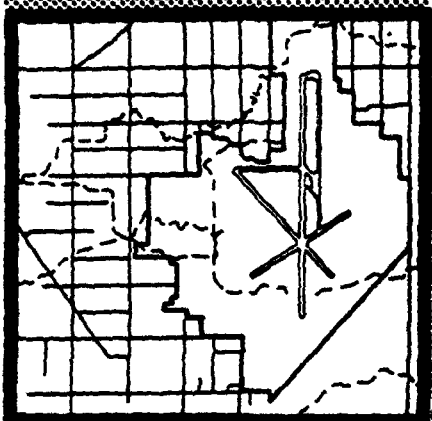


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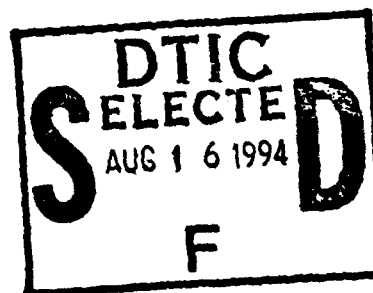
INSTALLATION RESTORATION PROGRAM (IRP)

**McClellan Air Force Base Operable Unit B
Two-Phase Extraction System
Demonstration Test
Work Implementation Plan**

for McCLELLAN AFB, CALIFORNIA

FINAL

3 AUGUST 1994



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**PREPARED FOR:
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**United States Air Force
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This reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 94/08/03	3. REPORT TYPE AND DATES COVERED Final Copy
4. TITLE AND SUBTITLE McClellan Air Force Operable Unit B Xerox Two-Phrase Extraction System Demonstration Test - Work Implementation Plan			5. FUNDING NUMBERS
6. AUTHOR(S) Radian Corporation			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Radian Corporation 10389 Old Placerville Road Sacramento, CA 95827			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) SM-ALC/EMR McClellan AFB, California 95652-1036			10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified/Unlimited			12b. DISTRIBUTION CODE
13. ABSTRACT (Maximum 200 words) This document is an integrated demonstration and work plan that presents the technical approach for design, implementation, and testing of two-phrase extraction as compared with pump and treat technology in Operable Unit B, investigative cluster IC1 at the McClellan Air Force Base. This work is being coordinated with Clean Sites under a cooperative agreement with EPA's Technology Innovation Office and Superfund Innovative Technology Evaluation Program.			
14. SUBJECT TERMS			15. NUMBER OF PAGES
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT Unlimited

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force base
BGS	Below ground surface
BZ	Breathing zone
Cal/EPA	California Environmental Protection Agency
CFR	Code of Federal Regulations
CNS	Central nervous system
CRZ	Contamination reduction zone
dBA	Decibels
DCE	Dichloroethene
DT	Detector tube
DQO	Data quality objective
ERMI	Environmental and Risk Management, Inc.
EW	Extraction well
EZ	Exclusion zone
FTL	Field task leader
GASP	Groundwater Sampling and Analysis Plan
GC	Gas chromatograph
gpm	Gallons per minute
GWTP	Groundwater treatment plant
HASP	Health and safety plan
IC	Investigation cluster
IWL	Industrial waste line
lbs/yr	Pounds per year
LCS	Laboratory control sample
mg/m ³	Milligrams per cubic meter
MS	Mass spectrometer
MS/MSD	Matrix spike/matrix spike duplicate
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
OU	Operable unit
OVC	Organic vapor concentrations
PCE	Tetrachloroethene
PEL	Permissible exposure limit
PHSO	Project health and safety officer
PID	Photoionization detector
P&ID	Piping and instrumentation diagram
PPE	Personal protective equipment
ppbv	Parts per billion by volume
ppm	Parts per million
ppmv	Parts per million by volume
PTFE	Teflon®: polytetrafluoroethylene

ACRONYMS AND ABBREVIATIONS

QA	Quality assurance
QA/QC	Quality assurance/quality control
QAPP	Quality assurance project plan
QC	Quality control
RPD	Relative percent difference
RREL	Risk Reduction Engineering Library
SA	Supplied air
SAIC	Science Applications International Corporation
SCBA	Self-contained breathing apparatus
scfm	Standard cubic feet per minute
SITE	Superfund Innovative Technology Evaluation
SMAQMD	Sacramento Metropolitan Air Quality Management District
SOP	Standard operating procedure
SS	Sampling site
SZ	Support zone
TCE	Trichloroethene
TDTM	Technology Demonstration Technical Memorandum
TLV	Threshold limit value
TPE	Two-phase extraction
TPH	Total petroleum hydrocarbon
TRL	Target reporting limit
USAF	United States Air Force
U.S. EPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WIP	Work implementation plan
$\mu\text{g/L}$	Micrograms per liter

EXECUTIVE SUMMARY

The purpose of this work implementation plan (WIP) is to describe the design, operation, implementation, and testing of a two-phase extraction system at McClellan Air Force Base (AFB).

ES.1 McClellan Two-Phase Extraction Demonstration Test Summary

Key objectives of the Two-Phase Extraction Demonstration test are to:

- Estimate the mass of volatile organic compound (VOC) contaminants removed by the two-phase extraction system, and compare the removal rate with the current pump-and-treat system;
- Determine the transfer rate of VOC contaminants from the water to the vapor phase in the two-phase extraction unit;
- Evaluate the radius of capture and influence for the groundwater and soil vapor, respectively, to determine two-phase extraction effectiveness at controlling the groundwater plume and minimizing additional groundwater contamination or surface flux of soil vapor contamination; and
- Evaluate the cost effectiveness of the two-phase extraction unit for removing contaminants from the well to use as a basis for evaluating application of the technology at other sites.

The test will be conducted on extraction wells EW-233 and EW-234 at investigation cluster (IC) 1 (see Figure ES-1) in Operable Unit (OU) B, located near the southeast corner of Building 655 at McClellan AFB. The duration of the test is expected to be 4 to 6 months beginning in late July 1994. OU B encompasses approximately 325 acres in the southwest portion of the base, and has historically contained storage yards, warehouses, a chemical laboratory, an aircraft fueling area, a wood shop, an instrument repair facility, a paint facility, two industrial waste treatment plants, and a plating shop. Materials handled at the various locations within OU B include: solvents, dimethyl ether,

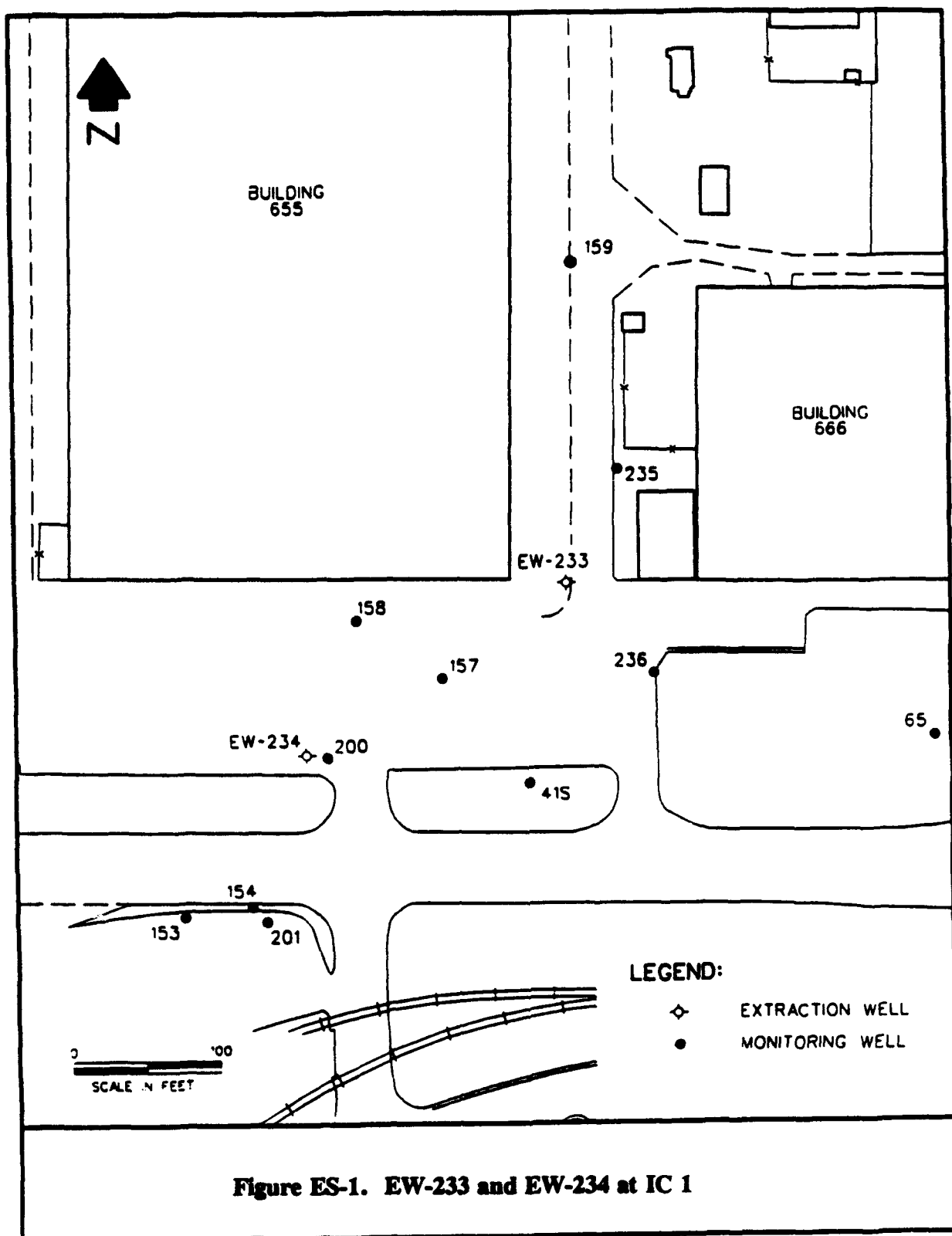


Figure ES-1. EW-233 and EW-234 at IC 1

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low-level radioactive wastewater, and waste chemicals generated during plating activities. Site characterization activities identified significant concentrations of trichloroethene (TCE), tetrachlorethene (PCE), and trichlorotrifluoroethene (Freon® 113) in the subsurface soil, soil gas, and groundwater. These three compounds are the primary target analytes.

IC 1, located in the central portion of OU B, is contaminated primarily with PCE and TCE in concentrations up to 7,000,000 parts per billion by volume (ppbv). The subsurface geology consists of four distinct and laterally continuous layers of silt and three layers of sand/silty sand. Groundwater beneath IC 1 occurs at approximately 100 to 110 feet below ground surface (BGS) and flows generally south to southwest. Three groundwater monitoring wells and one extraction well (all A zone) within IC 1 boundaries are used to characterize and monitor groundwater flow and quality. Additional monitoring wells located in different zones and/or outside IC 1 boundaries are also used to monitor groundwater conditions. Three piezometer nests and two companion wells were installed to monitor flow of groundwater and vacuum around Well 233. Figures 3-3 and 3-4 in Section 3.1 of the QAPP describe locations and construction of these wells.

EW-233 and EW-234 were installed to mitigate and control an identified groundwater plume contaminated primarily with the target analyte chemicals. The previously operated pump-and-treat system was used at these wells to prevent the flow of contaminated groundwater off the base.

ES.2 McClellan Two-Phase Extraction Demonstration Team

The McClellan Air Force Base (AFB) Two-Phase Extraction Demonstration team consists of the United States Environmental Protection Agency (U.S. EPA) Technology Innovation Office (TIO) and Superfund Innovative Technology Evaluation (SITE) program, the USAF, Clean Sites, Radian, SAIC, ERMI, and the Public-Private Partnership. (Private partners are Dow Chemical Company, Beazer East, Inc., Southern California Edison; Xerox Corporation; American Telephone and Telegraph Company; Monsanto Chemical Company; and DuPont Chemicals.) The demonstration will be conducted as part of the U.S. EPA SITE Program and in coordination with research efforts sponsored by the USAF. Project responsibilities will be coordinated between all team members to ensure that the demonstration test is conducted and data collected so that the two-phase extraction technology can be evaluated relative to the project goals and objectives.

1.0 TECHNOLOGY DESCRIPTION/BACKGROUND

1.1 General Description of the Two-Phase Extraction Technology

The two-phase extraction system was developed and patented by Xerox Corporation for remediation of volatile organic compounds (VOCs) in soil, soil vapor, and groundwater in low permeability formations like that at McClellan Air Force Base (AFB). The two-phase extraction system uses high-vacuum extraction to simultaneously recover groundwater and soil vapor through an extraction pipe in a recovery well screened both above and below the water table. Figure 1-1 shows a detailed schematic of a typical two-phase extraction well configuration; a typical two-phase system setup is provided on Figure 1-2.

In a two-phase extraction well, the lower end of the extraction pipe or "straw" (which is cut at a 45° angle) is set at the static water level. After the wellhead is sealed, high-vacuum (18 to 25 inches of mercury) is applied to the extraction pipe and vapor from the surrounding soil or bedrock is drawn at high velocity into the pipe, entraining groundwater into the vapor stream. Atmospheric air can be drawn into the annulus at the well head through an inlet valve to provide sufficient vapor flow to entrain groundwater. Vapor and entrained groundwater are conveyed to a knockout pot immediately upstream of the vacuum source. Upon entering the knockout pot, the velocity of the two-phase stream abruptly decreases, separating the entrained groundwater from the vapor. The liquid and vapor streams are then treated individually.

As extraction time increases, the two-phase extraction progressively depresses the surrounding water level. Final groundwater levels for steady state operation are usually within inches of the total well depth in the well area. This depression of the water level also increases the amount of unsaturated material exposed to the well screen, increasing the soil vapor flow drawn into the well. If the increased vapor flow from the formation becomes sufficient to sustain groundwater entrainment, the volume of atmospheric air entering the well can be reduced or completely eliminated. The extraction of vapors from the formation is then more effective.

The two-phase extraction technology has been applied at several dozen low permeability sites and has consistently proven to be more effective at removing subsurface VOCs from low permeability formations than conventional pump-and-treat or soil-vapor

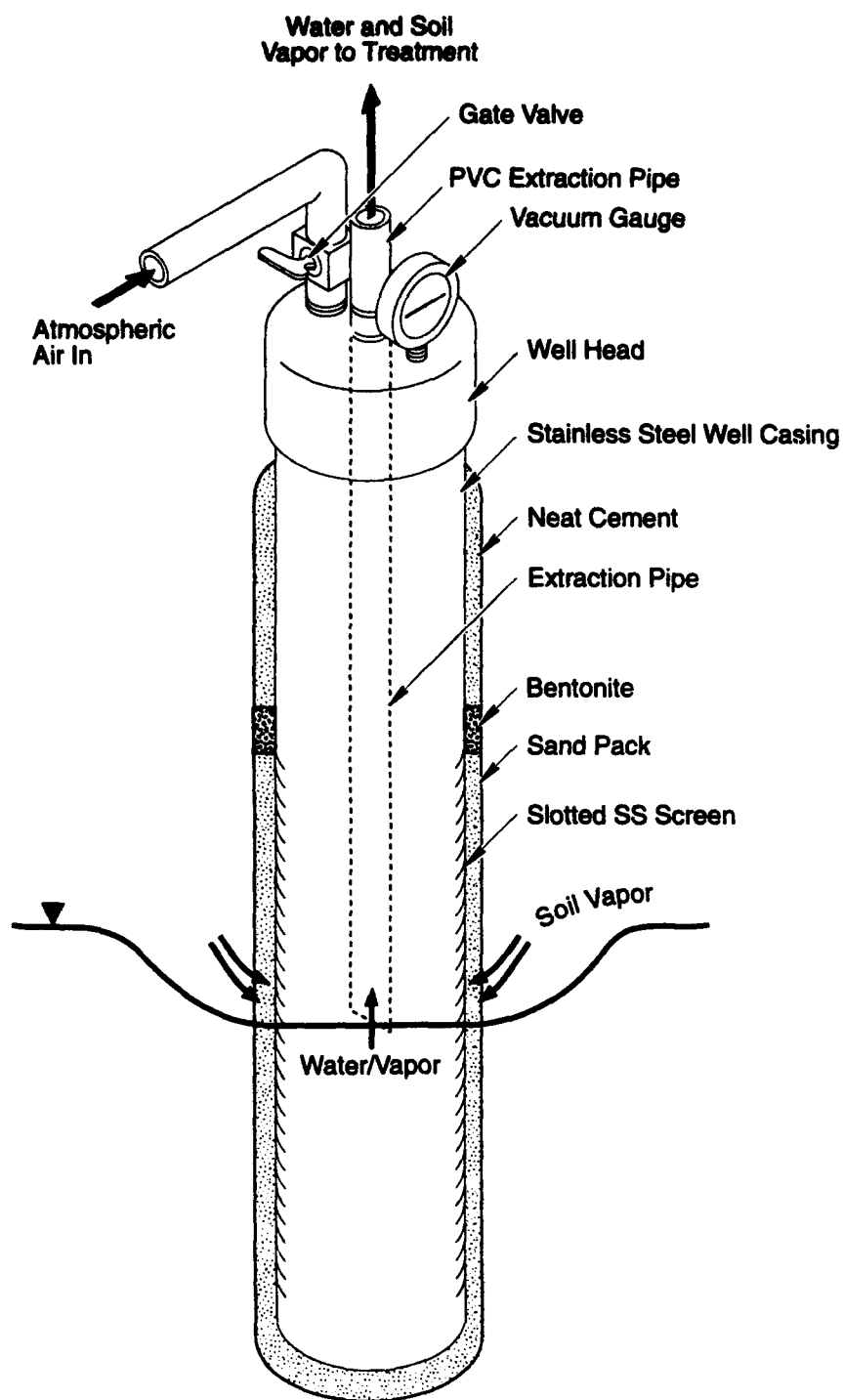


Figure 1-1. Schematic of a Two-Phase Extraction Well Configuration

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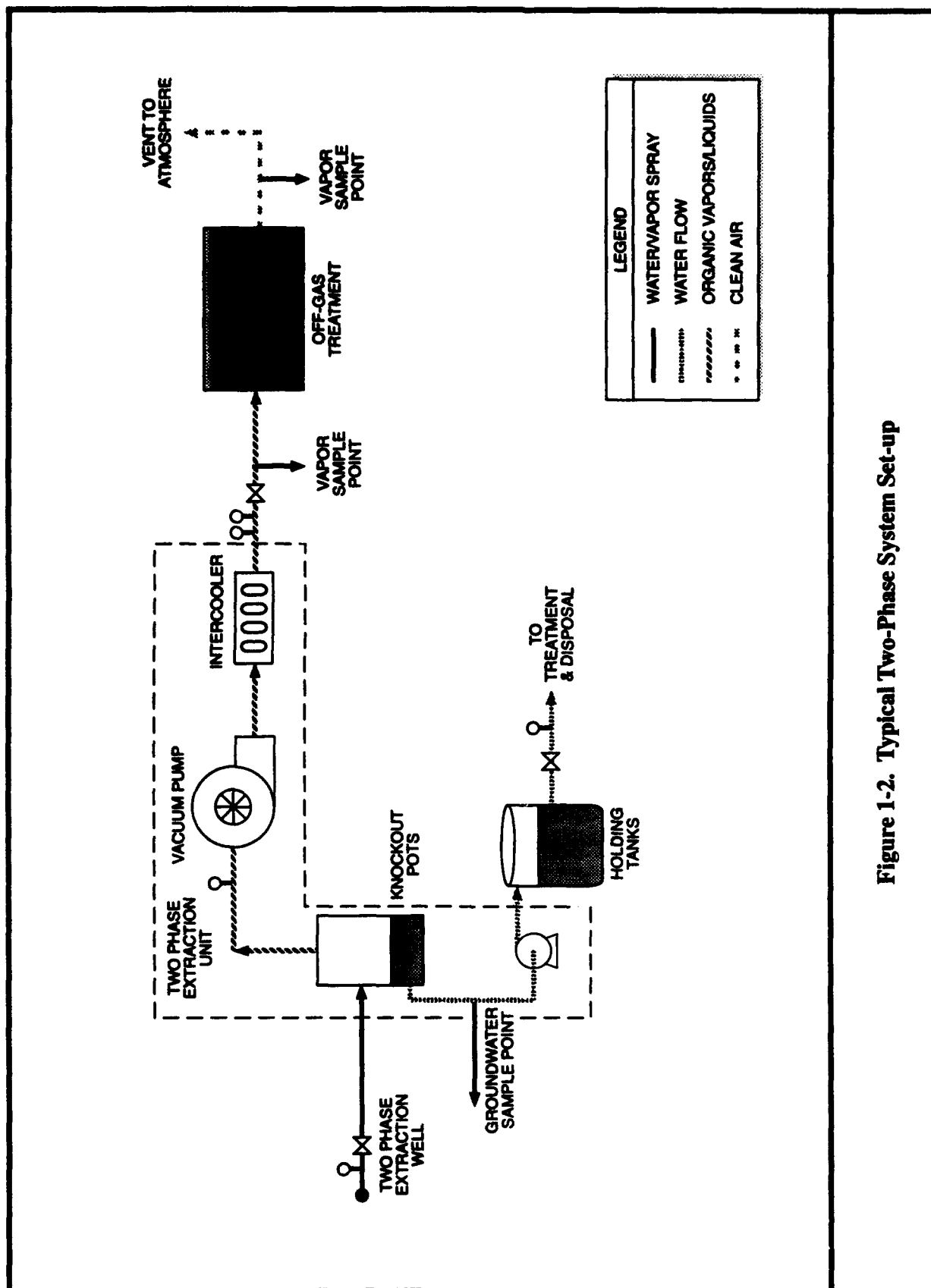


Figure 1-2. Typical Two-Phase System Set-up

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extraction systems. This increase in effectiveness is due to the increase in soil vapor and groundwater flow from the formation produced by the high vacuum gradients in the subsurface. The extracted groundwater lowers the water table, which increases the volume of formation available for contaminant removal by vapor extraction. The high vacuum applied to the well annulus (residual vacuum) increases the effective drawdown of the well and creates a greater groundwater flow into the well than would occur with a conventional pump-and-treat system. Also, the turbulence caused as the entrained groundwater moves up the extraction pipe may transfer up to 95% or more of the VOCs from the water to the vapor phase; the separated water phase may then only require carbon polishing prior to discharge. Combining the VOCs transferred from the liquid phase with contaminated soil vapor results in higher VOC concentrations in the vapor phase. VOCs in the vapor phase can typically be treated more efficiently than VOCs in the liquid phase.

1.2 Previous Pilot Testing at McClellan AFB

Two two-phase extraction pilot tests have been conducted at McClellan AFB Operable Unit (OU) B, Investigation Cluster (IC) 1. The first test was conducted on extraction well (EW) 234 in the fall of 1993; the second test was conducted on EW-233 in March 1994.

EW-234

The one-day pilot test conducted on EW-234 used three different extraction pipe diameters and a small (5 hp vacuum pump) trailer-mounted unit. The objective of this short term study was to determine if Two-phase extraction would be applicable to the IC 1 area. As indicated by Radian Corporation's (Radian's) analytical results, this test demonstrated that two-phase extraction was capable of:

- Groundwater flowrates between 0.35 and 0.92 gallons per minute (gpm) using straw diameters from 3/4" to 1-1/4" at depths up to 111 feet;
- An average vapor flowrate of 7 standard cubic feet per minute (scfm);

- Transferring 88% of the total VOCs from the groundwater to the vapor phase, resulting in increased concentrations of the vapor phase by 165%; and
- A projected contaminant removal rate of 193 pounds per year (lbs/yr) compared to 5 lbs/yr with conventional pump and treat.

EW-233

The pilot test on EW-233 was conducted for four days, and used a larger (25 hp vacuum pump) trailer-mounted two-phase extraction unit. The objectives of this pilot study were to:

- Gather data in support of the first study, which indicated two-phase extraction would be applicable to the IC 1 area; and
- Compare the effectiveness of the two-phase extraction system in controlling and remediating subsurface VOCs in the groundwater plume with the existing pump-and-treat system.

This test was conducted as part of the United States Environmental Protection Agency (U.S. EPA) Superfund Innovative Technology Evaluation (SITE) Program in coordination with research efforts sponsored by the United States Air Force (USAF). Radian installed and operated the two-phase extraction system; Science Applications International Corporation (SAIC), U.S. EPA's SITE Program contractor, and Environmental Risk Management Inc. (ERMI), Air Toxics Limited, and Coast-to-Coast Analytical Laboratories provided analytical support for characterization of water and vapor samples. Highlights of the test based on Radian's analytical results are as follows:

- Groundwater flow rates were increased by approximately a factor of 2 to 2.5 from a reported 3.5 to 4.6 gpm with the pump-and-treat system to 8 to 9 gpm with the two-phase extraction system.
- The mass of contaminants extracted by the two-phase extraction system was increased by a factor of 9 versus the existing pump-and-treat technology. An estimated 130 lbs/yr of contaminants were removed by

the pump-and- treat technology based on a 4.6 gpm flow rate and the baseline concentration data. The concentration and flow data for the last two days of two-phase extraction testing (relatively steady state operations) equate to a removal rate of approximately 1,200 lbs/yr in the offgas and 20 lbs/yr in the treated water for a total of 1,220 lbs/year.

- Approximately 95% of the VOCs present in the groundwater were transferred to the vapor phase by two-phase extraction.

These results indicate that two-phase extraction will increase groundwater and vadose zone remediation rates, and will improve hydraulic control of the groundwater plume by increasing groundwater production. Based on these results, McClellan AFB is planning to convert the existing pump-and-treat system to two-phase extraction. This is the basis for this work implementation plan (WIP) and the demonstration described in the following sections.

2.0

PROJECT GOALS AND OBJECTIVES

The goal of this Demonstration Test is to evaluate the effectiveness of the Xerox Two-Phase Extraction technology.

The primary objectives of the Demonstration Test are to:

- Determine the total mass removal rate of the system for target volatile organic compounds (VOCs), and comparing the results with the pump-and-treat technology used in the past. This objective will be achieved by measuring the VOC concentration and the volume of the liquid and gas phases extracted.
- Determine the percent transfer of target VOCs from entrained groundwater to vapor as the water travels up the extraction tube. VOC concentrations in water will be measured in the extraction well prior to system startup and in a nearby companion well during operation. These concentrations will be compared to outlet water samples collected downstream of the knockout tank.
- Collect full-scale operating cost (e.g., capital, operating and maintenance) and performance data (e.g., extraction rates, mass removal, etc.) as necessary.

Additional objectives of the Demonstration Test are to:

- Estimate the zone of influence of the two-phase extraction system by measuring groundwater levels and soil vapor vacuum in surrounding wells and piezometers. The volume of unsaturated soil (vertical and horizontal) exposed to vapor recovery will also be evaluated.
- Measure the extraction rate of groundwater by observing the flow per unit of time.

- Use groundwater level measurements to determine whether the system prevents groundwater mounding, which is normally encountered during conventional soil vapor extraction.

Project goals that will be evaluated for the specific conditions at the site include:

- Enhancing control of contaminated groundwater;
- Expediting contaminant removal;
- Providing cost-effective remediation;
- Reducing health and environmental risks;
- Providing data to evaluate basewide application of the technology as a presumptive remedy; and
- Providing data to evaluate compliance with air and water discharge regulations.

The data collection effort during the demonstration test will help evaluate the system operation relative to each of these goals.

3.0

EXPERIMENTAL DESIGN/SAMPLING AND ANALYSIS PLAN

The Xerox two-phase extraction demonstration program will consist of system effectiveness measurements, zone of influence measurements, and standard operating condition measurements. Two-phase extraction technology effectiveness will be evaluated by determining the total mass removal rate of volatile organic compounds (VOCs), and by determining the percent of VOC mass transferred from the liquid to the vapor phase during extraction. The two-phase extraction system's zone of influence will be determined by measuring groundwater surface drawdown in surrounding monitoring wells and induced vacuum in the surrounding vadose zone. Systems operating data will be collected for use in determining the optimum conditions for long-term system operation and to develop data on the relative cost-effectiveness of two-phase extraction compared to pump-and-treat technology. The experimental design described below is modified from the *Demonstration Plan* prepared by Science Applications International Corporation (SAIC) for the United States Environmental Protection Agency (U.S. EPA) Superfund Innovative Technology Evaluation (SITE) Program.

3.1

System Effectiveness

System effectiveness will be determined by collecting groundwater and soil gas samples for comparison to two-phase extraction water and offgas vapor samples. The samples to be collected are listed in Table 3-1; sample locations are shown in Figure 3-1. Table 3-2 lists the number and type of samples, including quality assurance/quality control (QA/QC) samples. Detailed sampling and demonstration efforts will be performed on EW-233 to evaluate the technology relative to the demonstration test primary objectives. Some sampling will be conducted on EW-234 streams in order to evaluate the secondary objectives of the test (e.g., total mass of contaminants removed).

Baseline soil vapor and groundwater samples will be collected prior to system operation and again at the end of the testing period. The baseline groundwater samples will be collected from the EW-233 and the companion wells for EW-233. These samples will determine the initial groundwater VOC concentrations. A minimum of three well volumes will be pumped from each well using a submersible pump before sampling with a bailer.

Baseline soil vapor and groundwater samples will be collected from companion piezometers and monitoring wells prior to and following system operation. The piezometer

Table 3-1
Samples To Be Collected

Media Sampled/Measured	Sample Location¹	Analytical Method
<u>Pre-Test Sampling</u> Groundwater Soil Gas Two-Phase Extraction Trailer Blanks Groundwater Elevation Vadose Zone Pressure	S1, S2 S6 S4, S5 Extraction & Monitoring Wells Piezometers	U.S. EPA Method 8260 TO-14 U.S. EPA Method 8260 & TO-14 E-line Magnehelic®/Barometer
<u>Demonstration Test</u> Groundwater Soil Gas Treated Water Offgas Groundwater Elevation Vadose Zone Pressure	S2 S6 S4 S5 Monitoring Wells Piezometers	U.S. EPA Method 8260 TO-14 U.S. EPA Method 8260 TO-14 E-line Magnehelic®/Barometer
<u>Post-Test Sampling</u> Groundwater Soil Gas/Vapor Groundwater Elevation Vadose Zone Pressure	S1, S2 S6 Extraction & Monitoring Wells Piezometers	U.S. EPA Method 8260 TO-14 E-line Magnehelic®/Barometer
<u>Vapor Discharge Sampling</u> Treated Vapor	S7	TO-14

¹ See Figure 3-1.

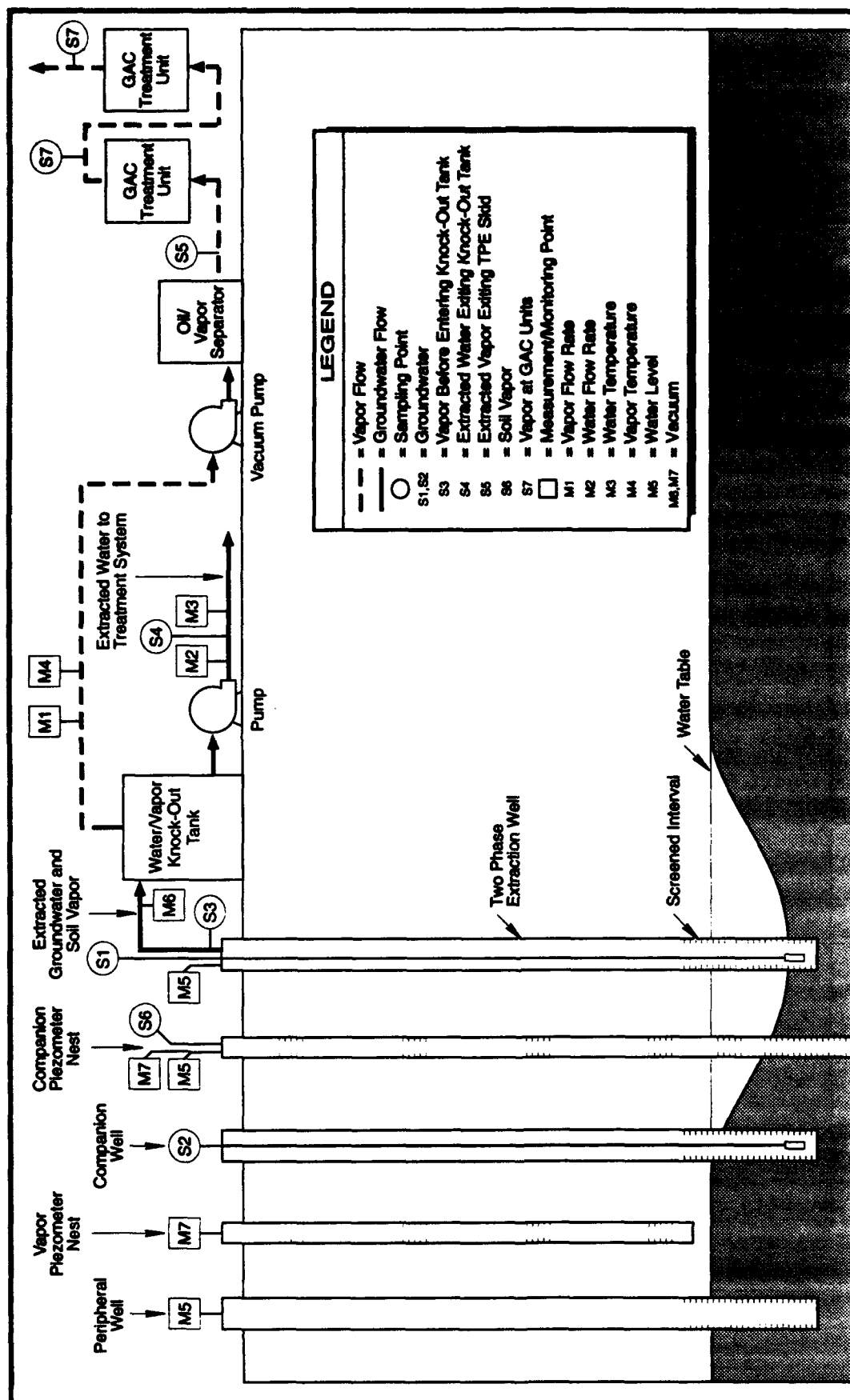


Figure 3-1. Process Schematic of the Two-Phase Extraction System Showing Sample and Measurement Points

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Table 3-2

Summary of Number of Samples Required for the Two-Phase Extraction Demonstration

Measurement	No. of Samples*	Field Duplicates	Laboratory Duplicates	Matrix Spikes	Matrix Spikes Duplicates	Field Blanks	Trip Blanks	Equipment Blank*	Total
BASELINE									
Baseline Groundwater at EW-233 under static conditions (EW-233, CW-1, CW-2, PN-1) (4 wells, 1 sample each) Volatiles (8260)	4	1	0	1	1	0	1	0	7
Baseline Groundwater at EW-233 under dynamic conditions (EW-233, CW-1, CW-2, PN-1) (4 wells, 5 samples each) Volatiles (8260)	20	2	0	1	1	0	1	0	24
Baseline Soil Vapor at EW-233 Companion Piezometer Nest (PN-1) (3 piezometers, 1 sample each) Volatiles (TO-14)	3	1	1	NA ^d	NA	0	NA	0	5
Baseline Soil Vapor at Five Piezometer Nests around EW-233 (PN-2, PN-3, VPN-7, VPN-8, VPN-9) (2 piezometer nests - 1 sample each at 5 piezometers in each; 3 piezometer nests - 1 sample each at 6 piezometers in each) Volatiles (TO-14)	28	2	2	NA ^d	NA	0	NA	0	32
Two-Phase Extraction System Water Blank at EW-233 Volatiles (8260)	1	0	0	0	0	NA	NA	0	1
Two-Phase Extraction System Vapor Blank at EW-233 Volatile (TO-14)	1	0	0	0	0	NA	1	0	1
DURING TEST									
Inlet Vapors at EW-233 (PN-1) (companion piezometer) Volatiles (TO-14)	38	2	2	NA ^d	NA	NA	NA	NA	42
Outlet Vapors at EW-233 and EW-234 (2 knock-out tanks) EW-233 EW-234	38 16	4 1	4 1	NA ^d NA ^d	NA NA	NA NA	NA NA	3 1	49 18
Inlet Groundwater at EW-233 (CW-1, CW-2, and/or PN-1) (2 companion wells, 1 sample each) Volatiles (8260)	76	8	NA	4	4	2	1	2	96
Outlet Water exiting at EW-233 and EW-234 (2 knock-out tanks) Volatiles (8260)	38 16	4 1	NA NA	2 1	2 1	2 NA	1 1	NA NA	48 19
Effluent Vapors at Carbon Canisters* (between carbon vessels) Volatiles (TO-14)	6*	1	1	0	0	NA	NA	0	8

Table 3-2

(Continued)

Measurement	No. of Samples ^a	Field Duplicates	Laboratory Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Trip Blanks	Equipment Number ^b	Total
POST-TEST									
Groundwater at EW-233 (EW-233, CW-1, CW-2, PN-1) (4 wells, 1 sample each)	4	2	0	1	1	1	1	1	10
Volatiles (8260)									
Soil Vapor at EW-233 companion piezometer nest (PN-1) (1 piezometer nest, 3 sample each)	3	1	1	NA ^c	NA	0	NA	0	5
Volatiles (TO-14)									
Soil Vapor or Piezometer Nests around EW-233 (2 piezometer nests - 1 sample at 5 piezometers each; 3 piezometer nests - 1 sample at 6 piezometers each)	28	2	2	NA ^c	NA	0	NA	0	34

^a Assumes a six-month demonstration.

^b A trip blank will accompany each cooler containing samples for volatiles analysis (approximately 24).

^c Equipment blanks for water and vapor samples are discussed in Appendix 1, Section 3.4.4.

^d Laboratory control samples will be analyzed with each analytical batch.

^e Samples will be collected between the vapor-phase treatment vessels and at the outlet stack. Outlet stack samples will only be analyzed if breakthrough is detected between the carbon vessels.

^f Samples and analysis between and at the discharge of GAC wastewater treatment to be provided by others.

NA = Not analyzed.

samples will be collected by evacuating the headspace within the piezometers for a short period of time, followed by sample collection using evacuated SUMMA canisters. Soil vapor sampling from companion piezometers will also be conducted during system operation.

Groundwater samples will be collected from companion wells to monitor changes in VOC concentrations during the test since representative sampling of groundwater within the extraction wells themselves will not be possible during system operation. The companion well samples will be collected as described for the baseline sampling; i.e., the wells and piezometers will be purged prior to sampling. During system operation, both the groundwater and soil gas samples will be collected at the same time as the treated water and offgas samples described below.

In order to determine which well or set of wells are the most representative of the actual EW-233 inlet concentration, dynamic testing will be conducted during the start-up phase. The dynamic testing will consist of operating the two-phase extraction unit for a limited amount of time, shutting the system down, and taking water samples from each of the companion wells and EW-233 itself. This will be repeated a number of times and the well or combination of wells that best represents the EW-233 inlet will be determined statistically.

The mass of VOC removed from the site and the extent to which VOC in the groundwater are transferred to the vapor phase will be determined from effluent water and offgas samples. For the two-phase extraction demonstration test, effluent water refers to groundwater which has been partially stripped of VOCs in the extraction tube and two-phase extraction unit, and offgas refers to the soil vapor exiting the two-phase extraction unit. Treated water and vapor refers to the streams after treatment with carbon adsorption. The demonstration test is only intended to determine the percent of VOCs transferred from the groundwater to the offgas, not the effectiveness of carbon adsorption to treat the resulting water and vapor streams. Effluent water will be sampled as it is pumped out of the two-phase extraction system knockout pots and prior to polishing with carbon adsorption. A sampling port installed immediately downstream of the pumps will be purged prior to sampling. Offgas will be sampled downstream of each of the knockout pots prior to the point where the vapor flow from the two wells are combined. Offgas samples will be collected in stainless-steel canisters from a port installed in each of the outlet lines. The port will include a glass fiber filter to prevent water or residual pump oil from being carried into the sample container.

Samples collected during the two to six months of two-phase system operation will include effluent water, offgas, companion well groundwater, and companion piezometer soil vapor. Detailed sampling procedures are given in Appendix 1. Samples will be collected for EW-233 from each of these streams as follows:

- Twice daily during the first four days of operation (8 sampling events);
- Once daily for the 5th through 7th day of operation (3 sampling events);
- Every other day for the second week of operation (4 sampling events);
- Every third day for the third week of operation (2 sampling events); and
- Once per week for the remainder of the demonstration test (21 sampling events).

Samples for total vapor concentration from EW-234 will be taken at the sampling port located downstream of the knockout pot. EW-234 samples taken at the outlet to the EW-234 knockout tank will be added to EW-233 water concentrations to determine total mass removal via the water phase. Water and vapor samples will be collected once per day during week 1, twice per week during week 2, once per week during weeks 3 and 4, and once per month during months 2 through 6.

Offgas from between the two GAC vapor treatment beds will be sampled monthly. Details of the sampling and analysis plan including discussion of the QA/QC measures to be taken, target analytes, detection limits, and sampling procedures are provided in the quality assurance project plan (QAPP) provided in Appendix 1.

The demonstration test is planned to last from four to six months. Testing will be completed when significant changes in sample concentrations are no longer occurring, up to a maximum duration of six months.

Mass Removal Rate and VOC Transfer Calculations

EW-233 vapor and liquid data will be evaluated for system effectiveness by calculating the contaminant mass removed and the percent transfer of VOCs from the liquid to vapor phase. These calculations are:

$$\text{Total Mass Removed} = \Sigma (C_{wi} \times V_{wi}) + \Sigma (C_{vi} \times V_{vi})$$

where: C_{wi} = concentration of effluent water during interval i;
 V_{wi} = volume of water produced during interval i;
 C_{vi} = concentration of offgas during interval i; and
 V_{vi} = volume of offgas produced during interval i.

In general, the water and offgas sample intervals will be concurrent because all sampling will be performed during the same periods.

$$\text{Average Percent Transfer from Liquid to Vapor Phase} = \frac{\Sigma [(C_{gwi} - C_{wi})/C_{gwi}] \times 100}{n}$$

where: C_{gwi} = concentration of the groundwater (based on companion well data) during interval i; and

n = number of terms summed in equation numerator.

Groundwater and soil vapor samples collected during each time interval can be used to perform a mass balance versus the treated water and offgas results to check for data validity as:

$$(C_{wi} \times V_{wi}) + (C_{vi} \times V_{vi}) = (C_{gwi} \times V_{wi}) + (C_{svi} \times V_{vi})$$

where: C_{svi} = concentration of the soil vapor during interval i.

3.2 Zones of Influence

The zones of influence for groundwater and soil gas will be determined by measuring the groundwater elevation in surrounding wells and the induced vacuum in surrounding piezometers. Groundwater elevations will be measured in the extraction well and all surrounding wells prior to system operation to determine a baseline groundwater elevation; the existing extraction wells will be shut off for two days before taking the baseline measurements. Data will also be collected to evaluate the effects of a local water supply well on the water levels in the monitoring wells. During system operation, the groundwater elevation in each monitoring well will be measured concurrent with sampling

events. More levels may be collected at the beginning of the test. The elevations will be plotted versus distance from the well to show the groundwater zone of influence.

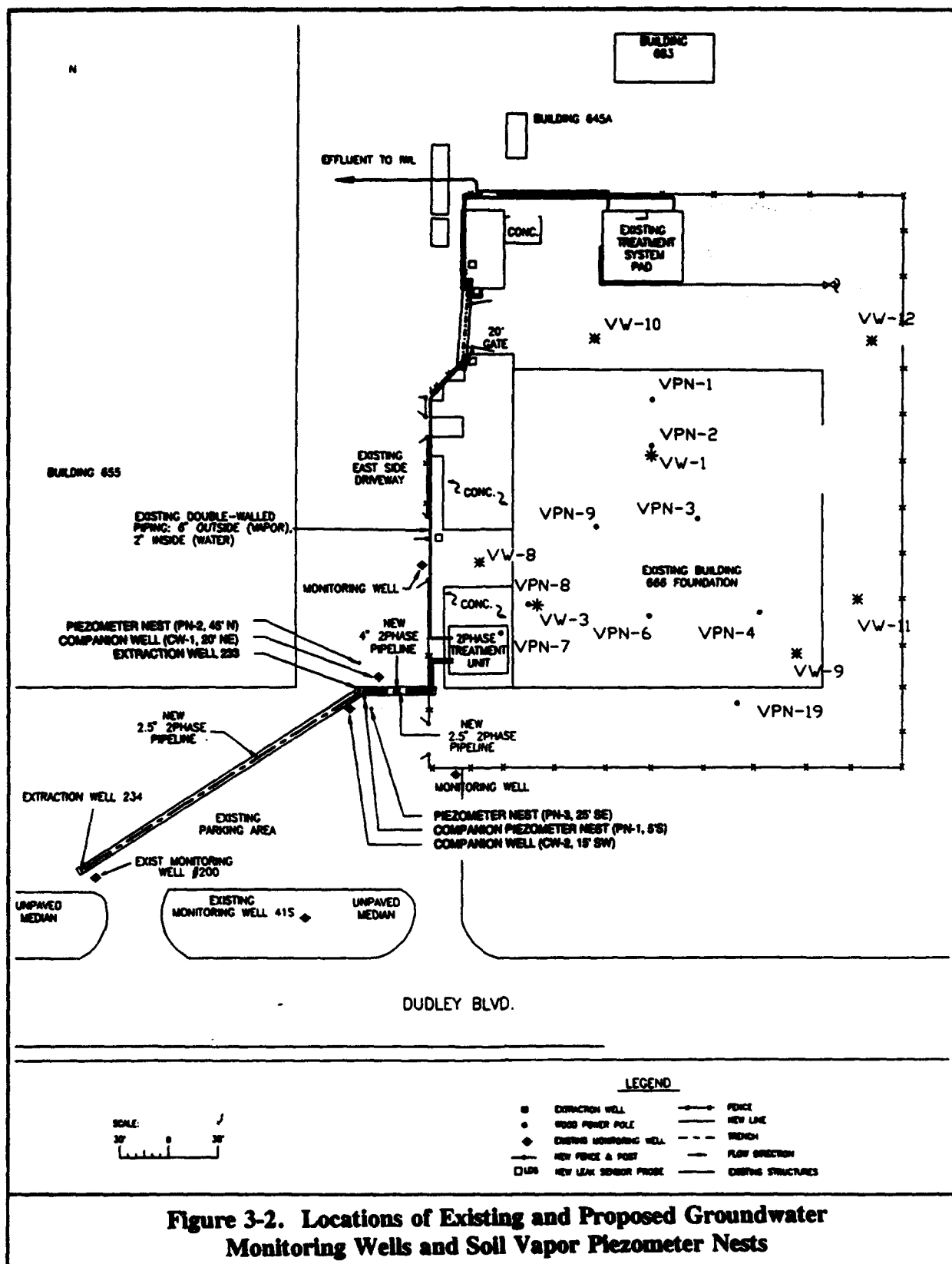
The radius of influence for vapor extraction will be determined by measuring the induced vacuum in piezometers. Induced vacuum measurements will be performed at the same time the water level readings are taken. The induced vacuum will be measured relative to atmospheric pressure using a Magnehelic®, and the data corrected to absolute pressure using hourly barometric readings from the McClellan Air Force Base (AFB) Meteorological Station; an on-site barometer may also be used to determine barometric pressure. The induced vacuum results will be plotted versus distance from the extraction well to graphically determine the radius of influence; an induced vacuum of 0.1 inch water will be used to indicate the extent of influence.

Locations of the groundwater monitoring wells and soil vapor piezometer nests are shown in Figure 3-2. A vertical cross section showing the well placement is provided in Figure 3-3.

3.3 System Operating Data

Parameters that will be measured for use in calculating system effectiveness are:

- Vapor Flow Rate will be determined for each extraction well and the total system. The flow rate will be measured at the outlet of the knockout pot for well EW-234 and at the outlet to the two-phase extraction blower (combined flow). The flow for EW-233 will be determined by subtraction.
- Applied Vacuum will be measured in the straw at the well head and at the inlet of the two-phase extraction blower.
- Well-Head Vacuum will be measured at each well head (indicates the actual vacuum applied to the formation).
- Water Production Rate will be measured separately for each well at the knockout pot transfer pumps.



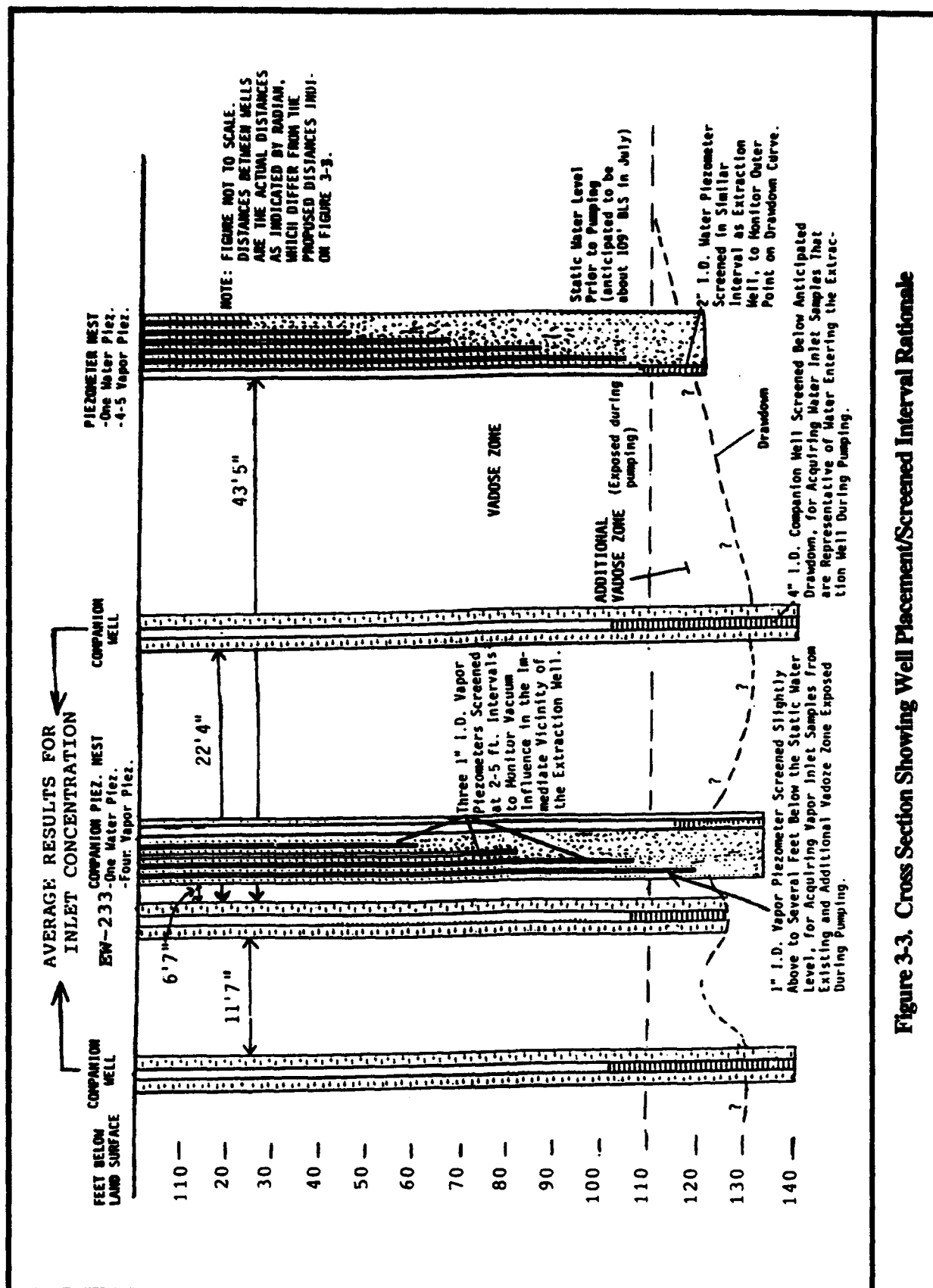


Figure 3-3. Cross Section Showing Well Placement/Screened Interval Rationale

SOURCE: SAIC

- Temperature will be measured at the two-phase extraction skid blower inlet and outlet near the flow meters.
- Pressure will be measured at the two-phase extraction skid outlet.
- Temperature, pressure, vacuum, liquid levels, and other measurements will be made at other intermediate locations within the two-phase extraction system and the carbon treatment systems. These data will be used to confirm proper system operation.

3.4 Data Collection Recordkeeping

The demonstration test Two-Phase Data Sheets are provided in Figure 3-4. To the extent possible, process data collection efforts will be coordinated to correspond with the collection of the liquid and vapor samples. Data collection sheets that will be used to record water levels and soil vapor pressure head readings are provided as Figures 3-5 and 3-6, respectively.

[illegible][illegible]

5 -- Gas high pressure alarm gauge should have same reading.

Figure 3-4. Two-Phase System Data Sheets

Two-Phase Treatment System -- Operation Data Sheet

Date (m/d/y)	Time (24 hour)	Initials	Flow Totalizers (Note 1)				Dehumidifier		Effluent Flow Rate (gpm)
			Chart Time (24 hour)	EW-233 (gal) (Pen 1)	Combined (gal) (Pen 2)	Effluent (gal) (Pen 3)	Gas Flow Rate (ccfm) (Pen 4)	Relative Humidity (%)	

Date (m/d/y)	Time (24 hour)	Water Pumps (Note 3)				Water-Phase Carbon		Air-Phase Carbon		Vinyl Chloride		
		North Pump Outlet Press (psi)	South Pump Outlet Press (psi)	Filter Inlet Press (psi)	Filter Outlet Press (psi)	Tank 1 Outlet Press (psi)	Tank 2 Outlet Press (psi)	Inlet Temp (°F)	Tank 1 Inlet Press (psi)	Tank 1 Outlet Press (psi)	Tank 2 Outlet Press (psi)	Tank 1 Outlet (ppmv) (Note 4)

- Footnotes:
 1 -- Record flow totalizer values from control panel chart -- record most recent totals and time printed.
 2 -- Push relative humidity readout to obtain temperature reading.
 3 -- Check when pump(s) is running. Change water filter when pressure exceeds (TBD) psi.
 4 -- Check Tank 2 outlet concentration only if breakthrough is detected at Tank 1 outlet.

Figure 3-4. Two-Phase System Data Sheets (continued)

[illegible]

Continued Yes/No

Figure 3-5. Data Collection Sheet for Water Level

Date: _____ Page ____ of ____
 Site: IC-
 Well Tested: VW- Peizometer: VPN-
 Samplers: _____ Distance from Extraction Well: _____ ft

[illegible]

Continued: Yes / No

Figure 3-6. Data Collection Sheet for Soil Vapor Pressure Head Readings

4.0 DQO/QAPP/QA/QC

Data collected during the demonstration will be used to assess the technology's performance against the Demonstration Test goals and objectives discussed in Section 2.0, the potential need for pre- and post-processing of the waste, and potential operational problems. Due to the critical nature of the sampling and analysis results, approved quality control procedures must be stringently followed throughout the demonstration program.

4.1 Data Quality Objectives

The data collected during the demonstration test will be used to address the following issues:

- Estimate the mass of volatile organic compound (VOC) contaminants removed by the two-phase extraction system, and compare the removal rate with the current pump-and-treat system;
- Determine the transfer rate of VOC contaminants from the water to the vapor phase in the two-phase extraction unit;
- Evaluate the radius of capture and influence for the groundwater and soil vapor, respectively, to determine two-phase extraction effectiveness at controlling the groundwater plume and minimizing additional groundwater contamination or surface flux of soil vapor contamination; and
- Evaluate the cost effectiveness of the two-phase extraction unit for removing contaminants from the well to use as a basis for evaluating application of the technology at other sites.

Preliminary data quality objectives (DQOs) are outlined for each of these issues in Tables 4-1 to 4-4.

Table 4-1

Data Quality Objective - Mass Removal Rate

Evaluation Item

Evaluate and compare the two-phase extraction system versus the pump and treat system based on mass removal rate of VOC contaminants from the two wells.

Input Data

- Process data collected during operation of the pump and treat system at EW-233 and EW- 234, including flow rates, and sample concentrations.
- "Outlet" concentrations of effluent water and vapor offgas.
- "Inlet" concentrations of groundwater sampled in the EW-233 companion wells, and soil vapor in the EW-233 companion piezometers.
- Process data collected during operation of the two-phase system including vapor and water flow rates, vapor pressure, and vapor temperature.

Calculation/Output Data

- Data provided on the pump and treat system's contaminant removal rate will be used as is, no additional data calculations will be performed.
- Vapor sample results will be converted from concentration values (i.e., ppbv for vapor) to a mass basis (lbs/scf). This will be done using the measured concentration of each contaminant times the molecular weight of that contaminant divided by the molar volume of a gas at standard conditions. Water samples will be converted to lbs of contaminant per gallon from $\mu\text{g/L}$ using a simple unit conversion.
- Vapor flow rates will be determined by an air flow meter reading in scfm. The EW-233 flow rate at the knockout pot outlet and the combined EW-233 and EW-234 flow will be measured.
- Water flow rates will be determined from flow meter reading data taken at the effluent water transfer pump outlet line. An average flow rate will be determined for each sampling interval by subtracting the previous totalized flow reading (in gallons) from the current reading (in gallons) and dividing by the time interval (excluding system down time) between the two readings to obtain an average gpm flow rate value.
- The mass basis vapor and liquid concentration values (i.e., lbs/scf and lbs/gallon, respectively) will be multiplied by their respective flow rates to get short term extraction rates for both the water and vapor phases. These values will be added together to obtain the overall contaminant extraction rate using the two-phase extraction system. This value will be averaged with the previous extraction rate and multiplied by the operating interval between the two values to estimate the mass of contaminants extracted within that period. The sum of the extracted mass for each period during the demonstration test will be used to estimate the total contaminant removal rate over the duration of the demonstration test.

Table 4-1
(Continued)

Calculation/Output Data (Cont'd.)

- The extraction rates calculated for the two-phase extraction system will be compared with the data from the pump and treat operation extraction rate information to determine which has the greater extraction rate.

Uncertainties

- Potential error may exist in the existing pump and treat information.
- Potential error may exist in the analytical results for samples collected during two-phase operation.
- Collection of water and vapor samples and collection of flow data at different times may misrepresent the actual extraction rate.
- Error may exist in the flow, temperature, and pressure readings taken on the system due to instrument error.
- Error may exist in the flow, temperature, and pressure readings taken on the system due to human error in taking the readings.
- Error may exist in extrapolating nearly instantaneous sampling results and data readings to long time intervals.

Data Quality Decision Rules

Existing pump and treat data error

- Radian will not conduct any quality assurance activities of the existing data; it will be accepted as is. Any obvious errors or suspect information identified will be noted in any comparison done using that data.

Analytical Data Error

- The QA/QC analysis of the analytical data is discussed in the QAPP provided in Attachment 1. Unless this review identifies obvious, substantial problems, the data will be used "as is." If problems are identified with the data, an assessment of the magnitude of the problem will be made and used as the basis for deciding to either: use the data as is; use a portion of the data and/or correct a portion of the data; or not use the data. If it is decided not to use the data, the data collected immediately before and after will be used to represent the conditions during the period.

Non-Simultaneous Data Collection Error

(Note: use of "acceptable" refers to use of the data to calculate the contaminant extraction mass and rate.)

- Vapor flow rate data collection should occur within 20 minutes of collection of a vapor sample; however, data that is collected within two hours of the vapor sample will be accepted as is.

Table 4-1

(Continued)

Data Quality Decision Rules (Cont'd)

- Vapor flow rate, temperature, and pressure should be collected within 5 minutes of each other; however, data that is collected within one hour of each other will be accepted as representative.
- Vapor flow rate data collected after 2 hours of vapor sample collection and process data that is collected after one hour of each other will be evaluated based on the variability of the data over that period, and a determination made as to the acceptability of the data. Any calculations or results made for which this data is key will include a note to the effect that the data were not collected simultaneously.
- Water flow rate data that is collected within 24 hours of the water sample will be accepted as representative.
- Water flow rate data not collected within 24 hours of water sample collection will be evaluated based on the variability of the data over that period, and a determination made as to the acceptability of the data. Any calculations or results made for which this data is key will include a note to the effect that the data were not collected simultaneously.

Instrument Error (Flow, Temperature, and Pressure)

Instrument calibration and redundancy will be used to maintain instrument error within acceptable bounds for the purposes of our calculations. The following instrument calibration frequency will be used for instruments used to obtain data for the vapor or treated water flow rate calculation:

- Prior to initiation of the demonstration test;
- At the end of the second and fourth week of the test;
- Monthly thereafter unless the instrument has remained within 50 percent of the calibration limits for the last two calibrations in which case calibration will be done every other month.

The following procedures will be used for the instrument readings:

- If the instrument is within the calibration limits at the time of the next calibration, all measurements taken between that calibration and the previous calibration will be considered acceptable without adjustment;
- If the instrument is not within the calibration limits, the measurements taken between that and the previous calibration can be used after adjusting for the variation. The adjustment will be assumed to be linear with time between the two calibrations. If the instrument is more than 200 percent out of the calibration range, the readings taken during the previous interval will not be considered valid.

Table 4-1
(Continued)

Data Quality Decision Rules (Cont'd)

The calibration limits for the various measurements are provided below:

- Vapor flow $\pm 15\%$;
- Vapor temperature $\pm 5\%$;
- Vapor pressure $\pm 5\%$; and
- Water flow $\pm 10\%$

Operator Instrument Reading Error

Error in taking measurement readings can occur from a number of sources including the operator reading the instrument incorrectly or instability in the instrument readout requiring the operator to estimate the middle of the range of readings observed. If review of the collected data indicates that an individual data point appears to be an outlier, the person that recorded the reading will first be questioned regarding the value. If it still appears that the reading is an outlier, it will be evaluated based on the variability of the data over that period, and a determination made as to the acceptability of the data. Any calculations or results made for which this data is key will include a note to the effect that the data were not collected simultaneously. Additionally, data will be provided on the approximate variations in the readings over the observation period.

Extrapolation to Long-Term Intervals Error

The resulting cumulative extrapolation rate should be considered an approximation of the amount of contaminants removed during the demonstration test. No modifications to the calculation method will be performed to account for this potential error.

Table 4-2

Data Quality Objective - Mass Transfer Efficiency

<u>Evaluation Item</u>
Determine the efficiency of the VOC contaminants mass transfer from the water to the vapor phase.
<u>Input Data</u>
• Inlet groundwater VOC contaminant concentration data from companion wells during operation • Inlet soil vapor contaminant concentration data from companion piezometer. • Effluent water VOC contaminant concentration data from the two-phase extraction outlet. • Offgas VOC contaminant concentrations data from the two-phase extraction outlet.
<u>Calculation/Output</u>
• The total mass of VOC contaminants per unit volume of water in the corresponding inlet (i.e., companion well) and outlet of the two-phase extraction unit will be determined from the inlet and outlet sampling done on EW-233. Mass transfer efficiency will be calculated by subtracting the outlet from the inlet and dividing the result by the inlet concentration. • Mass balance calculations will be performed as a secondary check on the mass transfer efficiency calculations. The inlet vapor and groundwater VOC contaminant concentrations and the outlet vapor and effluent water VOC contaminant concentration will be put on a mass basis using the vapor and water flow rates at the two-phase extraction unit. The sum of the inlet VOC mass in the vapor and groundwater should approximately equal the sum of the outlet water and vapor contaminant mass. The mass balance will be done on EW-233 only since EW-234 does not have any companion samples to estimate inlet concentrations.
<u>Uncertainties</u>
• The use of companion monitoring well sampling results to represent the two-phase extraction inlet could introduce error into the transfer efficiency calculation due to the directional nature of the samples. Lower or higher concentration gradients within the groundwater or soil gas may not be detected in the companion wells if the concentration gradient moves to the extraction wells from a different direction or depth than the companion wells. • The samples to estimate the inlet concentration are from a companion well and will not be actual inlet concentrations; this may cause the mass estimates in the inlet and outlet to not balance.

Table 4-2
(Continued)

Data Quality Decision Rules

- The baseline results will be used as the inlet concentration for the initial two-phase extraction operating results. The results from the companion wells will be used as the primary source of inlet concentration data for the calculation during operation.
- The potential error due to the directional nature of the monitoring well sampling to determine inlet concentrations will be minimized by strategically placing the companion wells relative to the extraction wells and the groundwater plume. In order to minimize the potential error caused by the directional nature of the contaminant flow, dynamic testing (samples taken from both the companion wells and EW-233 immediately after system operation) will be conducted prior to the demonstration test. The results will be analyzed statistically to determine the most representative well or combination of wells for the inlet concentrations.
- A mass balance will be conducted on the inlet and outlet. If the mass balance matches to within 50%, the inlet data will be used as is. If the mass balance does not match within 50%, the data will be reviewed to determine if the transfer efficiency should be adjusted or deleted. The mass balance will be considered approximate; no quality assurance activities, beyond the analytical QA/QC controls, will be performed on the data.

Table 4-3

Data Quality Objective - Radius and Zone of Influence

<u>Evaluation Item</u>
Determine the zone of influence in the groundwater and the radius of influence in the soil vapor.
<u>Input Data</u>
Water level readings from surrounding monitoring wells and vadose zone pressure readings from surrounding piezometer nests.
<u>Calculation/Output</u>
Zone of influence for the groundwater plume will be determined using data on the groundwater depression in the monitoring wells and each well's distance from the extraction wells. The distance-drawdown data will be plotted to identify the maximum zone of influence in the groundwater. Vadose zone pressure readings (induced vacuum) will be normalized to absolute pressure using barometric pressure data. The pressure-distance data will be plotted to determine the radius of influence.
<u>Uncertainties</u>
• Regional groundwater effects from Base supply wells may interfere with obtaining consistent water level readings. • Piezometer readings or atmospheric pressure corrections may not have been recorded correctly. • Data may not adequately account for directional variations due to regional water gradients, variable soil conditions, the overlapping influences of the two extraction wells, or surface variations (i.e., the surface is capped for different distances in different directions). • The curve-fitting function may not accurately describe the radius or zone of influence beyond the distance that good monitoring data is available.
<u>Data Quality Decision Rules</u>
<u>Atmospheric Pressure Readings</u> Atmospheric pressure will be obtained from MAFB meteorological staff. This data is only recorded on an hourly basis; it will be assumed to be within adequate data quality limits and will be accepted as provided. Changes in barometric pressure will be considered to be straight line between hourly readings for use in adjusting Magnehelic® readings.

