE (maximum detection = 64.8 μ g/L; MCL = 5 μ g/L); and TCE (maximum detection = 126 μ g/L; MCL = 5 μ g/L). The MCL exceedences remain sporadic indicating no discernible "point" source, but rather the impact of possibly one or more small spills of solvent.

Based on the bedrock aquifer monitoring well sampling conducted during the AREE 34 SRI (USACE, 2003b), the bedrock aguifer is also contaminated with VOCs (see Figure 1-9). Five VOCs were detected above their corresponding MCLs (see Figure 1-9). These five VOCs are: CCl₄ (maximum detection = 9.1 μ g/L; MCL = 5 μ g/L); 1,1-DCE (maximum detection = 156 μ g/L; MCL = 7 μ g/L); PCE (maximum detection = 84.4 μ g/L; MCL = 5 μ g/L); TCE (maximum detection = 81.8 μ g/L; MCL = 5 μ g/L); and 1,1,2trichloroethane (1,1,2-TCA) (maximum detection = $6.2 \mu g/L$; MCL = $5 \mu g/L$). Bedrock aquifer monitoring well MW34-7D contained the highest concentration of total VOCs (342.49 µg/L) of the three bedrock aguifer monitoring wells sampled. Bedrock aquifer monitoring well MW34-7D is the most upgradient bedrock aquifer monitoring well based on the general direction of horizontal groundwater flow in the bedrock aquifer at AREE 34. As discussed in Section 1.1.3, Production Well No. 1 is located 400 ft hydraulically downgradient of AREE 34 with respect to the general direction of horizontal groundwater flow in the bedrock aquifer. The VOC contamination in the bedrock aquifer decreases as it moves downgradient toward Production Well No. 1 (total VOCs are 27.9 µg/L at MW34-5D and 2.96 µg/L at MW34-6D). Recent sampling and analysis of groundwater discharging from Production Well No. 1 showed no detectable concentrations of VOCs at a detection limit of 0.5 µg/L, suggesting that there is limited hydraulic connection between the contaminated bedrock aguifer monitoring wells at AREE 34 and Production Well No. 1.

A review of historic building drawings conducted by Shaw in June, 2003, identified two features that should be considered when evaluating the presence of subsurface VOC contamination at AREE 34 (see Figure 1-10). The line of saturated overburden monitoring wells showing high concentrations of TCE and PCE (i.e., NP-PZ2 and MW34-2 in particular) are in line with an abandoned sewerline behind Building 2400. This abandoned sewerline initiated at Building 2410, a building which housed operations that do not appear to have used chlorinated solvents. Further, monitoring well MW34-1, located near the start of the abandoned sewerline, does not contain detectable levels of VOCs. The highest concentrations (primarily) of VOCs, particularly CCl₄, identified at AREE 34 are at the location of saturated overburden monitoring well MW34-4, which is located at the former location of an incinerator.

1.3 OBJECTIVES OF FURTHER DELINEATION OF VOC CONTAMINATION IN OVERBURDEN

Data gaps were identified based on the results of the AREE 34 RI and SRI Reports. Specifically, the SRI data clearly show that the extent of the VOC contamination in the overburden was not defined in the southeasterly direction.

Objectives of this FDVCO were to:

- 1. Identify the highest concentration of VOCs in the overburden soil and groundwater;
- 2. Determine the placement of additional permanent saturated overburden monitoring wells, if any, to further evaluate risk posed to human health; and
- 3. Gather soil analytical data, if warranted, to evaluate risk posed to human health.

1.4 FDVCO-SR ORGANIZATION

This FDVCO-SR consists of the following sections:

Section 1.0 – Introduction

This section presents a brief overview of the investigation activities for the VOC contamination detected in the groundwater at AREE 34. This section also presents the objectives of the FDVCO and the FDVCO-SR organization.

Section 2.0 – Field Procedures

This section describes the field procedures for the: installation of passive diffusion bag (PDB) samplers in existing monitoring wells and collection of groundwater samples; use of the MIP for the collection of nearly continuous, real-time VOC data; collection of sorbent traps from the MIP for speciation of VOCs; collection of collaborative subsurface soil samples; installation of temporary monitoring wells and collection of groundwater samples of sorbent trap, soil, and groundwater samples for VOCs; off-site sample handling; off-site laboratory analysis of soil and groundwater samples for TCL VOCs; data management and communications; decontamination; and management of investigation-derived wastes (IDW).

Section 3.0 – Quality Assurance/Quality Control

This section describes the quality assurance/quality control (QA/QC) procedures associated with the MIP, the DSITMS, and the off-site laboratory. This section also discusses the QA/QC data and what corrective actions were required.

Section 4.0 – FDVCO Investigation Results and Discussion

This section describes the results of the PDB groundwater sampling program, the high density sampling program using the MIP and sorbent traps, and the collaborative soil and groundwater sampling program.

Section 5.0 – Summary and Conclusions

This section summarizes the findings of the FDVCO investigation and presents conclusions.

Section 6.0 – References

2.0 FIELD PROCEDURES

This section describes the field procedures used for the FDVCO investigation. Field procedures for PDB groundwater sampling, high density sampling using the MIP and sorbent traps, collaborative soil and groundwater sampling, on-site DSITMS analysis, off-site sample handling, off-site laboratory analysis, data management and communications, decontamination, and disposal of IDW are presented in Sections 2.1 through 2.9, respectively. The field work was conducted between October 27 and November 25, 2003.

2.1 PASSIVE DIFFUSION BAG GROUNDWATER SAMPLING

PDB groundwater samples were collected for VOC analysis from four saturated overburden monitoring wells and two bedrock aquifer monitoring wells at the start-up of the FDVCO field activities. The PDB samplers were positioned within each well to provide complete coverage throughout the well screen interval. The goals of the PDB groundwater sampling were: 1) to determine the vertical stratification, if any, of VOC contamination in the groundwater to provide background data relative to the subsequent high density sampling (see Section 2.2) program; and 2) to assess, assuming there is stratification of the VOC contamination, whether the source may be local or some distance away. Shaw installed the PDB samplers in the wells, removed the PDB samplers from the wells, and collected the groundwater samples for VOCs using the DSITMS (see Section 2.4.2.3). Shaw arranged for the off-site laboratory analysis of selected PDB groundwater samples, and packaged and shipped the samples to the off-site laboratory (see Sections 2.5 and 2.6).

2.1.1 Passive Diffusion Bag Sampling Locations

PDB samplers were installed in saturated overburden monitoring wells NP-PZ2, MW34-2, MW34-3, and MW34-4, and in bedrock aquifer monitoring wells MW34-5D and MW34-7D. The PDB groundwater samples from the saturated overburden monitoring wells provided VOC stratification information within the well screen intervals. The stratification of VOC contamination in saturated overburden monitoring well MW34-4 was used to guide the high density sampling at its point of initiation (see Section 2.2). The PDB groundwater samples from the bedrock aquifer monitoring wells provided results regarding the stratification of VOC contamination within the well screen interval that was useful in refining the CSM.

2.1.2 Passive Diffusion Bag Groundwater Sampling Procedures

The PDB samplers were 2 ft long and were installed on October 27, 2003, with continual coverage of the well screen interval. Prior to placement of the PDB samplers, the depth to water and total depth for each of the six selected monitoring wells was measured, with an electric water level indicator with an accuracy of 0.01 ft, from the top of the polyvinyl chloride (PVC) casing and recorded in the field logbook. The tape and probe were decontaminated between measurements at different wells as discussed in Section 2.8.5. The total length of the water column was then calculated and recorded. In each well, the water level was above the top of the monitoring well screen. Therefore, the number of PDB samplers to be installed in each monitoring well was the screen length divided by 2, and rounded down to the nearest whole number (i.e., the 15-ft screen interval in NP-PZ2 utilized seven PDB samplers).

At each well location the following procedure was be performed:

- a. Filled each PDB sampler with deionized, organic-free water and removed any air pockets if any were visible;
- b. Inserted the bottom plug into each PDB sampler (a small air bubble from the plug was not a concern);
- c. Connected a stainless steel weight to the bottom of a tether line, making sure the weight was hanging below the bottom PDB sampler;
- d. Attached the PDB samplers to the tether line such that the bottom of the top sampler was just above the top of the second sampler, etc.;
- e. Lowered the tether line with the filled PDB samplers into the well; and

f. Secured the tether line so that the stainless steel weight at the bottom was approximately 0.1 ft from the bottom of the well.

The PDB samplers remained within the well for 3 weeks to allow for: 1) the equilibration of the well hydraulics (water levels to return to static levels and the flow through the well screen to return to equilibrium – at least one week); and then 2) equilibrium of the VOC concentrations in the groundwater and the PDB samplers (up to 7 days).

On November 17, 2003, the PDB samplers were retrieved from the monitoring wells. A groundwater sample was collected from each PDB sampler. For each PDB groundwater sample, a total of five 40 milliliter (mL) volatile organic analysis (VOA) vials were filled with zero headspace. Two of the vials were unpreserved (hold time of 7 days), and three of the vials were preserved with hydrochloric acid (HCI) to pH of <2 (hold time of 14 days). All of the groundwater sample bottles were kept on ice at the site to maintain a temperature of $4\pm2^{\circ}$ C until the samples were analyzed for VOCs by Tri-Corders using the on-site DSITMS (see Section 2.4.2.3), shipped off site for TCL VOC analysis by the off-site laboratory (see Section 2.6), and/or discarded.

All of the PDB groundwater samples were analyzed for VOCs using the on-site DSITMS using the unpreserved sample aliquots. In addition, the FST decided to send five PDB groundwater samples (plus two field duplicate samples) off site for TCL VOC analysis. The FST's decision was based on the results of the on-site DSITMS analysis of the PDB groundwater samples. The off-site laboratory analysis was conducted on the remaining preserved sample aliquots and was conducted with an expedited turnaround time due to the limited sample holding time that remained.

There was no pre-sample purging when collecting the groundwater samples from the PDB samplers because the PDB samplers were already in equilibrium with the groundwater flowing through the well screen. Since there was no pre-sample purging, there was no monitoring of field stabilization parameters (temperature, pH, conductivity, redox, dissolved oxygen [DO], and turbidity). The following PDB groundwater sampling procedures were followed:

- 1. A clean piece of plastic sheeting was spread on the ground around the well to protect the sampling equipment from possibly becoming contaminated.
- 2. Headspace readings in the well and in the breathing zone immediately above the well were measured with a photoionization detector (PID). All PID readings were less than 1 part per million (ppm) in the samplers' breathing zone, and Level D personal protective equipment (PPE) was worn while sampling the wells.
- 3. The depth to water was measured, with an electric water level indicator with an accuracy of 0.01 ft, from the top of the PVC casing and recorded in the field logbook. The tape and probe were decontaminated between measurements at different wells, as discussed in Section 2.8.5.
- 4. The groundwater sample was discharged directly from the PDB sampler into the sample containers (five 40-mL VOA vials) by using a disposable discharge tube. The tube was pressed into the clear polyethylene membrane of the PDB sampler until it pierced the membrane. Flow began immediately from the discharge tube. Two of the VOA vials did not contain any preservative (7-day holding time), and the other three VOA vials were preserved to a pH of <2 with HCl (14-day holding time). The VOA vials were filled slowly to minimize air bubbles and agitation of the sample. The VOA vials were filled with zero headspace.</p>
- 5. Sample bottles were labeled, enclosed in a plastic bag, and placed in a cooler maintained at 4±2°C immediately after sample collection and preservation.
- 6. The field sample number, number of sample containers, sample container type, and sample preservation method were recorded for each PDB groundwater sample collected on the Sample Collection Log Sheet (included as part of the Daily Quality Control [QC] Reports; see Appendix A).

Disposable sampling equipment was discarded as discussed in Section 2.9.2. All excess sample water remaining in the PDB samplers was containerized in a 55-gallon drum and disposed with the decon water from the FDVCO investigation as discussed in Section 2.9.1.

All of the preserved PDB groundwater samples that were collected for potential off-site analysis were kept in coolers maintained at $4\pm 2^{\circ}$ C until they were either shipped to the off-site laboratory or discarded. PDB groundwater samples sent for off-site laboratory analysis were packaged and shipped as discussed in Section 2.5.4.

Each PDB groundwater sample was given a unique field sample number that identified the location and screen interval of the sample. An example of the field sample numbering system is:

where:

MW34-4	 Indicates the well identification number from which the groundwater sample was collected;
PDB	 Indicates this is a PDB groundwater sample; and
1	= Indicates the relative location of the PDB sampler on the sample tether and in the well screen (i.e., 1 = the top of the well screen, and 5 = the bottom of the well screen [in wells with 10-ft well screens]).

On-site DSITMS analysis of the PDB groundwater samples began with the samples from saturated overburden monitoring well MW34-4 since this well is located in the area where the high density sampling was being conducted (see Section 2.2).

2.2 HIGH DENSITY SAMPLING USING MEMBRANE INTERFACE PROBE

A high density sampling program, utilizing a MIP with support from the on-site DSITMS, helped achieve the objectives of the FDVCO investigation. The MIP collects six channels of data at a time; these channels of data including three chemical data sets, electrical conductivity (EC), penetration rate, and temperature. The MIP continuously monitored environmental conditions with depth using a PID and an electron-capture detector (ECD). Although the MIP was also equipped with a flame-ionization detector (FID), the FID was taken off-line so that sorbent trap samples could be collected. A portion of the MIP vapor was split, and VOCs were captured on a sorbent trap and analyzed for VOCs using the on-site DSITMS (see Section 2.4.2.1). The EC, penetration rate, and temperature data provided by the MIP provided insight into the subsurface lithology and presence of saturated zones. These tools generated real-time data that was used by the FST to decide where, and how, to continue the FDVCO investigation.

Prior to initiation of the MIP investigation, Shaw: 1) arranged for clearance of underground utilities through VHEDA personnel and Miss Utility; and 2) laid out the sampling grid system described in Section 2.2.4. Columbia operated the Geoprobe® drill rig and MIP, collected the sorbent trap samples, and uploaded real-time data from the field investigation into its data management system for posting on a secure web-page (see Section 2.7.1). Tri-Corders analyzed the sorbent trap samples (see Section 2.4.2.1) using the on-site DSITMS.

2.2.1 Membrane Interface Probe Equipment

The MIP is a down-hole probe, approximately 12-inches in length and 1.5-inches in diameter, that consists of a heating block, a gas permeable membrane, and a gas loop to bring the gases that migrate across the membrane to the surface for analysis. The heating block is normally set to attain temperatures of 120°C. The temperature of the probe is quenched when it penetrates groundwater, and if maximum temperature is desired, then the standard operating procedure (SOP) calls for stopping advancement at specific intervals for the probe to reheat. The purpose of the heating block is to volatilize VOCs that the probe comes in contact with. These volatiles then migrate across a Teflon®-coated, stainless steel membrane and are captured in the inert gases that sweep the backside of the membrane and are brought to the surface for analysis. The membrane does get damaged with wear and when encountering sharp gravels

or fill material, but is easily replaced. Carrier gas flow rate is monitored to detect when the membrane is damaged.

EC sensors are located near the leading tip of the probe. The measurements recorded by the EC sensors generate soil conductivity data. The soil conductivity data provide an indication of grain size and thus different soil strata. In addition, if contaminant concentrations are high enough, the EC sensors may also provide an indication of ion content and thus contaminant distribution with depth.

A rubber-coated transfer line protects the electrical conduit and gas lines and connects the probe to the surface analytical equipment. This transfer line is threaded through the rods that are used to push the probe into the ground. At the surface, the gases are delivered to the analytical instrumentation of choice. There are a variety of ways to analyze the extracted gases. The most common approach involves running the gases through a series of detectors, typically a PID, a FID, and an ECD, to measure total VOC response. This high productivity protocol is often adequate for locating sources and mapping the extent of the compounds of interest. The PID (which uses a 10.2 electron volt [eV] ultraviolet lamp) is often used for aromatic compounds (e.g., benzene, toluene, ethylbenzene, and xylene) that have ionization potentials below 10.2 eV, the FID is used for alkanes (e.g., methane), and the ECD is used for chlorinated hydrocarbons (e.g., TCE, PCE, CCl₄). The PID, FID, and ECD measure total VOCs and typically have a sensitivity of approximately 500 parts per billion (ppb) although lower sensitivity was achieved by the ECD during this FDVCO investigation (see Section 4).

Since alkanes are of less importance to the AREE 34 investigation than chlorinated and aromatic hydrocarbons, the FID was not used for this FDVCO investigation. In its place, sorbent traps were collected for analysis using the on-site DSITMS (see Section 2.4.2.1) to speciate the VOC compounds. The DSITMS results from the sorbent traps were not considered a quantitative measurement for comparison with soil or water results, but were used solely as a means for speciation of the individual VOC components that contribute to total MIP/ECD VOC response.

2.2.2 Membrane Interface Probe Operation

The MIP was hammered into the ground at a nominal rate of one foot per minute (ft/min) utilizing a tractor mounted Geoprobe® drill rig. As it was pushed into the ground, the probe cooled down. At each foot interval, the probe was allowed to heat back up in order to optimize its ability to volatilize chemical constituents that it came in contact with. Near real-time measurements were recorded and were observed on a lap top computer available in the associated analytical van.

In addition to the real-time measurements, the gas stream was trapped onto a Tenax® tube for VOC analysis by the on-site DSITMS (see Section 2.4.2.1). These samples are referred to as sorbent trap samples. (Note: Tenax® tubes were reused; therefore, each sorbent trap sample was run through the DSITMS twice to ensure that the Tenax® tube was clean.) The gas stream over either a 2ft interval (MW34-4-MIP), 5-ft interval [MW34-4(2)-MIP and F20-MIP], or entire length of the MIP probe was concentrated into one sorbent trap sample. The rationale for the different length intervals is discussed in Section 4.1. Each sorbent trap sample was given a unique field sample number that identifies the location and depth interval of the sample. An example of the field sample numbering system is:

F20-ST-(5-10)

where:	
F20	= Indicates the AREE 34 grid location (as discussed in Section 2.2.4);
ST	Indicates that this is a sorbent trap sample; and
(5-10)	 Indicates the depth interval (ft bgs) over which the gas stream has been concentrated.

Additional MIP probes advanced at specific locations were designated with a "(2)", "(3)", etc. after the grid location [e.g., MW34-4(2)-ST-(5-10)]. Each sorbent trap sample was recorded in the field logbook and on the Sample Collection Log Sheet (included as part of the Daily QC Reports; see Appendix A).

The Geoprobe® operator monitored the advancement of the probe and advised the MIP operator when refusal was met. At this point, the rods were removed from the ground, and the vehicles moved to a new location. The hole left behind when the MIP was removed was either sealed using bentonite pellets or was used for the installation of a temporary monitoring well (see Section 2.3.2). The MIP did not require decontamination between sampling locations because contaminants are burned off as a result of the high operating temperatures used during operation of the MIP.

The MIP was operated in accordance with the Geoprobe® MIP SOP (see Appendix A of the FDVCO-WP [USACE, 2003c]). The sorbent traps were collected following the SOP for collection of sorbent traps provided in Appendix B of the FDVCO-WP.

2.2.3 Membrane Interface Probe Data

At the completion of each hole, a hard copy of the MIP log was printed and provided to the FST for review (see Appendix B). Each MIP log (PID, ECD, EC, and probe temperature) was given a unique identification number that defined the location of the MIP sampling point. An example of the sample numbering system is:

F20-MIP

where:

- F20 = Indicates the AREE 34 grid location (as discussed in Section 2.2.4); and
- MIP = Indicates this is a MIP log.

If additional MIP probes were advanced at a specific location for any reason, they were designated with a "(2)", "(3)", etc. after the grid location [e.g., F20(2)-MIP]. The MIP was also advanced within the well casing and screen of monitoring well MW34-4; this MIP log was labeled MW34-4-MWMIP.

At the end of each day, the MIP logs, and associated on-site DSITMS results, were E-mailed to Columbia's main office where they were normalized, processed, and posted on the secure web-page by the next morning (see Section 2.7).

2.2.4 Membrane Interface Probe Locations

As discussed in Section 1.2, a series of temporary monitoring wells were installed during the AREE 34 RI, and as shown on Figure 1-6, the temporary monitoring wells were installed on a 10-ft grid system utilizing an alpha-numeric labeling system. "Northeast-southwest" lines were given number designations, and "northwest-southeast" lines were given letter designations. Grid points are referred to by the intersection of the two lines (i.e., A20, K25). The MIP probes were located on a grid system that was expanded from the original grid system (see Figure 2-1). The grid system was expanded to the left of the "A" line. The grid lines to the left of the "A" line were designated with "double" letters. There is only one "A" line (i.e., no "AA" line) so that the grid designations are symmetrical (i.e., KK20 and K20 are equidistant from the "A" line). Upon completion of all the MIP probes, the MIP probe locations (with the exception of J16 and L18) were located (latitude and longitude) using a global positioning system (GPS) unit (see Appendix C). All MIP locations are presented on Figure 2-1.

The first high density sampling point was located adjacent to saturated overburden monitoring well MW34-4 to establish a benchmark to compare all other high density sample results, and to compare the MIP/ECD response with depth to the MW34-4 PDB groundwater sample results. The first probe at this location reached refusal at 13.2 ft bgs, approximately 7 ft shallower than the saturated overburden monitoring well. A second MIP probe was advanced at MW34-4 to 16 ft bgs. The maximum VOC (MIP/ECD) response detected in the second MW34-4 MIP probe location [i.e., MW34-4(2)-MIP] was noted and used to establish the relative difference of the other high density sampling locations.

The next high density sampling location, after the two at MW34-4, was at grid point F20. This next sampling location (upgradient of MW34-4 with respect to the direction of horizontal groundwater flow in the saturated overburden material) helped establish that the area of VOC contamination at MW34-4 is small and localized.

The remainder of the high density sampling locations were determined by the FST based on:

- 1. The objectives of the FDVCO investigation;
- 2. Historical data collected from AREE 34;
- 3. Data collected during this FDVCO investigation; and
- 4. Their knowledge and experience.

The selection of the high density sampling locations generally followed the Sample/Probe Location Decision Guide (hereinafter referred to as the Decision Guide) presented in Figure 2-2. The initial high density sampling locations were selected to identify whether the VOC contamination at MW34-4 was part of a large expansive area of contamination. Further discussion of the Decision Guide and criteria considered by the FST when selecting MIP locations can be found in Section 3.4 of the FDVCO-WP (USACE, 2003c). Shaw recorded significant decisions in the Daily QC Reports (Appendix A) that documented the FST's basis for selecting each high density sampling location. The FST's rationale for selection of each MIP location is presented in Section 4.1.

2.3 COLLABORATIVE SOIL AND GROUNDWATER SAMPLING

At the discretion of the FST, overburden soil and groundwater samples were collected during and after the high density sampling activities to collaborate the MIP results. The FST's rationale for selection of each collaborative soil or temporary monitoring well groundwater sample is presented in Section 4.1.

Collaborative soil samples were collected using a Geoprobe® drill rig, and temporary monitoring wells for collaborative groundwater sample collection were installed in the boreholes created by the advancement of the MIP using the Geoprobe® drill rig. Columbia operated the Geoprobe® drill rig and installed the temporary monitoring wells under the supervision of Shaw's senior hydrogeologist. Tri-Corders collected the collaborative soil samples for on-site DSITMS analysis from the soil cores, Shaw collected the collaborative soil samples for off-site laboratory analysis from the soil cores, and Shaw collected the collaborative groundwater samples for the temporary monitoring wells. Tri-Corders analyzed collaborative soil and groundwater samples for VOCs using the on-site DSITMS (see Section 2.4.2.3). Shaw arranged for the off-site laboratory analysis of collaborative soil and groundwater samples selected by the FST for off-site laboratory analysis, and packaged and shipped the samples to the off-site laboratory (see Sections 2.5 and 2.6).

2.3.1 Collaborative Soil Samples

Soil samples were collected and analyzed for VOCs using the on-site DSITMS (see Section 2.4.2.2), based on the decision of the FST, to collaborate the MIP/ECD responses from the high density sampling (see Section 2.2). Collaborative soil samples were collected using a Geoprobe® drill rig. The FST documented the rationale for both the location and depth of the collaborative soil samples on the Daily QC Reports (see Appendix A).

2.3.1.1 Geoprobe **Ò** Drilling Techniques

Drilling activities were conducted in accordance with the USACE <u>Monitor Well Design, Installation,</u> <u>and Documentation at Hazardous and/or Toxic Waste Sites</u> (USACE, 1994a) to ensure the safety of drilling personnel and the integrity of the samples. As noted in Section 2.2, Shaw arranged for clearance of underground utilities prior to initiation of the high density sampling. All drilling activities were performed under the direct supervision of Shaw's senior hydrogeologist.

A fully-equipped, tractor mounted Geoprobe® drill rig equipped with push-rods, points, 4ft long acetate liners, and a 4ft long stainless steel Macrocore sampler were used to drill soil borings at AREE 34. The Geoprobe® drilling did not employ the use of any drilling fluids. The following procedures were followed in preparation for Geoprobe® drilling of boreholes:

a. Prior to its initial use (and at the end of the field work), the Geoprobe® drill rig and all drilling equipment was decontaminated according to the procedures detailed in Section 2.8.2. The decontaminated, stainless steel Macrocore sampler, drill rods, and other downhole equipment

were placed onto a rack. The resulting decontamination water was managed as indicated in Section 2.9.1.

b. Plumbness was obtained in each borehole by careful leveling of the drill rig prior to commencement of drilling. The borehole was maintained in a plumb and true condition during drilling by sustaining a drilling speed that was sufficiently low to prevent deviation of the borehole. In addition, drilling proceeded in an efficient and controlled manner to eliminate wandering of the stainless steel sampler.

Following these initial setup procedures, continuous subsurface soil samples were collected from each soil borehole at discrete 4ft intervals (or less) using the Macrocore sampler until the desired depth for collaborative soil sample collection was reached. The Macrocore sampler is a two-inch outside diameter (O.D.) by 4ft long sampler that utilizes clear acetate liners to help ensure sample integrity and sample removal from the device. Once removed from the borehole and the Macrocore sampler, the acetate liners were opened, and the soil was screened with a PID. A new acetate liner was placed in the Macrocore sampler for every 4ft sample collected. Each borehole was advanced until the desired depth (established by the FST) was reached. Shaw's senior hydrogeologist monitored each 4ft sample with a PID, and recorded the reading on the boring log to further assist in the evaluation of vertical extent of contamination. Before moving to the next borehole location, all downhole tools were decontaminated using the procedures described in Section 2.8.3. The Macrocore sampler did not require decontamination between each use within a single borehole since a new acetate liner was used for collection of each 4-ft soil sample.

Shaw's senior hydrogeologist logged the drilling and sampling activities associated with each subsurface soil boring on an original boring log (see Appendix D). The following information, where applicable or available, was recorded on the boring logs during the course of the drilling and sampling activity:

- a. Depths of the boring in feet and fractions thereof (tenths of feet);
- b. Soil descriptions, in accordance with the Unified Soil Classification System (USCS), including:
 - 1. Classification,
 - 2. USCS symbol,
 - 3. Secondary components and estimated percentage,
 - 4. Color (using the Muncell Soil Color Chart, or equivalent),
 - 5. Plasticity,
 - 6. Consistency (cohesive soil) or density (non-cohesive soil),
 - 7. Moisture content,
 - 8. Texture/fabric/bedding, and
 - 9. Grain angularity;
- c. Cutting descriptions, including basic classification, secondary components, and other notable features;
- d. Numerical, visual estimates of secondary soil constituents (if terms such as "trace", "some", or "several" were used, their quantitative meanings were defined in a general legend);
- e. Length of sample recovered in the Macrocore sampler (percent recovery);
- f. Blow counts, where applicable;
- g. Depth interval for each sample;
- h. Depth to water first encountered during drilling and the method of determination (any distinct water-bearing zones below the first zone were also noted);

- i. General description of the drilling equipment used, including the rod size, bit type, pump type, rig manufacturer, model, and names of drilling personnel;
- j. Drilling sequence;
- k. Any unusual problems;
- I. Start and completion dates of borings, and a chronological time-sequence of events;
- m. Lithologic boundaries;
- n. Fluid losses, where applicable;
- o. Soil boring identification number and location;
- p. Rock type, where applicable; and
- q. PID readings.

All soil cuttings and acetate liners generated as a result of drilling activities at AREE 34 were drummed, labeled, and transported to the former Army, Air Force Exchange System (AAFES) Service Station to await off-site disposal based on waste characterization data to be collected as part of a subsequent field investigation at AREE 34. Disposal of soil cuttings is described in Section 2.9.3.

Each borehole was abandoned using 3/8-inch diameter bentonite pellets hydrated with USACEapproved water (unchlorinated water from Production Well No. 3). Bentonite pellets were poured in from the ground surface to seal the entire length of the borehole. Where a borehole had penetrated through asphalt, the top four inches of the hole were to be backfilled with asphalt patch material and compacted. The asphalt patch was to be packed in as solidly as possible to avoid future settling into small pockets that would allow water and ice to degrade the asphalt. Asphalt patching was postponed until ambient temperatures are acceptable for the asphalt to set properly.

Upon completion of soil boring drilling activities, the H14 borehole location was located (latitude and longitude) using a GPS unit (see Appendix C). The J16 borehole location was not located using the GPS unit.

2.3.1.2 Collaborative Soil Sample Locations

Discrete collaborative soil samples (see Figure 2-1) were collected to collaborate VOC responses detected by the MIP and to provide data to support refinement of the CSM (as updated by the MIP data). Further, the analytical results of the collaborative soil samples provide an understanding of the magnitude of contamination associated with the observed range (i.e., low, medium, and high) of MIP/ECD responses in concentration units that are well understood (i.e., micrograms per kilogram [μ g/kg]).

The need for, frequency of, location of, and depth of collaborative soil samples was determined by the FST based on a combination of the MIP data (see Section 2.2), the PDB groundwater sample results (see Section 2.1), and the results of the temporary monitoring well collaborative groundwater samples (see Section 2.3.2). Rationale for the collection of discrete collaborative soil samples for on-site DSITMS analysis is presented in Section 4.1 and in the Daily QC Reports (Appendix A).