Table 4-4

Data Quality Objective - Two-Phase Extraction System Cost Effectiveness

<u>Evaluation Item</u> Comparison of the cost effectiveness of the two-phase extraction system versus the pump and treat system for VOC contaminant removal.
<u>Input Data</u> • Cost data on the pump and treat operation at EW-233 and EW-234. • Estimated cost data for the two-phase extraction system. • VOC contaminant removal rate for the pump and treat system (e.g., lbs/year removed). • VOC contaminant removal rate for the two-phase extraction system (e.g., lbs/year removed).
<u>Calculation/Output</u> The cost data (including estimated capital, operating, and maintenance costs) will be annualized to a cost per pound of VOC removed for comparison purposes.
<u>Uncertainties</u> • Error may exist in estimating the total cost of both the systems. The amount, quality, availability, and level of detail available on the pump and treat system is unknown at this time. Long-term operating and maintenance costs for the two-phase extraction system will have to be estimated based on the results of the short-term test. • Error may exist in the VOC contaminant removal rate estimated for both the pump and treat system and the two-phase extraction system (refer to the DQO discussed in Table 4-1). • Error may exist in estimating system life cycle.
<u>Data Quality Decision Rules</u> • The available cost data will be used for the comparison, however, uncertainty in the cost estimates for each system will be presented in the comparison to the extent that it can be evaluated. • The potential error in the contaminant removal rate estimate will be addressed as discussed above in the DQO for the mass removal rate.

4.2

QAPP/QA/QC

The Demonstration Test Quality Assurance Project Plan (QAPP), as modified from the Science Applications International Corporation (SAIC) QAPP, is provided in its entirety in Appendix 1. The QAPP follows the guidelines presented in U.S. Environmental Protection Agency's (EPA's) Office of Research and Developments (ORD) Risk Reduction Engineering Laboratory (RREL) Document EPA/600/8-91/004. This document describes the methods to handle and analyze samples and perform other relevant data gathering activities needed to evaluate the two-phase extraction system. Groundwater and vapor samples will also be collected according to the procedures described in Appendix 1.

4.2.1 Sample Analysis

Groundwater samples will be analyzed by Method SW8260, and vapor samples will be analyzed by Method TO-14. Three volatile compounds have been identified as critical: tetrachloroethene, trichloroethene, and trichlorotrifluoroethane (Freon® 113). Previous testing has shown that these compounds comprise the significant portion of groundwater and soil vapor contaminant concentrations. The target reporting limits are approximately 5 micrograms per liter ($\mu\text{g/L}$) for groundwater and 10 parts per billion by volume (ppbv) for soil vapor for these critical compounds.

4.2.2 Quality Assurance Objectives

The two-phase extraction demonstration DQOs are based on project requirements and are designed to ensure that the data are of known and acceptable quality to achieve the project's technical objectives. The critical measurements are expressed in terms of the data quality indicators: precision, accuracy, completeness, method detection limits, representativeness, and comparability.

Precision: Precision objectives are represented as the relative percent difference (RPD) between matrix duplicates, or the RPD between matrix spike/matrix spike duplicate (MS/MSD) analyses. The DQO is an RPD $\leq$ 30 percent.

Matrix duplicates will be analyzed to evaluate precision for the critical TO-14 analyses and critical VOC analyses by Method 8260.

Guidelines for evaluating the precision of field duplicates will be the analytical results within ± 10 percent.

Accuracy: Objectives for accuracy are represented as percent recovery of laboratory matrix spikes. Matrix spikes will be performed on water samples for VOCs, and the DQO shall meet the limits of 70-130 percent. Accuracy for TO-14 analyses will be determined using a NIST Standard Reference Material (NIST SRM 1804).

Completeness: Objectives for data capture, expressed as completeness, are 90% for the critical parameters. Completeness is defined as the ratio of the number of valid measurements to the total number of measurements taken (refer to Appendix 1).

Target Reporting Limits: Demonstration Test target reporting limits (TRL) objectives are based on project requirements and the sample matrix to be analyzed.

Comparability: The use of standard, validated United States Environmental Protection Agency (U.S. EPA) methods achieves comparability of measurement data. Reporting the data in standard units of measure as specified in the methods, adhering to the method-defined calibration procedures and, when possible, meeting the method detection limit all contribute to the comparability of the data.

Representativeness: A well-defined sampling strategy ensures that samples are representative. Sufficient samples are planned during the Two-Phase Extraction Demonstration Test to ensure that results for both water and vapors are representative of the conditions encountered.

4.2.2.1 Sampling Procedures

The following table indicates the sampling methods, analytical parameters, container sizes, and sample quantities required for analysis of samples to be collected during the two-phase extraction technology demonstration. Sampling methodologies are summarized in Appendix 1.

Sample Type	Sampling Method	Analysis Parameter	Sample Quantity Required for Analysis	Container Size
Vapors	TO-14	Volatiles	SUMMA canister	1.5 liter
Water	Bailer	Volatiles	5 ml	2-40 ml vials

4.2.2.2 Sample Preservations and Holding Times

The following table indicates the required preservation techniques and holding times for each of the sample parameters.

Analysis Parameter	Sample Type	Preservation	Maximum Holding Time
VOCs	Water	pH < 2 with HCl; no headspace; cool at 4°C	14 days
VOCs	Vapor	None	30 days

4.2.3 Field Objectives

4.2.3.1 Field Documentation

All handwritten documentation must be legible and completed in permanent ink. Corrections must be marked with a single line, dated, and initialed. All documentation, including voided entries, must be maintained within project files.

Field documentation shall consist of a project logbook, one or more site-specific field logbooks, field forms, sample logs/labels, and an equipment calibration log. All logbooks must be permanently bound with hard covers and have sequentially number pages. In addition, each logbook will be uniquely identified and sequentially numbered. Logbooks will be maintained on site until complete, then stored in the project files.

4.2.3.2 Equipment Decontamination

The decontamination of major equipment (e.g., drill rigs) and sampling equipment is necessary to minimize contamination of clean zones, to reduce exposure to

personnel, and to reduce cross-contamination of samples when equipment must be reused during a sampling event. Sampling equipment will be stored in a clean area prior to and after decontamination.

Rinsate samples will be collected at a frequency of 5%, as required, from the decontaminated sampling equipment by rinsing the cleaned equipment with chromatography grade water (or equivalent). Disposable material (e.g., gloves, Tyvek® suits, etc.) generated during decontamination will be bagged and placed in a disposal area designated by McClellan Air Force Base (AFB).

4.2.4 Sample Custody

The possession of samples or other evidence shall be traceable beginning at the time samples are collected. This will be accomplished through chain-of-custody procedures. Chain-of-custody forms will accompany the sample shipment and will be shipped in the appropriate container (cooler). Copies of the completed chain-of-custody forms will be included in appropriate data validation packages.

4.2.4.1 Field Custody Procedures

One individual from the field sampling team will be designated as the responsible individual for all sample transfer activities. This person will be responsible for sample care and custody until the samples are properly transferred to another person or facility.

4.2.4.2 Laboratory Custody Procedures

The laboratory sample custodian or designated alternate will receive and assume custody of samples until they have been properly logged in and stored in a secure area. Specific procedures discussed in Appendix 1 will be performed for both the groundwater samples and vapor canister samples.

4.2.5 Analytical Procedures and Calibration

The selection of appropriate methods to prepare and analyze the Two-Phase Extraction Technology Demonstration samples is based on the specific analytes of interest,

the sample matrix, and the minimum detectable concentrations needed to meet the project objectives. The references used are as follows:

- 1) **Test Methods for Evaluating Solid Waste, Volumes 1A-1C:**
Laboratory Manual, Physical/Chemical Methods; and Volume II: Field Manual, Physical/Chemical Methods, SW-846, Third Edition, Office of Solid Waste, U.S. Environmental Protection Agency, Document Control No. 955-001-00000-1, 1986 (Includes Final Update I to SW-846, November 1990).
- 2) **EPA Compendium of Methods for the Determination of Toxic Organics in Ambient Air.**

Analytical Procedures

Method 8260 - Volatile Organic Compounds by GC/MS: Capillary Column Technique

Method 8260 will be used to analyze groundwater samples for VOCs. The VOCs are introduced into the gas chromatograph (GC) by the purge-and-trap method, and are then detected with a mass spectrometer (MS) interfaced to the GC.

Method (TO-14) - Determination of VOCs in Ambient Air Using SUMMA Passivated Canister Sampling and GC Analysis

Method TO-14 will be used to analyze soil vapor samples for VOCs. The method is based on the collection of whole air samples in SUMMA passivated stainless-steel canisters. VOCs are isolated from the air matrix cryogenically, separated by capillary-column gas chromatography, and detected by mass spectrometry. Method TO-14 provides general guidelines for these determinations. The CCAS Standard Operating Procedure (SOP) in Appendix 1 provides specific details for these analyses.

4.2.6 Data, Validation, and QC Samples

All raw data are recorded in laboratory notebooks or on worksheets in standardized format by the analyst performing the test. Each analytical method contains detailed instructions and equations for calculating the respective analyte concentration.

Within the laboratory, raw data reductions are verified by an independent analyst or a section quality control (QC) specialist. Any problems or errors discovered during this review will initiate a 100% review of the batch. All QC samples are compared to quality assurance (QA) objectives for precision and accuracy; any outliers will be investigated and corrective action followed. Qualifying statements will describe any problems encountered and any restrictions on data use. Field data will be validated by a similar procedure.

Data Reporting

All original laboratory data will be recorded in a permanent manner, and will be readily traceable through all steps of the data generation/reduction/validation/review process. Field measurements will be recorded in appropriate field notebooks and results will be reported in tabulated summary forms.

Final Technical Report

The validated field and analytical data will be used to prepare the Technology Demonstration Technical Memorandum (TDTM) evaluating the demonstration technology and assessing its potential applications. The TDTM will include a QA review and discussion as a separate section. The QA section will provide validation of the measurements to be used in the evaluation and subsequent acceptance/rejection of the innovative technology.

4.2.6.1 Field and Laboratory Quality Control

Specific QC samples, collected and analyzed by the appropriate methods, are introduced into the laboratory as a check. These field QC samples are defined below and are summarized in Table 4-5 along with frequency and acceptance criteria.

Table 4-5

Summary of Laboratory Internal QC Checks for the Two-Phase Extraction Site Demonstration

Parameter	Matrix	Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
VOCs	Water	8260	Tuning	Daily	See SOP	Correct problem, return
			Initial calibration	Initially and when continuing check unacceptable	RSD < 30%	Recalibrate
			Continuing calibration	Every 12 hours	% difference < 25%	Recalibrate
			LCS	Each sample batch	% R = 70-130 ^a RPD < 30	Evaluate effect; reanalyze if necessary, or flag data
			Method blank	Each sample batch or group of 20 samples	Concentration < method PQL	Evaluate effect; reanalyze if necessary, or flag data
			MS/MSD	Two groundwaters and two waters exiting knock-out tank	% R = 70-130 RPD < 30	Review analyses; notify SABC QA/QC coordinator; retest, or flag data as appropriate
			Surrogates	All samples	See Table 3-14	Reanalyze if sample available, or flag data
			Tuning	Daily	See SOP	Correct problem, return
			Initial Calibration	When continuing calibration not acceptable	RSD < 30% for all analytes	Recalibrate
			Continuing calibration	Daily	< 30% difference from initial for all analytes	Recalibrate
VOCs	Vapor	TO-14	Zero air blank	Every 10 samples	< 2 ppbv difference from initial for all analytes	Correct problem; reanalyze affected samples
			Surrogate	All samples and blanks	70-130%	Reanalyze
			Laboratory Control Sample	Every analytical batch	70-130% ^a	Correct problem; reanalyze; notify SABC QA/QC coordinator
			Duplicates	Two soil vapors and two vapors exiting knock-out tank	RPD < 30	Reanalyze; notify SABC QA/QC coordinator
			Canister Cleaning	One per batch of 8 ^b	< 10 ppbv	Reclean and recheck

^a For critical VOCs.^b All 8 canisters in a batch will be analyzed for the first three batches as an initial check on canister cleaning system.

- **Field Duplicates** - are two sample aliquots collected simultaneously or sequentially; the comparison of results helps evaluate total precision.
- **Equipment (Field QC) Blanks** - check the integrity of sample collection and handling procedures and equipment decontamination procedures.
- **Field Blanks** - assess contamination attributable to field and laboratory handling procedures.
- **Trip Blanks** - assess contamination attributable to shipping and field handling procedures.
- **Temperature Blanks** - assess sample handling and preservation between the field and laboratory.

4.2.6.2 Laboratory QC

This section describes the various laboratory internal quality control checks to be performed during analyses of critical parameters. Table 4-5 summarizes which QC checks will be performed for each parameter and the frequency, acceptance criteria, and corrective action to be followed. Calibration procedures were discussed and are summarized in the table.

- **Matrix duplicates** evaluate precision through the calculation of data to produce the RPD.
- **MS/MSD** measures both precision and accuracy. The analysis of the two spiked aliquots generates recovery data (accuracy). Comparing the results of the two spiked aliquots allows the calculation of the RPD between the two measurements (precision).
- **Laboratory control samples (LCSs)** measure accuracy of the method procedure.
- **Method blanks** are analyzed with each batch of samples analyzed or every 20 samples, whichever is more frequent, for Method 8260

analyses. Blanks evaluate any potential affect of external laboratory contamination on data results.

- Surrogate spikes assess the ability of the method in recovering target analytes.
- Internal standards measure the performance of the instrumentation.

4.2.7 Performance and System Audits

Audits are an independent way to confirm the operation or capability of a measurement system, and to document the use of QC measures designed to generate valid data of known and acceptable quality. An audit is, by necessity, performed by a technically qualified person who is not directly involved with the measurement system being evaluated. A performance evaluation is generally an objective audit of a quantitative nature, and a systems audit is a qualitative evaluation of the capability of a measurement system to produce data of known and acceptable quality.

4.2.8 Corrective Action

The need for corrective action comes from several sources: equipment malfunction, internal QA/QC checks outside of acceptance criteria, deficiencies noted during performance or systems audits, and noncompliance with sampling/analysis QA requirements (e.g., hold times). In all instances, except for responding to audit findings, the field and laboratory personnel performing the measurement task are responsible for identifying any nonconformance or potential problem with the protocols, equipment, or method. The responsible individual must immediately notify the appropriate supervisor that a problem exists. If the individual identifying the problem can correct it independently, such corrective action must take place before any further sample collection or analysis occurs. The corrective action to be taken must be determined on a case-by-case basis, considering the nature of the problem and the extent of the error.

4.2.9 Quality Control Reports to Management

A report on analytical-related activities will be prepared monthly. Information submitted in this report will include any proposed changes or modifications to the QAPP, a

summary of field QA/QC activities, laboratory QA/QC activities, and an overall tentative assessment of data quality to date. The reports will discuss any problem conditions and corrective actions, audit events and results, sampling and analysis QA/QC status, and a general review of the achievement of data objectives for the project.

The final demonstration report will include a QA section documenting the QA/QC activities which support the credibility and validity of the data. A summary of the data quality information will be provided and will include an assessment of the QA objectives which were achieved. This summary will also discuss which QA objectives, if any, were not met, why they were not met, and the impact to the project.

5.0

SITE HEALTH AND SAFETY PLAN SUMMARY

The health and safety plan (HASP) designed to address this project's health and safety issues is included as Appendix 2. The following sections outline the HASP and summarize the more important sections of the HASP. Although this summary provides useful information, it is not intended to replace the HASP. The HASP provides greater detail and can clarify specific topics only slightly addressed in the summary. The anticipated work activities for this project include:

- Demonstration: Xerox Two-Phase Extraction technology;
- Modification of the Groundwater Treatment Plant (GWTP);
- Well modification and installation; and
- Collecting soil, water, and soil gas samples.

5.1

Key Personnel and Responsibilities

Gordon Kingsley of Radian Corporation (Radian) will be the project manager. John Clark will be the task leader for the field effort and is the technical contact for the project. A complete discussion of key personnel and responsibilities is provided in Appendix 2. These sections include:

- Radian project manager/project director responsibilities;
- Radian on-site engineer responsibilities; and
- Contractor/subcontractor employee responsibilities.

5.2

Hazard Analysis

This section of the HASP addresses specific on-site hazards which may be encountered during the activities described in Section 5.1. A summary of the information provided in each section of the HASP is provided below.

5.2.1 General Safety

This section discusses the general site safety hazards and what site workers must do to comply with HASP requirements. These hazards include: 1) heavy equipment with moving/rotating parts (including equipment guards and vacuum lines; 2) proper lock-out/tag-out procedure requirements; 3) electric shock from wiring or equipment; and 4) falls from climbing. The normal work period is eight hours per day, 40 hours per week. The length of the project is shown in Figure 10-1, Two-Phase Extraction Schedule.

5.2.2 Chemical Hazards

This section discusses some of the more hazardous chemicals and what site workers must do to comply with HASP requirements. Based on previous studies, volatile organic compounds (VOCs) of concern are listed in Table 5-1, along with their respective health effects. Inhalation of VOCs and skin contact with contaminated material are the most likely routes of personnel exposure in the work area. Real-time air monitoring instruments will indicate the presence of vapors before a chronic inhalation hazard exists. The following safety precautions will be implemented to ensure the protection of site workers from potential chemical hazards:

- Protective clothing available/required for specific tasks (Table 5-2 and Section 5.3); and
- An air monitoring program as outlined in Section 5.4 to measure volatile organic compounds.

5.2.3 Physical Hazards

Physical hazards include:

- Mechanical: moving equipment and machinery, sharp or heavy objects;
- Electrical: buried cables and overhead power lines, lightening during electrical storms, and electrical shock (see Sections 5.2.1 and 5.2.3.5 for additional electrical hazards)

Table 5-1**Available Information Regarding Health Effects
of Chemicals of Concern**

Chemical	Airborne Exposure Criteria¹	Health Effect
Activated Carbon (sorbent material)	10 mg/m ³	Nuisance dust, respiratory irritation
Chloroform	10 ppm	Cancer, CNS depression, damage to blood-forming systems
Chloromethane	100 ppm	CNS depression, liver and kidney damage
1,1-Dichloroethane	100 ppm	CNS depression, liver and kidney damage, drowsiness
1,2-Dichloroethane	10 ppm	Cancer, CNS depression, liver and kidney disease
Freon® 113	1,000 ppm	Irritation, dermatitis, dizziness
Carbon Tetrachloride	5 ppm	Cancer, CNS depression, damage to kidney, liver, and lungs
Tetrachlorethane	50 ppm	Cancer, dermatitis, CNS depression, liver diseases, cardiac arrhythmia; acts synergistically with alcohol
Trichloroethene	50 ppm	Cancer, CNS depression, acts synergistically with alcohol
Vinyl Chloride	1 ppm	Cancer, liver and bone diseases

¹ American Conference of Governmental Industrial Hygienists threshold limit value (TLV); or Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) if lower than the TLV.

CNS = Central nervous system.

Table 5-2**Personal Protective Equipment Requirements**

PPE	Task A Non-Construction	Task B Construction	Task C Drilling	Task D Sampling
Steel-Toe Boots	TBD	Yes	Yes	Yes
Safety Glasses¹	Yes (Face-shield TBD)	Yes	Yes	Yes (Face-shield TBD)
Clothing¹	Work clothes	Work clothes (Tyvek® TBD)	Work clothes (Tyvek TBD)	Work clothes (Tyvek TBD)
Gloves	(Chemical- resistant TBD)	Leather (Chemical- resistant TBD)	Leather (Chemical- resistant TBD)	Chemical- resistant
Hearing Protection	TBD	TBD.	TBD	TBD
Hard Hat	TBD	Yes	Yes	TBD
Respirator	No	No	TBD	TBD

PPE = Personal protective equipment.

TBD = To be determined.

¹ A face shield will be required if the potential for liquid splashes or pressurized gas streams exists at any time during field activities and any time acids are handled. An upgrade to Tyvek may be warranted if contact with contaminated liquids and soils is anticipated.

- **Fire:** buried gas lines, grass fires, and equipment fires (see Section 5.2.3.5); and
- **Slips, trips, and fall hazards** (see General Safety, Section 5.2.1.).

Prior to any intrusive actions, the contractor shall consult with base personnel about the location of utility lines and other underground hazards, and shall obtain all McClellan Air Force Base (AFB) required permits. If excavation or drilling cuttings indicate the possible presence of underground drums or cylinders, operations shall be stopped immediately.

5.2.3.1 Open Trenches, Pits, and Holes

This section discusses open trench hazards; marking trenches; and personnel entry requirements (adequate means of access and egress, toxic or combustible gas, and oxygen deficient air monitoring requirements).

5.2.3.2 Heavy Equipment

This section discusses personnel responsibilities, equipment safety requirements, safe operating procedures and maintenance practices, and traffic/pedestrian control.

5.2.3.3 Noise

This section discusses noise hazards and the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) of 90 dBA or the action limit of 85 dBA.

5.2.3.4 Heat Stress

This section discusses the signs and symptoms of heat stress/heat stroke, and instructs the response for a worker demonstrating these symptoms.

5.2.3.5 Gas and Power Lines

This section discusses the hazards associated with underground utility lines and the precautions required to prevent an undesirable encounter. These precautions include:

- 1) locating and marking underground utility lines to prevent breakage during excavation or drilling activities;
- 2) stop work and shut down equipment if a line is damaged; and
- 3) responsibility for line repair.

5.3 Personal Protective Equipment (PPE)

The major chemical exposure hazards at the site result from: inhalation of airborne contaminants, and dermal contact or ingestion of contaminated material. Real-time air monitoring results may require an immediate upgrade in respiratory protection or cessation of work activities until hazardous vapor concentrations disperse. Specific air monitoring guidance is provided by Table 5-3.

Personal protective equipment (PPE) shall be used to adequately reduce employee exposure hazards. PPE selection shall be based on specific task activities, historical data of contaminants known to exist at the site, site conditions, and the results of the air monitoring program described in Section 5.4. PPE requirements by task are provided in Table 5-2, and a complete list of PPE required for the site is provided in the HASP.

The following task descriptions are intended to address the general PPE requirements pertaining to the activities scheduled for this project. Soil disturbing activities are subject to all PPE and air monitoring requirements as provided in the Operable Unit (OU) B HASP (August 1993) and the Groundwater Sampling and Analysis Plan (GSAP) HASP (1993). Site personnel should contact the Radian project health and safety officer (PHSO) for further discussion and clarification of PPE requirements.

Task A Description (Non-construction): All non-construction tasks with no or minimal potential for dermal exposure to contaminated soils, liquids, or materials.

Task B Description (Construction, etc.): Construction and maintenance tasks, or activities in an area with construction, maintenance, or other material movement occurring. These tasks present no or minimal potential for dermal exposure to contaminated soils, liquids, or materials.

Table 5-3
Hydrocarbon Response Criteria

OVC Readings at SS by PID or TPH as Measured By DTs	Sampling Frequency	Action Taken (Log of Results)
OVC from 0 to 1 ppmv > 2 minutes	When disturbing the soil; and every 15 minutes or 1-foot depth by HA or 5-foot depth by MB; and after collecting the sample.	- Modified Level D protection — Cotton work clothes — Safety glasses — Steel-toed work boots — Gloves — Tyvek coveralls required for personnel working in the exclusion zone. - Proceed with sampling procedures - Log results and dates on permanent record for future reference
OVC from 2 to 10 ppmv > 2 minutes - Collect DTs at SS for: — Vinyl chloride (VC)* and — Benzene (B) DT at SS for B and VC* reveal NDC.	When disturbing the soil and every 15 minutes or 1-foot depth by HA or 5-foot depth by MB, and after collecting the sample.	- Modified Level D protection - Proceed with sampling procedures - Log results and dates
OVC from 10 to 100 ppmv > 2 minutes - Collect DTs at SS for: — Vinyl chloride* and — Benzene DT at SS for VC* reveal NDC B= 1 to 10 ppmv with a half-face respirator B= 10 to 50 ppmv with a full-face respirator	When disturbing the soil and every 15 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	- Modified Level C protection: — Half or full face respirator with OV/HEPA cartridges. — Tyvek* coveralls, nitrile and neoprene gloves, neoprene boots. - Work crew moves upwind for 15 min. - Proceed with sampling upwind of SS. - Log results and dates.
OVC from 100 to 500 ppmv - Collect DTs at SS for: — Benzene — Vinyl chloride* DT measurements at SS for VC* reveal NDC B= 10 to 50 ppmv at SS, but < 10 ppmv in BZ.	When disturbing the soil and every 20 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	- Level C protection - Monitor VOC in BZ with PID & DT. If OVC > 500 ppmv or if DTs exceed criteria, upgrade to full-face respirators. - Work crew moves upwind of SS for 15 min. - Proceed with sampling upwind of SS. - Log results and dates.
OVC from 500 to 5,000 ppmv - Collect DTs at SS for: — Trichloroethene — Benzene — Vinyl chloride* Detector tube measurements at SS for VC* reveal detectable concentrations at SS, but not BZ; or benzene > 50 BZ, or trichloroethene > 500 ppmv at SS, but < 1,000 ppmv in BZ.	Immediately before and after disturbing the soil and every 20 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	- Continue Level C protection: — Use full-face respirators. - Monitor BZ for B, VC*, TCA, and TPH. - Work crew moves upwind from SS. - Re-evaluate — Wait 15 minutes — OVC < 500 ppmv, resume sampling — OVC > 500 ppmv, wait 15 minutes - If concentrations remain > 500 ppmv $\geq$ 2 hours: Contact FTL and PHSO. - Initiate vapor suppression techniques (i.e., downhole nitrogen injection) - Monitor vapor emissions with a CGI.

Table 5-3
(Continued)

OVC Readings at SS by PID or TPII as Measured by DTs	Sampling Frequency	Action Taken (Log of Results)
OVC > 5,000 ppmv or CGI > 10% LEL in work area, or CGI > 25% in the borehole, or BZ concentrations for > 2 minutes: vinyl chloride* > 10 ppmv, or benzene > 50 ppmv	Immediately before and after disturbing the soil and every 20 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	• Work crew dons SA or SCBA; or • Stop work, wait for vapor concentration to subside • Continue vapor suppression • Work crew positions themselves upwind from cuttings or borehole • Continue to monitor with CGI • Contact PHSO and Project Director
OVC > 5,000 ppmv, or CGI > 25% LEL in borehole or CGI > 10% LEL in work area.	Immediately before and after disturbing the soil and every 20 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	• Stop work, wait for vapors to subside • Work crew moves upwind • Contact PHSO and Project Director
Detectable concentrations of vinyl chloride in the workers breathing zone require immediate response. See bold print footnote following table.	Continuously to every 20 minutes.	• Work crew dons full-face respirators with OVCs. Replace OVCs every hour while exposed to 1 to 10 ppmv VC, or • Work crews don SA or SCBA, or • Work stops. • Work crew moves upwind. • Re-evaluate — Wait 15 minutes — Sample VC with DT in the BZ - VC not detected in BZ, resume sampling - VC detected in BZ, wait 15 minutes, resample for VC. • Inform project PHSO.

* OSHA approves the use of full-face air purifying respirators with organic cartridges (OCs) for concentrations of vinyl chloride ≤ 10 ppmv for one hour (CFR 29, Part 1910, 1017, pg. 138, 1989). If full-face air purifying respirators are used in atmospheres known to contain detectable concentrations of vinyl chloride ≤ 10 ppmv, a rigorous assessment of vinyl chloride concentrations will be conducted. Draeger® tubes for vinyl chloride will be collected in the workers' breathing zone once every 20 minutes to confirm concentrations are ≤ 10 ppmv. In addition, due to the PEL of vinyl chloride (1 ppmv), OCs exposed to vinyl chloride will be replaced every hour and disposed of at the close of sampling activities. If, at any time, a variance from these procedures should be observed or reported, or airborne concentrations of vinyl chloride exceed 10 ppmv, sampled air or self-contained breathing apparatus will be mandatory for all sampling activities associated with wells or borings known to contain detectable airborne concentrations of vinyl chloride.

1,1,1-Trichloroethane = 350 ppmv; Vinyl chloride* = 1 ppmv; Trichloroethene = 50 ppmv; Benzene = 1 ppmv

* Occupational Safety and Health Administration Permissible Exposure Limit 29 CFR 1910.1017.

BZ = Breathing Zone
 CGI = Combustible Gas Indicator
 DT = Detector Tubes
 FTL = Field Task Leader
 HA = Hand Auger
 MB = Mechanical Boring
 PHSO = Project Health and Safety Officer
 NDC = No Detectable Concentrations
 NIOSH = National Institute of Occupational Safety and Health
 OSHA = Occupational Safety and Health Administration
 OVC = Organic Vapor Concentrations

Table 5-3
(Continued)

PEL = Permissible exposure limit for 8 hours/day, 40 hours/week, for a working lifetime
PHSD = Project Health and Safety Director
PID = Photoionization Detector
SA = Supplied Air
SCBA = Self-Contained Breathing Apparatus
SS = Sampling Site
TPH = Total petroleum hydrocarbon
TLVs = Threshold Limit Values recommended by the American Conference of Governmental Industrial Hygienists for 1989-90.

Task C Description (Drilling): All well drilling/development operations with potential for dermal exposure to contaminated soils, liquids, or materials.

Task D Description (Sampling): Groundwater, soil, and soil vapor sampling activities inherently provide the potential for exposure to contaminated soils, liquids, or materials.

Temperature Limitations: PPE use can cause rapid fatigue and inhibit body cooling. Personnel shall pace themselves to ensure adequate rest periods.

5.4 Air Monitoring and Safe Work Practices

Air Monitoring

Air monitoring will be conducted according to the schedule provided in Table 5-3. Air monitoring will also be performed at the outlet of the system to determine the potential for worker exposure. The following precautions will be taken in order to ensure personnel are not being over-exposed to organic vapors:

- The extraction system will be equipped with an exhaust stack at least 10 feet above grade;
- All work associated with the extraction testing will be performed upwind of the exhaust stack whenever possible; and
- After initiating work on the system, Draeger® colorimetric indicator tube samples will be collected from breathing zone (BZ) height in the general work area to determine the airborne concentration of vinyl chloride.

If vinyl chloride is detected at concentrations greater than 1 ppm using the Draeger system, field personnel will follow the guidance and continued monitoring in the McClellan AFB OUB HASP for PPE. Specific PPE and work area air monitoring procedures are also provided in Table 5-3.

Training and Medical Surveillance Requirements

See HASP.

Recordkeeping Requirements

Records of training and medical surveillance will be maintained at Radian.

5.5 Work Zones and Decontamination Procedures

Details on work zone purpose and construction can be found in the HASP. The following work zones are anticipated for this project: general work zone, exclusion zone (EZ), contamination reduction zone (CRZ), and the support zone (SZ).

Decontamination Procedures

Decontamination of equipment and PPE shall be conducted in the CRZ prior to entering a SZ from the EZ. See HASP for decontamination procedures.

5.6 Emergency Response

Emergency response procedures are provided in the HASP and are designed to give the field team instruction in handling medical emergencies. The sections provided in the HASP include:

- Injuries;**
- Heat Stress;**
- Emergency Equipment; and**
- Emergency Phone List.**

6.0 MODIFICATION TO EXISTING GROUNDWATER TREATMENT SYSTEM

The existing groundwater extraction and treatment plant in IC 1 will be converted from a conventional pump-and-treat system to a two-phase extraction and treat system. The existing groundwater pump system consists of: two extraction wells (EW-233 and EW-234), each containing a submersible pump; two 20,000-pound liquid-phase carbon adsorption units operated in series; and associated piping, storage tanks, pumps, and controls. Effluent from the existing carbon treatment units drains to the Base industrial waste line (IWL). The existing system is described in detail in the *Operable Unit B Groundwater Treatment Facility, Operation and Maintenance Manual* (Radian, 1991). Results of the pilot testing were used to help evaluate the required system modifications. These results are provided in Appendix 3. The groundwater pumps and well heads will be removed and transferred to the Base groundwater treatment plant (GWTP) for storage and future use. One existing carbon unit will be supplied with vapor-phase carbon while the second bed will be drained and partially dehumidified and both reused in the modified system; existing piping, tanks, controls, etc., will be reused to the maximum extent possible.

The conversion to two-phase extraction will require the following modifications: installation of a high-vacuum oil seal liquid ring pump system; installation of vacuum extraction pipes in the existing wells; conversion of the existing carbon units from aqueous-phase to vapor-phase treatment; installation of new aqueous-phase carbon units; and replumbing of the transfer lines and treatment plant pumps and storage tanks. Each of these modifications is discussed below. Flow diagrams, layout, and piping plans are shown in Section 8.0.

Modification to Extraction System

Following removal of the existing submersible pumps, new well heads will be installed on each extraction well. The new well head (see Figure 6-1) consists of a 6" diameter collar and riser capped with a blank flange or cap, which matches the well diameter. The blank flange contains compression fittings for installation of the extraction straw (2" or 3" diameter) and an air injection line (1/2 to 1 1/2 inch diameter). The flange will also be equipped with a vacuum gauge to measure the vacuum produced within the well, and an ambient air inlet manifold (1/2" diameter pipe with ball valve and rotameter). The air assist line will allow atmospheric air at ambient pressure to be used to clear the standing

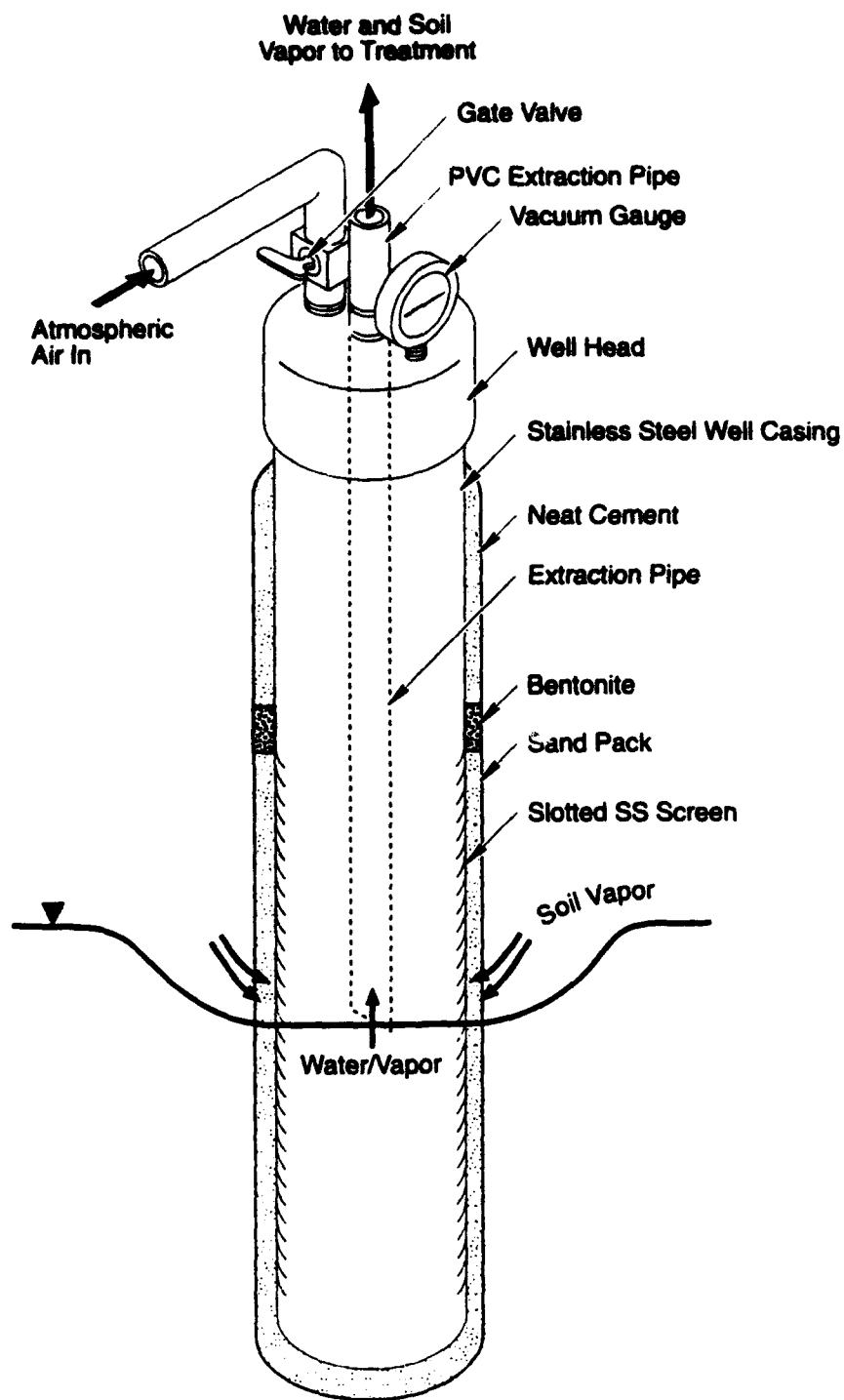


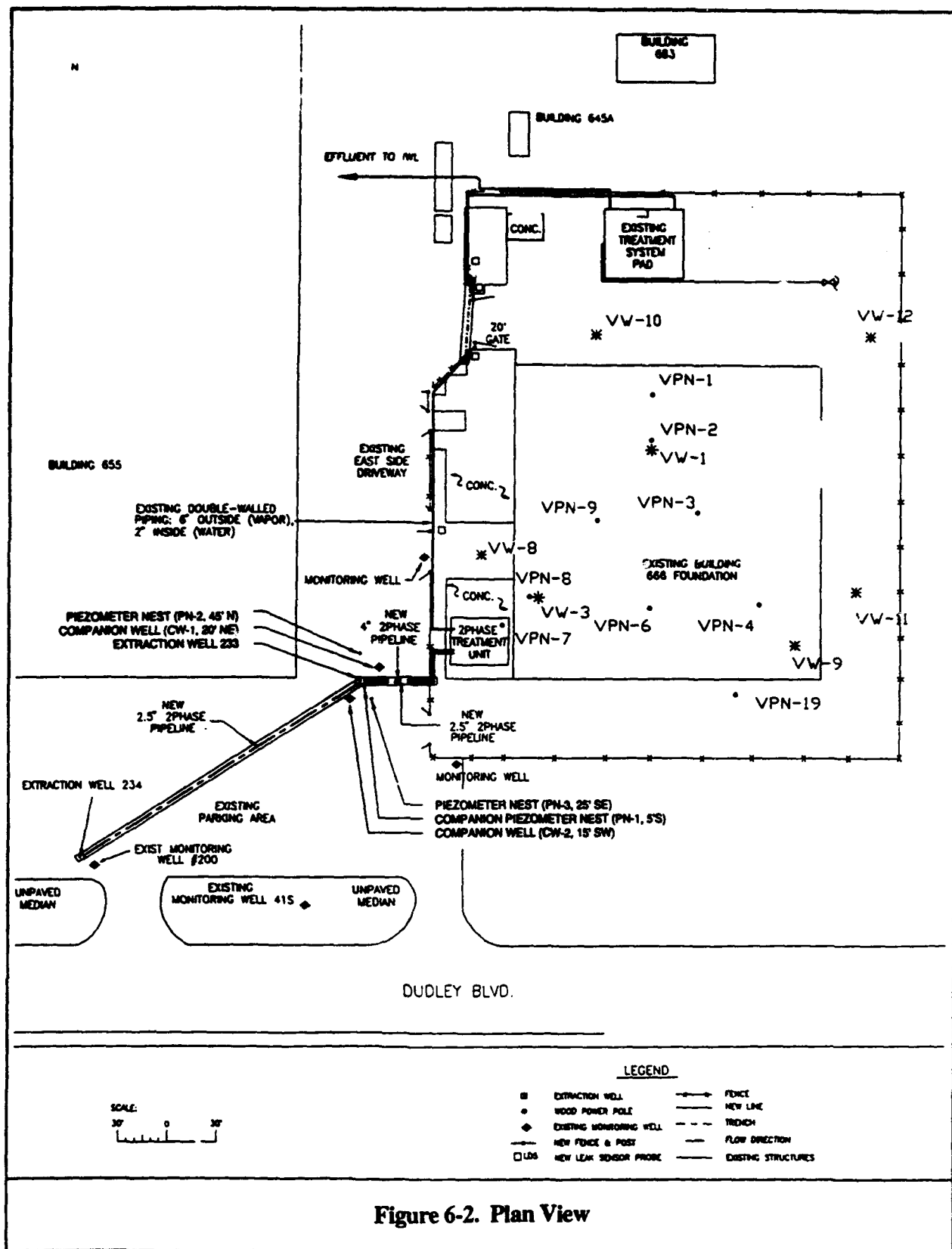
Figure 6-1. New Well Head

water from the bottom of the extraction straw during startup; this line will remain closed during normal system operation. The air assist line will be equipped with a valve to control flow and provide flow shut-off. The ambient air wellhead inlet line should allow sufficient air into the well to produce the air velocity necessary to entrain and extract the water. The ambient air line will only be opened if the formation cannot supply sufficient soil gas for adequate water extraction. The quantity of ambient air entering the system will be measured using a rotameter if needed.

The extraction straws will consist of PVC pipe casing. A 3" diameter straw will be used in EW-233, and a 2" diameter straw will be used in EW-234; the 3" straw sizes for EW-233 was used during the pilot test and the 2" straw size for EW-234 will be tested to see if increased flow can be achieved. During normal system operation, the straw will be connected to the transfer pipe using a short (approximately 2 feet long) section of transport pipe connected by unions. Should startup using recycled blower exhaust air prove ineffective, the short flexible hose section will be disconnected from the transfer pipe, and a 20-foot long section of flexible hose will be installed on the Tees. The straw will then be raised until the end of the straw is at the groundwater surface. With the system running, the straw will be lowered slowly to the bottom of the well as the water is evacuated, and the short section of flexible hose reinstalled for normal operation.

The existing underground double-wall transfer pipe (2" diameter pipe with 6" containment sleeve), which serves both extraction wells, will be replaced. Separate transfer pipes will be installed in the underground trench for each well, and will connect the wells to the two-phase extraction skid. The new transfer pipe will consist of Schedule 80 PVC; 4" diameter pipe will be used for EW-233 and 2.5" diameter pipe will be used for EW-234. The sizing is based on operational experience at other facilities, and is one half to one pipe size larger than the straw. Where the transfer straw exits the trench, i.e., rises vertically, the pipe size will be reduced to the size of the straw. Because this portion of the system is under vacuum, the transfer pipes will be single wall. The concrete trench will provide secondary containment. A plan view of the system is provided in Figure 6-2.

The two-phase extraction will be a standard system designed for Xerox. The unit will contain a 50-horsepower oil-ring vacuum pump, an inlet knockout tank to separate the vapor/liquid phases, and ancillary equipment. A more detailed description of the two-phase extraction vacuum system is provided in Section 8.0. The two-phase extraction system will contain two knockout pots, one on the two-phase extraction skid and a second, stand-



alone knockout pot. The two pots will allow separate measurement of the water and vapor production from each well. The stand-alone knockout pot will be a temporary installation, and may be removed at the completion of the demonstration program.

The two-phase extraction skid will be located inside the fence surrounding IC 1, approximately 60 feet east of well EW-233 (see Figure 6-2). The skid will be located on the foundations of the former Building 666 Wastewater Treatment Plant. All controls for the two-phase extraction skid will be self contained, allowing the system to be moved to other sites in the future. Power service to the two-phase extraction skid will be provided from a new overhead service from a new disconnect at the 750 KVA transformer to a new service panel near the treatment pad (see Section 7.0 for details). No other utilities will be required.

The liquid and vapor phase effluent will be pumped to the IC 1 GWTP in the existing double contaminant pipe. The 3" interior pipe will carry water, and the annular space between the 3" pipe and the 6" exterior pipe will carry vapor. The existing line is a 3" diameter pipe with 6" secondary containment.

During normal operation, soil vapor is drawn into the bottom of the extraction straw, causing water to be aspirated from the well and carried up the straw. During system startup, however, water in the straw and well casing can prevent vapor from flowing up the straw. To break this vapor lock, the air injection line from the atmosphere will allow air into the straw to break the vapor lock. The air can be lowered into the straw through a compression fitting to provide the vapor flow necessary to entrain water and evacuate the straw. Once the straw is evacuated, the recycle line will be slowly closed to allow normal system operations.

Modifications to Treatment System

At the GWTP, the water transfer line will be disconnected from the existing liquid-phase carbon vessels. Two new 1,600-lb liquid-phase carbon adsorption units, installed in series, will provide final polishing of the stripped groundwater prior to discharge to the industrial waste line (IWL). The water line will be replumbed such that water can be directed to the new carbon units or to the existing holding tanks prior to carbon treatment. The carbon treatment vessel is a standard portable unit which can treat the expected groundwater production rate of 8 to 12 gallons per minute (gpm). Portable units which can easily be transported off-site when their adsorption capacity is expended will be used. The

units will be plumbed in direct series. During removal of expended carbon units, the water will be directed into the existing holding tanks. The outlet from the new carbon units will be plumbed to the plant's existing water flow meters/totalizers, monitoring/sampling equipment, and outfall to the IWL. The plumbing modification will also allow water to be directed to an existing holding tank, through the existing headers, and then through the new carbon units.

The existing carbon units at the IC 1 GWTP will provide treatment of the vapor-phase contaminants. The existing carbon vessels will be disconnected from the liquid phase operations and connected to the offgas line from the two-phase extraction system. The liquid phase carbon in the first container will be replaced with 10,000 pounds of dry vapor phase carbon. The second vessel has carbon which is expected to be relatively free of contaminants. Radian will drain and recondition the carbon to remove as much water from the carbon as possible and thus minimize the pressure drop through the vessels. This will allow reuse of the carbon as the backup bed thereby avoiding the expense of carbon disposal and replacement. The adsorption efficiency will be reduced due to the previous water contact, but it will be adequate for the secondary bed.

A stack will be connected to the outlet of the carbon units to direct the treated offgas upward to a minimum height of 17 feet or higher. The final stack height will provide sufficient clearance above the carbon vessels.

7.0

UTILITY CONNECTIONS

A new electrical service and connections to the existing treatment system electrical and control systems are the only utility connections necessary to implement two-phase extraction at investigation cluster (IC) 1. The existing treatment system site has a metered 240/120, 3-phase service fed overhead on power pole by a 480 volt aerial circuit. This circuit will be abandoned and disconnected at the top of the pole.

The existing treatment system service and the new two-phase extraction system will be fed from a new overhead service. The new service will tap into a base transformer with 750 KVA capacity. A new overhead service will be installed from a new disconnect at the 750 KVA transformer to a new service panel located near the gate west of the treatment system pad. The treatment system and two-phase extraction system will be fed from this service using existing conduit.

The two-phase extraction unit requires 3-phase, 480 volt service and 100 amps. A step-down transformer will be installed near the two-phase extraction skid to provide 110-volt power for lights, power outlets, and flow meters at the two-phase extraction unit.

Existing signal conduit will be used to connect the two-phase extraction system into the existing treatment system control panel. New inputs from the two-phase extraction unit will be connected to the chart recorder and autodialer. Changes will be made to the plant control panel logic to incorporate control logic from the two-phase extraction system. Existing power and signal service to the well heads will be abandoned in place to allow for possible future use.

Existing utility connections to the base phone system, potable water serve, and the industrial wastewater treatment line will not require modifications due to conversion of the system to two-phase extraction operation.

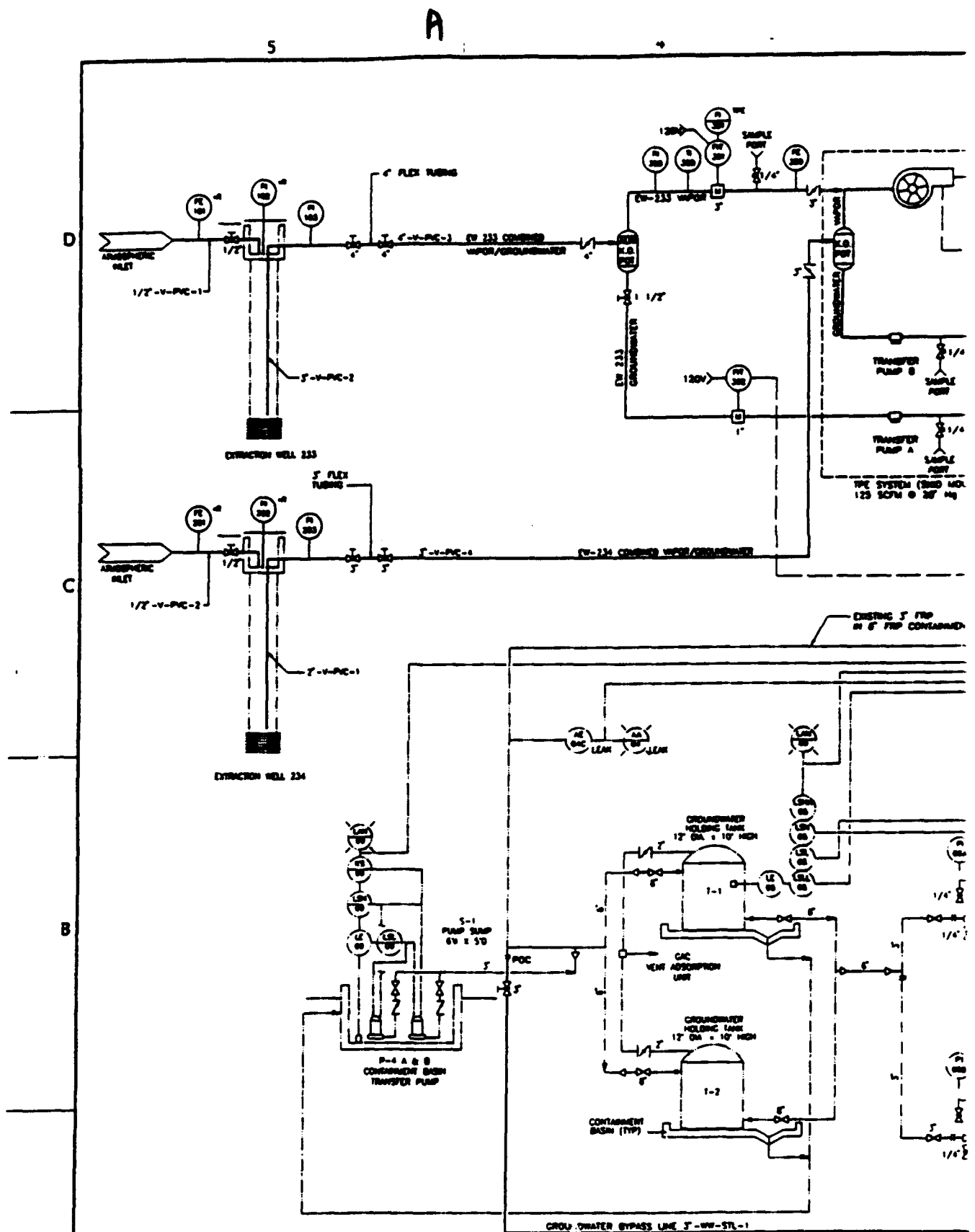
8.0

DEMONSTRATION APPARATUS DESCRIPTION

The demonstration apparatus consists of two modified extraction wells, transfer piping, a two-phase extraction unit, and liquid- and vapor-phase carbon treatment units. A number of current and proposed monitoring wells and piezometer nests will monitor conditions in the surrounding groundwater and vadose zone. Descriptions of the modified extraction wells, transfer piping, and the carbon treatment units are provided in Section 6.0, Modification to Existing Groundwater Treatment System. Figure 8-1 provides a preliminary piping and instrumentation diagram (P&ID), including the flow of water and vapor through the system. A plan view of the entire system from the extraction wells to the carbon treatment units is included in Section 6.0.

The two-phase extraction system is a skid-mounted unit fabricated by Wintek according to Xerox specifications. The vapor and groundwater will be piped through separate transfer lines from each extraction well to separate knockout vessels (i.e., inlet separators). Only one knockout vessel will be on the skid-mounted unit; the second knockout vessel and associated pump and hardware will be for demonstration only (to allow monitoring of the individual flow rates from each well). Each knockout vessel will be equipped with high- and low-level indicators that will activate separate transfer pumps. The unit will also include a high-high level indicator that will shut down the vacuum pump if the high-high level is exceeded. The transfer pumps will pump the treated water from the knockout vessels to the liquid-phase carbon treatment units for removal of any remaining VOC contaminants prior to discharge to the Base industrial waste line (IWL). The inlet separator will include a sight glass level indicator. The separators will also include access for grit cleanout from the bottom of the vessel. Liquid sampling ports will be provided on the outlet from each transfer pump, and will consist of a 1/4-inch needle valve and fitting.

The water/vapor from extraction well (EW) 233 will enter the auxiliary knockout vessel and water/vapor from EW-234 will enter the unit's knockout vessel. The water and vapor phases will be separated from each other in these vessels. The outlet vapor will then be combined prior to entering an Intervac, air-cooled, liquid-ring vacuum pump with a cast-iron housing, ductile-iron impellers, stainless-steel shaft, carbon face mechanical and PTFE elastomer seals. The outlet vapor will go to an air/oil separator, an aftercooler, condenser, condensate separator, and a heater before being sent to the vapor-phase carbon treatment system. A vapor sampling point will be located downstream of the condensate separator and will consist of 1/4-inch, stainless-steel Swagelok® fittings with a glass wool filter



A LEGEND

— NEW ELECTRIC SIGNAL	— BUTTERFLY VALVE	(UA) AUTO DIALER	(FI) FLOW INDICATOR	(FM) FLOW METER
— NEW PROCESS FLOW	— FLANK	(FR) FLOW RECORDER	(LSL) LEVEL SWITCH LOW LEVEL	(PI) PRESSURE INDIC
— EXISTING	— NEEDLE VALVE	(LE) LEVEL ELEMENT	(LSH) LEVEL SWITCH HIGH LEVEL	(PDI) DIFFERENTIAL PD
(BV) BALL VALVE	NC NORMALLY CLOSED	(LL) LEVEL SWITCH LOW	(FIT) FLOW INDICATOR TRANSMITTER	(T) TEMPERATURE IN
(CV) CHECK VALVE	(RV) RELIEF VALVE	(LH) LEVEL SWITCH HIGH	(FE) FLOW ELEMENT	(AE) ANALYSIS ELEMENT
(BPF) BACKFLOW PREVENTER				(AL) ANALYSIS ELEMENT LEAK
(GV) GATE VALVE				

to prevent oil and water from entering the vapor samples. Primary vapor flow rate measurements will be taken after the EW-233 knockout pot and at the heater outlet, along with pressure and temperature readings. Additional vapor, condensate, and oil temperature and pressure indicators are provided for operation of the system.

9.0

HEALTH RISK ASSESSMENT

The purpose of the health risk assessment (HRA) screening is to demonstrate that offgas vapors after carbon treatment will not exceed 1×10^{-7} cancer risk or a chronic hazard index greater than 1 at the property line. Conservative assumptions and procedures were used throughout the HRA to ensure the health effects will not be underestimated. This will protect the health and safety of both McClellan AFB personnel and possible off-site receptors. These results were discussed with the Sacramento Metropolitan Air Quality Management District (SMAQMD) to ensure compliance with substantive air quality requirements for emission sources at McClellan AFB.

Emissions Calculations

Volatile organic compounds (VOC) emissions from the two-phase extraction system will be controlled by two granular activated carbon (GAC) units in series (the first bed containing 10,000 pounds of new carbon; the second bed containing 20,000 pounds of drained existing carbon). The emissions from the two-phase extraction unit during the Demonstration Test were conservatively estimated based on concentration levels between the two GAC units that will require the carbon in the first unit to be changed out. The health risk assessment screening is based on these emissions, provided in Table 9-1. These emissions will not be reached at the actual system outlet since the second GAC unit is expected to control the emissions of the carcinogenic chemicals identified in the pilot test to below detectable limits.

Compound	Pilot Test Emission Rate (lb/min)	Carbon Bed Change-out Concentrations (ppbv)	Emission Rate Assumed for Risk Assessment*
1,1-DCE	6.67×10^{-6}	22	6.67×10^{-7}
TCE	1.58×10^{-3}	582	2.37×10^{-5}
PCE	3.45×10^{-4}	101	5.18×10^{-6}
Freon 113	4.80×10^{-4}	160,000	9.28×10^{-3}

*Based on change-out concentration and 120 scfm flow rate.

Based on the estimated carbon usage rate of approximately 31 pounds per day (per carbon vendor), the expected life of a fresh GAC unit is approximately 320 days (Freon 113 is assumed to be uncontrolled by the GAC units). As a result, the sampling frequency between the beds will be once per month. If significant concentrations of other contaminants are identified in the project sampling (especially vinyl chloride), additional carbon change-out concentrations will be developed and an updated health risk screening submitted to the SMAQMD.

Atmospheric Dispersion Modeling

Atmospheric modeling of uncontrolled emissions from the treatment system was conducted using SCREEN2. This Gaussian model examines a range of stability classes and wind speeds to identify the "worst case" maximum one-hour concentration. An ambient air concentration based on a unit (1 gram per second) emission rate was calculated at the nearest point of the base boundary, located 360 meters west-southwest of the treatment system near the West Gate entrance.

The following source parameters were used:

- Location: existing carbon treatment units;
- Stack height: 5.2 meters (top of carbon treatment units);
- Exit velocity: 6.7 meters per second;
- Stack diameter: 0.067 meters; and
- Stack gas temperature: 293°K (ambient).

Building downwash effects from Building 655 were evaluated in the model run.

The maximum one-hour ground-level concentration based on a one gram per second emission rate was 991 micrograms per cubic meter. Based on United States Environmental Protection Agency (U.S. EPA) guidance, a conversion factor of 0.1 was used to convert the maximum 1-hour concentration to an annual average concentration of 99.1

micrograms per cubic meter. This average concentration value was used to convert the calculated emissions rates to downwind ambient air concentrations.

Exposure and Toxicity Assessment

Inhalation doses were calculated for a resident living at the nearest point of the base boundary. The calculated concentrations in ambient air and the following standard exposure parameter values were used:

- Inhalation rate: 20 cubic meters per day;
- Body weight: 70 kilograms;
- Exposure frequency: 350 days per year;
- Exposure duration: 70 years;

The highest of the U.S. EPA and California Environmental Protection Agency (Cal/EPA) cancer potency (slope) factors for PCE, TCE, and 1,1-DCE were used to calculate excess cancer risk. The reference dose for Freon® 113 was obtained from the IRIS on-line data base.

Results

The calculated total excess cancer risk was 9.6×10^{-8} . TCE accounted for approximately 65% of the total. The chronic hazard index for Freon 113 was 3.5×10^{-7} , well below the threshold hazard index level of 1.0.

Dispersion model outputs, emissions, and risk calculations are presented in Appendix 4.

10.0

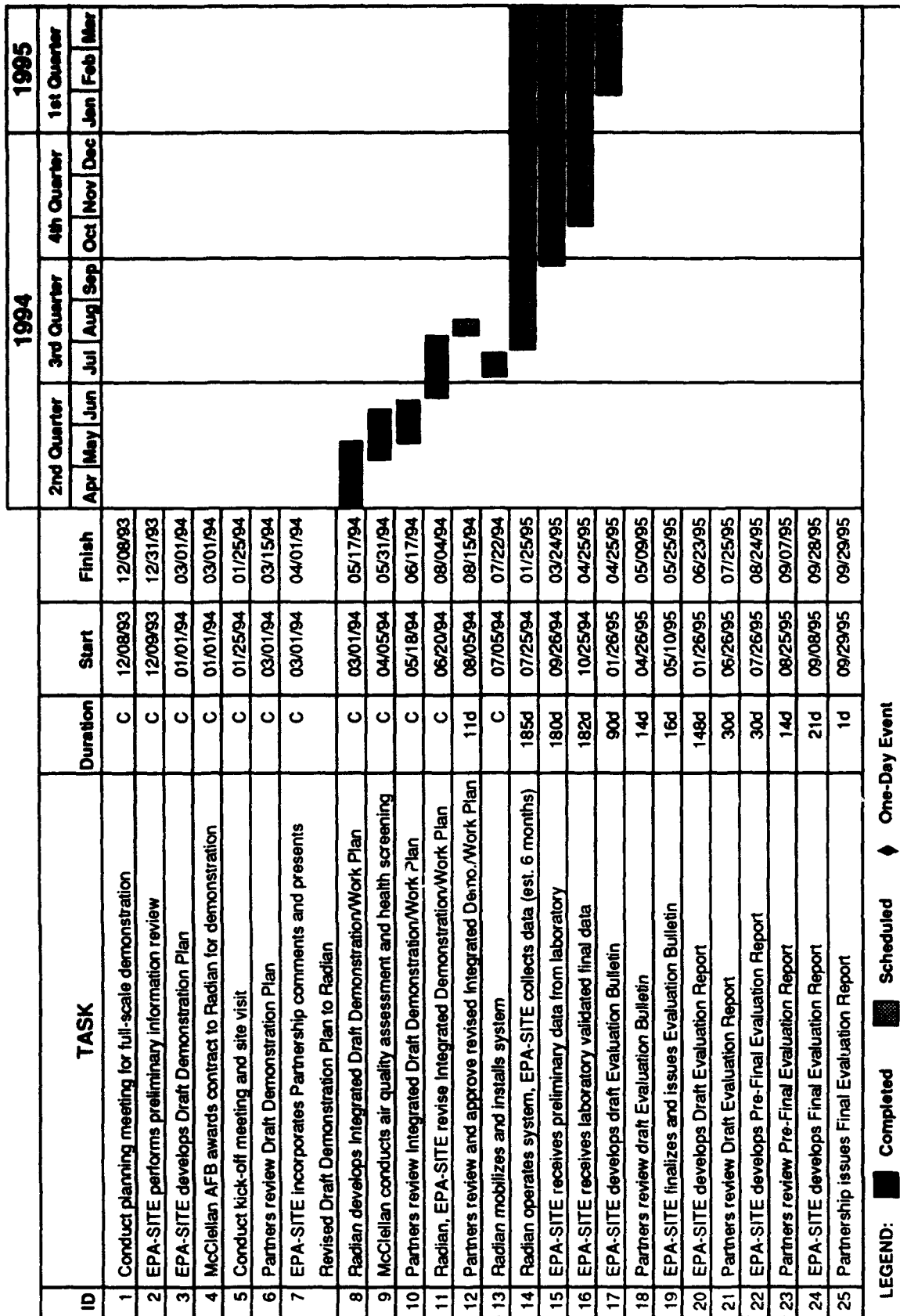
SCHEDULE

Figure 10-1 is a schedule for design, construction, implementation, and testing of the two-phase extraction system. Completed activities are identified by "C" in the duration column of Figure 10-1. Record of construction drawings will be produced from field working copies maintained by the contractor. The demonstration test is anticipated to require a maximum of six months; with an end of July start date, the test will be completed in January 1994. Preparation of a Technology Demonstration Technical Memorandum (TDTM) will complete the study. A maintenance manual will be prepared based on contractors' submittals for equipment and materials, and an operations manual will be prepared based on design and actual field experience.

Other tasks include activities associated with meeting the substantive requirements of the Sacramento Metropolitan Air Quality Management District (SMAQMD) for system air emissions (see Section 9.0).

Review and approval of this Work Implementation Plan (WIP) will parallel the above activities and will be complete prior to the start of the demonstration test.

Figure 10-1
Two-Phase Extraction
Roadmap



"Partners" includes McClellan AFB, EPA-TIO, Cal-EPA, EPA-Region 9, Clean Sites, and the Private Partners.

LAST UPDATE: 08/04/94



CLEAN SITES

11.0

COSTS

The estimated cost for design, implementation, demonstration testing, and associated activities by Radian is \$560,000 (does not include analytical costs). Table 11-1 provides detailed cost estimates for each activity. These costs are based on utilization of existing groundwater treatment facilities and are not intended for estimating grassroots or other two-phase systems. The Innovative Technical Evaluation Report (ITER) will contain cost data that will allow technology comparisons.

Table 11-1 is Radian Corporation's (Radian's) breakdown for preparation of the Work Implementation Plan (WIP); design, procurement, installation, and operation of the system; and installation of additional wells and piezometer nests. Approximately 40% of the costs are for procurement and construction of the system. The remainder is for preparation of the WIP and assistance to SAIC in preparing the ITER, operation and monitoring of the system, and coordination and reporting of these activities with McClellan Air Force Base (AFB), Clean Sites, Science Applications International Corporation (SAIC), United States Protection Agency (U.S. EPA) Technology Innovation Office (TIO) and Superfund and Innovative Technology Evaluation (SITE), and the Public-Private Partners.

Table 11-1 also is a breakdown of the equipment, materials, and installation costs. Fabrication, testing and delivery of the two-phase extraction unit by Wintek is approximately \$70,000. A purchase order for this work has been let and fabrication has been initiated.

Instrumentation has been identified as a possible long-lead item and, therefore, will be purchased by Radian and installed by the installation contractor. Estimated costs for flow, pressure, temperature, and transmittal and recording is estimated to be \$60,000.

Electrical power will be provided utilizing existing conduit and power near the two-phase extraction unit. A 440-volt, 3-phase, 50 hp service is required and is estimated to cost \$10,000.

Activated carbon will be utilized for both water and offgas treatment. Two new 1,600-pound activated carbon beds will be purchased and installed for wastewater treatment at an estimated cost of \$4,000. In addition, two existing 10,000-pound capacity beds currently used for water treatment will be converted to vapor treatment at an estimated cost of \$10,000.

Revised: 4/29/94

Task		Labor	ODCs	Travel	Supplies/ Subs	Totals
Description						
1.0	Notification of Change of Personnel	\$188	\$0	\$0	\$0	\$188
2.0	Coordination of Data Among Contractors	\$54,571	\$435	\$75	\$0	\$55,081
3.0	Suppliers Meeting Materials	\$4,378	\$51	\$8	\$0	\$4,437
4.0	Statement of Work Modification	\$2,824	\$14	\$0	\$0	\$2,838
5.0	Community Relations Support	\$469	\$2	\$0	\$0	\$471
6.0	Engineering Network Analysis	\$13,676	\$36	\$0	\$0	\$13,712
7.0	Field Progresss Reports	\$5,244	\$20	\$0	\$0	\$5,264
8.0	Modification to Health and Safety Plan	\$1,746	\$70	\$8	\$0	\$1,824
9.0	Electronic Technical Project Files	\$2,730	\$0	\$0	\$0	\$2,730
10.0	Water Levels	\$4,622	\$0	\$0	\$0	\$4,622
11.0	Design Documents	\$38,923	\$522	\$0	\$0	\$39,445
12.0	Monthly Status Reports	\$1,355	\$90	\$0	\$0	\$1,445
13.0	Data Analysis Meetings	\$6,740	\$155	\$0	\$0	\$6,895
14.0	Eng. Constr. & Oper TPE	\$57,734	\$10,240	\$0	\$201,850	\$269,824
15.0	Health Screening	\$4,430	\$36	\$15	\$0	\$4,481
16.0	Specifications	\$9,821	\$118	\$0	\$72	\$10,011
17.0	Field Sampling & Analysis Plan	\$8,464	\$81	\$0	\$0	\$8,545
18.0	Work Implementation Plan	\$28,287	\$1,416	\$0	\$180	\$29,883
19.0	Technology Demonstration Plan	\$28,130	\$266	\$0	\$600	\$28,996
20.0	Operations and Maintenance Manual	\$5,009	\$50	\$0	\$60	\$5,119
21.0	Monitoring Wells	\$9,044	\$986	\$1,000	\$44,106	\$55,136
SUBTOTAL		\$288,385	\$14,588	\$1,105	\$45,017	\$550,945
					G&A	\$4,464
					Fee	\$2,276
					Total	\$557,685

	Concrete Pad (12' x 20' x 1') =	\$4,000
	Piping (1,500 linear feet) =	\$40,000
Equipment:		
	New carbon vessels =	\$4,000
	Remove pumps =	\$1,000
	Modify carbon vessels =	\$10,000
	Two phase unit =	\$72,000
Electrical:		
	Primary power =	\$10,000
Instrumentation:		
	Vortex Meter - Flow, Data Logger,	\$60,000
	Vacuum Gauges, Pressure/Temperature	
	Gauges, etc	
Supplies:		
	Approximately \$500 in startup	\$850
	expendable supplies and then \$50/month	

11-2

for piping and equipment modifications. Replacement of the liquid-phase carbon with vapor-phase carbon in the primary bed will cost approximately \$18,000.

Piping including the extraction tubes, collection manifolds, well head modifications, and vapor and water conveyance pipes will be constructed from PVC piping and installed utilizing existing pipe trenches, vaults, and existing piping (where appropriate) for an estimated cost of \$40,000.

Two companion wells and three piezometer nests will be installed to supplement existing wells at an estimated cost of \$60,000.

Miscellaneous items such as removal of the existing groundwater extraction pumps, provision of a portable eye bath, etc. are estimated to cost \$10,000.

APPENDIX 1

QAPP

Source: SAIC Demonstration Plan, Section 3.0



Science Applications International Corporation
An Employee-Owned Company

July 19, 1994

Mr. Greg McNelly
Clean Sites
1199 N. Fairfax St., Suite 400
Alexandria, VA 22314

RE: EPA Contract No. 68-CO-0048, WA 0-55
SAIC Project No. 01-0832-07-1129-008

Dear Mr. McNelly:

Enclosed is the revised Demonstration Plan for the 2-Phase Extraction System. This document incorporates your comments as well as comments provided by USEPA, Cal/EPA and Radian.

A single-sided copy is enclosed for your convenience in copying the document. It is my understanding that you will forward copies to all of the public-private partners, including McClellan AFB. SAIC will provide Radian their copy.

If you have any questions, please call me at (513) 723-2600, ext. 2610.

Sincerely,

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Peggy Grobman
for

Jim Rawe
Work Assignment Manager

JR/aef

cc: Laurel Staley, EPA-RREL
Clyde Dial, SAIC
Art Shattuck, SAIC
Jamie Winkelman, SAIC
Joe Tillman, SAIC
Evelyn Hartzell, SAIC
Gordon Kingsley, Radian

S22b:del-3.ltr

**SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION/
PUBLIC-PRIVATE PARTNERSHIP
2-PHASE EXTRACTION DEMONSTRATION PLAN**

**Evaluation of the 2-Phase Extraction System
(Developed by Xerox Corp. and implemented by Radian Corp.)
at McClellan AFB, California**

FINAL

July 19, 1994

Prepared by:

**Science Applications International Corporation
635 West Seventh Street, Suite 403
Cincinnati, OH 45203**

Submitted to:

**Ms. Laurel Staley, Work Assignment Manager
U.S. Environmental Protection Agency
Risk Reduction Engineering Laboratory
26 West Martin Luther King Dr.
Cincinnati, OH 45268**

**EPA Contract No. 68-C0-0048
Work Assignment No. 0-62
SAIC Project No. 01-0832-07-1129-007**

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SECTION 1

INTRODUCTION

1.1 Overview of the Site Program

A formal program has been established by the U.S. Environmental Protection Agency (EPA) to accelerate the development of new and innovative technologies used to solve hazardous waste site cleanup problems. This program is called the Superfund Innovative Technology Evaluation or SITE Program. The Program's objectives are to identify, investigate, and evaluate technologies that will create permanent solutions to contaminated sites. The SITE Program has four objectives:

- 1) Identify and, where possible, remove impediments to the development and commercial use of alternative technologies.
- 2) Conduct Demonstration Tests of promising technologies to establish reliable performance and cost information for site characterization and cleanup decision making.
- 3) Develop procedures and policies that encourage selection of available alternative treatment remedies at Superfund sites.
- 4) Structure a development program that nurtures emerging technologies.

To locate the best available technologies, the EPA solicits proposals to demonstrate innovative technologies. A screening and selection process is conducted on the proposals received. The focus of the screening process is to determine the ability of the technology to treat Superfund waste, the treatment cost expectations, the technology's performance, the developer's approach to testing, and the applicability of the technology for full-scale demonstration. Technologies that meet the above criteria become possible candidates for demonstration.

The SITE Demonstration Program is jointly administered by two departments of the EPA, namely the Office of Solid Waste and Emergency Response (OSWER) and the Office of Research and Development (ORD). Together, OSWER and ORD are responsible for reviewing and evaluating the proposals submitted for consideration, soliciting the EPA Regional Offices for demonstration sites, and matching the technologies with appropriate demonstration sites.

SITE demonstrations are usually conducted at Superfund waste sites; however, it is also possible to conduct a Demonstration Test at EPA testing and evaluation facilities, at other government facilities, at sites undergoing private cleanup, at the developer's test facilities, or at privately owned facilities. Final selection of the test site is made by OSWER and ORD. This decision is made in close cooperation with the developer to ensure that the technology will be evaluated properly on wastes that the process has been designed to treat.

This demonstration is being conducted in coordination with the McClellan Air Force Base (AFB) Public-Private Partnership of which the EPA SITE Program is a member. SAIC is EPA-SITE's contractor for the implementation of this demonstration. Other members of the Partnership include the U.S. Air Force (USAF), EPA's Technology Innovation Office (TIO), EPA Region 9, the State of California's Department of Toxic Substances Control (DTSC), and a number of industry participants. Radian is McClellan AFB's contractor for installation and operation of the 2-phase extraction system. The Partnership is coordinated by Clean Sites. The responsibilities of participants are outlined in Section 1.5.

1.2 Purpose of This Demonstration

The Xerox patented 2-phase extraction system will be used by Radian Corporation at McClellan AFB (Figure 1-1) to increase the efficiency for remediating subsurface soil and groundwater contaminated with volatile organic compounds (VOC) in relatively low-permeability formations (i.e., sandy silt). The system extracts both groundwater and soil vapor from a single extraction well by applying a high vacuum (18 to 29 inches of mercury) through a central lift pipe, called the extraction tube, that extends down the well. Soil vapor drawn into the well by the vacuum creates a high velocity vapor stream at the bottom tip of the tube, which entrains the contaminated groundwater and lifts it to the ground surface. The vapor and water phases are then separated at the surface in a knock-out tank prior to carbon treatment. The turbulence caused when the entrained groundwater moves up the extraction tube is reported effective in transferring greater than 90 percent of the volatile organic compounds (VOCs) from the water to the vapor phase; the separated water phase then only requires carbon polishing before discharge, provided that the compounds are adsorbable. The VOCs transferred from the liquid phase, combined with contaminated soil vapor, result in higher VOC concentrations in the vapor phase, which can be more efficiently treated than VOCs in the liquid phase.

The primary objectives of the Demonstration Test are to:

- Determine the mass removal of critical target volatile organic compounds (VOCs) from the 2-Phase Extraction Well (EW-233), and
- Determine the percent transfer of those critical target VOCs from the surrounding groundwater to vapor as the water is pulled up through EW-233's extraction tube to ground level under vacuum.

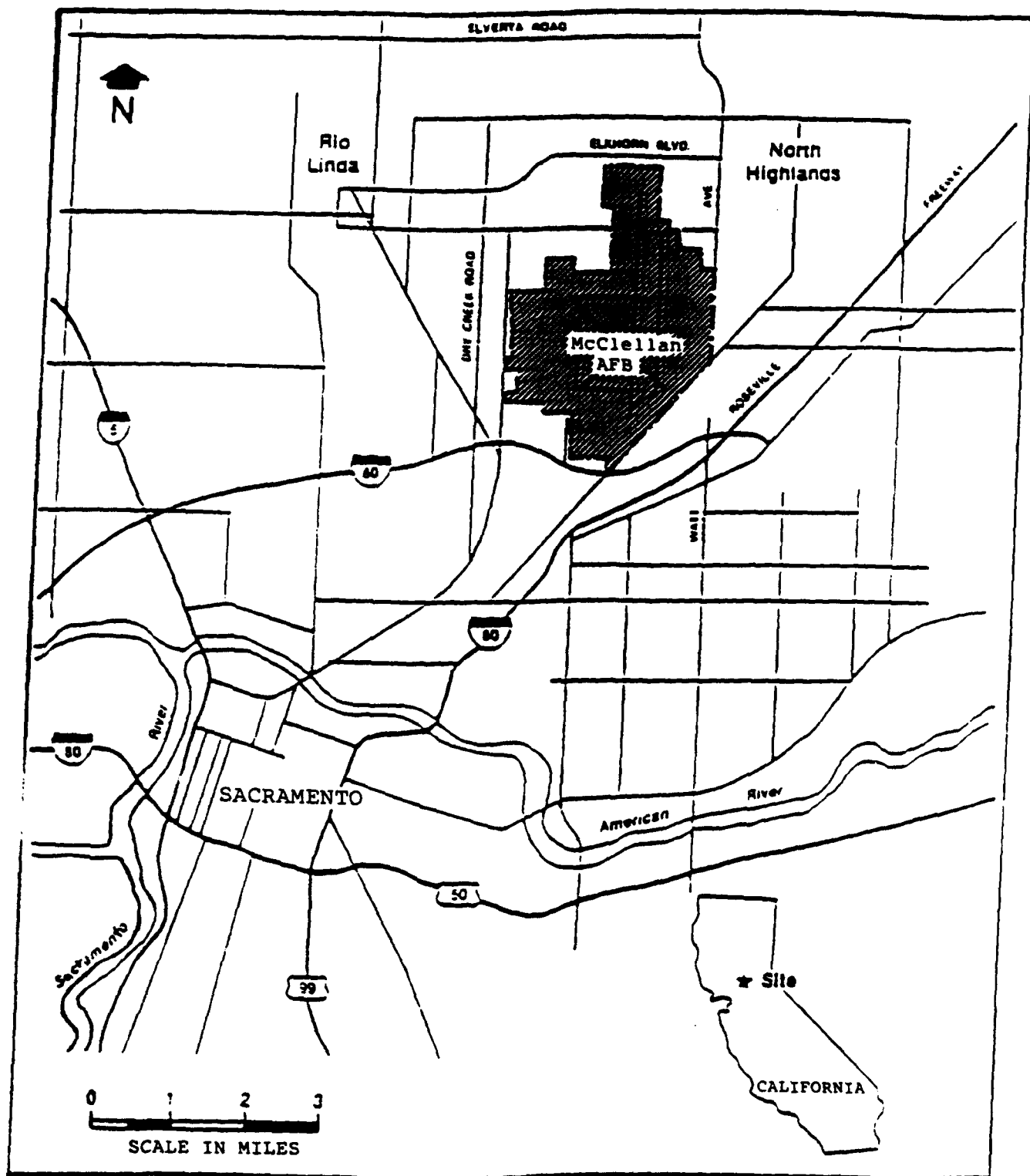


Figure 1-1. Regional and Base Location Map of McClellan Air Force Base, Sacramento, California.

Secondary objectives of the Demonstration Test are to:

- Determine the total mass removal of non-critical target VOCs from EW-233 and the percent transfer of total VOC's from the surrounding groundwater to vapor as the water is pulled up through EW-233's extraction tube to ground level under vacuum.
- Determine the combined total mass removal of all target VOCs by EW-234 (located approximately 230 feet southwest of EW-233) and by EW-233.
- Document the simultaneous extraction of groundwater and soil vapor from both 2-phase wells.
- Observe the zone of influence of the 2-phase extraction system at EW-233. Determination of the shape of the drawdown curve will also indicate whether the system prevents groundwater mounding, which is normally encountered during conventional soil vapor extraction
- Measure the extraction rate of the groundwater.
- Compare pre-test (baseline) groundwater and soil vapor concentrations to post-test concentrations.
- Collect other full-scale operating cost and performance data as necessary.

More information about specific test objectives and how data will be collected and interpreted are presented in Sections 2.1 and 3.1 of the QAPP.

1.3 Process Overview

The 2-phase extraction system is an innovative technique developed by Xerox Corporation for in-situ remediation of low-permeability formations where VOCs are present in soils and groundwater. The 2-phase extraction system simultaneously recovers groundwater and soil vapor under vacuum using a specially sized and positioned extraction tube installed within a modified conventional recovery well. The system uses high vacuum (18-25 inches of Hg at the source) to remove groundwater by entrainment in the flow of recovered soil vapors, supplemental atmospheric air, or a combination of the two. Figure 1-2 provides a detailed schematic of a typical 2-phase extraction well configuration.

Groundwater and soil vapors drawn into the well under vacuum are removed from the well casing through the extraction tube. The vacuum causes vapor to be drawn into the tip of the extraction tube at high enough velocity to entrain water and convey a water/vapor spray up the tube and to the surface. This in turn results in increased soil vapor and groundwater flow from the formation by enhancing pressure gradients. The vapor and water phases are then separated at the surface in a knock-out tank prior to off-gas treatment. The turbulence caused as the entrained groundwater moves up the extraction tube has been reported to effectively transfer more than 90 percent of the VOCs from the water to the vapor phase (although not a specific claim); the separated water phase then only requires carbon polishing before

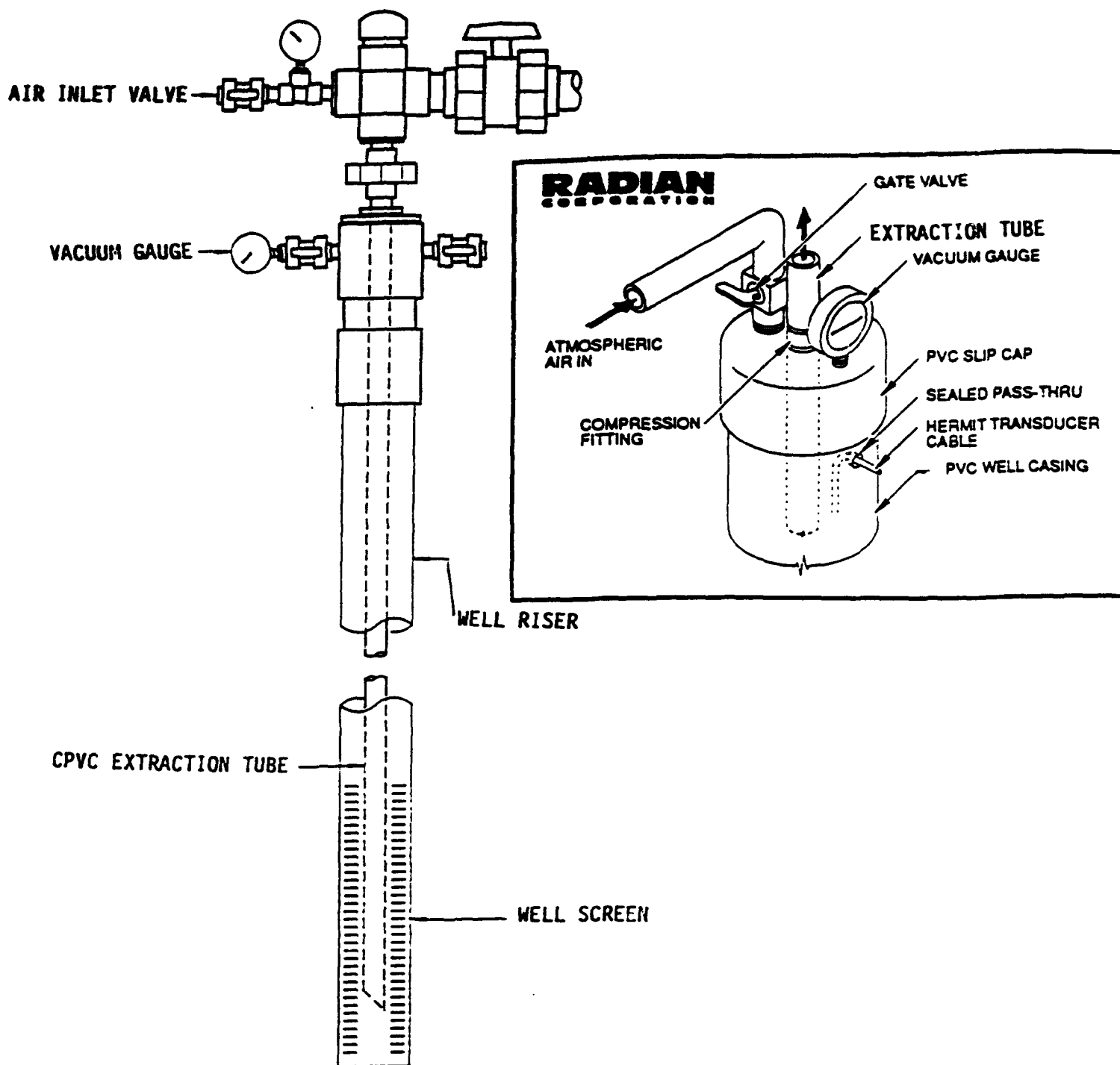


Figure 1-2. Schematic of a 2-Phase Extraction Well
 (Sources: Xerox, H&A, Radian)

discharge. Combining the VOCs transferred from the liquid phase with contaminated soil vapor, result in higher VOC concentrations in the vapor phase, which can be more efficiently treated than VOCs in the liquid phase.

The 2-phase extraction method is applied to wells whose screens extend both above and below the water table. Depending on the production rate of the aquifer, the groundwater extracted through the tube can depress the water level and increase the amount of unsaturated soil exposed to the well screen. The high vacuum levels from the 2-phase extraction system remove more of the contaminated water (specific yield plus specific retention) by drawing down the water table and increasing the thickness of the unsaturated portion of the aquifer. The compression fitting on the well allows the extraction tube to be lowered under full vacuum as the groundwater table is depressed. The flow of atmospheric air can be regulated by adjustment of the gate valve to: 1) optimize the air-to-water flow ratio to minimize water "slug" production during start-up, and 2) maximize the steady-state groundwater flow rate. During a pilot-scale test of the 2-phase extraction system at McClellan AFB, atmospheric air was not required during system operation over a three- to four-day period after startup.

1.4 Description of the Demonstration

The demonstration will focus on Extraction Well EW-233, located near Buildings 655 and 666 within Operable Unit B on McClellan AFB, California. This well has been converted from a standard pump-and-treat well to a 2-phase extraction well and will be the primary focus of the demonstration since it will capture relatively high levels of contaminants in a groundwater plume whose source is nearby. A second converted extraction well (EW-234), located approximately 230 feet southwest of EW-233, will be investigated only as a secondary objective since it is located away from the main plume area. Operable Unit B (OU B) encompasses approximately 325 acres in the southwest portion of the Base, and includes six sites with known contamination, 23 locations, and 19 study areas that are potential sources of hazardous substances to the soils and groundwater. Specifically the demonstration area will encompass the immediate vicinity of Building 655 and 666 and approximately 300 feet south. In actuality, only the foundation of Building 666 (a former plating facility) remains, and is the source of the soil and groundwater contamination in the area (i.e., waste chemicals generated during plating activities). Contaminants detected in groundwater and soil gases during preliminary sampling during a pilot-scale test conducted at EW-233 (February/March of 1994) are listed in Tables 1-1 and 1-2, respectively.

**TABLE 1-1. CONTAMINANTS IN GROUNDWATER SAMPLES COLLECTED FROM EW-233
(February 1994)**

Compound	Concentration ($\mu\text{g/L}$)
Chloroform	1.6
1,2-Dichloroethane	11
Tetrachloroethene (PCE)	1,150
Trichloroethene (TCE)	4,890
Freon® 113	37

Source: Analytical Results from samples collected by Radian and analyzed by SITE.

TABLE 1-2. CONTAMINANTS IN SOIL GAS SAMPLES COLLECTED FROM EW-233 (March 1994)

Compound	Concentration (ppbv)
Freon® 113	2,700
Tetrachloroethene	2850
Trichloroethene	6500
Methyl Ethyl Ketone	29.5

Source: Analytical results are the average of duplicate analyses of a single wellhead vapor sample collected and analyzed by SITE.

The system will operate continuously for a period of 2 to 6 months. The full-scale demonstration will be terminated when contaminant concentrations reach steady-state. Steady-state is defined, for purposes of this demonstration, as the point where target critical volatile compound concentrations (as measured in the selected companion wells and/or water piezometer in the immediate vicinity of EW-233) do not vary by more than 30% over a 1-month period. Groundwater and vapor sampling for laboratory analysis will be performed for the duration of the demonstration in order to meet the primary objectives stated in Section 1.2.

Samples will be collected and analyzed according to the criteria discussed in Section 2 and specified in detail in Section 3, the Quality Assurance Project Plan (QAPP). Information will also be gathered regarding energy consumption and other operational parameters so that a cost estimate pertaining to this technology may be generated.

1.5 Responsibilities of the Participants

The demonstration will be conducted as part of the EPA SITE Program and in coordination with research efforts sponsored by the McClellan Air Force Base Public-Private Partnership. This partnership is a cooperative effort among a large number of Air Force, EPA, State, and industry participants. The Public-Private Partnership will provide technical expertise in evaluating the performance of the 2-phase extraction unit. The following section provides a brief description of the responsibilities of each of the participants in this demonstration. Additional detail on these responsibilities is provided in Section 2.11.

Clean Sites, under contract to EPA's Technology Innovation Office (TIO), will facilitate implementation of the Public-Private Partnership by Coordinating information exchange and organizing and providing support to technical work groups. McClellan AFB will provide: coordination between its contractor, Radian, and EPA and its contractor, SAIC; the site; and required services and utilities. McClellan AFB also will dispose/treat any wastes generated from the demonstration. Radian Corporation reports directly to McClellan AFB and is responsible for all remediation activities; will install, operate, and maintain the 2-phase extraction system during the demonstration, and is responsible for supporting equipment, process monitoring, and compliance sampling. EPA-SITE will provide coordination between the USAF and SAIC and assumes the overall lead for the demonstration. SAIC, EPA's SITE Program contractor, will verify the performance of the 2-phase extraction system based on operational data supplied by Radian and independent observations, perform pre- and post-test monitoring of soil vapor and groundwater contaminant concentrations, and perform sampling of the aqueous and air streams during the demonstration. SAIC will also take the lead in preparation of the reports evaluating this technology; Radian will assist in report preparation by providing technical input and comments. Radian will supply sampling support of both water and vapor streams during the demonstration (i.e., purging of wells). Radian will also conduct 3rd quarter 1994 and 1st quarter 1995 groundwater monitoring (sampling and analyses) for the RI/FS being conducted at the base. These sampling events will be conducted as close as possible to the start and completion, respectively, of the Demonstration Test. SAIC's subcontractor analytical laboratory, Coast-to-Coast Analytical Services, will characterize all samples taken for the demonstration. SAIC's sampling subcontractor, ERMI, will oversee the sampling of the vapor stream during the first week of sampling. SAIC may provide split samples with the Public-Private Partnership if so desired (the California EPA has expressed interest in potentially acquiring split samples).

NOTE: Radian will be conducting additional sampling for compliance with air and water discharge regulations, which is not included in this plan.

1.6 Quality Assurance/Quality Control

A Quality Assurance Project Plan (QAPP) has been developed for the 2-Phase Extraction Demonstration Project. The QAPP is tailored to conform to a Category II QAPP as specified for EPA SITE demonstrations. In addition, the QAPP has been written to incorporate requirements of the USAF Installation Restoration Program (IRP) Quality Assurance Manual.

The objectives of the QAPP for this project are two-fold. First the plan provides the mechanism for ongoing control and evaluation of measurement data quality throughout the course of the project. Second, the plan is structured so that audit results and quality control data will ultimately be used to define data quality and accuracy. The data quality estimates will, in turn, be used to define the level of the uncertainty associated with the measured parameters and process test values.

Further discussion regarding quality assurance and quality control is provided in Section 3, the QAPP for the demonstration.

1.7 Health and Safety

The Health and Safety Plan (HSP) defines the risks involved for SAIC's employees, its subcontractors, and EPA for this particular Demonstration Test and describes how these risks will be mitigated. The HSP is presented in Section 4. Radlan has prepared a separate HSP for its employees, subcontractors, and other members of the Public-Private Partnership. However, its plan and the SAIC plan have similar action levels and a shared understanding of the risks associated with the demonstration.

SECTION 2

TEST DESCRIPTION

2.1 Objectives and Assumptions

The primary objectives of the Demonstration Test are to:

- Determine the mass removal of each of the critical target VOCs (TCE, PCE, and Freon 113) from the 2-phase extraction well (EW-233) by measuring the individual concentrations of these three critical target compounds in both the liquid and gas phases and the volume of the liquid and gas phases recovered from the underlying aquifer and vadose zone during the six-month (approximate) demonstration.
- Determine the percent transfer of each of these critical target VOCs from the surrounding groundwater to vapor as the water is pulled up through EW-233's extraction tube to ground level under vacuum. This will be accomplished by measuring contaminant concentrations in groundwater (inlet water) in some combination of one or more of the nearby companion wells and/or the companion piezometer during operation, and comparing those concentrations to outlet water samples collected downstream of EW-233's knock-out tank during operation.

Because these are primary objectives, all measurements used to evaluate these objectives will be critical. For the first primary objective listed, the total mass removal of critical target VOCs from EW-233 (pounds removal over the approximate 6-month test duration) will be determined by measuring the flow rates of the recovered water and vapor streams and the concentrations of critical target organics in those two streams at the extraction unit.

Water flow rates will be measured at the totalizing water flow meters just downstream of the respective knock-out tanks for EW-233 and EW-234. The flow meters will be factory-calibrated before and after the project and field-calibrated once a month during the project (see Section 3.4.5). Totalized water flow readings will be taken immediately before each water sample is collected. Since water flow rates are expected to vary somewhat over the short term, an average flow rate will be determined for each sampling interval by subtracting the previous totalized flow reading (in gallons) from the current reading (in gallons) and dividing by the time interval (in minutes) between the two readings (excluding any system down time) to obtain an average flow rate (gpm). That average flow rate will be assumed to be the flow rate at the time the sample is taken.

Vapor flow rates will be calculated from gas stream velocity measurements made using a standard pitot tube and an inclined water manometer in accordance with procedures outlined in USEPA Method 2. The standard pitot tube will traverse one diameter of the duct through an air-tight Swagelock fitting located up-stream of the VOC sampling port and downstream of the auxiliary knock-out tank (see Section 3.4.2.3

for more detail on the sampling method). A new pitot tube will be used for this demonstration test. Factory certification of the pitot tube's manufacturing specifications will be verified and will be available in the field. Because vapor flow rates are expected to remain fairly constant, no average flow rate will be calculated as was done for water. Instead, the measured flow rate calculated from the velocity measurement will be assumed to be representative of the flow rate during sampling. Velocity measurements will be taken just after each vapor sample is collected and will be used to calculate the volumetric flow rate of the vapor stream using the following equation:

$$Q = C_p \cdot V_s \cdot F_d \cdot F_p \cdot A_s \cdot 60$$

An explanation of the nomenclature for this equation and other equations in this section is provided in Table 2-1 (see Appendix B for velocity calculations).

TABLE 2-1. CALCULATION NOMENCLATURE

A_s	Area of stack, Sq. Ft. (square feet)
B_w	Moisture, % (percent)
C_p	Pitot coefficient, n.d. (nondimensional) (0.99)
F_d	Gas Density correction factor, n.d.
F_p	Gas pressure correction factor, n.d.
M_w	Molecular weight, lb/lb-mole
P_{st}	Stack static pressure, H ₂ O (Inches of water)
P_{sd}	Standard pressure, 29.92 (Inches of Hg)
PPM	Parts per million
T_s	Stack temperature, degrees F
T_{sd}	Standard temperature, 528 (degrees Rankine)
V_s	Stack gas velocity, FPS (feet per second)
Q	Volumetric flow rate, CFM
Q_{sd}	Standard volumetric flow rate, DSCFM

The volumetric flow rate is then corrected to Dry Standard Cubic Feet per minute (dscf/min) using the following calculation:

$$Q_{sd} = Q \cdot P_{st} \cdot T_{sd} \cdot (100 - B_w) / P_{sd} \cdot (T_s + 460) \cdot 100$$

Outlet vapor concentrations for each sample will be converted from a volumetric basis (ppbv) to a mass basis (lbs/dscf vapor removed) using the measured concentration of each critical VOC multiplied times the molecular weight of that contaminant divided by the molar volume of extracted gas, at standard conditions, as shown in the following calculation:

$$C_v = (PPM \cdot MW)/(385 \cdot 10^6)$$

Note: Should the results be presented as PPB, they must either be converted to PPM or the above calculation should be divided by 10^9 rather than 10^6 .

Outlet water concentrations (ug/L) for each sample will be converted to pounds of contaminant per gallon (lbs/gallon) of extracted water using simple unit conversion.

The vapor and water concentrations calculated above (i.e., lbs/dscf and lbs/gallon, respectively) for each critical VOC at each sample time will be multiplied times their respective flow rates (i.e., dscf/min and gpm, respectively) to get a mass removal rate for each critical VOC in the vapor (lbs/min.) and water (lbs/min.) phases at each sample time. These calculated mass removal rates apply only to the actual sample times, not the interval between samples. To calculate the mass removal during the interval between samples, it is assumed that the change in mass removal rate from one sample time to the next is linear. Therefore, it is assumed that the average mass removal of two sample points applies to the complete interval between samples. The mass removal rate for the first vapor sample will be averaged with the mass removal rate of the second vapor sample and multiplied by the operating interval (in minutes) between the two sampling times to estimate the mass (in pounds and kilograms) of each critical contaminant extracted within that period. The mass removal rates of the second and third vapor samples will be similarly averaged to yield the mass removal for each critical VOC during that time period. This procedure will be applied to all sample intervals for the vapor samples. The sum of the mass removals for each time period will be used to calculate the total contaminant removal (in pounds and kilograms) by the vapor stream during the Demonstration Test. The mass of each critical VOC extracted in the water during each time interval will be calculated in a similar fashion. (NOTE: time intervals for vapor and water sampling may vary, so mass removal for each physical phase must be calculated separately). The total mass removal of each critical VOC in the water phase will be calculated from the mass removal during each time period. The sum of the mass removed of each critical VOC in the vapor and water phases will be the total mass removed of each critical VOC during the Demonstration Test.

For the second primary objective, the percent transfer of each of the critical target VOCs from the surrounding groundwater to the vapor stream, as the water enters EW-233 and is pulled to ground level by the system vacuum, will be determined by comparing the concentrations of each critical target organic

compound in groundwater samples collected from nearby wells and/or a water piezometer (screened at the same interval as, and in close proximity to, EW-233) to the concentration of the same critical target organics in outlet water exiting EW-233's knock-out tank at the same time. These "companion" wells are needed because collection of representative groundwater samples at the extraction well is not deemed possible during system operation since the groundwater at the extraction well bore hole is agitated by the applied vacuum. Groundwater samples will be taken within EW-233, the two companion wells (CW1 and CW2), and the companion piezometer nest (PN1) just prior to the demonstration under both static and dynamic conditions. The static condition samples will provide a baseline of localized groundwater concentrations. The 2-phase extraction system then will be operated for approximately two days to simulate pumping conditions during the demonstration. One sample each will be taken from CW1, CW2, and PN1 while pumping continues. Each of these wells will be purged (3 well volumes) before sampling. EW-233 will be turned off and a sample collected. No purging is required at EW-233 since it is continuously pumping. EW-233 will be turned on again for approximately 4 to 6 hours and samples will be collected in an identical manner as was just described. A total of five sets of samples will be collected in this fashion. Standard regression analysis will be applied to determine the best fit of any single well or combination of two wells among CW1, CW2, and PN1 to EW-233. The well or combination of wells which is the best fit to EW-233 during sampling under dynamic conditions will be used to monitor inlet concentrations at EW-233. The same four wells will be sampled following system operation to compare the measured concentrations of target organics with one another to substantiate that the groundwater concentration in the selected companion well(s) and/or piezometer is representative of the inlet water pulled in by EW-233 at the end of the demonstration. Further explanation of the use of the regression analysis to select inlet monitoring points is provided in Section 3.1.2.

During the demonstration, percent transfer from the water to the vapor streams will be calculated as follows:

$$\frac{\sum_{k=1}^n [(C_{w_k} - C_{t_k}) / C_{w_k}] \times 100}{n} = \text{Average Percent Transfer}$$

where C_{w_k} is the weighted concentration of each target organic in water in the selected companion wells and/or piezometer at each sample time, C_{t_k} is the corresponding concentration at the outlet from the knock-out tank, and n is the number of sampling events.

Secondary objectives of the Demonstration Test are to:

- Determine the total mass removal of total (non-critical and critical) target VOCs from EW-233 and the percent transfer of total VOCs from the surrounding groundwater to vapor, as

the water enters EW-233 and is pulled to ground level by the system vacuum, by the same means as described previously.

- Determine the combined total mass removal of all target VOCs by EW-234 (located approximately 230 feet southwest of EW-233) and EW-233 by measuring the total VOC concentration and flow rate in the gas phase for each of those two wells and adding the two values, and by measuring the total VOC concentration in and flow measured at the outlet water from each of the two knock-out tanks and adding those two values.
- Document the simultaneous extraction of groundwater and soil vapor from both 2-phase wells by recording the differences in the groundwater levels and soil vacuum levels in nearby groundwater and vapor piezometers, respectively, and by measuring the volume of water and vapor extracted from the two wells.
- Observe the zone of influence of the 2-phase extraction system at EW-233 by measuring groundwater and soil vacuum levels in surrounding wells and piezometers to estimate the extent of the cone of depression and determine if a greater volume of unsaturated soil (vertical and horizontal) is exposed to vapor recovery. Determination of the shape of the drawdown curve will also indicate whether the system prevents groundwater mounding, which is normally encountered during conventional soil vapor extraction.
- Measure the extraction rate of the groundwater by observing the flows per unit of time.
- Compare pre-test (baseline) groundwater and soil vapor concentrations to post-test concentrations in surrounding wells and vapor piezometers.
- Collect other full-scale operating cost and performance data as necessary.

Tables 3-1, 3-2, and 3-3 of the QAPP summarize project measurements to include critical and noncritical parameters for the groundwater and vapor samples. Additional process monitoring will include extracted vapor and water temperatures, and vacuum levels in the extraction tube and the annular space within the 2-phase extraction system. Table 3-4 of the QAPP summarizes the total number of vapor, groundwater, and associated QA samples for the Demonstration Test.

2.2 Project Background

The 2-phase extraction technology was originally developed by Xerox to increase the efficiency for remediating subsurface soil and groundwater contaminated with VOCs. Radian is licensed by Xerox to use this technology. Radian will assume the traditional responsibilities of the developer, to include installing, operating, and maintaining the 2-phase extraction system for McClellan AFB. The responsibilities of each organization participating in this demonstration are discussed in Section 2.11 of this Demonstration Plan.

2.3 Test Site

The demonstration will take place at McClellan AFB, Sacramento, California. McClellan AFB is an active aircraft maintenance facility associated with the Air Force Materiel Command. As part of past routine maintenance procedures at the base, a variety of hazardous materials were handled and disposed of.

Initial investigations to identify and characterize contamination on and near the base have identified 171 individual sites, most of which have been grouped into four geographical areas of the base, designated Operable units (OUs) A, B, C, and D, which are shown in Figure 2-1. The test will be sited at OU B and just outside of Investigation Cluster (IC) 1, at extraction wells (EW) 233 and 234, located near Building 655, McClellan AFB. The majority of activities will focus around EW-233. Figure 2-2 illustrates a plan view of the site and Figure 2-3 is a cross section that cuts diagonally through the test site area (parallel to the general groundwater flow direction).

OU B encompasses approximately 325 acres in the southwest portion of the base, and includes six sites with known contamination and 23 locations and 19 study areas that are potential sources of hazardous substances to the soils and groundwater. This site has historically been used as storage yards, warehouses, a chemical laboratory, an aircraft fueling area, a woodshop, an instrument repair facility, a paint facility, two industrial waste treatment plants (IWTPs), and a plating shop. Materials handled at various locations within the OU include: solvents, dimethyl ether, low-level radioactive wastewater, and waste chemicals generated during plating activities. Refer to Tables 1-1 and 1-2 for identified contaminants in groundwater and soil gases at EW-233 within IC 1.

2.4 Test Contaminants

Contaminants identified during previous site characterization are identified in Tables 1-1 and 1-2. Operable Unit B contains significant concentrations of trichloroethene (TCE), tetrachlorethene (PCE), and Freon 113[™]. Their concentrations were measured to range from 37 parts per billion (ppb) to almost five parts per million (ppm) in groundwater. Soil gas concentrations were measured to range from 220 ppb to 11 ppm. Based on the results from the pre-demonstration testing, Radian will define operational parameters for the 2-phase extraction system to maximize the potential for removing target contaminants.

2.5 Detailed Process Description

2.5.1 Process Introduction

The 2-phase extraction system was developed as a result of observations of vapor extraction effectiveness on contaminant removal in unsaturated soil. Vapor extraction takes advantage of the volatile nature of halogenated and non-halogenated hydrocarbons, and other VOCs, by inducing air flow through the soils. Vapor extraction in water bearing formations can cause mounding of the water table, thereby reducing performance and providing the potential for increased dissolved phase contamination. Vapor-phase contaminants are entrained in the extracted air and removed from the subsurface. As the contaminant mass is removed in the vapor phase, mass that is sorbed onto the soil matrix is desorbed and entrained in the extracted air flow.

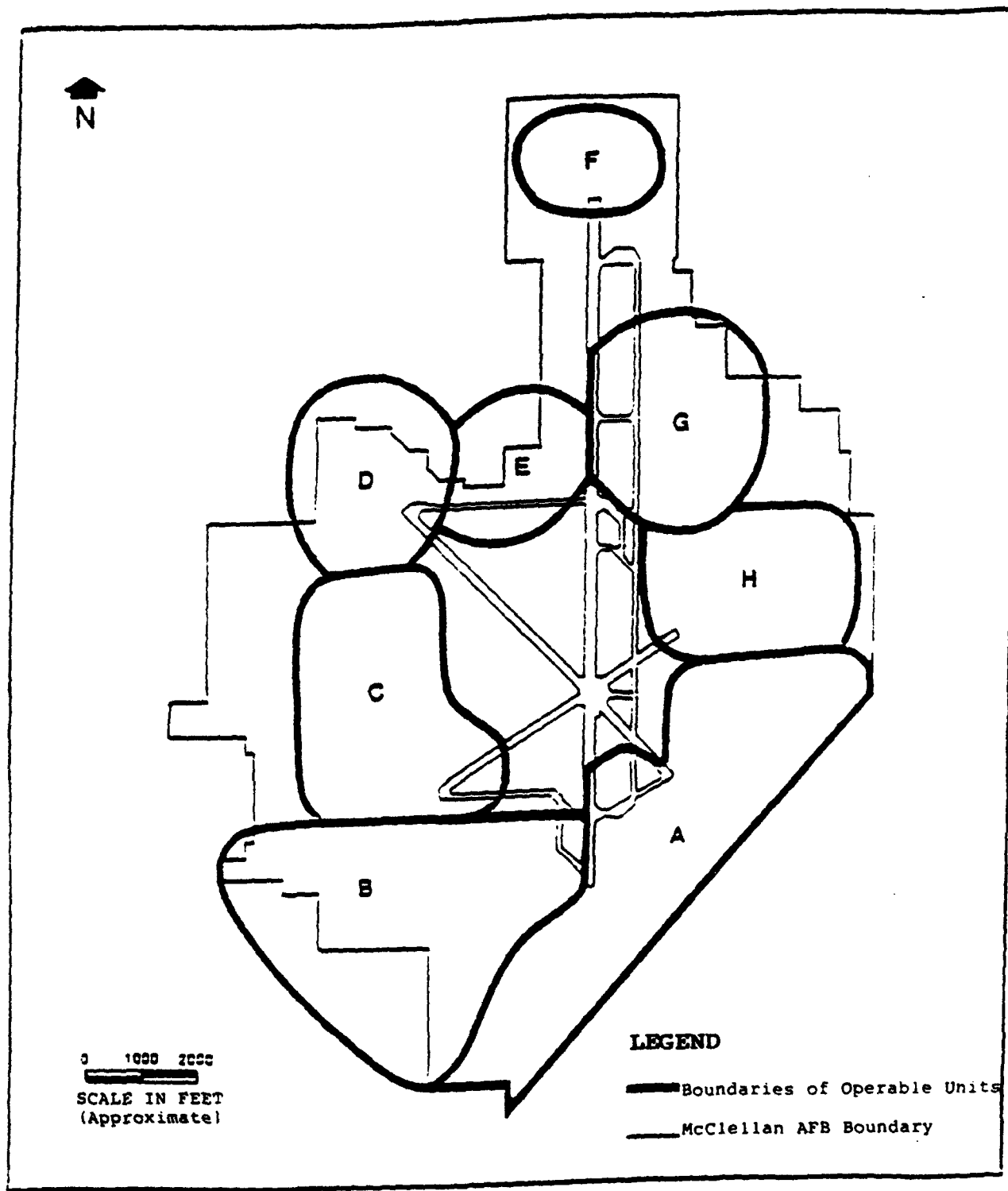


Figure 2-1. Base Map of Operable Units.

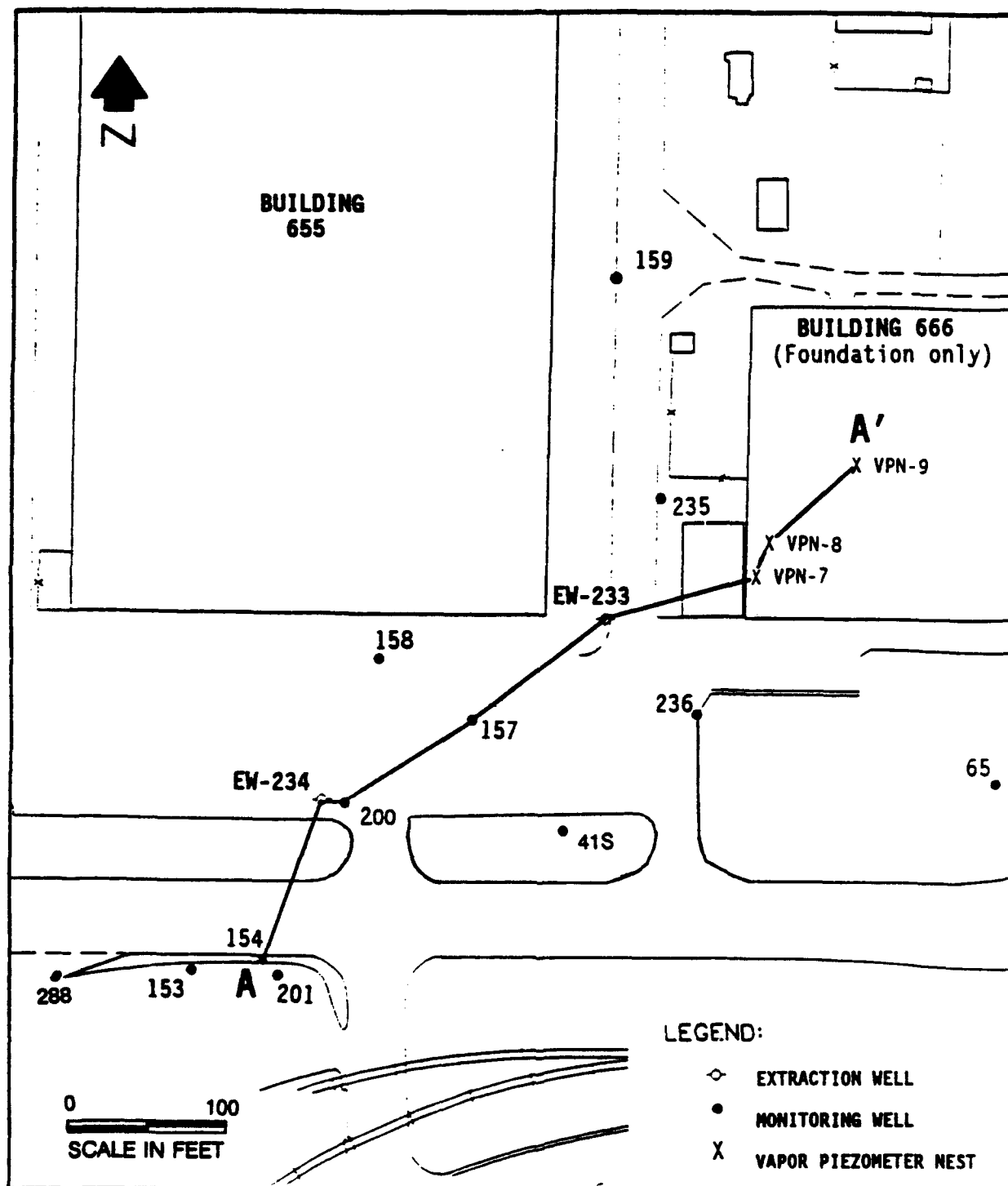


Figure 2-2. Location of Test Site.

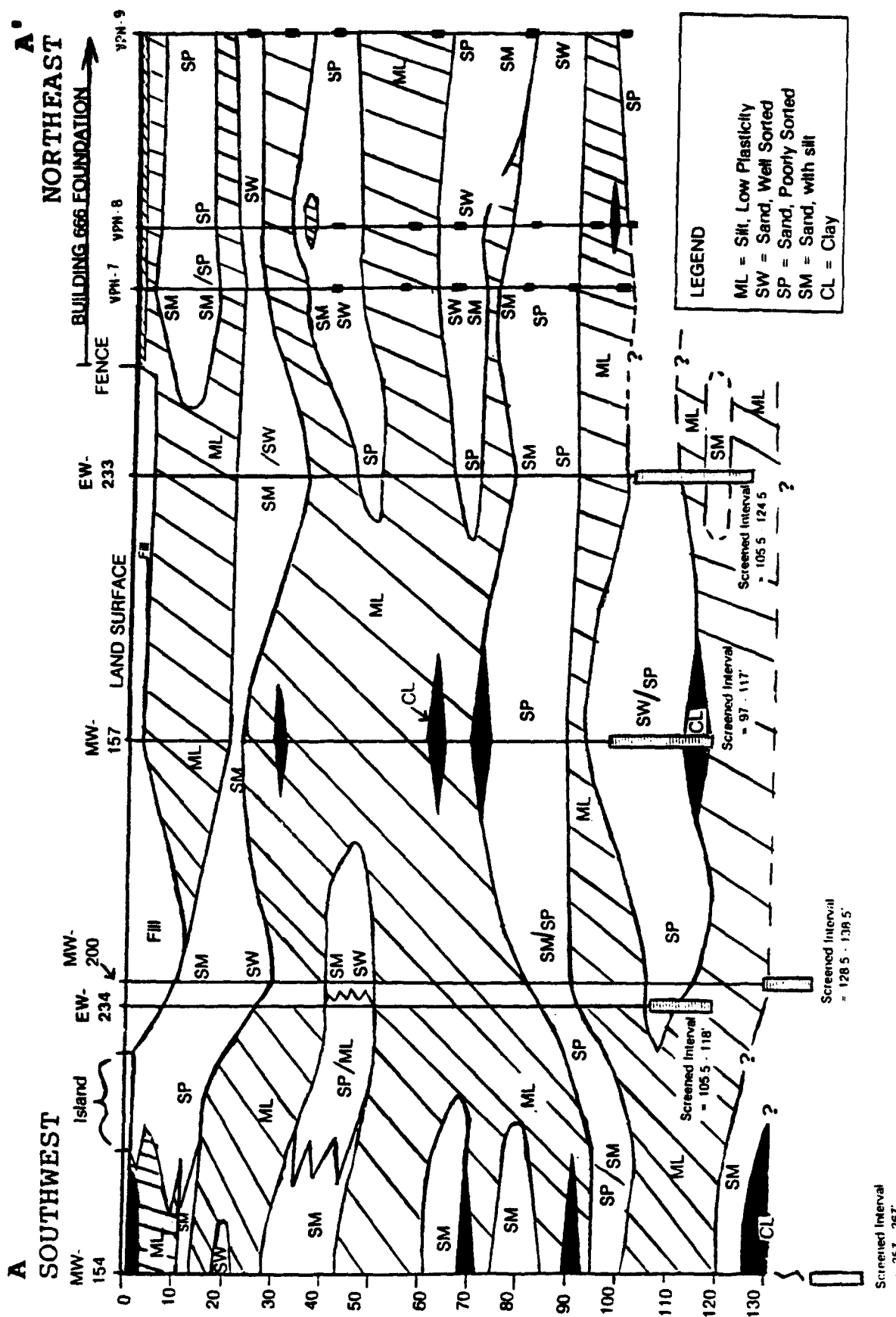


Figure 2-3. Cross Section Between MW-154 and VPN-9 Showing Underlying Lithology.
 (Source: Generalized Interpretation from Radlan Boring Logs)

Two-phase extraction was developed as an alternative to conventional pump-and-treat technology particularly in low conductivity formations, such as silts and clays, which are impacted by VOCs. Two-phase extraction uses a high-vacuum applied to an extraction tube within a water well to increase groundwater removal rates (and consequently the dissolved phase) and to volatilize and extract that portion of contaminant from the sorbed or free product phases. Vacuum lift of water is not a limiting factor in the application of the technology. Since a mixed vapor/liquid column is extracted from the well, the 2-phase extraction technology allows a single piece of equipment (a high-vacuum source) to remove contaminants in both the liquid and vapor phases.

2.5.2 Process Components and Installation

To extract both groundwater and soil vapor from a single extraction well, the 2-phase extraction system utilizes a vacuum pump to apply a high vacuum through a central extraction tube, which extends down the well. Soil vapor drawn into the well by the vacuum provides for a high-velocity vapor stream at the bottom tip of the extraction tube, which entrains the contaminated groundwater and lifts it to the ground surface. As the groundwater moves up the tube, more than 90 percent of the VOCs in the water phase are reported to be transferred to the vapor phase. The vapor and water phases are then separated at the surface in a knock-out tank. The water phase then requires only carbon polishing prior to discharge, provided that the compounds are adsorbable. The vapor phase is then subjected to carbon treatment, or other vapor phase treatment (based on contaminant characteristics, mass loadings, and economics), prior to release to the atmosphere.

Refer to Figure 1-2 for a schematic of a 2-phase extraction well. The compression fitting shown allows the extraction tube to be lowered under full vacuum as the groundwater table is depressed. Its use, however, may not be necessary. A kick start alternative could be used to induce flow and help de-water the well. The flow of atmospheric air can be regulated by adjustment of the gate valve to: (1) optimize the air-to-water flow ratio to minimize water "slug" production start-up (Note: the term "slug" refers to an irregular pulsation of water through the extraction tube which indicates irregular water flow); (2) maximize tube penetration into the saturated zone; and (3) maximize the groundwater flow rate by optimizing the applied vacuum to the well's annular space.

Typical installation activities require connection of a power supply, piping and vacuum system leveling, connection to the extraction well(s) and connection of vapor- and liquid-phase discharge connections to final treatment process(es).

2.5.3 Contaminant Collection

The 2-phase extraction system extracts both groundwater and soil vapor from a single extraction well through the extraction tube. As the extracted mixture emerges from the well at the surface, it is routed to a knock-out tank where the vapor phase is separated from the water phase. The separated water phase is then subjected to carbon polishing and discharged to the existing groundwater treatment system. The vapors are routed through a demister which removes any oil droplets picked up during passage through the vacuum pump. Off-gas treatment also consists typically of carbon treatment prior to discharge to the atmosphere.

2.5.4. Demonstration Setup

The overall configuration of the 2-phase extraction system that will be installed at EW-233 and EW-234 for the demonstration is shown in Figures 2-4 and 2-5, respectively. Extracted vapors and entrained groundwater from EW-233 will be piped to a separate auxiliary knock-out tank where the water and vapor phases will be separated. Outlet water will be piped to the existing groundwater transfer line which goes to the groundwater treatment system. Vapors exiting the auxiliary knock-out tank will be piped to the vapor treatment system. This knock-out tank will be installed with sample ports, water flow meters, and vapor flow measurement ports to separately account for mass removal in the vapor and water streams.

Extracted water and vapor from EW-234 will be piped to the knock-out tank mounted on the 2-phase extraction system (see Figure 2-5). The outlet water from the EW-234 knock-out tank will be sampled before the connection to the groundwater transfer line. The vapors from EW-234 will be sampled in the outlet from the knock-out tank.

The outlet vapor sample points for EW-233 and EW-234 are upstream of the one vacuum pump, the connection between the respective knock-out tanks, and the manifold line leading to the vacuum pump. The outlet water sample points are downstream of the respective water pumps but upstream of the manifold line leading to the water treatment system.

2.6 Sampling and Analysis

Baseline groundwater and soil vapor samples for EW-233 will be collected from surrounding wells and vapor piezometer nests just prior to the system startup. In addition, groundwater samples will be collected from EW-233 (S1), the two adjacent companion wells (CW-1 and CW-2), and the water piezometer in the adjacent piezometer nest (PN-1) under both static and dynamic conditions. The results of this sampling will be used along with drawdown measurements in CW-1, CW-2, and PN-1 to determine which individual well or combination of two wells, and their relative contributions, best match the concentration in EW-233. The one or two wells selected by this process will serve as the sample point for inlet groundwater

(S2). Further discussion of the selection process and subsequent weighting of sample concentrations (if two sample points are used) are provided in section 3.1.2.

During system operation, various process variables (water and vapor flow rates and temperatures, and system vacuum levels) will be monitored by Radian and verified by SAIC. Water and vapor samples will also be collected for analysis for the duration of the demonstration. Process monitoring and sample points for EW-233 and EW-234 are shown individually on Figures 2-4 and 2-5, respectively. For EW-233, samples will be collected twice daily for the first four days of the demonstration, once each within the first and last hours of a normal 8-hour shift. For the remaining three days of the first week, samples will be taken once daily. During the second and third weeks, sample frequency will drop to once every other day and twice per week, respectively. From week 4 through the end of the demonstration, samples will be taken once per week. A listing of the samples to be collected and the corresponding analytical methods are shown in Table 2-2.

Samples for total vapor concentrations from EW-234 will be taken at the sampling port located downstream of the knock-out tank. EW-234 water samples will be taken at the outlet to the EW-234 knock-out tank and added to EW-233 water concentrations to determine total mass removal via the water phase. Water and vapor samples will be collected once per day during week 1, twice per week during week 2, once per week during weeks 3 and 4, and once per month during months 2 and 6.

Vapor flow rates (M1 and M10) will be measured using a pitot tube (the accepted EPA Method). Water flows (M2 and M9) will be measured using calibrated totalizing water meters. Water temperature (M3) and vapor temperature (M4) will be measured using bimetallic thermometers. Water levels in all wells will be measured using a well sounder (M5) and vacuum will be measured using a Magnehelic® vacuum gauge or a vacuum gauge of equivalent accuracy for the 2-phase extraction annular space and a differential pressure transducer for the extraction tube (M6). The vacuum pressure in the piezometers will be measured with pressure gauges fitted to the top of the tubes (M7). Inlet (atmospheric makeup air) to the extraction well will be measured with a flow element (M8).

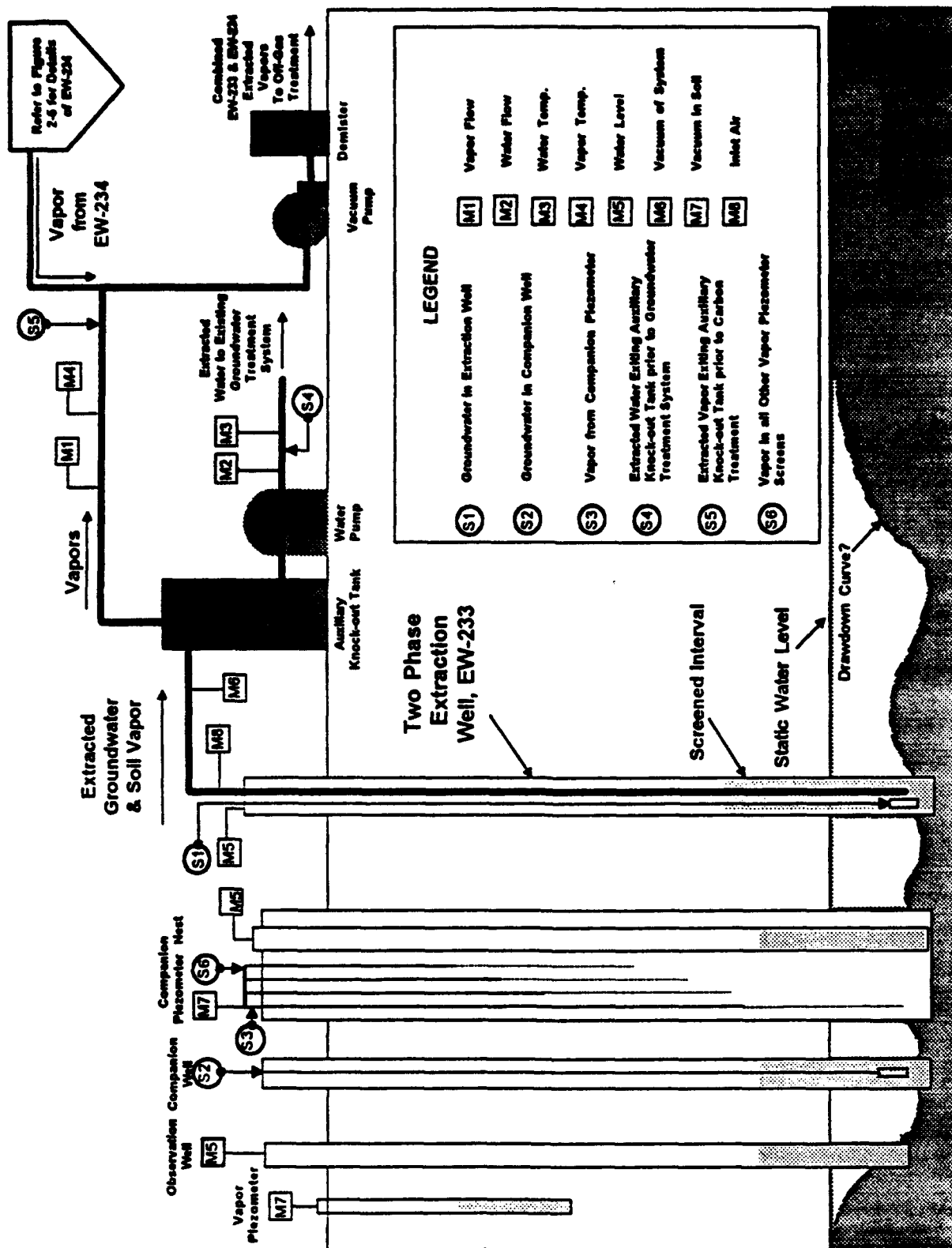


Figure 2-4. Process Schematic of the 2-Phase Extraction System Showing Sample and Measurement Points for EW-233.

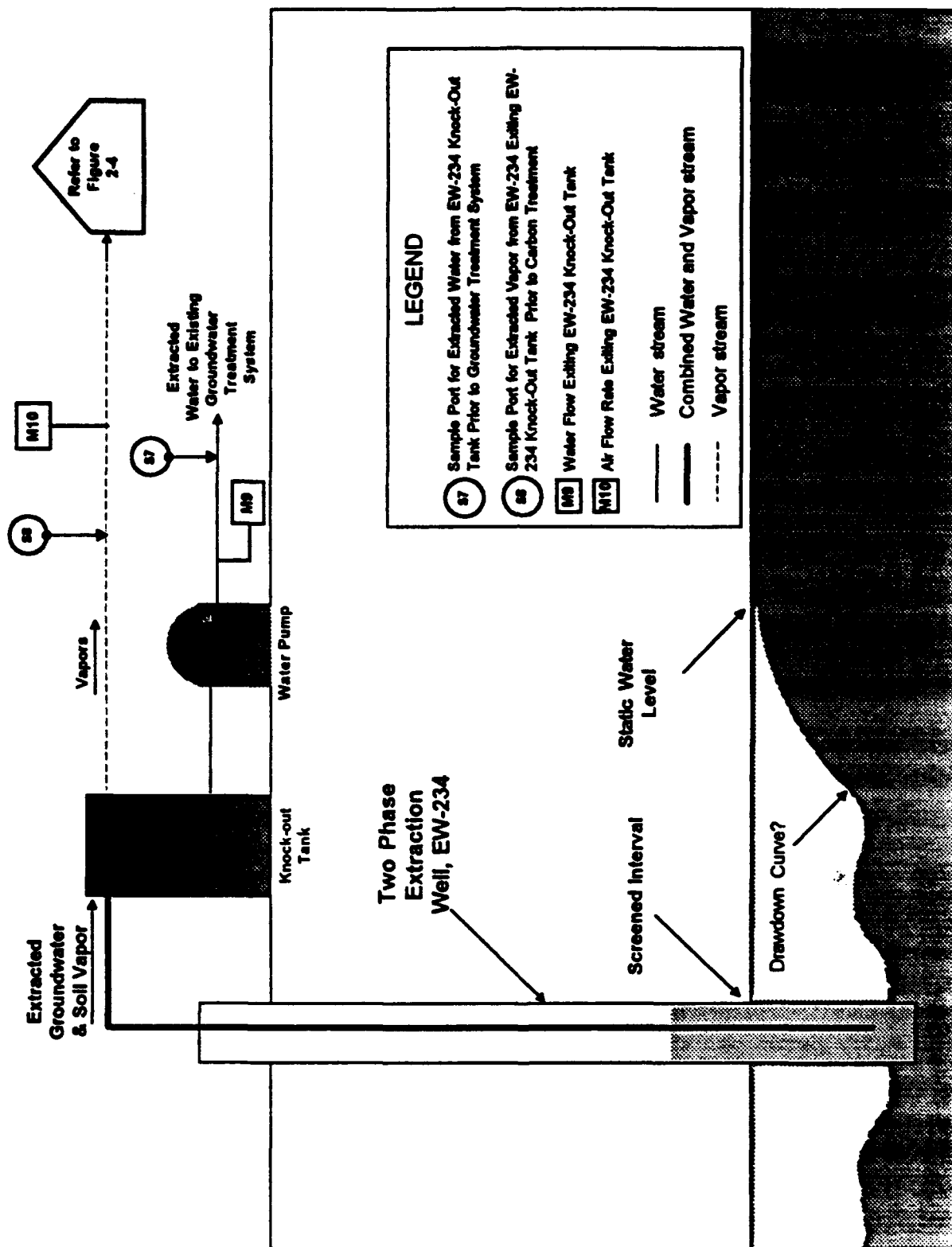


Figure 2-5. Process Schematic of the 2-Phase Extraction System Showing Sample and Measurement Points for EW-234.

TABLE 2-2. SAMPLE COLLECTION AND ANALYTICAL METHODS

Media	Stream Number ^a	Analytical Method
<u>Initial (Baseline) Testing</u>		
Water	S1, S2	8260
Vapor	S3, S6	TO-14
<u>Demonstration^a</u>		
Water	S2, S4, S7	8260
Vapor	S3, S5, S8	TO-14
<u>Post-Demonstration Testing</u>		
Water	S1, S2	8260
Vapor	S3, S6	TO-14

^a Samples to be taken over a duration of operational period (2-6 months).

^b Stream number locations are shown in Figure 2-4.