The FST selected specific soil samples for off-site laboratory analysis to collaborate the MIP/ECD responses and the on-site DSITMS soil analytical results, and to provide data for evaluation of the human health risk associated with the VOC contamination in the overburden soil at AREE 34. A total of ten soil samples, including associated field QC samples (see Section 3.3.1), were sent to the off-site laboratory for analysis of TCL VOCs. Rationale for the location and depth of the discrete collaborative soil samples for off-site laboratory analysis was documented in the Daily QC Reports (Appendix A) and is presented in Section 4.1.

2.3.1.3 Collaborative Soil Sample Collection and Handling Procedures

Discrete collaborative soil samples were collected directly from the soil cores produced by the Macrocore sampling device. Collaborative soil samples were collected after the Macrocore sampler had

been removed from the borehole, the Macrocore sampler and acetate liner had been opened, and the soil core had been screened with a PID. Different procedures were used for collaborative soil sample collection depending on whether the soil sample was analyzed on site using the DSITMS or the soil sample was analyzed by the off-site laboratory.

Soil Sample Collection and Handling Procedures for On-site DSITMS Analysis. Tri-Corders collected the collaborative soil samples that were analyzed on site using the DSITMS following a modified USEPA Method 5035 (see Appendix C in the FDVCO-WP [USACE, 2003c]). Collaborative soil samples for on-site DSITMS analysis were collected using a reusable plastic 10 mL syringe (decontaminated between samples if reused) with the tip removed. The syringe was used as a sub-sampling device to collect a soil sample from the soil core. The syringe was pushed into the soil core at the desired location to collect approximately 5 mL of soil. Immediately upon collection, Tri-Corders placed the collected soil sub-sample into a VOA vial containing an extraction solvent (distilled water for low-level samples and methanol for high-level samples) as described in Section 2.4.2.2. Detailed soil sampling procedures for on-site DSITMS VOC analysis are presented in Appendix C of the FDVCO-WP.

Soil Sample Collection and Handling Procedures for Off-site Laboratory Analysis. Shaw collected the collaborative soil samples that were analyzed by the off-site laboratory for TCL VOCs. Collaborative soil samples for off-site laboratory analysis were collected using 25-gram En Core® samplers. Three En Core® samplers were filled for each collaborative soil sample for off-site laboratory analysis. Each En Core® sampler was filled using the following procedure:

- 1. Pushed the plunger rod down until the small O-ring rests against the tabs.
- 2. Released the locking lever on the En Core® T-Handle and place the coring body, plunger end first, into the open end of the T-Handle, aligning the two coring body slots with the two locking pins in the T-Handle.
- 3. Pushed the T-Handle into the soil until the coring body is completely full (i.e., O-ring is centered in the T-Handle viewing hole).
- 4. Capped the coring body while it remained in the T-Handle. The locking arm grooves on the cap must be fully seated over the coring body ridge for a proper seal.
- 5. Removed the capped En Core® sampler by depressing the locking lever on the T-Handle while twisting and pulling the En Core® sampler from the T-Handle.
- 6. Locked the plunger by turning the extended plunger rod fully counter-clockwise until the wings rested fully against the tabs.

The soil samples collected using En Core® samplers were required to be extracted by the off-site laboratory within 48 hours of sample collection. Therefore, soil samples for off-site laboratory analysis were packaged and shipped to the off-site laboratory (see Section 2.5.4) on the day of sample collection.

Collaborative Soil Sample Identification. Each collaborative soil sample was given a unique field sample number that identified the location and depth of the sample. An example of the field sample numbering system is:

J16(2)-SB-13.5

where:	
J16(2)	 Indicates the AREE 34 grid location (as discussed in Section 2.2.4) and denotes that this is the second borehole at this grid location (see below);
SB	 Indicates this is a collaborative soil sample from a soil boring; and
13.5	Indicates the depth of the soil sample (ft bgs).

Additional soil borings advanced at a specific location were designated with a "(2)", "(3)", etc. after the grid location [e.g., J16(2)-SB-13.5]. Each collaborative soil sample was recorded in the field logbook and on the

Sample Collection Log Sheet (included as part of the Daily QC Reports; see Appendix A) whether it was analyzed for VOCs using the on-site DSITMS or analyzed for TCL VOCs by the off-site laboratory.

Collaborative soil samples for on-site DSITMS analysis were immediately extracted and analyzed for VOCs by Tri-Corders using the on-site DSITMS (see Section 2.4.2.2). Collaborative soil samples for off-site laboratory analysis were kept on ice at the site to maintain a temperature of 4±2°C until the samples were shipped off site for TCL VOC analysis by the off-site laboratory (see Section 2.6). For collaborative soil samples analyzed for TCL VOCs off site, En Core® samplers were packaged and shipped as discussed in Section 2.5.

2.3.2 Collaborative Temporary Monitoring Well Groundwater Samples

Collaborative groundwater samples were collected from temporary monitoring wells installed in the boreholes created by the advancement of the MIP using the Geoprobe® drill rig. The FST determined the exact location, depth, and screen length for each temporary monitoring well. The FST also determined whether the samples were analyzed on site by the DSITMS, or shipped off site for analysis by the off-site laboratory. The FST documented the rationale for the location, depth, and screened interval for each temporary monitoring well as well as the rationale for whether the samples were analyzed on site or off site in the Daily QC Reports (see Appendix A). The FST's rationale regarding collaborative temporary monitoring well groundwater samples is presented in Section 4.1.

The FDVCO-WP stated that the temporary monitoring wells would be installed with a Geoprobe® rig pushing a Macrocore sampler. Very early in the FDVCO investigation, the FST decided to install temporary monitoring wells in each MIP probe location. The FST also decided to install the temporary monitoring wells immediately after removing the MIP from the ground. The borehole diameter created by the MIP is 1.5 inches, and the borehole diameter created by the Macrocore sampler is 2.0 inches. The FST decided to attempt the installation of the temporary monitoring wells into the smaller diameter borehole in order to speed up the temporary monitoring well installation (rather than drilling a second borehole at the same location). This process proved to be satisfactory, although two temporary monitoring wells could not be installed (at locations F21 and L18) because of squeezing clay.

2.3.2.1 Temporary Monitoring Well Construction and Installation

Temporary monitoring wells were constructed using flush-threaded, Schedule 40, 1 inch inside diameter (I.D.), PVC casing and well screen. A 0.01-inch slot size well screen was used to construct each temporary monitoring well. Actual screen length was determined by the FST based on the high density sampling. The screen length in all but one temporary monitoring well (FF20-TW) was 10 ft; the screen length in FF20-TW was 5 ft (see Table 2-1). The PVC materials conformed to National Sanitation Foundation Standard 14 for potable water usage or American Society for Testing and Materials (ASTM) equivalent. No plastic solvents or glues were used on any of the well materials. As discussed in Section 2.8.4, the temporary monitoring well casing and screen were not decontaminated prior to use.

The filter pack consisted of sieve size 20/40 silica sand. This size is compatible with both the screen slot size and the overburden materials.

The bentonite seal consisted of bentonite pellets installed over the filter pack. Once installed at the proper depth, the bentonite seal was allowed to hydrate. No grout was used in the temporary monitoring well construction.

Because the temporary monitoring wells were in place for no more than seven days, no protective covers were installed over them. To prevent infiltration of precipitation into the temporary monitoring wells, the open end of the PVC riser (i.e., the portion of the PVC casing that extends above the ground surface) was covered with a plastic bag which was secured to the PVC riser to prevent it from blowing away. In addition, bentonite pellets were placed around the base of the PVC riser to prevent infiltration of surface runoff. These protections were kept in place until the temporary monitoring wells were sampled and later removed.

The temporary monitoring well installation proceeded immediately after reaching refusal in the MIP probe and upon removal of the MIP from the borehole, and, once begun, continued uninterrupted until the

bentonite seal was installed. Shaw's senior hydrogeologist confirmed the depth of the borehole with a weighted tape before the temporary monitoring well screen and casing were installed.

After attaching a bottom cap to the well screen, each casing section was threaded to the section immediately below it and lowered into the borehole. Clean latex gloves were worn at all times during the handling of the well screen and casing.

Filter pack (a.k.a., sand pack) installation was accomplished by pouring sand in from the ground surface, dwn the annulus, and along the outside of the well screen and casing. The filter pack was generally installed to a height at least two feet above the top of the well screen, unless directed otherwise by Shaw's senior hydrogeologist. The height of the filter pack could not be verified using a weighted tape during installation due to the narrow annulus. However, the depth to the top of the filter pack could be estimated because the top of the filter pack was visible from the ground surface.

The bentonite seal consisted of bentonite pellets installed directly over the top of the filter pack. Pellets were poured in from the ground surface. Each bentonite seal had a thickness of at least one foot, as visually estimated immediately after placement.

The temporary monitoring well construction details are presented in Table 2-1. The top of the filter pack material and the thickness of the bentonite seal are not reported in Table 2-1 because the narrow annulus did not permit weighted tape measurements (the placement was completed based on visual observations).

At the completion of the FDVCO investigation, each temporary monitoring well (with the exception of J16-TW) was located (latitude and longitude) using a GPS unit (see Appendix C).

The temporary monitoring wells were not developed because of the anticipated slow recovery of the temporary monitoring wells (based on recovery rates of previously installed temporary and permanent monitoring wells at AREE 34) and the necessity to collect samples within a short time frame.

After completing the FDVCO investigation, the temporary monitoring well screens and casings were pulled straight out of the ground by hand. Temporary monitoring well materials that were lifted to the surface were containerized in a 55-gallon drum, labeled, and transported to the former AAFES Service Station to await off-site disposal based on waste characterization data to be collected as part of a subsequent field investigation at AREE 34. Disposal of the temporary monitoring well materials is described in Section 2.9.2.

Each temporary monitoring well borehole was abandoned using 3/8-inch diameter bentonite pellets hydrated with USACE-approved water (unchlorinated water from Production Well No. 3). Bentonite pellets were poured in from the ground surface to seal the entire length of each borehole. Where a borehole penetrated through asphalt, the top four inches of the hole were to be backfilled with asphalt patch material and compacted. The asphalt patch was to be packed in as solidly as possible to avoid future settling into small pockets that would allow water and ice to degrade the asphalt. Asphalt patching was postponed until ambient temperatures are acceptable for the asphalt to set properly.

2.3.2.2 Temporary Monitoring Well Locations

Early in the FDVCO investigation, the FST decided to install a temporary monitoring well at each MIP location because the probe was not able to penetrate the substrate to the desired depth (as indicated by the MW34-4 PDB groundwater sample results [i.e., approximately 20 ft bgs]). The rationale for this decision was documented in the Daily QC Report (Appendix A) and is presented in Section 4.1. The locations of all installed temporary monitoring wells are shown on Figure 2-1. A temporary monitoring well was installed at each MIP location with the exception of MW34-4, since there was already a permanent monitoring well at that location, and grid points L18 and A21, as a result of squeezing clay. Groundwater samples were collected for on-site DSITMS analysis from all but three of the 18 temporary monitoring wells installed during the FDVCO investigation (see Section 2.3.2.3).

The primary goals of the temporary monitoring wells were to allow for collection of groundwater samples to collaborate the VOC responses detected by the MIP and to provide data to support refinement of the CSM (as updated by the MIP data). Further, the analytical results of the collaborative groundwater

samples provide an understanding of the magnitude of contamination associated with the observed range (i.e., low, medium, and high) of MIP/ECD responses in concentration units that are well understood (i.e., $\mu g/L$).

The FST selected specific temporary monitoring wells for collection of groundwater samples for off-site laboratory analysis to collaborate the MIP/ECD responses and the on-site DSITMS temporary monitoring well groundwater analytical results, and to provide data for evaluation of the human health risk associated with the VOC contamination in the overburden groundwater at AREE 34. A total of 15 groundwater samples, including associated field QC samples (see Section 3.3.1) and off-site PDB groundwater samples (see Section 2.1), were sent to the off-site laboratory for analysis of TCL VOCs as part of the FDVCO investigation. Of these 15 groundwater samples, six were from temporary monitoring wells. Rationale for selection of temporary monitoring wells for collection of groundwater samples for off-site laboratory analysis was documented in the Daily QC Reports (Appendix A) and presented in Section 4.1.

2.3.2.3 Temporary Monitoring Well Groundwater Sample Collection and Handling Procedures

A groundwater sample was collected from each temporary monitoring well (excluding the temporary monitoring wells installed at D13 and K30) for either on-site analysis of VOCs using the DSITMS (see Section 2.4.2.3), off-site laboratory analysis for TCL VOCs (see Section 2.6), or both. The FST determined where the samples were to be analyzed.

Temporary monitoring wells were sampled using disposable ½inch I.D., 3ft bng polyethylene bailers no sooner than one hour after installation of the temporary monitoring well. A new bailer was used to sample each temporary monitoring well. Bailers were selected for collecting groundwater samples from the temporary monitoring wells for the following reasons: 1) the limited volume of groundwater expected to be present in the temporary monitoring wells based on past experience during the AREE 34 RI field work makes pumping infeasible; and 2) analytical results for temporary monitoring well groundwater samples collected using bailers during the AREE 34 RI were found to correlate well with analytical results for groundwater samples collected from permanent monitoring wells using the low-flow sampling method (USACE, 2003a) (see Section 4.4.3). There was no pre-sample purging because of the anticipated slow recovery of the temporary monitoring wells (based on recovery rates of previously installed temporary and permanent monitoring wells at AREE 34) and the necessity to collect samples within a short time frame. Since there was no pre-sample purging, there was no monitoring of field stabilization parameters (temperature, pH, conductivity, redox, DO, and turbidity). The following groundwater sampling procedures were followed:

- 1. A clean piece of plastic sheeting was spread on the ground around the well to protect the sampling equipment from possibly becoming contaminated.
- 2. Headspace readings in the well and in the breathing zone immediately above the well were measured with a PID. All PID readings were less than 1 ppm in the samplers' breathing zone, and Level D PPE was worn while sampling the wells.
- 3. The depth to water was measured, with an electric water level indicator with an accuracy of 0.01 ft, from the top of the PVC casing and recorded in the field logbook. The tape and probe were decontaminated between measurements at different wells, as discussed in Section 2.8.5.
- 4. The approximate height of the water column was calculated based on the installed total depth of the temporary monitoring well. A minimum water column height of 2 ft was required to provide sufficient volume of water to fill the sample containers.
- 5. The disposable bailer was slowly lowered into the well until it was at the mid-point of the screened interval or at the mid-point of the water column if the static water level was below the top of the well screen.
- 6. The bailer was then slowly removed from the well, and the sample containers (five 40-mL VOA vials where possible) were filled. If it was possible to fill five VOA vials, two of the VOA vials were not preserved (7-day holding time), and the other three VOA vials were preserved to a pH of <2 with HCl (14-day holding time). In many instances, there was insufficient groundwater in</p>

the temporary monitoring well to fill five VOA vials. In these instances, the number of VOA vials filled and the sample preservation was determined based on whether the groundwater sample was to be analyzed by the on-site DSITMS (two unpreserved VOA vials required) or the off-site laboratory (three preserved VOA vials required). The VOA vials were filled slowly to minimize air bubbles and agitation of the sample. The VOA vials were filled with zero headspace.

- 7. Sample bottles were labeled, enclosed in a plastic bag, and placed in a cooler maintained at 4±2°C immediately after sample collection and preservation.
- 8. The field sample number, number of sample containers, sample container type, and sample preservation method were recorded on the Sample Collection Log Sheet (included as part of the Daily QC Reports; see Appendix A).

Disposable sampling equipment was discarded as discussed in Section 2.9.2. Excess sample water remaining in the bailers was containerized in a 55-gallon drum and disposed with the decon water from the FDVCO investigation as discussed in Section 2.9.1.

Each temporary monitoring well groundwater sample was given a unique field sample number that identified the sample location and the screen interval of the temporary monitoring well. An example of the field sample numbering system is:

F20-TW-(8-18)

where:

F20	= Indicates the AREE 34 grid location (as discussed in Section 2.2.4);
TW	= Indicates this is a temporary monitoring well sample; and
(8-18)	= Indicates the screen interval of the temporary monitoring well (ft bgs).

Additional groundwater samples collected from a specific temporary monitoring well were designated with a "(2)", "(3)", etc. after the grid location [e.g., F20(2)-TW-(8-18)]. Each collaborative temporary monitoring well groundwater sample was recorded in the field logbook and on the Sample Collection Log Sheet (included as part of the Daily QC Reports; see Appendix A) whether it was analyzed for VOCs on site using the DSITMS or analyzed for TCL VOCs by the off-site laboratory.

All temporary monitoring well groundwater sample bottles were kept on ice at the site to maintain a temperature of $4\pm2^{\circ}$ C until the samples were analyzed for VOCs by Tri-Corders using the on-site DSITMS (see Section 2.4.2.3), shipped off site for TCL VOC analysis by the off-site laboratory (see Section 2.6), and/or discarded. The unpreserved sample aliquots were used for the on-site VOC analysis since the samples were analyzed within a day of collection. Preserved sample aliquots were used for TCL VOCs off-site laboratory analysis. For temporary monitoring well groundwater samples analyzed for TCL VOCs off site, sample bottles were packaged and shipped as discussed in Section 2.5.

2.4 ON-SITE DIRECT SAMPLING ION TRAP MASS SPECTROMETER ANALYSIS

Tri-Corders mobilized their DSITMS to AREE 34 for on-site analysis of PDB groundwater samples (Section 2.1), sorbent traps (Section 2.2), collaborative soil samples (Section 2.3.1), and collaborative groundwater samples (Section 2.3.2) for VOCs. The DSITMS was housed in a fully-equipped enclosed trailer pulled by a supply truck. Since the DSITMS was used for analysis of sorbent traps, soil samples, and groundwater samples on any given day, Tri-Corders began each day by calibrating the DSITMS for each of these media.

2.4.1 Direct Sampling Ion Trap Mass Spectrometer Equipment

The analysis of samples for VOCs by DSITMS is based upon USEPA Method 8265 (see Appendix C in the FDVCO-WP [USACE, 2003c]). DSITMS is a very rapid method for the detection and quantification of VOC contaminants of concern. The technique consists of a set of sampling interfaces that allow the introduction of vapor samples containing VOCs directly into an ion trap mass spectrometer. As opposed to a gas chromatograph/mass spectrometer (GC/MS) instrument, the DSITMS approach does not

separate analytes into individual components before detection by mass spectrometry. The DSITMS introduces all VOCs present in a sample into the mass spectrometer as a mixture. The DSITMS depends on the uniqueness of each compound's mass spectra for both identification and quantification.

DSITMS is well suited for the rapid quantitative measurement, continuous real-time monitoring, and qualitative and quantitative preliminary analysis of VOCs in water, soil, soil gas, and air. DSITMS introduces sample materials directly into an ion trap mass spectrometer by means of a simple interface (such as a capillary restrictor). There is little if any sample preparation and no chromatographic separation. The response of the instrument to analytes in a sample is nearly instantaneous. In addition, the instrument is field transportable, rugged, and relatively easy to operate and maintain.

2.4.2 Direct Sampling Ion Trap Mass Spectrometer Operation

The DSITMS was used during this project to analyze a variety of matrices for VOC contaminants of concern. These matrices included vapor samples collected on sorbent traps from the MIP, discrete soil samples, and discrete groundwater samples.

Tri-Corders' SOPs and Quality Assurance Plan (QAP) for DSITMS analysis of sorbent traps, soil samples, and groundwater samples are included in Appendix C of the FDVCO-WP (USACE, 2003c). These SOPs provide details regarding operation and instrument output. The SOPs describe the procedures for the analysis of sorbent traps, discrete soil samples, and discrete groundwater samples. This includes the procedures for analysis of discrete soil samples by both low-level (slurry preparation) and high-level (methanol extraction). These documents together specify calibration requirements, analysis procedures, QC sample analysis, and corrective actions. Frequency of QC check samples are presented in the SOPs and are generally specified at 5% (i.e., one QC sample for every 20 environmental samples) at a minimum. The DSITMS was calibrated for the VOC contaminants of concern at AREE 34 based on the results of the AREE 34 RI and SRI (USACE, 2003a; 2003b). The DSITMS was calibrated for chloroform plus trichloroethane (CHCl₃ + TCA) (using chloroform), CCl₄, TCE, dichloroethene (DCE) (using cis-1,2dichloroethene [cis-1,2-DCE]), and PCE. The main limitation of the DSITMS is that any compounds having the same ions are reported as an analyte pair or sum (e.g., 1,1-DCE and cis/trans-DCE; CHCl₃, 1,1,1trichloroethane [1,1,1-TCA], and 1,1,2-TCA). This limitation is discussed in USEPA Method 8265 (see Appendix C in the FDVCO-WP).

2.4.2.1 Analysis of Sorbent Traps

Initial calibration of the DSITMS for the analysis of sorbent traps consisted of analysis of calibration standards at seven concentrations (ranging from 0 to 1,000 nanograms [ng] on the sorbent trap) for each VOC contaminant of concern for the site. The calibration range for the sorbent trap analysis was initially set to cover the expected range of MIP vapor concentrations and the site-specific lower action level. After the DSITMS had been calibrated and passed the performance evaluation check (PEC) standard, sorbent trap samples were analyzed. Sorbent traps provided by the MIP operator were analyzed using the DSITMS thermal desorption interface (TDI) (see SOP for sorbent trap DSITMS analysis in Appendix C of the FDVCO-WP [USACE, 2003c]). Traps were thermally desorbed by placing them in the TDI which was heated while the carrier gas was allowed to flow through the trap. The concentrations of each VOC compound in the MIP vapor are typically reported in parts per billion vapor (ppbV) based on the mass of contaminant detected and the volume of MIP vapor that flowed through the Tenax® tube for the collection of the sorbent trap (see Section 2.2). The detection limits for VOC contaminants of concern in sorbent trap samples using the DSITMS are dependent upon the matrix, but are typically on the order of 100 ppbV.

On the first day of MIP operation and sorbent trap collection, the FST observed that the MIP/ECD was proving to be sufficiently sensitive to meet the FDVCO objectives. Therefore, the FST decided to collect only one sorbent trap for the entire length of a MIP probe for speciation purposes only. Therefore, for this FDVCO investigation, quantitative sorbent trap results were not reported by Tri-Corders.

Periodic QC samples (i.e., blanks, continuing calibration checks (CCCs), and PECs) were analyzed on a continuing basis. The analytical procedures are described in detail in the sorbent trap DSITMS analysis SOP (see Appendix C in the FDVCO-WP). (Note: Tenax® tubes used for the collection of sorbent

trap samples were reused; therefore, each sorbent trap sample was run through the DSITMS twice to ensure that the Tenax® tube was clean before reuse.)

2.4.2.2 Analysis of Soil

Analysis of soil samples by DSITMS was conducted using the 40-mL vial purge interface (see SOP for soil DSITMS analysis in Appendix C of the FDVCO-WP [USACE, 2003c]). Initial calibration of the DSITMS for the analysis of soil samples consisted of analysis of aqueous calibration standards at seven concentrations (ranging from 0 to 250 μ g/L) for each VOC contaminant of concern for the site. After the DSITMS was calibrated and passed the PEC, soil samples were analyzed. It should be noted that the calibration procedure for the analysis of soil slurries and methanol extracts was the same procedure used to calibrate for groundwater analysis (Section 2.4.2.3).

Soil cores collected using direct push methods were immediately sub-sampled as described in Section 2.3.1.3 to collect discrete soil samples. The soil samples were placed into 40-mL VOA vials containing distilled water for low-level VOC contamination analysis and containing methanol for high-level VOC contamination analysis. To analyze a soil slurry sample, a small amount of the aqueous sample from the 40-mL VOA vial was decanted and discarded. Soil methanol extract samples were analyzed by filling a 40-mL VOA vial with distilled water, decanting and discarding a small amount of water from the vial, and injecting 200 microliters (μ L) of the methanol extract into the vial. The sample was then placed on the 40-mL VOA vial purge interface, and the sample was analyzed. Soil data were reported as μ g/kg for both low-level and high-level VOC contamination soil analyses. The method detection limits (MDLs) for VOC contaminants of concern in soil samples using the DSITMS ranged from 13.5 to 35.5 μ g/kg for the low-level VOC contamination analyses and 630 to 1,660 μ g/kg for the high-level VOC contamination analyses.

CCCs, PECs, and blanks were analyzed routinely, and frequently, as part of the method. The analytical procedures are described in detail in the soil DSITMS analysis SOP (see Appendix C of the FDVCO-WP).

2.4.2.3 Analysis of Groundwater

Analysis of groundwater samples by DSITMS was conducted using the 40-mL vial purge interface (see SOP for groundwater DSITMS analysis in Appendix C of the FDVCO-WP [USACE, 2003c]). Initial calibration of the DSITMS for the analysis of groundwater consisted of analysis of calibration standards at seven concentrations (ranging from 0 to 250 μ g/L) for each VOC contaminant of concern for the site. After the DSITMS was calibrated and passed the PEC, groundwater samples were analyzed. Groundwater was analyzed by decanting a small amount of the aqueous sample from the 40-mL VOA vial, placing the vial on the DSITMS, and purging the sample. Groundwater data were reported as μ g/L. The MDLs for VOC contaminants of concern in groundwater samples using the DSITMS ranged from 2.7 to 7.1 μ g/L.

CCCs, PECs, and blanks were analyzed routinely, and frequently, as part of the method. The analytical procedures are described in detail in the groundwater DSITMS analysis SOP (see Appendix C of the FDVCO-WP).

2.4.3 Direct Sampling Ion Trap Mass Spectrometer Data

Data generated by the DSITMS was reduced using the Varian 2000 software provided by the DSITMS manufacturer. The results were reported by the software as ng for sorbent traps or as µg/L for soil and groundwater samples. Reduced data generated by the DSITMS software was entered into a spreadsheet where further reduction was carried out. The mass data (ng) for the sorbent trap analysis was converted to ppbV as described in Section 2.4.2.1. The data reported for the groundwater analysis was entered into the spreadsheet and reported directly, adjusted only for any dilution required. The data reported for the low-level soil analysis was adjusted for dilution based on the mass of soil collected and the amount of water in the extract (see SOP for soil DSITMS analysis was adjusted for dilution based on the mass of soil collected, 2003c]). The data reported for the high-level soil analysis was adjusted for dilution based on the mass of soil collected, 2003c]). The data reported for the high-level soil analysis was adjusted for dilution based on the mass of soil collected, 2003c]). The data reported for the high-level soil analysis was adjusted for dilution based on the mass of soil collected and the amount of the FDVCO-WP [USACE, 2003c]).

VOC results from the DSITMS were recorded in bound logbooks and summarized daily in a spreadsheet. The VOC results spreadsheet containing the data for each day of field work was provided to the FOL at the beginning of the next field day, and was forwarded to Columbia's main office via E-mail for uploading in the data management system for posting on the secure web-page (see Section 2.7). The DSITMS calibration data were recorded and documented in the field notebooks, and these data were reviewed by the FST each field day. QC sample data were reviewed by the DSITMS analyst as the data were collected. Since the DSITMS analysis is very rapid, any QA problems encountered were corrected in near real time as they occurred. Any QA problems encountered were noted in the field DSITMS logbook, brought to the immediate attention of the FOL, and annotated in the daily data summary spreadsheet.

Final data reduction included a summary of all QA data as well as the field sample data. These data were provided by Tri-Corders to Shaw after the conclusion of the field investigation. The data were provided in spreadsheets and included the field sample data and all QA data collected.

2.5 OFF-SITE SAMPLE HANDLING

Samples for off-site laboratory analysis included PDB groundwater samples, temporary monitoring well groundwater samples, soil samples, and associated QC samples (see Section 3.3.1). This section provides details regarding sample labels; chain-of-custody (COC) forms; the field logbook and Daily QC Report; and sample containers, packing, and shipment for samples that were sent to the off-site laboratory.

2.5.1 Sample Labels

Each off-site field and QC sample had a sample label uniquely identifying the sampling point, sampling time, and analysis parameters. As each sample was collected, a sample label was completed with the following information:

- a. Project name;
- b. Project number;
- c. Location/Site Identification entered the temporary or permanent monitoring well number or grid location, and other pertinent information (e.g., depth) concerning where the sample was collected;
- d. Field sample number (see Sections 2.1.2, 2.3.1.3, and 2.3.2.3);
- e. Date of sample collection;
- f. Time of sample collection;
- g. Analysis to be performed;
- h. Preservatives;
- i. The number of containers (i.e., 1 of 2, 2 of 2); and
- j. Initials of collector.

The label information was double-checked by Shaw's senior hydrogeologist to ensure that it was correct. The completed label was affixed to the sample container. The label was covered with clear tape, completely encircling the container.

2.5.2 Chain-of-Custody Forms

A COC form consisting of at least three copies was used to track the custody of the off-site samples from the collection point to the off-site analytical laboratory. The COC form included the following information:

- a. Site name, project name, and project number;
- b. Field sample number (see Sections 2.1.2, 2.3.1.3, and 2.3.2.3);
- c. Date of sample collection (for each individual sample);

- d. Time of sample collection (for each individual sample, in military time);
- e. Indication whether sample is a grab or composite sample (for each individual sample);
- f. Total number of containers per sample (for each requested analysis);
- g. The analyses requested for each sample container, including size and type of container;
- h. The type of preservative, if any, in each container;
- i. Name of analytical laboratory;
- j. Name of carrier service and airbill number used for tracking purposes;
- k. Name and signature of sample team leader;
- I. Name and telephone number of Shaw point of contact; and
- m. Date and time samples were relinquished, signature of person who relinquished samples, and, if possible, signature of person accepting samples (not necessary if relinquished to national carrier service).

Upon completing the COC form, the "shipper" copy was retained and the other copies were placed inside a zip seal plastic bag, inside the sample cooler.

2.5.3 Field Logbook and Daily QC Report

Information pertinent to the FDVCO investigation sampling efforts was recorded in a bound logbook as each activity occurred. All boring/sampling procedures and observations were recorded directly onto an original boring log without transcribing from a field logbook. The field logbook contains any administrative occurrences, conditions, or activities that may have affected the field work or data quality of any environmental samples or field QC samples on any given day or during a given field task.