2.7 System Operation

After system installation, the 2-phase extraction system will be operated to check for leaks and to ensure the system is operating properly. Baseline groundwater concentrations will be measured immediately before the demonstration in EW-233 and in two surrounding companion wells and a companion piezometer nest located immediately upgradient, downgradient, and lateral of EW-233. These measurements will be used to determine which single well or combination of two wells to use for inlet water samples for EW-233. Baseline soil vapor samples will be measured in the companion vapor piezometer laterally located about 7 feet from EW-233. The 2-phase extraction demonstration will proceed until a trend, or steady-state appears to have been achieved (approximately two to six months). The system will operate for an additional 30 days to confirm that steady-state conditions have been achieved. During this time, sample points will be plotted and a linear regression calculated. The slope of the regression will be tested where the null hypothesis is that the slope equals zero. If the test hypothesis is not rejected, then steady-state conditions are assumed to have been reached. If so, surrounding wells will be monitored for groundwater and soil gas concentrations. If conditions prove not to be steady-state during this 30-day period, the demonstration will continue at the end of the 30-day period for up to approximately 6 months. However, it may be decided at that time to change monitoring activities to account for non-steady-state conditions. In either case, the system will then continue to operate for an extended period after the demonstration has been completed to continue site remediation.

2.8 Disposal of Residues

Two process output streams (organic vapors and groundwater containing dissolved organic constituents) will be generated during the demonstration, which are subject to on-site treatment prior to

discharge. Nonprocess waste generated during demonstration phases include disposable personal protective equipment (e.g., Tyvek suits and gloves), groundwater purged from wells before sampling, and equipment decontamination washes. All such nonprocess waste will be containerized in drums or otherwise collected based on direction from McClellan AFB and stored on pallets at the site for final disposal. McClellan AFB is responsible for allocation of clean-up costs and management of cleanup activities. All drummed wastes will be labeled and handled according to Title CFR Part 262 - Standard Applicable to Generators of Hazardous Waste.

It is anticipated that process waste will be treated on-site at the McClellan AFB. In the unlikely event that the wastes are unsuitable for treatment or retention onsite, they will be removed by McClellan AFB.

It is not anticipated that any shipment of samples will exceed the reportable quantity (RQ) for any of the substances in the water or air. However, if any exceedence of an RQ is of concern at the time of shipment, the cooler will be marked as follows:

- Proper shipping name: Hazardous substance, liquid, or solid
- Hazardous class: To be determined (label placed in upper left corner of outer container)
- Labels: "This Side Up" or arrows placed on the opposite side of the outer container if a liquid is being shipped
- Custody tape is wrapped twice, in a single strip, around the outside of each cooler and signed over the seam.

A hazardous material shipper's certification will be filled out and accompany the shipment. The container will be secured with strapping tape to prevent leakage.

2.9 Documentation and Reporting

SAIC will be responsible for ensuring that all field data (including measurements), activities, and sample analyses resulting from the test are properly documented and secured for EPA's SITE Demonstration Program. SAIC will maintain a file on all work documentation including raw data, calculations, assumptions, and sources of information. SAIC will take 2" x 2" 35mm color slides of all field activities and will provide copies of these slides to the EPA Work Assignment Manager (WAM). SAIC will also make arrangements for videotaped documentation of the Demonstration Test. A 12-minute videotape will be prepared for EPA by a professional videotape production company. Copies of the slides and videotape will also be provided for Clean Sites to distribute to the private partners.

The Demonstration Test findings will be presented in the form of an Innovative Technical Evaluation Report (ITER). The ITER summarizes the results of the Demonstration Test, as well as supporting data from previous testing activities and other background information included in the ITER's tabulated data, including process measurement data (i.e., extraction rates) as well as analytical concentration data. It provides an economic analysis and information for a comparative evaluation against similar technologies. A brief SITE Technology Capsule and Bulletin will also be prepared and submitted. The Technical Evaluation Report (TER) will be compiled and will be submitted to the WAM; the TER will not be published.

2.10 Schedule for the Demonstration Test

The overall schedule for the Demonstration Test is included in Table 3-5.

2.11 Responsibilities of the Participants

The following sections identify the responsibilities of the participants in the Demonstration Test. Quality assurance personnel organization may be found in Section 3.2.

2.11.1 EPA

EPA has overall project responsibility for the SITE demonstration, which is being conducted in cooperation with McClellan AFB and members of the Public-Private Partnership. The EPA WAM is responsible for overseeing the technology testing and for ensuring the completion of the individual program tasks under the SITE Program. EPA will develop and coordinate the demonstration with Clean Sites and McClellan AFB personnel and its subcontractor, SAIC. EPA has assigned the development of the Demonstration Plan to SAIC. EPA will review and approve the overall Plan as well as its individual components. EPA will provide the sampling contractor as well as the sample analysis and the evaluation of the test through SAIC and its subcontractors. In conjunction with McClellan AFB and the Public-Private Partnership, EPA has selected Operable Unit B, Site IC 1 and immediate surrounding areas at McClellan AFB for studies and demonstrations which may result in remedial attention. EPA's Work Assignment Manager is Laurel Staley.

2.11.2 SAIC

SAIC is responsible for completion of the Demonstration Plan to implement the demonstration testing including pre-test, during test, and post-test sampling activities. SAIC will identify technical and nontechnical obstacles interfering with the completion of the demonstration and report these to EPA. SAIC will also be responsible for packing and shipping all samples during these periods to Coast-to-Coast, SAIC's analytical subcontractor laboratory. SAIC and Coast-to-Coast are directly responsible for data quality of lab analyses. SAIC will document the activities during the Demonstration Test and will evaluate the results of

the tests in conjunction with EPA. SAIC will be responsible for the safety of its personnel. SAIC reports directly to the EPA WAM. SAIC's Work Assignment Manager is Jim Rawe. SAIC's Field Manager is Jamie Winkelman.

2.11.3 Coast-to-Coast

Coast-to-Coast Analytical Services reports directly to SAIC and is responsible for the characterization of all samples taken for the demonstration. SAIC will ship these samples to Coast-to-Coast's laboratory. Coast-to-Coast's Project Manager is Larry Hilbert.

2.11.4 ERMI

ERMI reports directly to SAIC and is responsible for overseeing the sampling of the vapor stream during the first week of the demonstration. SAIC will package and ship all vapor stream samples to Coast-to-Coast laboratory. ERMI's Project Manager is Craig Douglas.

2.11.5 Public-Private Partnership

The Public-Private Partnership will provide technical expertise for the project in evaluating the performance of the 2-phase extraction units. The partnership will directly provide its information and expertise to Clean Sites who will perform liaison activities between members of the partnership and EPA, McClellan AFB, and their respective contractors.

2.11.6 Clean Sites

Clean Sites has been contracted by EPA's Technology Innovation Office (TIO) and will facilitate implementation of the Public-Private Partnership. Clean Sites will convene conference calls, prepare monthly reports, and alert members of the public-private partnership to issues that arise during the course of the project. Clean Sites' Project Manager and Task Manager are Ellen Fitzpatrick and Greg McNelly, respectively.

2.11.7 Air Force

The USAF will provide coordination between EPA and Radian, as well as the site and required services and utilities. McClellan AFB has contracted Radian to oversee the installation and operation of the 2-phase extraction system. McClellan AFB's Project Manager is Doris Varnadore.

2.11.8 Radian

Radian reports directly to McClellan AFB and will be responsible for: all remediation activities; installation, operation, and maintenance of the 2-phase extraction system; and treatment/disposal of all wastes generated during the demonstration. Radian will also assist in sample preparation activities (most notably purging of groundwater and vapor wells) for all sampling activities. Radian's Project Manager is Gordon Kingsley. Radian's Field Manager is John Clark.

**SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION/
PUBLIC-PRIVATE PARTNERSHIP 2-PHASE EXTRACTION
QUALITY ASSURANCE PROJECT PLAN**

**Evaluation of the 2-Phase Extraction System
(Developed by Xerox Corp. and implemented by Radian Corp.)
at McClellan AFB, California**

FINAL

July 19, 1994

Submitted to:

**Laurel Staley, Work Assignment Manager
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Submitted by:

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**EPA Contract No. 68-C0-0048
Work Assignment 0-62
SAIC Project No. 01-0832-07-1129-008**

QUALITY ASSURANCE PROJECT PLAN DISTRIBUTION LIST

<u>Organization</u>	<u>Name</u>	<u>Title</u>	<u>Copies</u>
EPA	Laurel Staley	WA Manager	1
EPA	Ann Leltzinger	QA Officer	2
SAIC	Art Shattuck	Deputy SITE Program Manager	1
SAIC	Jim Rawe	Project Manager	1
SAIC	Joseph Evans	SITE QA Manager	1
SAIC	Lauren Drees	QC Coordinator	1
SAIC	Jamie Winkelman	Field Manager	1
SAIC	Evelyn Meagher-Hartzell	Site Safety Coordinator	1
Radian	Gordon Kingsley	Project Manager	1
Radian	John Clark	Field Manager	1
Coast to Coast Analytical	Larry Hilpert	Laboratory Coordinator	1
Coast to Coast Analytical	Margaret Kimball	Laboratory QC Coordinator	1
ERMI	Craig Douglas	Project Manager	1
USAF, McClellan AFB	Doris Varnadore	Project Manager	1
Clean Sites	Greg McNelly	Demonstration Coordinator	1
Clean Sites	Ellen Fitzpatrick	Project Manager	1

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3.0 QUALITY ASSURANCE PROJECT PLAN

The Superfund Innovative Technology Evaluation (SITE) Program is intended to enhance the development and demonstration, and thereby establish the commercial availability, of innovative technologies for hazardous waste treatment.

The objective of the SITE Demonstration Program is to develop reliable engineering performance and cost data on innovative alternative technologies, so that potential users can evaluate each technology's applicability for a specific site compared to other alternatives. Demonstrations are conducted at hazardous waste sites or under conditions that closely simulate actual wastes and conditions, to assure the accuracy and reliability of information collected.

Data collected during a demonstration are used to assess the performance of the technology, the potential need for pre- and post-processing of the waste, applicable types of wastes and media, the potential operating problems, and approximate capital and operating costs. Demonstration data can also provide insight into long-term operating and maintenance costs and long-term risks. Sampling and analysis procedures are, therefore, very critical. Approved quality control procedures must be stringently followed throughout the Demonstration Program.

Science Applications International Corporation (SAIC) has prepared this Quality Assurance Project Plan (QAPP) to include the following key elements required for a Category II QAPP.

- Project description, including the intended use of the data
- Organizational chart and a delineation of QA/QC responsibilities
- Data quality objectives for critical measurements, in terms of precision, accuracy, completeness, method detection limits, representativeness, and comparability
- Site selection and sampling procedures
- Analytical and calibration procedures
- Data reduction, validation, and reporting, including the handling of invalid/missing data
- Internal quality control checks and audits
- Systems and performance audits
- Calculation of data quality indicators (precision, accuracy, completeness, and method detection limits)
- Corrective actions (criteria and procedures)

- Quality control reports to management

This QAPP follows the guidelines presented in U.S. Environmental Protection Agency's (EPA) Office of Research and Developments (ORD) Risk Reduction Engineering Laboratory (RREL) Document EPA/600/8-91/004. It describes the methods that SAIC's SITE Team, which includes Coast-to-Coast Analytical Services (CCAS), the subcontractor laboratory, will use to handle and analyze samples and perform other relevant data gathering activities needed to evaluate Radian's 2-Phase Extraction system at McClellan Air Force Base, Sacramento, California. Groundwater and vapor samples will be collected by SITE, according to the procedures described in Section 3.4 of this QAPP.

*

3.1 PROJECT DESCRIPTION

3.1.1 Project Background

The Demonstration Test will be conducted as part of the EPA SITE Program and in coordination with research efforts sponsored by the USAF. Radian Corporation, the technology licensee, will install and operate the 2-phase extraction system. SAIC, EPA's SITE Program contractor, will document system installation, provide sampling support, verify system performance based on data supplied by Radian and independent observation, and document sampling activities during the demonstration. SAIC will also provide subcontract analytical support for characterization of all groundwater and soil vapor samples. The following sections describe Radian's proposed application of the 2-phase extraction technology at the demonstration site, and site characteristics.

3.1.1.1 2-Phase Extraction Process Description

The 2-phase extraction process is used to increase the remediation efficiency for subsurface soil and groundwater contaminated with volatile organic compounds (VOCs) in low-permeability formations. The system extracts both groundwater and soil vapor from a single extraction well by applying a high vacuum (18 to 25 inches of mercury) through a central lift pipe, called an extraction tube, that extends down the well. Soil vapor drawn into the well by the vacuum creates a high velocity vapor stream at the bottom tip of the tube, which entrains the contaminated groundwater and lifts it to the ground surface. A schematic of the extraction well is illustrated in Figure 3-1. The vapor and water phases are then separated at the surface in a knock-out tank prior to treatment. The turbulence caused as the entrained groundwater moves up the extraction tube has been reported to transfer more than 90 percent of the VOCs from the water to the vapor phase; the separated water phase then only requires carbon polishing before discharge (see Figure 3-7.). The VOCs transferred from the liquid phase, combined with contaminated soil vapor, result in higher VOC concentrations in the vapor phase, which can be more efficiently treated than VOCs in the liquid phase.

The 2-phase method is applied to wells whose screens extend both above and below the water table. Depending on the production rate of the aquifer, the groundwater extracted through the extraction tube can depress the water level and increase the amount of unsaturated soil exposed to the well screen. The high vacuum levels from the 2-phase extraction system remove more (specific yield plus specific retention) of the contaminated water by drawing down the water table and increasing the thickness of the unsaturated portion of the aquifer.

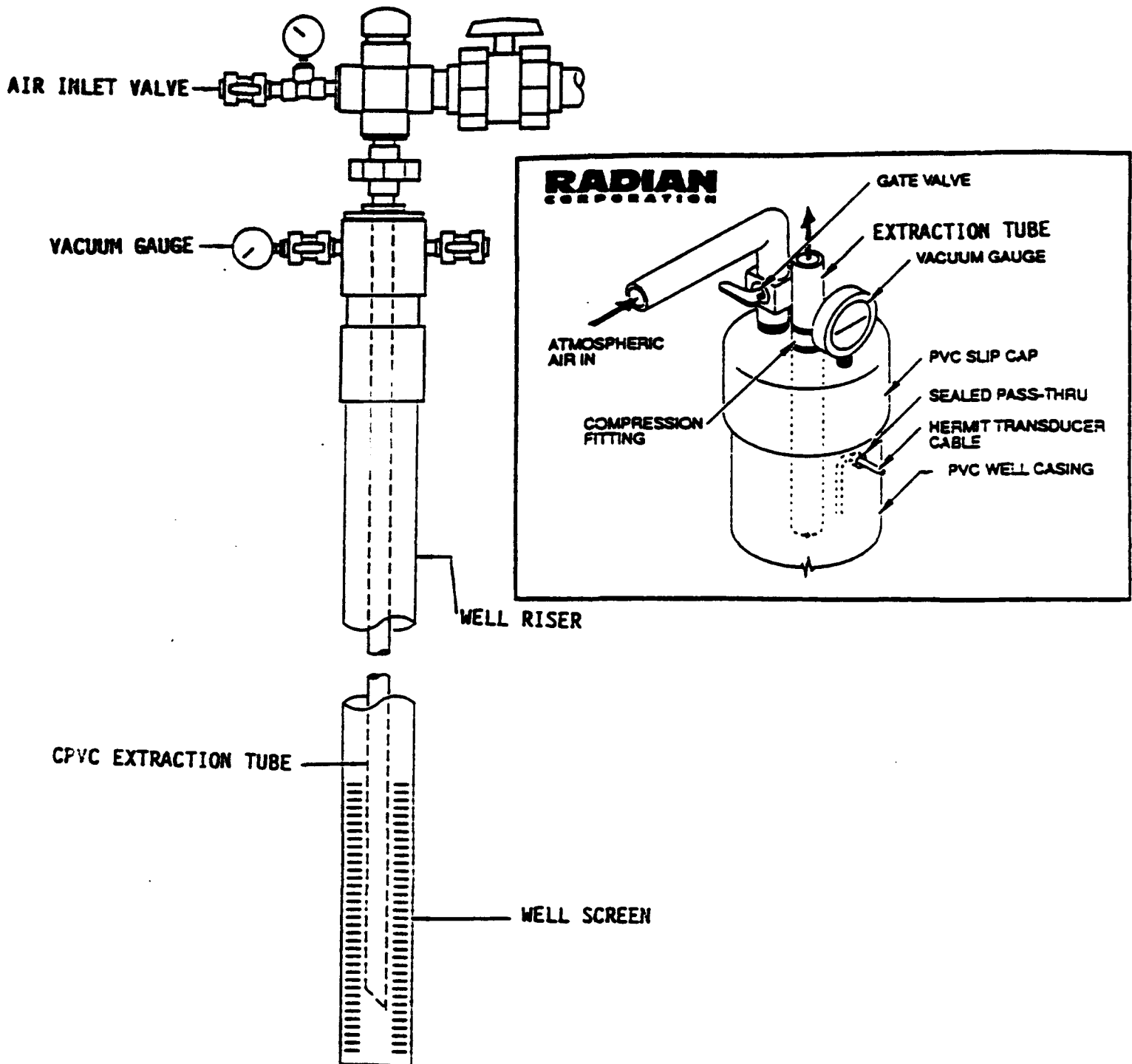


Figure 3-1. Schematic of 2-Phase Extraction Well. (Sources: Xerox, H&A, Radian)

The compression fitting on the extraction well allows the extraction tube to be lowered under full vacuum as the groundwater table is depressed (However, if the kick-start option is used, the compression fitting is not necessary). The flow of atmospheric air can be regulated by adjustment of the gate valve to optimize the air-to-water flow ratio thus minimizing water "slug" production during start-up and maximize the vacuum applied to the formation and steady-state groundwater flow rate. During system operation (after startup) atmospheric air will not be added.

3.1.1.2 Above-Ground Treatment System

The 2-phase extraction wells are each flush-mounted in a vault that extends a couple of feet below the paved surface. Extracted vapors and groundwater from EW-233 will be routed through an adjacent auxiliary knock-out tank, then are routed to a trailer-mounted treatment system. Extracted vapors and groundwater from EW-234 are routed through the main skid-mount knock-out tank, where the liquid condensate is separated from those vapors and piped to a groundwater treatment line after combining with the EW-233 outlet water. This line routes groundwater collected from various wells to a large groundwater treatment plant located just north of the Building 666 foundation. The vapors are routed and combined downstream of the skid-mounted knock-out tank, through the vacuum pump, and are passed through an oil/vapor separator which removes any oil droplets that may have accumulated in the vapors. The vapors are then routed to off-gas treatment (i.e., carbon tanks).

3.1.1.3 McClellan Air Force Base: Site Location and History

The primary site for the 2-phase extraction demonstration is located at and around Extraction Well 233 near Investigative Cluster (IC) 1, in Operable Unit (OU) B, located near buildings 655 and 666 at McClellan AFB, California. A second Extraction Well (EW-234) is located approximately 230 feet southwest of EW-233 and is a non-primary area of study for this demonstration. A description of the test site is provided in Section 2.3 of the Demonstration Plan.

3.1.2 Project Objectives

The primary objectives of the Demonstration Test are to:

- Determine the mass removal of each of the critical target VOCs (TCE, PCE, and Freon 113) from the 2-Phase Extraction Well (EW-233) by measuring the individual concentrations of these three critical target compounds in both the liquid and gas phases and the volume of the liquid and gas phases recovered from the underlying aquifer and vadose zone during the six-month (approximate) demonstration.
- Determine the percent transfer of each of these critical target VOCs from the surrounding groundwater to vapor as the water enters EW-233 and is pulled to ground level by the

system vacuum. This will be accomplished by measuring contaminant concentrations in groundwater (inlet water) in nearby companion wells during operation, and comparing those concentrations to outlet water samples collected downstream of EW-233's knock-out tank during operation.

Note: Two companion wells and one companion piezometer nest for EW-233 have been installed for this demonstration. These are considered necessary to meet primary objective goals. This is because design and operation of a 2-phase extraction well does not allow for representative groundwater sampling within the extraction well itself (due to agitation caused by the vacuum). Section 3.1.3 (Experimental Design) presents a detailed rationale for the locating and sampling of these wells.

Because these are primary objectives, all measurements used to evaluate these objectives will be critical. For the first primary objective listed, the total mass removal of critical target VOCs from EW-233 (pounds removal over the approximate 6-month test duration) will be determined by measuring the flow rates of the recovered water and vapor streams and the concentrations of critical target organics in those two streams at the extraction unit.

Water flow rates will be measured at two totalizing water flow meters just downstream of the respective knock-out tank for EW-233 and EW-234. The flow meters will be factory-calibrated before and after the project and field-calibrated once a month during the project (see Section 3.4.5). Totalized water flow readings will be taken immediately before each water sample is collected. Since water flow rates are expected to vary somewhat over the short term, an average flow rate will be determined for each sampling interval by subtracting the previous totalized flow reading (in gallons) from the current reading (in gallons) and dividing by the time interval (in minutes) between the two readings (excluding any system down time) to obtain an average flow rate (gpm). That average flow rate will be assumed to be the flow rate at the time the sample is taken.

Vapor flow rates will be calculated from gas stream velocity measurements made using a standard pitot tube and an inclined water manometer in accordance with procedures outlined in USEPA Method 2. The standard pitot tube will traverse one diameter of the duct through an air-tight Swagelok fitting located up-stream of the VOC sampling port and downstream of the auxiliary knock-out tank (see Section 3.4.3.3 for more detail on the sampling method). A new pitot tube will be used for this Demonstration Test. Factory certification of the pitot tube's manufacturing specifications will be verified and will be available in the field. Because vapor flow rates are expected to remain fairly constant, no average flow rate will be calculated as was done for water. Instead, the measured flow rate calculated from the velocity measurement will be assumed to be representative of the flow rate during sampling. Velocity measurements will be taken just after each vapor sample is collected and will be used to calculate the volumetric flow rate of the vapor

stream in Dry Standard Cubic Feet (dscf/min) using the calculations presented in Section 2.1.

Outlet vapor concentrations for each sample will be converted from a volumetric basis (ppbv) to a mass basis (lbs/dscf vapor removed) using the measured concentration of each critical VOC multiplied times the molecular weight of that contaminant divided by the molar volume of extracted gas, at standard conditions, as shown in the calculation above (see Section 2.1 for calculations).

Outlet water concentrations (ug/L) for each sample will be converted to pounds of contaminant per gallon (lbs/gallon) of extracted water using simple unit conversion.

The vapor and water concentrations calculated above (i.e., lbs/dscf and lbs/gallon, respectively) for each critical VOC at each sample time will be multiplied times their respective flow rates (i.e., dscf/min and gpm, respectively) to get a mass removal rate for each critical VOC in the vapor (lbs/min.) and water (lbs/min.) phases at each sample time. These calculated mass removal rates apply only to the actual sample times, not the interval between samples. To calculate the mass removal during the interval between samples, it is assumed that the change in mass removal rate from sample time to the next is linear. Therefore, it is assumed that the average mass removal of two sample points applies to the complete interval between samples. The mass removal rate for the first vapor sample will be averaged with the mass removal rate of the second vapor sample and multiplied by the operating interval (in minutes) between the two sampling times to estimate the mass (in pounds and kilograms) of each critical contaminant extracted within that period. The mass removal rates of the second and third vapor samples will be similarly averaged to yield the mass removal for each critical VOC during that time period. This procedure will be applied to all sample intervals for the vapor samples. The sum of the mass removals for each time period will be used to calculate the total contaminant removal (in pounds and kilograms) by the vapor stream during the Demonstration Test. The mass of each critical VOC extracted in the water during each time interval will be calculated in a similar fashion. (NOTE: time intervals for vapor and water sampling may vary, so mass removal for each physical phase must be calculated separately). The total mass removal of each critical VOC in the water phase will be calculated from the mass removal during each time period. The sum of the mass removed of each critical VOC in the vapor and water phases will be the total mass removed of each critical VOC during the Demonstration Test.

For the second primary objective, the percent transfer of each of the critical target VOCs from the surrounding groundwater to the vapor stream as the water is pulled up through the extraction tube to ground level will be determined by comparing the concentration of each critical target organic compound

in groundwater samples collected from one or more companion wells (screened at the same interval as, and in close proximity to, EW-233) to the concentration of the same critical target organics in outlet water exiting EW-233's knock-out tank at the same time. These companion wells are needed because collection of representative groundwater samples at the extraction well is not deemed possible during system operation since the groundwater at the extraction well bore hole is agitated by the applied vacuum.) Groundwater samples will be taken within EW-233, the two companion wells (CW-1 and CW-2) and the companion piezometer (PN-1) just prior to and following system operation to compare the measured concentrations of target organics with one another to substantiate that the weighted groundwater concentration in the selected companion wells and/or piezometer are representative of the inlet water pulled in by EW-233.

Since EW-233 cannot be sampled during the test, the problem is to predict influent concentration at the extraction well based on measurements taken at nearby companion wells. The proposed approach is to use a preliminary study to estimate the best statistical regression model that represents measured concentration at EW-233 as a linear function of the concentrations at two of the three companion wells, CW-1, CW-2, and PN-1. Then concentrations measured during the demonstration at the two selected wells can be plugged into the regression equation to generate predicted EW-233 concentrations, as well as their confidence intervals. The following steps will be taken to implement this analysis:

- Conduct a preliminary study in which concentrations at all three wells are measured at a set of five time points, $t=1, \dots, n$. The time span of 4 to 6 hours between samples should be long enough to ensure that a fairly wide range of groundwater concentrations occurs at the wells.
- Collect concentration measurements at each well for each time point, i.e., $CW1_t$, $CW2_t$, $PN1_t$, and $EW233_t$ for $t=1, \dots, n$.
- Use standard least-squares regression to estimate the parameters that produce the best fit (i.e., highest correlation between actual and predicted EW-233 concentration, measured by R^2) from among three possible regression equations: independent variables CW-1 and CW-2, CW-1 and PN-1, or CW-2 and PN-1. For example, suppose the model which uses CW-1 and CW-2 has the highest R^2 . The regression equation would then have the following form:

$$EW-233 \text{ (predicted)} = \beta_0 + \beta_1 CW1 + \beta_2 CW2$$

where the β parameters are estimated from the preliminary study data.

- During the demonstration, predict extraction well concentration for any time for which corresponding proxy measurements are available, by plugging the values of CW-1 and CW-2 into the above equation.

In addition, the water levels in CW-1, CW-2, and PN-1 will be measured under static conditions and

during each sampling event under dynamic conditions to plot a draw-down curve. These draw-down measurements will be used to support the decision to exclude one of these three wells from consideration.

Percent transfer from the water to the vapor streams will be calculated as follows:

$$\frac{\sum_{k=1}^n [(\hat{C}_{w_k} - C_{t_k}) / \hat{C}_{w_k}] \times 100}{n} = \text{Average Percent Transfer}$$

where $\hat{C}_{w_k}$ is the weighted concentration of each target organic in water in the selected companion wells and/or piezometer at each sample time, C_{t_k} is the corresponding concentration at the outlet from the knock-out tank, and n is the number of sampling events.

Secondary objectives of the Demonstration Test are to:

- Determine the total mass removal of total (non-critical and critical) target VOCs from EW-233 and the percent transfer of total VOC's from the surrounding groundwater to vapor as the water enters EW-233 and is pulled to ground level by the system vacuum, by the same means as described previously.
- Determine the combined total mass removal of all target VOCs by EW-234 (located approximately 230 feet southwest of EW-233) and EW-233 by measuring the total VOC concentration and flow rate in the gas phase for each of those two wells and adding the two values, and by measuring the total VOC concentration in and flow measured at the outlet water from each of the two knock-out tanks and adding those two values.
- Document the simultaneous extraction of groundwater and soil vapor from both 2-phase wells by recording the differences in the groundwater levels and soil vacuum levels in nearby groundwater and vapor piezometers, respectively, and by measuring the volume of water and vapor extracted from the two wells.
- Observe the zone of influence of the 2-phase extraction system at EW-233 by measuring groundwater and soil vacuum levels in surrounding wells and piezometers to estimate the extent of the cone of depression and determine if a greater volume of unsaturated soil (vertical and horizontal) is exposed to vapor recovery. Determination of the shape of the drawdown curve will also indicate whether the system prevents groundwater mounding, which is normally encountered during conventional soil vapor extraction.
- Measure the extraction rate of the groundwater by observing the flows per unit of time.
- Compare pre-test (baseline) groundwater and soil vapor concentrations to post-test concentrations in surrounding wells and vapor piezometers.
- Collect other full-scale operating cost and performance data as necessary.

Tables 3-1, 3-2, and 3-3 summarize project measurements to include critical and noncritical parameters for the groundwater and vapor samples. (As was shown in Tables 1-1 and 1-2, there is contamination in both soil gas and groundwater.) Based on pre-demonstration sampling and analysis, three volatile compounds have been identified as critical. These compounds are tetrachloroethene (PCE), trichloroethene (TCE), and trichlorotrifluoroethane (Freon 113) and have been determined to comprise the significant portion of the groundwater and outlet vapor sample concentrations. Additional process monitoring is to include extracted groundwater and vapor flow rates and temperatures and vacuum levels within the extraction tube and the annular space within the 2-phase extraction system. Critical process operation measurements include the water flow rate and the air flow rate exiting the knock-out tank. Table 3-4 summarizes the total number of vapor, groundwater, and associated QA samples for the 2-phase extraction test.

3.1.3 Experimental Design

This demonstration will focus on the EW-233 2-phase extraction well for two primary reasons. First, EW-233 is located very close to the suspected groundwater and vadose zone contamination source (Building 666). A groundwater plume map, generated by Radian (Figure 3-2), indicates that EW-233 is located less than 100 feet southwest of the 10,000 ppb isopleth for total volatile organic compounds. This is a significantly higher contaminant recovery potential when compared to EW-234, which lies just within the 1000 ppb isopleth. Secondly, EW-233 has a 19-foot long well screen whose upper portion is set in a 10-foot thick sand unit that appears to be continuous on either side, and whose lower portion taps a second 5-foot sand unit (refer to Figure 2-3). In contrast, EW-234 has a 12.5-foot well screen in which the upper portion only draws from approximately five feet of sand and whose lower portion is set entirely in silt (Figure 2-3). As a result, EW-233 will (and has) out-produced EW-234 by a considerable amount. Therefore, EW-233 will be used to determine the system capabilities and treatment effectiveness of the 2-phase extraction system. EW-234 will be used only to determine the total mass of contaminants removed (in conjunction with EW-233 mass removal rates). These data will be used by Radian to compare the effectiveness of this technology with a conventional pump and treat system previously used at the same two extraction wells.

TABLE 3-1. PROJECT MEASUREMENTS

Measurement	Location Code	Classification
ANALYTICAL		
Groundwater - Before and after test at EW-233 (compare to companion wells)	S1	C
Groundwater - Before, during, and after test at two companion wells and piezometer nest near EW-233 (inlet water) ^a Volatiles (8260) ^a	S2	C
Vapors at EW-233 Companion Piezometer (inlet vapor) Volatiles (TO-14) ^b	S3	C
Water exiting the EW-233 knock-out tank (outlet water) Volatiles (8260) ^a	S4	C
Vapors exiting the EW-233 knock-out tank (outlet vapor) Volatiles (TO-14) ^b	S5	C
Vapors at Nearby Piezometers (baseline and post-demo vapor) Volatiles (TO-14) ^b	S6	NC
Water exiting the EW-234 knock-out tank (outlet water) Volatiles (8260) ^a	S7	NC
Vapors exiting the EW-234 knock-out tank (outlet vapor) Volatiles (TO-14) ^b	S8	NC
FIELD		
Air flow rate exiting knock-out at EW-233	M1	C
Water flow rate exiting EW-233 knock-out tank	M2	C
Temperature of water	M3	NC
Temperature of vapor	M4	NC
Groundwater levels	M5	NC
System vacuum levels	M6	NC
Soil vacuum levels	M7	NC
Air Inlet (atmospheric makeup air) at EW-233	M8	NC
Water flow rate exiting EW-234 knock-out tank	M9	NC
Air flow rate exiting knock-out tank at EW-234	M10	NC

C Critical
NC Noncritical
a See Table 3-2
b See Table 3-3

TABLE 3-2. TARGET VOCs BY METHOD 8260, GROUNDWATER SAMPLES

Compounds	Target Reporting Limits ($\mu\text{g/L}$)	Classification
Acetone	50	NC
Benzene	5	NC
Bromochlorobenzene	5	NC
Bromodichloromethane	5	NC
Bromoform	5	NC
Bromomethane	10	NC
2-Butanone (MEK)	50	NC
n-Butylbenzene	5	NC
sec-Butylbenzene	5	NC
tert-Butylbenzene	5	NC
Carbon disulfide	5	NC
Carbon tetrachloride	5	NC
Chlorobenzene	5	NC
Chloroethane	10	NC
2-chloroethyl-vinylether	5	NC
Chloroform	5	NC
Chloromethane	10	NC
2-Chlorotoluene	5	NC
4-Chlorotoluene	5	NC
Dibromochloromethane	5	NC
1,2-Dibromo-3-chloropropene	5	NC
1,2-Dibromoethane	5	NC
Dibromomethane	5	NC
1,2-Dichlorobenzene	5	NC
1,3-Dichlorobenzene	5	NC
1,4-Dichlorobenzene	5	NC
Dichlorodifluoromethane (Freon 12)	5	NC
1,1-Dichloroethane	5	NC
1,2-Dichloroethane	5	NC
1,1-Dichloroethene	5	NC
cis-1,2-Dichloroethene	5	NC
trans-1,2-Dichloroethene	5	NC
1,2-Dichloropropane	5	NC
1,3-Dichloropropane	5	NC

TABLE 3-2. TARGET VOCs BY METHOD 8260, GROUNDWATER SAMPLES (Continued)

Compounds	Target Reporting Limits ($\mu\text{g/L}$)	Classification
2,2-Dichloropropane	5	NC
1,1-Dichloropropene	5	NC
cis-1,3-Dichloropropane	5	NC
trans-1,3-Dichloropropene	5	NC
Ethylbenzene	5	NC
2-Hexanone	50	NC
Hexachlorobutadiene	5	NC
Isopropylbenzene	5	NC
4-Isopropyltoluene	5	NC
Methylene chloride	5	NC
4-Methyl-2-pentanone (MIBK)	50	NC
Styrene	5	NC
1,1,2,2-Tetrachloroethane	5	NC
Tetrachloroethene (PCE)	5	C ^a
Toluene	5	NC
1,2,3-Trichlorobenzene	5	NC
1,2,4-Trichlorobenzene	5	NC
1,1,1-Trichloroethane	5	NC
1,1,2-Trichloroethane	5	NC
Trichloroethene (TCE)	5	C ^a
Trichlorofluoromethane (Freon 11)	5	NC
1,2,3-Trichloropropane	5	NC
Trichlorotrifluoroethane (Freon 113)	5	C ^a
1,2,4-Trimethylbenzene	5	NC
1,3,4-Trimethylbenzene	5	NC
Vinyl acetate	10	NC
Vinyl chloride	10	NC
Xylenes	10	NC

^a At EW-233 only.

TABLE 3-3. TARGET VOCs BY METHOD TO-14, SOIL GASES

Compounds	Target Reporting Limits, (ppbv)	Classification
Acetone	20	NC
Benzene	10	NC
Bromodichloromethane	10	NC
Bromoform	10	NC
Bromomethane	10	NC
1,3-Butadiene	10	NC
2-Butanone (MEK)	20	NC
Carbon disulfide	20	NC
Carbon tetrachloride	10	NC
Chlorobenzene	10	NC
Chloroethane	10	NC
2-Chloroethyl vinyl ether	10	NC
Chloroform	10	NC
Chloromethane	10	NC
Dibromochloromethane	10	NC
1,2-Dibromoethane	10	NC
1,2-Dichlorobenzene	10	NC
1,3-Dichlorobenzene	10	NC
1,4-Dichlorobenzene	10	NC
1,1-Dichloroethane	10	NC
1,2-Dichloroethane	10	NC
1,1-Dichloroethene	10	NC
cis-1,2-Dichloroethene	10	NC
trans-1,2-Dichloroethene	10	NC
Dichloromethane	20	NC
1,2-Dichloropropane	10	NC
cis-1,3-Dichloropropane	10	NC
trans-1,3-Dichloropropane	10	NC
Ethylbenzene	10	NC
2-Hexanone	10	NC
4-Methyl-2-pentanone (MIBK)	20	NC
Styrene	10	NC
1,1,2,2-Tetrachloroethane	10	NC
Tetrachloroethene (PCE)	10	C*
Toluene	10	NC

TABLE 3-3. TARGET VOCs BY METHOD TO-14, SOIL GASES (continued)

Compounds	Target Reporting Limits, (ppbv)	Classification
1,1,1-Trichloroethane	10	NC
1,1,2-Trichloroethane	10	NC
Trichloroethene (TCE)	10	C ^a
Trichlorofluoromethane (Freon 11)	10	NC
Trichlorotrifluoroethane (Freon 113)	10	C ^a
Vinyl acetate	10	NC
Vinyl chloride	20	NC
Xylenes, total	20	NC

a At EW-233 outlet only.

**TABLE 3-4. SUMMARY OF NUMBER OF SAMPLES REQUIRED
FOR THE 2-PHASE EXTRACTION DEMONSTRATION**

Measurement	No. of Samples*	Field Duplicates	Laboratory Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Trip Blanks	Equip. Blanks ^b	Total
PRE-DEMONSTRATION PHASE									
<u>Baseline Groundwater at EW-233 Site (EW-233, CW-1, CW-2, PN-1) Under Static Conditions</u> (4 wells, 1 sample each)									
Volatiles (8260)	4	1	0	1	1	0	— ^a	0	8
<u>Baseline Groundwater at EW-233 Site (EW-233, CW-1, CW-2, PN-1) Under Pumping Conditions</u> (4 wells, 5 samples each)									
Volatiles (8260)	20	2	0	1	1	0	— ^a	0	24
<u>Baseline Soil Vapor at EW-233 Companion Piezometer Nest (PN-1)</u> (1 sample each at 3 piezometers above static water table)									
Volatiles (TO-14)	3	1	1	NA ^c	NA	0	NA	0	5
<u>Baseline Soil Vapor at Five Piezometer Nests around EW-233 (PN-2, PN-3, VPN-7, VPN-8, VPN-9)</u> (2 piezometer nests - 1 sample each at 5 piezometers in each; 3 piezometer nests - 6 piezometers each/1 sample each)									
Volatiles (TO-14)	28	2	2	NA ^c	NA	0	NA	0	32
<u>2-Phase Extraction System Water Blank at EW-233 site</u>									
Volatiles (8260)	1	0	0	0	0	NA	NA	0	1
<u>2-Phase Extraction System Vapor Blank at EW-233 site</u>									
Volatiles (TO-14)	1	0	0	0	0	NA	— ^a	0	1
DEMONSTRATION PHASE									
<u>Inlet Vapors at EW-233 site (PN-1)</u> (from companion piezometer)									
Volatiles (TO-14), EW-233	38	2	2	NA ^c	NA	NA	NA	NA	42

**TABLE 3-4. SUMMARY OF NUMBER OF SAMPLES REQUIRED
FOR THE 2-PHASE EXTRACTION DEMONSTRATION (continued)**

Measurement	No. of Samples ^a	Field Duplicates	Laboratory Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Trip Blanks	Equip. Blanks ^b	Total
Outlet Vapors at EW-233 and EW-234 sites (2 knock-out tanks)									
Volatiles (TO-14)									
EW-233	38	4	4	NA ^c	NA	NA	NA	3 ^d	49
EW-234	16	1	1	NA ^c	NA	NA	NA	NA	18
Inlet Groundwater at EW-233 site (CW-1, CW-2, and/or PN-1) (2 companion wells) ^{**}									
Volatiles (8260)	76	8	NA	4	4	2	— ^a	2	96
Outlet Water exiting at EW-233 and EW-234 sites (2 knock-out tanks)									
Volatiles (8260)									
EW-233	38	4	NA	2	2	2	— ^a	NA	48
EW-234	16	1	NA	1	1	NA	— ^a	NA	19
POST-DEMONSTRATION PHASE									
Groundwater at EW-233 site (EW-233, CW-1, CW-2, PN-1) (4 wells, 1 sample each)									
Volatiles (8260)	4	2	0	1	1	1	— ^a	1	10
Soil Vapor at EW-233 Companion Piezometer Nest (3 samples at the companion piezometer)									
Volatiles (TO-14)	3	1	1	NA ^c	NA	0	NA	0	5
Soil Vapor at Piezometer Nests around EW-233 (2 piezometer nests - 1 sample each at 5 piezometers in each; 3 piezometer nests - 6 piezometers each/1 sample each)									
Volatiles (TO-14)	28	2	2	NA ^c	NA	0	NA	0	33

a A trip blank will accompany each cooler containing samples for volatiles analysis (approximately 24).

b Equipment blanks for water and vapor samples are discussed in Section 3.4.4.

c Laboratory control samples will be analyzed with each analytical batch.

d One sampling equipment blank will be collected prior to the demonstration, after the second week of sampling, and at the end of the demonstration.

* Assumes a six-month demonstration.

** Assumes 2 sampling points for inlet groundwater - any combination of 1 or 2 sample points among CW-1, CW-2, and PN-1 may be used depending on pre-demonstration sampling under pumping conditions.

NA Not Applicable

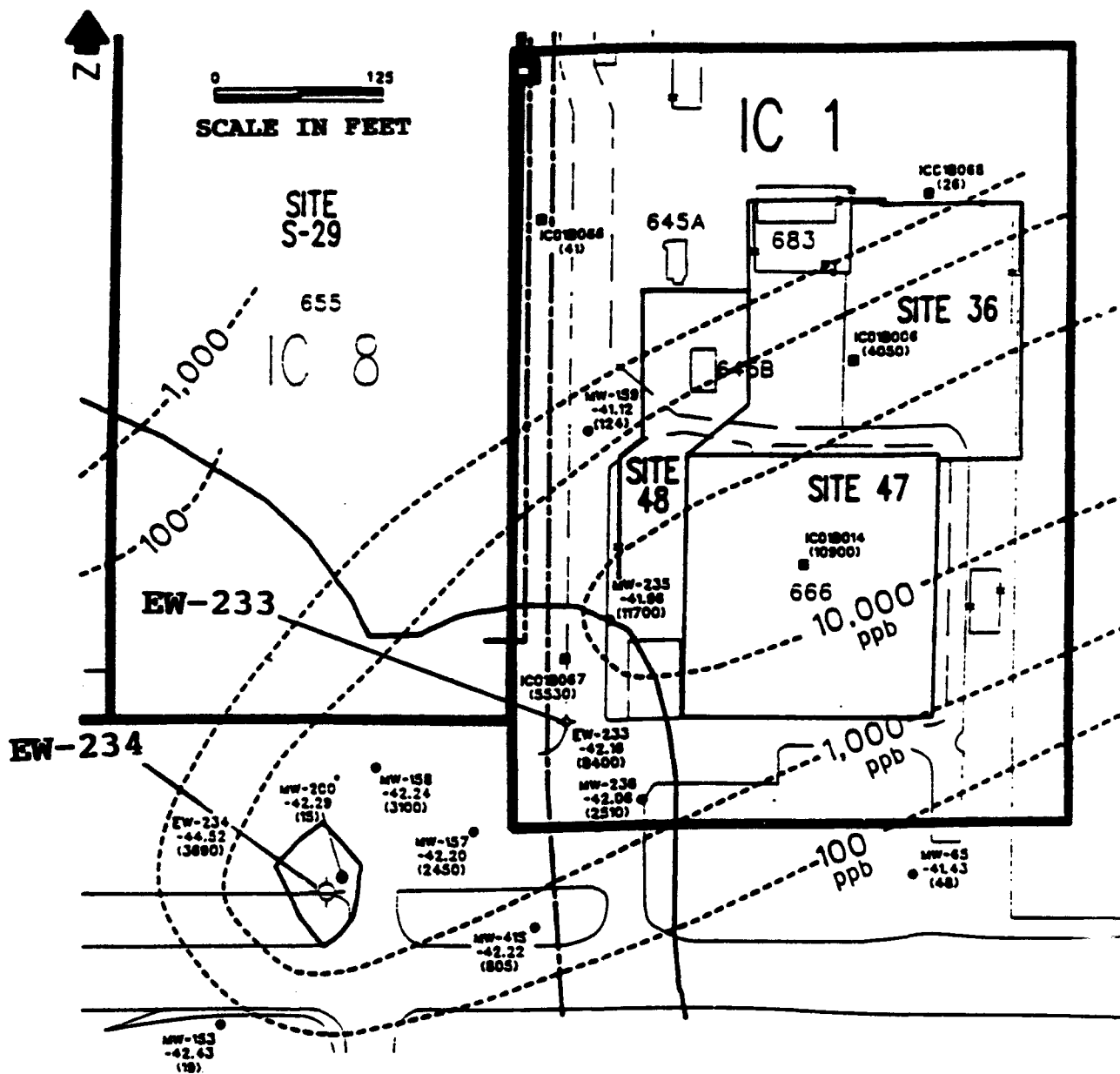


Figure 3-2. Isopleths of Total VOC Concentrations and Water Levels in Groundwater at the Demonstration Test Area.

The overall demonstration will consist of three distinct experimental phases: (1) pre-demonstration testing, (2) demonstration testing, and (3) post-demonstration testing. During the pre-demonstration phase static groundwater levels, static soil vacuum levels, and baseline groundwater and soil vapor concentrations in the surrounding area will be documented before system startup. Additionally, a comparison will be made between the concentration of critical VOCs in EW-233 and the concentrations of the same VOCs in the two companion wells (CW-1 and CW-2) and the adjacent piezometer nest (PN1). Sample concentrations will be compared by using a regression analysis to determine which combination of any one or two of the adjacent wells or the water piezometer is the best fit to the concentrations in EW-233. This comparison is being made to show that the system inlet concentration, which cannot be measured at EW-233 during 2-phase extraction system operation, can instead be determined from some combination of the selected companion wells and/or piezometer. To determine the bias and precision of the concentration values of the companion wells, SITE will also use the preliminary baseline sampling (static conditions) and analysis and five separate sampling events (dynamic conditions) to determine goodness of fit of the concentrations of contaminants in one or two companion wells (or piezometer) as compared to inlet groundwater at EW-233's location. The static results are expected to show that the concentrations do not vary significantly over short distances. Under pumping conditions, however, CW-1 is expected to have elevated values due to its being closer to the contaminant plume source, and CW-2 is expected to have lower values because contaminant diluted water will be passing through it from the downgradient from the plume source. The concentration at PN-1 is expected to be similar to that in EW-233 during pumping.

During the demonstration phase measurements will be made to determine 2-phase extraction system effectiveness in removing VOC-laden gas and groundwater from the treatment zone and transferring VOCs from extracted water to extracted vapor. Measurements also will be made to estimate the area of influence of the system in both the groundwater and vadose zones. Finally, during the post-demonstration phase, groundwater and soil vapor concentrations will be measured in the surrounding area after system shutdown to determine if the 2-phase extraction system was effective in reducing baseline concentrations. The following subsections describe each of these phases.

To accomplish the project objectives, two adjacent monitoring wells (CW-1 and CW-2) referred to as "companion wells", and one adjacent soil vapor piezometer nest, referred to as the "companion piezometer nest," containing a water well (PN-1) have been installed at the EW-233 site. Figure 3-3 shows their locations in plan view, as well as two additional combination water well/vapor piezometer nests (PN-2 and PN-3) that have been installed to sample pre-test and post-test soil vapor, and to monitor the drawdown curve and vacuum influence of the system. Figure 3-4 is a cross-section showing the placement and screened interval rationale for these additional wells and piezometer nests.

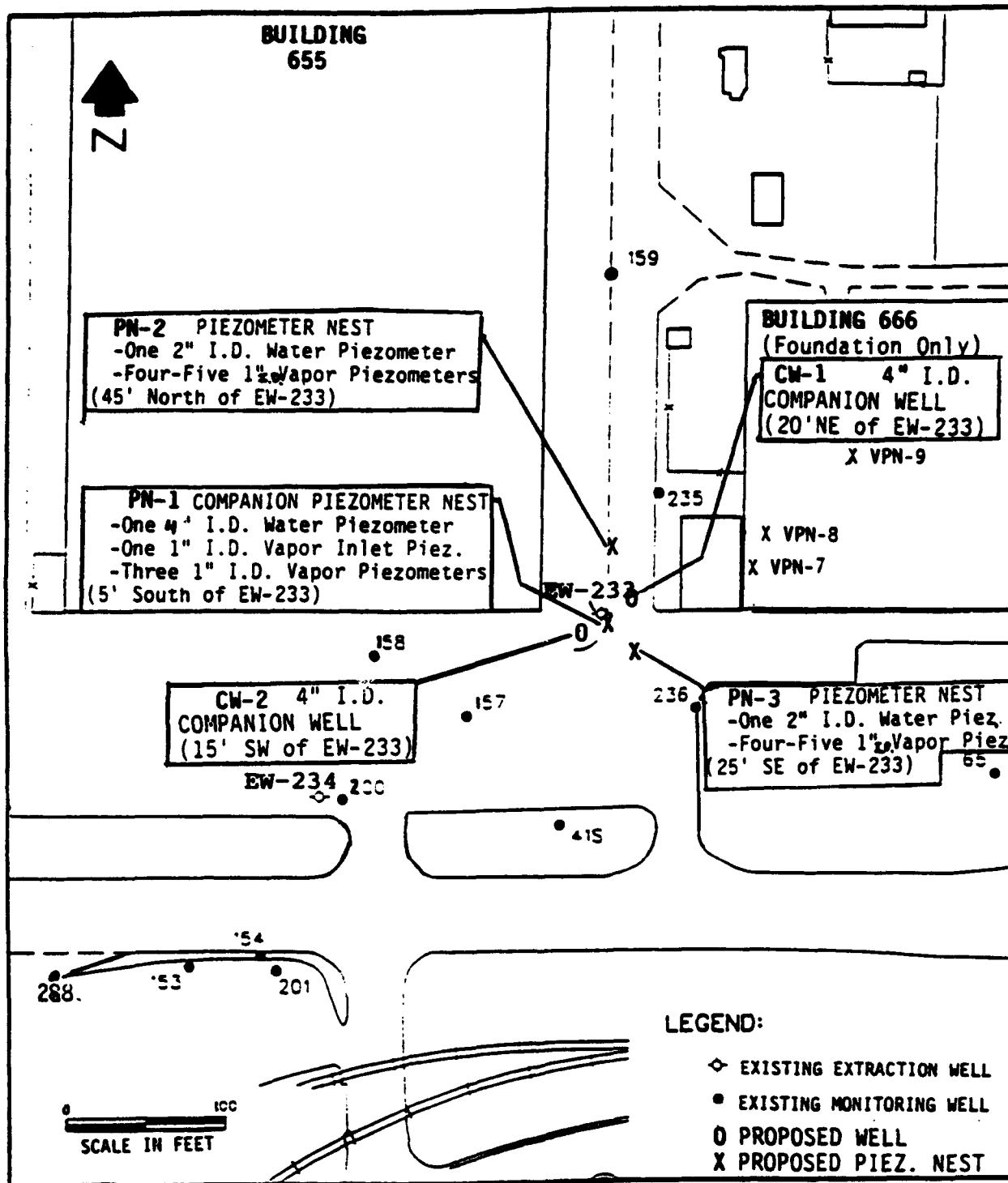


Figure 3-3. Plan View of Test Site Showing Location of Existing Wells and Additional Wells and Piezometers Installed for the Demonstration.

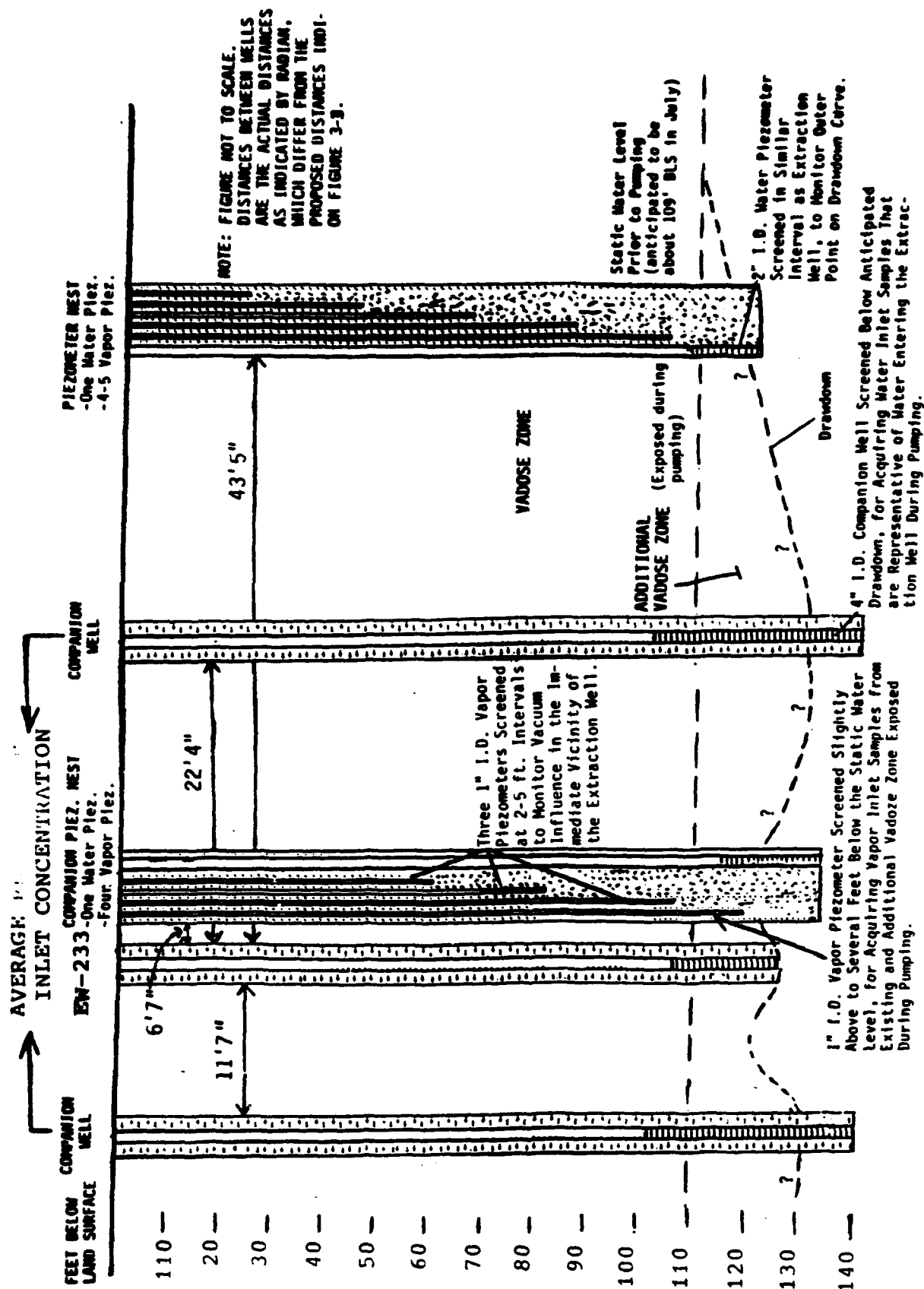


Figure 3-4. Cross-Section Showing Well Placement/Screened Intervals Rationale.

3.1.3.1 Pre-Demonstration Phase

Static groundwater levels will be measured before 2-phase extraction system startup to provide a baseline against which to measure groundwater drawdown during system operation. There are existing monitoring wells at the test site area as shown in Figure 3-3. However, monitoring of water levels in these wells during testing of the pilot-scale system during late February and early March 1994 showed no discernable drawdown influence. Therefore, the additional wells were installed closer to EW-233 to determine drawdown influence. Included are a water piezometer installed in the piezometer nest located immediately adjacent to the extraction well (PN-1) and water piezometers in each of two piezometer nests (PN-2 and PN-3) installed away from the EW-233 in order to monitor an outer point of the drawdown curve (Figure 3-3).

The additional water piezometers installed are intended to provide measurements to delineate the drawdown affects of the EW-233 2-phase system. The background information presented by Xerox Corporation visually displays a peculiar drawdown curve that is produced by its 2-phase extraction system, in which there is an upwell in the immediate vicinity of the extraction well, then an outward depression which potentially dips to a level below the extraction well (Figure 3-4). Radian has indicated that this type of drawdown curve has been observed in a physical 2-dimensional model demonstrated by Xerox. However, the model consisted of a homogeneous sand media and the drawdown effects on a large scale are not known, nor how a heterogeneous subsurface (which exists at McClellan AFB) affects the curve. Delineation of both the shape and the extent of water table drawdown are important to this demonstration because they will determine the radial influence of the system and the volume of additional vadose zone exposed for vapor treatment.

Static soil vacuum levels will be measured before 2-phase extraction system startup to provide a baseline against which to measure soil vacuum levels during operation. These data will be used to determine the zone of influence of the 2-phase extraction system within the vadose zone.

Just before the demonstration begins, baseline groundwater samples will be collected from surrounding monitor wells (157, 158, 41-S, 236, and 159) by Radian as part of routine quarterly monitoring. The results of these sample analyses will be compared to final groundwater concentrations after six months of operation to determine contaminant reduction in the groundwater.

Groundwater samples will be taken at EW-233 prior to inserting the extraction tube into EW-233 (static conditions); groundwater samples also will be collected from CW-1, CW-2, and PN-1 as close to the same time as possible. These sample points are labeled S1 and S2, respectively (see Figure 3-7 in Section

3.4). The companion wells are necessary due to the agitation caused by the vacuum exerted on the extraction well, which prevents collection of representative groundwater samples directly from EW-233. The purpose for installing the two companion wells is to account for higher levels of contaminants pulled in from upgradient of EW-233 (towards the plume source) and lower levels of contamination pulled in from downgradient of EW-233 (away from the plume source). PN-1 was installed to provide concentration data lateral to EW-233. A regression analysis will be used to determine which of these three wells or which combination of two of these wells best approximates the concentration in EW-233 under dynamic conditions. Dynamic conditions during the demonstration will be simulated by pumping EW-233 for 2 days and then purging (three well volumes) and sampling CW-1, CW-2, and PN-1 while EW-233 continues to operate. Then EW-233 will be turned off and sampled (no purging required). EW-233 will be turned on for 4 to 6 hours. Sampling of CW-1, CW-2, PN-1, and EW-233 will be as just described. The operation of EW-233 for 4 to 6 hours followed by sampling of CW-1, CW-2, PN-1, and EW-233 will be repeated three more times (a total of 5 sets of samples). Regression analysis will be applied to the data from these wells to determine the best fit to EW-233. The 1 or 2 wells which best match EW-233 will be used for inlet water sampling.

For sampling groundwater before system operation, a minimum of three well volumes will be evacuated from the well casings via a submersible pump operated by Radian. A teflon sampling tube (bailer) will be inserted into the wells and lowered into the water table. A sample will then be collected in the bailer. When field duplicate samples are taken, the bailer will be lowered a second time into the well to acquire that duplicate. The water samples will be placed in pre-cleaned glass containers for analysis.

To determine contaminant reduction in the soil (vadose zone), baseline soil vapor samples will be collected in three existing vapor piezometer nests (VPN-7, VPN-8, and VPN-9). Samples will be collected at each of six piezometers in each nest. Vapor samples also will be collected from three of the screened intervals in the companion piezometer nest (PN-1) at sample point S6 and from the two other newly-installed piezometer nests (PN-2 and PN-3). As with groundwater, representative inlet soil vapor samples cannot be collected from EW-233. This is because a water well (whether standing or agitated) will have some transfer of volatile contaminants to the vapor phase. To acquire better inlet vapor samples representative of contaminant concentrations in the vadose zone, the inlet vapor samples should be pulled from the actual vadose formation, thus the need for the Companion Piezometer Nest and the two peripheral vapor piezometer nests. Since the 2-phase extraction well is claimed to expose additional vadose zone via depression of groundwater in the vicinity of the well, the screen for the inlet vapor sample collection point at the companion piezometer will be at least partially screened beneath the static water level so that vapor is acquired from this additional exposed volume of vadose zone.

For vapor sampling, a vacuum pump will be run for short period (approximately 5 minutes) to purge vapors from within each piezometer tube, and a vapor sample will be extracted. The sample will be collected through a standard needle valve in a SUMMA canister connected to the tube with a 1/4 inch Swagelock tube fitting. All vapor samples will be collected following groundwater sampling.

3.1.3.2 Demonstration Phase

After system installation, the 2-phase extraction system will be operated to check for leaks and to ensure the system is operating 2-phase extraction properly. System water and air blanks will be taken at S4 and S5 before the system is started for the demonstration. Once it is operating properly, the system will operate continuously for two to six months. The 2-phase extraction demonstration will end at a yet-to-be-determined point within the two to six month window when steady-state conditions are achieved. Various process variables (water and vapor flow rates and temperatures, and system vacuum levels) will be monitored. Water and vapor samples will also be collected for analysis periodically throughout the demonstration. Process monitoring and sample points are shown on Figure 3-2. Table 3-5 shows the samples frequency of primary (non-QC) samples collected during activation of the 2-phase extraction system. For the first four days of the demonstration, samples will be collected twice daily (8 samples for each 2-phase extraction system setup); once each within the first and last hours of normal 8 hour shift. For the remaining three days of the first week, samples will be taken once daily. During the second week sample frequency will drop to once every other day (4 samples per week for each 2-phase extraction system setup) and for the third week the frequency will be twice per week. From week 4 through the end of the demonstration, samples will be taken once per week.

TABLE 3-5. FREQUENCY OF PRIMARY WATER AND VAPOR SAMPLES TAKEN DURING TEST

MONTH 1				MONTH 2 ^d	MONTH 3 ^d	MONTH 4 ^d	MONTH 5 ^d	MONTH 6 ^d	TOTAL
Week 1 ^a	Week 2 ^b	Week 3 ^c	Week 4 ^d						
11	4	2	1	4	4	4	4	4	38

- a Two samples per day for first 4 days, then one sample per day last three days.
- b One sample every other day (assume 4).
- c Two samples per week.
- d One sample per week.

To determine the effectiveness of the 2-phase extraction system at EW-233, both the treatment capabilities of the system and its dynamic affects on the water table will be investigated. The treatment capabilities of the system consist of two components: the ability of the system to remove contaminants from

the soil and groundwater (mass removal) and the ability of the system to transfer contaminants from extracted groundwater to extracted vapor. To determine contaminant removal in both groundwater and soil vapor (vadose zone) resulting from 2-phase extraction and treatment, representative outlet water and vapor concentrations are necessary. Outlet water samples will be taken at sample point 4 (S4) on Figure 3-7, as the water is pumped out of the knock-out tank. Outlet vapor samples will be taken at sample point 5 (S5) on Figure 3-7, as the vapors exit the knock-out tank upstream of the vacuum pump. The water and vapor concentrations will be used along with the respective water and vapor flow rates to calculate mass removal.

To determine contaminant transfer from extracted groundwater to extracted soil vapor resulting from 2-phase extraction and treatment, representative inlet water and inlet vapor concentrations are necessary to compare with respective outlet values. One or two of the adjacent monitoring wells ("companion wells") and/or the companion piezometer will provide inlet concentrations; the adjacent soil vapor piezometer nest ("companion piezometer nest") will be used to measure inlet soil vapors.

3.1.3.3 Post-Demonstration Phase

At the end of the demonstration phase, when steady-state conditions are achieved, EPA-SITE will return for final sampling of soil vapor and groundwater in surrounding wells. Groundwater and soil vapor sampling, after system operation, will be identical to that during the pre-demonstration. Table 3-4 summarizes the total number of samples (and measurements) that are planned (QC analyses are included).

3.1.4 Schedule

Table 3-6 covers all technology demonstration activities from the planning phase to the completion of the test demonstration. Some pre-demonstration activities have already taken place (March, 1994) and the actual field demonstration is expected to begin July, 1994. The demonstration is expected to be completed January, 1995. All technical reports are scheduled for completion in late 1995.

*

TABLE 3-6. SCHEDULE FOR THE 2-PHASE EXTRACTION SITE DEMONSTRATION

Activities	Completion Dates/Proposed Timeframes
SITE Kick-off Meeting	January 25, 1994 (Completed)
Review Preliminary Draft Demonstration Plan (EPA)	February 14, 1994 (Completed)
Pre-Demonstration Characterization Sampling	February 28 - March 2, 1994 (Completed)
EPA and Partnership Review of Preliminary Draft Demonstration Plan	March 1, 1994
EPA-SITE Incorporates Partnership Comments and presents a revised Preliminary Draft Demonstration Plan to Radian	April 1 - May 1, 1994
Radian Develops Integrated Draft Demonstration Plan Work Plan	March 1 - April 15, 1994
Partnership Review and Comment to McClellan AFB	May 18 - June 17, 1994
Radian and EPA-SITE revise Workplan/Demonstration Plan	June 20 - July 4, 1994
Partnership Final Review	July 5-15, 1994
Mobilize/Install System	July 5-22, 1994
Initial Sampling	July 14-July 29, 1994 (Just prior System Start up)
System Operation	August 1, 1994 - Approximately February 1, 1995
Final Sampling	Approximately February 1, 1995
All Analytical Data Received	To be determined
EPA-SITE Reviews Data	To be determined
EPA-SITE prepares Draft ITER and TER	To be determined
Draft ITER distributed to Partnership for review and comment	To be determined
Partnership review and comments to EPA-SITE	To be determined
EPA-SITE revises Draft ITER and TER	To be determined
Partnership Final Review of Draft ITER	To be determined
Final Engineering Capsule	To be determined
Finalize Video	To be determined
Final ITER and TER	To be determined

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3.2 PROJECT ORGANIZATION

In implementing the plan for the 2-Phase Extraction System Demonstration, the parties involved have different responsibilities. This demonstration is being performed for McClellan AFB, in cooperation with the Public-Private Partnership of which McClellan AFB is a member. Clean Sites, a non-profit 501(c)(3) organization, and also a member of the Public-Private Partnership, will facilitate the Partnership in dialogues with demonstration participants and in providing technical review of SITE documentation. Demonstration responsibilities are divided between EPA, SAIC (the SITE contractor), McClellan AFB, and Radian (the technology licensee and USAF contractor). McClellan AFB will provide the site, site support, and will contract with Radian for system installation and evaluation. Radian will install and operate the technology and provide project management. EPA will provide funding for and technical management of all SITE activities. EPA will provide QA support (QAPP reviews and lab/field audits). EPA has contracted with SAIC to perform sampling, analysis, technology evaluation, and documentation of the most important activities. SAIC will subcontract the services of ERMI to oversee sampling of the vapor phase during the first week and Coast-to-Coast Analytical Services, Inc. to provide sample analysis support. Overall project and quality assurance organizational charts of all the involved parties are presented in Figures 3-5 and 3-6, respectively. The quality assurance and quality control functions have been organized to allow independent review of project activities, while providing on-site QC coordination with the person most knowledgeable of the sampling/analysis activities.

The EPA has overall responsibility for this demonstration. Ms. Laurel Staley is the EPA Work Assignment Manager (WAM). She has overall responsibility for data quality, data compilation, and preparation of the final SITE demonstration reports. Ms. Ann Litzinger is the EPA QA Officer and is responsible for reviewing and approving this QAPP.

The SAIC QA Manager, Mr. Joseph Evans, is responsible for the overall SAIC SITE QA activities. Mr. Evans will review the QA Project Plan, evaluate the QC programs for SAIC and will assure that the results of all QA/QC activities are properly documented. Mr. Jim Rawe, the SAIC Work Assignment Manager, has the responsibility for the overall SAIC technical effort, including data gathering/compilation and preparation of the final report. This includes the timely, cost-effective execution of all project activities. Mr. Howard Feller, the SAIC SITE Program Manager, has the ultimate responsibility for completing this program in accordance with the program objectives and within schedule and budget constraints. Mr. Art Shattuck is the SAIC SITE Deputy Program Manager.

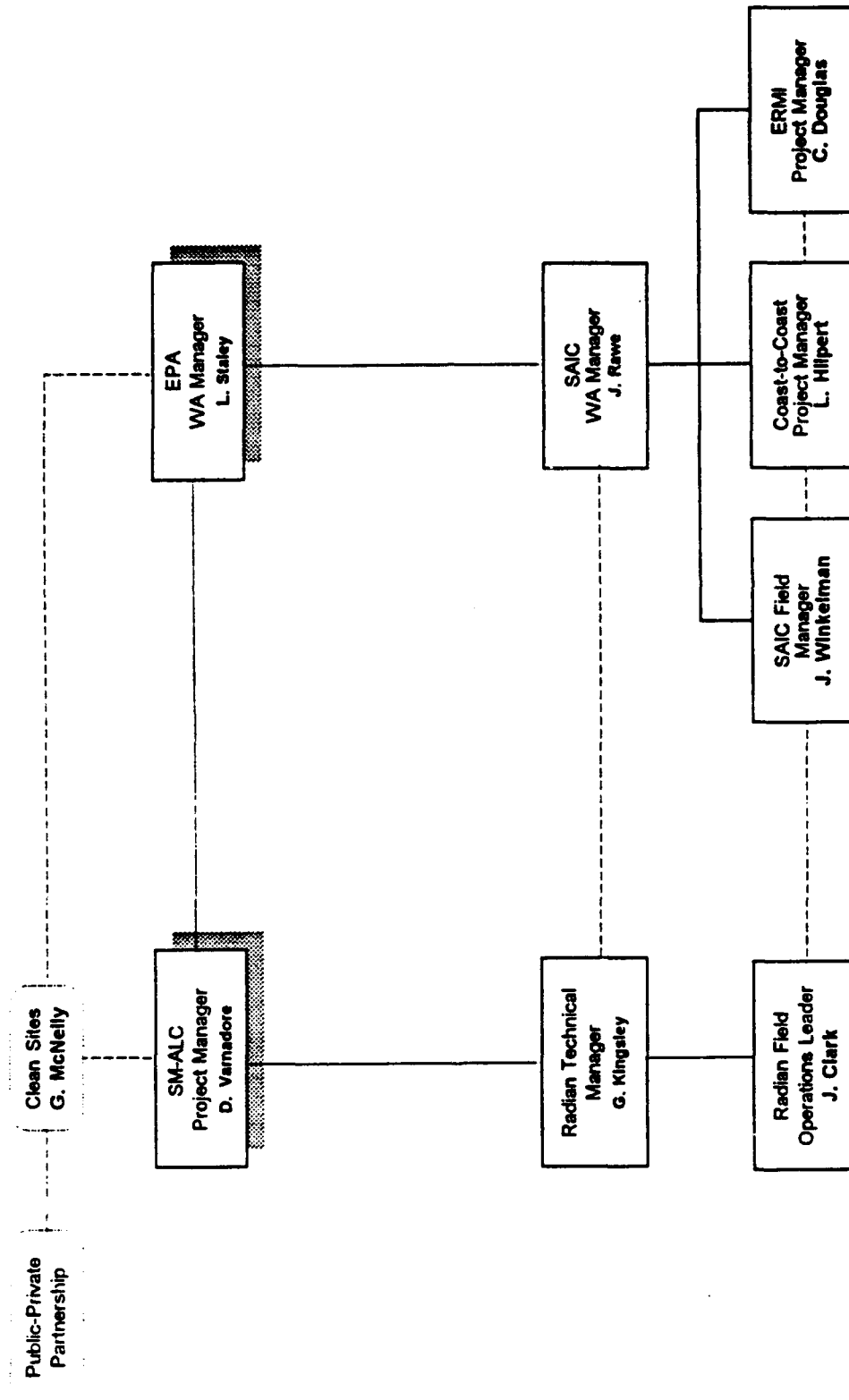


Figure 3-5. Overall Project Organization for the 2-Phase Extraction Technology Demonstration.

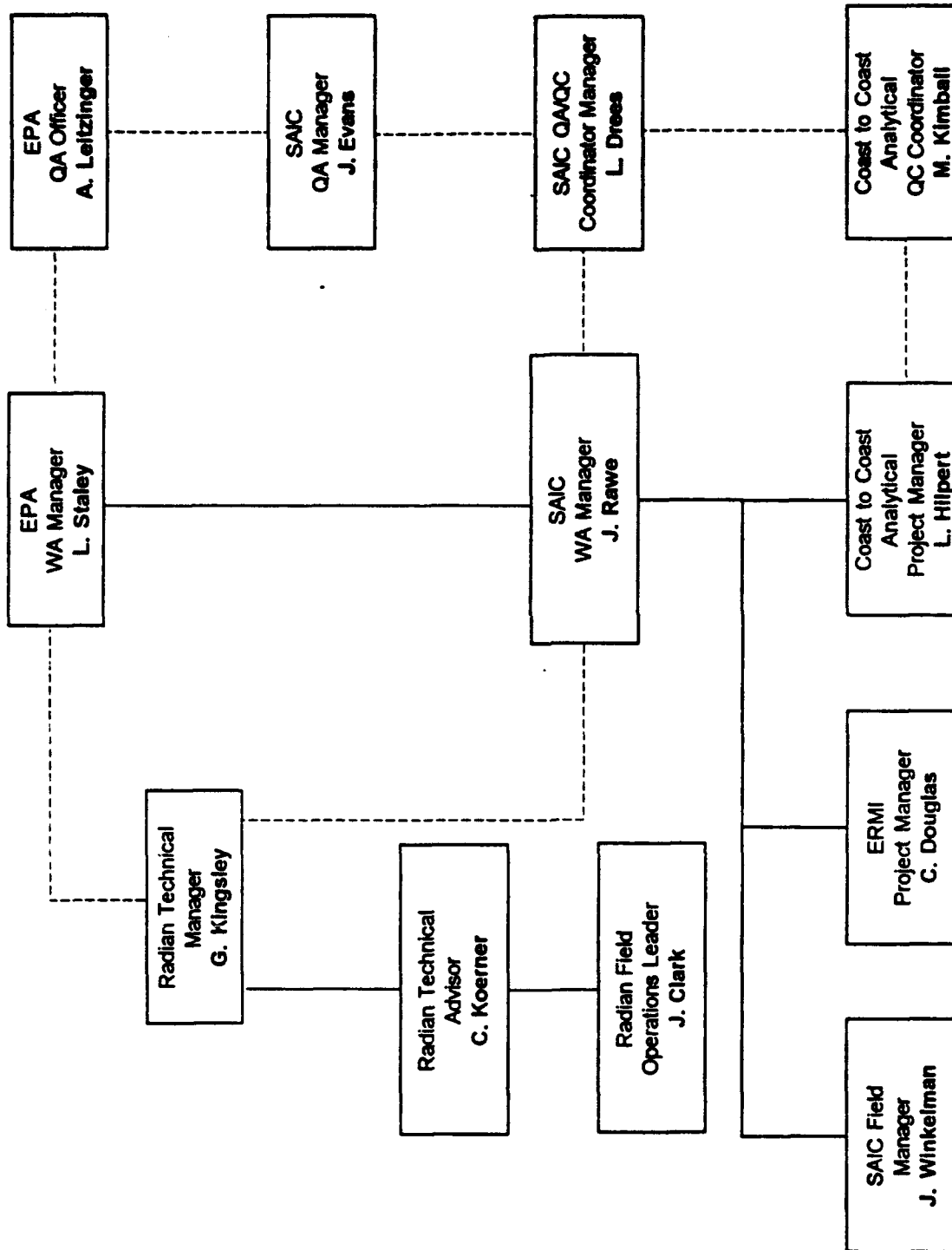


Figure 3-6. Overall Project and Quality Assurance Organization for the 2-Phase Extraction Technology Demonstration.

The SAIC Project QA/QC Coordinator, Ms. Lauren Drees, will be responsible for coordinating field and laboratory QA activities including sample tracking, and reviewing laboratory analytical data. Ms. Drees will write monthly memos to Mr. Evans to report nonconformance of field and/or laboratory activities with reference to the QA/QC protocols set forth in this QAPP and to summarize ongoing field and laboratory QA activities.

As SAIC's field manager, Ms. Jamie Winkelman, will be responsible for implementing the project-specific field quality control activities. She will oversee sampling for EPA-SITE, schedule SAIC's on-site QC activities, document that on-site sampling/analysis protocols (specified in this QAPP) are followed, and coordinate record keeping and data review and validation for SAIC. *

Mr. Gordon Kingsley is the project manager for Radian. Radian is responsible for installing and operating the 2-phase extraction system, and for coordinating and conducting quarterly groundwater sampling monitoring wells in the test area with the start and finish of the demonstration. Radian will also assist in sample preparation activities for all sampling activities and will perform all sampling activities beginning the third week of the demonstration and continuing until system shutdown. Mr. Chris Koerner is Radian's Technical Advisor for the project and Mr. John Clark is the field operations leader. Radian will assure that the system is properly constructed, the shakedown is complete, and the system is completely operational. SAIC will not be onsite during most of the above-ground installation activities, and Radian will inform the EPA and SAIC WAMs immediately of problems that may affect the demonstration. Demonstration sampling will be take place in conjunction with SAIC efforts. Radian will be responsible for the safe and proper operation of their system during the tests and will inform the EPA and SAIC WAMs immediately when the system is not operating correctly.

Coast-to-Coast Analytical Services (CCAS), SAIC's analytical subcontractor, will perform all measurements for critical parameters. Dr. Larry Hilpert, the CCAS Project Manager, will be responsible for the overall technical effort of the analytical laboratory. These responsibilities include the timely, cost-effective execution of all analytical activities in accordance with this QAPP. Dr. Hilpert will make weekly phone calls to Mr. Rawe, the SAIC Project Manager, with updates on the progress of the project.

As the CCAS QA Coordinator, Ms. Margaret Kimball will be responsible for the offsite analytical effort, which includes obtaining valid analytical data for all project samples and adhering to quality control protocols specified in the QAPP and the referenced analytical methods involved in this project. She will also be responsible for reviewing this QAPP, evaluating the internal QC program, and documenting the results of all QA/QC activities. Ms. Kimball along with the CCAS Project Manager, Dr. Hilpert, will review analytical

data to ensure that chain-of-custody procedures were followed and that analytical data meet the project's QA objectives and communication with the SAIC's Project QA/QC Coordinator. If any problems are encountered which have direct impact on this project, Ms. Kimball will fill out malfunction and corrective action reports and forward them to Dr. Hilpert who will forward them to Mr. Rawe and to Ms. Drees. Conferences and discussions will be held via telephone if immediate actions are required, and will also include Mr. Evans, as necessary.

The phone numbers of key project personnel are listed below:

Name	Organization	Location	Title	Phone Number
Laurel Staley	EPA	Cincinnati, OH	WA Manager	(513) 569-7863
Jim Rawe	SAIC	Cincinnati, OH	WA Manager	(513) 723-2600
Lauren Drees	SAIC	Cincinnati, OH	QA/QC Coordinator	(513) 723-2600
Joe Evans	SAIC	Idaho Falls, ID	QA Manager	(208) 552-7803
Jamie Winkelman	SAIC	San Diego, CA	Field Manager	(619) 546-6822
Gordon Kingsley	Radian	Sacramento, CA	Project Manager	(916) 362-5332
Chris Koerner	Radian	Sacramento, CA	Technical Advisor	(916) 362-5332
John Clark	Radian	Sacramento, CA	Field Manager	(916) 362-5332
Doris Varnadore	USAF McClellan AFB	Sacramento, CA	Project Manager	(916) 643-0830 ext. 373
Larry Hilpert	Coast-to-Coast Analytical	Camarillo, CA	Project Manager	(805) 389-1353
Margaret Kimball	Coast-to-Coast Analytical	Camarillo, CA	QA Coordinator	(805) 389-1353
Craig Douglas	ERMI	San Diego, CA	Project Manager	(619) 737-3125
Ann Leitzinger	EPA	Cincinnati, OH	QA Officer	(513) 569-7635

3.3 QUALITY ASSURANCE OBJECTIVES

The data quality objectives established for the demonstration of the 2-phase extraction technology are based on project requirements and are designed to ensure that the data generated during the demonstration are of known and acceptable quality to achieve the project's technical objectives. This section of the QAPP delineates the QA objectives for each of the critical measurements in terms of the data quality indicators: precision, accuracy, completeness, method detection limits, representativeness and comparability. In Section 3.7 of this document, a summary of all internal QC checks associated with each method will be presented. Objectives are outlined below, and summarized in Table 3-7, as they apply to overall project analyses for critical parameters. In addition, the calculation of data quality indicators is discussed in Section 3.9.

3.3.1 Data Quality Indicators

Precision: Precision objectives for critical project measurements are given in Table 3-7 as the relative percent difference (RPD) between laboratory duplicates or the RPD between matrix spike/matrix spike duplicate analyses.

Laboratory duplicates will be analyzed to evaluate precision for the critical TO-14 analyses. Matrix spikes and matrix spike duplicates will be analyzed on aqueous samples to evaluate precision for the critical VOC analyses by Method 8260.

Precision objectives for field sampling activities are more difficult to define quantitatively. Analyses of duplicate samples collected in the field (field duplicates) have inherent in the measurement combined variation due to field precision and analytical precision. If, overall, the analysis performed for field duplicates meets the analytical precision objectives, then the sample collection activities are considered representative and precise. Guidelines for evaluating the precision of field duplicates will be the analytical criteria ± 10 percent. These are only guidelines; actual values will be determined from the results of duplicate samples and analyses.

Accuracy: Objectives for accuracy as percent recovery are given in Table 3-7. Matrix spikes will be performed on water samples for VOCs. The matrix spikes will be performed in accordance with standard analytical procedures and will also provide information on specific matrix interferences.

TABLE 3-7. QA OBJECTIVES FOR ACCURACY, PRECISION, PRACTICAL
REPORTING LIMIT (TRL), AND COMPLETENESS

Parameter	Matrix (Units)	Method ^a	Accuracy, ^b % Recovery	Precision, RPD ^c	TRL ^d	Completeness, %
VOCs	Vapor (ppbv)	TO-14	70-130	30	See Table 3-3	90
VOCs	Water (ug/L)	8260	70-130	30	See Table 3-2	90
Flow rates	Extracted Vapor (scfm)	Standard Pilot Tube	± 1% ^{e,f}	NA	NA	90
	Extracted Groundwater (gal/min)	Totalizing Meter	± 0.1 gal ^f	NA	NA	90

^a Method references are provided in Section 3.5.

^b Determined by matrix spikes for Method 8200. Determined by laboratory control standard for Method TO-14.

^c Relative Percent Difference. Determined by lab duplicates for Method TO-14; and matrix spike duplicates for Method 8200.

^d Per specific compound, if applicable.

^e Adjusted for temperature and pressure.

^f Based on manufacturer's specifications.

NA Not Applicable

A NIST Standard Reference Material (NIST SRM 1804) will be analyzed with each sample batch to verify the accuracy of the entire analytical system. Since the true or actual concentrations in the SRM are accurately known, percent recoveries for each of the certified constituents may be calculated as follows:

$$\% \text{ recovery} = \frac{\text{measured value}}{\text{certified value}} \times 100\%$$

This internal QC check is discussed further in Section 3.7.

Since concentrations of selected target analytes in the 2-Phase Demonstration samples are expected to be significantly higher (1-10 ppmv) than levels in SRM 1804, an additional check for accuracy at high levels will be determined by analyses of a standard containing PCE, TCE, and Freon-113 at approximately the 1-10 ppmv level. This standard will be prepared by CCAS. Criteria for accuracy specified in Table 3-7 will also to analyses of the high level standard.

Completeness: Objectives for data capture, expressed as completeness, are 90 percent for the critical parameters. Completeness is defined as the ratio of the number of valid measurements to the total number of measurements planned.

Target Reporting Limits: Demonstration target reporting limit (TRL) objectives are presented in Table 3-7. These TRLs are based on project requirements and the sample matrix to be analyzed.

Comparability: The use of standard, validated EPA methods achieves comparability of measurement data. Reporting the data in standard units of measure as specified in the methods, adhering to the method defined calibration procedures and, when possible, meeting the method detection limit, all contribute to the comparability of the data. The use of EPA methods is discussed in Section 3.5.

Representativeness: A well-defined sampling strategy ensures that samples collected are representative. Sufficient samples are planned during the 2-Phase Extraction Demonstration to ensure that results for both waters and vapors are representative of the conditions encountered.

3.3.2 Impact of Not Meeting QA Objectives

The QA objectives presented in Table 3-7 represent the data quality necessary to establish the characteristics of the vapor and water samples to demonstrate the technology efficiency and meet the project's technical objectives. The QA/QC efforts discussed in this QAPP focus on controlling measurement error within

the precision, accuracy, and completeness limits listed, and ultimately provide a database for estimating the actual uncertainty in the measurement data for the project. QA objectives for precision and accuracy for critical measurements will be evaluated to see if the overall, averaged results for the project meet the stated objectives. If these objectives are not met, corrective action will be taken as documented in Section 3.10. However, if the data quality achieved is well-documented and known, then the project's technical objectives can still be met although with decreased certainty depending upon the variability of the data. Similarly, if the completeness objectives are not met, then the confidence limits of the determined process efficiency will be decreased.

3.4 SAMPLING AND FIELD MEASUREMENT PROCEDURES

3.4.1 Sampling Locations

There are actually two extraction wells located near IC1, EW-233 and EW-234. Both of these wells will be pumping simultaneously during the demonstration; however, they are approximately 230 feet apart and their influence on groundwater drawdown should be independent. The overall configuration of the 2-phase extraction system that will be installed at EW-233 for the demonstration is shown in Figure 2-4. Groundwater from EW-233 will be piped to a separate knock-out tank where the water and vapor phases will be separated. Outlet water will be piped to the existing groundwater transfer line which goes to the groundwater treatment system. This knock-out tank will be installed with sample ports, water flow meters, and vapor flow measurement ports to separately account for mass removal in the vapor and water streams.

There are six location types identified for sampling in the vicinity of the extraction well of interest (EW-233), as indicated in Figure 3-7. To determine if the second primary project objective is met (to demonstrate the percent transfer of target VOCs from the surrounding groundwater to vapors as the water is pulled up through the extraction tube), the groundwater must be sampled prior to entering the extraction tube before any vaporization has occurred. Therefore, prior to system activation, groundwater will be sampled from the extraction well, two companion wells (CW-1 and CW-2), and a water piezometer (companion water piezometer) in the companion piezometer nest (PN-1) at designated and consistent sample depths beneath the water level in the well casings. These two locations are labeled S1 and S2 on Figure 3-7, respectively. The rationale for choosing either one or some combination of two wells among CW-1, CW-2, and PN-1 as the inlet groundwater sample point (S2) was discussed in Section 3.1.3. Initial vapor samples will be collected from the lowest vapor piezometer in the companion piezometer (PN-1). Soil vapors will be sampled using the canister vacuum after each piezometer has been purged (3 piezometer volumes) using a pump fitted to the deepest screened vapor piezometer. This vapor collection point is labeled S3 on Figure 3-7. Vapor will also be sampled as it exits the knock-out tank (at S5). The extracted water will be pumped out of the knock-out tank; grab samples will be taken from a sample point on this line (S4). Outlet water samples from EW-234 and vapor stream samples from EW-234 will be collected. These sampling locations are designated as S7 and S8, respectively, in Figure 3-8. These data will be used in combination with similar data from EW-233 to determine total mass removal from the two 2-phase extraction well systems.

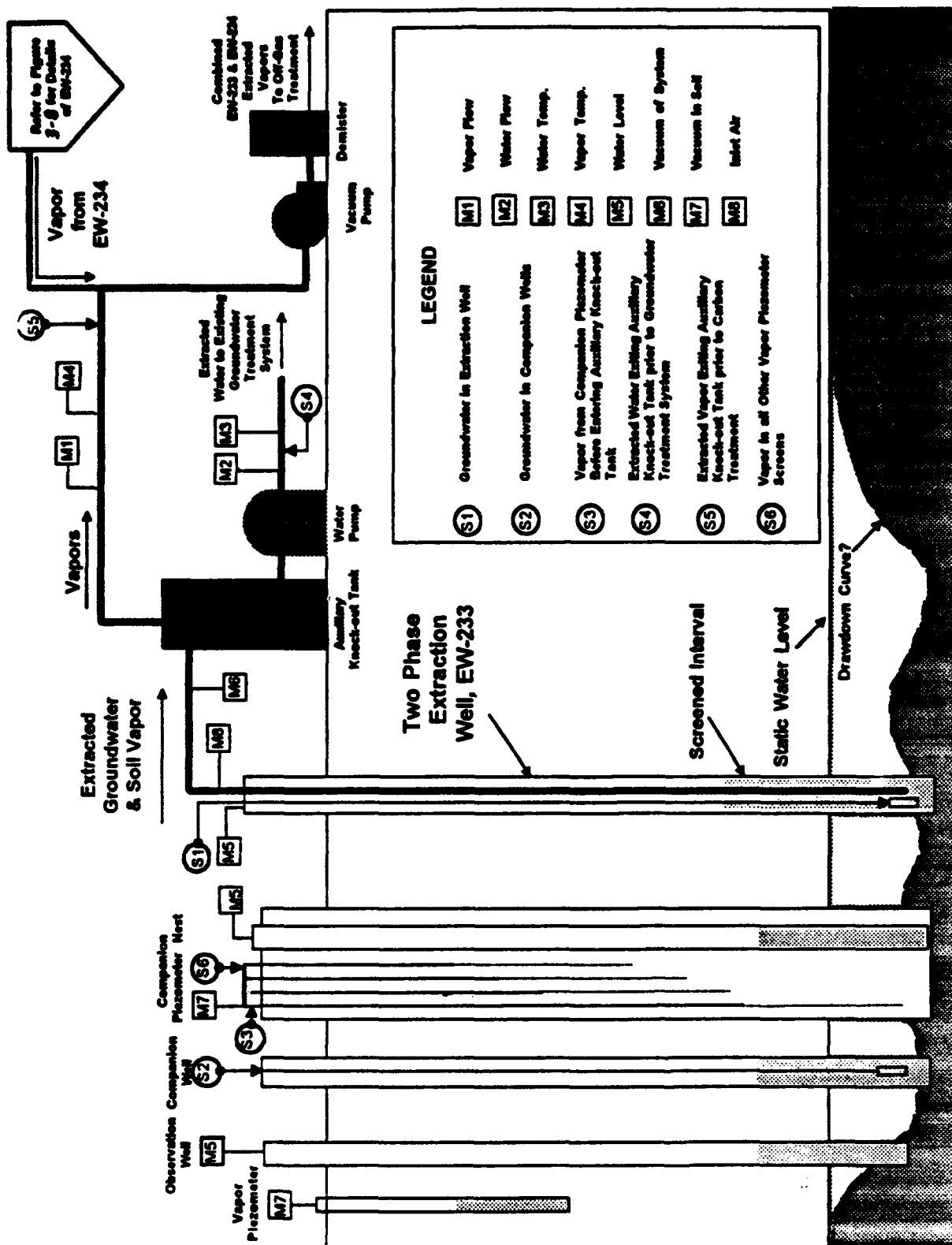


Figure 3-7. Process Schematic of the 2-Phase Extraction System Showing Sample and Measurement Points for EW-233.

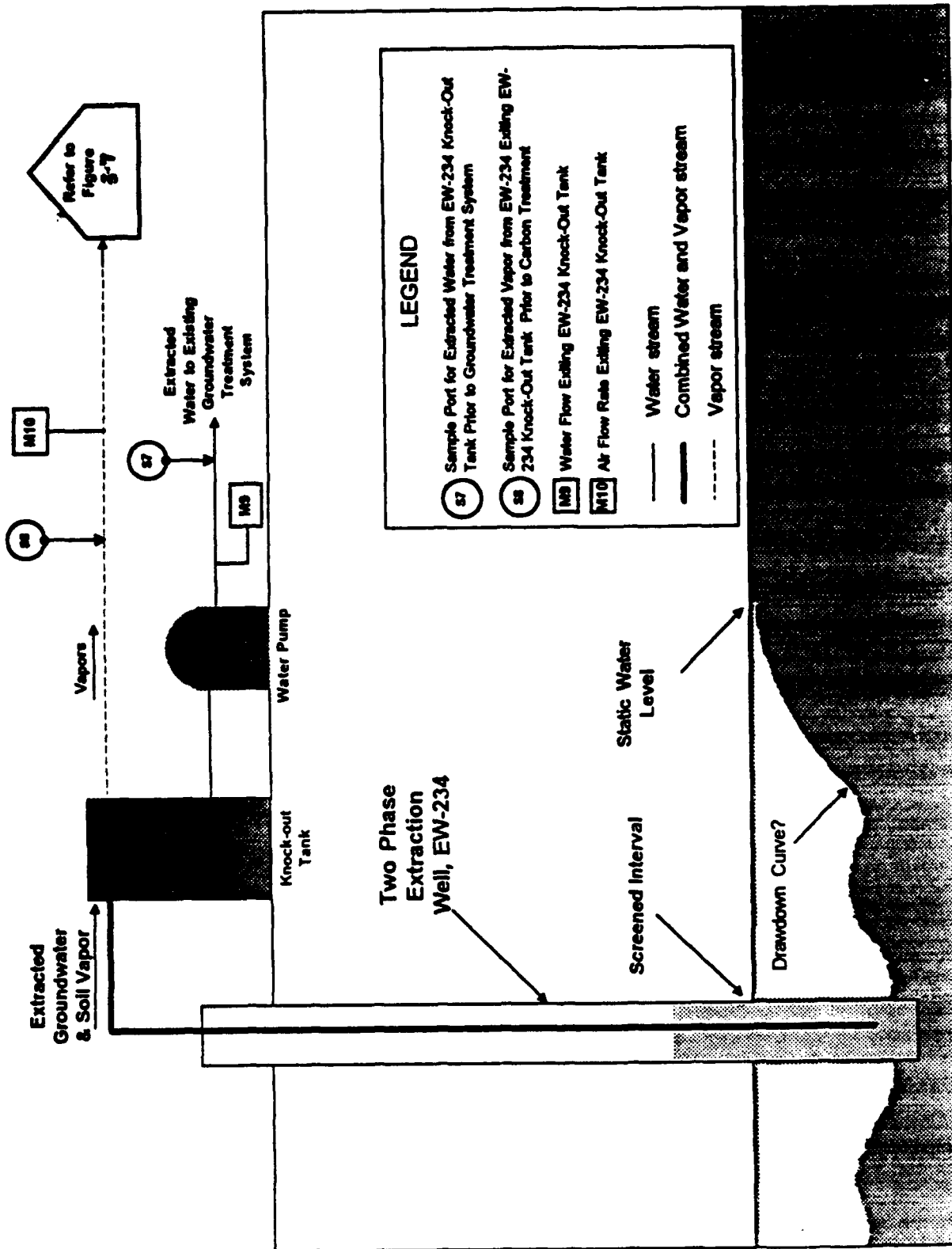


Figure 3-8. Process Schematic of the 2-Phase Extraction System Showing Sample Points for EW-234.

3.4.2 Sampling Procedures

Table 3-8 indicates the sampling methods, analytical parameters, container sizes, and sample quantities required for analysis for the samples to be collected during the 2-phase technology demonstration. There will be pre-test groundwater and soil vapor sampling conducted prior to pumping of the 2-phase wells, to establish a baseline for those media at the test site. Pre-demonstration groundwater samples will be taken during intermittent pumping of EW-233 (dynamic conditions). This will be followed by groundwater and soil vapor sampling during testing (described in this section), and finally post-test groundwater and soil vapor sampling that will mimic the pre-test sampling. SAIC will perform groundwater sampling and vapor sampling during the first two weeks of the demonstration (ERMI will provide subcontract support to oversee vapor sampling during the first week) and will provide analytical subcontract support for all analyses. Radian will perform the pre-sampling purging activities for groundwater during pre-demonstration, the demonstration, and the post-demonstration phases. SAIC will report to EPA any technical or nontechnical obstacles interfering with the completion of the demonstration.

TABLE 3-8. SUMMARY OF LABORATORY ANALYSES AND SAMPLE QUANTITY REQUIREMENTS

Sample Type	Sampling Method	Analysis Parameter	Sample Quantity Required for Analysis	Container Size
Vapor	Grab	VOCs	500 mL	6L or 15L SUMMA Canister
Water	Bailer	VOCs	5 ml	2-40 ml vials

3.4.2.1 Pre- and Post-Test Sampling

Pre- and post-test baseline sampling (before system startup and following system shutdown) will mimic each other. The groundwater sampling will consist of sampling three water wells by SITE (EW-233, CW-1, and CW-2) situated within 20 feet either side of EW-233 (refer to Figure 3-4 for plan view locations). SAIC will also sample PN-1. Each of these locations will be sampled once under static conditions and five times under dynamic conditions. SITE will also sample soil vapor from three newly-installed vapor piezometer nests in the immediate vicinity of EW-233 (PN-1, PN-2, and PN-3) and the three existing piezometers VPN-7, VPN-8, and VPN-9 (Figure 3-4). The existing nests contain six piezometers each. Two of the piezometer nests (PN-2 and PN-3) contain five vapor piezometers and the third one (PN-1), installed immediately adjacent to EW-233 (the "companion piezometer nest"), contains four soil vapor piezometers. However, the deepest of the vapor piezometers is designed to monitor inlet air at EW-233. It is screened in the same interval and is, therefore,

predominantly below the static water level until the extraction well is turned on. Therefore soil vapors will be collected only from the 3 shallower piezometers. During the pre- and post-test sampling events, the 2-phase extraction wells will not be activated. Therefore the piezometers will not be under negative pressure and soil vapor can be sampled directly into SUMMA canisters, which will be under a vacuum of approximately 30 in Hg.

Also, during the pre- and post-test periods, Radian will collect and analyze groundwater samples from pre-existing wells in the immediate vicinity to the test site of fulfill quarterly sampling requirements. These data will supplement SITE data for evaluating pre- and post-test groundwater conditions at the test site. For the pre-test sampling, the existing extraction wells (which will have been operating) will be shut off for two days before collecting any pre-test (baseline) samples. Comparably with the pre-test sampling, post-test sampling will be conducted at least two days past the system shutdown date.

3.4.2.2 Inlet Groundwater Sampling During Test

To avoid agitation and subsequent volatilization of the contaminants in the groundwater, a bailer will be used to obtain groundwater samples before, during, and after the test. The groundwater wells are not sealed and will be at atmospheric pressure. A minimum of three well volumes will be removed by Radian from the both the extraction and companion wells prior to all groundwater sampling to provide non-stagnated samples. Each of the 3 wells will have dedicated Teflon bailers that will be independently decontaminated between sampling events. Since volatiles are the target analytes, the bailer should be equipped with a bottom emptying device (stopcock). After rinsing the bailer with reagent-grade water, the bailer is lowered down the well and is slowly allowed to penetrate the water column until it reaches a standard depth (to be determined). The bailer is then slowly retrieved all the while keeping the bailer rope from touching the ground. Once the bailer has been fully retrieved the stopcock is quickly opened to fill the pre-preserved VOA vials to zero headspace. When field duplicate samples are required, the bailer will be lowered a second time into the well to collect the duplicate.

3.4.2.3 Outlet Water Sampling During Test

The treated water samples will be sampled from a valve in the pipeline downstream of the liquid knock-out tank and associated pump. A teflon line will be fitted to this valve so that water samples can be collected directly in the VOA vials. The valve will be opened to allow outlet water to drain to a bucket for a few seconds prior to collecting the sample (to purge the line). Then the pre-preserved vials will be filled to zero headspace.

3.4.2.4 Soil Vapor Sampling During Test

Soil vapor at the piezometer well heads (S3) and downstream of the knock-out tank (S5) sampling

points (see Figure 3-2) will be collected via SUMMA canisters via the same procedure. Both the inlet vapor piezometer sample point (S3) and the outlet vapor sample point (S5) will be under negative pressure. The piezometer well heads sampled pre- and post-test will not be under a negative pressure, however, since the vacuum system will not be operational during those sampling events.

Because the sampling locations S3 and S5 are anticipated to be under 18 to 20 inches Hg of negative pressure, and a SUMMA canister will be prepared and evacuated to approximately 30 inches Hg, very little sample volume would be collected by direct SUMMA canister sampling. The preferred method of sampling for VOCs at a location that is under considerable negative pressure utilizing a SUMMA canister, is to pull the gaseous effluent with a Teflon Head/Diaphragm pump and collect the sample with a SUMMA directly from the pump exhaust through the sampling manifold. A diagram of the proposed sampling system is presented in Figure 3-9.

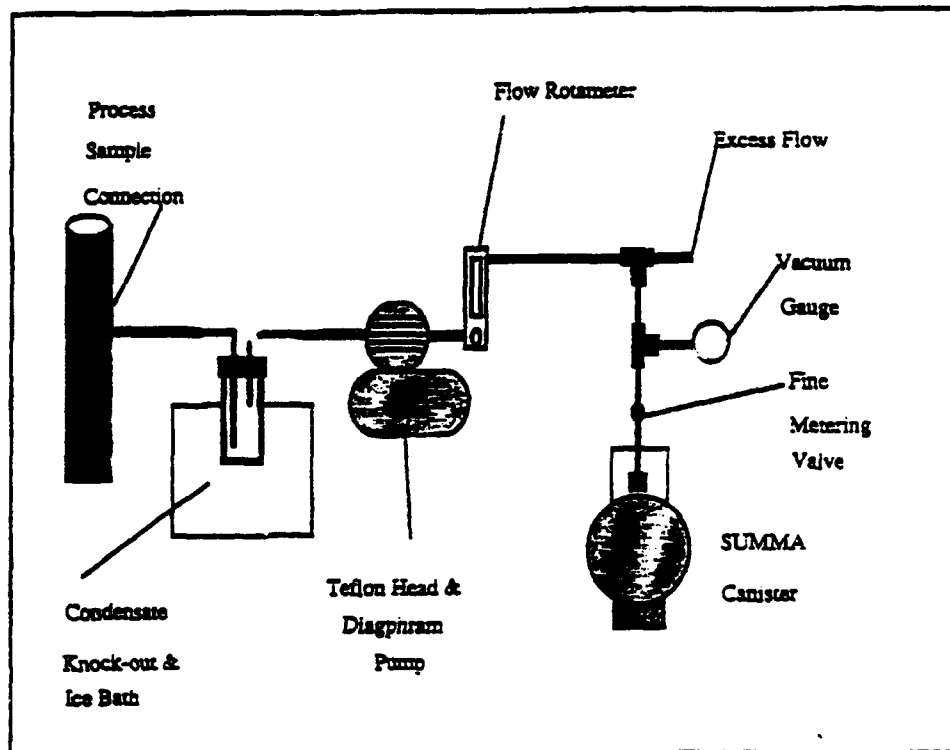


Figure 3-9. Proposed SUMMA Canister Sampling System.

In order to ensure that the SUMMA Canister is only sampling effluent gas stream from the source and not from ambient air, SITE will construct a sampling manifold which will be connected to the sample port of the pump. The manifold will be constructed of ¼-inch diameter Swagelock Stainless Steel fittings, and ¼ inch diameter Teflon tubing. The excess effluent gas stream will be controlled and monitored with a Dwyer Rotameter (0 to 5 liters per minute range). The SUMMA Canister will be equipped with a fine metering valve,

which will allow the sampler to control the sampling rate of the SUMMA Canister to ensure that the excess effluent gas stream will always be positive. An iced knock-out impinger will be used to knock-out any condensible volatiles prior to entering the SUMMA canister, unless an adequate sample can be collected which will not lead to loss of condensible volatiles. In which case, the sampling manifold will be simplified to not include the impinger. If a separate condensate sample is collected, VOC-free water will be used to eliminate headspace in the VOA vial. A sample of this VOC-free water will also be submitted for analysis.

Prior to collecting any process samples SITE will perform a static leak check on the entire system using a Dwyer water manometer. After the system integrity check has been performed, SITE will connect to the process sample connection a Tedlar Sample Bag (20 liter) filled with UHP grade air, which will be sampled by the SUMMA Canister. This sample will be designated as the initial system field blank. At the completion of the second week of sampling and again at the end of the demonstration, additional system equipment blanks will be collected in a similar manner.

Each of the SUMMA canisters will be field checked for negative pressure prior to sampling using a vacuum needle gauge, the vacuum (inches of water) will be recorded in the field notebook. If the pressure is found to be less than 28 inches of Hg, the canister will not be used. Prior to collecting each sample, the system will be purged with UHP air for five minutes. The SUMMA canister will be attached to the 1/4 inch stainless steel quick-connect valve on the sampling manifold, and the fine metering valve on the SUMMA canister will be slowly opened to allow the vacuum inside the SUMMA canister to draw the gaseous sample from the Thomas pump. Care will be taken to ensure that the Rotameter will always be reading positive throughout the duration of the sampling event. After collecting the air sample, SITE personnel will close the fine metering valve and remove the SUMMA canister from the quick-connect valve on the sampling manifold. The vacuum remaining (approximately -2 to -6 in Hg) in the SUMMA canister will be measured and recorded in the field notebook and on the chain-of-custody sheet. The laboratory will check the vacuum of the SUMMA canister upon receipt in order to determine that the SUMMA canister did not leak during transport.

The SUMMA canisters will be properly labeled and a chain-of-custody will be initiated in the field in accordance to the procedures described in Attachment B of this QAPP. The SUMMA canisters will be shipped by Federal Express overnight service to Coast-to-Coast Analytical Services under chain-of-custody for analysis.

3.4.3 Blank Samples

Four types of blank samples will be collected or maintained in the field. These include a 2-phase extraction system equipment blank, field blanks, equipment blanks, trip blanks, and temperature blanks. The 2-phase extraction system equipment blank will consist of running ambient air and tap water through the above-

ground treatment system equipment (i.e., knock-out tank, piping, etc.) to determine the absence (or residual level) of target analytes in the system prior to test startup. The 2-phase extraction system equipment blank will be collected once at the beginning of the test before contaminated water and soil gas are through the system.

Field blanks measure the potential for contamination of samples from the surrounding air during sample collection. Field blanks are not appropriate for SUMMA canisters because the canisters are connected directly to sample ports and there is no opportunity for cross-contamination from the surrounding air. Field blanks for water samples consist of ASTM Type I water (or equivalent) poured into sample containers in the immediate vicinity of sample collection points. One field blank each will be collected during pre- and post-test groundwater sampling at EW-233. During the demonstration, field blanks will be collected at a frequency of 5 percent of total number of samples taken and spread over the duration of the demonstration.

Equipment blanks measure any contamination resulting from the use of sampling equipment. For canister sampling at negative pressures (see Figure 3-8) system (equipment) blanks will be collected as described in Section 3.4.3.4. Equipment blanks for water samples consist of rinsate washes of the bailer(s) used to collect groundwater samples to determine the potential of contaminating water samples with residue on the inner walls of the bailers.

Trip blanks are not appropriate for SUMMA canisters. Because of their construction, the only way cross-contamination can occur is if the canister leaks (puncture or valve leakage). Each canister will be sent to the field under a high vacuum (at least -29" Hg). The vacuum will be recorded in the lab for each canister. The pressure of each canister will be checked and recorded in the field prior to use. If there is evidence of leakage (the pressure of a canister is less than 28 inches Hg) that canister will not be used. All canisters will be checked for leakage prior to sampling and again when received back at the lab. Trip blanks determine the potential for cross contamination of volatiles between sample containers and from shipment containers to sample containers. Trip blanks for aqueous samples consist of VOA vials filled with reagent grade water at the laboratory and placed in a sample shipment container for the duration of the container's round-trip from the lab to the field and back to the lab.

Temperature blanks consist of 40 ml vials filled with tap water, whose temperature is taken upon arrival at the lab to determine if iced samples have been maintained at 4°C. One temperature blank will be shipped with each cooler carrying water samples for VOC analysis.

3.4.4 Sample Preservations and Holding Times

Table 3-9 indicates the required preservation techniques and holding times for each of the sample parameters.

TABLE 3-9. REQUIRED PRESERVATION TECHNIQUES AND HOLDING TIMES

Analysis Parameter	Sample Type	Preservation	Maximum Holding Time
VOCs	Water	pH <2 with HCl; no headspace; cool at 4°C	14 days
VOCs	Vapor	None	30 days

3.4.5 Process Monitoring

Process monitoring will include measurement of water flow rate, temperatures of the water, vapor flow, groundwater levels, and system vacuum levels. Table 3-10 lists the process monitoring instrumentation and the range, accuracy, and calibration method for each.

3.4.5.1 Water Flow Rate

Total water flow will be measured using a totalizing meter (calibrated by the manufacturer before and after the test) located along the outlet water stream, just downstream of the knock-out tank. Field calibration will be performed monthly during the demonstration by Radian by filling a tared 55-gallon drum to capacity with outlet water and recording the fill time. Measurements will be taken by SAIC hourly during the first two weeks. It is expected that the system will stabilize during this time. For the remainder of the demonstration, Radian will monitor water flow daily. Associated documentation will be examined for accuracy and completeness during the first two weeks to verify procedures.

3.4.5.2 Vapor Flow

At the completion of the VOC vapor sampling procedures, the velocity of the gas stream vapor flow will be measured with a standard pitot tube and an inclined water manometer in accordance to the procedures outlined in USEPA Method 2. The standard pitot tube will traverse one diameter of the duct, through an air-tight Swagelock fitting, located upstream of the VOC sampling port. The velocity measurements which will be taken after collection of each vapor sample (by either SAIC or Radian, whichever is sampling), along with a measurement of the duct diameter will be used to calculate the volumetric flow rate of the gas stream (dry standard cubic feet). The volumetric flow rate will in turn be used to calculate the mass flow rate of each of the VOC compounds analyzed from the SUMMA canister (pounds per hour).

TABLE 3-10. PROCESS MONITORING INSTRUMENTATION, RANGE, ACCURACY, AND CALIBRATION METHODS

Instrument	Range	Accuracy	Calibration Method	Calibration Limits for Data Quality
PI102, PI103, PI202, PI203, PI300 (Magnehelic)	0" - 3" Hg vacuum	± 3%	Comparison to lab calibrated instrument	± 5%
PI304 (SS Pressure Gauge)	0-15 psi pressure	± 3%	Comparison to lab calibrated instrument	± 5%
PI305, PI306 (SS Pressure Gauge)	0-30 psi pressure	± 3%	Comparison to lab calibrated instrument	± 5%
TI300 (Bimetal Thermometer)	25°F-125°F	± 1% full scale	Comparison to lab calibrated instrument	± 5%
TI304 (Bimetal Thermometer)	0°F-250°F			
FIT301 Thermal Dispersion Meter	25-100 scfm	± 3% full scale	Factory calibration; instrument internal calibration; comparison to in-line pitot tubes	± 15%
FIT304 Thermal Dispersion Meter	50-150 scfm			
FIT302, FIT303, FIT300 (Magnetic Flow Meter)	2-50 gpm	± 2% full scale	Comparison of FIT302, FIT303 to FIT300; FIT300 calibrated with flow test using container of known volume	± 10%
TE305	25°F-500°F	± 1% full scale	Reference only, no calibration required	N/A
FE101, FE201 (Visi-Float Flow Meter Rotometer)	5-50 scfm	± 8%	Comparison to lab calibrated instrument, if atmospheric inlet is open	± 15%

PI = Pressure Indicator
TI = Temperature Indicator
FIT = Flow Indicator Transmitter
TE = Temperature Element
FE = Flow Element

3.4.5.3 Groundwater Levels

Groundwater levels in the companion water piezometer, companion wells, and in surrounding wells and piezometers will be monitored daily during the first two weeks of the demonstration using a water level indicator that is accurate to 0.01 feet. Table 3-11 lists the wells and piezometers whose water levels will be measured throughout the demonstration, and also lists their locations relative to EW-233 and screened intervals (refer to Figure 3-3 for plan view location). Since purging of soil vapor sampling wells could have a minor affect on water level measurements, water level measurements will be taken prior to purging soil vapor wells.

**TABLE 3-11. WELLS AND PIEZOMETERS TO BE MONITORED FOR
GROUNDWATER ELEVATION AND VACUUM LEVELS**

Well/Piezometer ^a	Proximity to EW-233	Screened Interval (Feet BLS)	Measurements
EW-233	---	105.5-124.5	Groundwater
EW-234	230' SW	105.5-118	Groundwater
CW-1	22'4" NE	105-125	Groundwater
CW-2	11'7" SW	104.5-124.5	Groundwater
PN-1	6'7" South	121-131 (water) 110-118 (inlet vapor) 66,87,103 ^b	Groundwater/Vacuum
PN-2	43'5" North	115-125 (water) 41, 60.5, 85, 96, 107 ^c	Groundwater/Vacuum
PN-3	20'9" SE	123-133 (water) 39.3, 66, 83, 101, 115 ^c	Groundwater/Vacuum
MW-157	108' SW	97-117	Groundwater
MW-158	145' West	102.5-112.5	Groundwater
MW-159	220' North	107-117	Groundwater
MW-235	85' NE	106-116	Groundwater
MW-236	85' SE	104-114	Groundwater
MW-41S	140' South	100-110	Groundwater
MW-65	272' SE	98-108	Groundwater
VPN-7	78' E-NE	41, 54, 65, 79, 88, 99 ^d	Vacuum
VPN-8	98' NE	41, 56, 66, 81, 93, 99 ^d	Vacuum
VPN-9	178' NE	22, 30, 40, 60, 79, 98 ^d	Vacuum

- a EW - Extraction Well (Existing) CW - Companion Well (New)
PN - Piezometer Nest (New) MW - Monitoring Well (Existing)
VPN - Vapor Piezometer Nest (Existing)

b The companion piezometer nest contains an inlet companion piezometer with a 10 foot long screen plus three additional vapor piezometers in which the numbers given are the depths of the screen bottoms, all of which are two to five feet long.

c These piezometer nests each contain five vapor piezometers in which the numbers given are the depths of the screen bottoms, which are four to ten feet in length.

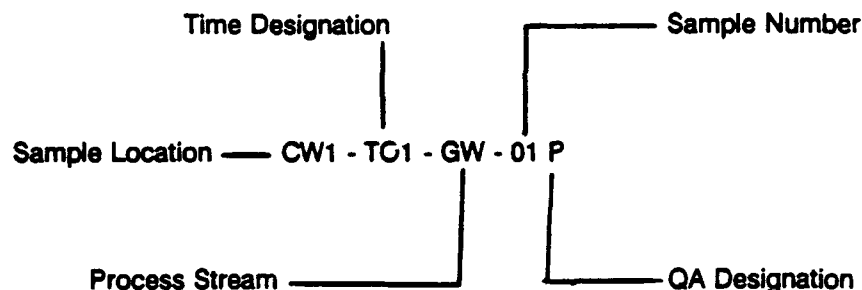
d The existing vapor piezometer nests contain six piezometers each in which the numbers given are the depths of the screen bottoms, all of which are two feet long.

3.4.5.4 System Vacuum Levels

The radius of influence for vapor extraction will be determined by measuring the induced vacuum in three newly-installed piezometer nests (PN-1, PN-2, and PN-3) and in three existing piezometer nests VPN-7, VPN-8, and VPN-9 (Figure 3-3). Induced vacuum measurements will be performed at the same time the water level readings are taken. The induced vacuum will be measured relative to atmospheric pressure using a Magnehelic®, or a vacuum pressure gauge of equivalent accuracy, and the data corrected to absolute pressure using hourly barometric readings from the McClellan Air Force Base (AFB) Meteorological Station; an on-site barometer may also be used to determine barometric pressure. The induced vacuum results will be plotted versus distance from the extraction well to graphically determine the radius of influence; an induced vacuum of 1 inch water or greater will be used to indicate the extent of influence.

3.4.6 Sample Identification

The sample numbering system will identify up to five (5) characteristics of these samples, for example:



Sample Location Code

233 - Extraction Well 233
234 - Extraction Well 234
CW1 - Northeast Companion Well
CW2 - Southwest Companion Well
PN1 - Companion Piezometer Nest
PN2 - North Piezometer Nest
PN3 - Southeast Piezometer Nest
VN7 - Existing Vapor Piezometer Nest
VN8 - Existing Vapor Piezometer Nest
VN9 - Existing Vapor Piezometer Nest

Time Designation Key

TO0 - Time 0
(TO1, TO2, TO3, etc.)

Process Stream Key

GW - Groundwater
OW - Outlet Water
IV - Inlet Vapor
OV - Outlet Vapor
TB - Trip Blank
EB - Equipment Blank
FB - Field Blank
SB - 2-Phase
Extraction System Blank

QA Designation Key

P - Primary Sample
D - Field Duplicate
MS - Laboratory Matrix Spike

Sample labels will be placed directly onto the 40 mL vials for the aqueous samples and sample tags will be placed on SUMMA canisters. In addition, the SUMMA's will already contain a three-digit canister identification tag, which will also be written on the chain-of-custody form.

3.4.7 Field Documentation

All handwritten documentation must be legible and completed in permanent ink. Corrections must be marked with a single line, dated, and initialed. All documentation, including voided entries, must be maintained within project files.

Field documentation shall consist of a project logbook, one or more site-specific field logbooks, field forms, sample logs/labels, and an equipment calibration log. All logbooks must be permanently bound with hard covers and have sequentially numbered pages. In addition, each logbook will be uniquely identified and sequentially numbered. Logbooks will be maintained on-site until complete, then stored in the project files.

3.4.7.1 Project Logbooks

The project logbook chronicles all field investigation activities, but does not have the same level of detail as the field logbook. It delineates conditions and activities occurring on a given day and references the appropriate field logbooks and forms for specific information. The project logbook is also used to record all field changes along with supporting rationale.

The senior person responsible for the field effort (Field Operations Leader) is also responsible for completing the project logbook, usually at the end of each work day. This individual must sign and date the logbook at the end of each day's entry. Pages will not be removed from the document. All partially used pages must be lined out to prevent data entry at a later date.

The front cover or first page of the project logbook must list the project name, the project number, and dates of use. The following items are to be included, as appropriate to the work scope, in the project logbook:

- Date
- Weather conditions
- List of all Radian and project personnel, by name, title, organization, and purpose, who entered the project area during the day
- Reference to all field logbooks used during the day, by logbook number and pages
- Brief descriptions of sampling activities, including boring and well numbers, as well as sample

Identification(s)

- Field changes or variances with references to the appropriate documentation of these changes
- Record of equipment decontamination, with references to any specific documentation information
- Chain-of-custody details, including chain-of-custody identification number, shipping receipt (air bill) numbers, sample identification numbers, and any pertinent information relative to sample status
- Identification numbers of monitoring instruments used during the day and references to any specific calibration logs
- Specific comments relative to peculiar problems that occurred during the day, if any, and their resolution
- A record of telephone calls (incoming or outgoing) pertaining directly to the decision-making process of the field investigation and a brief description of the content of these conversations

Documentation of activities related to operation of the field laboratory will be maintained by the manager of the field laboratory in separate notebooks.

2 Field Logbooks

All information required on the cover of the project logbook must also be provided on the cover of each logbook. Entries in the field logbook must be made in real time and must be signed by the responsible person at the end of each day. Unused pages or portions of pages must be lined out to prevent entry of additional information at a later date. Field logbook pages as well as the logbooks themselves will be sequentially numbered. The following are to be included in field logbooks:

- Date, and time of specific activities
- Weather conditions
- Names, titles, and organization of personnel on site, names of visitors, and times of visits
- Field observations to include, for example, specific details regarding sampling activities, (including type of sample, time of sample, and sample numbers), a description of any field tests and their results, and references to any field forms used.
- A description, in specific detail, of samples collected and duplicates or blanks that were prepared. A list of all sample identification numbers, packaging, and chain-of-custody form numbers, pertinent to each sample or a reference to the appropriate documentation should be noted.
- Specific problems, including equipment malfunctions, and their resolutions.
- A list of the time, equipment type and decontamination procedure followed (if different from the

project work plan) or a reference to the appropriate documentation.

Additional information may be recorded on field data logsheets (data sheets) at the discretion of the logbook user. Radian utilizes various field data log sheets, including those for dual-phase system parameters, and soil gas permeability test (piezometers). Examples of these two field data sheets are presented in Figures 3-10 and 3-11, respectively. In addition, groundwater levels will be recorded on forms tailored specifically for the monitoring wells and piezometers that will be monitored throughout the demonstration. These forms are presented as Figures 3-12 and 3-13.

3.4.8 Sampling Equipment Preparation and Decontamination

The decontamination of major equipment (e.g., drill rigs) and sampling equipment is necessary to minimize the spread of contamination to clean zones, to reduce exposure to personnel, and to reduce cross-contamination of samples when equipment must be used more than once during a sampling event. Sampling equipment will be wrapped in aluminum foil following decontamination and stored in a clean area prior to use.

At the site, sampling equipment will not be allowed to come into contact with the ground or any potentially contaminated surfaces. Aqueous sampling equipment will be decontaminated in tubs or drainage pans so that rinsate solvents can be collected and properly disposed of at the McClellan AFB IWTP. Major equipment will be decontaminated at a location designated by McClellan AFB. Rinsate samples (equipment blanks) will be collected at a frequency of 5%, by rinsing the cleaned equipment with HPLC water (or equivalent). Disposable material (e.g., gloves, Tyvek suits, etc.) generated during decontamination will be bagged and placed in a disposal area designated by McClellan AFB.

Canisters must be cleaned and certified prior to use. A batch of eight canisters are connected to a cleaning system manifold. The canisters are evacuated and pressurized 3 times with ultrapure nitrogen. The canisters are then re-evacuated to < 29 in. Hg vacuum.

All canisters are leaked tested by pressurizing to 30 psig with zero air and maintained for 24 hours. The pressure drop should be < 0.05 psig. Canisters are then evacuated to -29.5 in. Hg and maintained for 24 hours. The vacuum decrease should be < 0.1 in. Hg. If these criteria are not met, the canister will not be used.

DUAL-PHASE SYSTEM DATA SHEET

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Time		System Clock	Flow Rate		Inlet		Vacuum Pump		Oil System			Water Pump		Air Cooler				
Current	Elapsed (hr/min)		Low (scfm)	High (scfm)	Vacuum (in Hg)	Temp (F)	Inlet Oil Temp (F)	Inlet Oil Press (psi)	Outlet Temp (F)	Back Press (psi)	Recycle Press (psi)	Scaven Press (psi)	Inlet Press (psi)	Outlet Press (psi)	Water Motor (gal)	Inlet Temp (F)	Outlet Temp (F)	Outlet Press (psi)
Typical Value		na	na	na	na	na	150-160	+2	170	4-7	20	?	?	?	na	?	?	?

(Continued: yes / no)

Figure 3-10. Dual-Phase System Field Data Sheet. (Source: Radian)

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SOIL GAS PERMEABILITY TEST FIELD DATA SHEET (Poisonometers)

Date: _____ Page _____ of _____
 Site: IC-
 Well Tested: VW- Peizometer: VPN-
 Samplers: _____ Distance from Extraction Well: _____ ft

[illegible]

Continued: Yes / No

Figure 3-11. Soil Gas Permeability Test Field Data Sheet. (Source: Radian)

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[illegible]

Figure 3-12. Form for Recording Water Levels in Extraction and Companion Wells, and Water Piezometers in the Immediate Vicinity of EW-233.

WATER LEVELS IN OUTER SURROUNDING WELLS

Figure 3-13. Form for Recording Water Levels in Outer Surrounding Wells.

One out of every batch of eight canisters is pressured and analyzed by Method TO-14 for the target VOCs. For this project, canisters will be considered clean if the concentrations for all target VOCs are below 10 ppbv. If not, the batch of canisters will be re-cleaned and re-certified. As an additional check on CCAS's canister cleaning procedures, all eight canisters will be analyzed using a TO-14 for the first three batches used during this demonstration. If no problems are encountered, the frequency of cleanliness verification will be reduced to one out of every eight canisters.

3.4.9 Sample Custody

Table 3-12 provides a list of the sample custodians in the 2-Phase Extraction Demonstration project.

TABLE 3-12. SAMPLE CUSTODIANS IN THE 2-PHASE EXTRACTION DEMONSTRATION PROJECT

Name	Organization	Title
John Clark	Radian	Field Operations Leader
Jamie Winkelman	SAIC	Field Manager
Craig Douglas	ERMI	Sample Control Supervisor
Casey Owen	CCAS	Sample Custodian

The possession of samples or other evidence shall be traceable beginning at the time samples are collected. This will be accomplished through the use of chain-of-custody procedures. Chain-of-custody forms (Figure 3-14) will accompany the sample shipment and will be shipped in the appropriate shipping container (cooler). Copies of the completed chain-of-custody forms will be included in appropriate data validation packages.

A sample is said to be under custody if:

- It is in an individual's physical possession
- It is in the individual's view, after being in his/her possession
- It was in the individual's physical possession and he/she secured it to prevent tampering
- It is placed in a designated secure area

[illegible]

Figure 3-14. Chain-of-Custody Form.

3.4.9.1 Field Custody Procedures

- 1 To simplify the chain-of-custody record, as few people as possible should handle the samples or physical evidence. For this reason, one individual from the field sampling team will be designated as the responsible individual for all sample transfer activities. This field investigation will be personally responsible for the care and custody of the samples collected until they are properly transferred to another person or facility.
- 2 Field documentation of each sample will be made on a Sample Logsheet or site logbook entry. This documentation of each sample will be made in ink and will consist of, at a minimum, entry of the sample identification number, the sample location and the time/date of collection.
- 3 All samples will be accompanied by a chain-of-custody record similar to the example presented in Figure 3-13. This record will document the transfer of custody of samples from Radian to SAIC, and from SAIC to CCAS. Each change of possession must be accompanied by a signature for relinquishment and receipt of the samples.
- 4 Completed chain-of-custody forms will be placed in a plastic cover and placed inside of the shipping container used for sample transport from the field to the laboratory.
- 5 When samples are relinquished to a shipping company for transport, the tracking number from the shipping bill/receipt will be recorded on the chain-of-custody form or in the project logbook.
- 6 Custody seals will be used on both the sample containers and the shipping containers when samples are shipped to the CCAS laboratory to ensure no sample tampering occurred during transportation.

3.4.9.2 Laboratory Custody Procedures

The CCAS laboratory sample custodian or designated alternate will receive and assume custody of samples until they have been properly logged into the laboratory and stored in a secure area.

Upon receipt of a sample shipment, the shipping container will be inspected for security seals before it is opened. The sample custodian will open the container and check the contents for evidence of breakage or leaking. The temperature of the samples in the ice chest will be verified using temperature measurements of temperatures blanks upon arrival at the laboratory. The contents of the container will be inspected for chain-of-custody documents and other information or instructions. For aqueous sample shipments, the temperature of the temperature blanks will be noted on CCAS' addendum to the chain-of-custody document with the date and signature of the person making the entry. If the temperature is above 6°C, the SAIC QA/QC Coordinator will be notified. The sample custodian will verify that all information on the sample bottle labels is correct and in accordance with the chain-of-custody forms and will sign for the receipt. If discrepancies are identified between the chain-of-custody and the sample labels, SAIC's QA/QC coordinator

will be notified immediately. The chain-of-custody form will be retained in the project file, and a copy will be returned to the SAIC Project Manager to verify receipt.

For canister samples, the overall condition of each sample is observed. Any signs of damage or missing tags or labels are immediately reported to SAIC. Any discrepancy between information recorded on the Chain-of-Custody and that recorded on the canister tag is noted and reported to SAIC. Upon receipt in the laboratory, the pressure/vacuum of each sample canister is checked by attaching a pressure/vacuum gauge to the canister inlet. The canister valve is opened briefly and the pressure/vacuum is measured and recorded on the laboratory worksheet and the Canister Sampling Field Data Sheet accompanying each sample. If the pressure difference from the field to the lab is greater than 2 inches Hg, SAIC will be notified of a potential leakage problem. Samples are pressurized using certified clean ultra-pure helium. See CCAS Standard Operating Procedures (SOPs) for Method TO-14 in Appendix A for more details.

Any discrepancy between the samples and the chain-of-custody information, any broken or leaking sample bottles, or any other abnormal situation will be reported to CCAS' manager. SAIC will be informed of the problem, and corrective action options will be discussed and implemented. Notations of the problem and resolution will be made on the chain-of-custody form and initialed and dated by the sample custodian. Identifying information will be recorded in the CCAS Laboratory Sample Tracking System. The information required includes the following:

- Date of receipt
- Client name
- Client identifying number or description
- Project number
- Analyses required

The CCAS Laboratory Information System (LIMS) will be used for logging samples into the laboratory, tracking the progress of the analyses, and preparing the analysis report. All information pertinent to the identification of the sample and analyses to be performed will be entered into the LIMS. Each sample will be assigned a unique laboratory number. A laboratory sample label will be attached to each bottle. A work order will be prepared and provided to the laboratory supervisor for scheduling tests in accordance with method-required maximum holding times and client-requested response time. A bench sheet will be printed to inform the analysts of which tests are to be performed for each sample or split sample.

Aqueous samples will be stored in designated, refrigerated areas in accordance with the analyses to be performed. A log book will be maintained for each refrigerator, and the temperature will be recorded each working day. Canister samples will be stored in a locked storage area at room temperature.

A sample storage log book will be used to document the removal and replacement of a sample from the secure storage area.

3.4.10 Sample Packaging and Shipping

Aqueous samples should be packaged and shipped as follows:

1. Place each sample bottle/liner (including trip blanks) in a 2-mL plastic bag and seal the bag.
2. Fill a rigid insulated shipping container (cooler) one quarter full of packing material.
3. Place sample containers in cooler, allowing space between sample containers.
4. Place cooler blank in cooler for temperature measurement upon arrival at laboratory.
5. Fill several plastic bags with ice chips, seal the bags, and place the ice between the samples.
6. Fill the cooler with packing material.
7. Place the required paperwork (e.g., chain-of-custody records) going to the laboratory inside a plastic bag and tape it to the inside of the cooler lid.
8. Close the cooler, seal it with strapping tape, and place at least two custody seals over the edges (one on the front and one on the back).
9. Deliver the cooler to Federal Express (or other express carrier), using a standard airbill.

Canister samples collected should be packaged and shipped as follows:

1. Place each canister in a corrugated shipping box.
2. Fill the shipping container with packing material, if needed (no styrofoam or plastics will be used).
3. Place the required paperwork (e.g., chain-of-custody records) going to the laboratory inside a plastic bag and insert into the shipping container.
4. Close the box and place at least two custody seals over the edges (one on the top and one on the bottom).
5. Deliver the shipping container to Federal Express (or other express carrier), using a standard airbill.

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Samples will be shipped to:

Coast-to-Coast Analytical Services
4765 Calle Quetzal
Camarillo, CA 93012
Phone: (805) 389-1353
Fax: (805) 389-1438
Attention: Larry Hilpert

3.5 ANALYTICAL PROCEDURES AND CALIBRATION

The selection of appropriate methods to prepare and analyze the samples to be collected for the 2-phase extraction demonstration is based on the specific analytes of interest, the sample matrix, and the minimum detectable concentrations needed to verify the developer's claims and meet the project objectives discussed in Section 3.1. The references used are as follows:

- 1) Test Methods for Evaluating Solid Waste, Volumes 1A-1C: Laboratory Manual, Physical/Chemical Methods; and Volume II: Field Manual, Physical/Chemical Methods, SW-846, Third Edition, Office of Solid Waste, U.S. Environmental Protection Agency, Document Control No. 955-001-00000-1, 1986 (Includes Final Update I to SW-846, November 1990).
- 2) EPA Compendium of Methods for the Determination of Toxic Organics in Ambient Air.

Table 3-13 lists the two analytical methods chosen for this Demonstration program, both of which will be utilized for critical parameters, as discussed below in Section 3.5.1. Calibration procedures are discussed in Section 3.5.2.

**TABLE 3-13. ANALYTICAL METHODS AND REFERENCES FOR THE
TPE SITE DEMONSTRATION**

Parameter	Matrix	Classification	Preparation Method	Analytical Method	Reference ^a
VOCs	Aqueous	C	NA	8260	1
VOCs	Vapor	C	NA	TO-14 ^b	2

Key: C = Critical
NA = Not Applicable
a = See above
b = CCAS Standard Operating Procedure (SOP) - see Appendix A. The necessary modifications for source level samples are described throughout the QAPP.