The front of the logbook lists the project number and facility name; the names of the companies performing activities under the field investigation (e.g., drilling, on-site DSITMS analysis); the service client; the contract under which the investigation is being conducted; and the dates and duration of the field activities. Each page is consecutively numbered, dated, and signed. All entries were made in indelible ink, and all corrections consist of single line-out deletions that were initialed and dated. If only part of a page was used, the remainder of the page has an "X" drawn across it. Entries in the logbook included (as applicable), but were not limited to, the following:

- a. Project number;
- b. Unique field sample number (see Sections 2.1.2, 2.3.1.3, and 2.3.2.3);
- c. Location and description of each sampling point;
- d. Details of the sample site (e.g., the elevation of the casing, casing diameter and depth, integrity of the casing);
- e. Name of the field contact;
- f. Documentation of procedures for preparation of reagents or supplies which became an integral part of the sample (e.g., filters or absorbing reagents);
- g. Identification of sample crew members;
- h. Type of sample (e.g., soil, groundwater);
- i. Number and volume of sample taken;
- j. Requested analyses;
- k. Sampling methodology, including distinction between grab and composite samples;
- I. Sample preservation;

- m. Date and time (military) of sample collection;
- n. Associated QA/QC samples;
- o. Sample shipment (e.g., name of the laboratory and carrier agent: Federal Express, United Parcel Service, etc.);
- p. Field observations (e.g., oily sheen on groundwater sample, incidental odors);
- q. Any field measurements (e.g., pH, specific conductance, depth to water, PID readings); and
- r. Signature and date by the personnel responsible for observations.

In addition to the field logbook, a summary of each day's field activities was documented in a Daily QC Report (see Appendix A). This report summarizes the personnel and visitors on site, the equipment on site, the work performed during the day and work proposed for the next day, significant findings and field decisions, and safety issues. The Sample Collection Log Sheet (see Appendix A), which was used to record all samples collected during the FDVCO investigation, including field QC samples (see Sections 3.2.1 and 3.3.1), was attached to the Daily QC Reports.

2.5.4 Sample Containers, Packing, and Shipment

Preservatives were used, as applicable, to retard hydrolysis of chemical compounds and complexes, to reduce volatility of constituents, and to retard biological action during transit and storage prior to laboratory analysis. Sample holding time is defined as the interval between sample collection to sample extraction and analysis such that a sample may be considered valid and representative of the sample matrix. Sample containers, preservatives, and holding time requirements for samples collected for off-site TCL VOC analysis are as follows:

Soil Samples

Sample Container: Three 25-gram En Core® samplers, filled with zero headspace

Preservation Requirements: Cool to $4 \pm 2^{\circ}$ C

Holding Time: Preparation (i.e., transfer to the soil sample vials): 48 hours

Analysis: 14 days

Groundwater Samples

Sample Container: Three 40-mL glass vials with Teflon® septum, filled with zero headspace

Preservation Requirements: Cool to $4 \pm 2^{\circ}$ C, HCl to pH < 2

Holding Time: Analysis: 14 days (7 days if HCl preservation is not used)

Proper sample packing was essential for the safe delivery of unbroken sample containers to the off-site laboratory that provide reliable environmental data. Prior to shipment of PDB and temporary monitoring well groundwater samples, and associated field QC samples (i.e., duplicates and/or trip blanks), for off-site laboratory analysis, the following procedures were be performed on each sample container:

- a. The cap tightness was checked and it was verified that clear tape covered the label and completely encircled the container;
- b. Each sample container was wrapped in bubble wrap or closed cell foam sheets; and
- c. Each sample container was enclosed in a clear, zip seal, plastic bag.

Prior to shipment of soil samples, and associated field QC samples (i.e., co-located soil samples), for off-site laboratory analysis, the following procedures were performed on each sample container:

- a. The cap tightness of each En Core® sampler was checked;
- b. All three En Core® samplers (making up one sample) were each placed in a small foil envelope which was sealed and affixed with a sample label; and

c. The three sample envelopes were enclosed in a clear, zip seal, plastic bag.

Once the above procedures were completed for each sample container, the following procedures were performed for each sample cooler:

- a. Several layers of bubble wrap were placed on the bottom of the cooler. The cooler was lined with an open garbage bag, all samples were placed upright inside the garbage bag, and the bag was tied. A temperature blank was placed in each cooler to monitor internal temperature.
- b. Loose ice was double-bagged and sealed to prevent melting ice from soaking the packing material. The ice was placed outside the garbage bag containing the samples.
- c. Appropriate sample documentation (i.e., COC forms) was placed in a waterproof plastic bag (zip seal bag), and the bag was taped to the underside of the cooler lid. Each cooler had its own documentation.
- d. Each cooler was sealed with signed and dated custody seals so that if the cooler were opened, the custody seal would be broken. Clear tape was placed over the custody seal to prevent damage to the seal.
- e. Each cooler was taped shut with packing tape over the hinges, and tape was placed over the cooler drain (if the cooler had a drain plug).

Every effort was made to ship samples to the off-site laboratory on the day of collection or as soon after the day of collection as possible. Separate COC forms were prepared for each day of sample collection so that sample holding times could be more readily tracked.

2.6 OFF-SITE LABORATORY ANALYSIS AND DATA REPORTING

Soil and groundwater samples shipped off site for laboratory analysis were analyzed by Accutest Laboratories, Inc. (Accutest) located in Orlando, Florida, for TCL VOCs. Accutest is a Missouri River Division (MRD) validated laboratory. All sample analyses were performed following the method requirements and project-specific data quality indicator (DQI) requirements as noted in Appendix E of the FDVCO-WP (USACE, 2003c). The cited criteria have been adapted from the USEPA SW-846 methodology requirements (USEPA, 1996b) and the USACE Shell for Analytical Chemistry Requirements (USACE, 2001).

Samples were analyzed by Accutest for TCL VOCs using USEPA SW-846 Method 5035 Modified/8260B for solid samples and USEPA SW-846 Method 5030B/8260B for aqueous samples using purge and trap technology (USEPA, 1996b). The preparatory method (USEPA Method 5035) for the soil samples was modified to accommodate the 25 g En Core® samplers used. Five gram (5 g) sample aliquots were transferred to the preparatory vials at the laboratory. Laboratory SOPs for the extraction and analytical methods used for the analysis of off-site soil and groundwater samples may be found in Appendix E of the FDVCO-WP (USACE, 2003c). For solid samples, an inert gas was bubbled through a mixture of reagent water and 5 grams of the soil sample contained in a specifically designed purging chamber at 40°C. For aqueous samples, an inert gas was bubbled through a 25-mL groundwater sample contained in a specifically designed purging chamber at ambient temperature. The resulting vapor was swept through a sorbent column where the purgeable compounds were trapped. After purging was completed for both solid and aqueous samples, the sorbent column was heated and backflushed with the inert gas to desorb the purgeable compounds onto a gas chromatograph programmed to separate the purgeable compounds, which were then detected with a mass spectrometer.

Prior to sample analysis, chemical calibration of each target compound was performed to ensure that the analytical instrumentation was functioning within the established sensitivity range. Laboratory calibration steps include the performance of solution validation, initial calibration, daily calibration, and continuing calibration procedures. Protocols defining the QC procedures, rounding rules, corrective actions, and QC measurements for instrument calibration were in accordance with criteria specified in the analytical method, laboratory QA plan, and laboratory SOPs. The MDLs and the reporting limits (RLs) for the analytical methods used are found in Appendix E of the FDVCO-WP (USACE, 2003c).
As part of the FDVCO investigation, Accutest provided the analytical results for both laboratory and field QC samples, method blank results, matrix spike/matrix spike duplicate (MS/MSD) results, laboratory control sample (LCS) results, and initial and continuing calibration results. The laboratory also provided full Contract Laboratory Program (CLP)-equivalent data packages including all the QC results and raw data necessary for data validation in accordance with the USEPA Region 3 Modifications to the National Functional Guidelines (NFGs) (USEPA, 1994).

Laboratory QC data were reported separately from the environmental data, but were grouped by analysis method. Data necessary for calculation of percent recoveries were presented along with the analytical results. The section containing QC data also included upper and lower control limits for percent recovery. The following information was required for complete evaluation of the analytical data:

- Laboratory sample identification number;
- Shaw field sample number;
- Sample media and depth;
- Sample collection and laboratory receipt dates;
- Sample Delivery Group (SDG) identification numbers;
- Extraction and analytical method numbers used;
- Sample extraction and analysis dates;
- Volume or mass of sample purged or extracted;
- Percent moisture for each solid sample;
- Upper and lower control limits of percent recovery and relative percent difference (RPD) calculations for all applicable QC check analyses; and
- Parameter analyzed, analytical result, units, and detection level for each compound analyzed.

2.7 DATA MANAGEMENT AND COMMUNICATIONS

A critical component of the USEPA Triad approach used in conducting this FDVCO investigation was the management of the data collected in the field and the communication of that data to the FST and the WG. Management of the data was not restricted to only data generated during the field program, but historical data as well. Historical data were necessary for comparison of the real-time data that was generated during this FDVCO investigation.

2.7.1 Data Management

The management of the data generated during the FDVCO investigation, as well as the historical data, was handled by a software processing package called SmartData Solutions[™] which allowed: 1) the input of field data on a daily basis; and 2) the WG to review the data as three-dimensional images which were posted on a secure project web-page. Columbia uploaded data into and maintained the data management system following the procedures provided in the associated SOP (see Appendix F of the FDVCO-WP [USACE, 2003c]).

2.7.1.1 Historical and Background Data

Prior to the initiation of the FDVCO investigation, the following historical and background data were placed into the software:

- a. Groundwater elevation data from relevant past synoptic water level measurements;
- b. Groundwater quality data from previous sampling events of the permanent saturated overburden and bedrock aquifer monitoring wells;
- c. Groundwater quality data from the previous temporary monitoring well sampling event;
- d. Soil analytical data from the previous subsurface soil sampling event;

- e. Figures from the AREE 34 RI and SRI that graphically present sample locations, hydrogeologic data, and water quality results;
- f. The horizontal surveyed (or grid-based) locations (based on latitude and longitude) of the permanent groundwater monitoring wells, the previous temporary monitoring wells, and the previous soil borings; and
- g. The surveyed elevations (ft amsl) of the permanent groundwater monitoring wells and the previous temporary monitoring wells (to the extent available).

Before the initiation of the FDVCO investigation field activities, the historical and background data were posted to the secure project web-page. This allowed the FST and the WG to confirm that they were able to access the data on the web-page.

2.7.1.2 FDVCO Investigation Data

The following information generated during the FDVCO investigation was placed into the software as the field activities were conducted and the data became available:

- a. PDB groundwater sample on-site DSITMS analytical results;
- b. PDB groundwater sample off-site laboratory analytical results;
- c. MIP logs;
- d. Sorbent trap/on-site DSITMS analytical results;
- e. Collaborative soil sample on-site DSITMS analytical results;
- f. Collaborative soil sample off-site laboratory analytical results;
- g. Collaborative temporary monitoring well groundwater sample on-site DSITMS analytical results; and
- h. Collaborative temporary monitoring well groundwater sample off-site laboratory analytical results.

2.7.1.3 Data Input and Availability

As discussed in Section 2.7.1.1, the historical and background data were placed into the data management software prior to the initiation of the FDVCO investigation field activities. The data generated during the FDVCO investigation was E-mailed once a day (at the end of the day) to Columbia's main office where the data were normalized, processed, and posted on the secure project web-page. As mentioned above, the web-page was available for access prior to the start of the FDVCO investigation field activities. All members of the FST, and any appropriate other interested parties, were given the web-page address and a password that granted them access. In addition to the data generated by the FDVCO investigation field activities, the FDVCO-WP, Daily QC Reports, a map showing sample/probe locations, and three dimensional images of the FDVCO investigation results were posted on the web-page.

2.7.2 Data Communications

The primary focus of communication between the FST and the WG was the secure project webpage. Direct communication with the FST by members of the WG was channeled through the FOL. A conference call with the key members of the FST and the WG was held at 17:00 (Eastern Standard Time [EST]) on the second day of field activities. The conference call allowed the FST to update the WG on the progress of the FDVCO investigation and to review the on-site DSITMS PDB groundwater sample results as well as the initial MIP results and on-site DSITMS sorbent trap analytical results, and the on-site DSITMS temporary monitoring well groundwater analytical results. A second conference call was held at 12:00 EST on the fourth day of field activities to review the ongoing progress of the FDVCO investigation. During this second conference call, the FST presented the MIP findings from a location requested by VDEQ (i.e., H14). The MIP/ECD response from H14-MIP was higher than the MIP/ECD response at MW34-4. The WG decided to collect collaborative soil samples at this location for analysis by the on-site DSITMS, and discussed the rationale for additional MIP locations to determine the extent of the higher VOC contamination. During a follow-on conference call held on the afternoon of the fourth day upon receipt of the on-site DSITMS analytical results for the soil samples collected at H14, the WG discussed the rationale for selection of collaborative soil samples for off-site laboratory analysis.

2.8 DECONTAMINATION

In this section, construction of the decontamination (decon) pad and the decontamination water source are discussed as well as the decontamination procedures.

2.8.1 Decontamination Pad Construction

Columbia construct a temporary, portable decon pad prior to the start of the high density sampling field work. The decon pad was lined with two layers of polyethylene sheeting, and sloped to allow for the containment of decon water. The sides were constructed of two layers of polyethylene sheeting supported by timber walls. A centrifugal pump was used to pump the accumulated decon water from the pad into 55-gallon drums located adjacent to the decon pad.

The decon pad was used to contain the water from decontamination of the Geoprobe® drill rig, downhole equipment, and all sampling equipment. The Geoprobe® drill rig was backed into the decon pad and cleaned using the procedures outlined in Section 2.8.2. Downhole drilling equipment and Macrocore samplers were placed on metal sawhorses inside the decon pad for decontamination.

2.8.2 Decontamination of Geoprobe **Ò** Drill Rig and Downhole Equipment

Prior to beginning drilling operations, and at the end of the field work, the Geoprobe® drill rig and downhole equipment were steam-cleaned with USACE-approved water (unchlorinated water from Production Well No. 3). This activity was performed in the leak-proof decontamination pad that was constructed prior to commencement of the field work. The decontamination process is briefly outlined below.

- a. Steam cleaned using USACE-approved water; and
- b. Air dried.

2.8.3 Decontamination of Geoprobe **Ò** Macrocore Samplers

Between drilling locations, the Geoprobe® Macrocore samplers were decontaminated. This activity was performed in the leak-proof decontamination pad that was constructed prior to commencement of the field work. The decontamination process is briefly outlined below.

- a. Washed and scrubbed with non-phosphate detergent;
- b. Rinsed with USACE-approved water;
- c. Rinsed with deionized, organic-free water; and
- d. Placed on a metal rack (secured to the MIP vehicle) to prevent contamination during storage/transit.

2.8.4 Decontamination of Temporary Monitoring Well Casing and Screen

As discussed in Section 9.4 of the FDVCO-WP (USACE, 2003c), if the temporary monitoring well casing and screen materials were delivered to the site in sealed wrappers, an equipment rinse blank was to have been collected for analysis of VOCs using the on-site DSITMS to determine the need for decontamination prior to use. The temporary monitoring well casing and screen materials were delivered to the site in sealed wrappers. However, an equipment rinse blank was not collected as a result of the FST's haste to install the first temporary monitoring well. Having installed the first temporary monitoring well without prior decontamination of the well screen and casing, the FST continued this practice and never collected an equipment rinse blank to confirm that the well screen and casing materials were clean. Subsequent contact with the well screen and casing manufacturer following demobilization from the field indicated that these well construction materials were given an isopropyl alcohol rinse prior to placement and sealing in the plastic wrappers (see documentation from the well screen and casing manufacturer in

Appendix E). As a result, all of the temporary monitoring well groundwater samples were contaminated with acetone, a by-product of isopropyl alcohol. Further dscussion of the impact of this contamination of the off-site laboratory analytical results is presented in Section 3.3.5.

2.8.5 Decontamination of Sampling Equipment

The majority of the sampling equipment used during the FDVCO investigation was dedicated and disposal (e.g., PDB samplers, bailers, En Core® samplers). The syringes used to collect soil samples for on-site DSITMS analysis are reusable; however, there were a sufficient number of syringes available in the field such that reuse of syringes, and thus decontamination, was not required. The procedures for decontamination of the water level indicator, the only non-dedicated, non-disposable sampling equipment used during the FDVCO investigation, are briefly outlined below.

- a. Washed with non-phosphate detergent;
- b. Rinsed with USACE-approved water;
- c. Rinsed with deionized, organic-free water;
- d. Wrapped in plastic sheeting to prevent contamination during storage/transit.

2.9 DISPOSAL OF INVESTIGATION-DERIVED WASTE

This section describes the management of the IDW generated during the FDVCO investigation field activities.

2.9.1 Decontamination and Purge Water

Decon and purge water were disposed at the conclusion of the field activities. During the field activities, water was periodically pumped out of the decon pad into 55-gallon drums located adjacent to the decon pad. Any purge water (e.g., residual water from sampling groundwater from the PDB samplers and temporary monitoring wells) generated from the FDVCO investigation field activities was poured into one of the 55-gallon drums used to containerize the decon water. The accumulated decon and purge water was treated through a drum of granular activated carbon (GAC) to remove the VOC contaminants. Once treated, the water was discharged to the sanitary sewer system.

2.9.2 Personal Protective Equipment/Disposable Equipment/Other Solid Waste

All used PPE, acetate liners, disposable bailers, temporary monitoring well materials, used sample bottles, and plastic sheeting used in construction of the decon pad were containerized in a 55-gallon drum with the soil cuttings (see Section 2.9.3).

2.9.3 Soil Cuttings Derived from Drilling Activities

All soil cuttings generated as a result of drilling activities associated with the FDVCO investigation were drummed, labeled, and transported to the former AAFES Service Station to await off-site disposal based on waste characterization data to be collected as part of a subsequent field investigation at AREE 34. A single drum of soil cuttings and other solid waste was generated during the FDVCO investigation.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

This section presents the QA/QC protocols and procedures, as well as a review and discussion of the QA/QC data results, for the MIP; on-site DSITMS analysis of sorbent trap, soil, and groundwater samples; and off-site laboratory analysis of selected soil and groundwater samples.

3.1 MEMBRANE INTERFACE PROBE QUALITY ASSURANCE/QUALITY CONTROL

MIP data were collected by Columbia in accordance with the SOP published by the Geoprobe® manufacturer (see Appendix A in the FDVCO-WP [USACE, 2003c]). Specific QA/QC procedures were followed to ensure that the system was stable and reproducible.

3.1.1 Quality Assurance/Quality Control Procedures and Acceptance Criteria

Instrument stability and reproducibility checks were routinely monitored with performance tests (PTs) and by documenting the change over time. The PTs involved ex situ testing at the surface, using a freshly prepared solution which contained a 200 μ g/L mixture of TCE, PCE, and CCl₄ in water. The PT procedure involved the following:

- 1. Prepared standard with compound(s) of interest;
- 2. Immersed probe into clean water to stabilize the baseline;
- 3. Checked for stability of detector versus time data on MIP software;
- 4. Inserted probe into test solution of known concentration for 60 seconds;
- 5. Returned probe to clean water;
- 6. Recorded detector responses in field notes; and
- 7. Compared results to previous measurements.

The first PT was completed on November 17, 2003, using a brand new probe. On November 18, 2003, the FST decided that PTs would be run during the lunch break and at the end of the day in order to avoid carryover in the sorbent traps being collected at the same time as the MIP data were being collected. Only one PT was conducted on November 19, 2003, due to very hard rain that stopped work early in the day, and on November 21, 2003, the last day of MIP data collection when the MIP was discontinued and conventional sampling was performed during the afternoon.

The acceptance criteria for the PTs was $\pm 50\%$. If response changes exceeded $\pm 50\%$, then corrective action was required. Records were also kept of flow rates, probes used, membrane changes, all operating changes, and other conditions that may affect the results. The MIP PT detector responses are presented in Table 3-1. The MIP/ECD response for the first PT was much greater than the MIP/ECD response for the remaining PTs. A new probe was used for this project. Based on past experience, it was expected that the unseasoned membrane would have a higher response during a PT. The remaining PTs were all within the control limits ($\pm 50\%$) around an average value (after seasoning) of approximately 100,000 μ V on the ECD.

The PID detector had little or no response to the PTs. This was because of the relatively low concentrations of the compounds of interest (i.e., TCE, PCE, and CCl₄) used for the PTs, and the fact that the PID is used primary for detection of aromatic compounds. Commonly, concentrations of 1 to 10 ppm, rather than 0.2 ppm (200 μ g/L) standards are used for MIP PTs. The low concentration of target analytes for the PTs was chosen to reduce possible carryover from the PTs into the field samples.

In addition to conducting PTs, equipment or significant flow rate changes are sometimes needed to ensure that the data produced are of known quality. No equipment or significant flow rate changes were required during the FDVCO investigation.

MIP data were evaluated on a continuous and real-time basis for internal consistency of all of the data sets being collected. The MIP results for the two (PID and ECD) chemical data sets were compared and contrasted to determine if either detector was responding in an abnormal manner. The chemical data

sets were also compared to the EC, penetration rate, and temperature data sets. No anomalies were detected to indicate there was a problem in the data collection system.

MIP data were also evaluated on a continuous and real-time basis for compatibility against the current CSM. The MIP data were compared against existing hydrogeologic information as well as analytical data. No discrepancies were observed.

3.1.2 Corrective Action

If the PT responses revealed a change of greater than 50% from the initial reading, then the data set would be reviewed and the system evaluated. The system would be evaluated for leaks, blockages, detector malfunctioning, and data system and wiring problems. After these were checked, another PT would be conducted. If the PT records still revealed a change of greater than 50% from the initial reading, corrective action would be taken.

Because a new MIP probe and membrane were used from the beginning of the FDVCO investigation, the MIP/ECD response for the initial PT was greater than the MIP/ECD response for the remaining PTs. Based on experience, unseasoned MIP membranes tend to have higher responses than seasoned MIP membranes. Therefore, the response value used for evaluating the MIP/ECD PT variability was the average value of the PTs, after seasoning, (i.e., approximately 100,000 μ V) rather than the initial value. All PT MIP/ECD esponses presented in Table 3-1 were within acceptable limits; therefore, no corrective actions were required.

3.1.3 Operating Protocol Changes and Enhancements

During the usual operation of the MIP, the operator may from time to time adjust flow rates, hold times, or other operating variables to enhance the data that is collected. The operator would document any of these changes as they occurred. However, as stated above, no equipment or significant flow rates changes were made to the operation of the MIP during the FDVCO investigation.

In addition to the standard MIP QA/QC procedures, a trunk line blank sorbent trap was collected to evaluate analyte contribution to the sorbent traps from the MIP trunk line. Although the MIP unit had a stable baseline, a background concentration of target or non-target analytes was possible. As long as this concentration did not change significantly during the course of MIP data collection, the MIP data were not adversely impacted. However, for the analysis of sorbent traps by the on-site DSITMS, these compounds could have provided interfering mass/charge ions. The trunk line blank sorbent trap was collected to quantify the contribution from the MIP trunk line into the sorbent traps. The blank was collected for 30 minutes (the approximate time of field sample collection) with the MIP probe in ambient air.

An initial trunk line sorbent trap was analyzed by the on-site DSITMS on November 17, 2003, and indicated low-level hydrocarbon background in the MIP trunk line. When the decision was made to change to collection of a full-length sorbent trap for each MIP advancement, the level of hydrocarbon in the trunk line blank sorbent traps increased. As discussed in Section 2.4.2.1, the Tenax® tubes used for the collection of sorbent trap samples were reused. Each Tenax® tube was run as a sorbent trap blank on the on-site DSITMS before it was used for a MIP run. The results of these sorbent trap blanks were also used to establish the presence of hydrocarbons in the MIP trunk line. If the on-site DSITMS had been used to quantify the level of VOCs in the MIP sorbent traps, the background hydrocarbon spectra would have been quantified and subtracted. However, since the sorbent traps were used for speciation of VOC contaminants of concern only, the presence of hydrocarbon background in the MIP truck line MIP truck line had no impact on the FDVCO sorbent trap results.

3.2 QUALITY ASSURANCE/QUALITY CONTROL FOR ON-SITE DSITMS ANALYSIS

The on-site DSITMS was used to perform VOC analyses by USEPA Method 8265 following Tri-Corders' DSITMS SOPs and QAP (see Appendix C of the FDVCO-WP [USACE, 2003c]). The FDVCO-WP and Tri-Corders' QAP specified the necessary guidelines to ensure that the measurement system was in control, and provided detailed information on the analytical approach to ensure that data of known and adequate quality were obtained to achieve project objectives.

This section discusses QA/QC for the on-site DSITMS analysis of soil and groundwater samples. Although similar QA/QC was performed for the on-site DSITMS analysis of sorbent trap samples as discussed in Section 2.4.2.1, a detailed QA/QC discussion is not presented in this FDVCO-SR because quantitative results were not provided for the sorbent trap samples (refer to Section 4.3.2 for further discussion). Rather, the on-site DSITMS analyses were used only qualitatively to speciate the VOCs present in the sorbent trap samples.

3.2.1 Field Quality Control Samples for On-site DSITMS Analysis

Soil. Since soil samples for VOC analysis are not homogenized, "duplicate" soil samples could not be collected to assess sampling precision. However, co-located soil samples were to be collected to provide an indication of the variability associated with matrix heterogeneity. Co-located soil samples were to be collected from the same core as, and as close to the location of, the primary sample as possible. Co-located soil samples were to be collected at a frequency of 10% (i.e., one co-located soil sample for every 10 primary samples) for collaborative soil samples collected for on-site DSITMS analysis. Due to the nature of the dynamic FDVCO investigation (i.e., most of the soil samples were collected within the last two hours of the last day of field work), no co-located soil samples were collected for analysis. For the same reason, no soil laboratory analytical duplicates were analyzed.

The collaborative soil samples for on-site DSITMS analysis were collected utilizing reusable syringes. The syringes were to be decontaminated between samples. To assess the potential for cross-contamination between samples as a result of sampling equipment decontamination procedures, one equipment rinse blank (designated Emmddyy) was collected for each day that collaborative soil samples were collected for on-site DSITMS analysis. Equipment rinse blanks were prepared by pouring deionized, organic-free water over the decontaminated syringe and into two unpreserved 40-mL VOA vials. Equipment rinse blanks were analyzed for VOCs using the on-site DSITMS. It should be noted that although equipment blanks were collected and analyzed for the syringes, there were a sufficient number of syringes available in the field such that reuse of syringes was not required.

Groundwater. Field duplicate PDB and temporary monitoring well groundwater samples were collected to provide an indication of the variability associated with matrix heterogeneity and to assess sampling precision. Field duplicate PDB and temporary monitoring well groundwater samples were collected at a frequency of 10% (i.e., one field duplicate for every 10 primary samples) for analysis of VOCs using the on-site DSITMS. Field duplicate PDB and temporary monitoring well groundwater samples have the same field sample number as the primary sample with a "D" added to the end [e.g., MW34-4-PDB-2D, C23-TW-(7-17)D].

Equipment blanks were not collected since the PDB groundwater samples were collected directly from the disposable PDB samplers and the temporary monitoring well groundwater samples were collected using dedicated disposable bailers. Since the PDB samplers and bailers were dedicated and disposable, no decontamination was required. Therefore, cross-contamination between samples as a result of sampling equipment decontamination procedures was not an issue.

Daily field blanks (designated as Fmmddyy) were prepared by pouring deionized, organic-free water into two unpreserved 40-mL VOA vials. Field blanks were analyzed for VOCs using the on-site DSITMS to identify contamination from exposure to atmospheric contaminants. No field blank was prepared for the first day of field activities (November 17, 2003) due to an oversight by the FST who were busy with multiple field start-up activities and the collection of 32 PDB groundwater samples.

3.2.2 Sensitivity

The term sensitivity is used broadly to describe the method detection, quantitation, and reporting limits established to meet project-specific data quality objectives (DQOs); and is not limited to the definition which describes the capability of a method or instrument to discriminate between measurement responses. Each target compound for every sample was reported at a specific MDL. The target compounds detected below the MDL, were reported as estimated "J" values. In addition, as required by the USACE <u>Shell for</u>

<u>Analytical Chemistry Requirements</u> (USACE, 2001), detected values less than or equal to three times the MDL were qualified as estimated "J" during the data review.

The MDL is the minimum concentration of an analyte that can be measured and reported with a 99% confidence that the analyte is above zero and is identified from the analysis of a sample in a given matrix containing the analyte. The MDL values change periodically because each MDL is laboratory, instrument, analyst, matrix, and method specific. MDLs were statistically-derived by the methods described in USEPA SW-846 using CCC standard results. The units for aqueous samples were μ g/L, and the units for solid samples were μ g/kg. The MDLs ranged between 2.7 μ g/L (630 μ g/kg) for CCl₄ and 7.1 μ g/L (1,660 μ g/kg) for CHCl₃ + TCA. The MDL objectives (e.g., MDLs less than MCLs for groundwater samples) were met.

3.2.3 Data Quality Indicators

Precision and accuracy are two important DQIs used to assess the quality of data generated during the FDVCO investigation. Precision is defined as the degree of mutual agreement of independent measurements generated through repeated application of the process under specified conditions. Accuracy is the degree of agreement of a measured value with the true or expected value. Multiple groundwater and soil samples were collected during the FDVCO investigation for on-site DSITMS analysis. The Shaw Project Chemist performed a data review on all the on-site DSITMS data. CCC standards, analytical and field sampling duplicate samples, PEC standards, matrix spikes (MSs), and blank samples (i.e., method, field, and equipment) were used to assess precision and accuracy as discussed below. The criteria used for Shaw's data review are also described in the precision and accuracy sections, which follow. Appropriate data qualifiers were added to the results and may be found in Table 4-1 (PDB groundwater analytical results), Table 4-4 (soil analytical results), and Table 4-6 (temporary monitoring well groundwater analytical results) (see Section 4).

3.2.3.1 Precision

Analytical precision was measured for the on-site DSITMS using CCC standards and analytical duplicates. Field sampling duplicates were used to measure sampling precision. The duplicate samples were evaluated for precision by expressing the difference between the sample and sample duplicate results as a RPD. The RPD is calculated by the following equation:

RPD (%) =
$$\frac{/(XA - XB)/}{XM} * 100$$

where:

XA and XB are duplicate analyses, and

XM is the mean value [(XA + XB)/2] of the duplicate analyses.

The laboratory analytical duplicate and field sampling duplicate discussions below address groundwater only. As discussed in Section 3.2.1, soil field sampling duplicates (a.k.a., co-located soil samples) were not collected during the FDVCO investigation, and soil laboratory analytical duplicates were not analyzed by the on-site DSITMS analyst.

Continuing Calibration Check (CCC) Standards. One CCC standard was analyzed, at a minimum, for every 20 samples. The QA criteria for the agreement of the CCC standards measured by the on-site DSITMS with the true values was established at \pm 25% in Tri-Corders' QAP. A 20 ppb standard was used for the CCCs. The CCC QA criterion for a 20 ppb (a.k.a., 20 µg/L) standard is represented as a range from 15 to 25 µg/L. The CCC standard results are presented in Table 3-2. All CCC standards were within the QA criteria range with the exception of:

- CHCl₃ + TCA in CCC standards 20 ppb VH01 03 and 20 ppb VH01 04 analyzed on November 20, 2003; and
- PCE in CCC standard 20 ppb VH01 03 analyzed on November 20, 2003 (see Table 3-2).

As a result, all detected values of PCE in samples (both groundwater and soil) analyzed on November 20, 2003, were qualified estimated "J". The detected PCE values for NP-PZ2-PDB-5D, C20-TW- (7-17), H14(2)-SB-8.5, H14(2)-SB-9.5, H14(2)-SB-10.7, and H14(2)-SB-11.7 were qualified estimated "J". There were no detections of CHCl₃ + TCA in the groundwater and soil samples analyzed on November 20, 2003; therefore, no qualification was required for CHCl₃ + TCA.

The data for CCC standard 20 ppb VH01 06 analyzed on November 18, 2003, were not obtained because the DSITMS mass axis shifted by one mass unit during the analysis. The problem was corrected by re-calibration of the mass axis immediately after the run was completed. This problem had no impact on the collection of field sample data.

Groundwater Analytical Duplicates. One groundwater analytical duplicate was analyzed, at a minimum, for every 20 samples analyzed by the on-site DSITMS. The QA criterion for the agreement of the analytical duplicate sample pairs was established at RPD \leq 30% in Tri-Corders' QAP. The RPD was calculated only for those analytes which were detected at levels exceeding the MDLs in both samples of the duplicate pair. Analytical results were qualified as estimated "J" for any RPDs exceeding criteria.

Four groundwater analytical duplicate pairs were analyzed during the FDVCO investigation:

- MW34-2-PDB-5/MW34-2-PDB-5 AD;
- MW34-5D-PDB-2/MW34-5D-PDB-2 AD;
- NP-PZ2-PDB-5D/NP-PZ2-PDB-5D AD; and
- K10-TW-(2-12)/K10-TW-(2-12) AD.

The compound concentrations found in each analytical duplicate pair with associated RPD values are presented in Table 3-3. All detected compounds found in both samples of the analytical duplicate pairs were within precision criteria limits (RPD = 30%) with the exception of:

- CHCl₃ + TCA in analytical duplicate pair MW34-2-PDB-5/MW34-2-PDB-5 AD; and
- TCE in analytical duplicate pair MW34-5D-PDB-2/MW34-5D-PDB-2 AD.

CHCl₃ + TCA in MW34-2-PDB-5 and TCE in MW34-5D-PDB-2 were qualified as estimated "J".

Groundwater Field Sampling Duplicates. One groundwater field sampling duplicate was collected and analyzed for every 10 samples analyzed by the on-site DSITMS. The QA criterion for the agreement of the field sampling duplicates was established at RPD \leq 30% in Tri-Corders' QAP. The RPD was calculated only for those analytes which were detected at levels exceeding the MDLs in both samples of the duplicate pair. Analytical results were qualified as estimated "J" for any RPDs exceeding criteria.

Five groundwater field sampling duplicate pairs were analyzed during the FDVCO investigation:

- MW34-4-PDB-2/MW34-4-PDB-2D;
- MW34-5D-PDB-1/MW34-5D-PDB-1D;
- MW34-7D-PDB-3/MW34-7D-PDB-3D;
- C23-TW-(7-17)/C23-TW-(7-17)D; and
- NP-PZ2-PDB-5/NP-PZ2-PDB-5D.

The compound concentrations found in each field sampling duplicate pair with associated RPD values are presented in Table 3-4. All detected compounds found in the environmental sample and its field sampling duplicate were within precision criteria limits (RPD = 30%) with the exception of:

- TCE, DCE, and PCE in field sampling duplicate pair MW34-7D-PDB-3/MW34-7D-PDB-3D;
- PCE in field sampling duplicate pair C23-TW-(7-17)/C23-TW-(7-17)D; and
- DCE in field sampling duplicate pair NP-PZ2-PDB-5/NP-PZ2-PDB-5D.

TCE, DCE, and PCE in field sampling duplicate pair MW34-7D-PDB-3/MW34-7D-PDB-3D; PCE in field sampling duplicate pair C23-TW-(7-17)/C23-TW-(7-17)D; and DCE in field sampling duplicate pair NP-PZ2-PDB-5/NP-PZ2-PDB-5D should be considered estimated "J".

3.2.3.2 Accuracy

Accuracy is the measure of bias in a system. On-site DSITMS analytical accuracy was assessed through the use of PEC standards, MSs, method blanks, and field/equipment blanks. Laboratory analytical accuracy was evaluated using the PEC standards and method blanks, and field sampling accuracy was evaluated using MSs and field/equipment blanks. Data qualification was applied as appropriate. The accuracy of the results was measured by percent recovery (%R). For non-spiked samples, accuracy was measured by the following equation:

% R = <u>test value</u> * 100	
true value	

For spiked samples, accuracy was measured by the following equation:

% R = <u>test value- spike added</u> * 100 true value

Performance Evaluation Check (PEC) Standards. One PEC standard was analyzed, at a minimum, for every 20 samples to evaluate the accuracy of the on-site DSITMS VOC analytical results. The PEC standard was a known quantity of TCE (20 μ g/L [a.k.a., 20 ppb]) purchased from a reputable supplier that was spiked into distilled water. The QA criteria for the agreement of the PEC standard measured by the DSITMS with the true value was established at %R \pm 30% in Tri-Corders' QAP. The PEC QA criterion for a 20 μ g/L standard is represented as a range from 14 to 26 μ g/L. The PEC standard results are presented in Table 3-5. All PEC standard recoveries were within the QA criteria range (%R \pm 30%). No qualification was required.

Matrix Spikes (MSs). Another factor that can affect data accuracy is extraction efficiency. The degree to which the sample matrix affects recovery is evaluated by spiking the sample matrix with known quantities of contaminants of concern and analyzing the sample. These spike samples are referred to as MSs. MSs are prepared by spiking field samples, previously analyzed and determined not to contain contaminants of concern, with the CCC standard (which contains known concentrations of the target compounds). MSs were prepared and analyzed at a minimum frequency of one for every 20 samples. The QA criteria for the agreement of the MSs measured by the on-site DSITMS with the true values was established at %R \pm 30% in Tri-Corders' QAP. The MS results for groundwater and soil are presented in Table 3-6.

Groundwater MSs were performed on samples NP-PZ2-PDB-1 (spiked with 20 ppb and 200 ppb CCC standards), A18-TW-(1-11) (spiked with 20 ppb CCC standard), and C18-TW-(5-15) (spiked with 20 ppb CCC standard). A soil MS was performed on sample J16(2)-SB-2 (spiked with 20 ppb CCC standard). The analytical results for these MSs are presented in Table 3-6 along with the associated QA criteria concentration ranges. All recoveries were within accuracy criteria limits ($%R \pm 30\%$) with the exception of CHCl₃ + TCA and DCE for NP-PZ2-PDB-1. CHCl₃ + TCA and DCE should be considered estimated bias low "L" for the spiked sample (i.e., NP-PZ2-PDB-1) based upon the low recoveries.

Tri-Corders' QAP specified that the corrective action for exceeding the MS recovery criteria was to immediately run a CCC standard to determine if the analytical system was still within CCC QA criteria. The

results of the CCC standard run after analysis of sample NP-PZ2-PDB-1 ms 20 (i.e., 20 ppb VH01 05 on November 18, 2003) were within QA criteria (see Table 3-2). However, the DCE results were on the low side of the range. Therefore, a new vial of the VH01 working standard solution was opened and used. This corrected the problem.

Method Blanks. One method blank was analyzed, at a minimum, for every 20 samples analyzed by the on-site DSITMS, for both groundwater and soil samples. The method blank is a volume of analyte-free water or soil that is processed through the entire analytical scheme (i.e., extraction, digestion, concentration, and analysis). Method blanks monitor potential laboratory-induced contamination. Results are qualified "B" for blank contamination by the laboratory and/or through the data review process. In accordance with USEPA Region 3 data validation guidelines, reported sample results were considered "non-detect" and qualified with the letter "B" if the detected sample concentration was within 5 times the concentration in the associated method blank. The method blank contamination assessment was evaluated during the data review process. All method blank results were non-detect, indicating a lack of bias and no carryover after high level samples were analyzed. No qualification was required.

Field/Equipment Blanks. During the FDVCO investigation, one field blank was collected on each day of field work (except for the first day which was missed due to an oversight by the FST) for on-site DSITMS analysis. The field blanks were prepared by pouring the required volume of deionized, organic-free water into appropriate sample containers in the field. The field blank results were used to assess the potential incidental contamination due to sample transport before, during, and after field operations (i.e., exposure to air) and/or contamination due to the sample container. In accordance with USEPA Region 3 data validation guidelines, the detected concentration in the sample was considered a "non-detect" (i.e., qualified "B" for blank contamination) and was excluded from consideration if the sample concentration was within five times the concentration in the associated field blank. All field blank results were non-detect; therefore, no qualification was required.

During the FDVCO investigation, one equipment blank was collected on each day that soil samples were collected for analysis by the on-site DSITMS. This protocol was followed even though the syringes used to collect the soil samples for on-site DSITMS analysis were not reused. Equipment blanks were prepared by pouring deionized, organic-free water over the decontaminated syringe and into two unpreserved 40-mL VOA vials. Equipment blanks are intended to identify cross-contamination between samples as a result of sampling equipment decontamination procedures. In accordance with USEPA Region 3 data validation guidelines, the detected concentration in the sample was considered a "non-detect" (i.e., qualified "B" for blank contamination) and was excluded from consideration if the sample concentration was within five times the concentration in the associated equipment blank. All equipment blank results were non-detect; therefore, no qualification was required.

3.2.4 Representativeness

Representativeness is a measure of the degree to which the measured results accurately reflect the medium being sampled for the FDVCO investigation. While several precautions were taken to generate data of known quality by documenting control of the measurement system, the data must also be representative of true site conditions. Representativeness is a qualitative parameter that is addressed through the proper design of the sampling program in terms of sample location, number of samples, and actual material collected as a "sample" of the whole. Sampling protocols have been developed to assure that samples collected are representative of the media. Field handling protocols (e.g., storage and handling in the field) have also been designed to protect the representativeness of the collected samples. Proper field documentation and QC inspections were used to establish that protocols were followed and that sample identification and integrity was maintained. Documentation reviewed to infer sample representativeness included analytical records (holding times), blank contamination assessment (secondary inference), and associated project records. Inferences from accuracy, precision, and completeness suggest that the designed sampling program resulted in the collection of representative samples.

The representativeness of the on-site DSITMS analytical data was addressed using high density sampling and analysis with the MIP/ECD to establish a CSM describing the VOC contaminant distribution in

the overburden at the site. The CSM developed using the MIP data set was collaborated by the on-site DSITMS analysis of discrete soil and groundwater samples using USEPA Method 8265 (see further discussion in Section 4).

Sampling representativeness was also evaluated by the analysis of field sampling duplicates, which provide insight into the homogeneity, or heterogeneity, of the matrix. Field sampling duplicates have inherent in the result combined field and analytical variability. Field sampling duplicates evaluate whether the data collected represent the conditions at a particular sampling location. If RPDs for field sampling duplicates are within QA criteria, it is inferred that the sample collection process was similar and, therefore, likely representative, and that the matrix was homogeneous. The data for groundwater field sampling duplicates presented in Table 3-4 indicate that the majority of the RPDs are less than 30% (i.e., the QA criteria). These data support the conclusion that groundwater sampling was representative of site conditions within the monitoring wells (permanent and temporary).

3.2.5 Completeness

Completeness is a measure of the amount of information that must be collected during the field investigation to allow for successful achievement of the objectives. An adequate amount and type of data must be collected for conclusions **b** be valid. Missing data may reduce the precision of estimates or introduce bias, thus lowering the confidence level of the conclusions. The completeness goal of useable data for the FDVCO investigation was set at 90% for both the sampling and analytical completeness.

Completeness was inferred from records review. Sampling completeness was assessed through evaluation of the total number of samples proposed for collection versus the actual number of samples collected and analyzed. Analytical completeness was assessed by comparing the number of useable data points collected to the total number of data points generated. For the purposes of this report, unusable data are defined to include rejected data points ("R" qualifier) or those data points which have been considered as "non-detects" due to blank contamination ("B" qualifier). Completeness is calculated using the following equations:

% Sampling Completeness = <u>Number of A</u>	ctual Samples Collected	
Numbe	r of Proposed Samples	

% Analytical Completeness = <u>Number of Useable Data</u> Number of Requested Analyses

For the FDVCO investigation, collection of 32 groundwater samples from the PDB samplers installed in six permanent monitoring wells at AREE 34 was planned. All of these PDB groundwater samples were collected and analyzed by the on-site DSITMS, resulting in a sampling completeness quotient of 100%. In addition, the FDVCO-WP allowed for the collection of collaborative soil and groundwater samples (from temporary monitoring wells). However, the FDVCO-WP did not establish a set number of samples to be collected. Therefore, sampling completeness was not evaluated for collaborative soil and groundwater samples.

The overall analytical percent completeness was also determined for the soil and groundwater samples collected. Since no samples were qualified "B" for blank contamination or "R" for data rejection, all on-site DSITMS analytical results were found to be usable, resulting in an overall analytical completeness quotient of 100%.

3.3 QUALITY ASSURANCE/QUALITY CONTROL FOR OFF-SITE LABORATORY ANALYSIS

QA is defined as the overall system for assuring the reliability of data generated in support of the FDVCO investigation. The system provides independent verification that the established QC measures are implemented by project participants in a manner that ensures the integrity of the environmental sampling

and analysis activities. This section presents an assessment of the QA/QC program for the off-site analysis of samples for the FDVCO investigation and demonstrates its effectiveness in achieving the data quality goals established in the FDVCO-WP (USACE, 2003c). Field QC samples collected during the FDVCO investigation are discussed in Section 3.3.1. An evaluation of data quality is provided in Sections 3.3.2 through 3.3.7.

3.3.1 Field Quality Control Samples for Off-site Laboratory Analysis

Soil. Since soil samples for VOC analysis are not homogenized, "duplicate" soil samples could not be collected to assess sampling precision. However, co-located soil samples were collected to provide an indication of the variability associated with matrix heterogeneity. Co-located soil samples were collected from the same core as, and as close to the location of, the primary sample as possible. Co-located soil samples were collected at a frequency of 10% (i.e., one co-located soil sample for every 10 primary samples) for collaborative soil samples collected for off-site laboratory analysis. Co-located soil samples have the same field sample number as the primary samples with a "D" added at the end [e.g., H14(3)-SB-8.5D].

The collaborative soil samples for off-site laboratory analysis were collected utilizing En Core® samplers that were dedicated sampling devices. Since each sample was collected with a new En Core® sampler and no decontamination was required, cross-contamination between samples as a result of sampling equipment decontamination procedures was not an issue. Therefore, equipment blanks were not collected.

Trip blanks are not required for solid samples and, therefore, did not accompany collaborative soil samples sent to the off-site laboratory for analysis.

Groundwater. Field duplicate groundwater samples were collected to provide an indication of the variability associated with matrix heterogeneity and to assess sampling precision. Field duplicate groundwater samples were collected at a frequency of 10% (i.e., one field duplicate for every 10 primary samples) for collaborative groundwater samples collected for off-site laboratory analysis. There was insufficient groundwater in the temporary monitoring wells selected for collection of groundwater samples for off-site laboratory analysis to collect duplicate samples. Therefore, all of the field duplicate groundwater samples for off-site laboratory analysis were collected from the PDB samplers. Field duplicate PDB groundwater samples have the same field sample number as the primary sample with a "D" added to the end (e.g., MW34-4-PDB-2D).

Equipment blanks were not collected since the PDB groundwater samples were collected directly from the disposable PDB samplers and dedicated disposable bailers were used to sample the temporary monitoring wells. Since the PDB samplers and bailers were dedicated and disposable, no decontamination was required. Therefore, cross-contamination between samples as a result of sampling equipment decontamination procedures was not an issue. Therefore, equipment blanks were not collected.

In addition to field duplicates, field QC samples associated with the collaborative groundwater samples being shipped off site for laboratory analysis included trip blanks. Trip blanks are intended to identify contamination from exposure to atmospheric contaminants that may occur during various stages of the sampling process including: shipment of bottles to the site; storage of bottles on site; collection of samples on site; storage of samples on site; shipment of samples to the laboratory; and storage of samples at the laboratory. Trip blanks (designated as Tmmddyy) accompanied PDB groundwater samples and collaborative temporary monitoring well groundwater samples to the off-site laboratory and were analyzed for TCL VOCs by the off-site laboratory. The trip blanks were prepared by the off-site laboratory, shipped to the site along with the sample bottles, and shipped back to the laboratory with the samples.

3.3.2 Sensitivity

The groundwater samples were analyzed for TCL VOCs by the off-site laboratory using USEPA SW-846 Method 5030B/8260B. The soil samples were analyzed for TCL VOCs by the off-site laboratory using USEPA SW-846 Method 5035 Modified/8260B (USEPA, 1996b). The preparatory method (USEPA Method 5035) for the soil samples was modified to accommodate the 25 g En Core® samplers used. Five gram (5 g) sample aliquots were transferred to the preparatory vials at the laboratory. This methodology modification did not warrant any qualification for the data produced.

Accutest's MDLs and RLs for TCL VOC analysis of solid and aqueous samples by the analytical methods specified above are listed in Appendix E of the FDVCO-WP (USACE, 2003c). The MDL is the minimum concentration of a compound that can be measured and reported with a 99% confidence that the compound is above zero, and is determined from analysis of a sample in a given matrix containing the compound. The MDLs are derived by the method based upon 40 CFR Chapter 136, Appendix B. The laboratory used a RL to represent the level of sensitivity for each sample. The RL should be 3 times the MDL, but must be at least 2 times the MDL. The RL is the threshold value below which the laboratory reports any non-detected value as "U", "ND", or "<" and will vary for each sample based upon dilution, sample volumes, percent moistures (for solids), and the method performed. Any positive value found above the MDL for a given sample and below the RL or 3 times the MDL (whichever is greater) was reported as estimated "J".

3.3.3 Data Management and Validation

The off-site laboratory provided CLP-like hard copy data packages containing analytical results for environmental samples and field QC samples, supporting laboratory QC data, and all raw data. The off-site laboratory also provided an electronic copy of the analytical results for the environmental and field QC samples, which included, but was not limited to (as applicable), the following information:

- 1. Laboratory sample identification number;
- 2. Shaw field sample number;
- 3. Sample media and depth;
- 4. Sample collection date;
- 5. Analytical method citation; and
- 6. Parameter analyzed, analytical result, units, and quantitation level for each compound or parameter analyzed.

Shaw used this electronic information to create a database of analytical results.

An independent review of 100% of the off-site laboratory analytical data was performed. Data validation is defined as the systematic process for reviewing a data package against a set of criteria to provide assurance that the data are adequate for their intended uses. These criteria depend upon the type(s) of data involved and the purpose for which data are collected. The intended use of the data and the associated acceptance criteria for data quality were determined before the data collection effort began. The data validation services for the sampling effort were provided by the Shaw Project Chemist. The data were validated in accordance with the DQIs presented in Appendix E of the FDVCO-WP (USACE, 2003c), the USEPA SW-846 methodology requirements (USEPA, 1996b), and the USACE <u>Shell for Analytical Chemistry Requirements</u> (USACE, 2001). The data qualifier scheme was consistent with the Region 3 Modifications to the NFGs for Organic Data Review (USEPA, 1994). According to the FDVCO-WP, only the soil analytical data were to be validated fully. However, it was subsequently determined that it would be beneficial to fully validate the groundwater analytical results as well to increase their usability for possible future assessments (e.g., risk assessment).

Data packages were validated to ensure compliance with specified analytical and QA/QC requirements; data reduction procedures; data reporting requirements; and required accuracy, precision, and completeness criteria. These include (as applicable), but are not limited to:

- 1. Sample preservation and holding times;
- 2. Instrument performance checks;

- 3. Calibration (initial and continuing);
- 4. Blanks (laboratory and field);
- 5. Matrix spike and spike duplicate recoveries;
- 6. Sample duplicates;
- 7. Surrogate spike recoveries;
- 8. Laboratory control samples;
- 9. Internal standards and retention times; and
- 10. Quantitative verification.

In addition to the data validation, the Shaw Project Chemist performed a blank contamination assessment and field duplicate review on all data. The purpose of this review was to provide a check on the data validation process. The criteria used for Shaw's data review are described in the precision and accuracy sections, which follow.

The quality of the data collected in support of the sampling activity was considered acceptable, unless qualified rejected "R" or blank qualified "B" during the data validation process. Appropriate data qualifiers resulting from data validation were added to the results in the electronic database and in Table 4-2 (PDB groundwater analytical results), Table 4-5 (soil analytical results), and Table 4-7 (temporary monitoring well groundwater analytical results) (for the detected analytical results; see Section 4). Data obtained from both the laboratory and data validation were reviewed by the Shaw Project Chemist to determine whether the project-specific data quality goals were met.

3.3.4 Precision

Method or laboratory precision by the laboratory as well as overall sampling or field precision were evaluated during the data validation process. Precision is measured by calculating and evaluating the RPD between the results of field duplicates or laboratory duplicates (including spiked sample duplicates). The RPD is calculated by the following equation:



where:

XA and XB are duplicate analyses, and

XM is the mean value [(XA + XB)/2] of the duplicate analyses.

Field duplicates were collected to identify the cumulative precision of the sampling and analytical process. Duplicate samples were proposed, collected, and analyzed for the same parameters as the primary samples at a frequency of 10% per matrix. The RPD was calculated only for those analytes which were detected at levels exceeding the RLs in both samples of the duplicate pair. Analytes that were qualified as non-detect because of blank contamination (B-qualified) or were rejected (R-qualified) in either sample of the duplicate pair were excluded from the duplicate assessment. Precision control criterion was established at 50% RPD for the soil and groundwater samples. *A*nalytical results were qualified as estimated "J" for any RPDs exceeding criteria.

Field soil sample duplicate pair H14(3)-SB-8.5/H14(3)-SB-8.5D was collected during the field sampling event. All detected compound concentrations found in both the environmental sample and field duplicate with associated RPD values are presented in Table 3-7. 1,1-Dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-DCE, cis-1,2-DCE, 1,2-dichloroethene (1,2-DCE) (total), PCE, 1,1,2-TCA, and TCE were detected in this duplicate pair. The calculated RPD values exceeded the 50% RPD criteria

for 1,1-DCA, 1,2-DCA, 1,1-DCE, cis-1,2-DCE, 1,2-DCE (total), and TCE; therefore, the detected concentrations for these compounds were qualified as estimated "J" for the environmental sample and the field duplicate. The elevated RPDs for the majority of the detected compounds in the field soil sample duplicate pair were due to sample heterogeneity which is typical of soils.

Field groundwater sample duplicate pair MW34-4-PDB-2/MW34-4-PDB-2D was collected during the field sampling event. All detected compound concentrations found in both the environmental sample and field duplicate with associated RPD values are presented in Table 3-7. Acetone, CCI₄, chloroform, 1,1-DCA, 1,1-DCE, cis-1,2-DCE, 1,2-DCE (total), PCE, 1,1,2-TCA, and TCE were detected in this duplicate pair. The calculated RPD values were less than the 50% RPD criteria for all compounds; therefore, no qualification was required.

Field groundwater sample duplicate pair MW34-7D-PDB-3/MW34-7D-PDB-3D was collected during the field sampling event. All detected compound concentrations found in both the environmental sample and field duplicate with associated RPD values are presented in Table 3-7. Chloroform, 1,1-DCA, 1,2-DCA, 1,1-DCE, cis-1,2-DCE, 1,2-DCE (total), PCE, 1,1,2-TCA, and TCE were detected in this duplicate pair. The calculated RPD values were less than the 50% RPD criteria for all compounds; therefore, no qualification was required.

3.3.5 Accuracy

Accuracy is the measure of bias in a system. Laboratory analytical accuracy was assessed through the use of laboratory blanks (method and instrument), laboratory control samples, and MSs. Laboratory analytical accuracy was reviewed during the validation of the data. Data qualification was applied as appropriate. Sampling accuracy was assessed by evaluating blank contamination and determining the impact of contaminant contributions originating from non-point sources, such as field sampling equipment decontamination procedures, or laboratory contamination. QC samples evaluated for this FDVCO investigation included trip blanks and laboratory method blanks. No equipment blanks were collected as discussed below. The accuracy of the results was measured by %R. For non-spiked samples, accuracy was measured by the following equation:

% R = test value *	* 100
true value	

For spiked samples, accuracy was measured by the following equation:

The equipment, trip, and method blank analyses are discussed in detail below.

Equipment Blanks. Equipment blanks are intended to identify cross-contamination between samples as a result of sampling equipment decontamination procedures. Dedicated En Core® samplers were used for soil sample collection, disposable bags were used for PDB groundwater sample collection, and disposable bailers were used for temporary monitoring well groundwater sample collection. Since dedicated sampling equipment was used for collection of all soil and groundwater samples, no equipment blanks were required to be collected.

However, it was determined after examining the data that the PVC well materials used in the construction of the temporary monitoring wells had been cleaned with isopropyl alcohol by the manufacturer prior to being sealed in polyethylene bags (see Section 2.8.4 and Appendix E). The PVC well materials were not decontaminated prior to use, and no equipment blank was collected (although the FDVCO-WP called for the collection of an equipment blank if the PVC well materials were not decontaminated prior to use). Acetone is a resulting by-product from isopropyl alcohol and was detected in all of the temporary monitoring well groundwater samples. Isopropyl alcohol was also detected in aqueous samples G11-TW-(4-14), H14-TW-(5-15), J16-TW-(2-12), K24-TW-(4.5-14.5), and T112403 as a tentatively identified compound. Because of the possibility of source contamination from the isopropyl alcohol used by the manufacturer to

clean the PVC well materials, the acetone detections in all of the temporary monitoring well groundwater samples were qualified "B" for blank contamination and are considered "non-detect". The temporary monitoring well groundwater samples include C18-TW-(5-15), F20-TW-(8-18), G11-TW-(4-14), H14-TW-(5-15), J16-TW-(2-12), and K24-TW-(4.5-14.5).

Trip Blanks. Trip blanks were prepared by the off-site laboratory and accompanied the aqueous samples requiring VOC analysis. One trip blank was transported with the aqueous VOC samples to the off-site laboratory for each day of sampling. Trip blanks are not required for soil samples. The trip blanks were prepared by pouring the required volume of deionized, organic-free water into appropriate sample containers in the laboratory. The trip blanks were analyzed for TCL VOCs. The trip blank results were used to assess the potential incidental contamination due to sample transport before, during, and after field operations (i.e., exposure to air) and/or contamination due to the sample container. In accordance with USEPA Region 3 data validation guidelines, the detected concentration in the sample was considered a "non-detect" (i.e., qualified "B" for blank contamination) and was excluded from consideration if the sample concentration was within five times (10 times for common laboratory contaminants such as acetone, 2 butanone, and methylene chloride) the concentration in the associated trip blank. Table 3-8 outlines the trip blank assessment. Samples with detected value results below the action levels presented in Table 3-8 were "B" qualified and considered "non-detect".

Two trip blanks were collected and analyzed for TCL VOCs during the field sampling event: T112103; and T112403. The trip blank for November 21, 2003 (T112103), applies to the groundwater samples collected on November 17 and 21, 2003, since these samples were all shipped in the same cooler. The trip blank for November 24, 2003 (T112403), applies to the groundwater samples collected on that date. Trip blank for November 24, 2003 (T112403), applies to the groundwater samples collected on that date. Trip blank T112103 was non-detect for all target compounds. Trip blank T112403 contained acetone (see Table 3-8) and isopropyl alcohol (tentatively identified compound). For all associated samples, acetone was detected at concentrations that were greater than the action level listed in Table 3-8; therefore, no qualification was required based on the trip blanks.

Method Blanks. A method blank is a volume of analyte-free water or soil that is processed through the entire analytical scheme (i.e., extraction, digestion, concentration, and analysis). Method blanks monitor potential laboratory-induced contamination. Results are qualified "B" for blank contamination by the laboratory and/or through the data validation process. In accordance with USEPA Region 3 data validation guidelines, the detected concentration in the sample was considered "non-detect" (i.e., qualified "B" for blank contamination) and was excluded from consideration if the detected sample concentration was within 5 times (10 times for common laboratory contaminants: acetone, 2-butanone, and methylene chloride) the concentration in the associated method blank. The method blank contamination assessment was evaluated during the data validation process and may be found in the data validation reports.

VOC soil method blanks VK656-MB and VK657-MB were non-detect for all target compounds. No qualification was required. VOC aqueous method blanks VG912-MB, VG914-MB, and VJ205-MB were non-detect for all target compounds. No qualification was required.

3.3.6 Representativeness

Representativeness is a measure of the degree to which the measured results accurately reflect the medium being sampled. It is a qualitative parameter that is addressed through the proper design of the sampling program in terms of sample location, number of samples, and actual material collected as a "sample" of the whole.