3.5.1 Analytical Procedures

The analytical procedures to be employed for the project measurements are described in the following subsection. Specific QC procedures and acceptance criteria are presented in Section 3.7.

Method 8260 - Volatile Organic Compounds by GC/MS: Capillary Column Technique

Method 8260 will be used to analyze groundwater samples for VOCs. The VOCs are introduced into the gas chromatograph (GC) by the purge-and-trap method and then detected with a mass spectrometer (MS) interfaced to the GC. All VOCs will be quantitated from within the calibration curve.

Method TO-14 - Determination of VOCs in Ambient Air Using SUMMA Passivated Canister Sampling and GC/MS Analysis

Method TO-14 will be used to analyze vapor samples for VOCs. The method is based on the collection of whole air samples in SUMMA passivated stainless steel canisters. VOCs are isolated from the air matrix cryogenically, separated by capillary column gas chromatography and detected by mass spectrometry. Method TO-14 provides general guidelines for these determinations. The CCAS Standard Operating Procedure (SOP) in Appendix A provides specific details for these analyses. While this SOP is applicable to ambient air, the necessary modifications for source level samples are described throughout this QAPP.

A sample aliquot will be removed from the pressurized canister using a gas-tight syringe. This aliquot will range from 0.1 mL to 500 mL, depending on the expected sample concentration. Simultaneous with the transfer of the sample onto the cryogenic trapping loop, two internal standards (bromochloromethane and fluorobenzene) and a surrogate (2-bromochloropropane) are loaded onto the trap.

After the sample is pre-concentrated in the cryogenic trap, the trapped analytes are thermally desorbed onto the head of the DB-5 capillary column where they are cryogenically focussed. GC/MS operating conditions are specified in Table 1.0 of the CCAS SOP in Appendix A.

While the three critical VOCs (TCE, PCE, and Freon-113) are expected to be present at significantly higher concentrations than other target VOCs, the attempt will be made to get the best achievable detection limit to provide mass removal information for noncritical VOCs. All VOCs must be quantitated from within the calibration curve.

3.5.2 Calibration Procedures

Each analytical protocol defines calibration procedures and acceptance criteria in the referenced method. The following text summarizes these requirements for the analyses discussed in the previous subsection; these criteria are also summarized in Table 3-11 in Section 3.7.

Gas Chromatography/Mass Spectrometry - Volatile Organic Analyses by Method 8260

Ion intensity and mass fragmentation patterns are verified every 12 hours (that samples are analyzed) by the analysis of a tune performance compound - bromofluorobenzene (BFB). Acceptance criteria are given in the method. Initial calibration is based on the analysis of five standards with a concentration range for a low-level standard close to the method detection limit (MDL) to an upper concentration based on the linearity of the instrument. Individual response factors (RFs) for each compound, in each standard, are calculated and select system performance check compounds (SPCCs) are verified for a minimum RF value. Several calibration check compounds (CCCs) have a maximum value for relative standard deviation between the five RF measurements. These criteria are given in the method. Continuing calibration standards are analyzed every 12 hours (after an acceptable BFB) to verify the validity of the initial calibration. The same SPCCs and CCCs are evaluated for minimum RF and percent difference between the continuing standard RF and the average RF of the initial calibration. Criteria are given in the method. For this demonstration, the critical VOCs will also be included in the list of CCCs.

Gas Chromatography/Mass Spectrometry - Volatile Organic Analyses by Method TO-14

Ion intensity and mass fragmentation patterns are verified daily by analysis of BFB. The acceptance criteria are listed in Table 2.0 of the CCAS SOP for this analysis (Appendix A). An initial 5-point calibration is performed and the response factors (RFs) for each target analyte are determined (see Table 3.2). A single standard containing all target VOCs will be diluted to yield a calibration curve ranging from 50 ppbv to 500 ppbv. The relative standard deviations for the RFs must be less than 30% for each analyte or the initial calibration must be re-established.

Continuing calibration is performed daily by analysis of a mid-level calibration standard. The RF for each analyte must be within $\pm 30\%$ of the mean RF from the initial calibration. If the percent difference exceeds this criteria, a new initial calibration must be established.

With each analytical batch, an aliquot of NIST SRM 1804 will be analyzed to verify the calibration curve. The recoveries for all spiked analytes (see Table 3-14) must be 70-130 percent. In addition, with each analytical batch, a laboratory control sample containing the three critical VOCs at concentrations expected in the samples will be analyzed. The recoveries for this sample must also be 70-130 percent.

3.6 DATA REDUCTION, VALIDATION AND REPORTING

The analytical methods discussed in the previous section of this QAPP clearly describe the calculations used to reduce the measurement data into units of reporting which will meet the comparability needs of the project. The following section defines acceptance criteria for validating the measurement data. This section of the document provides an overview of the data reduction, validation and reporting scheme as summarized in Figure 3-15.

3.6.1 Data Reduction

All measurement system outputs (e.g., absorbance units, peak areas, etc.) must be reduced into units which are consistent with the methods and which meet the comparability objective. A summary of reporting units was given in Table 3-7 of Section 3.3. In general, all raw data are recorded in laboratory notebooks or on worksheets in standardized format by the analyst performing the test. Each analytical method contains detailed instructions and equations for calculating the respective analyte concentration.

3.6.2 Data Validation

The measurement data generated by the analyst are validated in several ways. Strict adherence to the analytical methods, and ensuring that the instrumentation employed was operated in accordance with defined calibration procedures, are critical functions to determining the validity of the generated data. Results generated by an unauthorized method, unapproved deviation from the standard protocol, or during the operation of uncalibrated or malfunctioning equipment will be rejected. The laboratory SOPs, along with the criteria given in various sections of this document, clearly define when such occurrences require corrective action and what that action should be (See Sections 3.7 and 3.10).

Within the laboratory, raw data reductions are verified by an independent analyst or a section QC specialist. Any problems or errors discovered during this review will initiate a 100 percent review of the batch. All QC samples are compared to QA objectives for precision and accuracy; any outliers are immediately flagged. Analytical outlier data are defined as those QC data lying outside of a specific limit for precision or accuracy for the specific method. Following the identification of the outlier, reasons for the failure are investigated, including instrumentation problems, calculation problems or difficulties with sample volume, spike volumes or sample matrix. Similarly, any outlier surrogate recoveries (for organic analyses)

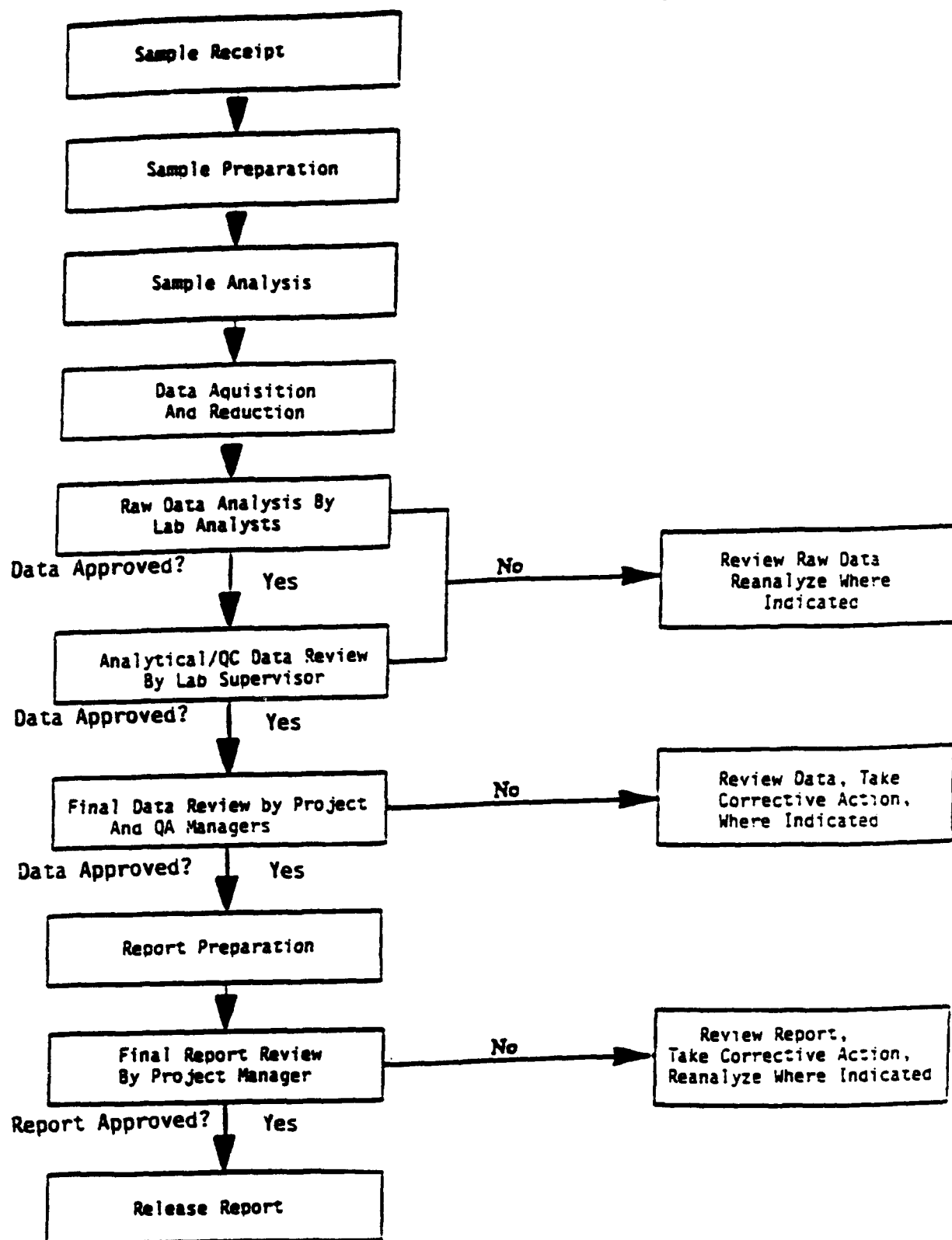


Figure 3-15. Summary of Data Reduction, Validation, and Reporting Scheme.

require investigation. The SAIC QC Coordinator will be notified promptly in order to determine whether re-analysis is justified. If re-analysis of the sample (when feasible) indicates sample matrix interferences, a statement to that effect accompanies the original data, and the entire batch is considered acceptable. If the reason for the failure cannot be determined, and re-analysis indicates that the original analysis was in error, the effect on the analytical batch is evaluated, and all interpretations and corrective actions are documented. As necessary, qualifying statements will describe any problems encountered and any restrictions on the use of the data.

Field data will be validated by a similar procedure. The field personnel will review 100 percent of the data generated, including calibration data and all calculations. The field personnel will sign and date all field notebooks. The field supervisor will review at least 10 percent of the generated data. The Work Assignment Manager will perform a review of 10 percent of the data quality indicators, including field calibration checks, and compare them to acceptance criteria. Any suspect data will be flagged and identified with respect to the nature of the problem.

3.6.3 Data Reporting

All original laboratory data will be recorded in a permanent manner, and will be readily traceable through all steps of the data generation/reduction/validation/review process. Field measurements will be recorded in appropriate field notebooks and results will be reported in tabulated summary form.

Laboratory data are originally reported by the analyst on analysis-specific report forms. These data are reviewed, and approved by the section manager. The reported data are then validated, as discussed previously, and approved for reporting by the laboratory QA/QC coordinator. The final report requires the laboratory manager's approval prior to being issued. The project manager then compares the combined field and analytical data to the project goals.

For this project, the subcontractor laboratory, Coast-to-Coast Analytical Services (CCAS), will submit to SAIC all raw data in a report, which must include all Level 2 data package requirements. The requirements include, but are not limited to, the following:

- A summary of laboratory activities performed.
- A listing of laboratory identifications, project identification numbers, and field descriptions for all samples, blanks, and QA samples.
- A summary of exceeded holding times to include explanations.

- A table showing sample identification, analytical parameter, date sampled, date of laboratory receipt, extraction date, and date analyzed. Re-extraction and/or reanalysis dates should be included.
- QA discussion for each parameter, to include analytical anomalies, corrective actions, samples lost, and deviations from QAPP specifications. Any batch QC results should be reported.
- Copies of field chain-of-custody records.
- List of detection limits for all parameters.
- For volatiles, summary data sheets, including quantitation reports and chromatograms for each sample, surrogate recovery summary, matrix spike summary, method blank summary, tuning form, initial and daily calibration summary and quantitation report and chromatogram.
- A list of control limits used for surrogate recoveries, laboratory control samples, and MS/MSDs.

All samples (including canisters) will be maintained by CCAS until notified by SAIC that validation activities have been completed by SAIC. All raw data associated with this project will be retained by CCAS until notified by SAIC that the final report has been accepted by EPA.

Due to canister quantity limitations, it will be necessary to expedite the validation process for these analyses. CCAS will provide a preliminary analytical report including copies of quantitation reports via fax or overnight carrier within 72 hours of sample receipt. The SAIC QA/QC Coordinator will review this information within 48 hours of receipt. SAIC will then notify CCAS that canisters may be cleaned or additional analyses are needed.

3.6.4 Final Technical Report

The validated field and analytical data will be used to prepare the Innovative Technical Evaluation Report (ITER) evaluating the demonstration technology and assessing its potential applications. The ITER, TER, Demonstration Bulletin, and Engineering Capsule will contain, at a minimum, the information requirements as specified in the EPA guidance document entitled "SITE Program Guidelines and Procedures," Report Packages, October, 1993. The draft ITER report will be reviewed by Radian and the Private Partners and appropriate comments will be incorporated. The ITER will include a QA review and discussion as a separate and identifiable section. This review will include, at a minimum, the following information:

- A thorough discussion of the procedures used to define data quality and usability and the results of these procedures. The discussion will focus on the data quality indicators such as precision, accuracy, completeness, comparability and representativeness and will include summary tables of the QC data obtained during the demonstration. Results will be compared

to the data quality objectives set forth in the QAPP to provide an assessment of the factors that contributed to the overall quality of the data.

- The results of any technical systems and/or performance audits performed during the course of the project will be documented, including corrective actions initiated as a result of these audits and any possible impact on the associated data. If any internal audits were performed, these too will be reviewed.
- All changes to the original QAPP will be documented regardless of when they were made. The rationale for the changes will be discussed along with any consequences of these changes.
- The identification and resolution of significant QA/QC problems will be discussed. Where it was possible to take corrective action, the action taken and the result of that action will be documented. If it was not possible to take corrective action (for example, a sample bottle was broken in transit), this, too, will be documented.
- A discussion of any special studies initiated as a result of QA/QC issues and/or corrective actions, including why the studies were undertaken, how they were performed and how the results impacted the project data.
- A summary of any limitations on the use of the data will be provided including conclusions on how these constraints affect project objectives.

The QA section will provide validation of the measurements to be used in the evaluation (and subsequent acceptance/rejection) of the innovative technology. This section (and the final report) will be subject to review by the SAIC Work Assignment, QA, and Program Managers. The review will assess the assumptions made in evaluating the data and the conclusions drawn. The Program Manager must approve the reports prior to release.

3.7 INTERNAL QUALITY CONTROL

Reliable analytical measurements of environmental samples require continuous monitoring and evaluation for the analytical processes involved, i.e., quality assurance. To ensure optimum valid data generation, a scientifically sound and strictly adhered to quality control program must be incorporated into the sample collection and analytical laboratory program. Such a QC program employs a prescribed sequence of routine procedures to control and measure the quality of the data generated. Inherent in this program to maximize valid data generation is the use of scientifically sound sample collection procedures and approved analytical methods and calibration protocols, as described previously. Additionally, specific quality control samples, collected and analyzed by the appropriate methods, are introduced into the laboratory as a check on the overall analytical system. These samples are defined below and are summarized in Table 3-12 along with frequency and acceptance criteria. If deviations from acceptance criteria cannot be corrected by the laboratory, immediate notification of project management is necessary.

3.7.1 QC for Field Activities

The sampling strategy to be used to collect samples during the 2-phase extraction demonstration was presented in-depth in Section 3.4. The different types of field QC checks are described in detail below, along with frequency and acceptance criteria.

Field Duplicates

A field duplicate sample is defined as one of two sample aliquots collected simultaneously or sequentially. Field duplicate frequency is outlined in Table 3-4; field duplicates will be collected and analyzed for VOCs for groundwater and vapor samples.

Equipment Blanks

Collection and analysis of equipment blanks are intended as QC checks on equipment decontamination procedures. These blanks were discussed in Subsection 3.4.4 and the frequency of collection will be as shown in Table 3-4. Equipment blanks are collected for both groundwater and vapor samples and analyzed for volatiles.

Field Blanks

Field blanks will be collected with the aqueous samples to document contamination attributable to field handling procedures. Field blanks, consisting of clean Type I water will (or equivalent) be exposed to the atmosphere as are the samples and will be analyzed for volatiles by Method 8260. These field blanks will be collected at a frequency of five percent (see Table 3-4).

Trip Blanks

Trip blanks will be prepared for aqueous samples by filling 40 ml VOA vials with ASTM Type I reagent water, transferring them to the site, and then returning them to the lab unopened. Trip blanks are used to document contamination attributable to shipping and field handling procedures. Trip blanks will be analyzed for all volatile organic target compounds via Method 8260.

For the vapor samples, pressure checks in the field and the lab will be used to verify that leakage has not occurred.

3.7.2 QC for Laboratory Activities

This section describes the various types of internal quality control checks to be performed by the laboratory during the analyses of the critical parameters. Table 3-14 summarizes which QC checks will be performed for each parameter and the frequency, acceptance criteria and corrective action to be followed. Calibration procedures were discussed in Section 3.5.2 and are summarized in the table.

Laboratory Duplicates

For Method TO-14 analysis, laboratory duplicates will be used to evaluate precision at a frequency of 10 percent. Two sample volumes are measured out and analyzed in the same manner. The data from the sample and the duplicate will generate the relative percent difference (RPD). Laboratory duplicates will be analyzed as listed in Table 3-4.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

The use of a matrix spike and matrix spike duplicate (MS/MSD) is a means of measuring both precision and accuracy in an analysis. Three sample aliquots are measured out, and a known amount of the targeted analyte(s) is spiked into two of the aliquots at the same concentration. The three portions are then prepared and analyzed in the same manner. The analysis of the unspiked aliquot produces sample data, and the analysis of the two spiked aliquots generates recovery data (accuracy). Comparison of the results of the two spiked aliquots allows the calculation of the relative percent difference (RPD) between the

TABLE 3-14. SUMMARY OF LABORATORY INTERNAL QC CHECKS FOR THE TPE SITE DEMONSTRATION

Parameter	Matrix	Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
VOCs	Water	8260	Initial calibration	Initially and when continuing check unacceptable	RSD < 30% for method CCCs and critical volatiles	Recalibrate
			Continuing calibration	Every 12 hours	% Difference < 25% for method CCCs and critical volatiles	Recalibrate
			LCS	Each sample batch	% R = 70-130 ^a RPD < 30	Evaluate effect; re-analyze if necessary or flag data
			Method blank	Each sample batch or group of 20 samples	Concentration < method PQL	Evaluate effect; re-analyze if necessary, or flag data
			MS/MSD	Six groundwater and three waters exiting knock-out tank (See Table 3-4)	% R = 70-130 RPD < 30	Review analyses; notify SAIC QA/QC Coordinator; reextract, or flag data as appropriate
			Surrogates	All samples	See Table 3-14	Re-analyze if sample available, or flag data
VOCs	Vapor	TO-14	Canister cleaning verification	One per batch of 8 ^b	< 10 ppbv	Re-clean and re-check
			Tuning	Daily	See SOP in Appendix A	Correct problem, re-tune
			Initial Calibration	When continuing calibration not acceptable	RSD < 30% for all targets	Re-calibrate
			Continuing calibration	Daily	< 30% Difference for all targets	Re-calibrate
			Zero air blank	Every 10 samples	< 2 ppbv	Correct problem; re-analyze affected samples
			Surrogate	All samples and blanks	% R = 70-130%	Re-analyze
			Laboratory Control Sample	Each sample batch	70-130% ^a	Correct problem; reanalyze; notify SAIC QA/QC Coordinator
			Duplicates	Eight soil vapors and five vapors exiting knock-out tank (See Table 3-4)	RPD < 30	Re-analyze; notify SAIC QA/QC Coordinator

a For critical VOCs

b As an initial check on the canister cleaning system, all eight canisters in a batch will be analyzed by TO-14 for the first three batches.

two measurements (precision). MS/MSDs will be analyzed for water samples at the frequency presented in Table 3-4. The advantage of analyzing the MS/MSD groups instead of a matrix duplicate and a single matrix spike is the guarantee of duplicate concentrations to measure precision (as opposed to non-detected values). The specific VOCs to be used for spiking are listed in Table 3-15. This table includes the critical VOCs in addition to the compounds recommended in Method 8260. Spiking concentrations will be based on screening analyses performed (the spike concentration should be approximately two to three times the concentration present or ten times the target reporting limit, whichever is greater).

Laboratory Control Sample (LCS)

LSCs are standards with known amounts of analyte which are carried through the entire analysis procedure. Since this sample should yield consistent results, anomalous results indicate a laboratory problem rather than a matrix problem.

Laboratory control samples (LCS) will be used to measure accuracy during both Method 8260 and the TO-14 analyses. These LCSs will contain the critical VOCs at a minimum. For Method TO-14, the concentration of the LCS will range from 1-10 ppmv. NIST Standard Reference Material (SRM) 1804 is also used during TO-14 analyses as a routine check on analytical quality. This SRM contains the compounds listed in Table 3-16. SRMs will be analyzed with each analytical batch of samples.

Method Blanks

A method blank will be analyzed with each batch of samples analyzed, or every 20 samples, whichever is more frequent, for Method 8260 analyses. A method blank consists of an aliquot of reagent water carried through all preparation and analysis steps, and is designed to document that the analytical equipment and reagents are free of contamination and/or interferences. If method blanks are observed to be above the method practical quantitation limits for a given compound, the effect on the sample data should be evaluated. If the amount found in the blank is less than five percent of the amount found in the samples, the data can be flagged without reanalysis.

For Method TO-14, a zero air blank is analyzed following the calibration to ensure no contamination is introduced by the analytical system. In addition, a zero air blank is also run following every 10 samples and immediately following highly concentrated samples, in order to monitor any carry over in the analytical system. The concentration of target VOCs should be less than 2 ppbv.

TABLE 3-15. VOC SPIKING COMPOUNDS (Method 8260)

Compounds	
1,1-Dichloroethene	Chlorobenzene
Trichloroethene	Toluene
Tetrachloroethene	Benzene
Trichlorotrifluoroethene (Freon 113)	

Method 8260 - Specific QC Checks

Method 8260 for volatile organic analyses also employs surrogates and internal standards. The surrogates and acceptance criteria are listed in Table 3-17. Internal standards and acceptance criteria are as specified in Method 8260.

TABLE 3-16. VOCs IN NIST 1804

Benzene	Ethylbenzene
Bromomethane	Tetrachloroethene (PCE)
1,3-Butadiene	Toluene
Carbon tetrachloride	1,1,1-Trichloroethane (TCA)
Chloroform	Trichloroethene (TCE)
1,2-Dibromoethane (EDB)	Trichlorofluoromethane (F-11)
1,2-Dichloroethane (EDC)	Vinyl Chloride
Dichloromethane	Xylenes

TABLE 3-17. VOLATILE (METHOD 8260) SURROGATES RECOVERIES

Surrogate	% Recovery
4-Bromofluorobenzene	86 - 115
1,2-Dichloroethane-d ₄	86 - 118
Toluene-d ₈	88 - 110

Method TO-14 - Specific QC Checks

One surrogate standard, 2-bromochloropropane, is added to all samples and blanks. The acceptance criteria are 70-130 percent. Two internal standards, bromochloromethane and fluorobenzene, are also added to all samples and blanks. The internal standard response shall be no less than 50% and no more than 200% of the mean internal standard response recorded during the analysis of the continuing calibration standard.

3.8 PERFORMANCE AND SYSTEM AUDITS

Audits are independent means of confirming the operation or capability of a measurement system, and document the use of QC measures designed to generate valid data of known and acceptable quality. An audit is by necessity performed by a technically qualified person who is not directly involved with the measurement system being evaluated. A performance evaluation is generally an objective audit of a quantitative nature, and a systems audit is a qualitative evaluation of the capability of a measurement system to produce data of known and acceptable quality.

Mr. Joe Evans, SAIC's QA Manager for the SITE program, will review program performance and complete a Technical Systems Review (TSR) of procedures and methods for taking critical measurements specified in the QA Project Plan (QAPP). Mr. Evans, or his designee, will perform field and laboratory audits. Information obtained during these audits will be relayed back to the laboratory and field staff to ensure compliance with the QAPP and initiate corrective action when necessary.

3.8.1 Kick-Off Audit

Prior to any sample analyses, a kick-off audit will be conducted at the subcontractor laboratory to ensure that the contents of this QAPP are known and understood. Participants will include the SAIC QA Manager, SAIC Project Work Assignment Manager, Laboratory Project Manager, and analysts.

3.8.2 Performance Audits

Performance evaluation samples are not currently envisioned as an integral part of the project. However, the analytical laboratory has been participating in the EMSL Water Program Performance Evaluation Study as a requirement for the SITE Program. SAIC and CCAS will cooperate with the EPA or other regulatory agencies with Agency-requested performance and/or system audits. Any performance and/or system audits requested will be coordinated through the RREL QA Officer and the SAIC QA Manager.

Internal performance audits, which are conducted more frequently, consist of a "blind" spiked sample or reference standard introduced into the system unknown to the analyst, by an individual independent of the measurement system for that parameter. (Thus a matrix spike cannot be considered a performance audit since the analyst himself spikes the sample with a known amount. Lab data validation procedures, however, are a type of performance audit of the data reduction system since an independent analyst

performs a second review of the calculation steps which are used to generate the sample concentration). The results of any external and internal performance audits for this project will be reported to the QA Manager and made available for review.

3.8.3 System Audits

A system audit is a qualitative determination of the overall ability of a measurement system to produce data of known and acceptable quality, by an evaluation of all procedures, personnel, equipment, etc. utilized to generate the data. It is an evaluation of whether adequate QC measures, policies, protocols, safeguards, and instructions are inherent in the measurement system to enable valid data generation, and/or the immediate identification of outlier data and subsequent actions. Systems audits during the 2-phase extraction demonstration will be conducted by RREL QA personnel, under the direction of Ms. Ann Leitzinger, and SAIC's QA Manager, Mr. Joe Evans, and will include both field and analytical activities, including subcontractors.

A systems audit will review the project organization and technical personnel involved. The Radian project organization is designed to maintain the independence of the QA Manager. Field activities will be evaluated, including: proper sampling equipment, procedures for equipment maintenance and decontamination, acceptable sampling protocol, calibration procedures for field measurements, proper sample handling, storage and shipping procedures, and adequate field documentation and recordkeeping procedures.

A laboratory systems audit will include a review of the technical abilities of lab personnel involved with analyzing 2-phase extraction samples. Instrumentation will be evaluated with respect to technical acceptability, maintenance procedures and records, availability of spare replacement parts (and/or service contracts), and general upkeep. Analytical methodology for all critical measurements of the 2-phase extraction project will be reviewed, including all extraction/preparation steps, analysis steps, data reduction and validation procedures, applicable QC sample analysis records, calibration records and general recordkeeping/documentation practices. Additionally, sample handling and tracking procedures will be evaluated including sample receipt, chain-of-custody, sample storage, sample/standard segregation and results reporting. The SAIC QA Manager will perform a systems audit for the subcontractor labs or review any external and/or internal systems audit results for these labs.

3.9 CALCULATION OF DATA QUALITY INDICATORS

The quality assurance objectives established for the 2-phase extraction demonstration in Section 3.3 of this QAPP are measured by the analysis of the QC samples defined and described in Section 3.7. This subsection provides the equations and data reduction procedures used to obtain a quantitative measure of precision, accuracy, completeness, and method detection limit.

3.9.1 Precision

Precision is the ability of the measurement system to generate reproducible data. For most parameters precision is determined from the results of the analysis of duplicate samples and/or spiked duplicates, and is reported as relative percent difference (RPD).

$$RPD = \frac{(C_1 - C_2)}{\left(\frac{C_1 + C_2}{2} \right)} \times 100$$

Where,

C_1 = Sample result (or matrix spike result)

C_2 = Duplicate result (or matrix spike duplicate result)

Duplicate sample portions (or MS/MSD) are aliquoted in the laboratory and analyzed at a frequency specified in Table 3-11. Acceptance criteria are specified in the table in Section 3.7, and are generally based on the precision guidelines of the referenced method and project-specific needs.

3.9.2 Accuracy

Accuracy is defined as the nearness of the analytical result to the "true" value. Accuracy is assessed by the analysis of matrix spikes (for water samples) and reported as percent recovery:

$$\% \text{ Recovery} = \frac{C_1 - C_o}{C_t} \times 100$$

where C_1 is the measured concentration in the spiked sample, C_o is the measured concentration in the unspiked sample and C_t is the known concentration of analyte added to the sample.

If reference standards are used to assess accuracy (as for Method TO-14), then recovery is determined by:

$$\% \text{ Recovery} = \frac{C_D}{C_T} \times 100$$

Where, C_D is the determined concentration in the reference standard
and C_T is the true concentration of the reference standard.

3.9.3 Completeness

Data completeness is a measure of the extent to which the data base resulting from a measurement effort fulfills the objective for the amount of data required. For this program, completeness is defined as the percentage of valid data obtained compared to the total number of tests required to achieve a statistical level of confidence in the results.

$$\% \text{ Completeness} = \frac{V}{T} \times 100$$

Where, V is the number of measurements judged valid, and
T is the total number of measurements.

3.9.4 Target Reporting Limits

Target reporting limit objectives as presented in Table 3-7 are based on project objectives. These are target values which may vary based on sample matrix.

Laboratory MDLs are generally determined by analyzing replicates of a spike containing the analyte of interest at a concentration 3 to 5 times the estimated MDL. The MDL is then determined by:

$$\text{MDL} = t_{(n-1, \alpha = 0.99)} \times S$$

Where $t_{(n-1, \alpha = 0.99)}$ is the one-sided t-statistic appropriate for the number of replicates at the 99 percent level, and S is the standard deviation of the replicate analyses.

3.10 CORRECTIVE ACTION

Strictly defined sample handling procedures, calibration procedures, QC sample analyses and all associated acceptance criteria are all part of a comprehensive QA program which enables recognition of situations which do not meet specific QA/QC requirements. The specific corrective action steps to be taken in response to failed criteria are discussed in Section 3.7 (Internal Quality Control). This section of the QAPP discusses corrective action procedures as part of the QA program for the TPE demonstration.

3.10.1 Initiation of Corrective Action

The need for corrective action comes from several sources: equipment malfunction, internal QA/QC checks outside of acceptance criteria, deficiencies noted during performance or systems audits, and noncompliance with sampling/analysis/ QA requirements (e.g., hold times). In all instances, except for responding to audit findings, personnel (field and laboratory) directly performing the measurement task are responsible for identifying any nonconformance or potential problem with the protocols, equipment, or method. The responsible individual must immediately notify the appropriate supervisor that a problem exists. If the individual identifying the problem can correct it independently, such corrective action must take place before any further sample collection or analysis occurs. The corrective action to be taken must be determined on a case-by-case basis taking into account the nature of the problem and the extent of the error. Depending upon the circumstances, the specific steps to be taken and the initiation of the corrective action can be decided by the field/laboratory technician, the section supervisor, the laboratory QA Manager and/or the SAIC QA Manager, if necessary by all of them in conference.

3.10.2 Documentation of Corrective Action

If, at any time during analyses, a process is out of control, corrective action shall be taken, and documented, with regard to:

- What actions were taken to bring the process back into control.
- What actions were taken to prevent recurrences of the out of control situation.
- What was done with the data obtained while the process was out of control.

The documentation is accomplished by filling out a corrective action form (see example given in Figure 3-16). This form is initiated either by field or laboratory personnel, the appropriate supervisor or the QA Manager depending on where the problem is recognized. The report will include the following information:

- Nature of the problem
- Analytical parameter affected
- Sample lot affected
- Personnel responsible for identifying the problem
- Corrective action measure(s) taken and final disposition/resolution of the problem
- Dates
- Initials of the analyst or data reviewer



Field Corrective Action

Page ____ of ____

Audit Report No. ____

Date/Originator: _____

Person Responsible for Response: _____

Description of Problem and when identified: _____

Cause of problem if known or suspected: _____

Sequence of Corrective Action (state date, person, and action planned): _____

Corrective action approval: _____ Date: _____

Follow-up dates: _____

Description of follow-up: _____

Final corrective action approved by: _____ Date: _____

Figure 3-16. Example Field Corrective Action Form

3.11 QUALITY CONTROL REPORTS TO MANAGEMENT

The quality-related results, actions, and decisions required by this Quality Assurance Project Plan, and other documents describing the 2-phase extraction demonstration project necessitate a reporting mechanism to keep project management informed as to project status. These reports, discussed below, are intended to provide management with the information necessary to assess the adequacy and success of the QA program and represents a minimum requirement.

3.11.1 Monthly Reports

A detailed report on quality-related activities will be prepared monthly by the SAIC Project QA Coordinator and submitted to SAIC's QA Manager (QAM), Mr. Joe Evans. Information submitted in this report will include: any proposed changes or modifications to the QAPP, summary of field QA/QC activities, laboratory QA/QC activities, and an overall tentative assessment of data quality to date. Any proposed deviations from the QAPP will be approved by the QAM and EPA prior to implementation. The reports will discuss any problem conditions and corrective actions, audit events and results, sampling and analysis QA/QC status, and a general review of the achievement of data objectives for the project.

3.11.2 Final Report

The final demonstration report will include a separate QA section that documents the QA/QC activities which lend support to the credibility and validity of the data as discussed in Section 3.6.4. A summary of the data quality information will be provided including an assessment of the QA objectives which were achieved and which, if any, were not, why they were not, and the impact to the project.

3.12 REFERENCES

1. U.S. Environmental Protection Agency, Test Methods for Evaluating Solid Waste (SW-846), Third Edition. November, 1986.
2. U.S. Environmental Protection Agency, Test Methods for Evaluating Solid Waste (SW-846), Third Edition, Final Update, September 1990.
3. U.S. Environmental Protection Agency, SITE Program Guidelines and Procedures - Report Packages, October 1993.
4. EPA Compendium of Methods for the Determination of Toxic Organics in Ambient Air.
5. RREL Preparation Aids for the Development of Category II Quality Assurance Project Plans.
6. Radian Corporation, Operable Units A & B Dual-Phase Extraction Pilot Testing. Draft Work Plan, October 8, 1993.
7. H&A of New York, Case Study-Xerox Building 209 2-Phase Vacuum Extraction System, Webster, New York, February 1993.
8. Radian Corporation, McClellan Air Force Base Operable Unit B, Xerox Two-Phase Extraction System Demonstration Test, Work Implementation Plan (Working Copy), May 17, 1994.

APPENDIX A

Coast-to-Coast Analytical Services SOP for

- **Method TO-14 (VOCs in SUMMA Canisters)**



COAST-TO-COAST ANALYTICAL SERVICES, INC.

STANDARD OPERATING PROCEDURE

for

DETERMINATION OF VOLATILE ORGANIC CONSTITUENTS IN AMBIENT AIR BY EPA METHOD TO-14

DOCUMENT # AL-EPA TO-14
Revision: 3
Date: Dec. 15, 1993
Author: Gesheng Dai, Ph.D.

Approved by:

Laurence R. Hilpert, Ph.D.
QA Officer

Approved by:

Mary Havlicek, Ph.D.
Laboratory Director

COAST-TO-COAST ANALYTICAL SERVICES, INC

STANDARD OPERATING PROCEDURE

DETERMINATION OF VOLATILE ORGANIC CONSTITUENTS
IN AIR BY EPA TO-14

1. Scope

1.1 This document describes a procedure for analysis of volatile organic compounds in ambient air. The method is based on collection of whole air samples in SUMMA passivated stainless steel canisters. The volatile organics are isolated from the air matrix cryogenically, separated by capillary column gas chromatography and detected by mass spectrometry. Samples collected to final pressures above, at, or below atmospheric pressure are acceptable for measurement by this method.

1.2 This method is applicable to volatile organic compounds that have been tested and determined to be stable when stored in pressurized and sub-atmospheric pressure canisters. Compounds which have been determined by the method are shown on the sample analytical report presented as Exhibit 1. Other volatile organic compounds may be measured by this method, however, performance of the method for the specific compound(s) must be demonstrated.

2. Summary of Method

2.1 Ambient air samples are collected into SUMMA electropolished stainless steel canisters. Both subatmospheric pressure and pressurized sampling modes use an initially evacuated canister to collect the sample. Pressurized sampling requires the use of cryogenic techniques or a sampling pump to provide positive pressure to the sample canister. Time-integrated samples may be collected by utilizing a calibrated critical flow orifice to introduce the sample into the canister at a constant rate for a specified period of time.

2.2 Following sample collection, the canister valve is closed, an identification tag is attached to the canister, a Canister Sampling Field Data Sheet is completed, and the canister is transported to the laboratory for analysis.

2.3 Upon receipt in the laboratory, the sample is logged in by sample control, sample information and canister ID's are checked with the chain-of-custody, and laboratory worksheets are prepared.

2.4 The pressure in the canister is measured and recorded on the chain-of-custody document and the laboratory worksheet. Samples received at sub-ambient pressures are pressurized to 10-30 psig using ultra-pure helium which has been certified free of contamination. The final canister pressure is recorded on the worksheet.

2.5 The analytical strategy for Method TO-14 involves cryogenic isolation of the analytes from the sample followed by high resolution capillary column GC/MS. In cases where very humid samples are analyzed, the moisture is removed by passing the sample through a short Ascarite cartridge or Nafion tubing prior to cryogenic trapping of the analytes. Internal and surrogate standards are added to the sample at the same time as the analytes are cryogenically isolated from the sample. The mass spectrometer is operated in either the full scan or selected ion monitoring (SIM) modes. Mass spectral data are obtained and recorded on magnetic media during the entire course of the GC/MS analysis. Lower detection limits can be attained for samples analyzed in the SIM mode, however, the number of analytes which can be determined is generally limited, and unique information contained in the full scan mass spectrum is not obtained. In the full scan mode the mass spectrometer operates as a universal detector and the resulting mass spectra permit unambiguous identification of target analytes as well as non-target analytes whose mass spectra can be interpreted by experienced mass spectrometrists. Due to the low concentrations of VOCs encountered in ambient air (generally less than 5 ppbv, and many below 1 ppbv) and the need for unambiguous compound identification, CCAS strongly recommends the use of mass spectrometric detection over GC selective detector methods such as photoionization detection (PID), electron capture detection (ECD), nitrogen-phosphorus detection (NPD), or non-selective detection methods such as flame ionization detection (FID).

3. Interferences and Limitations

3.1 Contamination may occur in the sampling system if canisters are not properly cleaned before use. Additionally, other equipment in the sampling train (pumps, tubing, filters, flow controllers) may introduce contamination and should therefore be thoroughly cleaned and tested prior to use to ensure that the sampling train will not contaminate the samples.

3.2 Interferences can occur in sample analysis if excessive moisture requires water removal using Nafion or Ascarite and moisture accumulates in the Nafion tubing or Ascarite cartridge. In cases where sample moisture is not a problem, Nafion or Ascarite are not used, and samples are transferred directly to the cryogenic trapping system. Since polar organic compounds may also permeate the Nafion tubing along with water, the analyst must be aware of the potential loss of polar compounds when analyzing moist samples using Nafion tubing. Similarly, compounds which react with base may be lost upon passage through Ascarite, and the analyst must be aware of the potential loss of base sensitive compounds when using Ascarite.

3.3 Impurities in the dilution gas and carrier gas and organic compounds out-gassing from the inlet system and GC plumbing may cause interference and contamination problems. The analytical system must be demonstrated to be free from contamination under the conditions of the analysis by analyzing zero air blanks prior to sample batches.

3.4 Significant contamination of the analytical system can occur whenever samples containing high VOC concentrations are analyzed. This in turn can result in carryover contamination in subsequent analyses. Whenever an unusually concentrated sample is encountered, it should be followed by analysis of zero air to document that the analytical system is free of contamination.

4. Apparatus and Equipment

4.1 Subatmospheric Pressure Sampling

4.1.1 CCAS recommends the use of either stainless steel or heavy walled Teflon tubing for the sample inlet line.

4.1.2 Sample canister - SUMMA passivated stainless steel canisters are available from a number of commercial suppliers. CCAS' major supplier is Scientific Instrumentation Specialists, Inc., Moscow, ID.

4.1.3 Vacuum/pressure gauge - capable of measuring vacuum (0 to -30 in.Hg) and pressure (0 to 30 psig) in the sampling system. Vacuum or pressure in the sample canister is measured immediately prior to analysis.

4.1.4 Flow controllers - CCAS recommends the use of compensating critical orifice flow controllers for subambient pressure sample collection. The critical orifices are laboratory calibrated, contain a tamper resistant cap to prevent inadvertent adjustment of flow rate, and circumvent the need for a sampling pump when obtaining time-integrated samples.

4.1.5 Particulate matter filter - 2 um sintered stainless steel in-line filter.

4.2 Pressurized Sampling

4.2.1 Sample pump - CCAS utilizes metal bellows pumps of the Rasmussen type which utilize, in order, a pump, a mechanical flow regulator, and a mechanical flow restricting device (back pressure flow regulator).

4.2.2 Sample transfer lines - all transfer lines with which the sample comes in contact should be chromatographic grade stainless steel or heavy walled Teflon tubing. All components of the sampling train should be tested for cleanliness prior to use.

4.3. GC/MS Analytical System

4.3.1 CCAS utilizes quadrupole mass spectrometer systems capable of acquiring and processing data in the full scan and selected ion monitoring modes. The mass spectrometer is operated in the electron impact (EI) mode with an electron energy of 70 eV. Ions in the mass range m/z 41-230 are collected and measured repeatedly during the course of the GC run. The mass spectrometer is scanned at such a rate that at least 6 data points are acquired across each chromatographic peak. The quadrupole gas chromatograph/mass spectrometer/data system consists of a Hewlett-Packard Model 5890 gas chromatograph, an HP 5970B mass selective detector, and an HP RTE data system.

4.3.2 Gas chromatographs - The gas chromatographs used are Hewlett Packard Model 5890's, capable of subambient temperature programming and which contain other generally standard features such as pressure control flow regulators, multi-level temperature programming, and heated capillary interfaces.

4.3.3 Cryogenic trap - CCAS utilizes a manual cryogenic trapping system for isolating volatile organic compounds from the sample and transferring them to the analytical GC/MS system. The system utilizes an evacuated reservoir, six-port and eight-port chromatographic switching valves, and a high accuracy vacuum gauge.

4.3.4 Vacuum pumps - CCAS employs general purpose vacuum pumps of the type specified in EPA TO-14.

4.3.6 Chromatographic column - 30m x 0.25mm i.d. fused silica capillary column with 1.0u film of DB-5 liquid phase.

4.3.7 Stainless steel cylinder pressure regulators standard, two-stage, compressed gas cylinder regulators

with pressure gauges for helium, zero air, and standard gas cylinders.

4.3.8 Gas Tight Syringes - Gas tight syringes in various sizes from 1 uL to 50 mL.

4.4 Canister Cleaning System

4.4.1 Vacuum pump - capable of evacuating sample canisters to an absolute pressure of -29.5 in. Hg.

4.4.2 Manifold - manifold with stainless steel and Teflon transfer lines and connections for cleaning up to eight canisters simultaneously.

4.4.3 Stainless steel vacuum gauge - capable of measuring vacuum in the manifold to an absolute pressure of -29. in Hg or less.

4.4.4 Cryogenic traps - One stainless steel U-shaped open tubular trap cooled with liquid nitrogen placed between vacuum pump and remainder of manifold cleaning system. Zero nitrogen for flushing canisters is distilled from cryogenic liquid nitrogen Dewar.

4.4.5 Stainless steel flow control valve - to regulate flow of zero nitrogen into canisters.

4.4.6 Heating Manifolds - CCAS uses individually thermostated heating manifolds for heating canisters.

4.5 Reagents and Materials

4.5.1 Gas cylinders of ultrahigh purity helium, nitrogen, and zero air.

4.5.2 Gas standards - Primary standard is NIST Standard Reference Material (SRM) 1804 containing 18 volatile organic compounds at approximately 5.0 ppbv. Secondary standards prepared by CCAS contain additional analytes at concentrations traceable to NIST SRM 1804.

4.5.3 Cryogens - CCAS utilizes both liquid argon (for cryogenic trap) and liquid nitrogen (for cryogenic GC oven).

4.5.4 4-Bromofluorobenzene (BFB) - introduced as a gaseous standard through the sample transfer system for monitoring mass spectrometer tuning.

4.5.5 Internal standards (bromochloromethane and fluorobenzene) and surrogate standard (2-bromochloropropane) - introduced as gaseous standards through the sample transfer system for quantitative

measurement and for monitoring sample transfer system efficiency.

4.5.6 Perfluorotributylamine (PFTBA) - introduced through a batch inlet system; used for mass spectrometer tuning (see Section 6.1.1).

4.5.7 Solvents - methanol, reagent grade

5. Analytical Measurement

5.1 GC/MS System Performance Criteria

5.1.1 GC/MS System Operation

5.1.1.1 Prior to analysis, the GC/MS system is assembled and checked according to the manufacturer's instructions.

5.1.1.2 Table 1.0 outlines operating conditions for the GC/MS system.

5.1.2 GC/MS Tuning & Verification

5.1.2.1 Initial tuning of the mass spectrometer is performed using perfluorotributylamine (PFTBA). At the beginning of each day, the tuning of the GC/MS system is checked to verify that acceptable mass spectra, capable of providing acceptable results when subject to computer search algorithms are achieved. Acceptable tuning of the GC/MS system is verified each day by analysis of the 4-bromofluorobenzene (BFB) standard (see 5.1.2.2 below). If acceptance criteria for the BFB standard are not met, the mass spectrometer must be retuned using PFTBA.

5.1.2.2 The BFB standard is introduced via the sample loop valve injection system and analyzed to insure that the tuning criteria are met. The specific ions and ion abundance criteria are presented in Table 2.0. Sample analysis can not begin until BFB ion abundance criteria are met. If the ion abundance criteria for any ion falls outside the acceptable range, the mass spectrometer must be retuned and the BFB analysis repeated until all acceptance criteria are met.

5.1.2.3 Assessment of GC column performance - BFB is added to every sample to monitor the GC column performance. Deviation from a symmetrical gaussian shaped peak is indication that the column performance has degraded or there are active sites in the analytical system.

TABLE 1.0

GC/MS OPERATING CONDITIONS FOR EPA METHOD TO-14

Gas Chromatography

Column: 30m x 0.25mm i.d. 1.0u DB-5 methyl silicone
(J & W Scientific, Folsom, CA), or equivalent
Carrier gas: Helium @ 7 psig
Flow control: Pressure regulation
Injection mode: Cryogenic focussing followed by thermal
desorption

Temperature program

Initial temp: 40 C
Initial hold time: 3 min
Program rate: 25 C/min to 85 C
hold 85 C 2 min
8.5 C/min to 130 C
hold 130 C 0 min
30 C/min to 225 C
Final temp: 225 C
Final hold time 1.5 min

Mass spectrometry

Instrument: Hewlett-Packard HP 5970B MSD
Ionization mode: Electron Impact, 70 eV
Source Temp: 200 C
Mode: Full Scan
Mass range: 41 to 200 amu
Scan rate: 200 amu/sec

TABLE 2.0

4-BROMOFLUOROBENZENE ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
50	15-40% of mass 95
75	30-60% of mass 95
95	Base peak, 100% relative abundance
96	5-9% of mass 95
173	Less than 2% of mass 174
174	Greater than 50% of mass 95
175	5-9% of mass 174
176	95-101% of mass 174
177	5-9% of mass 176

5.1.2.4 A Zero Air Blank is analyzed following analysis of the BFB tuning verification standard and prior to analysis of any samples to verify that the analytical system is free from any background contamination. If analysis of the zero air blank shows concentrations for any of the target analytes greater than or equal to the Practical Quantitation Limit (PQL) for that compound, the analytical system must be cleaned and analysis of the zero air blank repeated until concentrations for all target analytes are below the PQL or 0.2 ppbv, whichever is greater.

5.1.3 GC/MS Calibration

5.1.3.1 Initial Calibration - An initial 5-point calibration is performed using a calibration standard traceable to NIST SRM 1804 which contains all constituents to be determined in the samples. Response factors for each target analyte relative to the internal standard are determined according to the following equation:

$$RF(i) = \frac{A(i)}{C(i)} \times \frac{C(IS)}{A(IS)}$$

where: $A(i)$ = area for compound i
 $C(i)$ = concentration for compound i
 $C(IS)$ = concentration for IS
 $A(IS)$ = area for IS

The mean response factor and associated standard deviation for each analyte at the five concentrations are determined. The standard deviations for the RFs must be less than 30% for each analyte. If these criteria are not met, the initial calibration must be re-established.

5.1.3.2 Continuing Calibration - Verification of the analytical system calibration is carried out on a daily basis by analysis of a mid-level calibration standard. The RFs must be within $\pm 30\%$ of the mean RF for each analyte from the initial calibration. If the RFs fall outside this range, a new initial calibration must be established.

5.1.3.3 Surrogate Standard Calibration - calibration for the surrogate standard is established by determining the mean response factor (RF) from multiple measurements at the same concentration.

See section 6.2.3 for performance criteria for continuing calibration of surrogate standard.

5.2 Analytical Procedures

5.2.1 Canister Receipt

5.2.1.1 The overall condition of each sample canister is observed. Any signs of damage or missing tags or labels are immediately reported to the client. Any discrepancy between information recorded on the sample Chain-of-Custody or Field Canister Data Sheet and that recorded on the canister or canister tag is noted and reported to the client.

5.2.1.2 Each canister is logged in by the Sample Control department, and given a unique laboratory number for tracking and reporting purposes. Data pertaining to sample description, date collected and received are entered into the Laboratory Information Management System (LIMS).

5.2.1.3 Initial Canister Pressure Check - Upon receipt in the laboratory, the pressure of each sample canister is checked by attaching a pressure gauge to the canister inlet. The canister valve is opened briefly, and the pressure/vacuum is measured and recorded on the laboratory worksheet and the Canister Sampling Field Data Sheet accompanying each sample. Samples received at subambient pressures are pressurized using certified clean ultra-pure helium.

5.2.2 Sample Analysis

5.2.2.1 Analysis of samples can proceed only after satisfactory analyses of the BFB mass spectrometer performance standard (see 5.1.2.2) and the Zero Air Blank (see 5.1.2.4). The sample canister is connected to the inlet of the cryogenic trapping system. The canister valve is opened, and the sample flow is directed through the six port chromatographic valve to the trapping loop which is immersed in liquid argon (-185 C). The sample is loaded onto the trapping loop at a flow rate of approximately 200 mL/min. Approximately 250-500 mL of sample is analyzed. The sample volume analyzed is recorded in the GC/MS system logbook.

5.2.2.2 Simultaneous with transfer of the sample onto the cryogenic trapping loop, internal standards (bromochloromethane and fluorobenzene) and surrogate standard (2-bromochloropropane) are loaded

onto the trap from a 0.25 mL sample loop. The sample and internal standards/surrogate standard are introduced in the following sequence: Approximately one half of the analytical sample volume is loaded, then the second half of the sample is used to flush the internal standard/surrogate standard loop onto the cryogenic trapping loop. The GC oven is cooled to the initial set point of 40 C as the sample and internal standard are transferred to the cryogenic trapping loop.

5.2.2.3 After the sample is preconcentrated in the cryogenic trap, the sampling valve is cycled to the inject position and the cryogenic trap is heated using a hot air gun. The trapped analytes are thermally desorbed onto the head of the DB-5 capillary column where they are cryogenically focussed.

5.2.2.4 The chromatographic analysis is initiated following completion of the thermal desorption from the cryogenic trap and refocussing at the head of the capillary column. The chromatographic column is temperature programmed from 40 C, with an initial hold time of three minutes, at a rate of 25 degrees per minute to 85 C, hold two minutes, then at a rate of 8.5 C per minute to 130 C, change rate to 30 C per minute, to final temp of 225 C. The mass spectrometer is signaled by the computer to scan from m/z 41 to 230 repetitively during the entire course of the chromatographic run. Mass and intensity data for all ions detected as well as retention time data are stored on magnetic media for subsequent data analysis.

5.2.2.5 Compound identification is based on comparison of mass spectra and retention time data for sample constituents with those of the standards. Concentrations are calculated in ug/cu.M using the response factors determined from the initial calibration and verified during the continuing calibration check. All qualitative identifications and quantitative measurement values are reviewed by a Ph.D. chemist experienced in the interpretation of mass spectral data.

5.3 Canister Cleaning and Certification Procedures

5.3.1 Canister Cleaning Procedures

5.3.1.1 Connect the canisters to be cleaned to the canister cleaning system manifold. Open the vent valve and the canister valves to release any remaining pressure in the canisters. Start the

vacuum pump, close the vent valve and then open the vacuum valve. Evacuate the canisters to at least -29. in. Hg and hold this vacuum for at least one hour.

5.3.1.2 Close the vacuum and vent valve and open the nitrogen valve and pressurize the canisters to 30 psig with ultra pure nitrogen distilled from a Dewar of liquid nitrogen.

5.3.1.3 Close the nitrogen valve and open the vent valve and allow the canisters vent down to atmospheric pressure. Close the vent valve.

5.3.1.4 Repeat above procedures 3 times. The total evacuation/pressurization cycles for each set of canisters should be at least three times. The canister cleaning system has been set up to cycle through the evacuation/pressurization cycles automatically.

5.3.1.5 At the end of the evacuation/pressurization cycle, re-evacuate to < 29. in. Hg vacuum. The evacuated canister is now ready for leak testing and/or certification analyses.

5.3.2 Leak Testing of Canisters

5.3.2.1 Pressurize the canister to 30 psig with zero air. Maintain the canister for 24 hours then remeasure the pressure. If the pressure drops < 0.05 psig indicate there is no leak for the canister.

5.3.2.2 Evacuate the canister to -29.5 in. Hg. Maintain the canister under vacuum for 24 hours then remeasure the vacuum. The vacuum should not decrease by more than 0.1 in. Hg.

5.3.3 Canister Certification

5.3.3.1 Pressurize the cleaned canister to 20 psig with ultra high purity helium. Analyze the canister according to procedures specified in this SOP. If the concentrations for all the target compounds are below PQL or 0.2 ppbv, whichever is greater, then the canister is considered clean. Attach a blue gummed label to the canister and enter the analysis date and the analyst's initials on the blue dot. If any target compound is found above PQL the canister is considered unacceptable for use. A yellow dot is attached to the canister and it is returned for recleaning.

5.3.3.2 For each batch of cleaned canisters (8 canisters per batch) at least one canister is randomly selected for cleanliness certification. A history of all canister usage is maintained in canister log books.

Copies of the total ion chromatograms and quantitation reports for each of the canister cleanliness checks are maintained by the Air Toxics Group Leader.

6. Performance Criteria and Quality Assurance

6.1 Initial Checks of Analytical System Performance

6.1.1 Mass spectrometer tuning with PFTBA - the mass spectrometer must be tuned to yield a mass spectrum for PFTBA which has the following characteristics:

<u>Ion</u>	<u>Relative Abundance</u>
69	100% (base peak)
131	< m/z 219
219	30 - 100%
502	1 - 6%

Failure to achieve an acceptable spectrum for PFTBA indicates a need for ion source and/or mass filter (quadrupole or ion caps) cleaning.

6.1.2 Verification of mass spectrometer tuning with BFB - Analysis of a BFB standard must yield ion abundances in the ranges shown in Table 2.0 (see section 5.1.2.2). A typical GC/MS Performance Standard check report is shown as Exhibit 2.

6.2 Continuing Calibration Checks

6.2.1 Continuing Calibration for Target Analytes - Calibration for target analytes is checked on a daily basis by monitoring the relative percent difference (RPD) of the RFs from the mean RFs. The RPD must be $\leq 30\%$ or a new calibration must be established.

6.2.2 Internal Standard Response - The internal standard response shall be no less than 50% and no more than 200% of the mean internal standard response recorded during the analysis of the continuing calibration standard. The retention time shift should not be more than 20 seconds from the latest daily calibration check.

6.2.3 Surrogate Standard Response - Calibration for the surrogate is checked on a daily basis by monitoring the relative percent difference (RPD) of the RF from the mean

RF. The RPD must be $\leq 30\%$ or a new calibration must be established. The retention time shift of surrogate also should not be more than 20 seconds.

6.3 Analytical System Blanks

6.3.1 A Zero Air Blank is analyzed following the standard(s) and prior to any samples to insure no contamination is introduced by the analytical system. In addition, a Zero Air Blank is also run following every ten samples, and immediately following highly concentrated samples, in order to monitor any carryover in the analytical system.

6.4 Sample Duplicates

6.4.1 A sample duplicate is analyzed at least once every ten samples or once per analytical batch, whichever frequency is greater.

6.5 Quality Assurance Spike or Laboratory Control Samples

6.5.1 A Quality Assurance Spike, or Laboratory Control Sample consisting of an aliquot of NIST SRM 1804, is analyzed at least once every 12 hours or once per analytical batch, whichever frequency is greater. Since the analyte concentrations in SRM 1804 are accurately known, comparison of the measured values with the "true" or "certified" values demonstrates whether the entire analytical system is operating under control. Percent recovery for each analyte is calculated according to the formula:

$$\text{LCS \% Recovery} = \frac{\text{Measured Value}}{\text{Spiked Value}} \times 100\%$$

Acceptable % recoveries for all spiked analytes must fall within a range of $100 \pm 30\%$. If the % recovery for any analyte fails to fall within this acceptance range, the analytical system is considered "out of control" and corrective action up to and including recalibration must be performed and the analysis of SRM 1804 repeated until acceptable % recovery data are obtained. An example of a Quality Assurance Spike report is shown as Exhibit 3.

7. Method Safety

This procedure may involve hazardous materials, operations, and equipment. This SOP does not purport to address all of the safety problems associated with its use. The user is referred to the CCAS Health and Safety Manual to establish appropriate safety and health practices prior to the implementation of this procedure.

Material Data Safety Sheets (MSDSs) for all of the chemicals and reagents utilized by this method are available from the CCAS Safety Officer.



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COAST-TO-COAST ANALYTICAL SERVICES, INC.

SoCal Division (Camarillo Laboratory)
4765 Calle Quetzal, Camarillo, California 93012

(805) 389-1353
FAX (805) 389-1436

CLIENT: Coast-to-Coast Analytical Services, Inc.

Analyzed : 01/20/94
Analyzed by: YL
Method : EPA TO-14

INSTRUMENT BLANK REPORT OF ANALYTICAL RESULTS

Page 1 of 2

FILE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE RECEIVED		
INSTRUMENT BLANK	Air				
CONSTITUENT	(CAS RN)	*PQL µg/cu M	RESULT µg/cu M	NOTE	
VOLATILE ORGANICS BY EPA TO-14					
Acetone	(67641)	3.	ND		
Benzene	(71432)	0.5	ND		
1,1-Dichloromethane	(75274)	1.	ND		
Bromomethane (Methyl Bromide)	(74839)	1.	ND		
Chloroform	(75252)	1.	ND		
1,3-Butadiene	(106990)	1.	ND		
Butanone (MEK)	(78933)	1.	ND		
Carbon Disulfide	(75150)	5.	ND		
Carbon Tetrachloride	(56235)	1.	ND		
Chlorobenzene	(108907)	0.5	ND		
Chloroethane (Ethyl Chloride)	(75003)	0.5	ND		
1-Chloroethyl Vinyl Ether	(110758)	5.	ND		
Chloroform	(67663)	3.	ND		
Chloromethane (Methyl Chloride)	(74873)	0.5	ND		
Bromochloromethane	(124381)	1.	ND		
1,2-Dibromoethane (EDB)	(106934)	2.	ND		
1,2-Dichlorobenzene	(95501)	1.	ND		
1,3-Dichlorobenzene	(541731)	1.	ND		
1,4-Dichlorobenzene	(106467)	1.	ND		
1,1-Dichloroethane	(75343)	0.5	ND		
1,2-Dichloroethane (EDC)	(107062)	1.	ND		

Lab Certifications: CAELAP #1598 & #1783; UTELAP #E-142; AZELAP #AZ0162; A2LA #0136-01; L.A.Co.CSD #10

*RESULTS listed as 'ND' were not detected at or above the listed PQL (Practical Quantitation Limit)

(1) Concentrations in ug/cu M reported at 760 mm Hg pressure and 298 deg. K.

01/21/94
MS1/1P17K
GD/ge
CK9401-20

COAST-TO-COAST ANALYTICAL SERVICES, INC.

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4765 Calle Quetzal, Camarillo, California 93012(805) 389-1353
FAX (805) 389-1438

CLIENT: Coast-to-Coast Analytical Services, Inc.

Analyzed : 01/20/94
Analyzed by: YL
Method : EPA TO-14INSTRUMENT BLANK
REPORT OF ANALYTICAL RESULTS

Page 2 of 2

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE RECEIVED		
INSTRUMENT BLANK	Air				
CONSTITUENT	(CAS RN)	*PQL µg/cu M	RESULT µg/cu M	NOTE	
1,1-Dichloroethene	(75354)	1.	ND		
cis-1,2-Dichloroethene	(156694)	1.0	ND		
trans-1,2-Dichloroethene	(156605)	1.	ND		
Dichloromethane	(75092)	5.	ND		
1,2-Dichloropropane	(78875)	0.5	ND		
cis-1,3-Dichloropropene	(10061015)	0.5	ND		
trans-1,3-Dichloropropene	(10061026)	0.5	ND		
Ethylbenzene	(100411)	1.	ND		
2-Hexanone	(591786)	0.5	ND		
4-Methyl-2-Pentanone (MIBK)	(108101)	0.5	ND		
Styrene	(100425)	1.	ND		
1,1,2,2-Tetrachloroethane	(79345)	1.	ND		
Tetrachloroethane (PCE)	(127184)	1.	ND		
Toluene	(108883)	1	ND		
1,1,1-Trichloroethane (TCA)	(71556)	1.	ND		
1,1,2-Trichloroethane	(79005)	1.	ND		
Trichloroethene (TCE)	(79016)	0.5	ND		
Trichlorofluoromethane (F-11)	(75694)	1.	ND		
Trichlorotrifluoroethane (F-113)	(76131)	2.	ND		
Vinyl Acetate	(108054)	2.	ND		
Vinyl Chloride	(75104)	0.5	ND		
Xylenes	(1330207)	1.	ND		

Lab Certifications: CAELAP #1598 & #1783; UTELAP #E-142; AZELAP #AZ0162; A2LA #0136-01; L.A.Co.CSD #1018
 *RESULTS listed as 'ND' were not detected at or above the listed PQL (Practical Quantitation Limit)

01/21/94
MS1/1P17K
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CK9401-20Respectfully submitted,
COAST-TO-COAST ANALYTICAL SERVICES, INC.Gesheng Dai, Ph.D.
Air Toxics Group Leader

Exhibit 2

Bromofluorobenzene (BFB)

m/z	Ion Abundance Criteria	% Relative Abundance Base Peak	% Relative Abundance Appropriate Peak	Status
50	15-40% of mass 95	24.18	24.18	Ok
75	30-60% of mass 95	48.97	48.97	Ok
95	Base peak, 100% relative abundance	100.00	100.00	Ok
96	5-9% of mass 95	6.47	6.47	Ok
173	Less than 2% of mass 174	.66	.75	Ok
174	Greater than 50% of mass 95	87.59	87.59	Ok
175	5-9% of mass 174	6.63	7.57	Ok
176	95-101% of mass 174	85.88	98.04	Ok
177	5-9% of mass 176	5.72	6.66	Ok

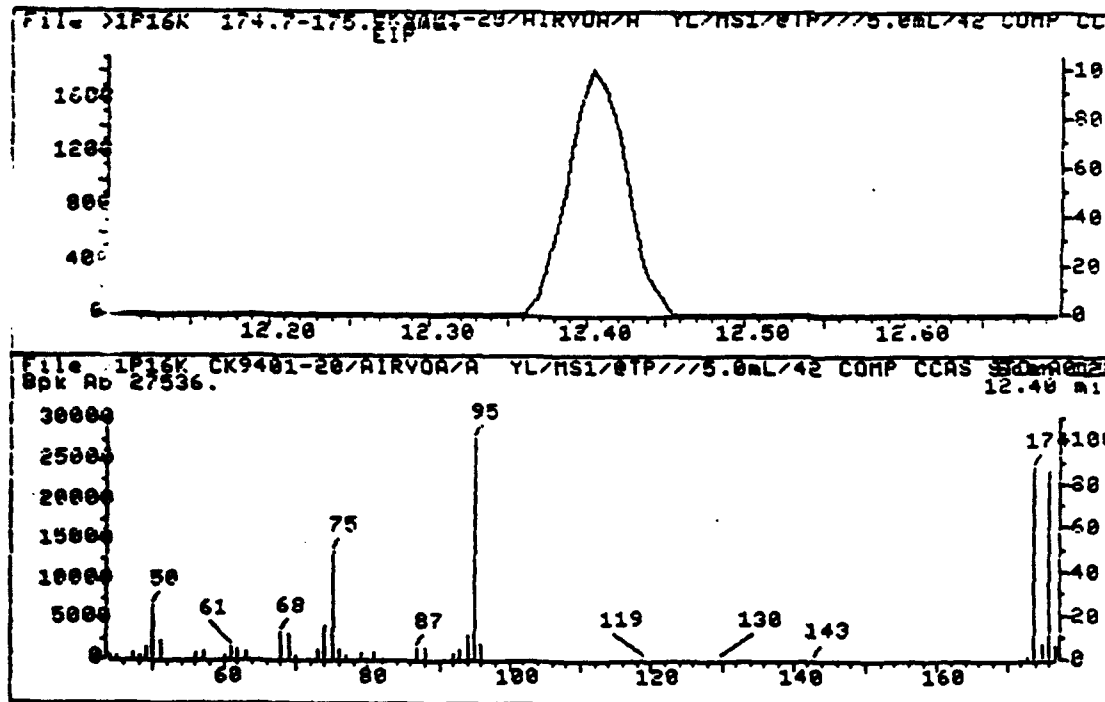
Injection Date: 01/20/94
 Injection Time: 11:35
 Data File: >1P16K
 Scan: 1220

BFB ok

gl

1/20/94

FMGR : AL



COAST-TO-COAST ANALYTICAL SERVICES, INC.