Sampling protocols have been developed to assure that samples collected are representative of the media. Field handling protocols (e.g., storage, handling in the field, and shipping) have also been designed to protect the representativeness of the collected samples. Proper field documentation and QC inspections were used to establish that protocols were followed and that sample identification and integrity was maintained. Documentation reviewed to infer sample representativeness included analytical records (holding times), blank contamination assessment (secondary inference), and associated project records. Inferences

from accuracy, precision, and completeness suggest that the designed sampling program resulted in the collection of representative samples.

3.3.7 Completeness

Completeness is a measure of the amount of information that must be collected during the field investigation to allow for successful achievement of the objectives. An adequate amount and type of data must be collected for conclusions to be valid. Missing data may reduce the precision of estimates or introduce bias, thus lowering the confidence level of the conclusions. The completeness goal of useable data for the FDVCO investigation was set at 90% for both the sampling and analytical completeness.

Completeness was inferred from records review and data validation. Sampling completeness was assessed through evaluation of the total number of samples proposed for collection in the FDVCO-WP (USACE, 2003c) versus the actual number of samples collected and analyzed. Analytical completeness was assessed by comparing the number of useable data points collected to the total number of data points generated. For the purposes of this report, unuseable data are defined to include rejected data points ("R" qualifier) or those data points which have been considered as "non-detects" due to blank contamination ("B" qualifier). Rejected data points determined through the data validation process may be found in Table 3-9. Completeness is calculated using the following equations:

% Sampling Completeness = <u>Number of Actual Samples Collected</u> Number of Proposed Samples

% Analytical Completeness = <u>Number of Useable Data</u> Number of Requested Analyses

For the FDVCO investigation, up to ten soil (including one duplicate soil sample pair) and up to 15 aqueous samples (including two duplicate groundwater sample pairs and two trip blanks) were proposed for collection and subsequent analysis by the off-site laboratory. All of these samples were collected and analyzed for TCL VOCs, resulting in a sampling completeness quotient of 100%.

Analysis of the soil samples resulted in the generation of 420 out of 430 data points determined to be useable, resulting in an overall analytical completeness quotient of 97.7%, which was within the predefined goal of 90% for this investigation, for the off-site laboratory analytical data. All of the unusable soil data were for compound 2chloroethyl vinyl ether which was qualified rejected "R" based upon the low calibration Relative Response Factor (RRF) result (see Table 3-9).

Analysis of the groundwater samples resulted in the generation of 551 out of 559 data points determined to be useable, resulting in an overall analytical completeness quotient of 98.6%, which was within the pre-defined goal of 90% for this investigation, for the off-site laboratory analytical data. The unusable groundwater data were for 2-chloroethyl vinyl ether which was qualified rejected "R" based upon no MS/MSD recovery (see Table 3-9), and for acetone which was generated from PVC well material cleaning procedures using isopropyl alcohol (see Table 3-8). Acetone is a resulting by-product from isopropyl alcohol.

3.4 COMPARABILITY

Comparability expresses the extent to which one data set can be compared to another. Comparability issues were addressed in large part by the level of detail included in the FDVCO-WP with respect to SOPs, adherence to USEPA Method 8265 for on-site DSITMS analysis, and use of standard methods (i.e., USEPA SW-846 8260B) for off-site laboratory analysis.

The MIP/ECD and the on-site DSITMS were used in combination to allow for high density sampling and on-site, near real-time results to assist in rapidly assessing sample representativeness and site heterogeneity with respect to VOC contaminant distributions. The on-site DSITMS analytical results for soil and groundwater samples were used to collaborate the data collected using the MIP/ECD. At locations the MIP/ECD indicated contamination, the groundwater and/or soil data produced by the on-site DSITMS analysis confirmed, speciated, and quantified the contamination (see Section 4). Both data sets, taken together, describe the same contaminant distribution patterns at the site within the areas investigated. As such, these field measurement tools effectively identified areas of contamination and aided in the development and refinement of the CSM in near real time.

Further, collaborative soil and groundwater samples for off-site laboratory analysis were selected and analyzed to support and verify the analytical trends identified in the CSM developed using the field measurement tools (i.e., DSITMS and MIP/ECD). Although the off-site laboratory groundwater analytical results were consistently higher (approximately 184% higher) than the on-site DSITMS groundwater analytical results, the off-site analytical results collaborate the on-site DSITMS and MIP/ECD data in that they exhibited the same contaminant distribution patterns (i.e., highest contaminant concentrations were found at the same sampling locations) (see Section 4). These results indicate that the field measurement tools provided data of adequate quality to support the objective for which the data were collected (i.e., to identify the highest concentration of VOCs in the overburden soil and groundwater within the spatial boundaries of the investigation). Further discussion of comparability between on-site DSITMS and off-site laboratory groundwater analytical results is presented in Section 4.5.

Comparability of the data collected during the FDVCO investigation can also be assessed by how well it compares with data collected during previous investigations. An initial test of comparability was executed by collecting groundwater samples from existing monitoring wells using PDB samplers and analyzing the samples by on-site DSITMS. In addition, the MIP/ECD was advanced adjacent to monitoring well MW34-4 as well as lowered directly into the screened interval of monitoring well MW34-4. The PDB groundwater samples from MW34-4 analyzed by the on-site DSITMS, the MIP/ECD results from penetrations adjacent to MW34-4, and the MIP/ECD results from lowering the MIP/ECD into MW34-4 collaborate each other and are consistent with previous groundwater analytical results from monitoring well MW34-4 (see Figure 1-8).

4.0 FDVCO INVESTIGATION RESULTS AND DISCUSSION

This section presents the chronology of the FDVCO investigation, including all major decisions as well as the rationale for the decisions (Section 4.1). Sections 4.2 through 4.4 present and discuss the results of the PDB groundwater samples, the MIP logs and sorbent traps, and the collaborative soil and temporary monitoring well groundwater samples. Section 4.5 presents a comparison of off-site laboratory and on-site DSITMS groundwater analytical results.

4.1 FDVCO INVESTIGATION CHRONOLOGY

Presented below is the chronology of significant FDVCO investigation field activities. Significant decisions by the FST, and the associated rationale, are also presented within the chronology. Further details can be found in the Daily QC Reports provided in Appendix A.

October 27, 2003. Installed 32 PDB samplers into monitoring wells NP-PZ2, MW34-2, MW34-3, MW34-4, MW34-5D, and MW34-7D. A total of five PDB samplers (each PDB sampler was 2 ft long) were installed in each monitoring well (10-ft well screens), except NP-PZ2 (15-ft well screen) where seven PDB samplers were installed. All water levels were above the top of the well screens as measured immediately prior to installation of the PDB samplers.

November 17, 2003. Collected all 32 PDB groundwater samples from the six monitoring wells (listed above) for on-site DSITMS analysis, and possible off-site laboratory analysis.

Prior to the start of the high density sampling, the FST decided to collect sorbent traps at 2ft intervals from the MIP advanced adjacent to monitoring well MW34-4 so that the depths of the sorbent trap results would correspond directly with PDB groundwater sample depth intervals. After reaching refusal at 13.2 ft bgs in the first MIP probe (MW34-4-MIP), the FST decided to advance a second MIP at the same location [MW34-4(2)-MIP] to assess whether the MIP could penetrate deeper than 13.2 ft bgs and to assess the variability of MIP/ECD response due to the soil heterogeneity at a known location. The FST also decided to collect sorbent traps at 5-ft intervals as initially proposed in the FDVCO-WP (USACE, 2003c) to speed up the investigation. MIP probe MW34-4(2)-MIP was able to penetrate to 16 ft bgs.

As suggested by the Decision Guide (Figure 2-2), F20-MIP was then completed. Sorbent traps were initially collected from F20-MIP at 5-ft intervals. However, during the advancement of F20-MIP, the FST observed that the MIP/ECD was proving to be sufficiently sensitive to meet the FDVCO objectives. Therefore, the FST decided to collect only one sorbent trap for the entire length of a MIP probe for speciation purposes only to increase MIP productivity. As a result of this decision, the final sorbent trap for F20-MIP was collected from 10 to 18 ft bgs.

After completing F20-MIP, the FST decided to install a temporary monitoring well at F20 for possible subsequent groundwater sampling.

Since the MIP was not able to penetrate to the desired depth (20 ft bgs), the FST decided to advance the MIP at F20 (already completed), C20, and A18 to form an "arc" of nearby locations upgradient (based on horizontal groundwater flow in the saturated overburden material) of MW34-4. The FST believed that the two extra points (C20 and A18 – not included on the Decision Guide) would provide more intense coverage in the immediate area upgradient of MW34-4.

The MIP was next advanced at C23, rather than A25 (suggested by the Decision Guide [Figure 2-2]), because A25 was located approximately 3 ft from a very large aboveground propane tank. The FST selected C23 because this grid point is upgradient of MW34-4 and is an adequate distance from the propane tank and Building 2300.

November 18, 2003. Prior to the start of field activities, the FST made the following decisions:

 To conduct MIP PTs at midday and the end of the day only (rather than conducting PT after each probe location as specified in the FDVCO-WP [USACE, 2003c]). In order to optimize the detection capability of the MIP, a reduction in the number of PTs would reduce the potential for raising background levels. This decision was justified since PTs conducted on November 16 and 17, 2003, showed that the system was stable.

- To give the MIP one minute to heat up, rather than two minutes as specified in the FDVCO-WP, after advancing 1.0 ft because approximately 80 percent of the VOCs are mobilized after one minute (sufficient for the MIP/ECD to identify amount of contamination) and this procedural change would save time (approximately 20 minutes per MIP probe location).
- To advance the MIP inside MW34-4 (within the groundwater present in the monitoring well) to assess the increase in response with depth on the MIP/ECD in comparison to the on-site DSITMS results of the PDB groundwater samples collected from MW34-4.
- To install a temporary monitoring well at each MIP location. Since the MIP/ECD response in the last MIP (C23-MIP) was significantly less than the MIP/ECD response in MW34-4(2)-MIP, the installation of a temporary monitoring well would allow the collection of a groundwater sample that could be analyzed by the on-site DSITMS with much lower detection limits.

The MIP was advanced in monitoring well MW34-4 and at C20 (which had been selected on November 17, 2003, as discussed above). The MIP was then advanced at:

- E23, rather than F25 (which was suggested by the Decision Guide [Figure 2-2]), because F25 lies within the footprint of Building 2320 and E23 is the closest grid point between F25 and MW34-4;
- K24, rather than K25 (which was suggested by the Decision Guide), because K25 is approximately 2 ft from a large trash dumpster; and
- A21, rather than A20 (which was suggested by the Decision Guide), because A20 was close to grid point A18 (already decided to add A18 as part of an "arc" close to MW34-4 [see above]) and visual observation indicated that A21 was located halfway between points A18 and C23 (more so than A20).

The FST then decided to advance the MIP at H23 to "fill in" the "arc" of MIPs/temporary monitoring wells formed by A21, C23, E23, and K24. H23 is also just off the corner of Building 2320 in which solvents were previously stored. The last MIP probe completed on this day was at A18 (which had been selected on November 17, 2003, as discussed above).

Groundwater samples were collected from temporary monitoring wells at grid points F20, C23, and E23.

November 19, 2003. Prior to the start of field activities, the FST decided to advance the MIP at C18 because the MIP/ECD responses in the two "arcs" upgradient of MW34-4 had been relatively small [except for F20-MIP, which was less than MW34-4(2)-MIP]. Grid point C18 was directly upgradient of MW34-4 and approximately splits the distance between MW34-4 and the closest "arc."

After advancing the MIP at C18, the FST decided to advance the MIP at A15 because all MIP/ECD responses to date indicated that there was no VOC contamination upgradient of MW34-4 that was greater than the VOC contamination at MW34-4. A MIP/temporary monitoring well at A15 would assess how much, if any, VOC contamination is present cross-gradient of MW34-4. The MIP was then advanced at FF20 and A30 as suggested by the Decision Guide (Figure 2-2). Although suggested by the Decision Guide, the FST decided not to advance the MIP at FF25 or FF30 because these two points lie within the footprints of Buildings 2300 and 2290, respectively; there are no closer grid points that are not within the buildings' footprints; and the MIP/ECD responses to date suggested that there was no VOC contamination greater than MWW34-4(2)-MIP at this distance and direction from MW34-4.

The field activities were terminated at 13:40 because of a very heavy rain. Prior to the heavy rain, groundwater samples were collected from temporary monitoring wells at grid points K24, H23, C20, and A18.

November 20, 2003. The MIP was advanced at F30 as suggested by the Decision Guide (Figure 2-2). The MIP was then advanced at H14, a location downgradient of MW34-4, at the suggestion of the VDEQ. In H14-MIP, the MIP/ECD response was off the scale between 8 and 12 ft bgs [significantly greater response than in MW34-4(2)-MIP] and the PID response (which was barely noticeable in all previous locations) was unusually high.

The FST decided to assess the extent of the high VOC contamination at H14. The MIP was advanced at K10 because this grid point was directly downgradient of H14 and approximately twice the distance (of H14) from MW34-4. This grid point also provided an opportunity to compare temporary monitoring well results from the AREE 34 RI to this FDVCO investigation. After a minimal MIP/ECD response in K10-MIP, the FST decided to use the Geoprobe® rig/Macrocore sampler to collect soil samples from the location of the highest MIP/ECD response at H14 for analysis by the on-site DSITMS to provide information on the speciation and concentrations of the VOCs.

After collecting the soil samples, the FST decided to advance the MIP at J16 to assess the extent of VOC contamination to the east (cross-gradient) of H14. The MIP/ECD response in J16-MIP was much less than in H14-MIP, but was still greater than in MW34-4(2)-MIP. The FST decided to advance the MIP at L18 to assess the extent of VOC contamination to the east of J16. The MIP/ECD response in L18-MIP was less than in MW34-4(2)-MIP; therefore, the FST decided not to advance the MIP at any locations further east of L18.

No groundwater samples were collected this day because of the unexpected VOC contamination found at H14.

November 21, 2003. The MIP was advanced at:

- K30 as suggested by the Decision Guide (Figure 2-2);
- D13 to assess the extent of VOC contamination southwest of H14; and
- G11 to assess the extent of VOC contamination west of H14.

The MIP/ECD responses at these three locations were less than the MIP/ECD response in MW34-4(2)-MIP.

As decided by the FST, soil samples were collected at H14(3)-SB {a second soil boring located within 2 ft of the first soil boring [i.e., H14(2)-SB]} at approximately 1-ft to 2-ft intervals for on-site DSITMS analysis to assess changes in VOC concentrations and speciation with depth. Soil samples were also collected from H14(3)-SB from 4, 8.5, 9.5, 10.5, and 15.5 ft bgs for off-site laboratory analysis to collaborate the on-site DSITMS analytical results and to provide data for risk assessment.

The FST then decided to collect soil samples from J16(2)-SB at approximately 1-ft to 2-ft intervals for on-site DSITMS analysis because this location had the highest documented CCl₄ concentrations (based on the on-site DSITMS temporary monitoring well groundwater analytical results from J16-TW). Soil samples were also collected from J16(2)-SB at 4, 11, 12, and 13.5 ft bgs for off-site laboratory analysis to collaborate the on-site DSITMS analytical results and to provide data for risk assessment.

Groundwater samples were collected from the temporary monitoring wells at grid points A15, A30, C18, F20 (a second sample), F30, FF20, H14, J16, and K10 for on-site DSITMS analysis. In addition, groundwater split samples were collected from the temporary monitoring wells at grid points C18 and F20 for off-site laboratory analysis to collaborate the on-site DSITMS analytical results and to provide data for risk assessment. A groundwater sample from F20-TW was selected for off-site laboratory analysis because VOC contamination was present at this location, albeit at concentrations below those found at MW34-4. A groundwater sample from C18-TW was selected for off-site laboratory analysis as a location that was fairly "clean" based on the MIP/ECD response.

The MIP and DSITMS crews demobilized.

November 24, 2003. As decided by the FST, groundwater samples were collected from temporary monitoring wells at grid points G11, H14, J16, and K24 for off-site laboratory analysis to collaborate the

on-site DSITMS analytical results and to provide data for risk assessment. H14-TW and J16-TW were selected for collection of groundwater samples for off-site laboratory analysis because they contained the highest concentrations of VOCs based on the MIP/ECD and the on-site DSITMS analysis. G11-TW was selected for collection of a groundwater sample for off-site laboratory analysis because a groundwater sample was not collected for on-site DSITMS analysis on November 21, 2003, as a result of insufficient groundwater present in the temporary monitoring well. K24-TW was selected for collection of a groundwater sample for off-site laboratory analysis because it to contain high concentrations of toluene (the on-site DSITMS was not calibrated for toluene because it was not a contaminant of concern). All temporary monitoring wells, with the exception of the four that were sampled this day, were removed, and the boreholes were abandoned.

November 25, 2003. The four remaining temporary monitoring wells (at grid points G11, H14, J16, and K24) were removed, and the boreholes were abandoned. All of the temporary monitoring well materials, as well as all other IDW, were placed into a 55-gallon drum with the soil cuttings. This drum of IDW was labeled and stored in the AAFES Service Station for subsequent disposal (see Sections 2.9.2 and 2.9.3). All decon and purge waters were treated and discharged to the sanitary sewer system (see Section 2.9.1).

4.2 PASSIVE DIFFUSTION BAG GROUNDWATER SAMPLES

A total of 32 PDB groundwater samples (plus four field duplicate samples) were collected from four saturated overburden (NP-PZ2, MW34-2, MW34-3, and MW34-4) and two bedrock aquifer (MW34-5D and MW34-7D) monitoring wells for VOC analysis. The PDB groundwater samples were collected and analyzed to: 1) to determine the vertical stratification, if any, of VOC contamination in the groundwater to provide background data relative to the high density sampling program; and 2) to assess, assuming there is stratification of the VOC contamination, whether the source may be local or some distance away.

4.2.1 On-site DSITMS Analysis

All 32 PDB groundwater samples (plus four field duplicate samples) were analyzed by the on-site DSITMS. Table 4-1 presents the results of the on-site DSITMS analysis of the PDB groundwater samples, along with an indication of whether the monitoring wells sampled are screened in the saturated overburden or the bedrock aquifer. Note that there are seven sampling intervals for monitoring well NP-PZ2 because this monitoring well has a 15-ft well screen, while the other five monitoring wells have 10-ft well screens. As shown in Table 4-1, all 32 PDB groundwater samples had detectable concentrations of at least one VOC.

In the saturated overburden, three of the four monitoring wells sampled using the PDB samplers contained one or more VOC compounds at concentrations exceeding the corresponding MCLs; the one exception was monitoring well MW34-3. In monitoring wells NP-PZ2 and MW34-2, TCE, DCE, and PCE exceeded the corresponding MCLs. The maximum concentrations of these three VOCs in NP-PZ2 were 14.7 μ g/L TCE (MCL = 5 μ g/L), an estimated concentration of 23.7 μ g/L DCE (MCL = 7 μ g/L for 1,1-DCE), and 13.4 μ g/L PCE (MCL = 5 μ g/L). The maximum concentrations of these three VOCs in MW34-2 were 18.8 μ g/L TCE (MCL = 5 μ g/L), 21.1 μ g/L DCE (MCL = 7 μ g/L for 1,1-DCE), and an estimated concentration of 9.1 μ g/L PCE (MCL = 5 μ g/L). As shown on Table 4-1, the VOC concentrations in NP-PZ2 and MW34-2 were relatively consistent over the well screen interval. The one observation that can be made is that the upper two (MW34-2) to four (NP-PZ2) feet of groundwater within the screened intervals contain VOCs that are generally less than MCLs, while the groundwater collected below these depths contained VOCs in excess of the MCLs.

Monitoring well MW34-4 contained the highest concentrations and widest variety of VOCs of all the saturated overburden monitoring wells sampled using the PDB samplers, which was expected based on the results of the AREE 34 SRI (USACE, 2003b). In monitoring well MW34-4, CCl₄, TCE, DCE, and PCE exceeded the corresponding MCLs; MW34-4 was the only saturated overburden monitoring that contained CCl₄ above the MCL. The maximum concentrations of these four VOCs in MW34-4 were 79.4 μ g/L CCl₄ (MCL = 5 μ g/L), 57.6 μ g/L TCE (MCL = 5 μ g/L), 123 μ g/L DCE (MCL = 7 μ g/L for 1,1-DCE), and an estimated concentration of 9.6 μ g/L PCE (MCL = 5 μ g/L). These maximum VOC concentrations all occur in the deepest well screen interval. As indicated by the color shading in Table 4-1, the PDB groundwater

analytical results show that the VOC concentrations in MW34-4 (particularly CCI_4 , TCE, and DCE) increase with depth.

In the bedrock aquifer, monitoring well MW34-5D contained only one VOC (i.e., CCl₄) that exceeded the corresponding MCL at one depth interval, while monitoring well MW34-7D contained three VOCs (i.e., TCE, DCE, and PCE) that exceeded the corresponding MCLs throughout the entire length of the well screen. Monitoring well MW34-5D is co-located with saturated overburden monitoring well MW34-4 which was the only saturated overburden monitoring well sampled that contained CCl₄ in excess of the MCL. The one exceedence of the MCL for CCl₄ (i.e., 5 μ g/L) occurred in the 52 – 54 ft bgs depth interval within MW34-5D at an estimated concentration of 5.3 μ g/L.

The high concentrations of VOCs observed in the PDB groundwater samples from bedrock aquifer monitoring well MW34-7D were expected based on the results of the AREE 34 SRI (USACE, 2003b). The maximum concentrations of the three VOCs that exceeded MCLs in MW34-7D were 55.5 μ g/L TCE (MCL = 5 μ g/L), 74.8 μ g/L DCE (MCL = 7 μ g/L for 1,1-DCE), and 36.8 μ g/L PCE (MCL = 5 μ g/L). These maximum VOC concentrations all occur in the shallowest well screen interval. As indicated by the color shading in Table 4-1, the PDB groundwater sample results show that the VOC concentrations in MW34-7D (particularly PCE) decrease with depth. These data suggest that the source of the VOCs detected in MW34-7D are from a nearby source, and that the VOCs are migrating downward.

4.2.2 Off-site Laboratory Analysis

A total of five selected PDB groundwater samples (plus two field duplicate samples) were analyzed by the off-site laboratory for TCL VOCs to collaborate the on-site DSITMS PDB groundwater analytical results. These samples included three samples from MW34-4 (plus one field duplicate sample) and two samples from MW34-7D (plus one field duplicate sample). A summary of the detected off-site laboratory analytical results for the PDB groundwater samples is presented in Table 4-2. A comprehensive set of analytical results is provided in Appendix F. All of the PDB groundwater samples analyzed by the off-site laboratory are split samples (i.e., were collected at the same time) with the corresponding PDB groundwater samples analyzed by the on-site DSITMS.

In saturated overburden monitoring well MW34-4, CCl₄, 1,1-DCE, PCE, 1,1,2-TCA, and TCE exceeded the corresponding MCLs. The maximum concentrations of these five VOCs in MW34-4 were 160 μ g/L CCl₄ (MCL = 5 μ g/L), 322 μ g/L 1,1-DCE (MCL = 7 μ g/L), 22.5 μ g/L PCE (MCL = 5 μ g/L), 8.2 μ g/L 1,1,2-TCA (MCL = 5 μ g/L), and 115 μ g/L TCE (MCL = 5 μ g/L). The maximum VOC concentrations all occur in the deepest well screen interval.

In bedrock aquifer monitoring well MW34-7D, 1,1-DCE, PCE, and TCE exceeded the corresponding MCLs. The maximum concentrations of these three VOCs in MW34-7D were 86.3 μ g/L 1,1-DCE (MCL = 7 μ g/L), 18.1 μ g/L PCE (MCL = 5 μ g/L), and 41.7 μ g/L TCE (MCL = 5 μ g/L). These maximum VOC concentrations all occur in the shallower of the two well screen intervals analyzed.

The off-site laboratory analytical results for the PDB groundwater samples collaborate the on-site DSITMS analytical results that CCI_4 , TCE, DCE (in the form of 1,1-DCE), and PCE exceed the corresponding MCLs in MW34-4, and that TCE, DCE (in the form of 1,1-DCE), and PCE exceed the corresponding MCLs in MW34-7D. Further, even though the off-site laboratory analytical results are higher than the on-site DSITMS analytical results for the split samples (see Section 4.5 for further discussion), the concentration trends are the same. For example, the VOC concentrations in the PDB groundwater samples from MW34-4 clearly increase with depth.

4.3 MIP LOGS AND SORBENT TRAPS

During the high density sampling program, the MIP was advanced at 21 different locations within the grid area, with three probes at the first location, MW34-4 (two probes adjacent to the monitoring well, and one probe within the monitoring well itself) (see Figure 2-1). At least one sorbent trap was collected and analyzed from each MIP advancement.

4.3.1 MIP Logs

As the MIP was advanced into the subsurface soil, continuous MIP logs presenting six graphs of data were recorded. The individual MIP/ECD logs are provided in Appendix B. The first graph is soil conductivity (measured in milliSiemens per meter [mS/M]) where, in general, lower conductivities indicate coarser grained material such as sands, while higher conductivities indicate finer grained material such as silts and clays. The second graph is the rate of penetration (speed of the probe, measured in fl/min) that can be used to determine the density of the subsurface. The next three graphs are chemical data (PID, FID, and ECD) which give relative concentrations of contamination, measured in microvolts (μ V). Note that there are no results reported for the FID because the FID was not used during the FDVCO investigation (see Section 2.2.1). The last graph displays the temperature of the probe (measured in degrees Celsius [°C]) that can be used to determine the depth of the groundwater table. The MIP penetration met refusal at depths ranging from 12 to 22 ft bgs (see Table 4-3). Therefore, the MIP logs do not necessarily reveal the full vertical extent of VOCs within the overburden material at AREE 34.

The first two MIP locations were adjacent to monitoring well MW34-4, which was found to have the highest VOC concentrations of any saturated overburden monitoring well on site prior to the FDVCO investigation. The well screen in monitoring well MW34-4 is set at 10 to 20 ft bgs. The MIP was only able to penetrate to approximately 13 ft bgs at the first location, and 16 ft bgs at the second location. MIP profiles MW34-4MIP and MW34-4(2)-MIP were advanced within 2 ft to the south and east of MW34-4, respectively. The soil conductivity reveals a sharp increase in conductivity below 6 ft bgs suggesting finer grained (i.e., clay and silt) soils. This corresponds with the "red-brown clay and silt" identified on Figure 1-3, which becomes denser with depth. The MIP/ECD profiles reveal the presence of chlorinated solvents below 8 ft bgs on the MIP logs for both MW34-4-MIP and MW34-4(2)-MIP, with the strongest MIP/ECD response (i.e., maximum of approximately 8E+05 μ V; see MIP log in Appendix B) occurring between 9 and 12 ft bgs in MW34-4(2)-MIP. The highest MIP/ECD responses occur within the higher conductivity soils.

Upon review of the MIP logs for MW34-4MIP and MW34-4(2)-MIP (see Appendix B), MIP/ECD responses were observed at similar depths. However, the maximum MIP/ECD response in MW34-4(2)-MIP (approximately 8E+05 μ V, located to the east of MW34-4) was significantly stronger than the maximum MIP/ECD response in MW34-4-MIP (approximately 2E+05 μ V, located to the south of MW34-4). Therefore, the MIP/ECD response in MW34-4(2)-MIP was used as the benchmark for comparison with subsequent MIP advancements. The significant difference in MIP/ECD responses between MW34-4-MIP and MW34-4(2)-MIP, located within 4 ft of each other, exemplifies: 1) the heterogeneity of the subsurface VOC contamination at AREE 34; and 2) the trend toward lower VOC concentrations south of monitoring well MW34-4 as supported by the results of the MIPs advanced further south (i.e., upgradient) of MW34-4 (see below).

Figure 4-1 illustrates the lateral extent of the stronger MIP/ECD responses (depicted by the green area on the figure). With the exception of H14-MIP and J16-MIP (which are located downgradient of MW34-4 based on horizontal groundwater flow in the saturated overburden material), no other MIP/ECD responses exceeded the maximum MIP/ECD responses detected in MW34-4(2)-MIP. L18-MIP and F20-MIP both had MIP/ECD measurements close to, but lower than, MW34-4(2)-MIP. Many of the other locations near monitoring well MW34-4 had detectable MIP/ECD responses, but at much lower levels than MW34-4(2)-MIP. The green area on Figure 4-1 is centered on H14 and extends out to MW34-4(2) and J16. All of the other MIP/ECD responses were too small to show up on this krigged image (i.e., MIP/ECD response less than 4.0E+05 μ V).

The highest MIP/ECD responses were detected at H14 where: 1) the MIP/ECD response is off the scale of the detector (>1.4E+07 μ V; see MIP log in Appendix B); and 2) the PID also responded at the same depths as the ECD. Although it is possible that the PID might respond at the high concentrations of chlorinated VOCs detected in the soil at grid point H14 from 8 to 15 ft bgs, the PID is primarily used for detection of aromatic compounds. It appears that the PID may actually be responding to substituted aromatic benzenes that were noted by the on-site DSITMS analyst (see Section 4.4.1.2) and identified as tentatively identified compounds by the off-site laboratory (see off-site laboratory analytical reports for

H14(3)-SB-8.5D and H14(3)-SB-9.5 in Appendix F) in the collaborative soil samples collected from H14. The highest MIP/ECD responses at H14 occur from 8 to 12 ft bgs. High MIP/ECD responses continued from 12 ft bgs to the bottom of the MIP probe (15.6 ft bgs). There is also a zone of lower MIP/ECD responses [although still higher than the maximum MIP/ECD response in MW34-4(2)-MIP] starting at approximately 5 ft bgs which was observable when the MIP/ECD scale was normalized with the other MIP logs (see Appendix B). It appears that the first appearance of VOCs with depth at H14 corresponds to the depth where the soils start to become finer grained (as shown by increases in conductivity on the conductivity profile).