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(805) 389-1353
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CLIENT: Coast-to-Coast Analytical Services, Inc.

Analyzed : 01/20/94
Analyzed by: YL
Method : EPA TO-14

QC SPIKE REPORT OF ANALYTICAL RESULTS

Page 1 of 2

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE RECEIVED		
QC SPIKE	Air				
CONSTITUENT	*PQL µg/cu M	SPIKE AMOUNT	RESULT µg/cu M	%REC	NOTE
VOLATILE ORGANICS BY EPA TO-14					1,2
Acetone	3.		NS		
Benzene	0.5	16.	14.	88.	
Bromodichloromethane	1.		NS		
Bromomethane (Methyl Bromide)	1.	21.	16.	76.	
Bromoform	1.		NS		
1,3-Butadiene	1.	10.	8.1	81.	
2-Butanone (MEK)	1.		NS		
Carbon Disulfide	5.		NS		
Carbon Tetrachloride	1.	31.	36.	116.	
Chlorobenzene	0.5	23.	22.	96.	
Chloroethane (Ethyl Chloride)	0.5		NS		
2-Chloroethyl Vinyl Ether	5.		NS		
Chloroform	3.	25.	24.	96.	
Chloromethane (Methyl Chloride)	0.5		NS		
Dibromochloromethane	1.		NS		
1,2-Dibromoethane (EDB)	2.	10.	7.1	71.	
1,2-Dichlorobenzene	1.		NS		
1,3-Dichlorobenzene	1.		NS		
1,4-Dichlorobenzene	1.		NS		
1,1-Dichloroethane	0.5		NS		

Lab Certifications: CAELAP #1598 & #1783; UTELAP #E-142; AZELAP #AZ0162; A2LA #0136-01; L.A.Co.CSD #1018

* RESULTS listed as 'NS' were not spiked. PQL = Practical Quantitation Limit

(1) Concentrations in ug/cu M reported at 760 mm Hg pressure and 298 deg. K.

(2) Zero Air spiked with NIST SRM 1804, Cylinder # ALM-000881.

01/21/94

MS1/1P20K

GD/ge

CK9401-20



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CLIENT: Coast-to-Coast Analytical Services, Inc.

Analyzed : 01/20/94
Analyzed by: YL
Method : EPA TO-14

QC SPIKE REPORT OF ANALYTICAL RESULTS

Page 2 of 2

SAMPLE DESCRIPTION	MATRIX	SAMPLED BY	SAMPLED DATE RECEIVED		
QC SPIKE	Air				
CONSTITUENT	*PQL µg/cu M	SPIKE AMOUNT	RESULT µg/cu M	%REC	NOTE
1,2-Dichloroethane (EDC)	1.	20.	19.	95.	
1,1-Dichloroethane	1.		NS		
cis-1,2-Dichloroethane	1.0		NS		
trans-1,2-Dichloroethane	1.		NS		
Dichloromethane	5.	17.	18.	106.	
1,2-Dichloropropane	0.5	23.	20.	87.	
cis-1,3-Dichloropropene	0.5		NS		
trans-1,3-Dichloropropene	0.5		NS		
Ethylbenzene	1.	15.	15.	100.	
2-Hexanone	0.5		NS		
4-Methyl-2-Pentanone (MIBK)	0.5		NS		
Styrene	1.		NS		
1,1,2,2-Tetrachloroethane	1.		NS		
Tetrachloroethene (PCE)	1.	34.	37.	109.	
Toluene	1	18.	18.	100.	
1,1,1-Trichloroethane (TCA)	1.	28.	31.	111.	
1,1,2-Trichloroethane	1.		NS		
Trichloroethene (TCE)	0.5	27.	27.	100.	
Trichlorofluoromethane (F-11)	1.	29.	27.	93.	
Trichlorotrifluoroethane (F-113)	2.		NS		
Vinyl Acetate	2.		NS		
Vinyl Chloride	0.5	14.	13.	93.	
Xylenes	1.	15.	15.	100.	

Lab Certifications: CAELAP #1598 & #1783; UTELAP #E-142; AZELAP #AZ0162; A2LA #0136-01; L.A.Co.CSD #102

* RESULTS listed as 'NS' were not spiked. PQL = Practical Quantitation Limit

1/21/94
MS1/LF20K
ED/ge
JK9401-20

Respectfully submitted,
COAST-TO-COAST ANALYTICAL SERVICES, INC.

Gesheng Dai, Ph.D.
Air Toxics Group Leader

APPENDIX B

Summary of Calculations to Determine Gaseous Mas Emission Rates

The sequence and format for each of the equations required to calculate the gaseous effluent concentration and mass emission rates for each of the stack measurements is presented below. The specific nomenclature for each of the equations presented below is summarized in Figure B-1.

Equation 1. Find molecular weight (MW), lb/lb-mole for each test run.

$$M_w = 0.44 (\% \text{ CO}_2) + 0.320 (\% \text{ O}_2) + 0.280 (\% \text{ N}_2 + \% \text{ CO})$$

Equation 2. Find the gas density correction factor (Fd) for each test run.

$$F_d = M_{sd} / M_w \cdot 29.95 / M_w$$

Equation 3. Find stack static pressure (P_{sd}), inches of water for each test run.

$$P_{sd} = [(P_b + /- (P_{st} / 13.6))]$$

Equation 4. Find gas pressure correction factor (F_p) for each test run.

$$F_p = P_{sd} / P_s \cdot 29.92 / P_{sd}$$

Equation 5. Find area of the stack (A_s), square feet for the outlet duct.

$$A_s = \pi \cdot R_s^2 = \pi \cdot R^2$$

Equation 6. Find velocity of the stack gas (V_s), feet per second, for each test run (feet/second).

$$V_s = 85.49 \cdot C_p \cdot \Delta P^{1/2} \cdot \frac{T_s \cdot P_b}{P_s \cdot M_w}$$

Equation 7. Find volumetric flow rate (Q), cubic feet per minute, for each test run (SCFM).

$$Q = C_p \cdot V_s \cdot F_d \cdot F_p \cdot A_s \cdot 60$$

Equation 8. Find volumetric flow rate (Q_{sd}), corrected to standard conditions, dry standard cubic feet per minute, for each test run (DSCFM).

$$Q_{sd} = Q \cdot P_s \cdot T_{sd} \cdot (100 - B_w) / P_{sd} \cdot (T_s + 460) \cdot 100$$

Equation 9. Find emission rate (Erg), pounds per hour, for each of the VOCs.

$$\text{Erg} = (\text{PPM} \cdot M_w / 385 \cdot 10^6) \cdot Q_{sd} \cdot 60$$

Note: Should the results be presented as PPB, they must either be converted to PPM or the above calculation should be divided by 10^9 rather than 10^6 .

HEALTH AND SAFETY PLAN

For

**Evaluation of the 2-Phase Extraction System
(Developed by Xerox Corp. and implemented by Radian Corp.)
at McClellan AFB, California**

July 19, 1994

Prepared by:

**Science Applications International Corporation
635 West Seventh Street, Suite 403
Cincinnati, OH 45203**

**EPA Contract No. 68-C0-0048
Work Assignment No. 0-55
SAIC Project No. 01-0832-07-1129-009**

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4.0 HEALTH AND SAFETY PLAN

4.1 Introduction

This Health and Safety Plan (HSP) was developed to establish specific guidelines and requirements for the protection of SAIC and subcontract workers during the demonstration of the TPE system. This plan has been prepared in accordance with the regulatory requirements of 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response. It addresses those activities performed during the installation, sampling, and operation of the TPE system.

Radian Corporation, the USAF's contractor for McClellan AFB, is responsible for installing and operating the TPE system and for safe guarding of all Radian, Radian subcontractor, USAF, and partnership personnel involved in the SITE demonstration. Radian has developed a separate HSP identifying health and safety considerations and monitoring requirements during the TPE demonstration.

During the SITE demonstration, SAIC will be responsible for recording pertinent activities, for obtaining and analyzing the media samples, and for safe guarding the health and safety of any "SITE personnel" (i.e., SAIC, SAIC subcontractor, and U.S. EPA personnel) entering the test area during the demonstration. As part of this effort, SAIC will ensure that SITE personnel comply with the procedures and guidelines specified within the HSP. SAIC will also perform health and safety monitoring, as specified within this HSP. Table 4-1 provides some general information about the McClellan AFB Operable Unit B.

4.1.1 Scope and Applicability

The information provided in this Health and Safety Plan (HSP) was developed in support of EPA's SITE demonstration of the TPE system. This purpose of this HSP is to clearly define individual and corporate responsibilities, to establish personal protection standards and mandatory safety procedures, and to provide for contingencies that may arise during demonstration activities at McClellan AFB. The guidelines included in this health and safety plan were developed for SAIC, SAIC subcontractor, and U.S. EPA personnel involved within the TPE demonstration. SAIC disclaims responsibility for any use of this information other than the expressed purpose for which it is intended and assumes no liability for the use of this information for any other purpose. The evaluations of potential hazards and their controls reflect professional judgements subject to the accuracy and completeness of information available when the HSP was prepared. Appendix B to this Demonstration Plan provides an acknowledgement form for all onsite participants in the demonstration.

TABLE 4-1. OVERVIEW OF THE TPE SYSTEM DEMONSTRATION PROJECT

Site Name:	McClellan AFB, Operable Unit B
Site Location:	Sacramento, California
EPA Contract:	68-C0-0048, Work Assignment 0-55
EPA SITE Work Assignment Manager:	Laurel Staley
McClellan AFB - Environmental Management:	Doris Varnadore
Clean Sites Project Manager:	Ellen Fitzpatrick
Clean Sites Demonstration Coordinator:	Greg McNelly
Clean Sites Onsite Contact :	Colette Mrozek
SAIC Work Assignment Manager:	Jim Rawe
SAIC Project Health and Safety Officer:	George Andersen
SAIC Site Safety Coordinator:	Evelyn Meagher-Hartzell
SAIC Field Manager:	Jamie Winkelman
Radian Project Director:	Gordon Kingsley
Radian Field Task Leader/Onsite H&S Officer:	Mike McNamera
Radian Project Health and Safety Officer:	Kim Worl
Purpose of Field Work:	To test and determine the effectiveness of the TPE system at extracting VOCs from the subsurface
Date of Proposed Field Work:	July - December, 1994
Information Available From:	Laurel Staley, U.S. EPA (513-569-7863)
Overall Hazard Summary:	Low

4.1.2 Project Work Scope Overview

Table 4-1 provides an overview of the TPE system demonstration project to be conducted at the McClellan AFB in California. Figure 1-2 of the Demonstration Plan provides a detailed schematic of a typical 2-phase extraction well configuration. Figure 2-4 of the Demonstration Plan shows a process schematic of the TPE demonstration showing sample and measurement points.

4.1.3 Site Description

The Demonstration Test will take place at McClellan AFB, Sacramento, California (Figure 1-1). As shown in Figure 2-1, McClellan AFB has been separated into four geographic areas of the base, designated Operable Units (OU) A, B, C, and D. OU B encompasses approximately 325 acres in the southwest portion of the base, and includes six sites with known contamination and 23 locations and 19 study areas that are potential sources of hazardous substances within the soils and groundwater. Operable Unit B is located in the southwest portion of McClellan AFB. The TPE system will be installed in extraction wells (EW) 233

and 234 located near Building 655 (See Figure 4-1). The majority of activities, however, will center around EW-233 which will be the focus of the demonstration. Additional wells are being installed in the immediate vicinity of EW-233 for sampling and monitoring activities. Above ground equipment (i.e., pumps) will be set up on a trailer within a fenced area that surrounds the Building 666 Foundation. This fenced area will comprise the exclusion zone and will be clearly marked with yellow tape or signs.

Access to the base, and thus the demonstration area, is limited. Individuals entering the base must either possess a pass or be prepared to show the gate guard proper identification (i.e., a drivers license) and a vehicle registration or rental agreement.

4.1.4 Site History

The site history is discussed in Subsection 2.3 of the Demonstration Plan.

4.2 Project Organization and Responsibilities

In order to successfully implement this HSP, each person involved in the demonstration must clearly understand his or her responsibilities and the responsibilities assigned to the other individuals involved in the demonstration. The health and safety contingent of the SAIC team for this project is organized in accordance with SAIC's SITE Health and Safety Program Plan. As such, a Project Health and Safety Officer (PHSO) has been assigned to this demonstration project. A Site Safety Coordinator (SSC) has also been assigned as the PHSO's representative. The SSC will be onsite during any demonstration activities involving SITE personnel. While onsite, the SSC will oversee the implementation of the details of this plan. All SAIC site activities, health and safety or otherwise, are the responsibility of the SAIC Work Assignment Manager (WAM). A description of the responsibilities of each person is described in this section.

All activities involved in system installation, maintenance, operation, decontamination, and demobilization are the responsibility of Radian. SAIC will coordinate sampling and monitoring activities with Radian personnel. SAIC will perform health and safety monitoring whenever site personnel are onsite, as specified in the HSP. The SAIC WAM or Field Manager will notify non-SITE personnel working onsite of any known hazards. SAIC will also make available all health and safety records for inspection by EPA, SAIC, Radian, U.S. Air Force, or Occupational Safety and Health Administration (OSHA) personnel.

4.2.1 Work Assignment Manager

Jim Rawe is assigned as the SAIC WAM. He has ultimate responsibility for SAIC's field work at the site. The WAM will coordinate onsite health and safety activities and will provide technical supervision for ongoing activities at the site. Primary responsibilities of the WAM in the safety and health area include:

- Approving the HSP before the commencement of any field activities, after ensuring that it has been reviewed by an appropriately qualified individual, such as a Certified Industrial Hygienist, Certified Safety Professional, or other qualified individual
- Designating an individual to serve as the SSC for this project
- Assuring that personal protective equipment is available and properly utilized by all SITE personnel onsite
- Assuring that SITE personnel are aware of the provisions of this HSP, are instructed in the work practices necessary to ensure safety, and are familiar with the preplanned procedures for dealing with emergencies
- Assuring that SITE personnel are aware of the potential hazards associated with site operations
- Supervising the safety performance of all SITE personnel to ensure that safe work practices are employed
- Correcting conditions that may result in injury to SITE personnel or exposure to hazardous substances.

4.2.2 Project Health and Safety Officer

George Andersen is assigned as the PHSO for this demonstration project at the Operable Unit B. He is responsible for the overall health and safety of all SITE personnel onsite during this project and reports to the WAM for any activities related to the site operations. Mr. Andersen will provide technical information and assistance to the WAM on the hazards of waste components and the demonstration processes. He will also provide information for measuring and controlling exposure to toxic or unsafe components. Mr. Andersen will not be onsite. Mr. Andersen has designated an SSC to carry out necessary health and safety procedures when he is not onsite. Additional duties and responsibilities of the PHSO include:

- Reviewing and commenting on the HSP
- Obtaining copies of applicable federal, state and local regulations for the site
- Reviewing the health and safety monitoring and incident reports submitted by the SSC for SITE personnel
- Coordinating safety problems with the site WAM and SSC
- Determining what level of protection (protective clothing and respirator) will be used by SITE personnel at the site under the conditions as reported by the SSC
- Maintaining a current copy of the HSP along with medical qualification correspondence and records.

4.2.3 Site Safety Coordinator

Evelyn Meagher-Hartzell has been designated the SSC and will be responsible for implementing the details of this HSP. As the full-time representative of the PHSO, the SSC will conduct routine inspections to verify compliance with this HSP and will have full authority to resolve safety and health issues arising during site operations, provided that she reports her findings and decisions to the PHSO in a timely fashion. The SSC will train project team members on the subjects of potential hazards and provisions for exposure monitoring, use and care of personal protective equipment, and on the specific requirements of this plan. If site conditions become unsafe, the SSC has the authority to request the WAM to suspend all site activities and/or direct SITE personnel to evacuate the site until the unsafe conditions are corrected. The duties of the SSC, as they pertain to SITE personnel, include:

- Ensuring the proper cleaning and maintenance of protective equipment
- Supervising the ordering of safety and emergency supplies and equipment
- Overseeing the maintenance of records of occupational illnesses and injury (OSHA Form 102 or equivalent) and records of individual site assignment and exposure monitoring results
- Enforcing all health and safety procedures applicable to SITE personnel while they are onsite
- Determining the need for additional safety equipment (e.g., respirators), depending on site-specific conditions
- Obtaining emergency medical assistance
- Preparing and submitting incident reports
- Conducting daily reviews of key aspects of this HSP to respond to any changes in weather, site, or operational conditions
- Presenting initial safety and health training for new SAIC and SAIC subcontractor employees, in the absence of the PHSO
- Ensuring that entry and access to the site (exclusion zone) is controlled, to include ensuring that personnel (employees and visitors) allowed access inside the exclusion zone or other controlled areas have completed the required training (i.e., 40 hour/8 hour refresher and site briefing) and received medical clearance
- Ensuring that chemicals brought to the site and waste generated onsite by SITE personnel are properly handled, labeled, and stored.

4.2.4 SITE Personnel

SITE personnel involved in onsite investigations and operations are responsible for:

- Completing his or her work assignment in a safe and effective manner
- Accepting an assignment or beginning a task only after understanding the risks and hazards associated with that activity
- Completing the training, monitoring medical status, respirator fit testing, wearing protective clothing, etc., as specified in the HSP, before beginning any job
- Maintaining and providing to the SSC, a copy of medical correspondence and training certificate(s) needed to gain access to the site. (Note: Employees not possessing certificates of training/medical clearance will be denied access to operations inside an exclusion zone or other controlled areas at a site.)
- Not working alone at a field location (using the buddy system)
- Having a thorough knowledge of specific emergency response procedures at the McClellan AFB
- Immediately reporting any occupational illness or injury to the WAM and/or SSC, including any potential exposure to hazardous substances for which protection was not provided
- Wearing and maintaining personal protective equipment as specified in the HSP
- Reporting to the SSC any hazards not documented in the HSP or inadequately controlled by procedures contained in the HSP
- Implementing assigned responsibilities in accordance with the HSP (e.g., calibrating and using monitoring equipment)
- Reading and understanding this HSP, and signing-off to indicate understanding and willingness to comply. A sign-off sheet will be provided at the site and must be signed prior to commencement of work activities onsite.

4.3 Task Description

Details of the test process are presented in Section 3.1 of the Quality Assurance Project Plan (QAPP) for this project. Additional information also can be found in Subsection 2.5 of the Demonstration Plan. The test program for this demonstration is composed of the following tasks:

- Site preparation/system installation - These activities include: the installation of AC power, site lighting, fencing, water lines, and telephone lines; preparation of trailer parking area; installation of a secondary containment berm around the TPE system; designation of the exclusion, contamination reduction, and support zones; construction of personnel and equipment decontamination stations; and the installation of the two-phase extraction unit and any peripheral equipment. Radian is solely responsible for preparing the site for the demonstration and installing the TPE system, including performing health and safety monitoring during these activities. SITE personnel will not be on-site during these activities. In addition, groundwater monitoring wells and piezometers will be installed, by Radian, in

the vicinity of EW-233. These wells and piezometers will be sampled/monitored prior to, during, and following system operation.

- Baseline sampling/monitoring - Soil-vapor and groundwater samples will be collected from piezometers and two companion wells in the immediate vicinity of EW-233 by SAIC personnel prior to starting the TPE system in order to determine baseline conditions. Groundwater and soil vacuum levels will also be monitored before the demonstration to determine baseline conditions for these parameters. Pre-existing and newly installed monitoring wells within the vicinity of EW-233 will be used to monitor groundwater levels. Pre-existing piezometer and newly installed nests will be used to monitor soil vacuum levels. SAIC will coordinate these sampling and monitoring activities with Radian personnel. Only the outlet vapor and outlet water streams will be sampled for EW-234 process streams. SAIC will also coordinate health and safety monitoring with Radian during these activities. SAIC will subcontract AVS Video Production to video tape baseline sampling and monitoring activities.
- Process demonstration/sampling - Radian will be responsible for operating and maintaining the TPE system during the demonstration; SAIC will be responsible for sampling the various feed and product streams and monitoring groundwater levels and soil vacuum levels using nearby piezometer nests and monitoring wells. SAIC will coordinate these activities with Radian personnel. SAIC will perform health and safety monitoring during any demonstration activities involving SITE personnel or when SITE personnel are onsite. AVS employees will be onsite documenting demonstration and sampling activities.
- Process demobilization - These activities include: disconnection; decontamination and shipment of process system components; disposal of process generated waste; and termination of support systems (electric, water, etc.). Demobilization will be the sole responsibility of Radian and its subcontractors. SITE personnel will not be on-site during these activities.
- Final sampling - Groundwater and soil gas samples and monitoring data (i.e., groundwater and soil vacuum levels) will be collected after completion of the demonstration using the same monitoring wells and methods used during baseline sampling/monitoring. SAIC will coordinate these activities with Radian personnel. SAIC will coordinate health and safety monitoring with Radian during these activities.

4.4 Hazard Analysis

4.4.1 Chemical Hazards

A variety of contaminants were found in the soil, groundwater, and soil-vapors during previous studies performed at Operable Unit B. Table 4-2 lists a number of volatile and semivolatile contaminants found at the site which may present a hazard. Information regarding the contaminant's vapor pressures, Permissible Exposure Limits (PELs), and maximum detected concentrations has also been included within this table. Although the contaminant concentrations reported in Table 4-2 may not be representative of the actual or average concentrations that workers will be exposed to during the demonstration, appropriate chemical safety measures must be taken. Based on the contaminants identified at the site and the operational characteristics of the TPE system, VOC contamination, specifically vinyl chloride contamination, poses the most significant health hazard to workers involved in the TPE demonstration. Tables 4-3 and 4-4

present the results of the pre-demonstration sampling for groundwater and soil gas, respectively. Of these compounds, three were identified at relatively high levels during pre-demonstration sampling. They are trichloroethene (TCE), tetrachloroethene (PCE), and trichlorotrifluoroethane (Freon 113). These three compounds have been designated as critical parameters for the demonstration.

TABLE 4-2. POTENTIAL CHEMICAL VAPOR HAZARDS AT McCLELLAN AFB, OPERABLE UNIT B

Compound	OSHA TWA ¹ (ppm)	IDLH ² (ppm)	Skin Notation (Yes/No)	Vapor Pressure (mm Hg)	Flash Point (°F)	Maximum Concentration
Volatile Organic Compounds						
Benzene ^{3,6}	1	3,000	No	75 @ 68°F	12	0.023 mg/kg ⁶ , 0.028 ppmv ⁵ , 100 ppmw ⁵
2-Butanone (MEK) ⁵	200	3000	No	71 @ 68°F	16	1000 ppmv, 0.7 ppmw ⁵
Carbon tetrachloride ^{4,5}	2	300	Yes	91 @ 68°F	NA	500 ppmw ⁵
Chlorobenzene ⁵	75	2,400	No	12 @ 77°F	85	0.2 ppmw ⁵ , 0.2 ppmv ⁵ , 0.32 mg/L ⁶
Chloroform ^{4,5,6}	2	1000	No	160 @ 68°F	NA	0.25 ppmv ⁵ , 0.32 mg/L ⁵ , 1 ppmw ⁵
Chloromethane ⁴	50	10000	No	> 1 atm	NA (Gas)	
1,1-Dichloroethane ^{4,6}	100	4000	No	230 @ 77°F	22	0.24 ppmv ⁵ , 50 ppmw ⁵
1,2-Dichloroethane ^{4,5,6}	NVS ³	NVS ³				0.0009 mg/L ⁶ , 20 ppmw ⁵
1,2-Dichloroethene ^{5,6}	200	4000	No	180 @ 68°F	36	20 ppmw ⁵ , 3.6 ppmv ⁵ , 22 µg/kg ⁶
Ethyl benzene ⁵	100	2000	No	10 @ 79°F	55	0.1 ppmw ⁵
Hexachlorobutadiene ⁵	0.02	NVS ³	No			.20 ppmw ⁵
2-Hexanone (MBK) ⁵	5	5000	No	4 @ 77°F	77	190 ppmw ⁵
Hexone (Methyl isobutyl ketone - MIBK) ⁵	50	3000	No	16 @ 68°F	64	50 ppmw ⁵
Nitrobenzene ⁵	1	200	Yes	1 @ 112°F	190	5 ppmw ⁵
1,1,2,2-Tetrachloroethane ⁵	1	150	Yes	9 @ 86°F	NA	10 ppmw ⁵
Tetrachloroethene ^{4,5,6,7}	25	500	No	14 @ 68°F	NA	6900 ppmv ⁵ , 140 mg/kg ⁵ , 500 ppmw ⁵
Toluene ^{5,6}	100	2,000	No	20 @ 65°F	40	1.3 ppmv ⁵ , 0.025 mg/kg ⁵ , 20 ppmw ⁵
1,1,1-Trichloroethane ⁶	350					0.014 ppmv ⁶
1,1,2-Trichloroethane ⁶	10	500	Yes	19 @ 68°F	NA	31 ppmv ⁵ , 0.061 mg/kg ⁵
Trichloroethene ^{4,5}	50	1,000	No	58 @ 68°F	90	5000 ppmw ⁵ , 2100ppmv ⁵ , 3.6mg/kg ⁵
Trichlorofluoromethane ⁶						0.0078 ppmv ⁵

**TABLE 4-2. POTENTIAL CHEMICAL VAPOR HAZARDS AT McCLELLAN AFB,
OPERABLE UNIT B (Continued)**

Compound	OSHA TWA ¹ (ppm)	IDLH ² (ppm)	Skin Notation (Yes/No)	Vapor Pressure (mm Hg)	Flash Point (°F)	Maximum Concentration
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113) ^{4,6}	1,000	4,500	No	285 @ 68°F	None	270 ppmv ⁵
Vinyl chloride ^{4,5}	1		No	> 1 atm	NA (Gas)	0.005 ppmw ⁵ , 5 ppm ⁴
Xylenes(total) ⁵	100	1,000	No	7 @ 68°F	63 - 84	0.043 ppmv ⁵ , 0.55 mg/kg ⁵ , 500 ppmw ⁵
Semivolatile Organic Compounds						
Diethylphthalate ⁵	mg/m ³	mg/m ³				0.1 ppmw ⁵
2-Methylnaphthalene ⁵	0.6 ⁷	NVS ³	NVS ³	< 1 @ 68°F	NVS ³	10 ppmw ⁵
Naphthalene ⁵	10	500	No	0.08 @ 68°F	174	15 ppmw ⁵
Pentachlorophenol ⁵	0.5	150	Yes	0.0001 @ 68°F	NA	10 ppmw ⁵
Phenol ⁵	5	250	Yes	0.4 @ 68°F	175	0.2 ppmw ⁵
Polychlorinated biphenyls ⁵	0.5-1.0					50,000 ppmw ⁵
Total petroleum hydrocarbons (extractable)						110 mg/kg ⁴

- 1 Time Weighted Average. Represents the maximum concentration acceptable for inhalation throughout an 8-hour day for a 40-hour week.
- 2 Immediately Dangerous to Life or Health. Represents the maximum concentration for unimpaired escape within 30 minutes.
- 3 No Value Stated in available health and safety literature.
- 4 "Supplemental Health and Safety Plan", in the Draft Work Plan, Operable Units A&B, Dual-Phase Extraction Pilot Testing.
- 5 McClellan Air Force Base, Operable Unit B Remedial Investigation, Health and Safety Plan, August 1993.
- 6 Radian Corporation's Site Characterization Summary for IC 1.
- 7 Based on OSHA PEL for coal tar pitch volatiles.
- 8 Tetrachloroethene was reported as 46 ppmv in the near-surface soil gas which is approximately twice the PEL of 25 ppmv. Fortunately no other near-surface soil gas sample results exceeded LOC at IC 1 during Radian's site characterization of IC 1.

**TABLE 4-3. CONTAMINANTS IN GROUNDWATER SAMPLES
COLLECTED FROM EW-233 (February 1994)**

Compound	Concentration (µg/L)
Chloroform	1.6
1,2-Dichloroethane	11
Tetrachloroethene (PCE)	1,150
Trichloroethene (TCE)	4,890
Freon® 113	37

Source: Analytical Results from sample collected by Radian and analyzed by SITE.

TABLE 4-4. CONTAMINANTS IN SOIL GAS SAMPLES COLLECTED FROM EW-233 (March 1994)

Compound	Concentration (ppbv)
Freon® 113	2,700
Tetrachloroethene	2850
Trichloroethene	6500
Methyl Ethyl Ketone	29.5

Source: Analytical results are from a wellhead vapor sample collected and analyzed by SITE and are the average of duplicate analysis.

When assessing the relative risk posed by individual volatile compounds listed in Table 4-2, compounds with OSHA limits less than or equal to 5 ppm could potentially pose the highest risk to SITE personnel (i.e., benzene; carbon tetrachloride; chloroform; 2-hexanone; nitrobenzene; 1,1,2,2-tetrachloroethane; and vinyl chloride). However, since the majority of these "high risk contaminants" were reported within the OU B's HSP only (i.e., benzene; carbon tetrachloride; chloroform; 2-hexanone; nitrobenzene; and 1,1,2,2-tetrachloroethane) and since the OU B HSP addresses contamination discovered anywhere within the 326-acre operable unit, contaminants identified within the OU B HSP may not have been detected within the soil, soil-vapor, or groundwater found in IC 1. Thus, although in most cases concentrations were reported in excess of room air OSHA levels, the risk posed by these contaminants is considered relatively low, since the demonstration is outside and near IC 1 where a groundwater pump and treat system has been operating for some time. Based on the pre-demonstration the only contaminants having any appreciable concentrations are trichloroethene, tetrachloroethane, and Freon 113 (Table 4-4).

According to Radian's Draft Work Plan for the TPE study, vinyl chloride has historically been detected at concentrations up to 5 ppm in the extraction wells selected for testing; however, it has not been detected in any of the recent analyses conducted. Since vinyl chloride adsorbs poorly to activated carbon, chemical-specific real-time monitoring using Draeger tubes will be performed by Radian at the exhaust outlet, between the carbon beds, and within worker breathing space throughout the demonstration to determine whether workers are being exposed to unsafe levels of vinyl chloride. The following precautions will also be implemented in order to ensure that field personnel are not being exposed to unacceptable concentrations of vinyl chloride:

- The TPE system will be equipped with an exhaust stack which is at least 10 feet above grade (Note: Radian will be responsible for ensuring that this precaution is carried out and has indicated that a stack will be connected to the outlet of the carbon units to direct the treated offgas upward to a minimum height of 17 feet or higher).

- Within 15 minutes of initiating extraction at a given well, Draeger colorimetric indicator tubes samples will be collected by a Radian employee from breathing zone height in the general work area of SITE personnel to determine the airborne concentration of vinyl chloride.

Since the majority of the remaining volatile contaminants listed in Table 4-2 effectively adsorb to carbon, and since the TWAs for these contaminants do not extend below 10 ppm, non-specific chemical exposure monitoring using a FID or PID should adequately assess whether workers are being exposed to hazardous concentrations of these compounds (i.e., > 5 ppm above background).

The SVOCs identified within Table 4-2 present a low potential for airborne exposure, however, since they are not very volatile, and the testing area is paved. Therefore, dermal contact and ingestion of groundwater are the primary routes of exposure. Relatively low SVOC concentrations within the environmental samples further reduces the likelihood that personnel will encounter airborne concentrations of SVOCs near occupational health criteria.

Direct dermal contact with contaminated media, particularly VOC and SVOC contaminated groundwater, should be avoided. Splashes, leaks, and spills are unlikely since the water phase is contained in piping and tanks. Each knock-out vessel will be equipped with high- and low-level indicators that will activate separate transfer pumps. The unit will also include high-high and low-low level switches that will shut down the vacuum pump if the high-high or low-low levels are exceeded. Routine collection and handling of aqueous and gaseous samples may provide an opportunity for contaminants to penetrate through the skin, especially if inadequate gloves are used.

Heavy metals, SVOCs, and PCBs found in airborne soil particles and radioactive dust may also present a respiratory hazard. Although radionuclides have not been detected in IC 1, they have been detected in IC 4, located just southwest of IC 1. Since the primary routes of entry for heavy metals, PCBs, SVOC, and radionuclide contamination are inhalation and ingestion, and since limited soil handling or disturbance will take place during the demonstration, these contaminants are expected to present minimal hazards to field personnel. However, in addition to implementing good personal hygiene procedures, steps should be taken to avoid direct dermal and to control dust generation during field activities. If visible dust exposure periods occur, dust suppression techniques may need to be employed. If it's not possible to suppress particulate emissions in an area known to contain elevated levels of heavy metals, radioactive soils, or semivolatile compounds, SITE personnel will be required to use a respirator with a HEPA filter. Since the demonstration area is paved with concrete, the likelihood that demonstration related activities at the surface will result in visible dust releases is greatly reduced.

It should be noted, that according to the OU B HSP, the detected concentrations of radionuclides are generally near the background or threshold concentration for native soils. Also, although radionuclides may be present on the surface, they are more likely to be encountered in the subsurface. Thus at this time, individuals will not be monitored for radiation exposure.

Small quantities of hydrochloric acid will be used during the demonstration to preserve aqueous TPH samples. The acid will be predispensed into sample containers by the laboratory. Although an insignificant inhalation exposure is anticipated, personnel must wear gloves and safety glasses when sampling to prevent skin and eye contact. Appendix C presents the material safety data sheet for hydrochloric acid.

A detailed description of the sampling strategy and H&S precautions can be found in Subsection 4.5.

4.4.2 Physical Hazards

Various components of the TPE system are electrically powered. Electrical service will be provided from a new 480 volt service at the IC 1 Groundwater Treatment Plant. The TPE system will require 100 amps. Power will be delivered to the TPE skid at 480 volts. A step-down transformer will be provided at the TPE skid to convert to 100-volt power for instrumentation, sampling equipment, etc. This step-down transformer will be in addition to those supplied within the TPE skid. Although most workers automatically take precautions when approaching situations which may pose an electrical hazard, inadvertent contact with live electrical wires can occur. Additionally, equipment and instruments utilizing faulty wiring can be unintentionally employed. The following steps will be taken during the demonstration to try to prevent electrical shocks:

- All electrical power must have a ground fault circuit Interrupter as part of the circuit
- Applicable OSHA standards for protection from electrical hazards (29 CFR 1926.500) shall apply.

Additional requirements are described in Subsection 4.5.5.

Due to the relatively low concentrations of the volatile contaminants present in the soil and groundwater, there is no anticipated situations in which an explosive atmosphere could occur. The highest total VOC concentrations measured in outlet vapor samples collected during the pre-demonstration pilot test was under 50 ppmv, thus the lower explosive limit (LEL) of any compounds will not even be approached. The LEL and upper explosive limit (UEL) for the primary volatile (vapor pressure >1 mm Hg at 20°C) contaminants are listed in Table 4-5.

TABLE 4-5. UPPER AND LOWER EXPLOSIVE LIMITS

Compound	10% of LEL (%)	25% of LEL (%)	LEL (%)	UEL (%)
Benzene	0.13	0.33	1.3	7.9
2-Butanone (MEK)	0.14	0.35	1.4	11.4
Chlorobenzene	0.13	0.33	1.3	9.6
Chloromethane	0.81	2.03	8.1	17.4
1,1-Dichloroethane	0.56	1.40	5.6	NVS
1,2-Dichloroethane				
1,2-Dichloroethene	0.56	1.40	5.6	12.8
Ethyl benzene	0.10	0.25	1.0	6.7
Hexachlorobutadiene				
2-Hexanone (MBK)	NVS	NVS	NVS	8.0
Hexone (Methyl isobutyl ketone - MIBK) ⁵	0.12	0.30	1.2	8.0
Nitrobenzene	0.18	0.45	1.8	NVS
Toluene	0.12	0.30	1.2	7.1
1,1,1-Trichloroethane				
Trichloroethene	0.80	2.00	8	10.5
Trichlorofluoromethane				
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	NVS	NVS	NVS	NVS
Vinyl chloride	0.36	0.90	3.6	33
Xylenes(total)	0.10	0.25	1.0	7.0
Diethylphthalate				
2-Methylnaphthalene				
Naphthalene	0.09	0.23	0.9	5.9
Phenol	NVS	NVS	NVS	1.8

Note: Based on NIOSH Pocket Guide to Chemical Hazards, June 1990.

NVS is no value stated in available health and safety literature.

Normal physical hazards associated with heavy machinery, loud noise, and slips, trips, and falls also are present and must be addressed. These hazards are discussed in Subsection 4.5.5.

4.4.3 Task Hazard Analysis

Table 4-6 summarizes the job safety analysis by task for the TPE system demonstration.

TABLE 4-6. JOB SAFETY ANALYSIS BY TASK

Task	Associated Hazard	Hazard Control Method
Site preparation/system installation	Electrical, Mechanical, Skin Absorption, Inhalation	Not Applicable to SAIC
Baseline sampling/monitoring	Skin absorption, Inhalation, Explosion	Training, PPE, Observation, LEL/O ₂ Monitoring
Process demonstration/sampling	Skin absorption, Inhalation, Electrical, Mechanical	Training, PPE, Observation
Process demobilization	Skin absorption, Inhalation, Electrical, Mechanical	Training, PPE, Observation
Final sampling	Skin absorption, Inhalation, Explosion	Training, PPE, Observation, LEL/O ₂ Monitoring

4.5 Hazard Monitoring and Control

This section defines the actions that will be taken to monitor and control the hazards identified in Subsection 4.4. The specified control measures were determined based on the level of risk perceived to be associated with a particular activity.

4.5.1 Training

All SITE personnel planning on entering the demonstration area are required to undergo extensive training, as required by OSHA, so that they can perform their assigned tasks in a safe and productive manner.

The basic training program must comply with OSHA requirements and include:

- A personal protective equipment course, including a detailed respiratory protection program
- Health and safety training
- Emergency response procedures
- Quality assurance/quality control.

The basic training program requires 40 hours of classroom training covering the above topics. An 8-hour refresher course is required annually. All managers and supervisors directly responsible for hazardous waste operations will complete one 8-hour manager/supervisor training course in addition to the 40-hour training and 8-hour refresher course.

Site-specific training will also be provided that specifically addresses the site activities, procedures, monitoring, and equipment for the site operations. It will include a site and facility layout, hazards and emergency services at the site, and the standard operating procedures required at the site. The training will detail all provisions contained within this HSP. This training will also allow field workers to clarify anything they do not understand and to reinforce their responsibilities regarding safety and operations for their particular activity. This training will be presented prior to commencing field activities at the site.

In addition, project personnel will be given safety briefings as necessary to ensure that SITE personnel are aware of the requirements of the HSP and to further assist site personnel in safely conducting their activities. Briefings will be provided when new operations are to be conducted, when changes in work practices are to be implemented, or if the site or environmental conditions change. Briefings will also be given to facilitate conformance with prescribed safety practices and when performance deficiencies are identified during routine daily activities or as a result of safety audits. All site-specific training and safety briefings will be documented, including date and time, name and signature of person providing briefing, content of briefing, and signature of attendees.

4.5.2 Personal Protective Clothing and Equipment

Based on the potential hazards of the site and the type of work being performed, personnel at the demonstration site will be required to wear appropriate personal protective equipment (PPE). The specific type of PPE will depend on the operational status of the TPE system, monitoring, and worker proximity to the test area. Table 4-7 specifies the types of PPE that will be used in each work activity.

TABLE 4-7. PPE BY WORK ACTIVITY

Work Activity	Location	Hazard Requiring Protection	Type or Level of PPE
Sampling	Exclusion Zone	Skin absorption, Inhalation, Mechanical, Electrical	C/D
Monitoring	Exclusion Zone	Skin absorption, Inhalation, Mechanical, Electrical	C/D
Personnel decontamination	Contamination Reduction Zone	Skin absorption	D
Equipment decontamination	Contamination Reduction Zone	Skin absorption	D
Sample Preparation	Support Zone	Skin absorption	D

All personnel in the exclusion zone (see Subsection 4.5.5) will be required to wear specific work equipment during all onsite activities, which may include the following:

Level "D"

Hard Hat - Z89, polyethylene accessory kits if necessary
Coveralls - Tyvek coated or uncoated (polycoated tyvek will be used when splash hazards exist)
Gloves - Nitrile; inner surgical
Boots - Knee boot (over shoe), chemical resistant, steel toed/steel shanked, or
Boots - Over sock, chemical resistant, steel toed/steel shanked
Shoes - Oxford style, steel toed/steel shanked
Safety Glasses - Wide vision, chemical splash (Z87)
Face Shield - for use when splash hazards exist

Level "C"

All Level D requirements
Add full-face respirator - combination organic vapor (for vinyl chloride) and HEPA filter cartridge

Level D protection is suggested for most situations since hazardous levels of air contaminants are not expected to be present. Radian will conduct health and safety monitoring at the exclusion zone areas. A photoionization detector (PID), with a 10.2 eV lamp, will be used to monitor concentrations in the exclusion zone during TPE system operation. Additionally, Draeger tube samples will be taken in the worker air space, between the carbon beds, and at the exhaust 15 minutes after the system has started up and every hour thereafter, in order to monitor vinyl chloride and the other "high risk contaminants". PID and Draeger tube sampling will also be performed at the sampling port, within the workers breathing space, and 10 feet down wind of the sample port during sampling activities. The data from PID and Draeger tube monitoring efforts will be used to modify personnel protection equipment requirements as follows:

- Background to 5 ppm over background with the PID and less than 0.5 ppm vinyl chloride with the Draeger tube - Level D.
- 5 ppm or more over background for 5 minutes with PID or 0.5 ppm vinyl chloride or greater with the Draeger tube- Level C.
- If in Level D, upgrade to Level C if odors are a problem to field personnel.

4.5.3 Medical Surveillance

As a prerequisite to work in the field during the demonstration, all SAIC and subcontractor workers will undergo a physical examination that includes a medical and work history with special emphasis on symptoms related to the handling of hazardous substances, and on fitness for duty. The examination should evaluate the worker's ability to wear any personal protective equipment under conditions (i.e., temperature extremes) that may be expected at the work site. Workers who are provided annual physical examinations

as part of an ongoing medical program will not be required to undergo an additional physical examination prior to site entry.

4.5.4 Monitoring and Sampling Plan

Radian will provide instrumentation and personnel for all health and safety and environmental compliance monitoring activities designated within this HSP, however, SAIC's SSC will be responsible for corroborating and maintaining all health and safety monitoring records. Measurements shall be recorded in the log book. All employees working onsite will be informed of monitoring results. The monitoring plan is summarized in Table 4-8. The PHSO, at the request of the SSC, may reduce the monitoring frequency, if consistently low levels are observed during monitoring.

TABLE 4-8. MONITORING REQUIREMENTS

Type of Monitoring	Method of Monitoring	Location of Monitoring	Recommended Frequency of Monitoring
Organic Vapors	Photoionization detector	Breathing zone of workers subject to highest levels	Hourly
Vinyl Chloride	Draeger tubes	Breathing zone of workers subject to highest levels	Hourly
High Risk Contaminants ¹	Draeger tubes	Breathing zone of workers subject to highest levels	Hourly
Heat Stress	Wet bulb globe temperature or Questemp I	Area or personnel	Hourly

¹ High risk contaminants include benzene, carbon tetrachloride, 2-hexanone, nitrobenzene, and 1,1,2,2-tetrachloroethane.

Prior to entering the exclusion zone, downwind measurements shall be taken with a PID and Draeger tube to determine the level of respiratory protection required. During the operation of the TPE system, real-time PID and Draeger tube (i.e., vinyl chloride) readings will be taken hourly in the workers breathing spaces, at the downwind side of the TPE system, at the exhaust vent, and between the carbon beds. Since contaminant exposure will most likely occur during sampling operations, PID readings should be taken just above the sample port, within the samplers breathing space, and 10 feet downwind of the sampling location during sampling activities. Workers should avoid breathing vapors emitted from the sample port during sampling activities. Details of the location and frequency of sampling are given in Section 3.4 (Site Selection and Sampling Procedures) of this Demonstration Plan.

As stated in Subsection 4.4.1, Draeger tube monitoring for benzene, carbon tetrachloride, 2-hexanone, nitrobenzene, and 1,1,2,2-tetrachloroethane performed during the first 8 hours of operation. Readings will be obtained just above the sampling ports and within the workers breathing space at 2 hour intervals. If these contaminants are consistently detected at concentrations exceeding a quarter of their individual TWAs, periodic monitoring will continue throughout the demonstration. If concentrations are detected over one half of the TWA's for these contaminants, the SSC will immediately contact the PHSO in order to re-define site safety precautions. At a minimum, workers near areas with elevated levels will need to upgrade to level C PPE. The frequency and duration of future monitoring activities and PPE upgrades will be re-defined in an addendum to this HSP.

The following action levels shall be observed:

- Should breathing zone readings taken onsite at any time during the demonstration exceed 5 ppm over background for 5 minutes with the PID all exclusion zone entries shall be made in Level C protection until current conditions are assessed.
- Should Draeger readings within a worker's breathing zone exceed 0.5 ppm for vinyl chloride, or over one half of the individual TLV's "high risk contaminants" (benzene, carbon tetrachloride, 2-hexanone, nitrobenzene, and 1,1,2,2-tetrachloroethane) at any time during the demonstration, all exclusion zone entries shall be made in Level C protection until current conditions are assessed. If vinyl chloride are detected at concentrations over 10 ppmv with a Draeger tube, all exclusion zone entries will be discontinued or made in Level B PPE.
- If contaminant concentrations are detected at any time during the demonstration at above levels which cannot be safely controlled using the respiratory protection and cartridges available onsite, SITE personnel will discontinue site activities until appropriate equipment is available.

Air samples will also be collected by Radian personnel using EPA TO-18 (modified for vinyl chloride) at the exhaust vent. These samples will be used to further assess the potential for worker exposure to vinyl chloride. The analytical results from TO-18 sampling and analysis will not be available until two days after the samples have been obtained. PPE requirements and work area monitoring procedures can be modified once the results of the outlet air samples are available.

Please note that data from isotherm tests and slipstream testing, performed prior to the demonstration, will be used as a basis for securing Air Quality Management District approval for long-term testing. This data will also be used to refine PPE and work area monitoring procedures prior to the demonstration. An addendum to this HSP will be submitted to the EPA and associated parties prior to the beginning of the demonstration addressing any modifications to the health and safety procedures resulting from pre-demonstration testing.

Instrument calibration and maintenance requirements include the following:

- Carefully inspect each piece of monitoring equipment prior to work start up. All monitoring instruments shall be intrinsically safe and calibrated on a daily basis. Instrument calibration shall be documented in the equipment decontamination and calibration logbook. Failure of any of the equipment listed below to work properly must be reported to the WAM immediately.
- Calibrate the PID (using the 10.2 eV probe) prior to each day's activities, according to manufacturer's instructions. Recalibrate after cleaning the lamp or when background levels drift. This instrument is sensitive to humidity and may require periodic lamp cleaning if it is humid. Recharge at the end of each day. Monitor in accordance with Subsection 4.5.2 and record levels in the log book every hour during startup and shakedown and process demonstration/sampling.

4.5.5 Site Control Measures

Standard operating procedures needed to control and minimize health and safety hazards are described in this section. To minimize the transfer of hazardous substances from contaminated to uncontaminated areas, three discrete zones will be delineated with specific decontamination procedures required for each zone (See Figure 4-1). These areas are the work or "exclusion zone," the "contamination reduction zone," and the clean or "support zone." Radian will be responsible for designating, cordoning off, equipping, and constructing these zones.

Exclusion Zone: This is the area where contamination does or could occur. All SITE personnel entering the exclusion zone must wear the prescribed protective clothing and equipment. This zone encompasses at least the area in which the TPE system is operating. The boundary of the exclusion zone will be clearly marked with yellow tape or signs. This exclusion zone will remain in place until the PHSO determines that there is no possibility of contamination.

Contamination Reduction Zone: This zone occurs at the interface of the exclusion zone and support zone. This transition zone serves as a buffer to further reduce the probability of the support zone becoming contaminated. This zone provides additional assurance that the physical transfer of contaminated substances to people, equipment, or into the air is limited through a combination of decontamination, distance between zones, air dilution, zone restrictions, and work functions.

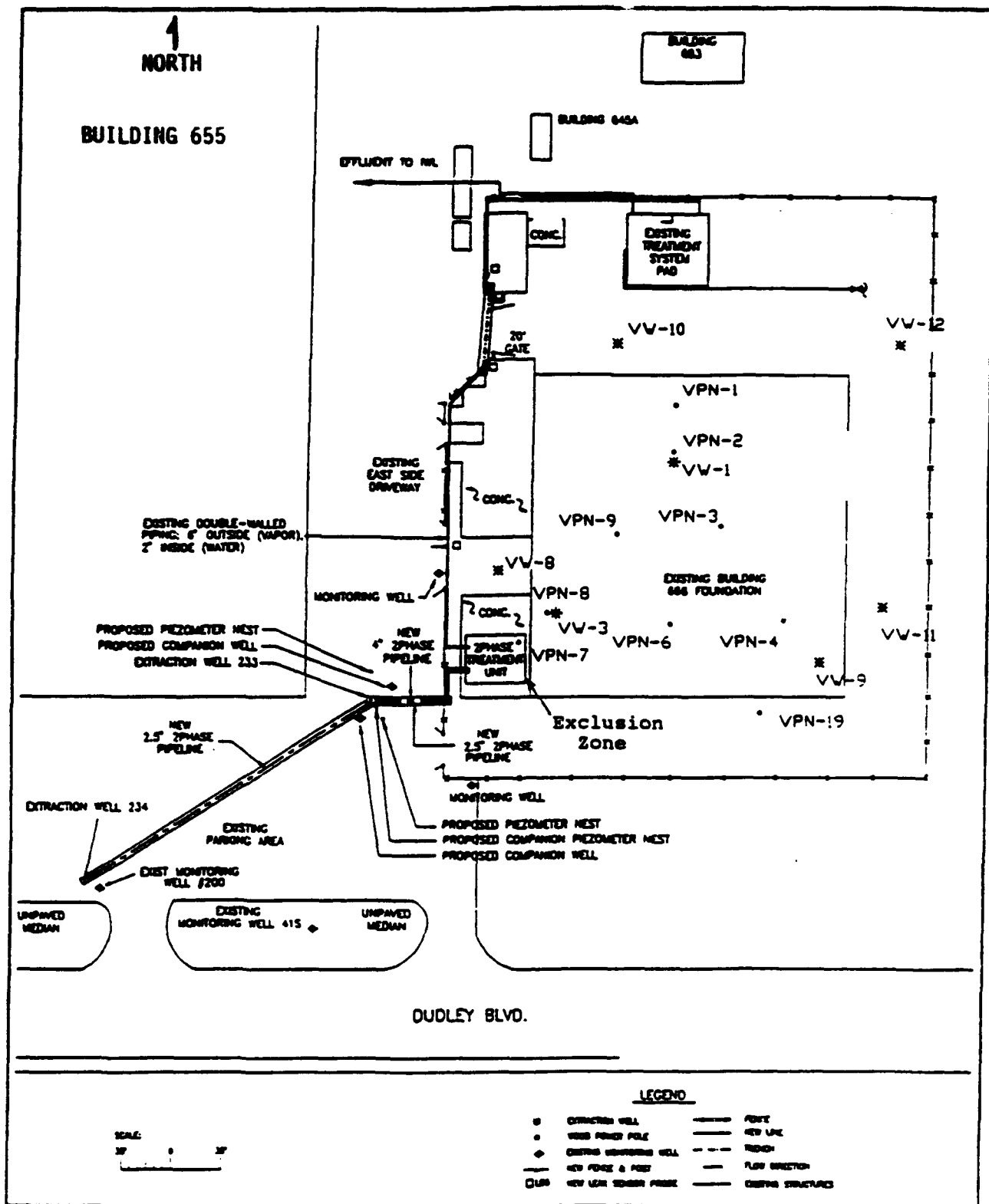


Figure 4-1. Work Zones and Decon Station Layout.

Entry to, or departure from the exclusion zone must be by way of the contaminant reduction zone. All equipment will be decontaminated at the contamination reduction zone. SITE personnel without proper safety equipment will not be allowed to enter this area. SITE personnel returning from the exclusion zone will not move from the decontamination area toward the support zone without decontaminating and/or removing their safety equipment.

Support Zone: At the site, the PHSO or SSC, in consultation with the WAM, will designate a "clean" area outside the contamination reduction zone. If possible, this support zone and the contamination reduction zone will be located upwind from the exclusion zone with the support zone farther away. The support zone is a location where field team members may take a rest break, eat, drink, or smoke. Toilet facilities are located in Building 655, which is adjacent to EW-233. Clean safety equipment may be brought into the support zone. Contaminated equipment (including personal safety gear) must be removed or decontaminated before entering the support zone. Water, first aid supplies, and communications equipment (for communications with persons not at the site) will be located in the support zone.

The following standard operating procedures shall apply to all SAIC and subcontractor activities:

- Only properly trained and equipped personnel shall be allowed to work in potentially contaminated areas.
- The number of personnel and amount of equipment in the exclusion zone will be kept to a minimum, consistent with safe site operations.
- Visual contact shall be maintained between pairs onsite in order to assist each other in case of emergencies.
- Workers shall not leave the exclusion zone or the contamination reduction zone until contaminated equipment and clothing have been removed and decontaminated or properly disposed. Except in emergencies, personnel shall not leave the area enclosed by the chain-link fence without first removing Tyvek suits and gloves.
- Contact with contaminated materials and surfaces shall be avoided. All personnel shall comply with contamination control measures.
- An SAIC hazardous waste management program has not been established for this site because SAIC is not responsible for residuals. As a result, all discarded waste materials shall be handled according to the procedures developed by Radian and in such a way to preclude the potential for spreading contamination, creating a sanitary hazard, or causing litter to be left onsite.
- All personnel entering the site shall be instructed by Radian in emergency procedures including locations of emergency equipment, procedures for site evacuation, emergency assembly areas and head count procedures, alarm systems, and site communications.

- All work paths and work areas must be kept clear of slip and trip hazards by Radian personnel. In addition, all areas presenting the potential for a fall hazard must be clearly posted and work must be routed away from the hazards by Radian. Applicable OSHA standards for walkways, stairways, etc. (29 CFR 1926.500) shall apply.
- No work will be conducted by SITE personnel over four feet in elevation or where a fall potential exists.
- All electrical power must have ground fault circuit interrupters as part of the circuit. All equipment must be suitable and approved for the class of hazard. Applicable OSHA standards for protection from electrical hazards (29 CFR 1926.500) shall apply. All electrical work, other than the use of extension cords, must be performed by a licensed electrician. Safety precautions shall include locking out of circuits being serviced, with the electrician performing the work retaining the key until the work is complete. The electrical subcontractor will provide Radian and SAIC with a copy of their written lock-out/tag-out program for review. The electrical contractor will also brief Radian and SAIC personnel and any other subcontractors on their lock-out/tag-out program with special emphasis on tag/lock designs, and procedures for removal of tags/locks and energizing circuits. Lockouts shall be documented in the Health and Safety/Personnel Entry log book.
- Work areas must have adequate lighting for employees to see to work and identify hazards (50-foot candles minimum.) This is typically comparable to a single 75 to 100 watt bulb. Personnel should carry flashlights in all normally dark areas for use in the event of a power failure. Applicable OSHA standards for lighting [29 CFR 1910.120 (m)] shall apply.
- When the temperature exceeds 70°F, and SITE personnel are wearing protective clothing, a heat stress monitoring program shall be implemented as appropriate. The SSC will be responsible for implementing this program and for monitoring SITE personnel for the signs and symptoms of heat stress.
- An ample supply of cool drinking water and a shaded rest area will be available at all times in the support zone. This area will be used by site personnel to take regular breaks and to replenish fluids. Additional heat stress prevention measures are discussed in Subsection 4.5.10.
- Overhead and underground utility hazards shall be identified and or inspected by Radian prior to conducting operations. SITE personnel will stand clear of any such hazards.
- The number of ground SITE personnel working around heavy equipment shall be minimized. Whenever personnel are required in the area of heavy equipment, a spotter should be assigned to each machine. This spotter will assist the operator in locating ground personnel and will direct personnel away from the machine. Workers should maintain eye contact with operators.
- The extraction equipment operates under approximately negative 25-30 inches of mercury. Caution should be used whenever work is performed on the unit. High vacuum can present hazards should there be an open pipe.
- Because of the potentially flammable materials at this site, the use of flame, heat or spark-producing equipment (e.g., cutting or welding torches) during startup and shakedown and process demonstration/sampling should be avoided. In the unlikely event that the use of such equipment is necessary during these phases of the project, a Hot Work Permit must be obtained first and the operation will be carefully monitored. This will be Radian's responsibility since they will be operating the TPE system.

- Those employees working around heavy equipment or in other noisy areas are subject to possible exposure to noise above the OSHA Permissible Exposure Limit of 90 decibels (dB). All personnel working around or visiting the extraction unit will be required to use hearing protection at all times while the pump is in operation, unless sound level measurements clearly demonstrate that protection is not required (i.e., levels are consistently maintained at less than OSHA action level of 85 dB). Employees will utilize hearing protection when normal speech becomes difficult.
- Field personnel shall position themselves upwind (if possible) of chemical exposure sources when conducting sampling activities, sampling collection, and equipment decontamination procedures.

4.5.6 Decontamination Plan

The following steps describe the decontamination sequence for each level of protection to be used onsite:

- Step 1 - Wash boots and outer gloves
- Step 2 - Remove boots
- Step 3 - Remove outer gloves
- Step 4 - Remove Tyvek garments
- Step 5 - Remove respirator
- Step 6 - Remove inner gloves
- Step 7 - Wash hands, face, and respirator

The following decontamination procedures apply if an SAIC employee, an subcontractor, or an EPA-SITE employee is accidentally splashed with contaminated materials:

- Proceed to decontamination area and decontaminate the personal protective equipment, assisted by a second person, if necessary.
- Use emergency eyewash when needed.
- Remove contaminated personal protective equipment and check for contaminated skin or clothing. If an individual is contaminated, remove clothing and wash the contaminated area of the body.
- Collect the waste and rinse water for disposal.
- Report to SSC to obtain medical evaluation.

Disposable coveralls, disposable sampling materials, unusable safety equipment (torn gloves, used respirator cartridges, punctured boots, etc.), and other contaminated materials such as bags and paper towels, will be disposed of in proper containers at the site. These items must be discarded using a procedure that will exclude reuse. Boots and gloves should be slashed into pieces. Used respirator cartridges are assumed to be contaminated and will be treated as such. Used cartridges will not be discarded in a trash can or waste basket. SITE personnel will discard according to the procedures specified by Radian. Radian will be responsible for the treatment and disposal of these items.

Items such as boots, Nitrile gloves, goggles, safety helmets, and reusable overalls are considered reusable. These items are decontaminated by washing them with a detergent such as Alconox, then rinsing thoroughly. The method for washing reusable equipment is presented below:

- Wash equipment in a small plastic tub or on plastic sheeting
- Wash off items with detergent. Remove all traces of dirt or other material
- Rinse thoroughly with clean water.

Details concerning decontamination of sampling equipment used by SAIC during this demonstration are presented in Subsection 3.4.7 of the Demonstration Plan. In general, the procedure includes:

- Wash with detergent such as Alconox
- Rinse with Demineralized (DI) water.

It is anticipated that the use of solvents (methanol and hexane) will not be required.

The used water from equipment and personnel decontamination is assumed to be contaminated and thus will be managed as a hazardous waste. It will be stored in drums for treatment or disposal by Radian in accordance with all applicable regulations.

Decontamination activities will be located to prevent and/or minimize cross contamination to uncontaminated personnel and equipment. Figure 4-1 is diagram of the work zones and decontamination station (decon station) layout. Decon Station contents include:

- Water
- Detergent
- Wash tub
- Rinse tub
- Long handled brushes
- Waste receptacle for PPE
- Waste receptacle for municipal solid waste (not contaminated)
- Drum for wastewater
- Trays for equipment decon
- Assorted small brushes for equipment decon
- Squirt bottles for rinsing equipment
- Absorbent material or pads for spills.

4.5.7 Sanitation

Potable water and/or Gatorade will be carried onsite in coolers. SITE personnel will have access to USAF/Radian toilet facilities. Showers will not be available, since corrosive chemicals are not expected.

4.5.8 Confined Space Entry Plan

No confined space entries will be made.

4.5.9 Hazardous Waste Management

Any wastes created as a result of this site investigation will be the responsibility of the USAF and Radian. Contaminated disposable coveralls, disposable sampling materials, unusable safety equipment (torn gloves, used respirator cartridges, punctured boots, etc.), contaminated decon water, and other contaminated materials such as bags and paper towels which are generated by SITE personnel during the demonstration will be stored according to procedures specified by Radian for treatment or disposal by Radian.

4.5.10 Other Hazard Control Measures

A program of heat stress monitoring will be implemented for SITE personnel when temperature exceeds 70 °F. Both heart rate (pulse) and Wet Bulb Globe Temperature (WBGT) will be monitored hourly at first and subsequently reduced at the discretion of the SSC. The TLV table for work/rest periods as described in Table 4-9 will be followed and will be modified if monitoring indicates that a decrease or increase in the work/rest sequence is warranted.

- **Heart Rate (HR) 30 Seconds**
If not in excess of 110/minute, maintain W/R.
If > 110/minute, shorten work period by 10 minutes.
If > 110/minute after shortening, shorten next work period by 33%.
- **Body Temperature (BT)**
If not in excess of 99.7°F (37.6°C), maintain W/R.
If > 99.7°F (37.6°C), shorten work period by 33%.
- **Both HR and BT in Excess**
If both the heart rate and body temperatures exceed guidelines, use the most conservative of the W/R regimens.

TABLE 4-9. PERMISSIBLE HEAT EXPOSURE TLV's WET BULB GLOBE TEMPERATURES

Work/Rest Regimen	Work Load					
	<u>Light</u>		<u>Moderate</u>		<u>Heavy</u>	
	°C	°F	°C	°F	°C	°F
Continuous	30.0	84.0	26.7	80.0	25.0	77.0
75W/25R	30.6	87.0	28.0	82.5	25.9	78.5
50W/50R	31.4	88.5	29.4	85.0	27.9	82.0
25W/75R	32.2	90.0	31.1	88.0	30.0	84.0

Ear plugs will be required for SITE personnel working in the vicinity of the extraction unit while the pump is in operation and in any other high noise areas (any area in which interference with normal speech is encountered).

Additional work limitations include:

- No eating, drinking, or smoking in the exclusion zone
- Partial decontamination must be performed prior to rest and drink breaks. A shaded rest area must be provided when ambient temperatures exceed 70°F. Heat stress symptoms should be reviewed prior to work onsite
- No facial hair that would interfere with respirator fit shall be allowed
- Use the "Buddy System" at all times in the exclusion zone.

4.5.11 Enforcement of the Site-Specific Health and Safety Plan

Formal inspections to ensure that SITE personnel are complying with the HSP will be conducted on a periodic basis, and informal inspections may be conducted at any time by the SSC. Deficiencies will be corrected immediately and documented for the project record.

Ineffective procedures will be identified and corrected. If SITE personnel are consistently not following given procedures, the reason will be determined through close observation and interviews with noncompliant individuals. Changes to the procedure will be implemented if a specific deficiency in the procedure is identified.

4.6 Emergency Response Plan

An emergency is defined as an accident, illness, explosion, hazardous situation at the site, or intentional acts of harm. Although effective implementation of the HSP can minimize the probability of an emergency, an emergency situation cannot be totally prevented. Hence, the following items will be located during the site orientation:

First aid kit
Eye wash
Fire extinguisher (multi-purpose)
Site telephone
Telephone contact list
Map showing route to hospital

Table 4-10 lists emergency contacts.

The following general fire prevention measures will be implemented for field operations involving SITE personnel where fire risks are encountered:

- Open fires shall not be permitted at any time in any work area
- If access to any portion of a building must be blocked, the PHSO shall notify the Contracting Officer
- Outside storage areas and temporary structures and trailers shall be placed at least 50 feet from existing buildings, structures, overhead piping, and other permanent installations
- A multi-purpose fire extinguisher shall be located in the area adjacent to the TPE system
- Internal combustion engine powered equipment shall be so located that the exhausts are well away from combustible materials. Storage of liquified petroleum (LP) gas within buildings is prohibited

Any person who becomes ill or injured in the exclusion zone must be decontaminated to the maximum extent possible. If the injury or illness is minor, full decontamination should be completed and first aid administered prior to transport. If the patient's condition is serious, at least partial decontamination should be completed. First aid should be administered while awaiting an ambulance or paramedics.

Minor first aid situations will be handled by onsite personnel with professional follow up care administered as necessary. In cases of major injury or sickness, the off-base paramedics will be summoned by calling 911. Since the response time of the on-base ambulance would be no more than 15 minutes, SAIC personnel will not be required to be certified in CPR or basic first aid.