The second highest MIP/ECD response was detected at J16 where the strongest response (maximum of approximately 5E+06 μ V; see MIP log in Appendix B) occurs from 9 to 13 ft bgs. The strongest MIP/ECD response occurs within the higher conductivity zone.

The MIP/ECD also detected VOCs with lower responses [i.e., less than the 8E+05 μ V maximum MIP/ECD response at MW34-4(2)-MIP] at the following grid points (approximate maximum MIP/ECD response in parenthesis) :

- L18 (5E+05 μV);
- F20 (5E+05 μV);
- C18 (4E+05 μV);
- FF20 (3.5E+05 μV);
- D13 (2.5E+05 μV);
- G11 (2.5E+05 μV); and
- C20 (2E+05 μV).

The highest MIP/ECD responses at these locations were generally between 10 to 18 ft bgs, and all were within finer grained soils.

Figure 4-2 presents a cross-section through AREE 34. The green area shows the stronger MIP/ECD responses (>4.0E+05 μ V), and the brown colored areas represent higher conductivity (i.e., finer grained) soils. A review of the MIP profiles (as depicted by Figure 4-2) show that there is a sharp increase in soil conductivity between 5 and 7 ft bgs across the site. The stronger MIP/ECD responses lie within these finer grained soils.

A MIP profile (MW34-4-MWMIP) was generated by lowering the MIP probe down into the existing monitoring well MW34-4. This profile shows a steady rise in concentration in the groundwater within the well from 13 ft bgs to the bottom of the hole at approximately 19 ft bgs (see Figure 4-3). This increase in VOC contamination is collaborated by the PDB groundwater analytical results as shown on Figure 4-3. The steady increase in MIP/ECD response in the monitoring well groundwater does not correlate directly with the in-situ variations in MIP/ECD responses in MIP logs MW34-4-MIP and MW34-4(2)-MIP. This suggests that chemical stratification within the monitoring well environment does not necessarily reflect the precise depths of chemical occurrence in the surrounding soils.

4.3.2 On-site DSITMS Analysis of Sorbent Traps

Sorbent traps were collected during advancement of each MIP. Initially, sorbent traps were collected at 2-ft to 5-ft intervals as the MIP advanced [at MW34-4-MIP, MW34-4(2)-MIP, and F20-MIP] with the intent of both speciating and quantifying the VOCs that were detected by the MIP/ECD. However, during the advancement of F20-MIP, the FST observed that the MIP/ECD, by itself, was proving to be sufficiently sensitive to quantify the degree of VOC contamination and meet the FDVCO objectives. Therefore, the FST decided to collect only one sorbent trap for the entire length of a MIP probe for speciation purposes only. Table 4-3 presents a listing of all of the sorbent traps was used only to speciate the VOCs detected by the

MIP/ECD, the results reported in Table 4-3 simply identify which VOCs were present and the degree to which they were present.

Sorbent traps were collected at 2ft intervals in the first MIP probe (MW34-4-MIP) to compare results directly to the PDB groundwater analytical results. MW34-4-MIP reached refusal at 13.2 ft bgs, and the on-site DSITMS only detected VOCs (CCl₄ and PCE) in the bottom sorbent trap [MW34-4-ST-(12-13.2)]. Sorbent traps were collected at 5ft intervals in the second MIP probe [MW34-4(2)-MIP]. The on-site DSITMS detected CCl₄, TCE, DCE, and PCE in the middle two traps in MW34-4(2)-MIP, which covered a depth range of 5 to 15 ft bgs. The on-site DSITMS also detected CCl₄, TCE, and DCE in the full-length sorbent trap collected from MW34-4-MWMIP, which was advanced inside monitoring well MW34-4.

Sorbent traps were initially collected at 5-ft intervals in the third MIP probe (F20-MIP); the bottom sorbent trap from F20-MIP was collected over an 8-ft interval. The on-site DSITMS detected only one VOC (PCE) in the bottom sorbent trap from F20-MIP [F20-ST-(10-18)]. However, the on-site DSITMS analysis of this sorbent trap indicated that there was a higher level of PCE present compared to most other traps.

The sorbent traps from F20 (PCE, as discussed above), C18 (PCE), C20 (CCl₄ and PCE), and FF20 (PCE) were the only MIP locations upgradient (based on the horizontal groundwater flow in the saturated overburden material) of monitoring well MW34-4 where the on-site DSITMS analysis of the sorbent traps identified detectable levels of VOCs. The detection of PCE in the sorbent trap collected from FF20-MIP is somewhat isolated from the remainder of the other sorbent trap detections.

The highest levels of VOCs detected in the sorbent traps by the on-site DSITMS were from H14-MIP and J16-MIP, which are located downgradient of MW34-4. The H14 on-site DSITMS sorbent trap results indicate that very high levels of PCE were present along with some DCE; while the J16 on-site DSITMS sorbent trap results indicate that high levels of both CCl_4 and PCE were present along with lesser levels of CHCl₃ + TCA, TCE, and DCE. These data suggest that the source of the VOC contamination at these two locations may be different.

On-site DSITMS analysis of two other sorbent traps located downgradient of monitoring well MW34-4 also identified the presence of VOCs: L18 (PCE); and K10 (TCE and PCE).

Comparison of the on-site DSITMS sorbent trap results presented in Table 4-3 with the MIP logs presented in Appendix B (and graphically presented on Figure 4-1) indicate that the qualitative on-site DSITMS results for the sorbet traps confirmed the presence of VOCs at each of the locations where there was a MIP/ECD response, with two exceptions. The two exceptions were D13-MIP and G11-MIP which showed very slight MIP/ECD responses (see Section 4.3.1). The only other anomaly appears to be K10-MIP for which the MIP log shows no obvious MIP/ECD response, but the on-site DSITMS analysis of the sorbent trap detected TCE and DCE.

4.4 COLLABORATIVE SOIL AND TEMPORARY MONITORING WELL GROUNDWATER SAMPLES

Soil and temporary monitoring well groundwater samples were collected for on-site DSITMS analysis and/or off-site laboratory analysis to collaborate the MIP/ECD and sorbent trap data.

4.4.1 Collaborative Soil Samples

Collaborative soil samples were collected for on-site DSITMS analysis to speciate and determine the approximate VOC concentrations of the strong MIP/ECD responses in H14-MIP and J16-MIP. Collaborative soil samples for off-site laboratory analysis were collected to collaborate the on-site DSITMS analytical results and to provide data to evaluate risk to human health posed by VOC contamination in the overburden soil at AREE 34.

4.4.1.1 Overburden Geology

A total of three soil borings were advanced during the FDVCO investigation for the collection of collaborative soil samples: two at grid point H14; and one at grid point J16. The boring logs for these three soil borings are presented in Appendix D. The soil boring for H14(2)-SB only provided geologic information for the 4-ft interval from which soil samples were collected. Soil borings H14(3) and J16(2) provided geologic

information from the ground surface to 15.7 and 14 ft bgs, respectively. The boring logs show similar overburden material as that described in previous field investigations (USACE, 2003a; 2003b). There are 5 to 6 ft of silt with some fine sand and trace clay, overlying 5 to 7 ft of silt and clay, which grades to silt with some clay and fine sand between 11 and 12 ft bgs, which finally grades to slightly weathered rock between 13 and 15 ft bgs. The change from the upper layer of silt with some fine sand and trace clay to the underlying silt and clay layer occurs at approximately 5 to 6 ft bgs. This change in grain size because of the increased amount of clay. This change in grain size is collaborated by the MIP conductivity readings in H14-MIP and J16-MIP which indicate a decrease in grain size (corresponding to an increase in conductivity readings) occurring at approximately 5 to 6 ft bgs.

4.4.1.2 On-site DSITMS Analysis

In response to the strong MIP/ECD response in H14-MIP, a total of four collaborative soil samples were collected from soil boring H14(2)-SB to speciate and quantify the VOC contamination in the soil from approximately 8 to 12 ft bgs. This depth range corresponds with the depth range on the H14 MIP log (see Appendix B) where the MIP/ECD response was off the scale. The soil samples were analyzed on-site by the DSITMS, and the results are presented in Table 4-4. PCE was the only VOC detected in the soil samples collected from H14(2)-SB. The very high concentration of PCE and the presence of substituted aromatic benzenes (noted by the on-site DSITMS analyst) raised the MDLs sufficiently for the other compounds that none were detected. The PCE concentrations in the soil samples from H14(2)-SB ranged from 560 to 11,068 μ g/kg (all estimated), with the highest concentration occurring at 8.5 ft bgs.

Subsequently, collaborative soil samples were collected for on-site DSITMS analysis at approximately 1-ft to 2-ft intervals from soil borings H14(3)-SB {a second soil boring located within 2 ft of the first soil boring [i.e., H14(2)-SB]} and J16(2)-SB to assess changes in VOC concentrations and speciation with depth. Collaborative soil samples were collected from grid point J16 because this location had the highest documented CCl_4 concentrations (based on the on-site DSITMS temporary monitoring well groundwater analytical results [see Section 4.4.2.1]).

The on-site DSITMS soil analytical results presented in Table 4-4 for H14(3)-SB show that PCE is the primary VOC present at this location. PCE was first detected at 6 ft bgs, and extended to the bottom of the borehole at approximately 15 ft bgs. PCE concentrations ranged from 56 to 1,200 μ g/kg (all estimated), with the highest concentration occurring at 7.5 ft bgs and the second highest concentration occurring at 8.5 ft bgs (990 µg/kg). The highly contaminated zone determined by on-site DSITMS analysis of soil samples from H14(3)-SB was determined to be from 7.5 to 12.5 ft bgs, which collaborates the zone of strong MIP/ECD responses in H14-MIP (see Figure 4-4 and discussion in Section 4.3.1). Figure 4-4 presents a comparison of the total VOC concentrations at the sampled depths within H14(3)-SB based on the on-site DSITMS soil analytical results versus the MIP/ECD response on the MIP log for H14-MIP. The total VOC concentrations are shown above the MIP/ECD profile at the proper depth to graphically present the collaboration of the on-site DSITMS soil analytical results and the MIP/ECD profile. The on-site DSITMS analysis of soil samples from both H14(2)-SB and H14(3)-SB also collaborates the speciation results obtained from the on-site DSITMS analysis of the sorbent trap sample from H14-MIP which identified very high levels of PCE and some DCE. Similarly to the samples collected from H14(2)-SB, the very high concentrations of PCE from 7.5 to 12.5 ft bgs and the presence of substituted aromatic benzenes (noted by the on-site DSITMS analyst) in the soil samples from H14(3)-SB raised the MDLs sufficiently for the other compounds that none were detected. At the depths where the PCE concentrations are lower (i.e., above [at 6 ft bgs] and below [at 15 ft bgs] the highly contaminated zone), low levels of TCE and DCE were also detected.

The maximum PCE concentration in H14(3)-SB (1,200 μ g/kg) was an order of magnitude less than the maximum PCE concentration in H14(2)-SB (11,068 μ g/kg), even though these two soil borings were within two feet of each other. This exemplifies the heterogeneity of the subsurface soil VOC contamination at AREE 34.

The on-site DSITMS soil analytical results presented in Table 4-4 for J16(2)-SB show no VOC contamination from 0 to 6 ft bgs. The soil samples collected below 6 ft bgs from J16(2)-SB indicate the

presence of CCl₄ (58 µg/kg maximum), TCE (17 µg/kg maximum [estimated]), DCE (23 µg/kg maximum [estimated]), and PCE (10 µg/kg maximum [estimated]). The contaminated zone determined by on-site DSITMS analysis of soil samples from J16(2)-SB was determined to be from 10 to 13 ft bgs, which collaborates the zone of MIP/ECD responses in J16-MIP (see Figure 4-5 and discussion in Section 4.3.1). Figure 4-5 presents a comparison of the total VOC concentrations at the sampled depths within J16(2)-SB based on the on-site DSITMS soil analytical results versus the MIP/ECD response on the MIP log for J16-MIP. The total VOC concentrations are shown above the MIP/ECD profile at the proper depth to graphically present the collaboration of the on-site DSITMS soil analytical results solit analytical results and the MIP/ECD profile. The on-site DSITMS analysis of soil samples from J16(2)-SB also collaborates the speciation results obtained from the on-site DSITMS analysis of the sorbent trap sample from J16-MIP which identified high levels of both CCl_4 and PCE and lesser levels of $CHCl_3 + TCA$, TCE, and DCE. The soil samples from grid point J16 showed considerably less contamination than was found at grid point H14.

The presence of CCl_4 in the soil samples from J16(2)-SB and the absence of CCl4 in the soil samples collected from H14(2)-SB and H14(3)-SB further suggest that the source of the VOC contamination at these two locations may be different.

4.4.1.3 Off-site Laboratory Analysis

Five soil samples (plus one field duplicate sample [a.k.a., co-located soil sample]) were collected from soil boring H14(3)-SB and four soil samples were collected from soil boring J16(2)-SB for off-site laboratory analysis of TCL VOCs. The purpose for collection of these soil samples for off-site laboratory analysis was to collaborate the on-site DSITMS soil analytical results and to provide off-site laboratory analytical results to evaluate the risk to human health posed by VOC contamination in overburden soils at AREE 34. A summary of the detected off-site laboratory soil analytical results is presented in Table 4-5. A comprehensive set of analytical results is provided in Appendix F. Note that soil samples collected for on-site DSITMS analysis and off-site laboratory analysis are all discrete grab samples; therefore, samples collected from what appears to be the same depth cannot be considered split samples. Although direct comparisons of the on-site DSITMS and off-site laboratory soil analytical results is not appropriate, conclusions regarding general trends with respect to contaminants present and depth of contamination can be made.

The off-site laboratory soil analytical results presented in Table 4-5 for H14(3)-SB show that PCE is the primary VOC present at this location. PCE concentrations ranged from 80.5 to 959 µg/kg, with the highest concentration occurring at 8.5 ft bgs and the second highest concentration occurring at 9.5 ft bgs (914 µg/kg). The highest concentrations of PCE in H14(3)-SB were within the highly contaminated zone of 7.5 to 12.5 ft bgs determined based on the on-site DSITMS soil analytical results (see Section 4.4.1.2). As a result of the analytical methodology used, the off-site laboratory was able to achieve better MDLs than could be achieved using the on-site DSITMS. Because of the better MDLs, the presence of DCE and TCE concentrations within the highly contaminated zone could be guantified. For the soil samples collected from 8.5 to 10.5 ft bgs, 1,1-DCE ranged from 226 to 665 μg/kg, cis-1,2-DCE ranged from 23.1 μg/kg (estimated) to 45.6 µg/kg (estimated), and TCE ranged from 73.3 µg/kg (estimated) to 320 µg/kg. Other detected compounds in the highly contaminated zone included DCA compounds, TCA compounds, trace chloroform (in only one sample), and trace xylene (in only one sample). CCl₄ was not detected in any of the soil samples from H14(3)-SB which collaborates the findings of the on-site DSITMS soil and sorbent trap analytical results. Similar to the on-site DSITMS soil analytical results, no VOCs were detected in the soil sample collected at 4 ft bgs, and the concentrations of VOC compounds in the soil sample collected at 15.5 ft bgs were generally lower than the concentrations observed in the samples collected at 8.5, 9.5, and 10.5 ft bas.

The off-site laboratory soil analytical results presented in Table 4-5 for J16(2)-SB show that CCl₄ is the primary contaminant, which is consistent with the on-site DSITMS soil analytical results (see Section 4.4.1.2). CCl₄ concentrations ranged from 20.2 to 37.6 μ g/kg in the soil samples collected from 11 to 13.5 ft bgs, which collaborates the contaminated zone determined by on-site DSITMS analysis of soil samples from J16(2)-SB of 10 to 13 ft bgs (see Section 4.4.1.2). Other chlorinated VOCs detected in the

contaminated zone based on off-site laboratory analysis included chloroform (5.6 μ g/kg [estimated] to 8.4 μ g/kg), 1,1-DCE (5.7 μ g/kg [estimated] to 19 μ g/kg), PCE (4.4 μ g/kg [estimated] to 13.5 μ g/kg), 1,1,2-TCA (4.6 μ g/kg [estimated]), and TCE (7.1 to 18.3 μ g/kg). All of these VOCs were also detected in both the on-site DSITMS soil analytical results for J16(2)-SB (see Section 4.4.1.2) and the on-site DSITMS sorbent trap analytical results for J16-MIP, which identified high levels of both CCl₄ and PCE and lesser levels of CHCl₃ + TCA, TCE, and DCE (see Section 4.3.2). Similar to the on-site DSITMS soil analytical results, no chlorinated VOCs were detected in the soil sample collected at 4 ft bgs.

4.4.2 Collaborative Temporary Monitoring Well Groundwater Samples

On the first day of the FDVCO investigation high density sampling, the FST decided to install a temporary monitoring well at each MIP location because the installation of a temporary monitoring well would allow the collection of a collaborative groundwater sample that could be analyzed by the on-site DSITMS with much lower detection limits. Temporary monitoring wells were installed at each MIP location with the exception of the two MIP locations adjacent to MW34-4, since there was already a permanent monitoring well at that location, and the MIP locations at grid points L18 and A21, as a result of squeezing clay, for a total of 18 temporary monitoring wells (see Table 2-1). Groundwater samples were collected from all but two of the 18 temporary monitoring wells (i.e., D13-TW and K30-TW) for analysis by the on-site DSITMS and/or the off-site laboratory.

4.4.2.1 On-site DSITMS Analysis

Groundwater samples were collected for on-site DSITMS analysis from all but three of the 18 temporary monitoring wells installed during the FDVCO investigation. Groundwater samples were not collected from D13-TW, K30-TW, or G11-TW for on-site DSITMS analysis (see Figure 4-6).

A total of 17 groundwater samples were collected from 15 of the temporary monitoring wells for analysis of VOCs by the on-site DSITMS. The two extra samples were a field duplicate sample collected from temporary monitoring well C23-TW and a second groundwater sample collected (three days after the first sample) from F20-TW. The on-site DSITMS results for the temporary monitoring well groundwater samples are presented in Table 4-6.

No VOCs were detected in the groundwater samples collected from 9 of the 15 temporary monitoring wells sampled for on-site DSITMS analysis as shown in Table 4-6 and on Figure 4-6. Of the remaining six temporary monitoring wells, the groundwater sample collected from C23-TW was the only one in which all of the detected VOCs were below the corresponding MCLs. TCE (estimated at 0.5 μ g/L) and PCE (estimated at 4.2 μ g/L) were detected in the groundwater sample from C23-TW.

The groundwater samples collected from five of the 15 temporary monitoring wells contained one or more VOCs that exceeded the corresponding MCLs: C20-TW (PCE only), F20-TW, H14-TW, J16-TW, and K10-TW (PCE only) (see Table 4-6 and Figure 4-6). PCE was the VOC with the highest concentration in four of the five temporary monitoring well groundwater samples in which MCLs were exceeded; CCl₄ was the VOC with the highest concentration in the groundwater sample from J16-TW. PCE was detected in the groundwater sample from each of these five temporary monitoring wells with concentrations that ranged between an estimated 8.3 μ g/L (at K10-TW) and 2,440 μ g/L (at H14-TW), which all exceeded the MCL for PCE of 5 μ g/L. TCE was only detected above the MCL of 5 μ g/L in the groundwater samples from H14-TW and J16-TW at concentrations of 743 μ g/L and 55 μ g/L, respectively. DCE was also only detected above the MCL for 1,1-DCE of 7 μ g/L in the groundwater samples from H14-TW and J16-TW at concentrations of 1,516 μ g/L and 53.6 μ g/L, respectively. CCl₄ was detected above the MCL of 5 μ g/L in the groundwater samples from F20-TW (6.7 μ g/L [estimated] to 12.7 μ g/L) and J16-TW (261 μ g/L). The observed differences between the on-site DSITMS analytical results for the two groundwater samples from F20-TW (collected three days apart) indicate the variability of groundwater quality over time.

The temporary monitoring well groundwater samples collected from H14-TW and J16-TW were the only samples that contained total VOCs at concentrations greater than what was found in the PDB groundwater samples collected from monitoring well MW34-4 (see Table 4-1). The highest level of VOC contamination (by one order of magnitude) in the groundwater was detected in H14-TW. The second highest

level of VOC contamination (one order of magnitude less than H14-TW) in the groundwater was detected in J16-TW. H14-TW and J16-TW are both located downgradient (based on horizontal groundwater flow in the saturated overburden material) of monitoring well MW34-4, as is K10-TW. The other two temporary monitoring wells showing exceedences of MCLs (C20-TW and F20-TW) are located upgradient of monitoring well MW34-4.

Comparison of the on-site DSITMS temporary monitoring well groundwater results presented in Table 4-6 with the MIP logs presented in Appendix B (and discussed in Section 4.3.1) indicates that the on-site DSITMS results collaborate the VOC contaminant distributions across the site as determined by the MIP/ECD responses. That is, for the locations for which temporary monitoring well groundwater samples were collected and analyzed by the on-site DSITMS, the highest VOC contamination is present at grid point H14, followed by J16, and then followed by F20. The on-site DSITMS analysis of temporary monitoring well groundwater samples also collaborates the speciation results obtained from the on-site DSITMS analysis of the sorbent trap samples which identified very high levels of PCE and some DCE at H14; high levels of both CCl_4 and PCE and lesser levels of $CHCl_3 + TCA$, TCE, and DCE at J16; and high levels of PCE at F20 (see Section 4.3.2).

The distribution of VOC contaminants across the site as determined based on the on-site DSITMS temporary monitoring well groundwater analytical results (see Table 4-6 and Figure 4-6), and in particular the limited extent of CCl_4 contamination across the site, support the CSM that there are at least two sources of the VOC contamination at AREE 34.

4.4.2.2 Off-site Laboratory Analysis

A total of six selected temporary monitoring well groundwater samples were analyzed by the off-site laboratory for TCL VOCs. The purpose for collection of these temporary monitoring well groundwater samples for off-site laboratory analysis was to collaborate the on-site DSITMS temporary monitoring well groundwater analytical results and to provide off-site laboratory analytical results to evaluate the risk to human health posed by VOC contamination in overburden groundwater at AREE 34.

Temporary monitoring well groundwater samples for off-site laboratory analysis were collected from C18-TW, F20-TW, G11-TW, H14-TW, J16-TW, and K24-TW. Groundwater samples from all of these temporary monitoring wells were also analyzed by the on-site DSITMS except for G11-TW. Only two of the temporary monitoring well groundwater samples analyzed by the off-site laboratory are split samples (i.e., were collected at the same time) with the corresponding temporary monitoring well groundwater samples analyzed by the on-site DSITMS; these are the groundwater samples from C18-TW and F20-TW. A summary of the detected off-site laboratory analytical results for the temporary monitoring well groundwater samples is presented in Table 4-7. A comprehensive set of analytical results is provided in Appendix F.

Similar to the on-site DSITMS temporary monitoring well groundwater analytical results, no VOCs exceeded MCLs in the groundwater samples collected from C18-TW and K24-TW.

The highest level of VOC contamination was detected in the groundwater sample from H14-TW where seven VOCs were detected above the corresponding MCLs (see Table 4-7 and Figure 4-7): 1,2-DCA (40.5 μ g/L; MCL = 5 μ L); 1,1-DCE (1,860 μ g/L; MCL = 7 μ L); cis-1,2-DCE (80.7 μ g/L; MCL = 70 μ L); methylene chloride (40.1 μ g/L; MCL = 5 μ L); PCE (607 μ g/L; MCL = 5 μ L); 1,1,2-TCA (97.9 μ g/L; MCL = 5 μ L); and TCE (422 μ g/L; MCL = 5 μ L). Not only do these results collaborate the on-site DSITMS temporary monitoring well groundwater results with respect to the fact that the highest level of VOC contamination is present at grid point H14, but they also collaborate the associated VOC speciation (i.e., PCE, DCE, and TCE are present above MCLs; CCl₄ is not present).

The second highest level of VOC contamination was detected in the groundwater sample from J16-TW where four VOCs were detected above the corresponding MCLs (see Table 4-7 and Figure 4-7): CCl₄ (172 μ g/L; MCL = 5 μ L); 1,1-DCE (78.2 μ g/L; MCL = 7 μ L); PCE (17.3 μ g/L; MCL = 5 μ L); and TCE (34.5 μ g/L; MCL = 5 μ L). Not only do these results collaborate the on-site DSITMS temporary monitoring well groundwater results with respect to the fact that the second highest level of VOC contamination is present

at grid point J16, but they also collaborate the associated VOC speciation (i.e., CCl₄, PCE, DCE, and TCE are present above MCLs).

Similar to the on-site DSITMS temporary monitoring well groundwater analytical results, the VOC contamination detected in the groundwater sample from F20-TW was lower than that found in either H14-TW or J16-TW. Only two VOCs were detected above the corresponding MCLs in the groundwater sample from temporary monitoring well F20-TW (see Table 4-7 and Figure 4-7): CCl_4 (21.2 µg/L; MCL = 5 µL); and PCE (100 µg/L; MCL = 5 µL). These results also collaborate the on-site DSITMS temporary monitoring well groundwater results with respect to the associated VOC speciation (i.e., CCl_4 and PCE are present above MCLs).

Two VOCs were detected above the corresponding MCLs in the groundwater sample from temporary monitoring well G11-TW (see Table 4-7 and Figure 4-7): 1,1-DCE (13.7 μ g/L; MCL = 7 μ L); and PCE (10.6 μ g/L; MCL = 5 μ L). There is no corresponding on-site DSITMS temporary monitoring well groundwater sample from G11-TW.

Acetone was detected in all six temporary monitoring well groundwater samples, but was qualified with a "B" indicating the analyte should be considered non-detect. As discussed in Section 3.3.5, it was determined after examining the data that the PVC well materials had been scrubbed with isopropyl alcohol and were sealed in polyethylene bags. Acetone is a resulting by-product from isopropyl alcohol and, therefore, all temporary monitoring well samples were qualified "B" for blank contamination for acetone.

4.4.3 Comparison of Temporary Monitoring Well and Permanent Monitoring Well Groundwater Analytical Results

A comparison of temporary monitoring well groundwater analytical results to permanent monitoring well groundwater analytical results is necessary to assess whether the temporary monitoring well results from the FDVCO investigation are representative of the existing site conditions such that they are suitable for use in risk assessment. None of the temporary monitoring wells installed as part of the FDVCO investigation were located adjacent to existing permanent monitoring wells. However, during the AREE 34 RI conducted during 2001 (USACE, 2003a), one temporary monitoring well (G6) was installed and sampled near permanent monitoring well NP-PZ2; and permanent monitoring wells MW34-1, MW34-2, and MW34-3 were installed at the locations of temporary monitoring wells U20, P15, and D6, respectively, approximately two months after the temporary monitoring well samples were collected. The locations of the RI temporary monitoring wells and the permanent monitoring wells are presented on Figure 21. The temporary monitoring wells installed as part of the RI were constructed similarly to the temporary monitoring wells installed during the FDVCO investigation, and the groundwater samples were collected using the same technique (i.e., no purging, small-diameter bailer). The corresponding analytical results for the temporary monitoring well/permanent monitoring well groundwater sample "pairs" are presented in Table 4-8. It should be noted that although the RI temporary monitoring well and the RI permanent monitoring well groundwater samples were analyzed by different laboratories, they were all analyzed by off-site laboratories using USEPA SW-846 Method 8260B. Analytical results are only presented for PCE and TCE in Table 4-8 because the temporary monitoring well groundwater samples collected during the RI were only analyzed for these two VOC compounds.

On March 5 and 7, 2001, respectively, groundwater samples were collected from temporary monitoring well G6 and permanent monitoring well NP-PZ2 using the no purging and small-diameter bailer sampling technique. The analytical results for the groundwater samples collected from temporary monitoring well G6 and permanent monitoring well NP-PZ2 (located approximately 10 ft apart) in March, 2001, indicate the variability of groundwater quality within localized areas. Table 4-8 presents analytical results for two groundwater samples collected from permanent monitoring well NP-PZ2 which were collected almost three months apart using different sample collection techniques. The groundwater sample collected on March 7, 2001, was collected using the no purging and small-diameter bailer technique (similar to the technique used to sample the temporary monitoring wells), while the groundwater sample collected on May 24, 2001, was collected from NP-PZ2 are nearly identical. This suggests that the no purging, small-

diameter bailer sampling technique used to sample the temporary monitoring wells can produce samples that are representative of actual site conditions.

PCE and TCE were not detected in the groundwater samples from either temporary monitoring well U20 or the corresponding permanent monitoring well MW34-1. This suggests that temporary monitoring well analytical results showing no detectable VOCs are representative of actual site conditions where there are no detectable VOCs present.

VOCs were detected in groundwater samples from temporary monitoring wells D6 and P15 and the corresponding permanent monitoring wells MW34-3 and MW34-2, respectively. In both instances, the VOC concentrations in the temporary monitoring well groundwater samples were slightly greater than the VOC concentrations in the permanent monitoring well groundwater samples. The observed difference between the temporary monitoring well and permanent monitoring well groundwater samples were collected almost three months apart. However, if the observed difference is related only to the well construction and sample collection technique, then the higher temporary monitoring well groundwater analytical results provide a more conservative representation of the site conditions. Thus, it can be concluded that not only can the no purging, small-diameter bailer sampling technique used to sample the temporary monitoring wells produce samples that are representative of actual site conditions (as discussed above), but also that temporary monitoring wells sampled using this technique provide groundwater samples that are representative of actual site conditions and are, therefore, suitable for use in risk assessment.

4.5 COMPARISON OF OFF-SITE LABORATORY AND ON-SITE DSITMS GROUNDWATER ANALYTICAL RESULTS

This section presents a comparison of off-site laboratory groundwater analytical results to on-site DSITMS groundwater analytical results. A comparison of the off-site and on-site analytical results can only be made for split samples as discussed further below. Since soil samples represent separate discrete grab samples, no true split samples exist for soil. Therefore, a comparison of off-site laboratory soil analytical results to on-site DSITMS soil analytical results could not be performed. Any variability between off-site laboratory and on-site DSITMS analytical results for soil samples collected at approximately the same depth is more likely due to contaminant heterogeneity characteristic of soils rather than analytical differences.