TABLE 4-10. EMERGENCY CONTACT/NOTIFICATION SYSTEM

Agency	Location/Description	Telephone
Police	On Base	From Base: 112 Other: 916-643-2111
	Off Base	Emergency: 911
Ambulance	On Base	From Base: 115
	Off Base	Emergency: 911
Paramedics		Emergency: 911
Fire Department	On Base	From Base: 117 or Other: 916-643-6666
	Off Base	Emergency: 911
On-base Health Clinic	On Base: Building 541	
Hospital	On Base	From Base: 115
	Off Base: Mercy-San Juan Hospital 6501 Coyle Avenue Carmichael, CA	916-537-5000
Poison Control Center		
EPA National Response Center		(800) 424-8802
Center for Disease Control	Emergency Response	
CHEMTREC		(800) 424-9300
TSCA HOTLINE		(202) 554-1404
RCRA HOTLINE		(800) 424-9346
Bureau of Alcohol, Tobacco, & Firearms		(800) 424-9555
Bureau of Explosives, A.A. Railways		
Federal Express - Hazardous Material Information		(901) 922-1666
McClellan Environmental Management	Doris Varnadore	(916) 643-0830, ext. 373
EPA Remedial Project Manager		
SAIC WAM	Jim Rawe	(513) 723-2600
SAIC PHSO	George Andersen	Office: (201) 489-5200 Home: (201) 489-8118
SAIC SSC	George Wahl	(513) 723-2600
Radian Safety Officer	Kim Worl	(916) 352-5332
Radian Safety Officer - Alternate	Rick Moore	(916) 352-5332
SAIC Medical Consultant	Environmental Medical Resources, Inc.	(800) 229-3674

The nearest public hospital to the Operable Unit B is Mercy-San Juan Hospital. The hospital route recommended is shown in Figure 4-2. As shown, exit the site onto Madison Avenue and head west for approximately 2½ miles. Make a left onto Milburn (see map inset). Go a short distance and Milburn dead ends into Coyle Avenue. The hospital will be on the north side of Coyle Avenue directly across from Milburn.

4.7 Spill Containment Program

The substances that could be involved in spills are the inlet groundwater and outlet water. Contaminated water could be spilled while being transported to and from the TPE system, or by leaks in the process piping. Failure of the TPE system piping, drop out tanks or hoses could result in a major spill. The unit, tanks and hoses will be inspected daily for leaks. Radian will be responsible for implementing appropriate spill containment procedures.

4.8 Recordkeeping

Records include the HSP, training records, monitoring equipment calibration records, exposure monitoring results, incident and accident reports, and audit reports. Types or categories of records are listed in Table 4-11. Occurrence of any incident involving SITE personnel will be documented with response actions taken and the eventual disposition recorded. An incident is defined as an accident, illness, or case of exposure (suspected or actual). Should an incident occur during any of the site activities, the PHSO or SSC is responsible for notifying the RPM and WAM and submitting an incident report (Form 308). Figure 4-3 is an example of the incident report. Another team member may submit the report if the SSC is unable to do so. The incident report will include the following:

- Date, time, and place of occurrence
- Person(s) involved
- Type of incident
- Description of incident and action taken
- Recommendations for prevention of a similar occurrence.

The SSC will forward the incident report to the WAM and PHSO for review and distribution. The WAM and PHSO will investigate the incident thoroughly to develop possible solutions for preventing a recurrence of the incident.

4.9 References

1. 29 CFR 1910.120 "Hazardous Waste Operations and Emergency Response."
2. 29 CFR 1910.1200 "Hazard Communication."
3. NIOSH Pocket Guide to Chemical Hazards. National Institute of Occupational Health and Safety, June 1990.

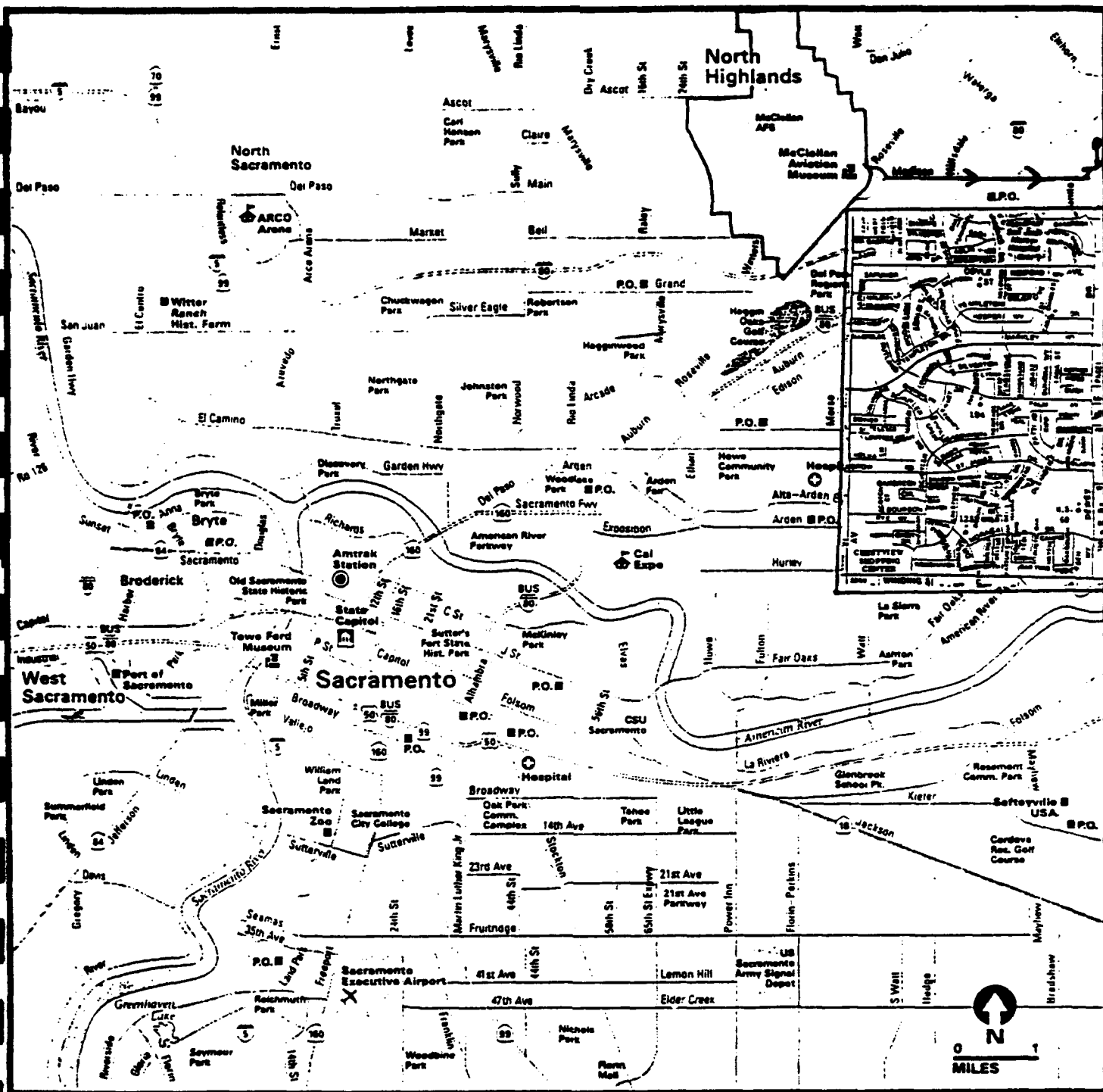


Figure 4-2. Hospital Route

TABLE 4-11. RECORDKEEPING

Health and Safety Area	Onsite Recordkeeping Required?	Monitoring/ Recordkeeping Frequency	Location of Documentation
Hazardous Chemical			
- Area Monitoring	Yes	Hourly	Logbook ¹
- Personnel Monitoring	No		Medical File, letter to affected employee
Oxygen Level Measurements	Yes	Hourly	Logbook ¹
Flammability Measurements (%LEL)	Yes	Hourly	Logbook ¹
Instrument Calibration	Yes	Daily	Logbook ²
Electrical			
- Lockout/Tagout Records	Yes		Logbook ¹
Temperature Extremes			
- WBGT Measurements	Yes	Air Temp. > 70°F	Logbook ¹
- Daily Temperature/Wind Speed	Yes	Daily	Logbook ¹
Noise			
- General Area Measurements	No	As Needed	Logbook ¹
- Personnel Exposure Samples	No	Activity Specific	Medical file, letter to employee
Illumination			
- Area Foot-Candle Measurement	No	As Needed	Logbook ¹
Personnel Medical Monitoring	No	Per Requirement	Medical file, letter to employee
Safety/Emergency Response			
- OSHA 200 Log	Yes	As Needed	Logbook ¹
- Accident/Incident Reports	Yes	As Needed	Logbook ¹ & Separate Records
Personal Protective Equipment			
- Inspection of:			
Clothing	Yes	Daily	Logbook ¹ if Defective
Respirators	Yes	Daily	Logbook ¹ if Defective
Gloves	Yes	Daily	Logbook ¹ if Defective
Boots	Yes	Daily	Logbook ¹ if Defective
Training of Employees	Yes	Annually	Site Office
Medical Approvals	Yes	Initially and as Required	Site Office

¹ Health and Safety/Personnel Entry Logbook

² Equipment Decontamination and Calibration Logbook

FORM 308

INCIDENT REPORT

DATE _____

Note: To be completed only for representative of SAIC.

Project: _____ Project No. _____

Injured Employee: _____ Employee No. _____

Date Injured: _____ Time: _____ a.m. p.m.

Date Reported: _____ Last Day Worked: _____

Did Employee Return to Work? _____ Date Returned: _____

Where Accident Occurred: _____

Witnesses: _____

Work Performed When Injured: _____

Kind and Extent of Injury: _____

Name and Address of Doctor/Hospital: _____

Description of Accident: _____

Was There Equipment Malfunction? ☐ Yes ☐ No

Describe Damage to Equipment or Property: _____

Figure 4-3. Example of Incident Report.

Unsafe Condition or Act Causing Accident: _____

Action Taken to Prevent Similar Accident: _____

Additional Recommendations or Action: _____

___ Photo(s) Taken (number of photos taken)

Field Supervisor: _____

Figure 4-3. Example of Incident Report (Continued).

APPENDIX 2

SITE HEALTH AND SAFETY PLAN

5.0 SITE HEALTH AND SAFETY PLAN

This Health and Safety Plan (HASP) is designed to address the health and safety issues associated with the activities described below. It is important to note that this HASP serves to supplement the existing base wide HASP, the OU B HASP (August 1993), and the Groundwater Sampling and Analysis HASP. These documents must be available on-site as a reference. It is expressly intended that all project work shall comply with applicable sections of the Occupational Safety and Health Administration (OSHA) standards for General Industry (29 CFR 1910), and for the Construction Industry (29 CFR 1926).

The tasks to be conducted during this project involve potential risk to field personnel. The physical and chemical hazards, associated with the anticipated work activities outlined below, are analyzed in the following sections.

Anticipated work activities include:

- Demonstration test of the Xerox Two-Phase Extraction technology;
- The modification of the Groundwater Treatment Plant (GTP);
- Extraction well modification and monitoring well installation using hollow stem auger drilling techniques;
- Installation of dual-containment pipeline;
- Installation of concrete containment pad;
- Transport and install equipment and piping;
- Handling, transport, and disposal of excavated materials and drill cuttings;
and
- Collect water samples from existing groundwater monitoring wells.

5.1 Key Personnel and Responsibilities

Radian Corporation disclaims any responsibility for the contractor's interpretation of the information presented by the Radian HASP. Radian Corporation will not assume any Contractor responsibilities for complying with the OSHA standards, and will not be responsible for the safety and health of the Contractor's and/or any subcontractor's employees.

Each Contractor is responsible for the safety and health of their employees and subcontractors.

5.1.1 Radian Project Manager/Project Director Responsibilities

Radian key personnel include the Project Manager/Director, Gordon Kingsley. The Project Manager/Director has the overall responsibility to ensure that the Radian HASP is implemented in accordance with federal, state, and local community requirements, and Radian Corporation policy. The Radian Task Leader, John Clark is the technical contact for the project.

5.1.2 Radian On-Site Engineer Responsibilities

The on-site Radian Engineer shall be responsible for on-site health and safety observations and appropriate health and safety recommendations in regard to Radian personnel. In the instance that noncompliance is observed, the engineer will report the incident to the supervisor of the employee in violation. In addition, the engineer shall have authority to stop the project based on his observation of health and safety concerns. Additional duties and/or responsibilities of the engineer are as follows:

- Locate support facilities in uncontaminated areas;
- Ensure site safety instruction for personnel as described in this plan;
- Conduct and/or observe air monitoring instrumentation and insure availability of applicable personal protective equipment;
- Initiate emergency phone calls when an injury or accident requires medical attention if applicable;

- Ensure that personnel observe safe work practices in accordance with this HASP;
- Maintain safety equipment in a usable condition;
- Report problems to the appropriate supervisor; and
- Maintain the project Health and Safety file.

5.1.3 Contractor/Subcontractor Employee Responsibilities

The Contractor/Subcontractor (C/S) shall be fully responsible for the health and safety of his employees. The C/S shall comply with applicable sections of the Occupational Safety and Health Administration (OSHA) standards for General Industry (29 CFR 1910), and for the Construction Industry (29 CFR 1926). Radian's observations of the C/S work practices does not imply that Radian concurs with the adequacy of these practices for protection of the health and safety of the persons involved, since this responsibility rests solely with the C/S.

Employees which are members of the work crew are to read and understand the HASP, perform work safely, be aware and alert for signs and symptoms of exposure to site contaminants and/or heat stress; and report any unsafe working conditions to their immediate supervisors. C/S supervisors shall be responsible for ensuring their work crews/compliance with the respective HASPs, and all applicable OSHA standards.

5.2 Hazard Analysis

This section of the HASP addresses specific on-site hazards which may be encountered during the activities described in Section 5.1. This plan addresses anticipated activities and hazards and allows provision for modification or amendment as health-related data are developed throughout the project.

5.2.1 General Safety

The presence of heavy equipment, moving/rotating pieces, and multiple pieces of equipment can contribute to the potential for safety hazard. All personnel shall be trained on any piece of equipment they are required to operate and maintain documentation in accordance

with federal law. Prior to operation of any machinery, all belt and coupling guards will be in place and secured. Personnel should not place anything behind a guard. The extraction equipment operates under approximately -30 inches of mercury. Caution should be used when disconnecting vacuum lines. Proper lock-out/tag-out procedure should be used whenever work is performed on the unit. High vacuum can present hazards should there be an open pipe.

Electric shock can occur by direct contact with live electrical wires or by contact with equipment and instruments utilizing faulty wiring. Electrical equipment such as pumps may present significant electric shock hazard if they become wet or have faulty wiring. Radian employees will not be allowed to perform any electrical work other than the use of extension cords. The electrical contractor will provide Radian with a copy of their written lock-out/tag-out program for review. The electrical subcontractor will also brief Radian personnel and any other subcontractors on their lock-out/tag-out program with special emphasis on tag/lock designs, and procedures for removal of tags/locks and energizing circuits.

Falls can occur when climbing ladders on Baker tanks. Personnel should always use both hands when climbing and never attempt to carry items while climbing. If equipment is needed on the top of the tank, it should be tied to a rope and hauled up from above. All railings should be provided on the Baker tank at all times. All fixed ladders shall meet the requirements of OSHA, 29 CFR 1910.27.

Safety features incorporated into the design includes shut down of the two-phase unit during high levels, temperatures and pressure, an eye wash, and labeling of process and utility lines in accordance with ANSI A13.1 or IAW AFOSH Standard 127.44.

5.2.2 Chemical Hazards

Some information on chemicals anticipated at the site has already been generated during previous studies. Based on the previous studies, volatile organic chemicals of concern from a health and safety perspective have been identified and are listed in Table 5-1, along with their respective health effects data.

Significantly contaminated soils and groundwater, if encountered, will produce elevated airborne concentrations and elevated point source concentrations that are readily detected with direct-reading instruments. Inhalation of volatile organic vapors and skin contact with contaminated soils, groundwater, and equipment is the most likely route of personnel

Table 5-1
Available Information Regarding Health Effects
of Chemicals of Concern

Chemical	Airborne Exposure Criteria¹	Health Effect
Activated Carbon (sorbent material)	10 mg/m ³	Nuisance dust, respiratory irritation
Chloroform	10 ppm	Cancer, CNS depression, damage to blood forming systems
Chloromethane	100 ppm	CNS depression, liver and kidney damage
1,1-Dichloroethane	100 ppm	CNS depression, liver and kidney damage, drowsiness
1,2-Dichloroethane	10 ppm	Cancer, CNS depression, liver and kidney disease
Freon® 113	1,000 ppm	Irritation, dermatitis, dizziness
Carbon Tetrachloride	5 ppm	Cancer, CNS depression, damage to kidney, liver, and lungs
Tetrachloroethene	50 ppm	Cancer, dermatitis, CNS depression, liver diseases, cardiac arrhythmias, acts synergistically with alcohol
Trichloroethene	50 ppm	Cancer, CNS depression, acts synergistically with alcohol
Vinyl Chloride	1 ppm	Cancer, liver and bone diseases

¹ American Conference of Governmental Industrial Hygienists Threshold Limit Value (TLV); or Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) if Lower than the TLV.

exposure in the work area. Real-time air monitoring instruments will indicate the presence of vapors before a chronic inhalation hazard exists.

The following safety precautions will be implemented to ensure the protection of Radian employees from potential chemical hazards:

- Protective clothing will be required during the work activities which present the potential for significant exposure to site contaminants (i.e., drilling operations), further direction is provided by the Radian Personnel Hydrocarbon Response Criteria (Table 5-2).
- An air monitoring program as outlined in Section 5.4 will be implemented periodically in order to measure airborne concentrations of volatile organic compounds potentially encountered during on-site work.
- Chemical-resistant protective clothing and respiratory protection will be available for specific tasks and in the event that air monitoring results indicate the presence of hazardous concentrations of organic vapors in air.

5.2.3 Physical Hazards

Personnel shall be aware at all times of the potential physical hazards. Physical hazards present include:

- Mechanical. Cuts; contusions; being struck by or striking objects; being caught between objects; becoming entwined in rotating tools; and falling objects. Heavy or moving equipment and machinery.
- Electrical. Possible excavation of buried cables and exposure of overhead power lines during drilling; lightening hazards during electrical storms; and electrical shock by electrical equipment (see Sections 5.2.1 and 5.2.3.5 for additional electrical hazards).
- Fire. Possible excavation of buried gas lines; grass fires; and equipment fires (see Section 5.2.3.5).

Table 5-2
Hydrocarbon Response Criteria

Organic Vapor Concentrations (OVC) Readings at Sampling Site (SS) by Photoionization (PID) or Total Petroleum Hydrocarbon (TPH) as Measured with Detector Tubes (DT)	Sampling Frequency	Action Taken (Log of Results)
OVC from 0 to 1 ppmv > 2 minutes	When disturbing the soil; and every 15 minutes or 1-foot depth by HA or 5-foot depth by MB; and after collecting the sample.	• Modified Level D protection — Cotton work clothes — Safety glasses — Steel-toed work boots — Gloves — Tyvek® coveralls required for personnel working in the exclusion zone. • Proceed with sampling procedures • Log results and dates on permanent record for future reference
OVC from 2 to 10 ppmv > 2 minutes • Collect DTs at SS for: — Vinyl chloride (VC)* and — Benzene (B) DT at SS for B and VC* reveal NDC.	When disturbing the soil and every 15 minutes or 1-foot depth by HA or 5-foot depth by MB; and after collecting the sample.	• Modified Level D protection • Proceed with sampling procedures • Log results and dates
OVC from 10 to 100 ppmv > 2 minutes • Collect DTs at SS for: — Vinyl chloride* and — Benzene DT at SS for VC* reveal NDC B = 1 to 10 ppmv with a half-face respirator B = 10 to 50 ppmv with a full-face respirator.	When disturbing the soil and every 15 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	• Modified Level C protection: — Half or full face respirator with OV/HEPA cartridges. — Tyvek® coveralls, nitrile and neoprene gloves, neoprene boots. • Work crew moves upwind for 15 min. • Proceed with sampling upwind of SS. • Log results and dates.
OVC from 100 to 500 ppmv • Collect DTs at SS for: — Benzene — Vinyl chloride*, and DT measurements at SS for VC* reveal NDC B = 10 to 50 ppmv at SS, but < 10 ppmv in RWBZ.	When disturbing the soil and every 20 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	• Level C protection: • Monitor VOC in RWBZ with PID & DT. If OVC > 500 ppmv or if DTs exceed criteria, upgrade to full-face respirators. • Work crew moves upwind of SS 15 min. • Proceed with sampling upwind of SS. • Log results and dates.
OVC from 500 to 5,000 ppmv • Collect DTs at SS for: — Trichloroethene, — Benzene, — Vinyl chloride*, or Detector tube measurements at SS for VC* reveal detectable concentrations at SS, but not BZ; or benzene > 50 BZ, or trichloroethene > 500 ppmv at SS, but < 1,000 ppmv in RWBZ.	Immediately before and after disturbing the soil and every 20 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	• Continue Level C protection: — Use full-face respirators. • Monitor RWBZ for B, VC*, TCA, and TPH. • Work crew moves upwind from SS. • Re-evaluate — Wait 15 minutes — OVC < 500 ppmv, resume sampling — OVC > 500 ppmv, wait 15 minutes. • If concentrations remain > 500 ppmv ≥ 2 hours: Contact FTL and PHSO. • Initiate vapor suppression techniques (i.e., downhole nitrogen injection) • Monitor vapor emissions with a CGI.

Table 5-2
(Continued)

Organic Vapor Concentrations (OVC) Readings at Sampling Site (SS) by Photoionization (PID) or Total Petroleum Hydrocarbon (TPH) as Measured with Detector Tubes (DT)	Sampling Frequency	Action Taken (Log of Results)
OVC >5,000 ppmv or CGI >10% LEL in work area, or CGI >25% in the borehole, or RWBZ concentrations for >2 minutes: vinyl chloride* >10 ppmv, or benzene >50 ppmv	Immediately before and after disturbing the soil and every 20 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	• Work crew dons SA or SCBA; or • Stop work, wait for vapor concentration to subside • Continue vapor suppression • Work crew positions themselves upwind from cuttings or borehole • Continue to monitor with CGI • Contact PHSO and Project Director
OVC >5,000 ppmv, or CGI >25% LEL in borehole or CGI >10% LEL in work area.	Immediately before and after disturbing the soil and every 20 minutes or 1-foot depth by HA or 5-foot depth by MB and after collecting the sample.	• Stop work, wait for vapors to subside • Work crew moves upwind • Contact PHSO and Project Director
Detectable concentrations of vinyl chloride in the workers breathing zone require immediate response. See bold print footnote following table.	Continuously to every 20 minutes.	• Work crew dons full-face respirators with OVCs. Replace OVCs every hour while exposed to 1 to 10 ppmv VC, or • Work crews don SA or SCBA, or • Work stops. • Work crew moves upwind. • Re-evaluate — Wait 15 minutes — Sample VC with DT in the WBZ - VC not detected in WBZ, resume sampling - VC detected in WBZ, wait 15 minutes, resample for VC. • Inform project PHSO.

* OSHA approves the use of full-face air purifying respirators with OVCs for concentrations of vinyl chloride ≤ 10 ppmv for one hour (CFR 29, Part 1910, 1017, pg. 138, 1989). If full-face air purifying respirators are used in atmospheres known to contain detectable concentrations of vinyl chloride ≤ 10 ppmv, a rigorous assessment of vinyl chloride concentrations will be conducted. Draeger® tubes for vinyl chloride will be collected in the workers' breathing zone once every 20 minutes to confirm concentrations are ≤ 10 ppmv. In addition, due to the (PEL)¹ of vinyl chloride (1 ppmv), OVCs exposed to vinyl chloride will be replaced every hour and disposed of at the close of sampling activities. If, at any time, a variance from these procedures should be observed or reported, or airborne concentrations of vinyl chloride exceed 10 ppmv, SA or SCBA will be mandatory for all sampling activities associated with wells or borings known to contain detectable airborne concentrations of vinyl chloride.

1,1,1-Trichloroethane = 350 ppmv; Vinyl chloride* = 1 ppmv; Trichloroethene = 50 ppmv; Benzene = 1 ppmv

* Occupational Safety and Health Administration Permissible Exposure Limit 29 CFR 1910.1017.

CGI = Combustible Gas Indicator

DT = Detector Tubes

HA = Hand Auger

MB = Mechanical Boring

PHSO = Project Health and Safety Officer

NDC = No Detectable Concentrations

NIOSH = National Institute of Occupational Safety and Health

OSHA = Occupational Safety and Health Administration

OVC = Organic Vapor Concentrations

PEL = Permissible exposure limit for 8 hours/day, 40 hours/week, for a working lifetime

PID = Photoionization Detector

RWBZ = Radian Workers Breathing Zone

SA = Supplied Air

SCBA = Self-Contained Breathing Apparatus

SS = Readings at Sampling Site

TLVs = Threshold Limit Values recommended by the American Conference of Governmental Industrial Hygienists for 1989-90.

- **Slips, trips, and fall hazards:** Areas may be muddy and have uneven surfaces. Radian personnel shall be aware of these and other possible hazards such as equipment on the ground (see General Safety, Section 5.2.1.).

During the planning/mobilization phase of the program, the contractor shall consult with base personnel about the location of utility lines and other such underground hazards and obtain all McClellan AFB-required permits. If excavation or drilling cuttings indicate the possible presence of underground drums or cylinders, operations shall be stopped immediately.

5.2.3.1 Open Trenches, Pits, and Holes

Open trenches (2'-4' deep), will present a hazard to personnel working in the area. An appropriate method of marking the trenches, such as boundary tape, yellow cones or flags shall be used. No worker shall enter any pit or trench greater than four feet in depth unless the sides are shored or laid back to a stable slope as specified in 29 CFR 1926.652.

If an employee is required to enter a pit or trench four or more feet in depth, an adequate means of access and egress such as a slope of at least 2:1 to the bottom of the pit, or a ladder or steps shall be provided. Prior to entering any trench which may have the potential for the accumulation of toxic gases or vapors, the atmosphere at the bottom of the pit and at four foot intervals thereafter (if greater than four feet in depth) shall be tested for oxygen deficiency, combustible gases, and organic vapors. Oxygen levels below 19.5% require the use of pressure demand self contained breathing apparatus (SCBA) or a pressure demand air line respirator with escape pack.

5.2.3.2 Heavy Equipment

The presence of heavy equipment on-site shall require all personnel be constantly aware of location, speed, and direction of the machinery. To ensure that equipment is easily recognized to be in the area, all equipment shall have back-up alarms that operate properly. When working around heavy machinery, employees must make their presence known to the equipment operators. All moving equipment shall consist of road legal vehicles and shall observe all the traffic regulations at McClellan AFB. Maintenance shall be conducted on a routine (as needed) basis at the work site or staging area. The work site shall be cordoned off with yellow tape and/or reflective safety flagging to prevent vehicle or pedestrian interference

with the work site. Work shall not impede normal traffic ways without providing orange traffic cones to direct traffic around the working site.

5.2.3.3 Noise

Work around heavy equipment can result in exposure to excessive noise. Operation of construction equipment normally does not result in noise levels in excess of OSHA PEL of 90 dBA or the Action Limit of 85 dBA. Excessive noise can be generated by the pumps operating on site, and can result in communication difficulties and hearing impairment. All personnel in the vicinity of the pumps will wear hearing protection at all times while the pump is in operation. The Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for noise is 90 dB (A); an OSHA action level of 85 dB (A) has also been established. All personnel working around or visiting the extraction unit will be required to wear hearing protection at all times while the pump is in operation.

5.2.3.4 Heat Stress

Exposure to outside temperature extremes, even while in U.S. EPA-Level D PPE, may result in heat stress. All personnel should be familiar with the following signs and symptoms of heat stress/heat stroke:

- Heat stress - Dizziness, light-headedness, slurred speech, fatigue, fainting, copious perspiration, cool clammy skin, and increased resting heart rate (> 110 beats per minute); and
- Heat stroke - Delirium, fainting, and hot, dry, flushed skin.

Any employee exhibiting heat stress symptoms shall be removed from field work immediately and requested to consume 2 to 4 pints of electrolyte fluid or cool water every hour. The individual shall not return to work until symptoms are no longer recognizable. If the symptoms appear critical, persist or get worse, medical attention shall be sought immediately.

5.2.3.5 Gas and Power Lines

Underground utility lines present in the area shall be located and marked to prevent accidental puncture or breakage during excavation or drilling activities. In the event an

unmarked buried utility line is damaged, work operations shall halt immediately and all equipment will be shut down until the nature of the line is discovered. Should damage occur to a natural gas utility line, all electrical and motorized equipment shall remain shut down and the contractor shall be responsible for having the line repaired immediately.

5.3 Personal Protective Equipment (PPE)

Personal protective equipment (PPE) shall be used by personnel when engineering controls and work practices are not feasible to adequately reduce employee exposure hazards. PPE selection shall be based on specific task activities, historical data of contaminants known to exist at the site, site conditions, and the results of the air monitoring program described in Section 5.4. The scope of this section is strictly limited to the activities describe in Section 5.0. Real-time air monitoring results may require an immediate upgrade in respiratory protection or cessation of work activities until hazardous vapor concentrations disperse. Specific guidance is provided by Table 5-2.

The major chemical exposure hazards at the site result from:

- Inhalation of airborne contaminants either in the form of dust or fugitive vapors emanating from the contaminated soils, liquids, or the carbon treatment vessels; and
- Dermal contact with, or ingestion of, contaminated soils and liquids.

PPE requirements for each task may be modified after concurrence between the on-site health and safety officer and the project health and safety officer. The required PPE which shall be available to site personnel for construction/excavation, installation and drilling activities includes:

- Hard hat;
- Safety glasses with side shields;
- Chemically-resistant clothing:
 - Disposable Tyvek® coveralls; coated Tyvek® shall be used in wet areas;

- **Steel-toe and shank work boots:**
 - **Leather (rubber if liquid contamination exists);**
- **Gloves**
 - **Leather work gloves, and**
 - **Double layer disposable gloves when liquid contamination exists (latex/nitrile combination);**
- **Half-face or full-face respirator with organic vapor/HEPA cartridges (for drilling and sampling activities); and**
- **Hearing Protection.**

The following task descriptions are intended to address the general PPE requirements pertaining to the activities scheduled for this project. In addition, specific tasks (such as drilling-task C, soil or water or soil gas sampling-task D, etc.) are subject to all PPE and air monitoring requirements as provided in the OU B HASP (August 1993) and the GSAP HASP (1993). If the exposure potential of a task is not fully characterized or is questionable, site personnel should contact the Radian Project Health and Safety Officer for further discussion and clarification of PPE requirements.

Task A Description (Non-construction): All non-construction tasks with no or minimal potential for dermal exposure to contaminated soils, liquids, or materials.

- **Safety glasses with side-shields;**
- **Long pants and a suitable sleeved shirt;**
- **Nitrile gloves (where contact with soils, waters, or contaminated equipment is anticipated); and**
- **Hearing protection (optional).**

A face shield will be required if the potential for liquid splashing or pressurized gas streams exists at anytime. An upgrade to Tyvek may be warranted if contact with liquids or soils is anticipated.

Task B Description (Construction, etc.): All construction and maintenance tasks or activities in an area with construction, maintenance, or other material movement occurring. These tasks present no or minimal potential for dermal exposure to contaminated soils, liquids, or materials. In addition to the requirements for Task A, the following PPE is required:

- Hard hat;
- Steel-toed safety boots; and
- No loose clothing and personal jewelry.

A face shield will be required if the potential for liquid splashing or pressurized gas streams exists at anytime during field activities and any time acids are handled. An upgrade to Tyvek may be warranted if contact with contaminated liquids and soils is anticipated.

Task C Description (Drilling): All well drilling/development operations with potential for dermal exposure to contaminated soils, liquids, or materials. In addition to the requirements described for Task A and B, the following PPE is required:

- Tyvek coveralls are required if contact with contaminated liquids and soils is anticipated.

Task D Description (Sampling): All groundwater, soil, and soil vapor sampling activities. These activities inherently provide the potential for exposure to contaminated soils, liquids, or materials.

- Steel-toed safety boots;
- Safety glasses with side-shields;
- Long pants and a suitable sleeved shirt;

- No loose clothing and personal jewelry;
- Nitrile gloves (where contact with soils, waters, or contaminated equipment is anticipated); and
- Tyvek coveralls are required if contact with contaminated liquids and soils is anticipated.

Temperature Limitations

Chemical-resistant protective clothing and respirator use can cause employees to fatigue rapidly and will inhibit body cooling. Personnel shall be instructed to pace themselves to ensure adequate rest periods.

5.4 Air Monitoring and Safe Work Practices

Air Monitoring

Air monitoring will be conducted according to the schedule provided in Table 5-2. Although this table was created for OU B drilling activities, the chemical hazards, air sampling strategy, and PPE action levels are applicable for this project.

Vinyl chloride has historically been detected in the extraction wells, however it has not been detected in any of the more recent analysis conducted. Vinyl chloride adsorbs poorly to activated carbon and may pass through the carbon beds with limited reduction in concentration. The other chemicals listed in Table 5-1 pose less exposure risk as they are more effectively adsorbed to activated carbon.

Air monitoring will be performed at the outlet of the system to determine the potential for worker exposure. The following precautions will be taken in order to ensure that field personnel are not being over-exposed to organic vapors.

- The extraction system will be equipped with an exhaust stack which is at least 10 feet above grade;

- All work associated with the extraction testing will be performed upwind of the exhaust stack whenever possible; and
- After initiating work on the system, Draeger® colorimetric indicator tube samples will be collected from breathing zone height in the general work area to determine the airborne concentration of vinyl chloride.

If vinyl chloride is detected at concentrations greater than 1 ppm using the Draeger system, field personnel will follow the guidance provided in the McClellan AFB OU B Health and Safety Plan with respect to personal protective equipment and continued monitoring. Specific PPE and work area air monitoring procedures are also provided in Table 5-2.

Training and Medical Surveillance Requirements

Drilling and sample collection personnel are required to be in compliance with the Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120 Hazardous Waste Operations health and safety training requirements. All field team personnel must have had a physical examination with medical clearance within the last year to conduct this work.

Recordkeeping Requirements

Records of training and medical surveillance will be maintained at Radian.

5.5 Work Zones and Decontamination Procedures

The Radian field task leader is responsible for establishing the appropriate work zone designation and defining the zone in accordance with this plan.

General Work Zone

A general work zones shall be established by the site safety officer or field task leader through the use of barricade tape or other appropriate barrier. A general work zone is characterized by not containing any uncontrolled chemical substances or materials. Minimal PPE requirements for this zone is defined by Tasks A and B. Refer to Figure 4-1, Work Zones and Decontamination Station Layout of the Quality Assurance Project Plan (QAPP).

Exclusion Zone

An exclusion zone shall be established to minimize the risk of chemical exposure and contaminant migration off-site, and to restrict unauthorized personnel from entering potentially dangerous work areas. No eating, drinking, or smoking shall be allowed in the exclusion zone. The exclusion zone will be established using barricade tape. A complete description of the EZ can be found in the OU B or GSAP HASP.

Contamination Reduction Zone

The contamination reduction zone (CRZ) acts as a buffer zone allowing personnel egress to and from the EZ. All contaminated clothing and equipment is disposed of or decontaminated in this zone. A complete description of the CRZ can be found in the OU B or GSAP HASP.

Support Zone

A support zone will be established outside of the exclusion zone. This zone is considered free of chemical and physical hazards and may be used for observational purposes. A complete description of the SZ can be found in the OU B or GSAP HASP.

Decontamination Procedures

Decontamination of equipment and PPE shall be conducted in the contamination reduction zone prior to entering a support zone from an exclusion zone. This includes decontaminating or isolating equipment and PPE before placing these in sampling vehicles.

Decontamination of sampling equipment shall occur before removing PPE. Decontamination procedures for sampling equipment will follow the procedures set forth in the work plan. If personnel come in contact with groundwater, the affected area should be thoroughly washed with soap and water.

5.6 Emergency Response

Emergency procedures listed in this plan are designed to give the field team instruction in handling medical emergencies.

5.6.1 Injuries

Medical problems that may occur on-site need to be handled competently and quickly. Each field team member shall know the location and contents of the first aid kit supplied to them. Each field team member shall be aware of the instructions and information given below.

- Become familiar with the emergency telephone numbers in Section 5.6.
- Seek professional medical attention for personnel who are not breathing, bleeding severely, experiencing intense pain, or are unconscious. Each member of the site team will know how to call for an ambulance (on- and off-base).
- If you get chemicals or dust in your eyes, flush them with water for 15 minutes.
- Do not remove objects that are stuck in the eye. Always seek medical attention for eye injuries.
- All burns (chemical or thermal) will be treated by running cold water over the affected area.
- Report all injuries to the Project Safety Officer and/or your supervisor and the Base fire department. A written incident/accident report shall be transmitted to the Base within 24 hours.
- In case of any emergency, the McClellan AFB Environmental Management will be notified.

5.6.2 Heat Stress

All project personnel should be familiar with the signs and symptoms of heat stress, as follows:

- **Heat Exhaustion** - dizziness, fatigue, copious perspiration, cool skin that is sometimes pale and clammy, and nausea; and
- **Heat Stroke** - hot, dry, flushed skin; delirium, and coma (in some cases).

If symptoms of heat exhaustion are observed, the person shall be required to rest in a shaded area and consume liquids. An appropriate work/rest regimen shall be initiated. This may involve limiting the work period so that after one minute of rest, a person's heart rate (HR) does not exceed 110 beats per minute.

5.6.3 Emergency Equipment

The following emergency equipment shall be available for immediate use. All field personnel shall be made aware of the location of the emergency equipment.

- Phone list and directions to the nearest emergency care center;
- First-aid kit;
- 1-10 lb ABC rated fire extinguisher;
- Eye wash station; and
- 5 gallons potable water.

5.6.4 Emergency Phone List

Three digit on-base phone numbers can only be used when calling from on-base phone system. For emergency calls made from cellular or off-base phones, use the commercial seven digit numbers indicated.

HOSPITALS

- On-base (if life threatening): 115 or 643-2334
- Out-patient Clinic: Building 541, 646-8577 or 646-8420

- Off-base: 537-5000
Mercy-San Juan Hospital - Emergency Room
6501 Coyle Avenue
Carmichael, CA

Figure 4-2, Hospital Route, is included on page 4-30 of the QAPP in the appendix.

URGENT CARE

- Immediate Care
Elkhorn Plaza
5339 Elkhorn Plaza
331-2800

FIRE

- On-base: 117 or 643-6666
- Off-base: 911

AMBULANCE

- On-base: 115 or 643-2334, 646-8577
- Off-base: 911

POLICE

- On-base: 112 or 643-6160, 643-2585, 643-6168
- Off-base: 911

RADIAN SAFETY OFFICER

- Rick Moore: (916) 362-5332 (office)
- Kim Worl: (916) 362-5332 (office)

ENVIRONMENTAL MANAGEMENT

- Elaine Anderson: (916) 643-0830

SURGEON GENERAL BRANCH

- Beeper: (916) 328-2042

APPENDIX 3

**TWO-PHASE EXTRACTION PILOT TEST-EXTRACTION WELL 233
TECHNICAL MEMORANDUM**

TWO PHASE EXTRACTION PILOT TEST - EXTRACTION WELL 233 TECHNICAL MEMORANDUM

1.0 Executive Summary

The results of the pilot test conducted on extraction well (EW) 233 indicated that the two-phase extraction (TPE) system is an effective and appropriate technology for improving control and remediation of the groundwater plume at Investigative Cluster (IC) 1. In particular, the TPE system achieved the following results during the pilot test:

- Groundwater flow rates were increased by approximately 2 times versus the existing pump and treat system flow rate.
- The TPE system appeared to pull higher contaminant concentrations to the well in both the groundwater and the soil gas versus the concentrations measured in the baseline testing.
- The mass of contaminants extracted by the TPE system was approximately 12 times greater than that extracted by the existing pump and treat technology, with approximately 80% of the increase due to extraction of soil gas.
- The TPE transferred approximately 95% of the groundwater VOCs to the gas phase.
- The system was able to run with little or no operator interaction on a continuous basis. The system ran for 70.5 consecutive hours including unattended operation at night and for most of the last two days of testing.

These results show that TPE will increase the rate of groundwater and vadose zone remediation and improve the hydraulic control of the groundwater plume as a result of the increase in groundwater production. It is recommended that the existing pump and treat system be converted to TPE.

2.0 Pilot Test Overview

The pilot test of the TPE system, a Xerox Technology, was conducted as part of the EPA SITE Program in coordination with research efforts sponsored by the USAF. Radian Corporation installed and operated the TPE system. SAIC, EPA's SITE Program contractor, and ERMI provided analytical support for characterization of water and vapor samples. The site for the pilot test was EW233 at IC 1 in OU B, located near the southeast corner of building 655 at McClellan Air Force Base. The installation and baseline testing of the TPE system began on February 22. Pilot test operation occurred between March 1 and March 4, 1994. Table 1 provides a chronology of the pilot test. Figure 1 shows a schematic of the TPE pilot test system.

During the pilot test, the system produced an average vacuum of 22 inches Hg in the straw. This resulted in an average soil gas flow rate of 65 to 70 standard cubic feet per minute (scfm), a groundwater production rate of approximately 8 to 9 gallons per minute (gpm), and a residual vacuum in the well of 2 inches Hg.

3.0 Results

The pilot test indicated that the TPE system is an effective technology for extraction of contaminants from the groundwater and soil vapor around EW233. Tables 2 and 3 provide a summary of the analytical data obtained for the pilot test while Table 4 summarizes flow rates and mass of VOCs removed (in pounds per year based on continuous operation at the given flow and sample concentrations). Tables 5 and 6 show groundwater depression and piezometer data used to estimate the groundwater and soil gas radius of influence, respectively. A summary of the key results of the pilot test is provided below.

- Groundwater flow rates were increased from an average 3.5 gallons per minute (gpm) with the pump and treat system to 8 to 9 gpm with the TPE system (approximately 2.5 times greater).
- The TPE system pulled higher contaminant concentrations to the well in both the groundwater and the soil gas versus the concentrations identified in the baseline testing. For example, the trichlorethene (TCE) soil gas concentration rose from 2800 parts per billion by volume (ppbv) in the pre-test soil gas samples to 33,000 ppbv in the post test data, an increase of 12 times higher. Groundwater concentrations were also generally increased, although to a smaller degree than in the soil gas. For example the water concentration of TCE in the pre-test sample was 5300 micrograms per liter (ug/l) versus a post test concentration of 9,500 ug/l, an increase of 2 times.

At the TPE pilot test flow rates of 9 gpm groundwater and 65 to 70 scfm soil gas, the mass removal rate of contaminants increased five time over the rate at the pilot test baseline concentration levels. This appears to be occurring as a result of the migration of higher concentration groundwater and soil vapor towards the well.

- The mass of contaminants extracted by the TPE system was increased by approximately 12 times versus the existing pump and treat technology. Approximately 100 lbs/yr of contaminants would be removed by the pump and treat technology based on a 3.5 gpm flow rate and the baseline concentration data. The concentration and flow data for the last two days of testing (relatively steady state operations) equate to a removal rate of approximately 1200 lb/yr in the offgas and 20 lb/yr in the treated water.
- The TPE transferred approximately 95% of the groundwater VOCs to the gas phase. This appears to be fairly consist between the baseline

water concentrations and the initial treated water results (250 lb/yr baseline with 10 lb/yr in treated water [96% removal]) and the post test water concentrations and the final treated water data (425 lb/yr post test and 23 lb/yr in the last treated water sample [95% removal]).

- A rough mass balance on the contaminant removal levels showed general agreement between the results of the test after a relative steady state operating condition was reached (March 3 and 4) and the post-test data. During steady state system operation gas phase contaminant removal increased to 1200 lb/yr in the off-gas and 20 lb/yr in the treated water (1220 lb/yr total). Based on the post test sample data and equivalent flow rates, the source of contaminants was approximately 450 lb/yr in groundwater and 600 lb/yr in soil vapor for a total of 1050 lb/yr.
- The groundwater depression resulting from the pilot test reached 190 feet from the well. The soil vapor radius of influence was estimated to extend 750 feet (to a vacuum of .1 inch of water) although the induced vacuum data do not show steady-state conditions. The area surrounding EW233 is well capped with asphalt (parking lots/roadways) or concrete (buildings, foundations) within the radius of the farthest piezometer nest. Extrapolation of this data beyond the capped area out to uncapped areas may overestimate the actual radius of influence.

One anomaly was identified in the baseline data: the concentrations appear to increase during the baseline testing between the samples taken at the wellhead versus the samples taken at the TPE unit outlet. This was confirmed by increases in gas contaminant concentrations when ambient air was pulled through the system prior to the start of the test. This would indicate that some residual contaminants were present in the system at the initial startup; possibly from shakedown testing of the system and trial operations with different extraction straw sizes prior to the start of the actual pilot test. As a result, the baseline samples collected at the wellhead are expected to be more representative of the baseline concentrations at the start of the pilot test.

Table 1
Pilot Test Chronology

Date	Time	Activity
2/25/94	1000-1045 1050	Collected baseline groundwater samples. Removed existing groundwater pump.
2/28/94	—	Tested TPE system with 2" and 3" straws. Selected 3" straw for pilot test.
3/1/94	1130-1230 1350	Collected ambient air and baseline soil vapor samples. Began pilot test with straw at 110.5 ft BLS and water table at 107.25 ft BLS; total well depth 123.5 ft BLS.
	1350-1700	Continued operation; slowly lowered straw in intervals to 115.3 ft BLS (ambient air bleed at wellhead at 10 scfm).
	1630-1645	Collected off-gas and treated water samples.
3/2/94	0915-1650	Continued operation; slowly lowered straw in intervals to 123.0 ft BLS (final straw depth 0.5 ft above well bottom).
	0945-1000 1005	Collected off-gas and treated water samples. Shut off ambient air bleed at well head.
	1345-1400	Collected off-gas and treated water samples (SAIC only).
3/3/94	0950-1005	Collected off-gas and treated water samples.
3/4/94	1030-1045 1220	Collected off-gas and treated water samples. End pilot test.
	1255-1300	Collected pot-test soil vapor samples.
3/11/94	1430	Collected post-test groundwater samples.

Table 2

McCLELLAN AFB
RESULT FOR DUEL-PHASE EXTRACTION TEST AT EW233
VAPOR ANALYSES

Sample #:	EW233-005	EW233-006	EW233-007	EW233-008	EW233-009	EW233-011	EW233-014	EW233-015	EW233-017	EW233-018
Date:	3/1/84	3/1/84	3/1/84	3/1/84	3/1/84	3/2/84	3/8/84	3/8/84	3/8/84	3/8/84
Time:	1103	1103	1204	1112	1028	0415	080	1030(DUP)	1030	1208
Matrix:	Ambient Air	Ambient Air	Soil Gas	Soil Gas	Off Gas	Off Gas	Off Gas	Off Gas	Off Gas	Soil Gas
Location:	Ambient	Trailer	Well Head	Trailer	Trailer	Trailer	Trailer	Trailer	Trailer	Well Head
US EPA Method TO-14										
Sample Specific										
Detection Limit:	4.0	8.0	8.0	24	120	240	320	280	320	140
Freon 12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	ND	ND	210	250	4000	14000	380	430	610	280
Methylene Chloride	ND	ND	ND	ND	ND	ND	12000	16000	15000	7100
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethane	ND	ND	16	25	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	4	2000	2000(E)	6000	36000	55000	34000	37000	43000	18000
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	7	18	300	83	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	1200	ND	920	5100	10000	12000	13000	12000	5700
Ethylene Dibromide	ND	ND	12	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	ND	16	ND	32	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	ND	10	ND	40	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Octane	ND	17	ND	ND	ND	ND	ND	ND	ND	ND
Bromotoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Propylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Butadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroprene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	12	27	15	310	ND	ND	ND	ND	ND	ND
Cyclohexane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

(E) Exceeds instrument calibration range, but within linear range.

(B) Compound present in laboratory blank, background subtraction not performed.

(ND) Not detected above sample specific detection limit.

Table 3

McCLELLAN AFB
RESULT FOR DUEL-PHASE EXTRACTION TEST AT EW233
WATER ANALYSES

Sample #:	EW233-001	EW233-002	EW233-004	EW233-010	EW233-012	EW233-013	EW233-016	EW233-019
Date:	2/25/94	2/25/94	3/1/94	3/2/94	3/3/94	3/3/94	3/4/94	N/A
Time:	1000	1045	1636	0958	1005	1006	1630	N/A
Matrix:	Groundwater	Groundwater	Treated Water	Treated Water	Treated Water	Treated Water	Treated Water	Groundwater
Location:	Wellhead Spigot	Well w/Batter	Trailer	Trailer	Trailer	Trailer	Trailer	Well w/Batter
Detection								
U.S. EPA Method 8010	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Chloromethane	0.5	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	0.5	ND	ND	ND	ND	ND	ND	ND
Bromomethane	0.5	ND	ND	ND	ND	ND	ND	ND
Chloroethane	0.5	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.5	ND	ND	ND	ND	ND	ND	ND
Freon 113	0.5	21	0.8	3.1	2.9	3.1	2.9	14
1,1-dichloroethene	0.5	4.7	ND	ND	ND	ND	ND	ND
Dichloromethane	0.5	ND	ND	ND	ND	ND	ND	ND
1,1,2-Dichloroethene	0.5	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.5	ND	ND	ND	ND	ND	ND	ND
c-1,2-Dichloroethene	0.5	14	0.7	1.3	1.3	ND	0.5	5.6
Chloroform	0.5	1.7	ND	ND	ND	ND	ND	1.7
1,1,1-Trichloroethane	0.5	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	0.5	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.5	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.5	3000	250	380	480	480	520	9500
c-1,3-Dichloropropene	0.5	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropene	0.5	ND	ND	ND	ND	ND	ND	ND
1,1,3-Dichloropropene	0.5	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	0.5	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.5	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.5	630	25	54	76	66	60	1700
Dibromochloromethane	0.5	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	0.5	ND	ND	ND	ND	ND	ND	ND
Bromoform	0.5	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.5	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	0.5	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.5	ND	ND	ND	ND	ND	ND	ND
1,1-Dichlorobenzene	0.5	ND	ND	ND	ND	ND	ND	ND
Detection								
U.S. EPA Method 8020	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Benzene	0.5	ND	ND	ND	ND	ND	ND	ND
Toluene	0.5	4	8	ND	ND	ND	ND	ND
Ethyl Benzene	0.5	ND	ND	ND	ND	ND	ND	ND
Total Xylenes	0.5	ND	5	ND	ND	ND	ND	ND

Table 4
Flow and Mass Extraction Rates

Vapor Data					Water Data					Vapor + Water	
Sample Number	Sample Descript.	Flow Rate (scfm)	Total VOC Conc. (ppbv)	Extract. Rate (lb/yr)	Sample Number	Sample Descript.	Flow Rate (gpm)	Total VOC Conc. (ug/l)	Extract. Rate (lb/yr)	Extract. Rate (lb/yr)	Extract. Rate @ 70 scfm & 9.1 gpm (lb/yr)
Baseline (Pre-Test) Data (GW from Spigot)											
007	Well Head	45	3355	26.8	001	Spigot	8.2	3675.4	132.2	159.0	188.4
							9.1	146.7	173.5		
		60		47.7			8.2	132.2	179.9		
							9.1	146.7	194.4		
		75		44.7			8.2	132.2	176.9		
							9.1	146.7	191.4		
		62		37.0			8.2	132.2	169.2		
			9.1	146.7	183.7						
		70		41.7	8.2	132.2	173.9				
					9.1	146.7	188.4				
Baseline (Pre-Test) Data (GW from Bailer)											
007	Well Head	45	6800	26.8	002	Bailer	8.2	6563	235.5	262.3	303.1
							9.1	261.3	288.2		
		60		47.7			8.2	235.5	283.2		
							9.1	261.3	309.0		
		75		44.7			8.2	235.5	280.2		
							9.1	261.3	306.1		
		62		37.0			8.2	235.5	272.5		
			9.1	261.3	298.3						
		70		41.7	8.2	235.5	277.2				
					9.1	261.3	303.1				
Pilot Test Data (GW from Bailer)											
										(Last Test Value)	
009	Off-Gas	80	45025	690.5	004	Treated H2O	8.2	278.5	9.9	700.4	1203.9
							9.1		11.0	701.5	
011	Off-Gas	75	79000	1170.4	010	Treated H2O	8.2	438.4	15.8	1180.3	
							9.1		17.5	1181.4	
014	Off-Gas	62	88380	1082.1	012	Treated H2O	8.2	580.2	20.1	1092.1	
							9.1		22.4	1093.2	
015	Off-Gas	62	104430	1265.3	013	Treated H2O	8.2	559.1	20.1	1275.2	
							9.1		22.3	1276.3	
017	Off-Gas	70	98810	1192.9	016	Treated H2O	8.2	583.4	21.0	1202.8	
							9.1		23.3	1203.9	
Post-Test Data											
018	Well Head	70	48080	630.1	019	Bailer	8.2	11239.3	404.2	1034.4	1078.7
							9.1	448.6	1076.7		
		80		720.2			8.2	404.2	1124.4		
							9.1	448.6	1168.7		
		75		675.2			8.2	404.2	1079.4		
			9.1	448.6	1123.7						
		62		558.1	8.2	404.2	962.3				
					9.1	448.6	1006.7				

Table 5

Result for Dual-Phase Extraction Test
McClellan AFB Extraction Well EW233

Groundwater Pump Removed: Feb 25 at 10:50

Dual-Phase Test Started: Mar 01 at 13:50

Dual_Phase Test Completed: Mar 04 at 12:20

Groundwater Elevation Data

Well Number	159	235	236	65	156	157	41S	154
Distance from EW233	220 N	85 NE	85 SE	272 SE	145 W	108 SW	140 S	310 SW
Date	Time	Depth to Groundwater (feet from Top of Casing)						
Feb 24	--	106.73	na	111.03	107.55	na	109.31	na
Mar 01	11:00	106.74	106.51	113.22	107.48	107.05	109.28	110.30
	14:30	106.65	106.48	113.21	107.43	107.35	109.23	110.48
	17:30	106.65	106.52	113.22	107.45	107.02	109.22	110.53
Mar 02	09:15	106.72	106.69	113.22	107.51	107.13	109.30	109.24
	11:15	106.67	106.64	113.20	107.47	107.08	109.26	109.95
	14:00	106.64	106.63	113.20	107.45	107.07	109.24	110.31
Mar 03	16:00	106.60	106.58	113.19	107.40	107.03	109.20	110.38
	12:30	106.78	106.45	113.20	107.55	107.17	109.34	110.47
Mar 04	11:30	106.78	106.79	113.19	107.58	107.21	109.37	110.04

Time is approximate (within +/- 15 min)

Apparent Drawdown (Change in Elevation versus Mar 01 at 11:00)

Well Number	159	235	236	65	156	157	41S	154
Distance from EW233	220 N	85 NE	85 SE	272 SE	145 W	108 SW	140 S	310 SW
Date	Time	Depth to Groundwater (feet from Top of Casing)						
Feb 24	--	0.01	na	2.19	-0.07	na	-0.03	na
Mar 01	11:00	baseline	baseline	baseline	baseline	baseline	baseline	baseline
	14:30	0.09	0.03	0.01	0.05	-0.30	0.05	-0.18
	17:30	0.09	-0.01	0.00	0.03	0.03	0.06	-0.23
Mar 02	09:15	0.02	-0.16	0.00	-0.03	-0.08	-0.02	1.06
	11:15	0.07	-0.13	0.02	0.01	-0.03	0.02	0.35
	14:00	0.10	-0.12	0.02	0.03	-0.02	0.04	-0.01
Mar 03	16:00	0.14	-0.07	0.03	0.06	0.02	0.08	-0.08
	12:30	-0.04	-0.36	0.02	-0.07	-0.12	-0.06	-0.17
Mar 04	11:30	-0.04	-0.39	0.03	-0.10	-0.16	-0.09	0.26

Time is approximate (within +/- 15 min)

Table 6

Results of Dual-Phase Extraction Testing
McChesley APB Extraction Well EW233Extraction Testing Started Mar 01 at 13:50
Extraction Testing Completed: Mar 04 at 12:20

Piezometer Date (Soil Gas Pressure Measured Relative to Atmospheric Pressure)

Piezometer Nest (VPN)

Distance from EW233 (feet)

Piezometer

Depth (feet)

Date

Mar 01

Mar 02

Mar 03

Mar 04

Mar 05

Mar 06

Mar 07

Mar 08

Mar 09

Mar 10

Mar 11

Mar 12

Mar 13

Mar 14

Mar 15

Mar 16

Mar 17

Mar 18

Mar 19

Mar 20

Mar 21

Mar 22

Mar 23

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Mar 25

Mar 26

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Mar 36

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Mar 40

Mar 41

Mar 42

Mar 43

Mar 44

Mar 45

Mar 46

Mar 47

Mar 48

Mar 49

Mar 50

Mar 51

Mar 52

Mar 53

Mar 54

Mar 55

Mar 56

Mar 57

Mar 58

Mar 59

Mar 60

VPN-7

88 NE

Reading (feet Water)

Change in Reading (feet Water)

Absolute P Reading (feet Water)

Barometric Pressure (feet Hg)

41 Pressure

54

68

82

96

110

124

138

152

166

180

194

208

222

236

250

264

278

292

306

320

334

348

362

376

390

404

418

432

446

460

474

488

502

516

530

544

558

572

586

600

614

628

642

656

670

684

698

712

726

740

754

768

782

796

810

824

838

852

866

VPN-7

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Absolute P Reading (feet Water)

Barometric Pressure (feet Hg)

41 Pressure

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88 NE

Reading (feet Water)

Change in Reading (feet Water)

Absolute P Reading (feet Water)

Barometric Pressure (feet Hg)

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446

APPENDIX 4

**HEALTH RISK SCREENING MODEL OUTPUTS,
EMISSIONS, AND RISK CALCULATIONS**

05/05/94
10:37:35

*** SCREEN2 MODEL RUN ***
*** VERSION DATED 92245 ***

McClellan 2 Phase

SIMPLE TERRAIN INPUTS:

SOURCE TYPE = POINT
EMISSION RATE (G/S) = 1.00000
STACK HEIGHT (M) = 5.2000
STK INSIDE DIAM (M) = .0760
STK EXIT VELOCITY (M/S) = 6.7000
STK GAS EXIT TEMP (K) = 298.0000
AMBIENT AIR TEMP (K) = 293.0000
RECEPTOR HEIGHT (M) = .0000
URBAN/RURAL OPTION = RURAL
BUILDING HEIGHT (M) = 12.2000
MIN HORIZ BLDG DIM (M) = 91.0000
MAX HORIZ BLDG DIM (M) = 183.0000

BUOY. FLUX = .002 M**4/S**3; MOM. FLUX = .064 M**4/S**2.

*** FULL METEOROLOGY ***

*** SCREEN AUTOMATED DISTANCES ***

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)		U10M STAB	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	SIGMA DWASH
360.	991.2	6	1.0	1.0	10000.0	5.22	18.41	16.61	SS
400.	909.6	6	1.0	1.0	10000.0	5.22	19.72	16.92	SS
500.	749.8	6	1.0	1.0	10000.0	5.22	22.96	17.70	SS
600.	633.3	6	1.0	1.0	10000.0	5.22	26.16	18.46	SS
700.	545.0	6	1.0	1.0	10000.0	5.22	29.32	19.20	SS
800.	475.8	6	1.0	1.0	10000.0	5.22	32.44	19.93	SS
900.	420.5	6	1.0	1.0	10000.0	5.22	35.53	20.64	SS
1000.	375.2	6	1.0	1.0	10000.0	5.22	38.60	21.33	SS

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 360. M:

360. 991.2 6 1.0 1.0 10000.0 5.22 18.41 16.61 SS

DWASH= MEANS NO CALC MADE (CONC = 0.0)

DWASH=NO MEANS NO BUILDING DOWNWASH USED

DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED

DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED

DWASH=NA MEANS DOWNWASH NOT APPLICABLE, $X < 3*LB$

***** CAVITY CALCULATION - 1 *****

CONC (UG/M**3) = 298.6
CRIT WS @10M (M/S) = 1.00
CRIT WS @ HS (M/S) = 1.00
DILUTION WS (M/S) = 1.00
CAVITY HT (M) = 12.20
CAVITY LENGTH (M) = 67.42
ALONGWIND DIM (M) = 91.00

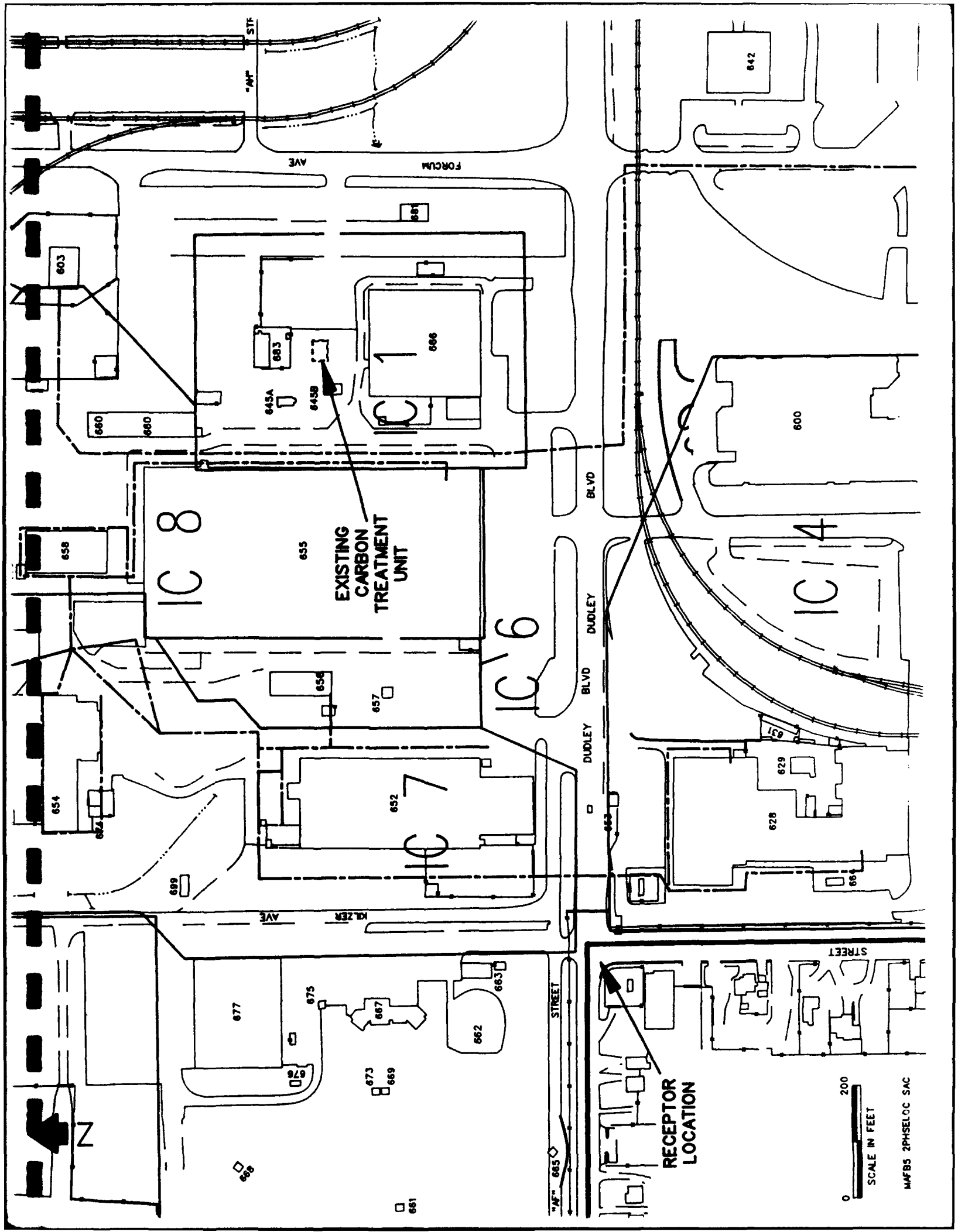
***** CAVITY CALCULATION - 2 *****

CONC (UG/M**3) = 600.5
CRIT WS @10M (M/S) = 1.00
CRIT WS @ HS (M/S) = 1.00
DILUTION WS (M/S) = 1.00
CAVITY HT (M) = 12.20
CAVITY LENGTH (M) = 55.59
ALONGWIND DIM (M) = 183.00

***** SUMMARY OF SCREEN MODEL RESULTS *****

CALCULATION PROCEDURE	MAX CONC (UG/M**3)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	991.2	360.	0.
BUILDING CAVITY-1	298.6	67.	-- (DIST = CAVITY LENGTH)
BUILDING CAVITY-2	600.5	56.	-- (DIST = CAVITY LENGTH)

**** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS ****



McC Dual Phase HRA

file: mceeca/dualrisk.wq1

Carcinogen	Emission Rate (g/sec)	Percent Control	Ambient Conc. (ug/m ^ 3)	Dose (mg/kg-d)	Inhalation Potency (a) (mg/kg-d)-1	Cancer Risk
TCE	0.012	98.5	0.017838	4.89E-06	0.01	4.9E-08
PCE	0.0027	98.5	0.004014	1.10E-06	0.0206	2.3E-08
1,1-DCE	5.05E-05	90	0.0005	1.37E-07	0.175	2.4E-08
Total						9.6E-08

Noncarcinogens	Emission Rate (g/sec)	Ambient Conc. (ug/m ^ 3)	Dose (mg/kg-d)	Reference Dose (mg/kg-d)	Hazard Index
Freon 113	0.07	6.937	6.65E-03	30	2.2E-04

Exposure Parameters:

25550 carcinogenic averaging time (days) RAGS

7300 noncarcinogenic averaging time

70 body weight (kg)

20 inhalation rate (m3/d)

70 exposure duration(years)

350 exposure frequency (days/yr)

Dispersion Modeling:

991 Concentration in ambient air (ug/m3)/(g/sec) for 1-hr. max. SCREEN2

0.1 Conversion factor: 1-hr. max. to annual average