Several temporary monitoring well and PDB groundwater samples were shipped off site for laboratory analysis. Many of the temporary monitoring wells had low yields, and were not able to provide sufficient groundwater to fill both the on-site (two 40-mL vials) and off-site (three 40-mL vials) sample containers. Based on the nature of the dynamic field program, preference was given to the collection of groundwater samples for on-site DSITMS analysis. In many cases, the temporary monitoring well groundwater samples for off-site laboratory analysis were collected several days after the temporary monitoring well groundwater samples for on-site DSITMS analysis were collected (see Table 2-1). A comparison of on-site and off-site analytical results can only be made for groundwater split samples; that is, when groundwater samples for on-site and off-site analysis were collected at the same time. When groundwater samples for on-site and off-site analysis were collected on different days, differences in analytical results may be the result of likely variability that can occur due to several factors affecting VOC concentrations.

On-site and off-site groundwater split samples were collected from only two temporary monitoring wells [F20-TW and C18-TW]. Three PDB groundwater split samples (plus one field duplicate sample) from MW34-4 were also collected for on-site DSITMS and off-site laboratory analysis. The analytical results for the four most-significant VOC contaminants (CCl₄, TCE, DCE, and PCE) for the groundwater samples collected from the saturated overburden and analyzed by both the on-site DSITMS and the off-site laboratory are presented in Table 4-9. (Note that although two PDB groundwater split samples [plus one field duplicate sample] were collected from MW34-7D for on-site and off-site analysis, the analytical results are not included in Table 4-9 since this assessment focuses on the VOC contamination in the saturated overburden material and not the bedrock aquifer.)

Table 4-9 presents the ratio between the off-site laboratory groundwater analytical results and the on-site DSITMS groundwater analytical results for split samples. A ratio between the off-site laboratory groundwater analytical results and the on-site DSITMS groundwater analytical results was only calculated for VOC compounds detected in both samples of the split sample pair; therefore, ratios are not presented for the temporary monitoring well groundwater split samples from C18-TW. The off-site laboratory groundwater analytical results ranged between 119.8 and 302.4 percent greater than the on-site DSITMS groundwater analytical results, with the average at 184.1 percent. The largest differences between the off-site laboratory and the on-site DSITMS groundwater analytical results occurred for DCE (see Table 4-9) which may be partially explained by the fact that the on-site DSITMS was calibrated using cis-1,2-DCE, while 1,1-DCE is the predominant DCE compound observed at AREE 34 (see Table 4-7).

Although the on-site laboratory groundwater analytical results are consistently higher than the on-site DSITMS analytical results, the comparison of the on-site DSITMS groundwater analytical results to the off-site laboratory groundwater analytical results presented in Table 4-9 clearly shows that the on-site DSITMS accurately identifies the individual VOC constituents present and effectively determines the relative differences of VOC contamination between groundwater samples (i.e., concentration trends are similar to those identified based on the off-site laboratory groundwater analytical results). Thus, while the on-site DSITMS groundwater analytical results may not be usable for quantitative assessment of site conditions (e.g., risk assessment), they are very effective in determining where the highest concentrations of VOC contamination exist as well as the distribution/speciation of VOC contamination across the site and, therefore, can be used to make qualitative risk management decisions. Based on the on-site DSITMS groundwater analytical results (in conjunction with the MIP/ECD measurements), it is clear that the grid locations having the highest VOC contamination are H14 and J16. Off-site laboratory analytical results are available for temporary monitoring well groundwater samples collected from these two grid locations to represent the locations of highest VOC contamination for use in risk assessment.

5.0 SUMMARY AND CONCLUSIONS

During this FDVCO investigation, a variety of on-site, real-time measurement tools were used in combination with conventional soil and groundwater sample collection and analysis techniques using a dynamic work approach to build a strong collaborative data set to refine the CSM for AREE 34. During the FDVCO investigation, the following data were collected at AREE 34:

- On-site DSITMS analytical results for 22 PDB groundwater samples collected from four saturated overburden monitoring wells and 10 PDB groundwater samples collected from two bedrock aquifer monitoring wells;
- Off-site laboratory analytical results for 3 PDB groundwater samples collected from one saturated overburden monitoring well (MW34-4) and two PDB groundwater samples collected from one bedrock aquifer monitoring well (MW34-7D);
- MIP logs for 21 different locations (with MW34-4 counting as one location even though the MIP was advanced three times at this location, including one advancement within the monitoring well itself) to provide a variety of real-time data including soil conductivity and ECD response for chlorinated VOCs;
- Qualitative on-site DSITMS VOC speciation results for at least one sorbent trap from each MIP advancement;
- On-site DSITMS analytical results for 21 soil samples collected from three soil borings at two locations;
- Off-site laboratory analytical results for nine soil samples collected from soil borings at two locations;
- On-site DSITMS analytical results for groundwater samples collected from 15 temporary monitoring wells; and
- Off-site laboratory analytical results for groundwater samples collected from 6 temporary monitoring wells.

As discussed in detail in Section 4, each piece of data collected during the FDVCO investigation collaborated all of the other data to build a strong collaborative data set. This summary presents the overall findings that can be gleaned from this collaborative data set as it relates to the CSM for AREE 34.

Utilizing the collaborative data set produced during the FDVCO investigation, the following observations regarding the VOC contamination in the overburden at AREE 34 can be made:

- The concentrations of VOC contaminants in monitoring well MW34-4 increase with depth, while the VOC concentrations in monitoring wells MW34-2, MW34-3, and NP-PZ2 are fairly consistent throughout the well screen interval;
- There is no source of greater VOC contamination upgradient (based on horizontal groundwater flow in the saturated overburden material) of monitoring well MW34-4;
- The highest VOC concentrations are located at grid point H14 (downgradient of MW34-4) at a depth of approximately 7.5 to 12.5 ft bgs, with the primary contaminant being PCE;
- The second highest VOC concentrations (at least one order of magnitude lower than the concentrations at grid point H14) are located at grid point J16 (downgradient of MW34-4) at a depth of approximately 10 to 13 ft bgs, with the primary contaminant being CCl₄;
- The third highest VOC concentrations are located at MW34-4 at a depth of approximately 9 to 12 ft bgs, with the primary contaminants being CCl₄ and DCE;
- The extent of the highest VOC contamination at grid point H14 appears to be very limited as demonstrated by the order of magnitude differences between soil analytical results for samples collected laterally within two feet of each other at the same depth horizon and one to two orders

of magnitude lower VOC concentrations at nearby sampling points (i.e., E15 [from the AREE 34 RI], G11, K10, J16, L18, K24, H23, F20, MW34-4, and C18);

- The CSM that there are two or more sources of contamination, possibly the result of small spills of solvent, is supported by the presence of CCl₄ as the primary VOC contaminant at grid point J16 and the lack of CCl₄ at grid point H14;
- The CCl₄ contamination exceeding the MCL has limited lateral extent, centered around MW34-4 and J16 and extending to F20 and MW34-2 (based on RI and SRI data);
- VOC contamination occurs within the finer grained soils that lie at depths greater than 5 to 6 ft bgs across the site;
- Off-site temporary monitoring well groundwater analytical results collected during the FDVCO investigation are representative of site conditions, are available for the two locations having the highest VOC concentrations (H14 and J16), and are, therefore, adequate and sufficient for evaluating risks associated with the VOC contamination in the overburden groundwater at AREE 34; and
- The concentration trends provided by the on-site DSITMS temporary monitoring well groundwater analytical results provide information on the extent of VOC contamination in the saturated overburden at AREE 34 that can be used to make qualitative risk management decisions.

Figure 5-1 provides a graphic presentation of the groundwater results from the FDVCO investigation as well as previous investigations at AREE 34. The sample locations highlighted in magenta represent locations where at least one VOC is present in the groundwater in excess of its MCL based on temporary monitoring well and/or permanent monitoring well groundwater analytical results. As shown on Figure 5-1, the sampling conducted during the FDVCO investigation, the RI, and the SRI have established the boundaries of the VOC contamination at AREE 34.

Based on this summary, it is concluded that the objectives of the FDVCO investigation have been achieved as follows:

- The highest concentration of VOCs in the overburden soil and groundwater at AREE 34 has been identified at grid point H14, and the highest concentration of CCl₄ in the overburden soil and groundwater at AREE 34 has been identified at grid point J16;
- 2. The off-site laboratory temporary monitoring well groundwater analytical data have been shown to be suitable for use in risk assessment such that additional permanent saturated overburden monitoring wells are not required to evaluate risk posed to human health by the VOC contamination in the overburden groundwater at AREE 34; and
- 3. Off-site soil analytical data to evaluate risk posed to human health by VOC contamination in the overburden at AREE 34 was collected.
6.0 REFERENCES

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APPENDIX A
DAILY QUALITY CONTROL REPORTS

SAMPLE COLLECTION LOG SHEET

APPENDIX B

MEMBRANE INTERFACE PROBE (MIP) LOGS

The scales for the MIP logs have been normalized. As a result of this normalization, some information on the Electron-Capture Detector (ECD) graphs on the MIP logs was lost for H14-MIP, J16-MIP, and MW34-4(2)-MIP. Therefore, two MIP logs are provided for H14-MIP, J16-MIP, and MW34-4(2)-MIP: the first one is normalized; and the second one is normalized for all graphs except the ECD graph.

APPENDIX C GLOBAL POSITIONING SYSTEM (GPS) DATA APPENDIX D BORING LOGS APPENDIX E

CLEANING PROTOCOL FOR TEMPORARY MONITORING WELL PVC MATERIALS

APPENDIX F

OFF-SITE LABORATORY ANALYTICAL RESULTS

SOIL SAMPLES

PASSIVE DIFFUSION BAG GROUNDWATER SAMPLES

TEMPORARY MONITORING WELL GROUNDWATER SAMPLES

TRIP BLANKS

CHAIN-OF-CUSTODY FORMS

Table 2-1

			Well				
			Screen		Analyzed	-	
Well	Grid	Date	Interval	Date	On Site or	Date	
ID	Location	Installed	(ft bgs)	Sampled	Off Site?	Abandoned	
A15-TW	A15	11/19/2003	2 - 12	11/21/2003	On	11/24/2003	
A18-TW	A18	11/18/2003	1 - 11	11/19/2003	On	11/24/2003	
A30-TW	A30	11/20/2003	8 - 18	11/21/2003	On	11/24/2003	
C18-TW	C18	11/19/2003	5 - 15	11/21/2003	On & Off	11/24/2003	
C20-TW	C20	11/18/2003	7 - 17	11/19/2003	On	11/24/2003	
C23-TW	C23	11/17/2003	7 - 17	11/18/2003	On	11/24/2003	
D13-TW	D13	11/21/2003	7 - 17	NS	NS	11/24/2003	
E23-TW	E23	11/18/2003	8 - 18	11/18/2003	On	11/24/2003	
	F20	11/17/2002	0 10	11/18/2003	On	11/01/0000	
F20-1VV	F20	11/1//2003	0 - 10	11/21/2003	On & Off	11/24/2003	
F30-TW	F30	11/20/2003	8 - 18	11/21/2003	On	11/24/2003	
FF20-TW	FF20	11/19/2003	4 - 9	11/21/2003	On	11/24/2003	
G11-TW	G11	11/21/2003	4 - 14	11/24/2003	Off	11/25/2003	
	LI11	11/20/2002	5 15	11/21/2003	On	11/25/2002	
T14-1VV	П1 4	11/20/2003	5 - 15	11/24/2003	Off	11/25/2005	
H23-TW	H23	11/18/2003	6 - 16	11/19/2003	On	11/24/2003	
	116	11/20/2002	2 12	11/21/2003	On	11/25/2002	
310-177	J 10	11/20/2003	2 - 12	11/24/2003	Off	11/25/2003	
K10-TW	K10	11/20/2003	2 - 12	11/21/2003	On	11/24/2003	
	K04	11/10/2002		11/19/2003	On	11/05/0000	
r\24-1VV	r\24	11/10/2003	4.3 - 14.3	11/24/2003	Off	11/20/2003	
K30-TW	K30	11/21/2003	8 - 18	NS	NS	11/24/2003	

AREE 34 FDVCO Temporary Well Construction Details

ft bgs - feet below ground surface

ID - Identification

NS - Not sampled

Off - Sample was analyzed off site by analytical laboratory

On - Sample was analyzed on site by DSITMS

Membrane Interface Probe Performance Test Results

			PID				ECE		
		PCE/				PCE/			
		TCE/				TCE/			
Performance		CCI₄				CCI₄			
Test		Conc.	Baseline	Response	Difference	Conc.	Baseline	Response	Difference
ID	Date	(μg/L)	(μ V)	(μV)	(μV)	(μ g/L)	(μ V)	(μV)	(μV)
PT-111703-01	11/17/2003	200	53,000	54,000	1,000	200	180,000	770,000	590,000
PT-111803-01	11/18/2003	200	52,000	52,000	0	200	230,000	300,000	70,000
PT-111803-02	11/18/2003	200	52,000	52,000	0	200	64,000	170,000	106,000
PT-111903-01	11/19/2003	200	50,000	50,000	0	200	35,000	140,000	105,000
PT-112003-01	11/20/2003	200	48,000	48,000	0	200	95,000	230,000	135,000
PT-112003-02	11/20/2003	200	47,000	48,000	1,000	200	82,000	160,000	78,000
PT-112103-01	11/21/2003	200	52,000	52,000	0	200	140,000	240,000	100,000

CCl₄ - Carbon Tetrachloride

ECD - Electron-capture Detector

ID - Identification

PCE - Tetrachloroethene

PID - Photoionization Detector

TCE - Trichloroethene

		CHCl ₃ +				_		
	Date	TCA ¹	CCI ₄ ²	TCE ³	DCE⁴	PCE⁵		
QC Sample ID	Analyzed	(μ g/L)	(μ g/L)	(μ g/L)	(μ g/L)	(μg/L)		
20 ppb VH01 03	11/17/2003	17.4	20.4	21.1	19.1	19.9		
20 ppb VH01 04	11/17/2003	15.0	19.0	19.2	16.2	19.0		
20 ppb VH01 02	11/18/2003	18.7	19.3	19.8	18.1	18.6		
20 ppb VH01 03	11/18/2003	19.2	21.0	22.8	19.2	19.0		
20 ppb VH01 04	11/18/2003	17.9	19.0	19.5	16.5	18.9		
20 ppb VH01 05	11/18/2003	18.7	20.2	20.8	18.1	20.0		
20 ppb VH01 06	11/18/2003	Data missed ⁶						
20 ppb VH01 02	11/20/2003	17.0	20.0	19.7	20.1	19.7		
20 ppb VH01 03	11/20/2003	27.0	23.7	24.6	22.9	25.9		
20 ppb VH01 04	11/20/2003	25.4	21.2	21.7	21.3	22.5		
20 ppb VH01 02	11/21/2003	21.3	22.4	22.5	21.7	22.4		
20 ppb VH01 04	11/21/2003	20.7	19.4	19.5	19.2	18.0		
20 ppb VH01 05	11/21/2003	23.2	21.4	21.4	20.3	22.1		
20 ppb VH01 06	11/21/2003	23.1	19.9	20.1	21.5	21.3		
20 ppb VH01 07 ⁷	11/21/2003	22.9	20.3	21.1	20.9	22.1		
20 ppb VH01 08 ⁷	11/21/2003	17.7	21.7	23.1	22.3	23.0		
20 ppb VH01 09 ⁷	11/21/2003	17.0	20.5	20.8	20.0	20.7		

Continuing Calibration Check Standard Results - On-site DSITMS Analysis

Shaded values are outside the Quality Assurance Criteria range (i.e., $15 - 25 \mu g/L$).

¹ Chloroform and Trichloroethane

² Carbon Tetrachloride

³ Trichloroethene

⁴ Dichloroethene

⁵ Tetrachloroethene

⁶ The data for this QC sample were not obtained because the DSITMS mass axis shifted during the analysis by one mass unit. The problem was corrected by re-calibration of the mass axis immediately after the run was completed.

⁷ Performed during analysis of soil samples. All other continuing calibration check standards were performed during analysis of groundwater samples.

ID - Identification

QC - Quality Control

		CHCl ₃ +				
	Date	TCA ¹	CCI ₄ ²	TCE ³	DCE ⁴	PCE⁵
Sample Number	Analyzed	(μ g/L)	(μg/L)	(μg/L)	(μ g/L)	(μ g/L)
MW34-2-PDB-5	11/18/2003	1.6 J	<2.7	18.8	20.8	8.2
MW34-2-PDB-5 AD	11/18/2003	1.0 J	<2.7	17.0	18.1	8.1
	%RPD	46.1	NA	10.1	13.9	1.2
MW34-5D-PDB-2	11/18/2003	2.2 J	5.3	0.4 J	<4.1	4.8
MW34-5D-PDB-2 AD	11/18/2003	2.6 J	6.0	0.9 J	<4.1	5.0
	%RPD	16.7	12.4	76.9	NA	4.1
NP-PZ2-PDB-5D	11/20/2003	<7.1	<2.7	14.7	23.7 J	12.6
NP-PZ2-PDB-5D AD	11/20/2003	<7.1	<2.7	14.2	23.1	14.3
	%RPD	NA	NA	3.5	2.6	12.6
K10-TW-(2-12)	11/21/2003	<7.1	<2.7	<3.2	4.6	8.3
K10-TW-(2-12) AD	11/21/2003	<7.1	<2.7	<3.2	5.1	7.4
	%RPD	NA	NA	NA	10.3	11.5

Groundwater Analytical Duplicate Results - On-site DSITMS Analysis

Shaded values exceed the Quality Assurance Criteria (i.e., RPD=30%).

¹ Chloroform and Trichloroethane

² Carbon Tetrachloride

³ Trichloroethene

⁴ Dichloroethene

⁵ Tetrachloroethene

J - Reported value may not be accurate or precise (estimated).

NA - Not Applicable

RPD - Relative Percent Difference

Field		CHCl ₃ +				
Sample	Date	TCA ¹	CCI ₄ ²	TCE ³	DCE ⁴	PCE⁵
Number	Analyzed	(μ g/L)	(μg/L)	(μ g/L)	(μg/L)	(μg/L)
MW34-4-PDB-2	11/17/2003	<7.1	13.3	11.3	17.8	3.0 J
MW34-4-PDB-2D	11/17/2003	<7.1	14.8	13.1	19.1	3.5 J
	%RPD	NA	10.7	14.8	7.1	15.4
MW34-5D-PDB-1	11/18/2003	1.6 J	4.3	0.8 J	<4.1	4.5
MW34-5D-PDB-1D	11/18/2003	1.8 J	4.9	0.9 J	<4.1	4.6
	%RPD	11.8	13.0	11.8	NA	2.2
MW34-7D-PDB-3	11/18/2003	<7.1	<2.7	25.7 J	42.7 J	9.1 J
MW34-7D-PDB-3D	11/18/2003	<7.1	<2.7	35.5 J	60.8 J	14.2 J
	%RPD	NA	NA	32.0	35.0	43.8
C23-TW-(7-17)	11/18/2003	<7.1	<2.7	0.5 J	<4.1	4.2 J
C23-TW-(7-17)D	11/18/2003	<7.1	<2.7	0.5 J	<4.1	1.9 J
	%RPD	NA	NA	0.0	NA	75.4
NP-PZ2-PDB-5	11/18/2003	<7.1	<2.7	14.2	16.9 J	11.5
NP-PZ2-PDB-5D	11/20/2003	<7.1	<2.7	14.7	23.7 J	12.6
	%RPD	NA	NA	3.5	33.5	9.1

Groundwater Field Sampling Duplicate Results - On-site DSITMS Analysis

Shaded values exceed the Quality Assurance Criteria (i.e., RPD=30%).

¹ Chloroform and Trichloroethane

² Carbon Tetrachloride

- ³ Trichloroethene
- ⁴ Dichloroethene
- ⁵ Tetrachloroethene

J - Reported value may not be accurate or precise (estimated).

NA - Not Applicable

RPD - Relative Percent Difference

		CHCl ₃ +				
	Date	TCA ¹	CCI ₄ ²	TCE ³	DCE ⁴	PCE⁵
QC Sample ID	Analyzed	(μ g/L)	(μ g/L)	(μ g/L)	(μ g/L)	(μ g/L)
20 ppb VOC M1A 01	11/18/2003	<7.1	<2.7	17.5	<4.1	<4.4
20 ppb VOC M1A 02	11/18/2003	<7.1	<2.7	20.0	<4.1	<4.4
20 ppb VOC M1A 01	11/20/2003	<7.1	<2.7	20.3	<4.1	<4.4
20 ppb VOC M1A 01	11/21/2003	<7.1	<2.7	22.6	<4.1	<4.4
20 ppb VOC M1A 02	11/21/2003	<7.1	<2.7	16.4	<4.1	<4.4
20 ppb VOC M1A 03 ⁶	11/21/2003	<7.1	<2.7	22.0	<4.1	<4.4

Performance Evaluation Check Standard Results - On-site DSITMS Analysis

Shaded values are outside the Quality Assurance Criteria range (i.e., 14 - 26 $\mu g/L)$ for TCE.

¹ Chloroform and Trichloroethane

² Carbon Tetrachloride

³ Trichloroethene

⁴ Dichloroethene

⁵ Tetrachloroethene

⁶ Performed during analysis of soil samples. All other performance evaluation check standards were performed during analysis of groundwater samples.

ID - Identification

QC - Quality Control

Matrix Spike Recovery Results - On-site DSITMS Analysis

		Quality Assurance CHCl ₃ +									
	Date	Criteria	TCA ¹		TCE ³	DCE⁴	PCE⁵				
QC Sample ID	Analyzed	(μ g/L)	(μ g/L)	(μg/L)	(μg/L)	(μ g/L)	(μ g/L)				
Groundwater											
NP-PZ2-PDB-1 ms 20	11/18/2003	14-26	13.1	14.9	15.0	12.1	15.3				
NP-PZ2-PDB-1 ms 200	11/18/2003	140-260	180.1	184.2	182	178	181				
A18-TW-(1-11) ms 20	11/20/2003	14-26	16.2	23.2	24.6	21.1	25.0				
C18-TW-(5-18) ms 20	11/21/2003	14-26	15.5	22.8	23.8	23.4	22.8				
Soil											
J16(2)-SB-2 ms 20	11/21/2003	14-26	20.9	23.1	24.1	23.0	22.1				

Shaded values are outside the Quality Assurance Criteria range.

¹ Chloroform and Trichloroethane

² Carbon Tetrachloride

³ Trichloroethene

⁴ Dichloroethene

⁵ Tetrachloroethene

ID - Identification

QC - Quality Control

Field Duplicate Results - Off-site Laboratory Analysis

Field Sample		Original		Duplicate				Meets
Number	Analyte	Concentration	Qual	Concentration	Qual	Units	%RPD	Criteria
			Soil					
H14(3)-SB-8.5	1,1-Dichloroethane	5.5	J	11.3	J	μ g/kg	69.0%	No
H14(3)-SB-8.5	1,2-Dichloroethane	5.1	J	8.6	J	μ g/kg	51.1%	No
H14(3)-SB-8.5	1,1-Dichloroethene	226	J	397	J	μ g/kg	54.9%	No
H14(3)-SB-8.5	cis-1,2-Dichloroethene	23.1	J	45.6	J	μ g/kg	65.5%	No
H14(3)-SB-8.5	1,2-Dichloroethene (total)	23.1	J	45.6	J	μg/kg	65.5%	No
H14(3)-SB-8.5	Tetrachloroethene	959		916		μg/kg	4.6%	Yes
H14(3)-SB-8.5	1,1,2-Trichloroethane	15.4		22.5		μg/kg	37.5%	Yes
H14(3)-SB-8.5	Trichloroethene	73.3	J	157	J	μ g/kg	72.7%	No
		Gro	undwater					
MW34-4-PDB-2	Acetone	6.9	J	6.5	J	μg/L	6.0%	Yes
MW34-4-PDB-2	Carbon Tetrachloride	21.5		22.2		μg/L	3.2%	Yes
MW34-4-PDB-2	Chloroform	5.3		5.3		μg/L	0.0%	Yes
MW34-4-PDB-2	1,1-Dichloroethane	3.2		3.1		μg/L	3.2%	Yes
MW34-4-PDB-2	1,1-Dichloroethene	31.2		32.7		μg/L	4.7%	Yes
MW34-4-PDB-2	cis-1,2-Dichloroethene	14.7		14.7		μg/L	0.0%	Yes
MW34-4-PDB-2	1,2-Dichloroethene (total)	14.7		14.7		μg/L	0.0%	Yes
MW34-4-PDB-2	Tetrachloroethene	6.1		6.0		μg/L	1.7%	Yes
MW34-4-PDB-2	1,1,2-Trichloroethane	0.65	J	0.64	J	μg/L	1.6%	Yes
MW34-4-PDB-2	Trichloroethene	18.5		18.6		μg/L	0.5%	Yes
MW34-7D-PDB-3	Chloroform	2.2	J	2.1	J	μg/L	4.7%	Yes
MW34-7D-PDB-3	1,1-Dichloroethane	3.2		3.1		μg/L	3.2%	Yes
MW34-7D-PDB-3	1,2-Dichloroethane	1.2	J	1.4	J	μg/L	15.4%	Yes
MW34-7D-PDB-3	1,1-Dichloroethene	86.3		81.8		μg/L	5.4%	Yes
MW34-7D-PDB-3	cis-1,2-Dichloroethene	2.2	J	2.2	J	μg/L	0.0%	Yes
MW34-7D-PDB-3	1,2-Dichloroethene (total)	2.2	J	2.2	J	μg/L	0.0%	Yes
MW34-7D-PDB-3	Tetrachloroethene	18.1		17.2		μg/L	5.1%	Yes
MW34-7D-PDB-3	1,1,2-Trichloroethane	4.6		4.2		μg/L	9.1%	Yes
MW34-7D-PDB-3	Trichloroethene	41.7		38.6		μg/L	7.7%	Yes

J - Reported value may not be accurate or precise (estimated).

Qual - Qualifier.

RPD - Relative Percent Difference.

Trip Blank Summary Results - Off-site Laboratory Analysis

				Concentration	Action	
Blank ID	Blank Type	Date Collected	Contaminant	(μg/L)	Level (µg/L)	Affected Samples
T112103	TB	11/21/2003	All <mrl< td=""><td>NA</td><td>NA</td><td>None</td></mrl<>	NA	NA	None
T112403	TB	11/24/2003	Acetone	7.3	73	None ¹

¹The PVC well materials used in the construction of the temporary wells were not decontaminated prior to use, and no equipment blank was collected. However, there is a possibility of source contamination from the isopropyl alcohol used by the manufacturer to clean the PVC well materials. Isopropyl alcohol was detected in aqueous samples G11-TW-(4-14), H14-TW-(5-15), J16-TW-(2-12), K24-TW-(4.5-14.5), and T112403 as a tentatively identified compound. Acetone is a resulting by-product from isopropyl alcohol. Therefore, acetone detections in all of the temporary well groundwater samples [i.e., C18-TW-(5-15), F20-TW-(8-18), G11-TW-(4-14), H14-TW-(5-15), J16-TW-(2-12), and K24-TW-(4.5-14.5)] have been "B" qualified and are considered "non-detect".

MRL - Method Reporting Limit NA - Not Applicable PVC - Polyvinyl Chloride TB - Trip Blank

Rejected Data Points - Off-site Laboratory Analysis

Analyte	Reason for Rejection	Affected Samples					
	Soil						
2-Chloroethyl Vinyl Ether	Low calibration RRF response	H14(3)-SB-4, H14(3)-SB-8.5, H14(3)-SB-8.5D,					
H14(3)-SB-9.5, H14(3)-SB-10.5, H14(3)-SB-15.							
		J16(2)-SB-4, J16(2)-SB-11, J16(2)-SB-12,					
		J16(2)-SB-13.5					
Groundwater							
2-Chloroethyl Vinyl Ether	No MS/MSD recovery	C18-TW-(5-15), G11-TW-(4-14)					

MS/MSD - Matrix Spike/Matrix Spike Duplicate RRF - Relative Response Factor

Summary of AREE 34 FDVCO On-site DSITMS Passive Diffusion Bag Groundwater Analytical Results

Field	Sample	Sample	CHCl ₃ +				
Sample	Collection	Depth	TCA ¹		TCE ³	DCE ⁴	PCE⁵
Number	Date	(ft bqs)	(μq/L)	(μq/L)	(μq/L)	(μq/L)	(μq/L)
		Satur	ated Overbur	rden			
NP-PZ2-PDB-1	11/17/2003	11 - 13	<7.1 UL	<2.7	0.6 J	<4.1 UL	1.4 J
NP-PZ2-PDB-2	11/17/2003	13 - 15	<7.1	<2.7	1.9 J	<4.1	2.2 J
NP-PZ2-PDB-3	11/17/2003	15 - 17	<7.1	<2.7	9.7	12.7	7.1 J
NP-PZ2-PDB-4	11/17/2003	17 - 19	<7.1	<2.7	10.0	12.4	6.9 J
NP-PZ2-PDB-5	11/17/2003	19 - 21	<7.1	<2.7	14.2	16.9 J	11.5 J
NP-PZ2-PDB-5D	11/17/2003	19 - 21	<7.1 D	<2.7 D	14.7 D	23.7 J,D	12.6 J,D
NP-PZ2-PDB-6	11/17/2003	21 - 23	<7.1	<2.7	14.5	18.6	13.4
NP-PZ2-PDB-7	11/17/2003	23 - 25	<7.1	<2.7	12.6	16.9	8.8 J
MW34-2-PDB-1	11/17/2003	10 - 12	<7.1	<2.7	7.8 J	4.9 J	3.8 J
MW34-2-PDB-2	11/17/2003	12 - 14	1.2 J	<2.7	17.6	20.3	8.6 J
MW34-2-PDB-3	11/17/2003	14 - 16	1.5 J	<2.7	18.5	19.4	9.1 J
MW34-2-PDB-4	11/17/2003	16 - 18	1.4 J	<2.7	18.3	21.1	6.9 J
MW34-2-PDB-5	11/17/2003	18 - 20	1.6 J	<2.7	18.8	20.8	8.2 J
MW34-3-PDB-1	11/17/2003	15 - 17	<7.1	<2.7	2.2 J	1.0 J	3.4 J
MW34-3-PDB-2	11/17/2003	17 - 19	<7.1	0.8 J	2.7 J	2.2 J	3.6 J
MW34-3-PDB-3	11/17/2003	19 - 21	<7.1	0.5 J	2.4 J	2.3 J	3.4 J
MW34-3-PDB-4	11/17/2003	21 - 23	<7.1	0.6 J	2.6 J	2.8 J	3.5 J
MW34-3-PDB-5	11/17/2003	23 - 25	<7.1	0.6 J	2.7 J	2.7 J	3.6 J
MW34-4-PDB-1	11/17/2003	10 - 12	<7.1	14.5	12.6	18.1	5.2 J
MW34-4-PDB-2	11/17/2003	12 - 14	<7.1	13.3	11.3	17.8	3.0 J
MW34-4-PDB-2D	11/17/2003	12 - 14	<7.1 D	14.8 D	13.1 D	19.1 D	3.5 J,D
MW34-4-PDB-3	11/17/2003	14 - 16	<7.1	29.2	21.1	28.7	6.4 J
MW34-4-PDB-4	11/17/2003	<u> 16 - 18</u>	4.2 J	53.3	37.9	67.9	7.9 J
MW34-4-PDB-5	11/17/2003	18 - 20	33.0	79.4	57.6	123	9.6 J
		Be	drock Aquife) er			
MW34-5D-PDB-1	11/17/2003	50 - 52	1.6 J	4.3 J	0.8 J	<4.1	4.5 J
MW34-5D-PDB-1D	11/17/2003	50 - 52	1.8 J,D	4.9 J,D	0.9 J,D	<4.1 D	4.6 J,D
MW34-5D-PDB-2	11/17/2003	52 - 54	2.2 J	5.3 J	0.4 J	<4.1	4.8 J
MW34-5D-PDB-3	11/17/2003	54 - 56	1.5 J	3.0 J	0.3 J	<4.1	2.5 J
MW34-5D-PDB-4	11/17/2003	56 - 58	1.3 J	1.9 J	0.3 J	<4.1	1.3 J
MW34-5D-PDB-5	11/17/2003	58 - 60	1.3 J	2.1 J	0.5 J	<4.1	1.4 J
MW34-7D-PDB-1	11/17/2003	50 - 52	<7.1	<2.7	55.5	74.8	36.8
MW34-7D-PDB-2	1/17/2003	52 - 54	<7.1	<2.7	41.5	73.4	18.1
MW34-7D-PDB-3	11/17/2003	54 - 56	<7.1	<2.7	25.7 J	42.7 J	9.1 J
MW34-7D-PDB-3D	11/17/2003	54 - 56	<7.1 D	<2.7 D	35.5 J,D	60.8 J,D	14.2 J,D
MW34-7D-PDB-4	1/17/2003	56 - 58	<7.1	<2.7	30.2	55.4	10.9 J
MW34-7D-PDB-5	11/17/2003	58 - 60	<7.1	<2.7	35.2	62.2	13.9

Yellow shaded values exceed the corresponding MCL by 1 to 3 times. Orange shaded values exceed the corresponding MCL by 3 to 6 times. Red shaded values exceed the corresponding MCL by 6 to 20 times.

¹ Chloroform and Trichloroethane (Since MCLs are 5 μ g/L for 1,1,2-trichloroethane, 200 μ g/L for

1,1,1-trichloroethane, and 100 µg/L for chloroform, a meaningful MCL comparison could not be performed.)

² Carbon Tetrachloride (MCL = $5 \mu g/L$)

³ Trichloroethene (MCL = 5 μ g/L)

⁴ Dichloroethene (MCL = 7 μ g/L for 1,1-Dichloroethene)

⁵ Tetrachloroethene (MCL = $5 \mu g/L$)

D - Duplicate analysis

ft bgs - feet below ground surface

J - Reported value may not be accurate or precise (estimated).

MCL - Maximum Contaminant Level. The maximum permissible level of a contaminant in drinking water which is delivered to any user of a public water system.

UL - Not detected. Quantitation limit is probably higher.

Parameter	MCL			Α	nalytical Resul	ts		
Field Sample Number		MW34-4-PDB-2	MW34-4-PDB-2D	MW34-4-PDB-4	MW34-4-PDB-5	MW34-7D-PDB-3	MW34-7D-PDB-3D	MW34-7D-PDB-5
Sample Collection Date (2003)		11/17	11/17	11/17	11/17	11/17	11/17	11/17
Sample Depth (ft bgs)		12-14	12-14	16-18	18-20	54-56	54-56	58-60
Volatile Organic Compounds	ձ (μg/L)							
Acetone	NE	6.9 J	6.5 J,D	<10	<25	<10	<10 D	<10
Carbon Tetrachloride	5	21.5	22.2 D	65.5	160	<2.0	<2.0 D	<2.0
Chloroform	100	5.3	5.3 D	14.4	44.2	2.2 J	2.1 J,D	2.3 J
1,1-Dichloroethane	NE	3.2	3.1 D	6.7	19.6	3.2	3.1 D	3.0 J
1,2-Dichloroethane	5	<1.0	<1.0 D	<2.0	<5.0	1.2 J	1.4 J,D	1.3 J
1,1-Dichloroethene	7	31.2	32.7 D	95.4	322	86.3	81.8 D	82.9
cis-1,2-Dichloroethene	70	14.7	14.7 D	21.4	49.9	2.2 J	2.2 J,D	2.0 J
1,2-Dichloroethene (total)	70 ¹	14.7	14.7 D	21.4	49.9	2.2 J	2.2 J,D	2.0 J
Tetrachloroethene	5	6.1	6.0 D	10.9	22.5	18.1	17.2 D	17.7
1,1,2-Trichloroethane	5	0.65 J	0.64 J,D	2.1 J	8.2	4.6	4.2 D	4.4
Trichloroethene	5	18.5	18.6 D	45.4	115	41.7	38.6 D	39.4

Summary of Detected AREE 34 FDVCO Off-site Laboratory Passive Diffusion Bag Groundwater Analytical Results

Shaded values exceed the corresponding MCL.

¹ cis-1,2-Dichloroethene value.

D - Duplicate analysis.

ft bgs - Feet below ground surface.

J - Reported value may not be accurate or precise (estimated).

MCL - Maximum Contaminant Level - The maximum permissible level of a contaminant in drinking water which is delivered to any user of a public water system.

NE - No MCL established for this parameter.

Field	Sample	Sample					
Sample	Collection	Depth	CHCl ₃ +				
Number	Date	(ft bgs)	TCA ²	CCI ₄ ³	TCE ⁴	DCE⁵	PCE ⁶
MW34-4-ST-(0-2)	11/17/2003	0 - 2					
MW34-4-ST-(2-4)	11/17/2003	2 - 4					
MW34-4-ST-(4-6)	11/17/2003	4 - 6					
MW34-4-ST-(6-8)	11/17/2003	6 - 8					
MW34-4-ST-(8-10)	11/17/2003	8 - 10					
MW34-4-ST-(10-12)	11/17/2003	10 - 12					
MW34-4-ST-(12-13.2)	11/17/2003	12 - 13.2		+			+
MW34-4(2)-ST-(0-5)	11/17/2003	0 - 5					
MW34-4(2)-ST-(5-10)	11/17/2003	5 - 10			+	+	+
MW34-4(2)-ST-(10-15)	11/17/2003	10 - 15		+	+	+	+
MW34-4(2)-ST-(15-16)	11/17/2003	15 - 16					
MW34-4-ST-MWMIP	11/18/2003	0 - 19.5		+	+	+	
A15-ST-(0-14.1)	11/19/2003	0 - 14.1					
A18-ST-(0-13.5)	11/18/2003	0 - 13.5					
A21-ST-(0-13.3)	11/18/2003	0 - 13.3					
A30-ST-(0-18.6)	11/19/2003	0 - 18.6					
C18-ST-(0-15.3)	11/19/2003	0 - 15.3					+
C20-ST-(0-18)	11/18/2003	0 - 18		+			+
C23-ST-(0-18)	11/17/2003	0 - 18					
D13-ST-(0-18.1)	11/21/2003	0 - 18.1					
E23-ST-(0-22.1) ⁷	11/18/2003	0 - 22.1					
F20-ST-(0-5)	11/17/2003	0 - 5					
F20-ST-(5-10)	11/17/2003	5 - 10					
F20-ST-(10-18)	11/17/2003	10 - 18					++
F30-ST-(0-19.6)	11/20/2003	0 - 19.6					
FF20-ST-(0-12.1)	11/19/2003	0 - 12.1					+
G11-ST-(0-15.2)	11/21/2003	0 - 15.2					
H14-ST-(0-15.6)	11/20/2003	0 - 15.6				+	+++
H23-ST-(0-18.7) ⁸	11/18/2003	0 - 18.7					
J16-ST-(0-13.5)	11/20/2003	0 - 13.5	+	++	+	+	++
K10-ST-(0-15.3)	11/20/2003	0 - 15.3			+		+
K24-ST-(0-16.2) ⁸	11/18/2003	0 - 16.2					
K30-ST-(0-18.2)	11/21/2003	0 - 18.2					
L18-ST-(0-18.5)	11/20/2003	0 - 18.5					+

Summary of AREE 34 FDVCO On-site DSITMS Sorbent Trap Analytical Results¹

¹The presence of a + in a cell indicates that the analyte was present in the analysis of the sorbent trap.

Multiple + signs indicate a higher level of contaminant in the sorbent trap sample.

²Chloroform and Trichloroethane

³Carbon Tetrachloride

⁴Trichloroethene

⁵Dichloroethene

⁶Tetrachloroethene

⁷Sample exhibited large level of toluene.

⁸Sample exhibited very large level of toluene.

ft bgs - feet below ground surface

Summary of AREE 34 FDVCO On-site DSITMS Soil Analytical Results

Field	Sample	Sample	CHCI ₃ +					
Sample	Collection	Depth	TCA ¹	CCI ₄ ²	TCE ³	DCE⁴	PCE⁵	Sample
Number	Date	(ft bgs)	(μ g/kg)	(μ g/kg)	(µg/kg)	(μ g/kg)	(µg/kg)	Туре
H14(2)-SB-8.5	11/20/2003	8.5	<1,660	<630	<750	<960	11,068 J	Methanol extract
H14(2)-SB-9.5	11/20/2003	9.5	<1,660	<630	<750	<960	570 J	Methanol extract
H14(2)-SB-10.7	11/20/2003	10.7	<1,660	<630	<750	<960	560 J	Methanol extract
H14(2)-SB-11.7	11/20/2003	11.7	<1,660	<630	<750	<960	1,089 J	Methanol extract
H14(3)-SB-2	11/21/2003	2	<35.5	<13.5	<16.0	<20.5	<22.0	Water extract
H14(3)-SB-4	11/21/2003	4	<35.5	<13.5	<16.0	<20.5	<22.0	Water extract
H14(3)-SB-6	11/21/2003	6	<35.5	<13.5	<16.0	11.0 J	56.0 J	Water extract
H14(3)-SB-7.5	11/21/2003	7.5	<1,660	<630	<750	<960	1,200 J	Methanol extract
H14(3)-SB-8.5	11/21/2003	8.5	<1,660	<630	<750	<960	990 J	Methanol extract
H14(3)-SB-9.5	11/21/2003	9.5	<1,660	<630	<750	<960	780 J	Methanol extract
H14(3)-SB-10.5	11/21/2003	10.5	<1,660	<630	<750	<960	540 J	Methanol extract
H14(3)-SB-11.5	11/21/2003	11.5	<1,660	<630	<750	<960	290 J	Methanol extract
H14(3)-SB-12.5	11/21/2003	12.5	<1,660	<630	<750	<960	760 J	Methanol extract
H14(3)-SB-15	11/21/2003	15	<35.5	<13.5	49.0	72.0	60.0 J	Water extract
J16(2)-SB-2	11/21/2003	2	<35.5	<13.5	<16.0	<20.5	<22.0	Water extract
J16(2)-SB-4	11/21/2003	4	<35.5	<13.5	<16.0	<20.5	<22.0	Water extract
J16(2)-SB-6	11/21/2003	6	<35.5	<13.5	<16.0	<20.5	<22.0	Water extract
J16(2)-SB-10	11/21/2003	10	<35.5	17.0 J	9.0 J	12.0 J	7.0 J	Water extract
J16(2)-SB-11.2	11/21/2003	11.2	<35.5	36.0 J	17.0 J	17.0 J	10.0 J	Water extract
J16(2)-SB-12.2	11/21/2003	12.2	<35.5	51.0	17.0 J	23.0 J	10.0 J	Water extract
J16(2)-SB-13	11/21/2003	13	<35.5	58.0	6.0 J	10.0 J	<22.0	Water extract

¹ Chloroform and Trichloroethane

² Carbon Tetrachloride

³ Trichloroethene

⁴ Dichloroethene

⁵ Tetrachloroethene

ft bgs - feet below ground surface J - Reported value may not be accurate or precise (estimated).

Summary of Detected AREE 34 FDVCO Off-site Laboratory Soil Analytical Results

Parameter					Analytica	al Results				
Field Sample Number Sample Collection Date (2003) Sample Depth (ft bos)	H14(3)-SB-4 11/21	H14(3)-SB-8.5	H14(3)-SB-8.5D	H14(3)-SB-9.5	H14(3)-SB-10.5	H14(3)-SB-15.5 11/21	J16(2)-SB-4 11/21	J16(2)-SB-11 11/21	J16(2)-SB-12 11/21 12 0	J16(2)-SB-13.5
Volatile Organic Compounds (µg/kg)										
Acetone	<u><62</u>	<71	<69 D	<66	<69	<58	34.9 J	<67	<72	<57
Carbon Tetrachloride	<6.2	<7.1	<6.9 D	<6.6	<6.9	<5.8	<6.9	37.6	20.2	30.2
Chloroform	<6.2	<7.1	<6.9 D	<6.6	2.9 J	<5.8	<6.9	8.4	7.0 J	5.6 J
1,1-Dichloroethane	<6.2	5.5 J	11.3 J,D	11.1	29.1	8.6	<6.9	<6.7	<7.2	<5.7
1,2-Dichloroethane	<6.2	5.1 J	8.6 J,D	9.3	18.6	9.2	<6.9	<6.7	<7.2	<5.7
1,1-Dichloroethene	<6.2	226 J	397 J,D	624	665	96.3	<6.9	19	<7.2	5.7 J
cis-1,2-Dichloroethene	<6.2	23.1 J	45.6 J,D	41.6	31.6	6.6 J	<6.9	<6.7	<7.2	<5.7
1,2-Dichloroethene (total)	<12	23.1 J	45.6 J,D	41.6	31.6	6.6 J	<14	<13	<14	<11
Tetrachloroethene	<6.2	959	916 D	914	669	80.5	<6.9	13.5	6.4 J	4.4 J
1,1,1-Trichloroethane	<6.2	<7.1	7.2 J,D	5.5 J	7.3 J	<5.8	<6.9	<6.7	<7.2	<5.7
1,1,2-Trichloroethane	<6.2	15.4	22.5 D	26.1	50.4	30.6	<6.9	4.6 J	<7.2	<5.7
Trichloroethene	<6.2	73.3 J	157 J,D	142	320	71.5	<6.9	18.3	10.9	7.1
Xylene (total)	<18	<21	8.3 J,D	<20	<21	<17	<21	<20	<22	<17

D - Duplicate analysis.

ft bgs - Feet below ground surface.

J - Reported value may not be accurate or precise (estimated).

Field	Sample	Well Screen	CHCl ₃ +		-		
Sample	Collection	Interval	TCA ¹		TCE ³	DCE ⁴	PCE⁵
Number	Date	(ft bgs)	(µg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
A15-TW-(2-12)	11/21/2003	2 - 12	<7.1	<2.7	<3.2	<4.1	<4.4
A18-TW-(1-11)	11/19/2003	1 - 11	<7.1	<2.7	<3.2	<4.1	<4.4
A30-TW-(8-18)	11/21/2003	8 - 18	<7.1	<2.7	<3.2	<4.1	<4.4
C18-TW-(5-15)	11/21/2003	5 - 15	<7.1	<2.7	<3.2	<4.1	<4.4
C20-TW-(7-17)	11/19/2003	7 - 17	<7.1	<2.7	<3.2	<4.1	14.3 J
C23-TW-(7-17)	11/18/2003	7 - 17	<7.1	<2.7	0.5 J	<4.1	4.2 J
C23-TW-(7-17)D	11/18/2003	7 - 17	<7.1 D	<2.7 D	0.5 J,D	<4.1 D	1.9 J,D
E23-TW-(8-18)	11/18/2003	8 - 18	<7.1	<2.7	<3.2	<4.1	<4.4
F20-TW-(8-18)	11/18/2003	8 - 18	16.2 J	6.7 J	1.5 J	<4.1	48.5
F20(2)-TW-(8-18)	11/21/2003	8 - 18	16.7 J	12.7	2.0 J	<4.1	67.9
F30-TW-(8-18)	11/21/2003	8 - 18	<7.1	<2.7	<3.2	<4.1	<4.4
FF20-TW-(4-9)	11/21/2003	4 - 9	<7.1	<2.7	<3.2	<4.1	<4.4
H14-TW-(5-15)	11/21/2003	5 - 15	<7.1	<2.7	743	1,516	2,440
H23-TW-(6-16) ⁶	11/19/2003	6 - 16	<7.1	<2.7	<3.2	<4.1	<4.4
J16-TW-(2-12)	11/21/2003	2 - 12	66.6	261	55.0	53.6	33.8
K10-TW-(2-12)	11/21/2003	2 - 12	<7.1	<2.7	<3.2	4.1 J	8.3 J
K24-TW-(4.5-14.5) ⁷	11/19/2003	4.5 - 14.5	<7.1	<2.7	<3.2	<4.1	<4.4

Summary of AREE 34 FDVCO On-site DSITMS Temporary Well Groundwater Analytical Results

Shaded values exceed the corresponding MCL.

Chloroform and Trichloroethane (Since MCLs are $5 \mu g/L$ for 1,1,2-trichloroethane, 200 $\mu g/L$ for

1,1,1- trichloroethane, and 100 µg/L for chloroform, a meaningful MCL comparison could not be performed.)

² Carbon Tetrachloride (MCL = $5 \mu g/L$)

³ Trichloroethene (MCL = 5 μ g/L)

⁴ Dichloroethene (MCL = 7 μ g/L for 1,1-Dichloroethene)

⁵ Tetrachloroethene (MCL = $5 \mu g/L$)

⁶ Sample exhibited low level of toluene.

⁷ Sample exhibited high level of toluene.

D - Duplicate analysis

ft bgs - feet below ground surface

J - Reported value may not be accurate or precise (estimated).

MCL - Maximum Contaminant Level. The maximum permissible level of a contaminant in drinking water which is delivered to any user of a public water system.

Parameter	MCL			Analytica	I Results		
Field Sample Number		C18-TW-(5-15)	F20-TW-(8-18)	G11-TW-(4-14)	H14-TW-(5-15)	J16-TW-(2-12)	K24-TW-(4.5-14.5)
Sample Collection Date (20	003)	11/21	11/21	11/24	11/24	11/24	11/24
Well Screen Interval (ft bgs	5)	5-15	8-18	4-14	5-15	2-12	4.5-14.5
Volatile Organic Compou	inds (μg/l	_)					
Acetone	NE	16.6 B	442 B	121 J,B	1,610 B	2,510 E,B	8,290 B
Benzene	5	<1.0	<1.0	0.56 J	<1.0	<5.0	<1.0
Carbon Tetrachloride	5	<1.0	21.2	<1.0	0.91 J	172	<1.0
Chloroform	100	<1.0	21.3	<1.0	6.8	38.4	<1.0
1,1-Dichloroethane	NE	<1.0	0.73 J	0.83 J	71.6	4.4 J	<1.0
1,2-Dichloroethane	5	<1.0	<1.0	<1.0	40.5	<5.0	<1.0
1,1-Dichloroethene	7	<1.0	1.8	13.7	1,860	78.2	<1.0
cis-1,2-Dichloroethene	70	<1.0	0.95 J	2.2	80.7	7.2 J	<1.0
trans-1,2-Dichloroethene	100	<1.0	<1.0	<1.0	1.2 J	<5.0	<1.0
1,2-Dichloroethene (total)	70 ¹	<2.0	<2.0	2.2 J	81.9	7.2 J	<2.0
Ethylbenzene	700	<1.0	<1.0	<1.0	<1.0	<5.0	0.64 J
Methylene Chloride	5	<2.0	<2.0	<2.0	40.1	<10	<2.0
Methyl Ethyl Ketone	NE	3.2 J	<5.0	<5.0	<5.0	<25	<5.0
Tetrachloroethene	5	0.66 J	100	10.6	607	17.3	<1.0
Toluene	1,000	0.75 J	<1.0	3.8	0.54 J	<5.0	8.4
1,1,1-Trichloroethane	200	<1.0	<1.0	<1.0	12.3	<5.0	<1.0
1,1,2-Trichloroethane	5	<1.0	<1.0	0.76 J	97.9	3.3 J	<1.0
Trichloroethene	5	<1.0	3.9	2.9	422	34.5	<1.0
Xylene (total)	10,000	<3.0	<3.0	<3.0	1.9 J	<15	1.7 J

Summary of Detected AREE 34 FDVCO Off-site Laboratory Temporary Well Groundwater Analytical Results

Shaded values exceed the corresponding MCL.

¹ cis-1,2-Dichloroethene value.

B - Analyte considered non-detect because of the possibility of source contamination from the isopropyl alcohol used by the manufacturer to clean the PVC well materials.

E - Value exceeds calibration range.

ft bgs - Feet below ground surface.

J - Reported value may not be accurate or precise (estimated).

MCL - Maximum Contaminant Level - The maximum permissible level of a contaminant in drinking water which is delivered to any user of a public water system.

NE - No MCL established for this parameter.

PVC - Polyvinyl chloride.

Comparison of Temporary Well Groundwater Analytical Results and Permanent Monitoring Well Groundwater Analytical Results from AREE 34 RI

Grid				
Well	Date	Date	PCE	TCE
ID ¹	Installed	Sampled	(μg/L)	(μg/L)
D6	3/7/2001	3/8/2001	27.1	7.36
MW34-3	5/2/2001	5/30/2001	14	4.8
G6	3/5/2001	3/5/2001	9.16	5.45
G6D	3/5/2001	3/5/2001	10.2 D	5.70 D
NP-PZ2 ²	10/23/1992	3/7/2001	27.7	17.4
NP-PZ2 ³	10/23/1992	5/24/2001	25	15
P15	3/7/2001	3/7/2001	35.1	47.9
MW34-2	5/4/2001	5/30/2001	28	35
MW34-2D	5/4/2001	5/30/2001	29 D	37 D
U20	3/6/2001	3/7/2001	<5	<5
MW34-1	5/4/2001	5/30/2001	<1	<1

¹ Grid location is provided for temporary wells, while well ID is provided for permanent monitoring wells.

² Groundwater sample collected using the same technique used for temporary wells - no purging prior to sampling, sample collected with small-diameter bailer.

³ Groundwater sample collected using the low-flow sampling technique.

D - Duplicate analysis

ID - Identification

PCE - Tetrachloroethene

RI - Remedial Investigation

TCE - Trichloroethene

Source: USACE, 2003a.

Comparison of AREE 34 On-site DSITMS and Off-site Laboratory Saturated Overburden Groundwater Analytical Results

		Carb	on Tetrachl	oride	Trichloroethene			Di	ichloroether	ie ¹	Tetrachloroethene		
On-Site	/	On-site		Off-site	On-site		Off-site	On-site		Off-site	On-site		Off-site
Field	/	DSITMS	Off-site	Divided by	DSITMS	Off-site	Divided by	DSITMS	Off-site	Divided by	DSITMS	Off-site	Divided by
Sample	Date	Analysis	Analysis	DSITMS	Analysis	Analysis	DSITMS	Analysis	Analysis	DSITMS	Analysis	Analysis	DSITMS
Number	Sampled	(µg/L)	(µg/L)	(%)	(µg/L)	(μg/L)	(%)	(µg/L)	(μg/L)	(%)	(μg/L)	(μg/L)	(%)
F20(2)-TW-(8-18)	11/21/2003	12.7	21.2	166.9	2.0 J	3.9	195.0	<4.1	2.75		67.9	100	147.3
C18-TW-(5-15)	11/21/2003	<2.7	<1.0		<3.2	<1.0]	<4.1	<1.0		<4.4	0.66 J	
MW34-4-PDB-2	11/17/2003	13.3	21.5	161.7	11.3	18.5	163.7	17.8	45.9	257.9	3.0 J	6.1	203.3
MW34-4-PDB-2D ²	11/17/2003	14.8	22.2	150.0	13.1	18.6	142.0	19.1	47.4	248.2	3.5 J	6.0	171.4
MW34-4-PDB-4	11/17/2003	53.3	65.5	122.9	37.9	45.4	119.8	67.9	116.8	172.0	7.9 J	10.9	138.0
MW34-4-PDB-5	11/17/2003	79.4	160	201.5	57.6	115	199.7	123	371.9	302.4	9.6 J	22.5	234.4

¹ The dichloroethene analysis results are for the dichloroethene compounds (i.e.,1,1-dichloroethene, cis-1,2-dichloroethene, and trans-1,2-dichloroethene).

² MW34-4-PDB-2D is a duplicate of MW34-4-PDB-2.

--- Cannot be calculated because one or both of the analytical results are non-detect.

DSITMS - Direct Sampling Ion Trap Mass Spectrometer

J - Reported value may not be accurate or precise (estimated).

PDB - Passive Diffusion Bag

TW - Temporary Well


























LEGEND:



NOTES:

- 1. GRID POINT K10 A RI TEMPORARY WELL WAS INSTALLED AND SAMPLED IN MARCH, 2001, AND A TEMPORARY WELL WAS INSTALLED AND SAMPLED AS PART OF THE FDVCO INVESTIGATION.
- RELATIVE BUILDING LOCATIONS/SIZES ON SITE MAP WERE ADJUSTED BASED ON RECENT SURVEY DATA PRESENTED IN THE AREE 34 RI REPORT (USACE, 2003a; APPENDIX D).



US ARMY CORPS OF ENGINEERS BALTIMORE DISTRICT				
CONTRACT NO. DACA31-01-F-0142		FIGURE 2-1		
		VINT HILL FARMS STATION		
Shaw" Shaw Environmental, Inc.				
PREPARED WSS	TASK NO: 84507913000000	SAMPLE LOCATION PLAN		
CHECKED NZ	SHAW DWG NO:			
DATE 1-12-04	GSA1-130-03-012			

Figure 2-2 Sample/Probe Location Decision Guide (see Note 1)



Notes:

1 – This Decision Guide presents the rationale that was used to determine subsequent sample/probe locations. Other criteria that were considered in determining subsequent sample/probe locations are discussed in Section 3.4 of the FDVCO-WP.

2 – If the MIP, with or without the sorbent traps, was not capable of collecting the data required to meet the objectives of the FDVCO investigation, soil and/or temporary monitoring well groundwater samples might have alternatively be used. In the event this situation occurred, the selection of sampling locations would have followed the approach presented in this Decision Guide.

3 – Probe only at the major grid points that are upgradient of grid points where the maximum VOC response exceeded the MW34-4 maximum VOC response.

4 - Probe only at those grid locations that have not already been probed (making reference to Note 3).

When there was a physical obstruction (i.e., a building) of a grid point to be sampled, the next closest grid point that has no physical obstruction was sampled.

50% RULE: Between two grid points where the more downgradient of the two points had a maximum VOC response greater than or equal to the maximum VOC response at MW34-4 and the more upgradient of the two points had a maximum VOC response less than the maximum VOC response at MW34-4, selected a grid point that represents approximately 50% of the distance between the two grid points for the next sample/probe location. Continued this methodology until the location of the highest VOC response was identified.

Figure 4-1 AREE 34 MIP ECD Responses



Figure 4-2 AREE 34 MIP ECD and Soil Conductivity Responses - Cross-Section View, Looking East



Figure 4-3 On-site DSITMS Groundwater Analytical Results - MW34-4 PDB Samples versus MW34-4-MWMIP



Figure 4-4 On-site DSITMS Soil Analytical Results - Total VOCs at H14 versus H14-MIP



Figure 4-5 On-site DSITMS Soil Analytical Results - Total VOCs at J16 versus J16-MIP









LEGEND:

O.U20 (NO VOCs DETECTED OR VOCs DETECTED BELOW MCLs)
• H10
➡MW34-1 (NO_VOCS_DETECTED_OR VOCS_DETECTED_BELOW_MCLS)
MW34-4 (VOCs DETECTED ABOVE MCL)
MW34-6D BEDROCK MONITORING WELL (VOCs DETECTED BELOW MCL)
MW34-7D BEDROCK MONITORING WELL (VOCs DETECTED ABOVE MCL)
Δ^{A21}
₩30 MIP LOCATION WITH TEMPORARY WELL, NO GROUNDWATER SAMPLE COLLECTED
←C23 (NO VOCs DETECTED OR VOCs DETECTED BELOW MCL)
₱F20

NOTES:

- 1. GRID POINT K10 A RI TEMPORARY WELL WAS INSTALLED AND SAMPLED IN MARCH, 2001, AND A TEMPORARY WELL WAS INSTALLED AND SAMPLED AS PART OF THE FDVCO INVESTIGATION.
- RELATIVE BUILDING LOCATIONS/SIZES ON SITE MAP WERE ADJUSTED BASED ON RECENT SURVEY DATA PRESENTED IN THE AREE 34 RI REPORT (USACE, 2003α; APPENDIX D).



US ARMY CORPS OF ENGINEERS

BALTIMORE DISTRICT

CONTRACT NO. DACA31-01-F-0142		FIGURE 5-1
		VINT HILL FARMS STATION
Shaw" Shaw Environmental, Inc.		AREE 34 FDVCO MIP/TEMPORARY
PREPARED WSS	TASK NO: 84507913000000	WELL LOCATIONS
CHECKED NZ	SHAW DWG NO:	AND GROUNDWATER
DATE 1-27-04	GSA1-130-03-015	SUMMARY